Planning the Eastern Channel Subcatchment

INNER WEST COUNCIL

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Kendrick Park, 1980.
(Photo: Marrickville Municipal Council, 1980, Available at: http://photosau.com/marrickville/scripts/home.asp)

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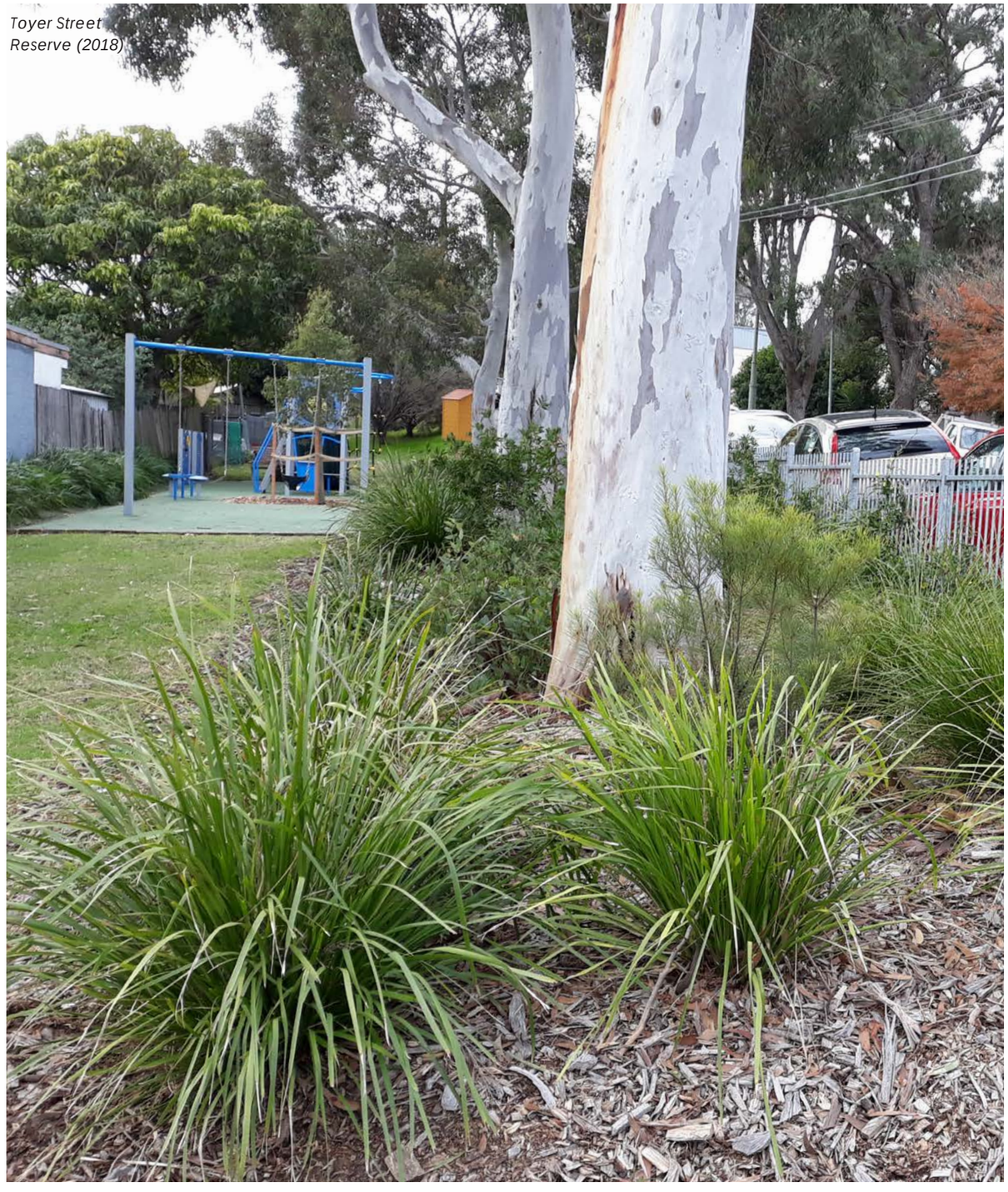
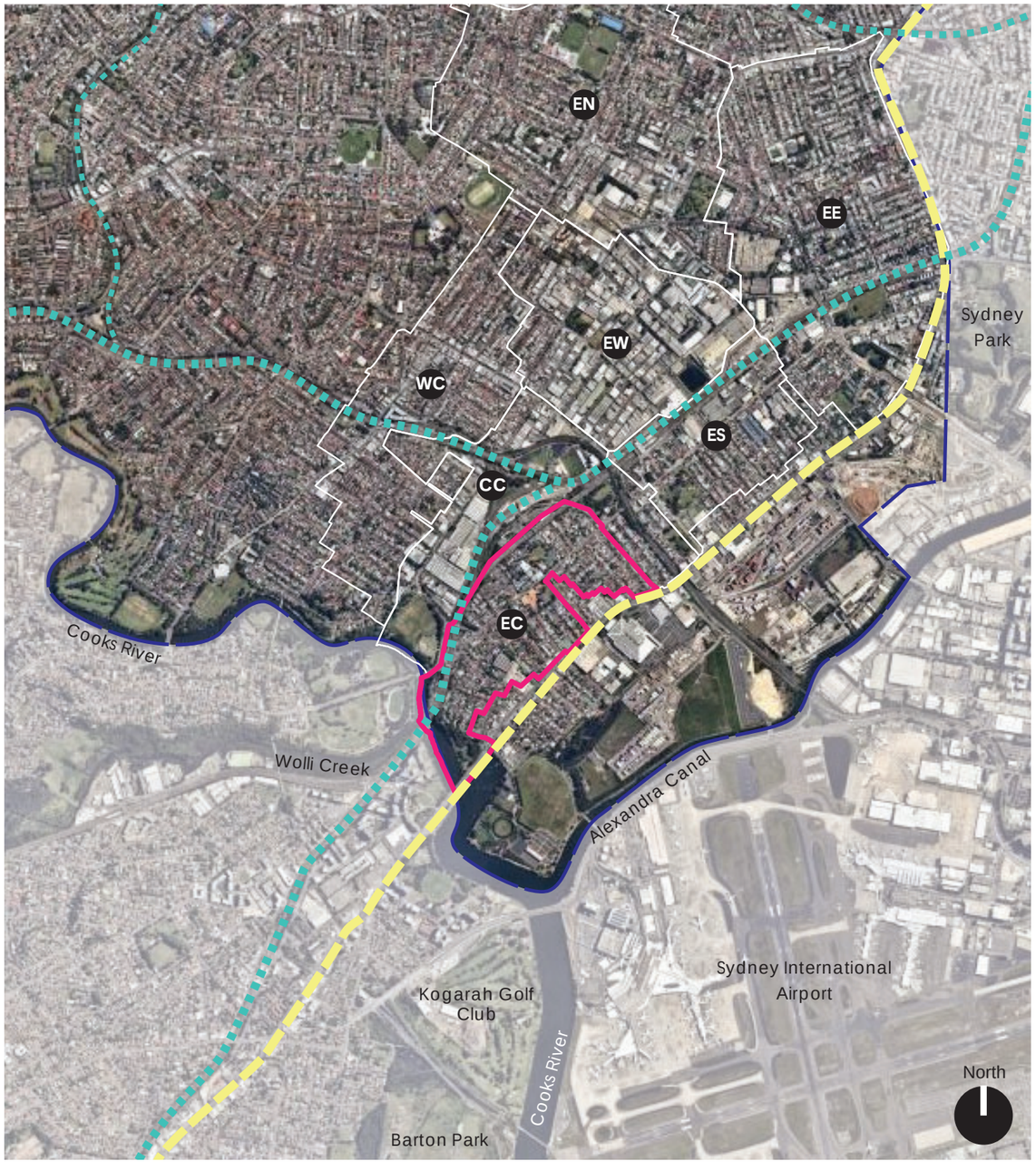


Toyer Street Reserve (2018)

Eastern Channel Subcatchment location



Eastern Channel (EC) Subcatchment boundary
Inner West Council LGA
Princes Highway
T4 Heavy rail line
Inner West lightrail line
Marrickville Valley subcatchments

The Eastern Channel Subcatchment

- in the southern part of the Inner West local government area (LGA)
- covers most of the suburb of Tempe
- bounded by Samuel Street to the north, Princes Highway to the east, Cooks River to the south and Eastern Channel and Eastern Suburbs and Illawarra rail line to the west
- Sydney International Airport is to the south-east

Key Definitions

Important concepts used in subcatchment planning (meaning as used in this booklet)

Biodiversity

Biodiversity is the variety of all living things, from the smallest microbe to the massive Blue Whale. Australia's native biodiversity is one of the most diverse, with many species found nowhere else in the world. For example, Long-nosed Bandicoots are endemic to the south-east coast of Australia, including inner western Sydney.

Ecosystem services

Ecosystem services are the benefits that plants, animals, water, soil, and air provide, e.g:

- trees acting as carbon sinks and providing oxygen and cooling;
- landscapes providing habitat, food, aesthetic, cultural and mental health benefits;
- fungi and insects supporting the food chain, soil formation and breaking down waste;
- bees, bats and birds pollinating plants

Green infrastructure

Green infrastructure is either the natural and engineered infrastructure that provides ecosystem services, e.g. trees, parks, wetlands, saltmarsh, roof gardens, habitat; or ecosystem service functions e.g. stormwater harvesting, recycled water and sewer mining.

Subcatchment

A subcatchment is a smaller catchment within a bigger catchment where the water drains to the waterway at the same point. In the EC catchment via the Eastern Channel next to the train line.

Urban ecology

Urban ecology is the interrelationship of nature with people and the built environment in towns and cities.

Urban forest

An urban forest is the totality of trees and shrubs on all public and private land in and around urban areas (including bushland, parkland, gardens and street trees) and is measured as a canopy cover percentage of the total area, and is recognised as a primary component of the urban ecosystem.

Water sensitive cities

Water sensitive cities are places that:

- serve as a potential water supply catchment, providing a range of different water sources at a range of different scales, and for a range of different uses;
- provide ecosystem services and a healthy natural environment, thereby offering a range of social, ecological, and economic benefits; and
- consist of water sensitive communities where citizens have the knowledge and desire to make wise choices about water, are actively engaged in decision-making, and demonstrate positive behaviours such as conserving water at home. (CRC for Water Sensitive Cities, 2018)

1. Introduction

Inner West Council has a program of subcatchment planning to improve ecological sustainability in the inner west. Council uses a collaborative approach to planning, inviting participation from everyone who lives, works, and owns or manages land in the area. This means that the plan and actions to improve ecosystems and liveability in the area are tailored to suit the local people and place.

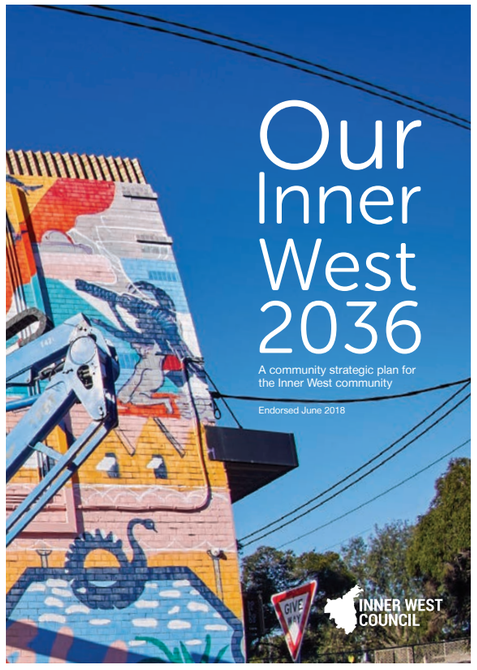
Council is currently completing subcatchment planning for the Eastern Channel (EC) subcatchment in the Tempe area in the southern part of the Inner West local government area (LGA).

Strategic framework

Community vision for 2036

The community vision is set out in the *Our Inner West 2036* Community Strategic Plan (CSP). It shows the community's future, long-term outcomes, strategies to get there, and how to measure progress towards that vision.

The community vision is:
"We are Inner West, land of the Gadigal and Wangal peoples, whose rich cultures, heritage and history we acknowledge and respect. We are defined by our diversity of people, places and ideas. We are an inclusive, vibrant, caring and progressive community where everyone is welcome, people and nature live in harmony, and creativity is a way of life."



An ecologically sustainable Inner West

The CSP contains five strategic directions to help achieve the community vision.

1. **An ecologically sustainable Inner West**
2. Unique, liveable, networked neighbourhoods
3. Creative communities and a strong economy
4. Caring, happy, healthy communities
5. Progressive local leadership

These are the big picture results which the community would like Council and its many partners to focus on achieving.

Strategic direction 1

Strategic Direction 1: An ecologically sustainable Inner West has three outcomes that directly relate to ecological sustainability as shown in the table below. Strategies will help achieve the outcomes.

Outcomes	Strategies
1.1 The people and infrastructure of Inner West contribute positively to the environment and tackling climate change	1. Provide the support needed for people to live sustainably 2. Reduce urban heat and manage its impact 3. Create spaces for growing food 4. Develop planning controls to protect and support a sustainable environment 5. Provide green infrastructure that supports increased ecosystem services*
1.2 Inner West has a diverse and increasing urban forest that supports connected habitats for flora and fauna	1. Support people to protect, restore, enhance and connect with nature in Inner West 2. Maintain and increase Inner West's tree canopy and urban forest, and enhance biodiversity corridors 3. Protect, conserve and enhance existing natural area sites for species richness and diversity
1.3 The community is water sensitive, with clean, swimmable waterways	1. Collaborate to deliver water-sensitive plans, decisions and infrastructure 2. Supply water from within Inner West catchments

Our Inner West 2036 (Inner West Council, 2018, page 17)

Urban Ecology in the Inner West

Council is committed to working towards an ecologically sustainable Inner West. This will be achieved in part by taking an urban ecosystem approach to improving and sustainably managing the urban forest and water.

The National Green Infrastructure Network's *Blueprint for Living Cities* (Davies et al. 2017) establishes a hierarchy to improve urban ecosystems through planning, design and practice.

Council will use this hierarchy to help improve urban ecosystems.

Protect and conserve
The protection and conservation of remnant ecosystems, where they exist, is crucial. In an increasingly urbanised world, such remnants provide important habitat and biodiversity.

Restore
Where ecosystems have been disturbed, restoration is the preferred option. Restoration includes bush regeneration and weed management in existing ecosystems.

Enhance
Where few existing ecosystems are available for restoration, improving green spaces is the next best option. This can be done by increasing the area of green spaces and the diversity and density of vegetation.

Create
If none of these options is available, new ecosystems must be created. Green infrastructure and water-sensitive urban design (WSUD) elements such as green roofs and bioswales can provide habitats and ecosystem services.

Urban ecology hierarchy (Davies et al., 2017)

Urban Forest

Council is enhancing the urban forest, including biodiversity, soils and tree canopy. Management of the urban forest across the LGA and at larger regional scales is generally guided by the principles of landscape ecology. Landscape ecology is the study of the interactions between the time and space of a landscape and the organisms within it (Forest Research, 2019). At a regional scale, landscape features such as corridors, patches and barriers form habitat mosaics for organisms to live in.

Water

Council is moving towards becoming a water sensitive community through its strategies and plans including the Marrickville Strategy for a Water Sensitive Community (2013). Council is an industry partner of the Cooperative Research Centre for Water Sensitive Cities (CRCWSC), that provides support, and develops new methods and technologies to achieve sustainable urban water management (SUWM).

Council has been working in partnership with its community for over 15 years on SUWM projects. It is moving current urban water management to a more sustainable and flexible approach that promotes liveable, productive, resilient and sustainable communities.

A Water Sensitive Community:
1. Supplies water from within its catchment
2. Provides green infrastructure to support ecosystem services
3. Participates in making plans, designs and decisions that are water sensitive

Sustainable urban water management:
• Reduces the amount of wastewater leaving a catchment that may cause pollution in other locations
• Reduces the reliance on drinking quality (potable) water brought in from outside the catchments
• Uses water that is fit-for-purpose i.e. using potable water for consumption only - not watering the garden or flushing the toilet
• Reduces the impact of stormwater on waterways

Subcatchment Planning

What is subcatchment planning?

Subcatchment planning is a collaborative and participatory process of planning local areas. It is one of the ways Council is working towards an ecologically sustainable Inner West. It involves the community directly affected in the planning decision-making process, as well as organisations responsible for managing the land and water. People from the community, government agencies and Council with various backgrounds and experience (e.g. social and urban planners, artists, environmental scientists, educators, engineers, parks and recreation managers) work together to identify problems and solutions for their neighbourhoods.

This approach to subcatchment planning grew out of evidence-based research to achieve sustainable urban water management. With six subcatchment plans complete, the plans now include urban forest (biodiversity, trees and soils).

This planning approach addresses three identified problems in conventional planning and management of urban ecosystems:

1. Technical experts, particularly engineers and scientists, have traditionally been responsible for developing solutions to complex urban problems. It is now recognised that we need to take a more holistic approach and include other thinkers, such as social scientists and landscape architects.

   Solution: Integrate the many disciplines, e.g. sociology, ecology, urban planning and engineering.

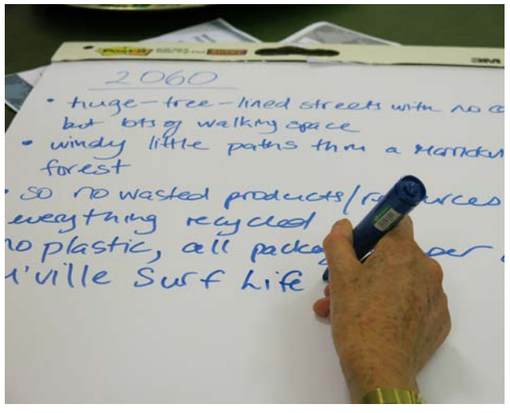
2. The people affected by environmental problems, including residents, businesses, community groups and government departments, have usually not been involved enough in planning discussions.

   Solution: Involve the whole subcatchment community in the decision making and implementation.

3. In the past, plans have been designed for large scale areas, e.g. whole river catchments or LGAs, rather than local more manageable areas.

   Solution: Reduce the planning unit to the local level, e.g. subcatchments

This approach provides a plan for green infrastructure and ecological sustainability actions for the next ten years. Actions are for Council, community and stakeholders, such as Sydney Water.



Photos from subcatchment planning vision sessions and planning forum

Planning the Eastern Channel subcatchment

What has happened so far?

Council has researched and compiled all the information presented in this planning booklet, including:

- Surveying residents about their knowledge, attitudes and behaviour to the local environment
- Calculating the water cycle, i.e. water coming in and going out of the area
- Working out how much is covered in hard (impervious) surfaces and the amount of pollution carried in stormwater going to the Cooks River
- Mapping of existing biodiversity, including soils and trees
- Developing a good understanding of the demographic characteristics of the subcatchment so programs can be delivered to meet the needs of the Eastern Channel communities

What is happening now?

At this stage of the project, residents of EC Subcatchment are imagining what urban ecosystems will look like in the subcatchment in 2070. Through vision sessions and other engagement activities, people who live and work in the subcatchment will contribute to a subcatchment vision. These visions will be the basis for goal setting and planning at the community planning forum that will be held in the first half of 2019. The forum will involve local residents and a broad range of stakeholders from business, government and community organisations.

Why do a community subcatchment vision?

By including the subcatchment vision from each of the subcatchment communities, this project maximises local knowledge and develops locally generated actions. This will ultimately produce a community subcatchment plan for each of the subcatchments in the Inner West that is tailor-made to local conditions so more widely accepted and adopted.

How to use this information booklet

This booklet presents information about Eastern Channel Subcatchment gathered to date to help all stakeholders make informed decisions. All the information we could find for the EC Subcatchment, relevant to urban ecosystems, has been compiled in this booklet. The first section contains an overview of the EC Subcatchment followed by detailed information about the subcatchment. It includes:

- history
- biophysical features (water, biodiversity, tree canopy,soil characteristics, hard surfaces and heat)
- social characteristics
- local organisations
- Council's planned capital works
- future development

The second section contains supporting information, including other topics to consider when planning for urban ecosystems, such as climate change.

Get ready for the visions sessions and planning forum

To help you take part in the vision sessions and planning forum, think ahead to the year 2070 and as you read this booklet imagine how things have changed. We encourage you to make notes of your ideas using the information in this booklet. Also note down any extra information we might have missed. When you finish, you might come up with possible answers to the list of questions on the next page.

Planning timeline

Questions to think about

As you read through this booklet think about the following questions.

What information is new to you?

How much biodiversity (including vegetation) is in the Eastern Channel Subcatchment at the moment?

What is the most surprising information?

How ecologically sustainable is the Eastern Channel Subcatchment now? Think about water, biodiversity, soils and tree canopy.

What's wrong with the water cycle now?

What part of the environment in the Eastern Channel needs the biggest changes?

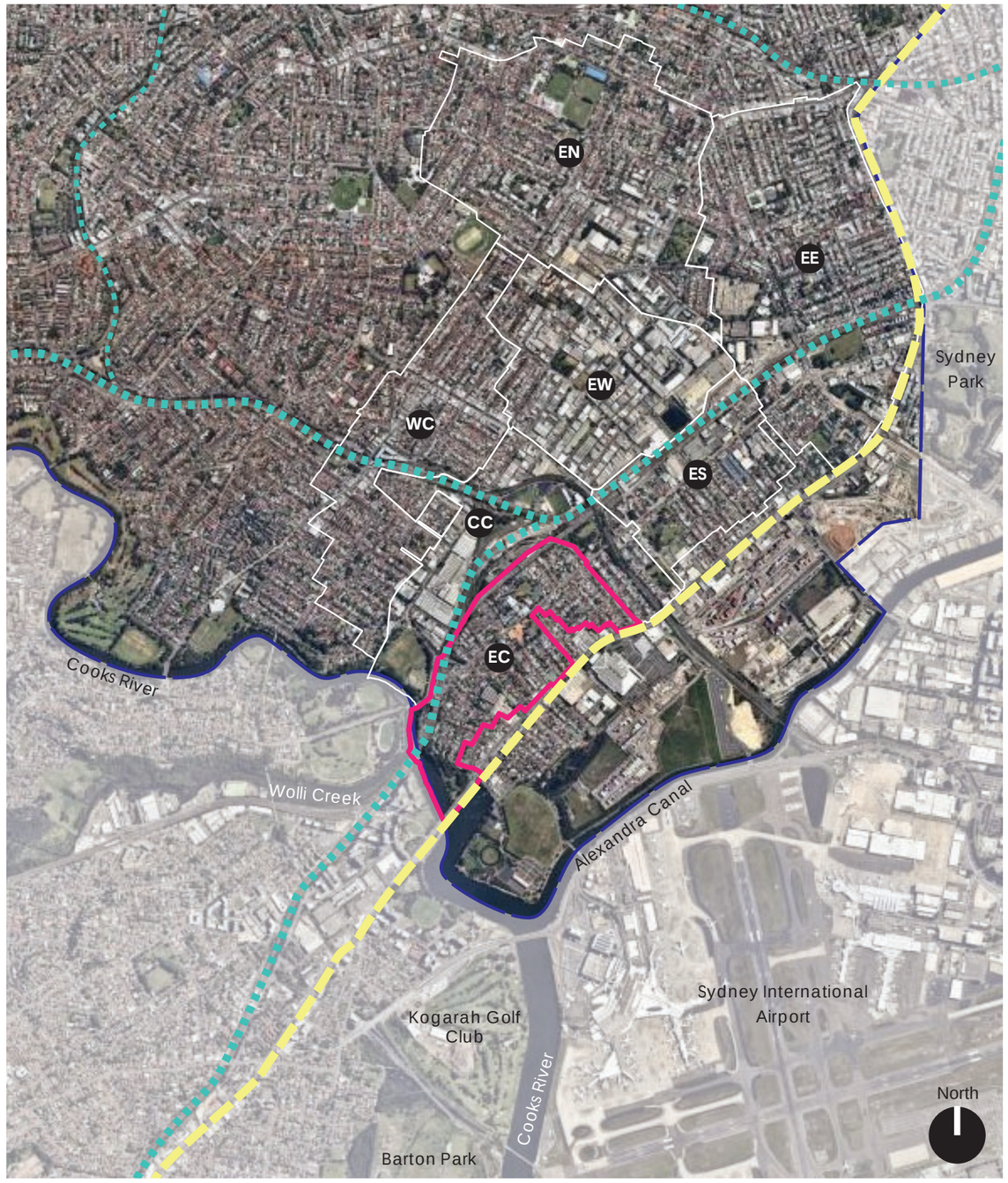
Where is the Eastern Channel Subcatchment?

The Eastern Channel Subcatchment (EC Subcatchment) is located in the southern part of the Inner West local government area (LGA). The EC Subcatchment covers most of the suburb of Tempe. It is bounded by Samuel Street to the north, the Princes Highway to the east, the Cooks River to the south, and the Eastern Channel and Eastern Suburbs and Illawarra rail line to the west. The Sydney International Airport is south-east of the Subcatchment.

The EC Subcatchment is part of the 345 hectare (ha) Marrickville Valley subcatchment. It is within the regional Cooks River Catchment and drains an area of 590ha to the Cooks River.

Seven subcatchments make up the Marrickville Valley (shown right):

- EE - Eastern Channel East (131 ha) (Subcatchment plan 2011)
- WC - Western Channel (81 ha) (Subcatchment plan 2014)
- EN - Eastern Channel North (136 ha) (Subcatchment plan 2013)
- EC - Eastern Channel 2 (52 ha)
- EW - Eastern Channel West (75 ha)
- ES - Eastern Channel South (43 ha)
- CC - Central Channel (71 ha)



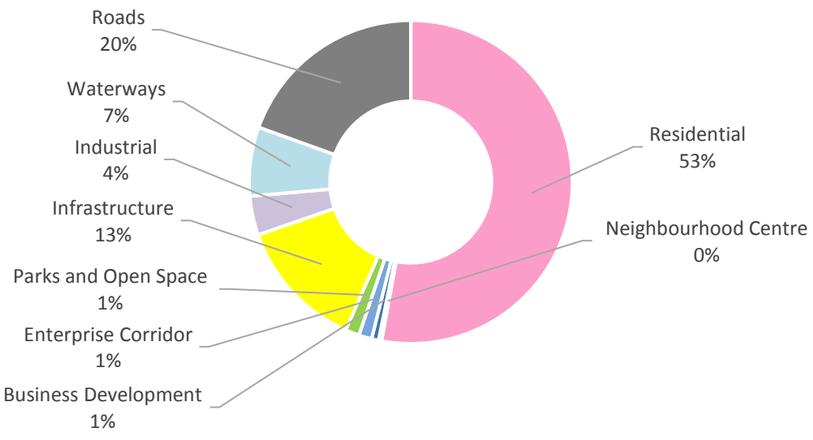
The Eastern Channel Subcatchment today: a snapshot

Population
- 2,720 residents
- 25% born overseas

Land use
- Mainly residential (see below)
- Some commercial along the Princes Highway
- Two schools (Tempe Public School and Tempe High School)
- Major transport infrastructure - bus depot, train line, Tempe train station and Princes Highway

Green space and vegetation
- Original vegetation Floodplain Forest and Cooks River sandstone vegetation
- Kendrick Park on the Cooks River
- Small local parks - Toyer Street Reserve and Green Street Park
- School playing fields

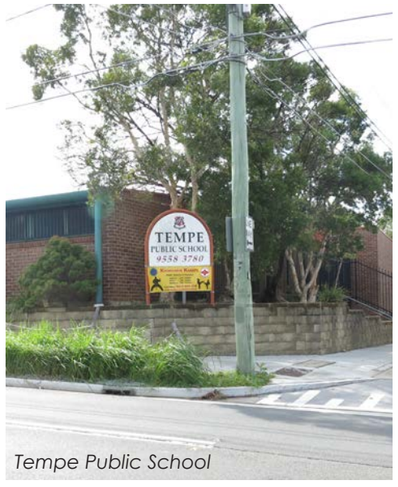
Water
- Catchment slopes gently to the south, draining to the Cooks River
- Concrete lined Eastern Channel drains most of the Marrickville Valley subcatchment, including the upper parts of the catchment
- Hard surfaces cover 70%
- Stormwater drainage responsibility of Council and Sydney Water



Land use in the EC Subcatchment

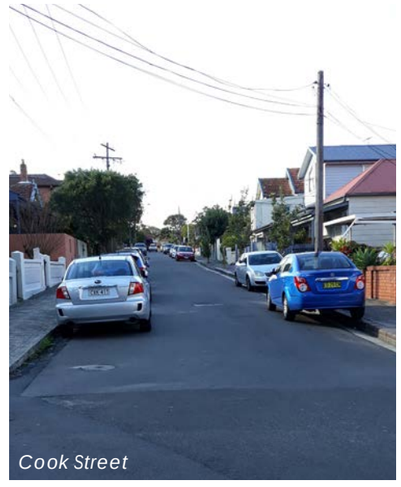

Tempe train line


Eastern Channel



Tempe Public School


Toyer Street Playground


Cook Street


Kendrick Park

2. The Eastern Channel Subcatchment planning context in 2019

Looking towards Fatima Island from Kendrick Park

History

Before European colonisation

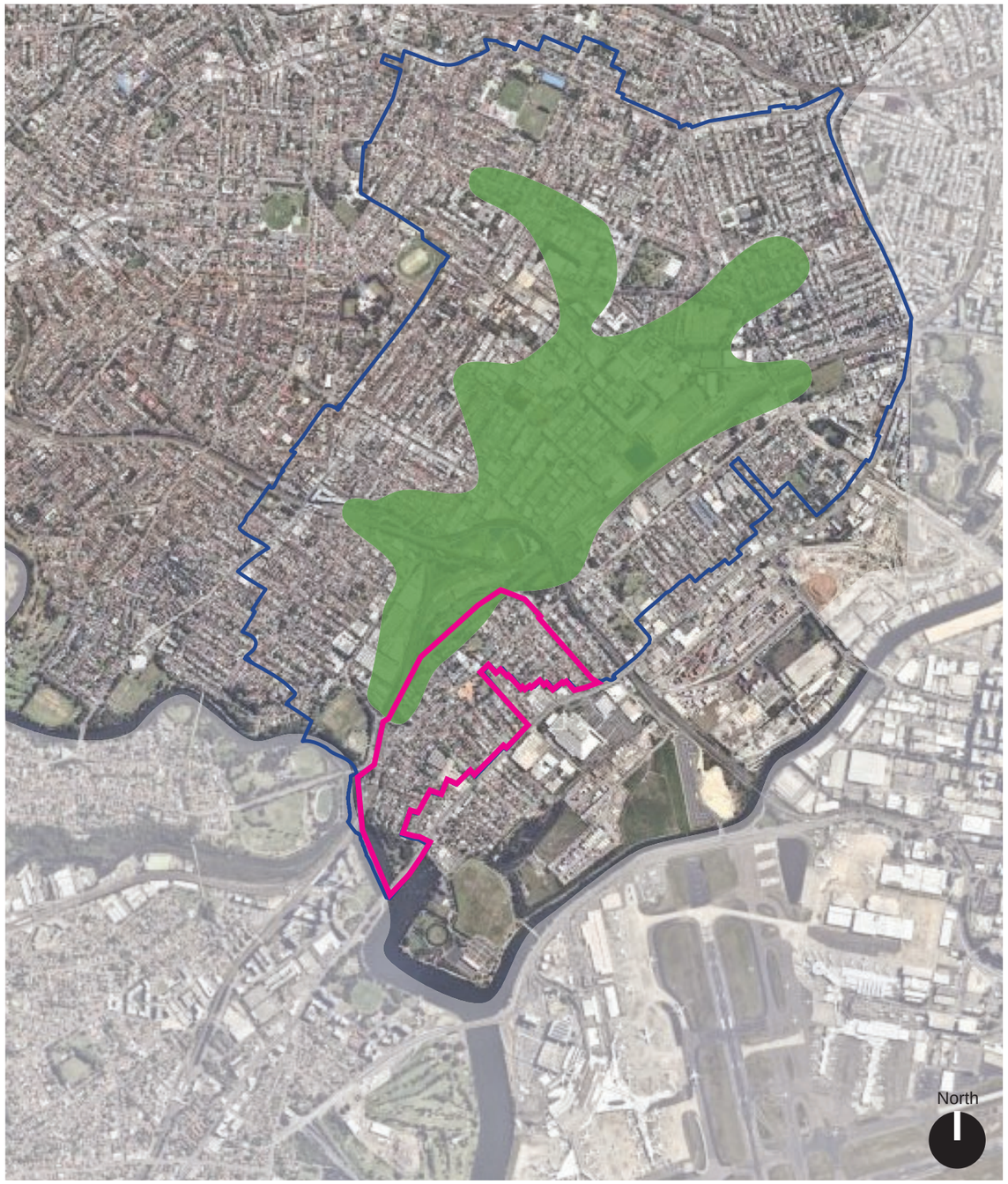
The Gadigal and Wangal people lived successfully along the Cooks River for thousands of years prior to the arrival of the First Fleet in 1788. Artefacts show that the Gadigal people lived in the Marrickville Valley area, known as Bullanaming, for at least 7,000 years. An enormous body of knowledge and special skills were developed to use the life sustaining resources that the Cooks River and its surrounding lands provided. This includes trapping birds and animals, exploiting fish and shellfish, gathering plants, making canoes and carrying dishes from bark, and using sandstone shelters for occupation and art.

The low-lying land in the centre of Marrickville Valley was a freshwater and brackish swamp (known as Gumbramorra Swamp). The size of the brackish and freshwater swamp varied depending on the season and rainfall and could double in size during wet periods. The main creek within Marrickville Valley was known as Gumbramorra Creek which joined the Cooks River at Tempe. The Gumbramorra Swamp along with the Cooks River and its associated mudflats, mangroves and salt marshes supported a rich variety of wildlife providing an abundant source of food for local Aboriginal people.

Gadigal history, like the history of many Aboriginal clans, is based on oral traditions handed down by many generations over millennia. However, through the invasion, the Gadigal and Wangal nations were dispersed, dispossessed and alienated from their traditional lands (Meader, 2008).

Spear fishing on the Cooks River
(Source: www.cadigalwangal.org.au)

White shells on the surface of the Kendrick Park midden.
(Source: Cooks River Alliance, 2017)



History
From European colonisation

The subcatchment area in Tempe, like the Cooks River, has had a varied history since European colonisation. The suburb was named after "Tempe House" built by Alexander Brodie Spark, a wealthy prominent resident on the south bank of the river in the 1836. The house was amongst other fine homes in the Marrickville Valley area which was in the 1830s, 'touted in colonial society as the up-and coming and 'most aristocratic part' of the new settlement' (Tyrrell, 2018).

During this time the colonial government began to build a dam at Tempe that significantly changed the ecology and hydrology of the river and remained until the 1960s. It was located in the position of the present bridge on the Princes Highway. The dam was built to provide a permanent water supply to the colony and to create a new road that linked the north and south banks. It brought in large numbers of convicts and "ticket of leave" men looking for work, many of whom stayed on to settle in the area (Tyrrell, 2018).

One of the first public buildings of the area was Tempe Public School on Unwins Bridge Road, a sandstone building built in 1874 on the site of the present day High School. This period saw an increase in urban expansion as transport improved in the area which encouraged further subdivision of land (Muir, L, 2019). The Tempe railway station was completed in 1884, originally called Cooks River Station. This train line also brought in many visitors to the area to enjoy activities along the river, such as swimming and boating (OEH, 2019).

Growth continued in the area and in the village of Tempe which was helped by arrival of the electrified Marrickville tramways. The Tempe tram shed opened on Princes Highway in 1912 and later became a bus depot after its closure in 1954.

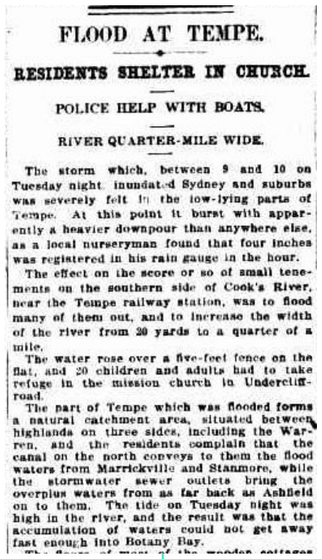
The changes to the local area from a garden and rural dominated landscape to one of increasing numbers of buildings, hard surfaced roads and paths further negatively impacted the natural environment and Cooks River. The already modified river drastically changed further when it was rerouted for the Sydney Airport expansion from the late 1940s (Tyrrell, 2018).

Map shows the Tempe railway station and the river course before extensive modification.
(Source: Higinbotham & Robinson, 1888)

History
From European colonisation

Dam across Cooks River at Tempe
(Source: National Library of Australia)

'Flood at Tempe' newspaper article
(Source: Sydney Morning Herald)



FLOOD AT TEMPE.

RESIDENTS SHELTER IN CHURCH.

POLICE HELP WITH BOATS.

RIVER QUARTER-MILE WIDE.

The storm which, between 9 and 10 on Tuesday night, inundated Sydney and suburbs was severely felt in the low-lying parts of Tempe. At this point it burst with apparently a heavier downpour than anywhere else, as a local nurseryman found that four inches was registered in his rain gauge in the hour.

The effect on the score or so of small tenements on the southern side of Cook's River, near the Tempe railway station, was to flood many of them out, and to increase the width of the river from 20 yards to a quarter of a mile.

The water rose over a five-feet fence on the flat, and 20 children and adults had to take refuge in the mission church in Undercliff-road.

The part of Tempe which was flooded forms a natural catchment area, situated between highlands on three sides, including the Warren, and the residents complain that the canal on the north conveys to them the flood waters from Marrickville and Stanmore, while the stormwater sewer outlets bring the overplus waters from as far back as Ashfield on to them. The tide on Tuesday night was high in the river, and the result was that the accumulation of waters could not get away fast enough into Botany Bay.

Train tracks over the Cooks River
(Source: Fairfax Media)

Aerial photo of Tempe
(Source: State of New South Wales)

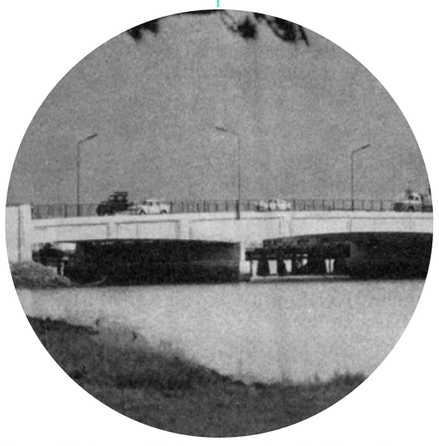
1836 | 1840 | 1900 | 1911 | 1920 | 1923 | 1930s | 1943 | 1962

Alexander Brodie Spark
(Source: State Library of New South Wales)

Boating on the River
(Source: Canterbury Bankstown Library)

Tempe Tramway Depot circa 1920
(Source: NSWGR Archives)

Students in playground at front of Tempe Public School
(Source: National Library of Australia)



Princes Highway Bridge over Cooks River, Tempe
(Source: Department of Main Roads)

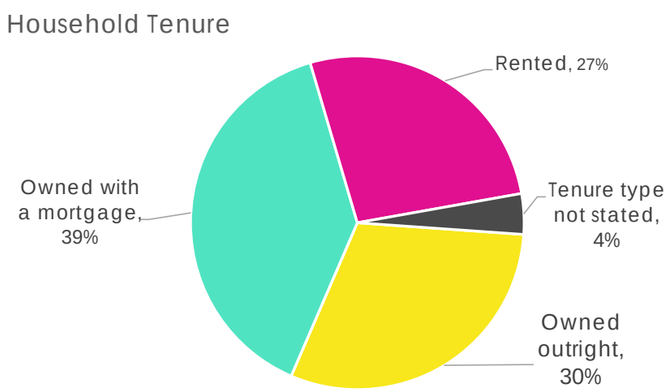
Social
Population characteristics

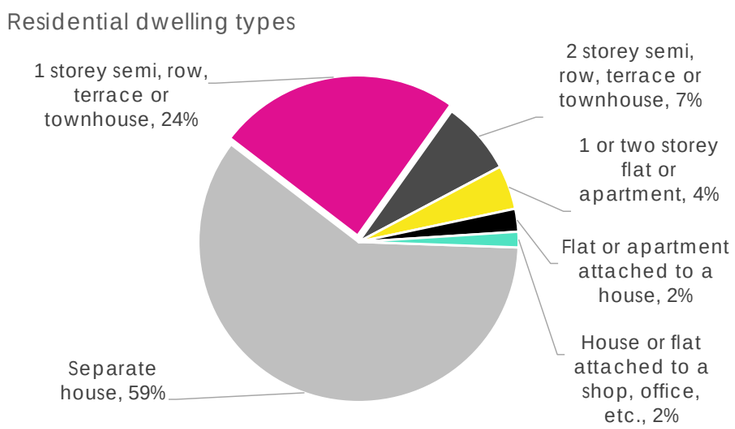
Key Statistics
Population - 2,721
Origin - 22% born overseas: 5% Vietnam, 3% England, 3% China, 3% FYR Macedonia, 3% Greece
Languages spoken at home - 26% non-English; 6% Vietnamese, 6% Greek and 5% Cantonese
Religion - 47% no religion, 23% Catholic, 11% Eastern Orthodox
Travel to work - 47% Car, 36% train, 5% walked only, 2% bus only, 2% train and bus
Education attainment - 32% University degree, 20% other (non-school qualifications)

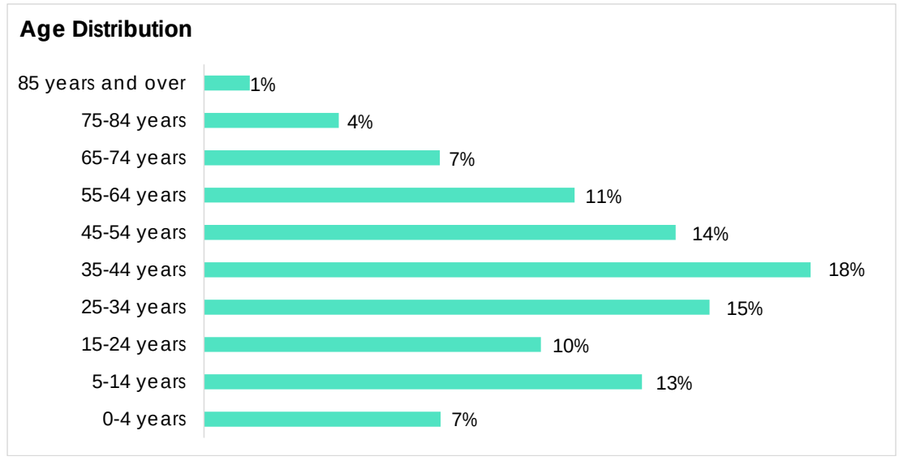
Current education attendance
- Preschool 6%
- Infant/primary 27%
- Secondary 17%
- Technical or further educational institution 7%
- University or other tertiary institution 17%
- Other education institution 8%

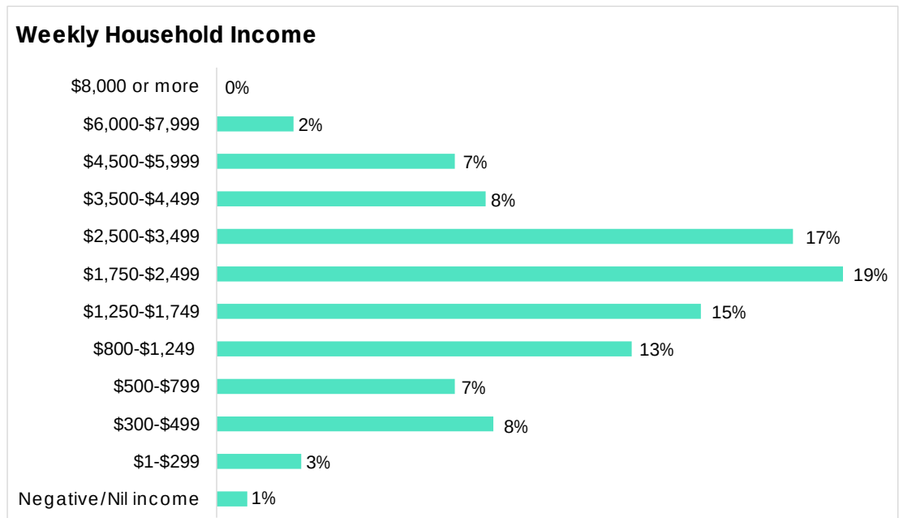
Employment
Of the total labour force:
- Full time - 68%
- Part time - 30%
- Away from work - 4%
- Unemployed - 4%

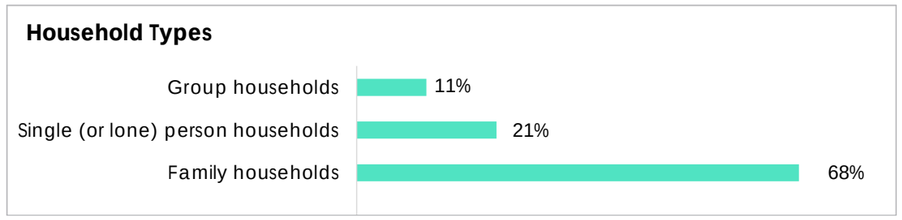
Household Income
- Around 38% of households have an income above the Inner West Council median of $2,042
- 21% of households have an income of above $3000 per week











Social

Eastern Channel local environment survey

The EC Subcatchment local environment survey was sent to all householders in December 2018.
The survey helps to inform Council's:

- understanding of people's knowledge and preferences in relation to the local environment; and
- development of a 10 Year Subcatchment Plan for the Eastern Channel Subcatchment.

Who answered the survey?

(Total: 91 responses, 10% of Eastern Channel Subcatchment households)

Gender	54% Female 46% Male
Language spoken at home	88% English 2% Macedonian 2% Spanish 1% Vietnamese 1% Portuguese 1% Thai 1% French 1% Cantonese 1% Bahasa Indonesia
Age	27% 35-44 years 24% 55-64 years 22% 45-54 years 10% 65-74 years 9% 25-34 years 3% 18-24 years 3% 75-84 years 1% 85+ years
Education	31% Bachelor Degree 29% Masters level degree or above 12% Year 11 or below (high school) 10% Certificate Level (I, II, III, IV) 8% Diploma or Advance Diploma 6% Year 12 (completed high school) 4% No educational attainment
Employment	55% Work full-time 20% Work part-time 15% Retired 5% Away from work 3% Student 2% Unemployed

Weekly household income	22% $2500-3499 18% $1250-1749 16% $1750-2499 10% $800-1249 8% $300-499 7% $0 6% $3500-4499 5% $500-799 4% $4500-5999 2% $6000-7999 1% $1-299 1% $8000 or more
Dwelling	66% Separate House – freestanding 28% Semi-detached, terrace or townhouse 6% Apartment/flat/unit
Tenure Type	49% Owned with a mortgage 32% Owned fully 18% Rented
Time in current residence	41% More than 10 years 21% More than 5 and less than 10 years 20% More than 2 less than 5 years 19% Less than 2 years

What are their answers?

Future environmental improvements in the next 20 years

Respondents were asked what long-term local environmental improvements they would like to see:

- Improved green spaces, community gardens and greener streets (more trees) (36)
- Cleaner, healthier Cooks River (26)
- Improved waste management (15)
- Enhanced habitat and wildlife protection (11)
- Improved urban water management (9)
- Less traffic and development (9)
- Improved cycleways, footpaths and walking tracks (8)
- Renewable energy (6)
- Less noise and pollution (6)
- Environmental education (5)
- Better weed and pest management (4)

Local environment knowledge – water and biodiversity

1. Rainwater in the street normally goes:

- 68% to the nearest waterway (correct answer)
- 25% to the sewerage system
- 4% directly to the sea
- 3% other

2. Water from which of the following would normally end up in the street drains?

Option	Responded
Kitchen sink (incorrect)	15%
Shower (incorrect)	15%
Toilet (incorrect)	9%
Washing machine (incorrect)	14%
Garden (correct)	79%
Driveways, footpaths (correct)	89%
Other paved areas (correct)	83%
Rainwater from the roof (correct)	73%

3. On average how many litres of water does a typical Sydney household use per day?

- 5% chose the correct range (over 500L per day)
- 95% underestimated daily water use

4. The native animals found in the Tempe area:

Native animals	Responded
Brushtail possum (correct)	61%
Ibis (correct)	89%
Common/Indian Myna (incorrect, not a native animal)	76%
Rainbow Lorikeet (correct)	78%
Koala (incorrect, not found in Tempe)	0%
Common Garden Skink (correct)	67%
Striped Marsh Frog (correct)	39%
Noisy Miner (correct)	72%
Superb Fairy Wren (correct)	31%
Grey-headed Flying Fox (correct)	50%

5. The following activities help protect native animals in the local area:

Activity	Responded
Keeping cats in doors (correct)	87%
Handing and petting native animals (incorrect)	0%
Keeping dogs on leash in wildlife areas (correct)	84%
Planting native gardens (correct)	89%
Leaving food out for native animals (incorrect)	6%
None of the above (incorrect)	6%

6. Local wildlife habitat areas:

Habitat areas	Responded
Tempe wetlands (correct)	92%
Kendrick Park (correct)	39%
Sydenham Green (correct)	29%
Toyer Street Park (correct)	20%
None of the above (incorrect)	5%

Behaviour

(Of 91 households)

1. Rainwater Tanks
- 19 respondents (21%) indicate that they have a rainwater tank installed.
- Tank size ranges from 50L to 10,000L
- 26% uses rainwater for garden
- 21% uses rainwater for toilets

2. Water Saving Devices
- 61 respondents (70%) indicate that they have water saving devices such as water saving showerheads, tap aerators and toilet flush water savers.

3. Wildlife Friendly Gardens
- 85 respondents (94%) indicated they have a garden
- 83% grow local native plants in in their garden, 44% have wildlife friendly logs and rocks, 23% have a frog pond and 10% have an insect hotel.

Receptivity to alternative water and biodiversity initiatives

1. The percentage of people that would consider using rainwater and recycled water and how they would consider using it:

	Rainwater from a tank	Treated Recycled Water
Drinking	14%	21%
Showering	30%	43%
Washing clothes	51%	58%
Flushing the toilet	78%	91%
Washing the car	74%	84%
Watering the garden	97%	92%

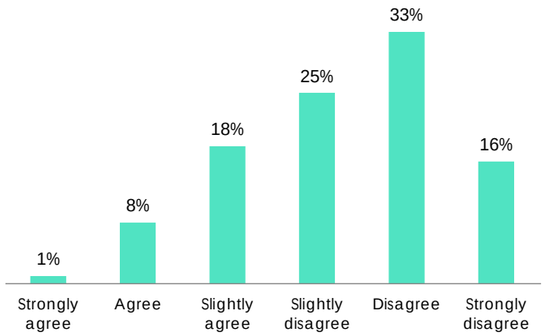
2. The percentage of people that would consider creating a wildlife friendly garden and how they would consider doing it:

Plant native shrubs and groundcovers	82%
Install nest boxes	47%
Grow large native trees	47%
Install old logs and rocks to attract lizards	61%
Build a frog pond	39%

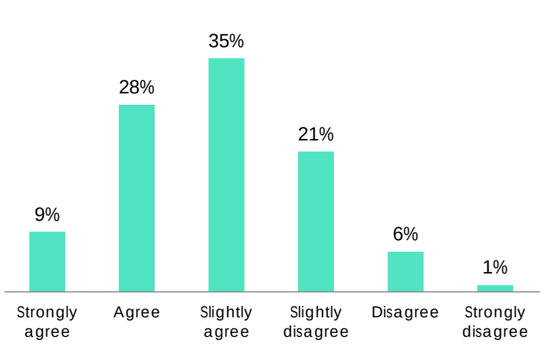
Social

Eastern Channel local environment survey

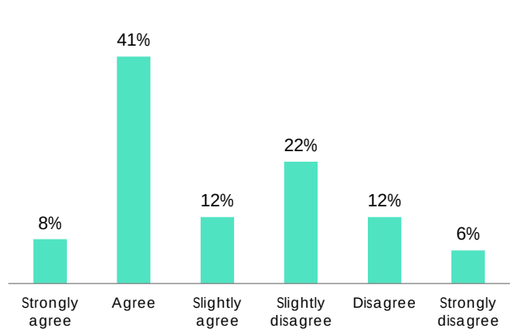
Attitudes



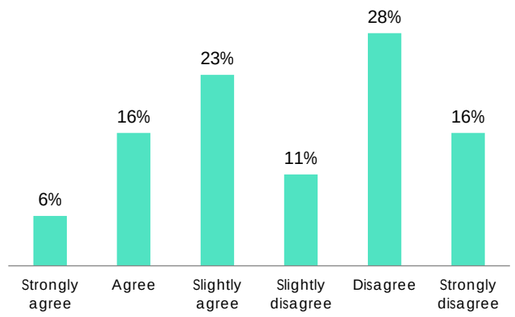
a) 'Jobs are more important than the environment'



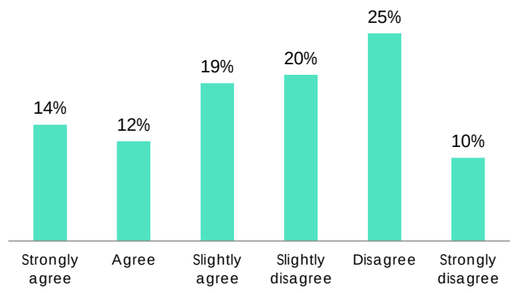
b) 'Access to a healthy natural environment is more important access to community facilities'



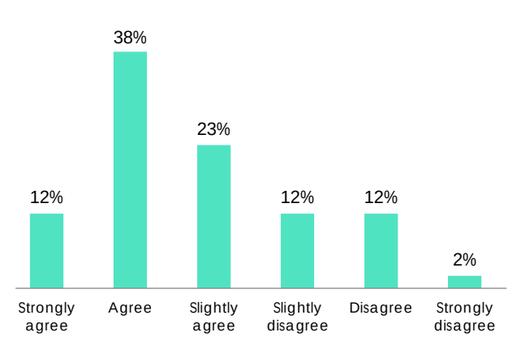
c) 'My daily activities have little negative impact on the environment'



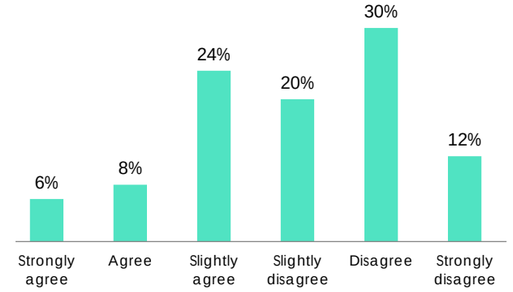
d) 'Government agencies should be mainly responsible for the environment rather than the individual'



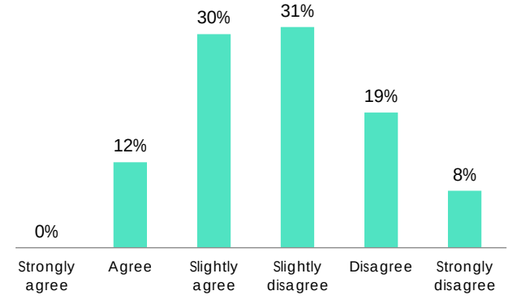
e) 'We should aim for the same environmental conditions as before the Europeans arrived more than 200 years ago'



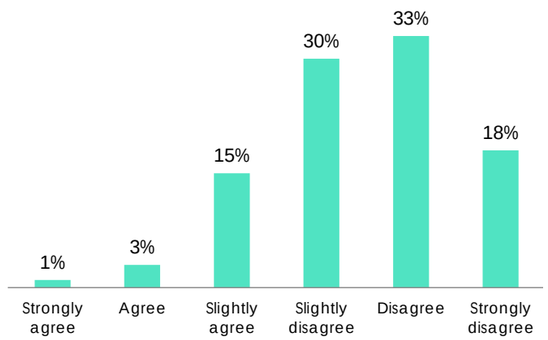
f) 'Most people want to help improve the health of the environment'



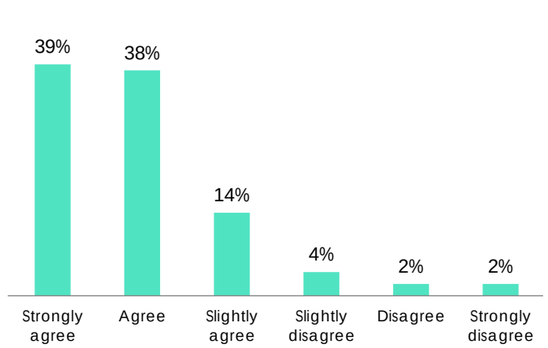
g) 'Laws are more effective than education for protecting the environment'



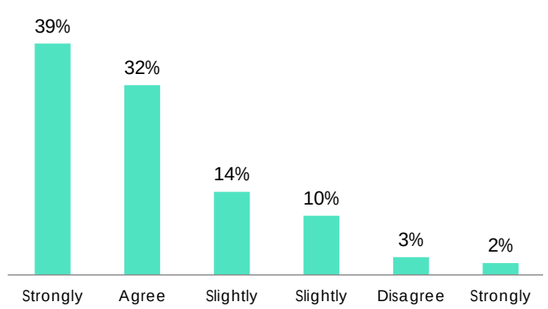
h) 'The local natural environment in the Tempe area is very healthy'



i) 'The Cooks River is very healthy'



j) 'We need more native plants and trees in our streets'

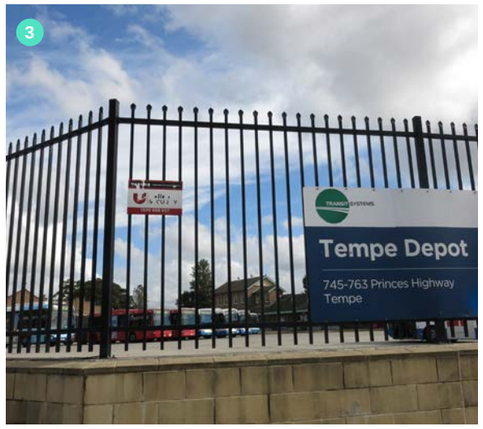


k) 'I feel comfortable in native bushland'

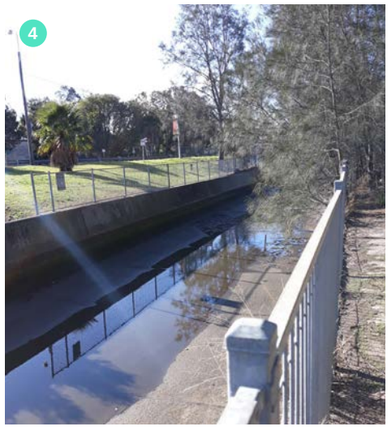
Major landmarks

Three large sites in the EC subcatchment are Tempe High School, Tempe Public School, and Tempe Bus depot. The Tempe train station is the main public transport hub in the subcatchment. Kendrick Park is the largest park and is along the river. The Eastern Channel runs along the western edge of the subcatchment.

Tempe High School and Tempe Public School

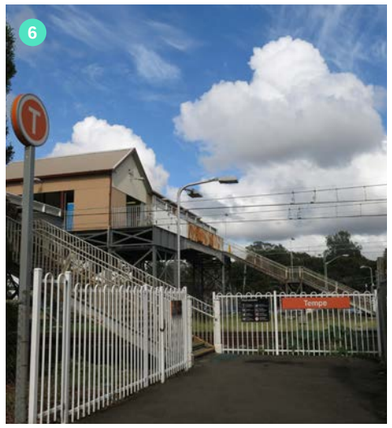


Tempe Bus Depot



Eastern Channel, next to Tempe Train Station car park

Kendrick Park



Tempe Train Station

EC Subcatchment boundary

Water

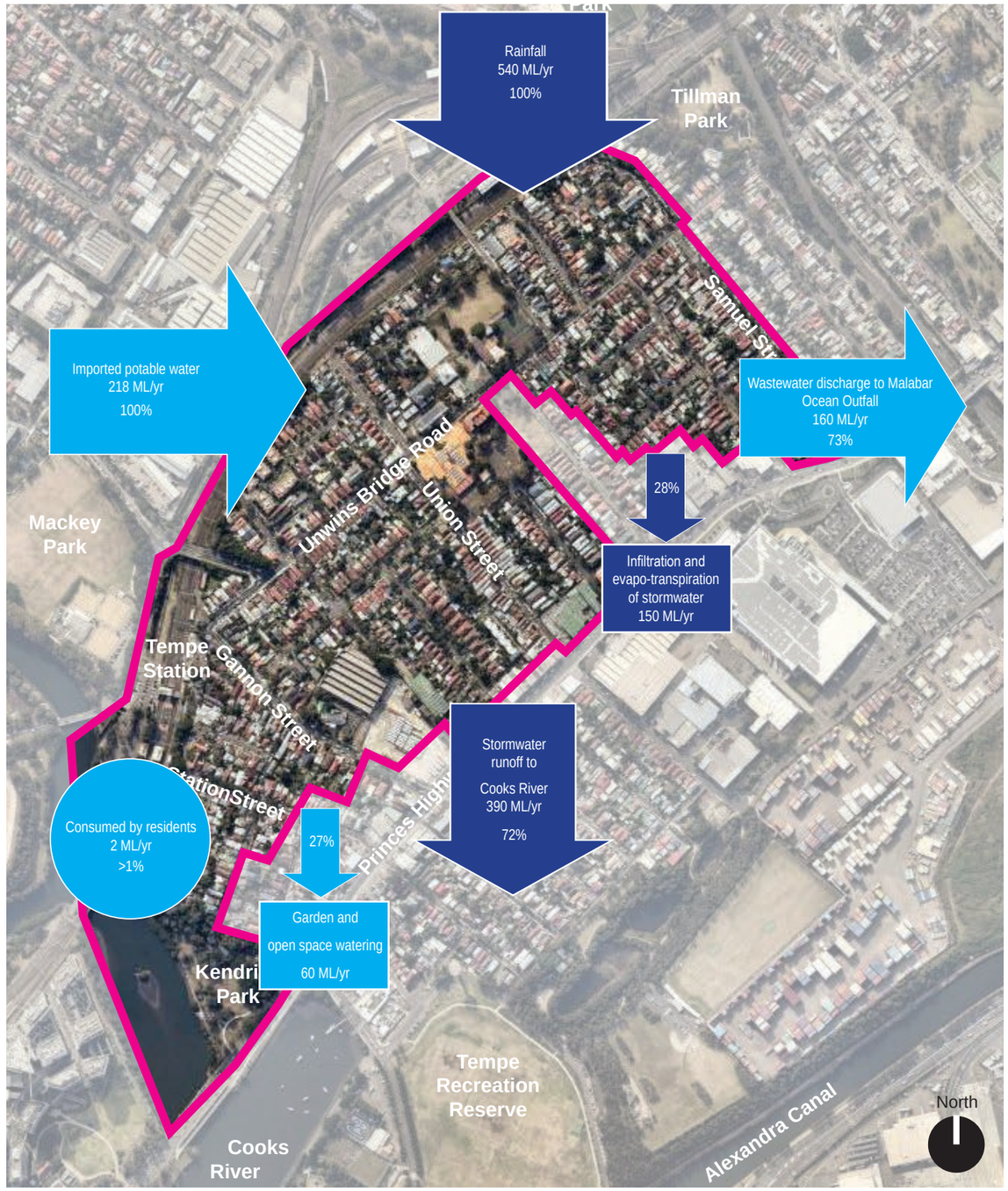
The Eastern Channel Subcatchment water cycle

The water cycle for the EC Subcatchment shown here is based on research and the results of stormwater modelling.

What does the picture tell us?

The Eastern Channel Subcatchment water cycle shows that more than double the amount of rain falls in the subcatchment compared to the volume that is imported from Sydney Water as mains water.
Only a tiny fraction of mains water – less than 1% - is actually consumed by residents. About a quarter (27%) is used for garden watering and irrigation, and about three quarters of all mains water (73%) is treated and discharged at the Malabar Outfall to the Tasman Sea after use.
More than three quarters of the rainfall ends up in the Cooks River via gutters and pipes.
The rest of the rain infiltrates into the ground or evapotranspires into the atmosphere.

This study of the urban water cycle highlights where opportunities for drinking quality water savings can be made through harvesting rainwater and stormwater. Stormwater harvesting also provides an opportunity to treat stormwater and reduce pollutant loads entering local waterways.

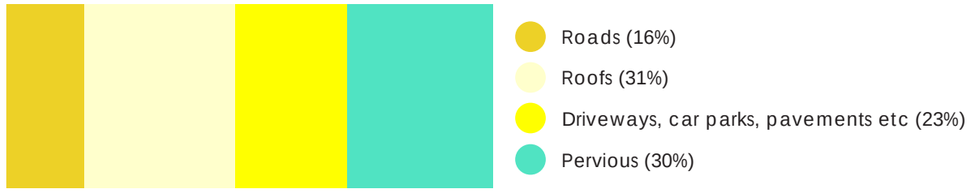


EC Subcatchment boundary

Water

Hard surfaces and pollutants

Approximately 70% of the EC Subcatchment is impervious, reflecting the high density residential character of the area. Of the impervious surfaces (i.e. hard surfaces which water cannot pass through), roads make up 16%; driveways, pavements and car parks make up 23%; and 31% is roofs.



Surface types in the EC Subcatchment

Water quality modelling determines the relative pollutant contributions from the subcatchment based on a breakdown of the impervious area.

With residential development making up 53% of the subcatchment, private property contributes significantly to gross pollutant and nitrogen loads due to the large volume of stormwater runoff from residential roofs and driveways. Reducing the flow volume would reduce the amount of gross pollutants and nitrogen mobilised into waterways.

Public roads collect a disproportionate amount of phosphorous and suspended solids. The stormwater drainage network combines runoff from public roads and runoff from private property. It is therefore important to target both public roads and private areas in order to reduce the movement of stormwater pollutants into waterways.

The table below shows the key types of pollutants that enter waterways and reduction targets for each. The table opposite shows the common pollutants that enter waterways via stormwater runoff.

Pollutant	Estimated Mean Annual Pollutant Load (kg/yr) *	Best Practice Stormwater Targets (% reduction)	Target Pollutant Load (kg/yr)
Total Suspended Solids^	89,000	85%	13,350
Total Phosphorus	170	65%	76.5
Total Nitrogen	1,300	45%	780

* Estimated with MUSIC modelling software.
^ Note: removal of suspended solids will result in a reduction of heavy metals and hydrocarbon loads.
These figures do not take into account the performance of existing gross pollutant traps within the subcatchment.

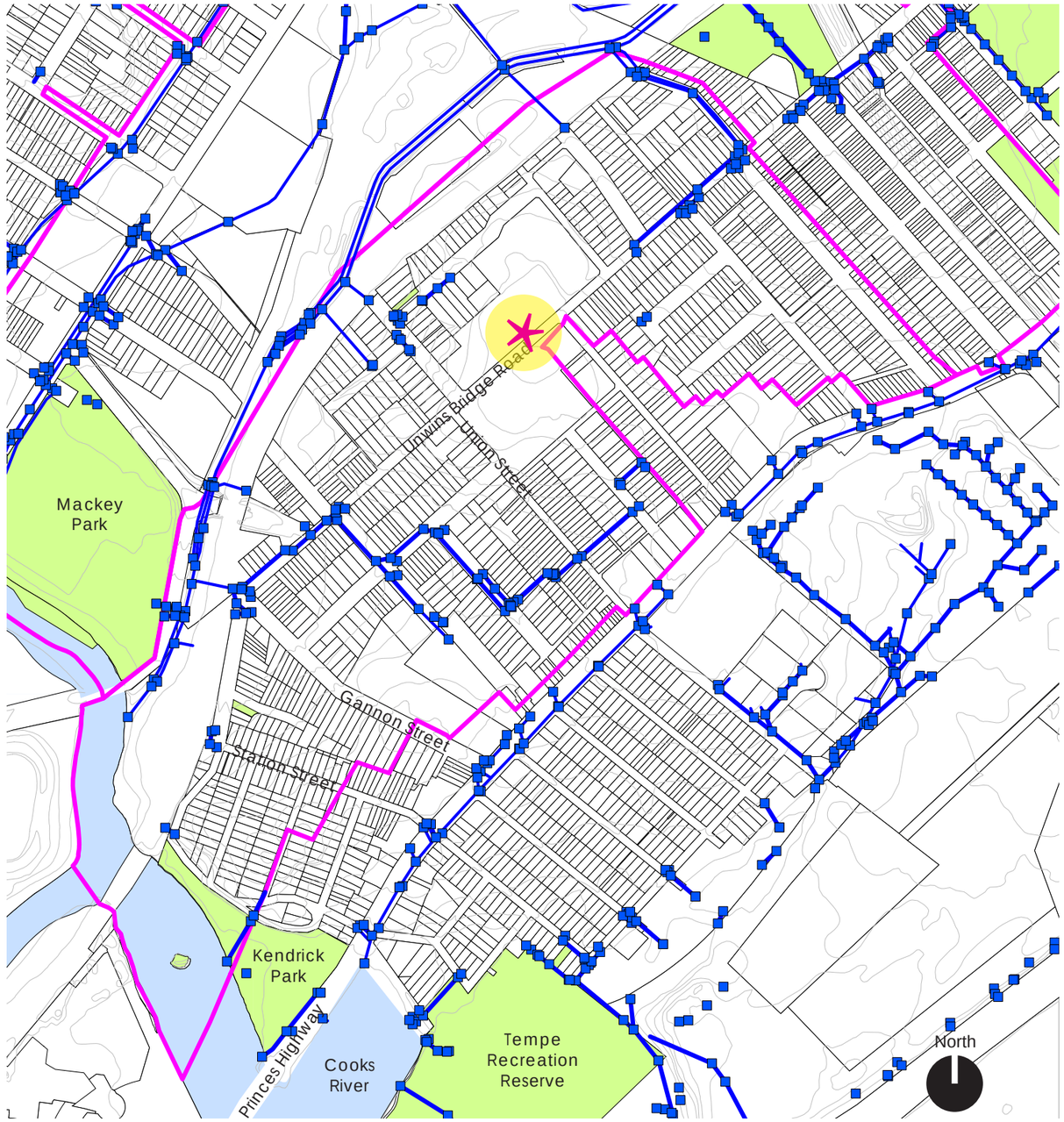
Pollutant	What are they?	What are their impacts?
Gross Pollutants	Litter Coarse sediments Organic matter	• Reduce stormwater drainage capacity • Impact on visual amenity • Impact on aquatic habitats • Impact on water quality indicators such as oxygen demand, hydrocarbons and metal
Suspended Solids	• Soil particles • Airborne particles • Sediment from erosion and land degradation • Leaf litter	• Reduce the penetration of light through water impacting on the respiration of aquatic plants • Phosphorus, heavy metals and organic chemicals utilise sediment as the medium for transportation in urban runoff
Total Nitrogen and Total Phosphorus	Nutrients from natural and non-natural sources including: • Atmospheric deposition • Soil particles • Human and animal faeces • Plant matter • Fertilisers • Vehicle exhaust	• Nutrients promote growth of aquatic plant life. In large concentrations they can produce algal blooms on the water surface • Algae are microscopic plants which occur naturally in water bodies. Increased nutrients promote algal growth resulting in a build up of toxins. Toxic algal blooms cause the closure of fisheries, water farming industries and public beaches
Organic matter	• Leaves • Grass clippings • Human and animal faeces	Organic matter can impact on: • Biogeochemical processes (cycling of substances) • Nutrient cycling • Ability of organisms to use or degrade • Chemical transport and interactions
Lead	Trace metals derived from petrol additives, hydrocarbons, old paint (prior to 1970), lead acid batteries Trace amounts derived from vehicle wear (tyres), herbicides, galvanised roofs	• Impact of metals on water bodies can vary widely. Impacts are affected by complex interactions with biophysical parameters such as pH, dissolved oxygen and temperature • Lead can be harmful or deadly to aquatic and human life • Low levels of zinc can be deadly to aquatic life
Pollutants: Zinc, Hydrocarbons	• Mineral oils • Automotive oil • Diesel fuel	• Impact on visual amenity • Lowers water quality • Increases chemical oxygen demand • Can be highly toxic to aquatic life in low to moderate concentrations

Water

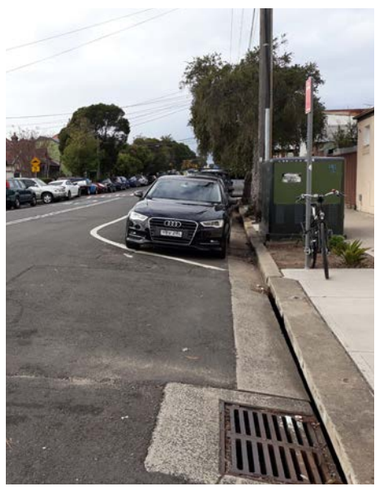
Topography, pits and pipes

The topography (or landform), influences how water moves through the subcatchment. Generally the land falls south towards the Cooks River. The high point is where Tempe Primary and Tempe High schools are located.

In the EC Subcatchment most streets do not have stormwater pits and pipes. This means that localised flooding or ponding is more likely to occur when it rains heavily.



Cutting into the sandstone for the train line



Stormwater drainage on Samuel Street

Looking down Collins Street from opposite the high school

Water

Flooding and dumping hot spots

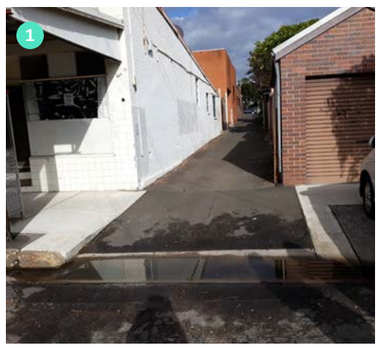
Stormwater flows within this subcatchment drain to the Cooks River via the Eastern Channel, along the north-eastern boundary of the subcatchment. Stormwater flows to the Channel by the kerb and gutter within the streets as well as Council's underground drainage network. In large storms, where the capacity of the underground drainage system is exceeded, the stormwater can spread across the road and into adjacent properties, and may result in localised flooding. The majority of this water runs over the road and into the downstream pipe network. In some locations development has occurred within and adjacent to natural flow paths, depressions, and low points leading to ponding and potential overland flow across these properties.

Known areas of ponding and overland flow include:

- Brooklyn Street
- Union Street
- Edwin Street
- Collins Street
- Hillcrest Street
- Bridge Street
- Unwins Bridge Road and Gannon Street intersection

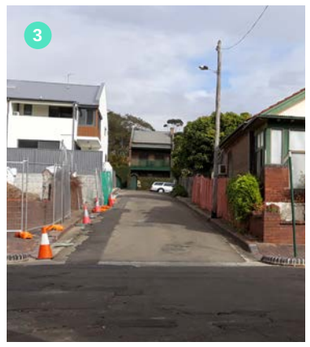
Dumping rubbish is regularly a problem in:

- Samuel Lane
- Milne Lane
- Ixion Lane
- School Lane
- Brooklyn Lane
- Little Brooklyn Lane
- Zuttion Lane
- Farrow Lane
- Edgar Lane
- Hillcrest Lane



Corner of Samuel St and Samuel Lane

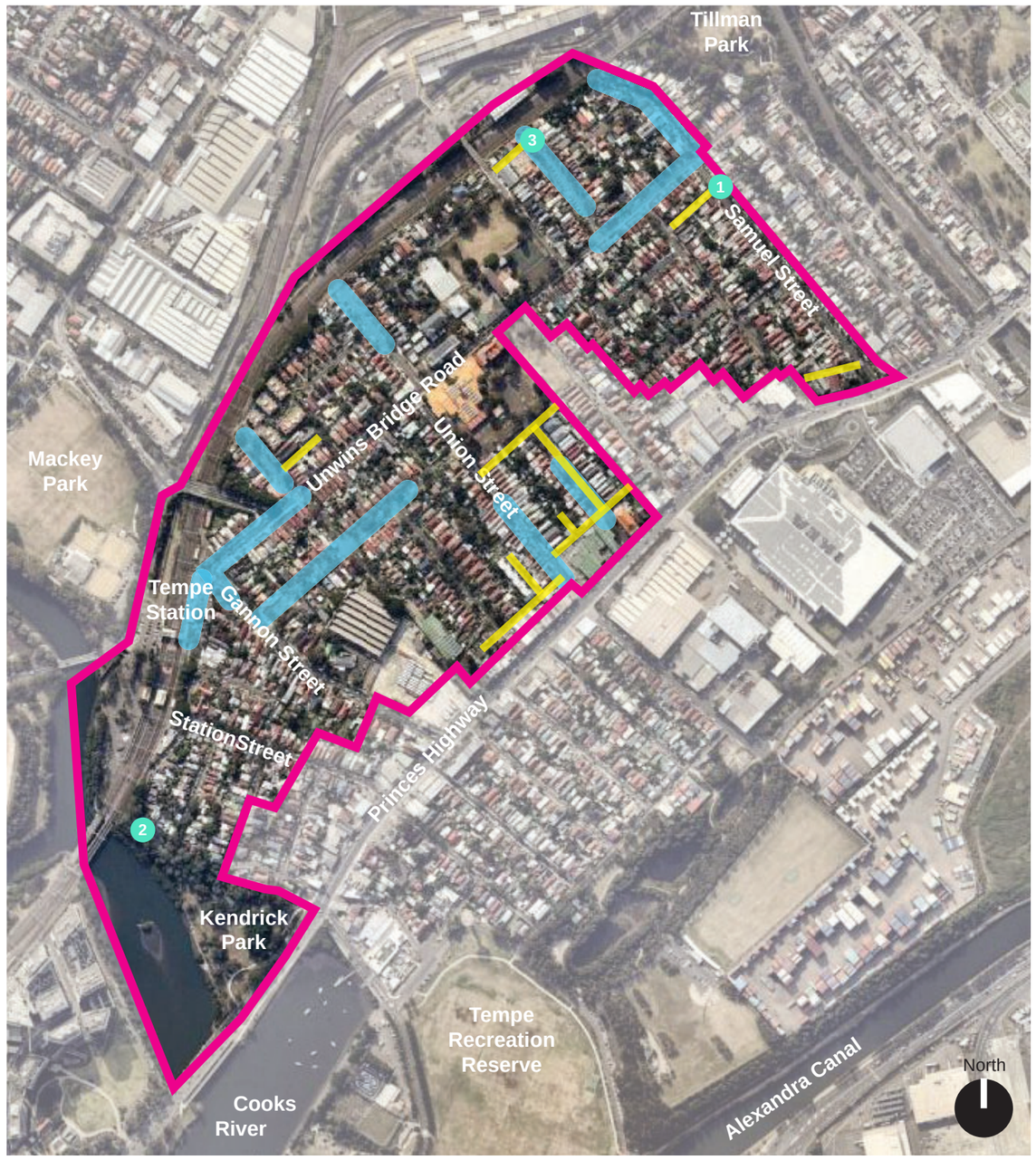
Path along the Cooks River in Kendrick Park



Hillcrest Lane

Further information about flood affected areas and overland flows paths in this subcatchment is available in these documents:

- Marrickville Valley Flood Study (WMA Water, 2013)
- Marrickville Valley Flood Risk Management Study & Plan (Cardno, 2017)
- Marrickville DCP 2011



Urban Forest

Wildlife corridor and priority biodiversity area

The land along the Cooks River foreshore is an important wildlife corridor. This is documented in Marrickville Local Environment Plan (LEP) 2011 which identifies a wildlife corridor along the river, from Marrickville Golf Course to Kendrick Park. In Kendrick Park, there is a natural area being restored and maintained through bush regeneration techniques and contractors.

The area of the EC Subcatchment along the Cooks River is part of the Cooks River Priority Biodiversity Area, identified in the Marrickville Biodiversity Strategy 2011 - 2021 (figure 9). It is important because it:

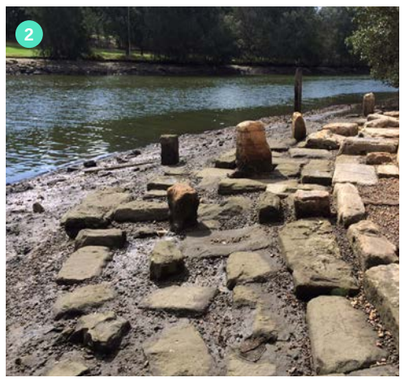
- provides structural habitat through a mixture of native and exotic vegetation and food resources for a range of fauna, including frogs, rock/crevice dependent reptiles, moisture dependent reptiles, nocturnal birds, small grain-eating birds, small nectar-eating and insect-eating birds, microbats and mega bats

- provides local and regional connectivity. In particular, Kendrick Park and the Cooks River link Mackey Park and Tempe Reserve via the low-lying land and vegetation along the river corridor

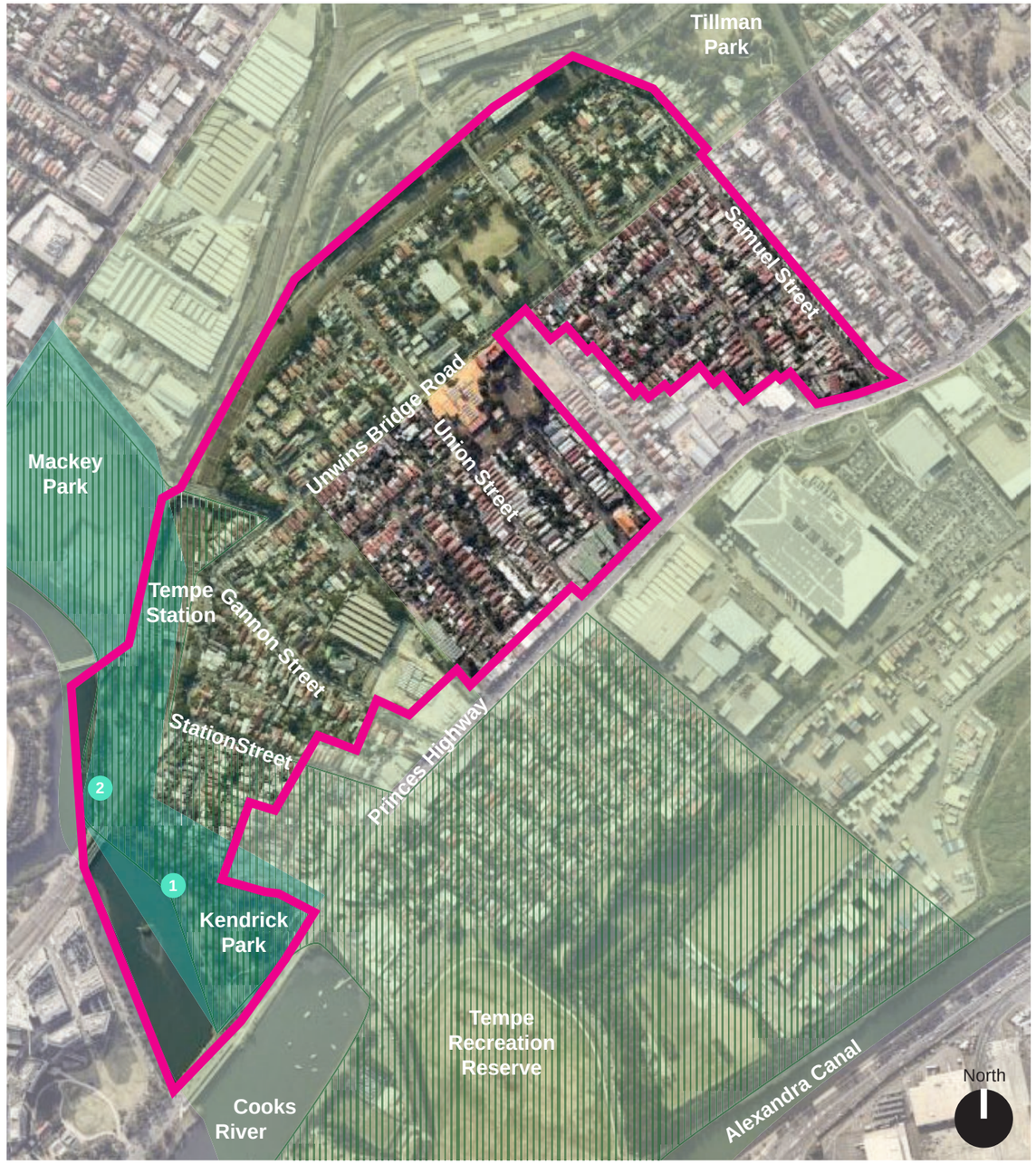
Council has identified Biodiversity Priority Planting Areas which are areas where local native species are planted in public spaces such as parks and streets.

Council's Sustainable Streets program supports the community to create, manage and maintain nature strip gardens and has seen more sustainable streetscapes emerge.

Kendrick Park foreshore



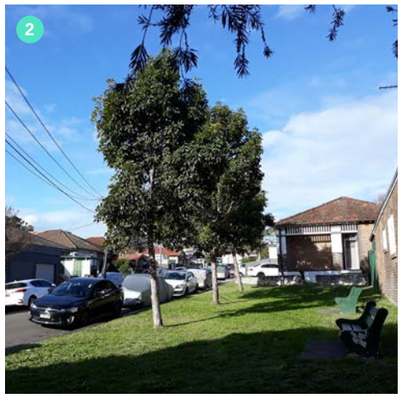
Foreshore restoration along the Cooks River pathway near the rail bridge



Urban Forest
Biodiversity and Parks

EC subcatchment has few parks. The largest is Kendrick Park along the Cooks River. Two small parks (Toyer Street Reserve and Green Street Playground) and playing fields within Tempe High and Tempe Public schools (not publicly accessible) also provide open green places and vegetation. Kendrick Park and Fatima Island in the Cooks River are included in the Cooks River Parklands Plan of Management and Masterplan (2016).

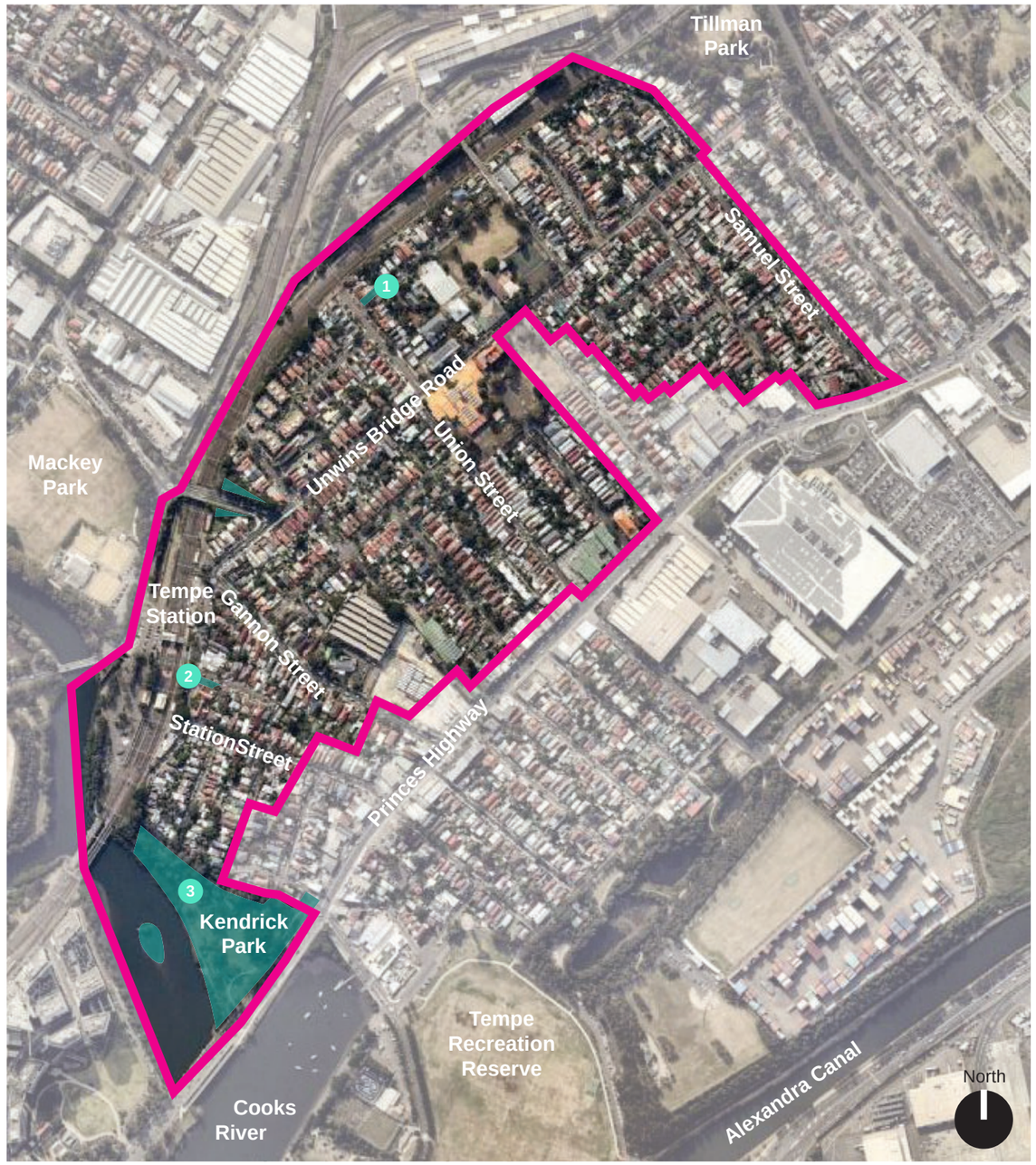
Toyer Street Reserve



Green Street Playground

Kendrick Park

Park, Playground or Reserve	Facilities
Toyer Street Reserve	• Street library • Playground • Seating
Green Street Playground	Grassed area with seating
Kendrick Park	• Playground • Grassed area with seating • Picnic shelters and BBQ • Public toilets • Cooks River cycleway • Canoe launch



EC Subcatchment boundary
Park
1 Toyer Street Reserve
2 Green Street Playground
3 Kendrick Park

Urban Forest
Fauna

A range of native and introduced fauna occur in the EC subcatchment, including terrestrial and aquatic species such as:

Terrestrial Fauna:
- frogs and reptiles such as snakes and lizards (rock/crevice dependent reptiles and moisture dependent reptiles)
- birds (nocturnal birds, small grain-eating birds, small nectar-eating and insect-eating birds)
- bats (microbats and mega bats)
- possums

Aquatic Fauna:
- fish and turtles
- oysters
- crabs and sea snails

The Grey-headed Flying Fox is a protected threatened species (*Biodiversity Conservation Act 2106*) and forages in the subcatchment.

Citizen Science

The subcatchment is close to Tempe Recreation Reserve where over 130 native species have been recorded (Tempe Birdos 2011 - 2019). The Bionet Atlas of NSW Wildlife (OEH, 2018) is an online tool anyone can use for reporting and mapping species. The following species have been recorded in the area including:

1. Great Cormorant (*Phalacrocorax carbo*)
2. Red Wattlebird (*Anthochaera carunculata*)
3. Little Black Cormorant (*Phalacrocorax sulcirostris*)
4. Australian White Ibis (*Threskiornis molucca*)

An Australasian Darter sunning itself at Kendrick Park

Red-Bellied Black Snake in Kendrick Park

Blue-tongue Lizard

EC Subcatchment boundary

Species recorded on Bionet Atlas of NSW map

Urban Forest
Tree canopy

Council is committed to increasing the tree canopy. Trees in parks, backyards, school grounds, street verges and the rail corridor form the urban canopy as part of the urban forest.

As outlined in the Marrickville Urban Forest Strategy (2011) the urban forest:
- Is a vital contributor to the social, ecological and economic health and well-being of Marrickville and its citizens.
- Provides social, ecological, economic and amenity benefits.
- Council aims to sustain and increase the urban forest on an intergenerational life cycle basis.

Across Tempe, there is a low street tree population which has resulted in a more visually sparse streetscape. According to the Marrickville Street Tree Masterplan (2014):
- 5% of trees are young
- 82% of trees are mature
- 41% of trees are in good condition
- 58% of trees are in fair, poor or very poor condition

Newly planted Banksias on Cook Street

Street trees on Stanley Street

In-road tree on Griffiths Street

Street trees planted under power lines on Station Street

Mature Melaleuca in grass verge on Leslie Street

Urban Forest
Soils

Healthy soils are important. They act as carbon sinks, provide habitat for micro-organisms and growing medium for plants.

Geology
Wianamatta Group shale is the underlying geology of the area in higher areas away from the Cooks River. Closer to the river, the geology is dominated by Wianamatta Group silt and clay alluvial materials (Chapman and Murphy, 1989).

Soils
Soils were originally a mix of sand, silt, clay and mudflats in the lower areas, with clay soils in higher areas further away from the Cooks River. Areas along the river have been filled to allow development.

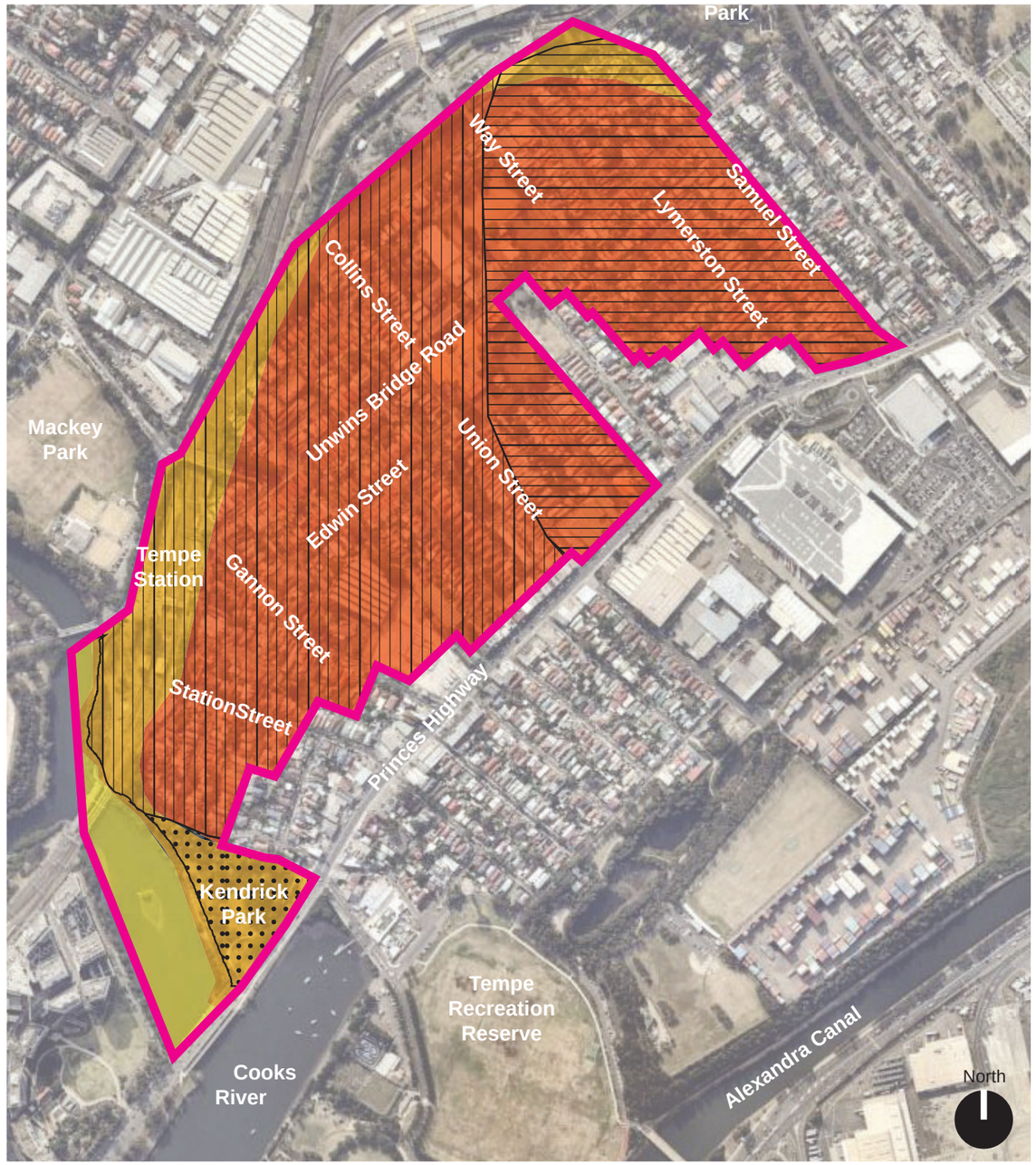
Contamination
No Council mapped contamination sites are located in the subcatchment, however it is likely that there is some soil contamination in the area. Research has shown there are consistently high lead concentrations in the older, inner city and inner west areas of Sydney (Rouillon et al., 2017). This is primarily due to the intense use of lead-containing products such as lead-based paints and leaded petrol over the last century.

Acid sulfate soils
The EC Subcatchment is affected by acid sulfate soils, natural sediments that contain iron sulfides. Common along the NSW coast, when disturbed or exposed to air, these soils can release acid. The acid and released metals can have many damaging effects:

- Killing plants and aquatic life
- Corrosion
- Toxic water and dust (OEH, 2018)

Acid sulfate soils classes:

- Class 1 - likely to be found on and below the natural ground surface. Any works will trigger the requirement for assessment and may require management.
- Class 2 - likely to be found below the natural ground surface. Any works beneath the natural ground surface, or works which are likely to lower the water table, will trigger the requirement for assessment and may require management.
- Class 3 area - likely to be found beyond 1 metre below the natural ground surface. Any works that extend beyond 1 metre below the natural ground surface, or works which are likely to lower water table beyond 1 metre below the natural ground surface, will trigger the requirement for assessment and may require management (MDCP 2011 2.23 and Sutherland Shire Council, 2018).



Urban heat and climate change

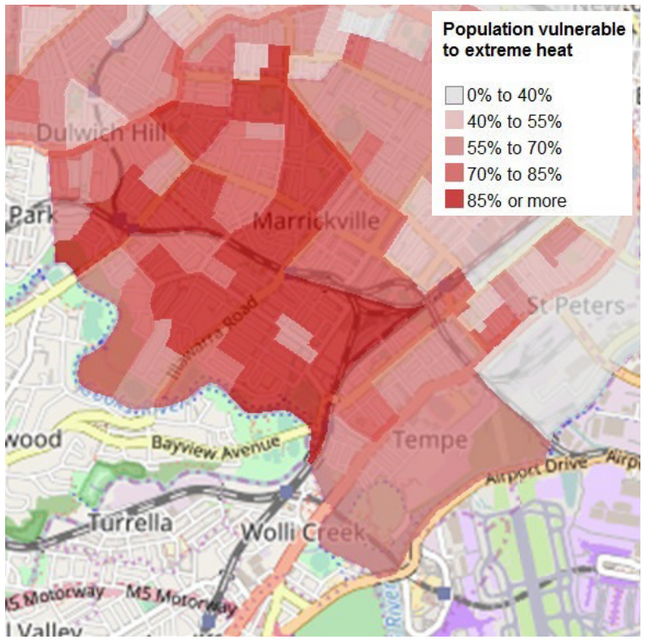
The Inner West is getting hotter. Urban areas with a high proportion of hard surfaces such as concrete and roads store and radiate heat, especially where there is little vegetation. This build-up of heat is known as the urban heat island (UHI) effect.

On top of the UHI, extreme heat events – heatwaves – are more frequent as a result of climate change. The combination of these two things can create very high temperatures.

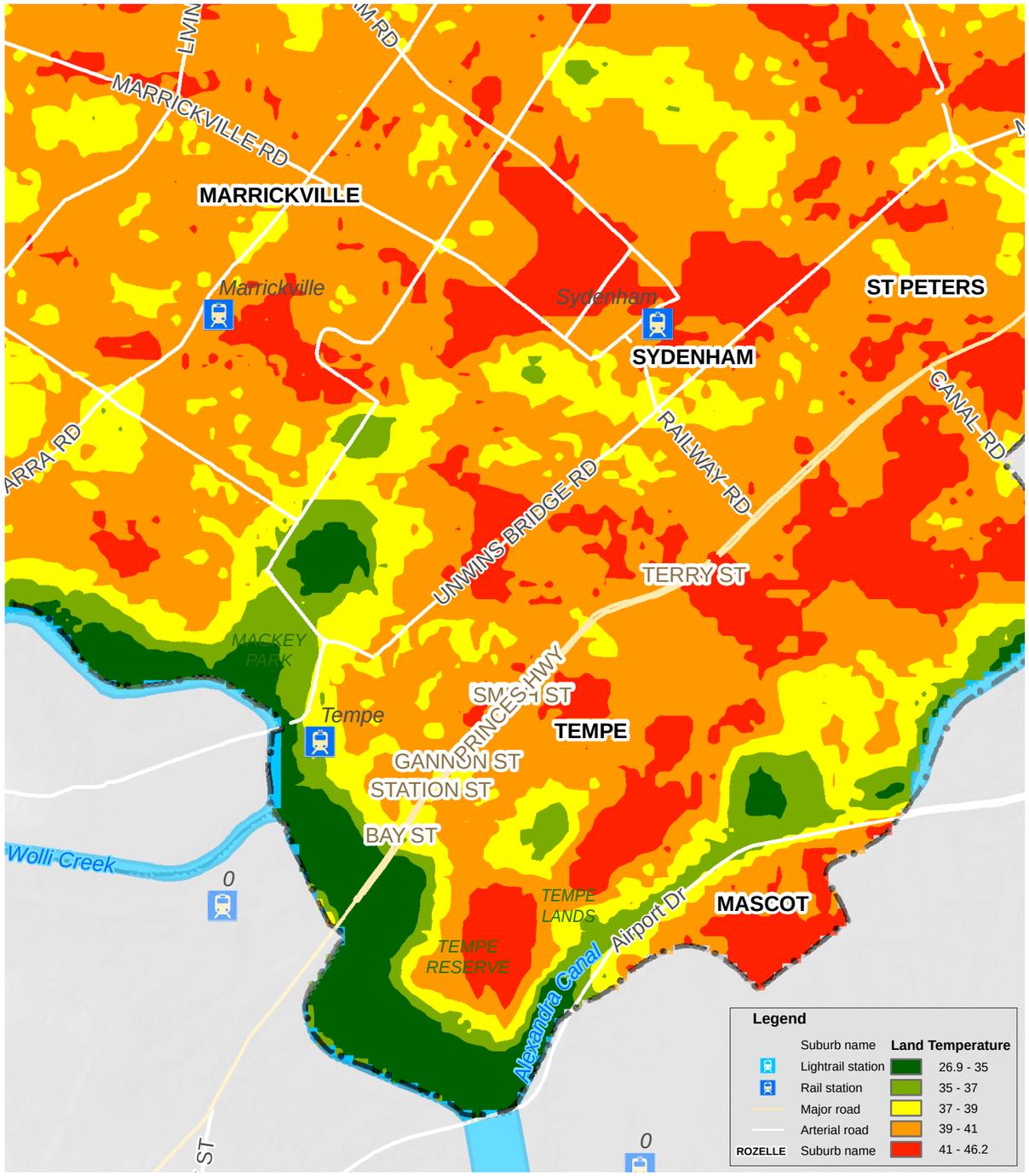
The urban heat map on the right shows land surface temperatures on 2 February 2011, a heatwave day (data provided by CSIRO and Geosciences Australia).

Addressing the risk of heatwaves and the UHI effect is a high priority. Some people are more vulnerable to heat stress due to age, health or other factors. The social vulnerability to heat map shows areas where the community is more vulnerable to heat stress, and this can be used, in combination with the urban heat map, to help prioritise locations where more green cover is needed most.

Urban heat can be reduced by increasing green cover. This includes planting trees with large canopies and installing green infrastructure, such as rain gardens, bio-swales, green roofs, green walls, and keeping more water in the landscape through water sensitive urban design (WSUD) in new and existing areas.



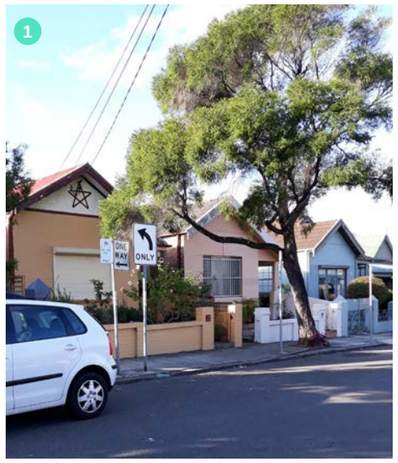
Social vulnerability to heat map



Heat Map 10am 2 February 2011

Zoning

As this map shows, there are a mix of land uses including light industrial, enterprise corridor, residential and private recreation, however the EC subcatchment area is mainly residential (R2 Low density residential). The schools, Princes Highway and railway corridor are zoned special infrastructure (shown in yellow). Kendrick Park is the main green space.

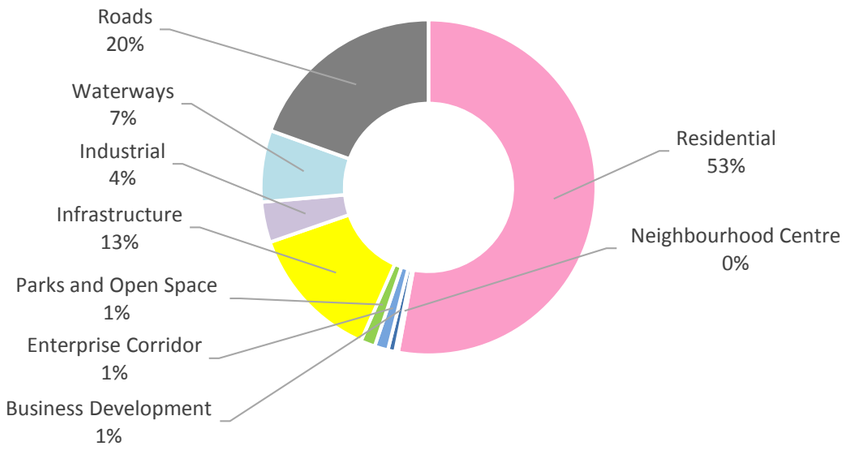


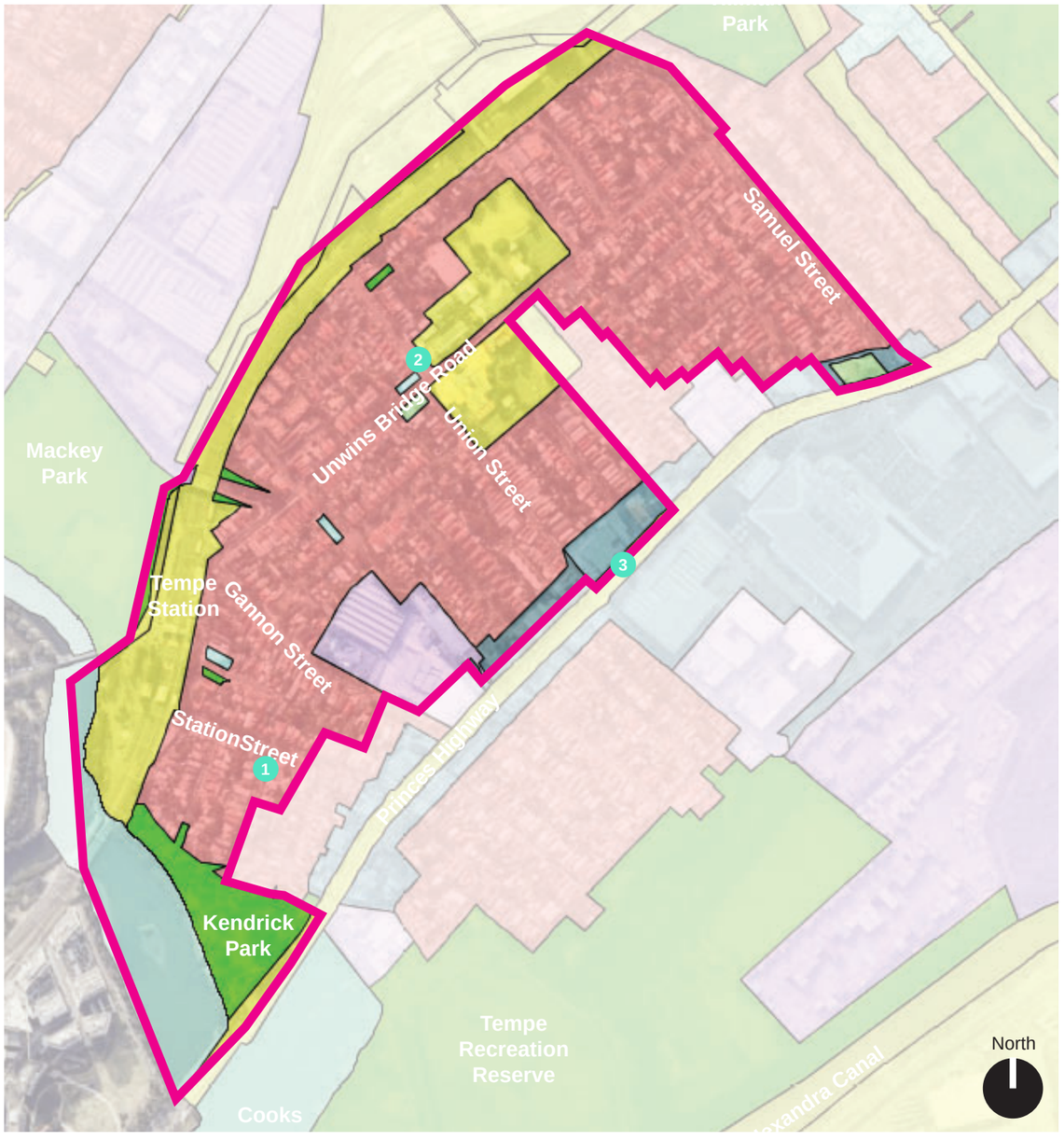
Low Density Residential zone (Station Street)

Neighbourhood Centre (corner of Collins Street and Unwins Bridge Road)

Business Development (Princes Highway)

Land use





NSW State Government assets

State Government agencies that own and are responsible for assets within the subcatchment are:

- **Sydney Water Corporation**. State Government agency responsible for trunk stormwater drainage, wastewater and potable water infrastructure and delivery.
- **Department of Education**. Responsible for delivering public education, and manages Tempe Public School and Tempe High School.
- **Transport for NSW**. Responsible for transport coordination, regulation, and infrastructure planning and delivery, including train and bus infrastructure. Transit Systems operates the bus network in Inner West Sydney, including the Bus Depot on Gannon Street.
  - **Sydney Trains**. Responsible for the management and maintenance of Tempe Train Station and associated rail infrastructure.
  - **Roads and Maritime Services (RMS)**. Responsible for building and maintaining some roads, and overseeing harbours and waterways (Cooks River). RMS manages and finances state roads, such as the Princes Highway. Regional and local roads are managed and financed by councils, though RMS provides financial assistance to councils for the management of regional roads.

EC Subcatchment boundary

Princes Highway

Tempe train station and rail corridor

The Eastern Channel

Business and community organisations

The commercial strip and industrial areas are located to the south of the subcatchment boundary, mainly along the Princes Highway (refer zoning map p. 33). This includes an auto smash repairs, taxi base, and the Tempe Hotel.

The non-commercial organisations are mainly religious institutions and reflect the multicultural community of the area. They include three Christian churches, a Buddhist temple and a Muslim mosque.

Two public schools and a privately operated swimming centre are also located in the area.

Non commercial organisations	Activities / Management	Address
Uniting Church - Siaola Congregation Uniting Church - Newtown Mission	• Places of religious worship	62 Union Street, Tempe and 19 Lymerston Street
St Peter & St Paul Catholic Church	• Place of religious worship	545 Princes Highway, Tempe
Tempe Mosque/ Al Hijrah Mosque	• Place of religious worship	45 Station Street, Tempe
Tempe Public School	• Public education	Unwins Bridge Road, Tempe
Tempe High School	• Public education	Unwins Bridge Road, Tempe
Yen Shan Tang True Buddha Order	• Place of religious worship	645 Princes Highway, Tempe
Betty Spears Childcare Centre and Pre-School	• Early childhood learning	1a Gannon Street, Tempe

Tonga Parish Uniting Church, Unwins Bridge Road

Tonga Parish Uniting Church, Princes Highway, Tempe

St Peter and St Paul Catholic Church, Princes Highway

Yen Shan Tang True Buddha Order, Princes Highway

Col Jones Swim Centre, Toyer St, Tempe

Betty Spears Childcare Centre and Pre-School, Gannon Street, Tempe

Council's capital works program

The planning process for capital works is carried out as part of the Council's planning and reporting requirements. The program is prepared in 4-year and 10-year timeframes including:

- Resourcing Strategy 2018 - 2028
- Delivery Program 2018 - 2022 (4 year plan)
- Operational Plan and Budget (1 year plan)

Council has a rolling program for capital works for new infrastructure, upgrades and renewal. Capital works programs will also be guided by other plans, such as Parks Plans of Management and Local Area Traffic Management Studies.

Stormwater drainage and WSUD works are currently prioritised by:

- condition – are they in good condition or should they be replaced?
- function – are they doing what they are designed / expected to do?
- level of service – do they meet community needs and expectations?
- long-term strategies and plans – are they meeting the goals of a strategy or plan?

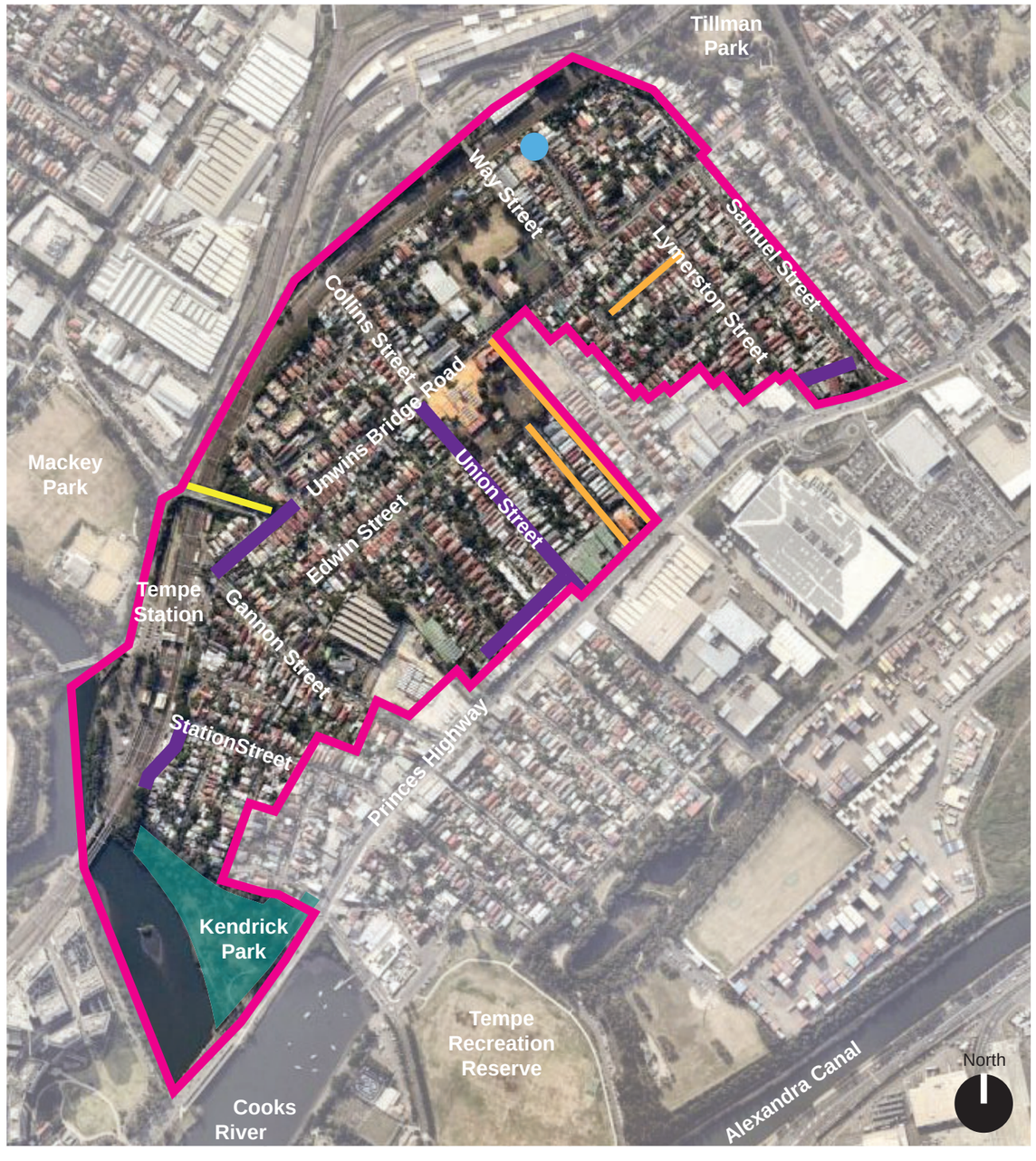
Biodiversity related works in this area are guided by the Marrickville Biodiversity Strategy and focus on works in the Cooks River Wildlife Corridor.

Capital works in the Eastern Channel subcatchment

The four-year capital works program currently includes the following capital works:

- Hillcrest Street rain garden
- Kendrick Park furniture and BBQ area upgrade
- Local road renewal along Edgar Street, Milne Lane, Union Street, Zuttion Lane and Griffiths Street
- Footpath renewal along John Street, Brooklyn Street and Foreman Street
- Bike Route LR07 (Richardsons Crescent, Cooks River to St Peters)

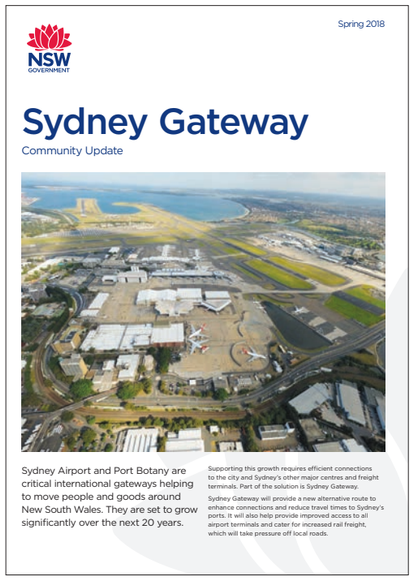
Note: Capital works listed in the program may change if different priorities or emergency works are identified.

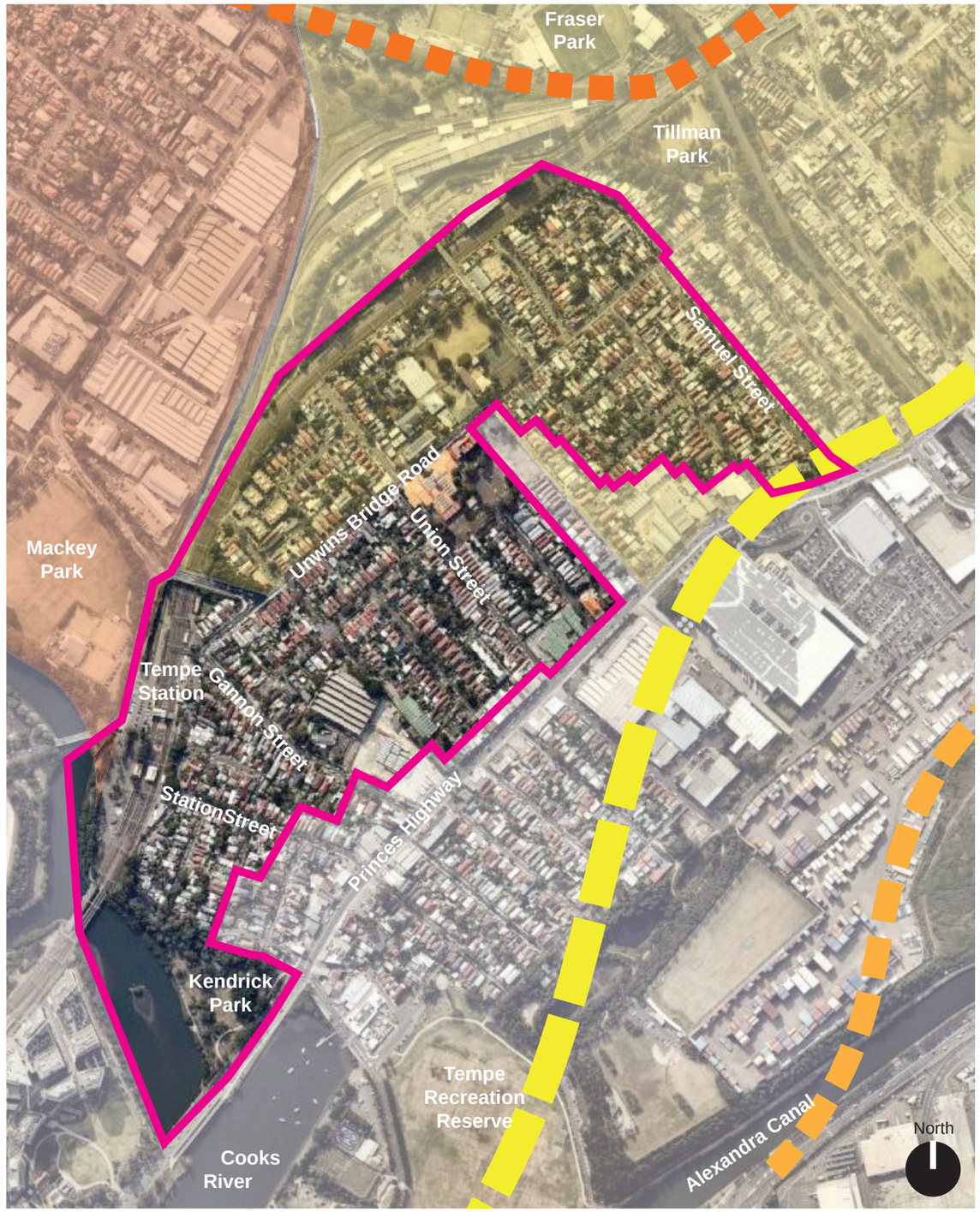


Urban development

Key future major infrastructure projects in and around the subcatchment are:

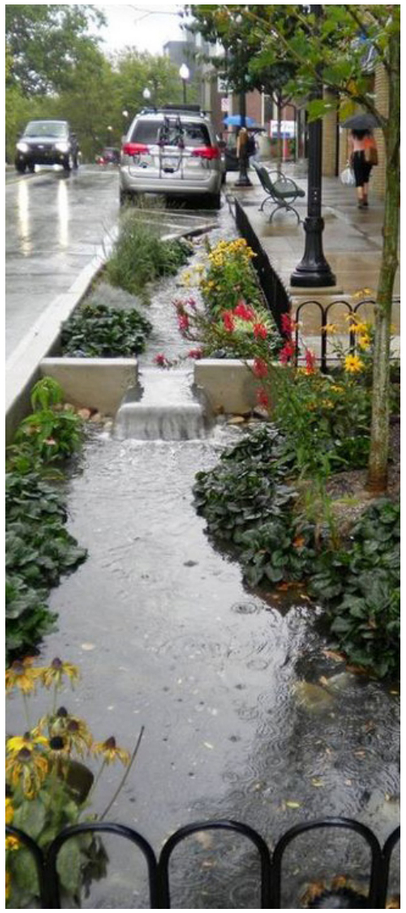
- Westconnex tunnel: tunnelling under Tempe to connect to the M4 - M5 link at St Peters
- Sydenham to Bankstown Metro Line: upgrade and conversion of existing train line to a metro line along with upgrades of existing train stations
- Sydenham to Bankstown Urban Renewal Area
- Sydney Gateway: Road upgrade to provide a new alternative route to the domestic and international airport terminals from the Sydney motorway network at St Peters Interchange, and the duplication of a three-kilometre section of the Port Botany freight rail line to increase capacity and improve service reliability
- Sydney Airport Master Plan 2039: Masterplan to set out development at the airport for the next 20 years

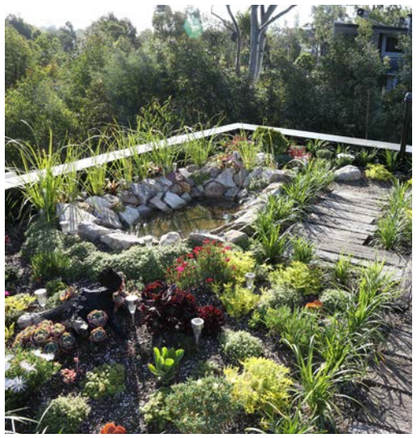




Vision ideas for the Eastern Channel Subcatchment in 2070

What would you like the Eastern Channel Subcatchment to look like in 2070?





3. Supporting Information

Eastern Channel looking towards the Cooks River

Strategic planning context

The NSW State Government has prepared policies and plans to guide strategic planning.

Eastern City District Plan

Five district plans have been prepared by the Greater Sydney Commission to set long-term planning priorities and actions for Greater Sydney. They focus on liveability, productivity and sustainability in each district. The EC subcatchment is in the Eastern City District. The Greater Sydney Commission and NSW Department of Planning have requirements for proximity and size of open space in Sydney. It aims for dwellings to be within 400m of local open space. The total areas for local and district level open spaces is to be 9% and 15% of the total area (including regional open space). Parts of central Tempe have below benchmark levels of open space (Cred Consulting, 2018). There is an opportunity to consider how open space could imaginatively be increased.

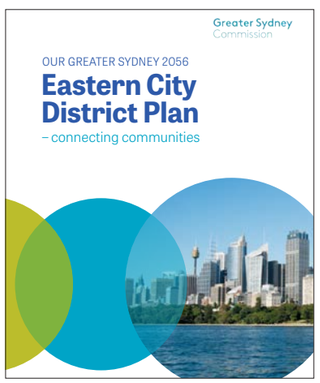
Green Grid

The Green Grid promotes the creation of a network of high quality open spaces that supports recreation, biodiversity and waterway health. The Green Grid is creating a network that connects strategic, district and local centres, public transport hubs, and residential areas. Green Grid project opportunities in the EC Subcatchment are:

- Cooks River Open Space Corridor
- Illawarra Rail Line: Wolli Creek to Redfern
- Bankstown to Sydenham Open Space Corridor

Greener Places

Greener Places is a draft Green Infrastructure policy produced by the Government Architect NSW to guide the planning, design and delivery of green infrastructure in urban areas across NSW. It aims to create a healthier, more liveable and sustainable urban environment by improving community access to recreation and exercise, supporting walking and cycling connections, and improving the resilience of urban areas.



Green Grid Hydrological Grid (Government Architect's Office, 2016)

Green Grid Ecological Grid (Government Architect's Office, 2016)

The Cooks River Catchment

The Cooks River begins in Yagoona and flows east for 23 kilometres through the inner south-west suburbs of Sydney to Botany Bay. As the Cooks River makes its way from Yagoona to Botany Bay it is joined by seven creeks. The Cooks River catchment (the area of land which feeds water to the river) covers approximately 100km^2 and flows through nine LGAs (see table below).

Water quality

The Cooks River is one of the most polluted urban rivers in Australia. Discharges of pollutants, sediments and gross pollutants combined with sewage overflows are significant contributors to the poor quality of the river. Various studies since 1997 have identified that after rainfall, the river contains high levels of faecal contaminants, elevated concentrations of heavy metals (lead, zinc, mercury, chromium, silver and copper), and high levels of nutrients (phosphorus and nitrogen) resulting in highly contaminated sediments and the potential for algal growth.

Stormwater runoff and sewer overflows have a negative impact on the river, resulting in less ecological diversity. There are 150 sewer overflow points in the Cooks River Catchment with typical overflow frequencies of over 20 times a year. Water quality for recreation is considered poor.

Biodiversity

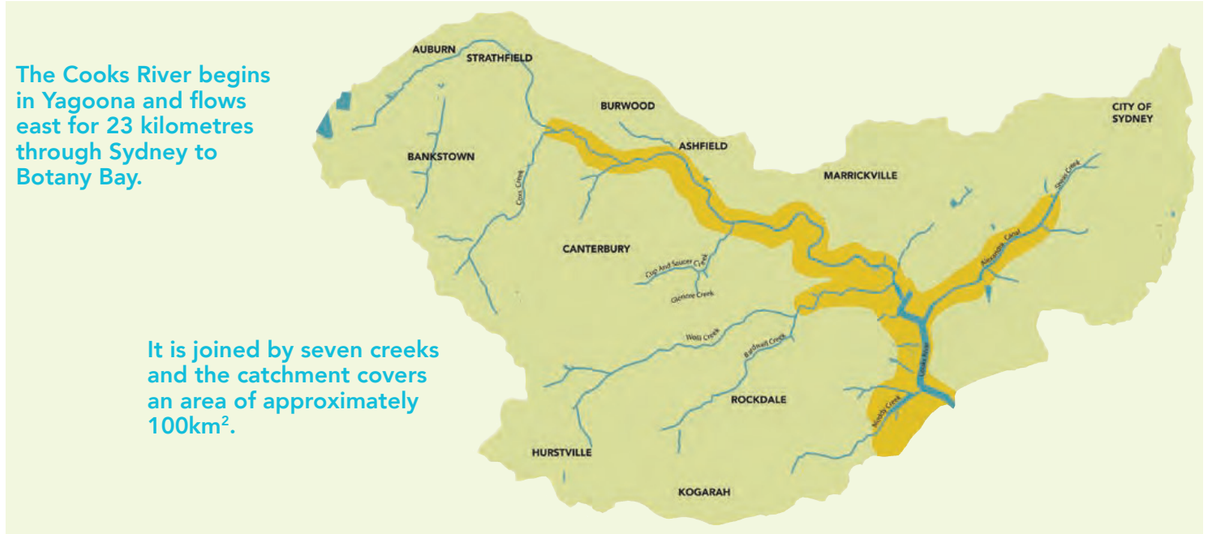
Biodiversity in the Cooks River catchment has decreased significantly as urbanisation has increased. Mangrove forest, salt marsh and Swamp Oak Forest used to grow along the Cooks River. Floodplain forests grew along it in sections. There were freshwater and brackish swamps and mudflats in low lying areas. Forests and heath were found on higher land and further inland. Today only small patches of this vegetation remain, and many animals found at colonisation no longer occur in the catchment.

Soils

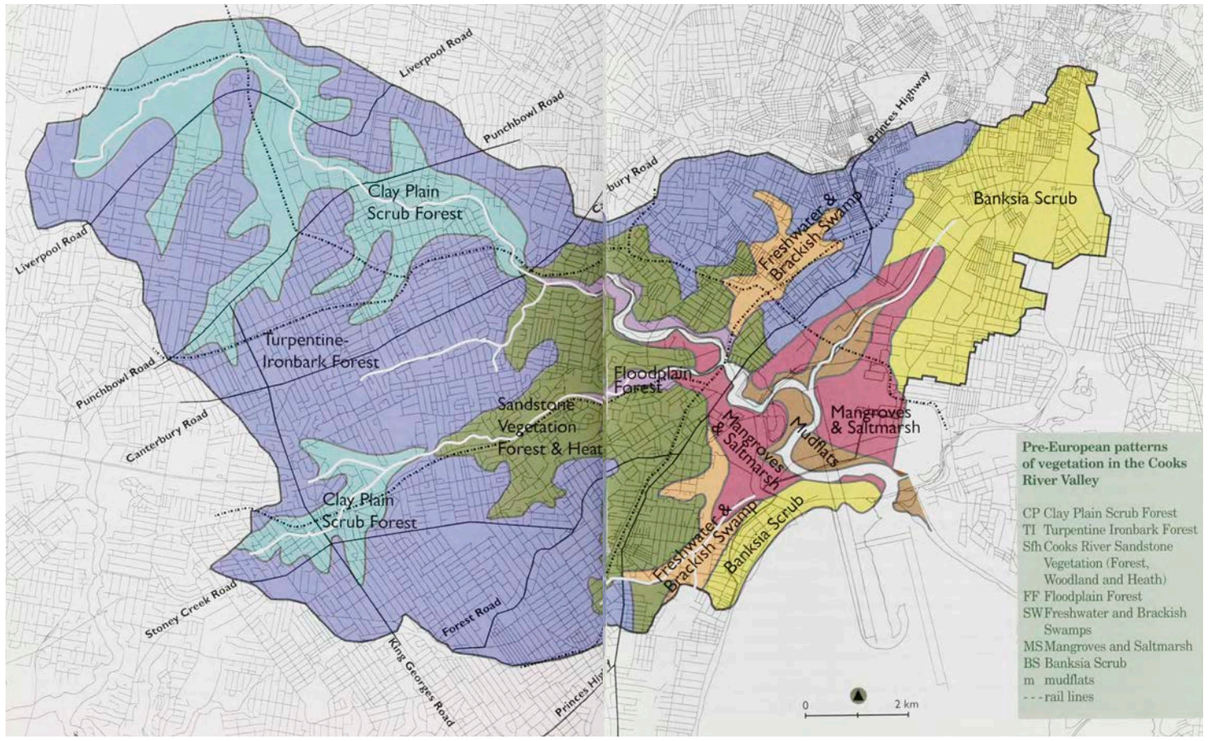
Soils in the Cooks River catchment are a product of the river environment. Sand, silt and clay and mudflats are found in the lower areas, with sandstone on higher grounds. Acid sulfate soils

Council	Percentage of catchment
Auburn	1%
Bayside	24%
Burwood	2%
Canterbury-Bankstown	34%
Georges River	9%
Inner West	11%
Randwick	1%
Strathfield	7%
City of Sydney	11%

One of the two litter booms located along the Cooks River at the Sugar Mills (2015)



The Cooks River catchment (Cooks River Alliance, 2017)



Pre-European vegetation patterns in the Cooks River catchment (Benson et al,. 1999)

Aboriginal weather knowledge

This information here is presented from the traditions of the D'harawal people. Inner West Council wishes to acknowledge the Gadigal Wangal people of the Eora Nation. Council is working with the Inner West Aboriginal and Torres Strait Islander working group on cultural and heritage issues of the Inner West LGA to continue updating local knowledge and understanding.

Aboriginal Australians have long held their own seasonal calendars based on the local sequence of natural events. From the Aboriginal perspective, all things past and present are interrelated, including the weather, landscape and previous generations, together with the plant and animal kingdoms. All these are connected as a continuum in which everything is placed in a proper order and has distinct meaning and relevance. Therefore, Aboriginal people can interpret the weather by recognising the different cycles in weather patterns and local ecology (Bureau of Meteorology, 2010).

Sydney's Climate

Frances Bodkin, a botanical author and elder on campus at Western Sydney University, is a traditional D'harawal Aboriginal descendant and one of the last people in Sydney to inherit tens of thousands of years of weather wisdom. Bodkin's clan is aware of two more cycles that run considerably longer than the yearly cycle, the Mudong, or life cycle which lasts about 11 or 12 years, and the Garuwanga, or Dreaming which is a cycle that lasts about 12,000 to 20,000 years (Australian Broadcasting Corporation, 2003).

GARUWANGA - Dreaming	MUDONG - Life
• Approx 12,000 to 20,000 years	• Approx 11 to 12 years
• Talara (Time of Ice) - When the sea is three days walk to the east from the Cave of Secrets • Gani (Time of Fire) - When the Sea Spirits reside in the Cave of Secrets	• Gadalung Burara - Hot and Dry • Murayung Murrai - Getting cooler and wetter • Tugara Murrai - Cold and Wet • Goray Murrai - Getting warmer and wet • Gadalung Murrai - Hot and wet • Murayung Burara - Getting Cooler and Drier • Tugara Burara - Cold and dry • Goray Burara - Getting warmer and drier • Ends with the appearance of the Aurora Australis in the sky

Interconnections

All the different lengths and levels of these cycles are interwoven. Every major cycle is slightly different to any other because it will arrive at a different time in relation to the smaller cycle.

Bodkin observed that in the last few years of the twentieth century there were several signs of a long term weather pattern. Over three consecutive years, she noted three very worrying signs. Firstly, there was the Aurora Australis in the skies over Sydney. The next sign was the "three sisters dancing in a line" referring to the alignment of three planets. The final occurrence was "the massive numbers of cicadas". According to Bodkin, these three things occurring together within a year or two of each other indicates a severe drought.

When all the messages are added together, every part of the environment can indicate what the weather for the day, week or the months ahead will be. Knowing how to recognise these signs is the key to understanding this information, which is inherent in the surrounding environment.

Seasons of the year

Goray'murrai Nov-Dec (approx)

- Time of the blooming of the Kai'arrewan (*Acacia binervia*)
- Warm and wet, do not camp near rivers
- Parra'dowee the Great Eel calls his children to him

Gadalung Marool Jan-Feb (approx)

- Time of the blooming of the Weetjellan (*Acacia implexa*)
- Hot and dry, eat only fruit and seeds
- Burra (kangaroos) start having their babies

Bana'murrai'yung Mar-May (approx)

- Time of the ripening of the fruit of the Lillipilli (*Syzygium spp*)
- Wet, getting cooler, time to make cloaks and start the journey to the coast
- Marrai'gang, the tiger quoll seeks her mate

Tugarah tuli Jun-Jul (approx)

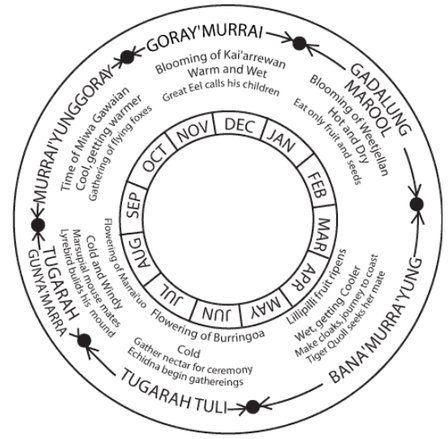
- Time of the flowering of the Burringoa (*Eucalyptus tereticornis*)
- Cold, time to gather the nectar for ceremony,
- Barrugin, the echidna begin their gatherings.

Tugarah gunya'marra Aug (approx)

- Time of the flowering of the Marrai'uo (*Acacia floribunda*)
- Cold and windy, build shelters facing the rising sun, time to begin the journey to the highlands along the rivers, plenty of fish
- Boo'gul the marsupial mouse mates and dies
- Wiritjiribin, the Lyrebird builds his mounds when season ends

Murrai'yunggoray Sep-Oct (approx)

- Time of the Miwa Gawaian (*Telopea peciosissima*)
- Cool, getting warmer, time for major ceremony
- Gathering of the Ngoonuni, flying foxes



© Bodkin/Andrews clan of the D'harawal
People Weather cycles for around Sydney from the Bodkin/Andrews clan of the D'harawal People
(pic: © Bodkin/Andrews clan of the D'harawal people)

Inner West water cycle

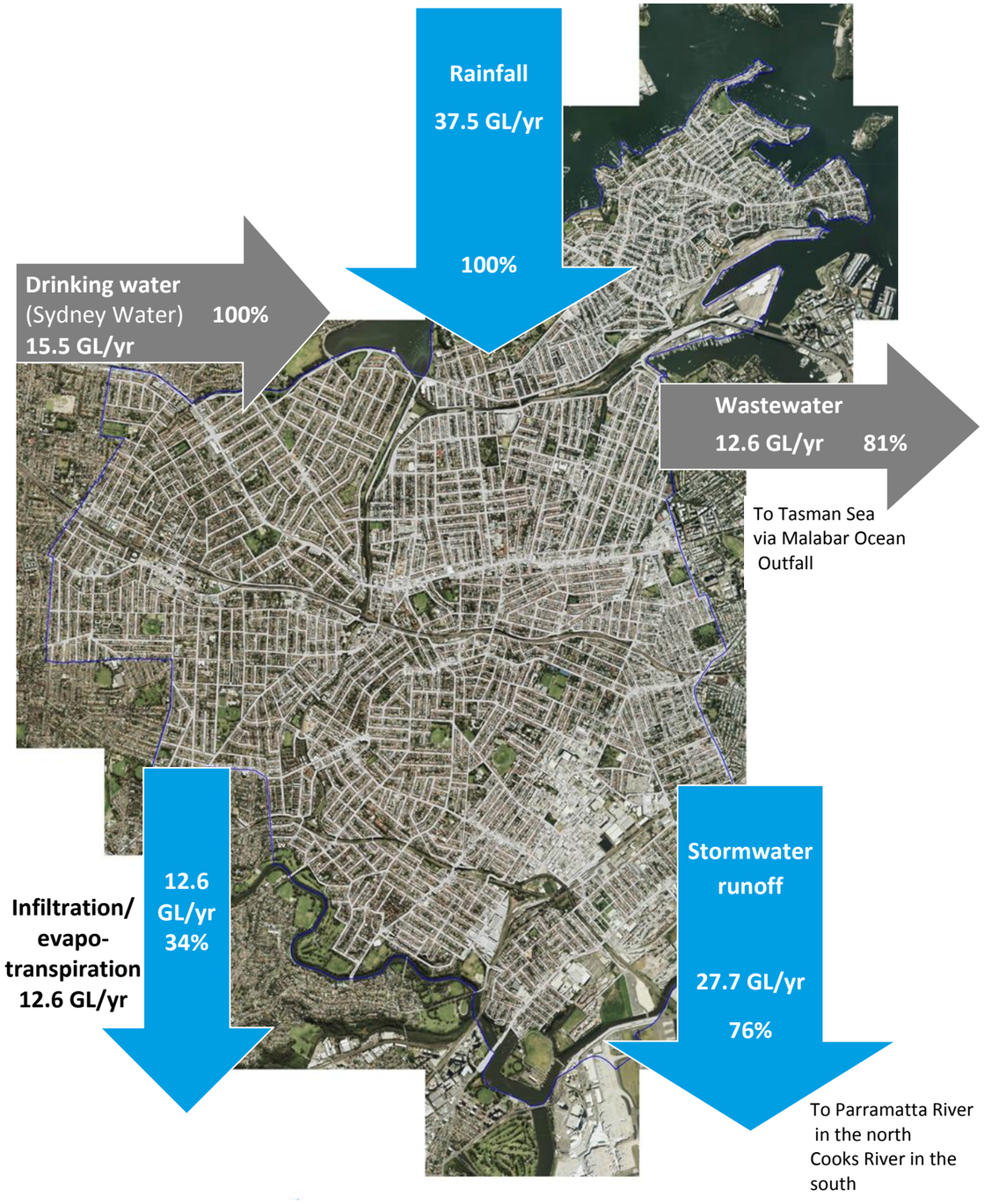
This page presents an overview of the water cycle for the Inner West LGA based on stormwater modelling.

71% of the area (35km^2) is impervious (or hard surfaces).

A study of the urban water balance highlights where drinking quality water savings can be made through harvesting rainwater, stormwater and sewage mining. Stormwater harvesting also provides an opportunity to treat stormwater and reduce pollutant loads.

WHAT DOES THE DIAGRAM TELL US?

The Inner West water cycle map shows that more than double the amount of rain falls in the area compared to the volume that is imported from Sydney Water as mains water. Only a small amount of mains water is actually consumed by residents. Almost all mains water (81%) is treated and discharged to the ocean after use. About three quarters of the rainfall ends up in the gutters and drains to the Cooks and Parramatta Rivers. The rest of the rain infiltrates into the ground or evapotranspires into the atmosphere.



Managing Flooding in the Marrickville Valley

The low lying parts of the Marrickville Valley have recorded flooding during major storms since records began. The potential for flooding is related to topography, size of stormwater drains, and historical patterns of development. Increases in hard surfaces together with changes in climate have produced the conditions for accumulations of flood waters, especially in flatter and more densely urbanised areas in the valley.

Modelling for the Marrickville Valley Flood Study (WMA Water, 2013) identifies a number of areas that experience flooding during significant rainfall or storms. These areas coincide with known flooding hotspots and include:

- Carrington Rd and surrounds
- Marrickville Industrial Area
- Malakoff St, downstream of Marrickville Oval and southern side of Sydenham Road (Livingstone Rd)
- Marrickville Railway Station and surrounds
- Sydenham Railway Station
- Jabez St and Shepherd St and surrounds

The map on the right shows areas most at risk from flooding. In Eastern Channel Subcatchment, flooding is likely to occur along the Cooks River (in-stream flooding), Kendrick Park and around Tempe Train Station.

The Floodplain Risk Management Study and Plan for the Marrickville Valley recommends the work and activities to help reduce future flood risks.

Corner of Carrington and Myrtle Roads, 2015

Lord Street, Marrickville, 2012

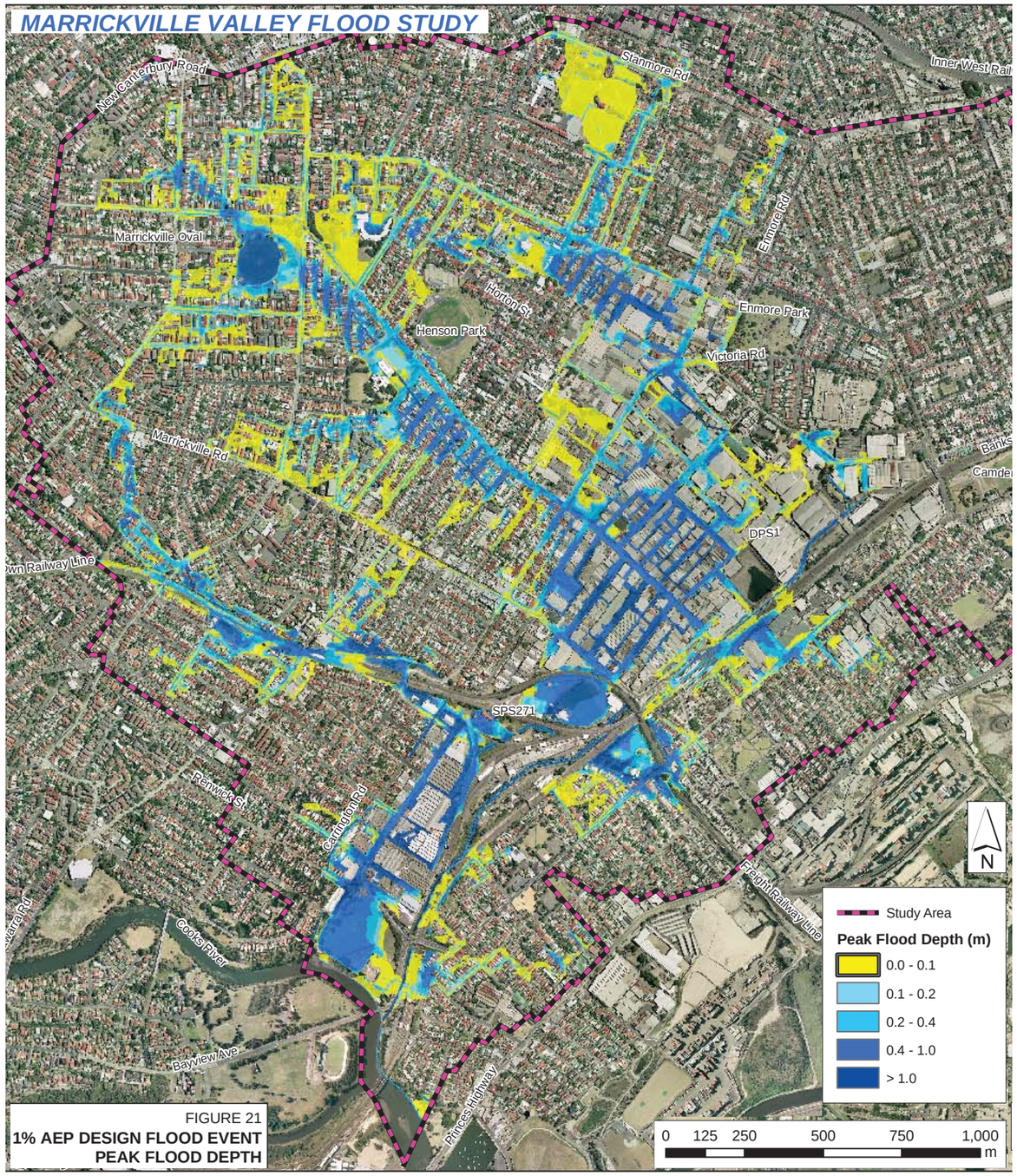


FIGURE 21
1% AEP DESIGN FLOOD EVENT PEAK FLOOD DEPTH

Council and community environmental initiatives

Native Plant Nurseries

Council supports two community native nurseries, Marrickville and Rozelle Bay. Council propagates plants which are native to the Inner West LGA for use in local bush restoration and capital works projects. They are also used in plant giveaways to the public and schools, and sold to the general public. Native plants are generally easy to maintain and require less water and care than many introduced species. They also attract native wildlife to gardens.

Bushcare

Numerous bushcare groups operate throughout the LGA, as shown on the map on this page. Council's Bushcare program enables residents to gain on-ground skills and experience, such as native plant identification, weed control techniques and how to build and protect habitat for native wildlife. Council also engages contractors to help restore ecological areas.

Council has a program of creating new habitat by installing habitat boxes for birds and bats, and creating habitat trees. Sustainable Streets and Living Lanes programs help facilitate biodiverse verge planting.

Community sustainability

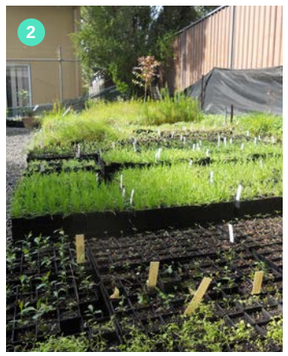
Council also supports community sustainability initiatives such as community gardens, community composts, worm farms and bees. The Green Living Centre is a sustainability initiative which runs workshops and projects around the Inner West to support the local community to reduce their environmental impact.

Community environmental groups

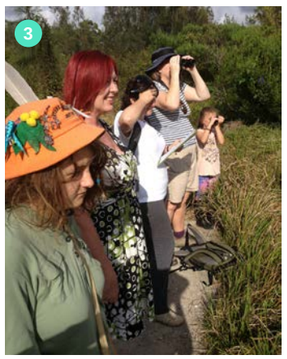
Community environmental groups (citizen science) also operate in the area including:

- The Mudcrabs: regularly collects rubbish and restores the bush along the river
- Inner West Microbat Monitors: a supervised volunteer group that meets for sunset surveys
- Tempe Birdos: monthly surveying at Tempe Wetlands and Reserve
- GreenWay Birdos: fortnightly surveys in the local area including around bushcare sites

The GreenWay

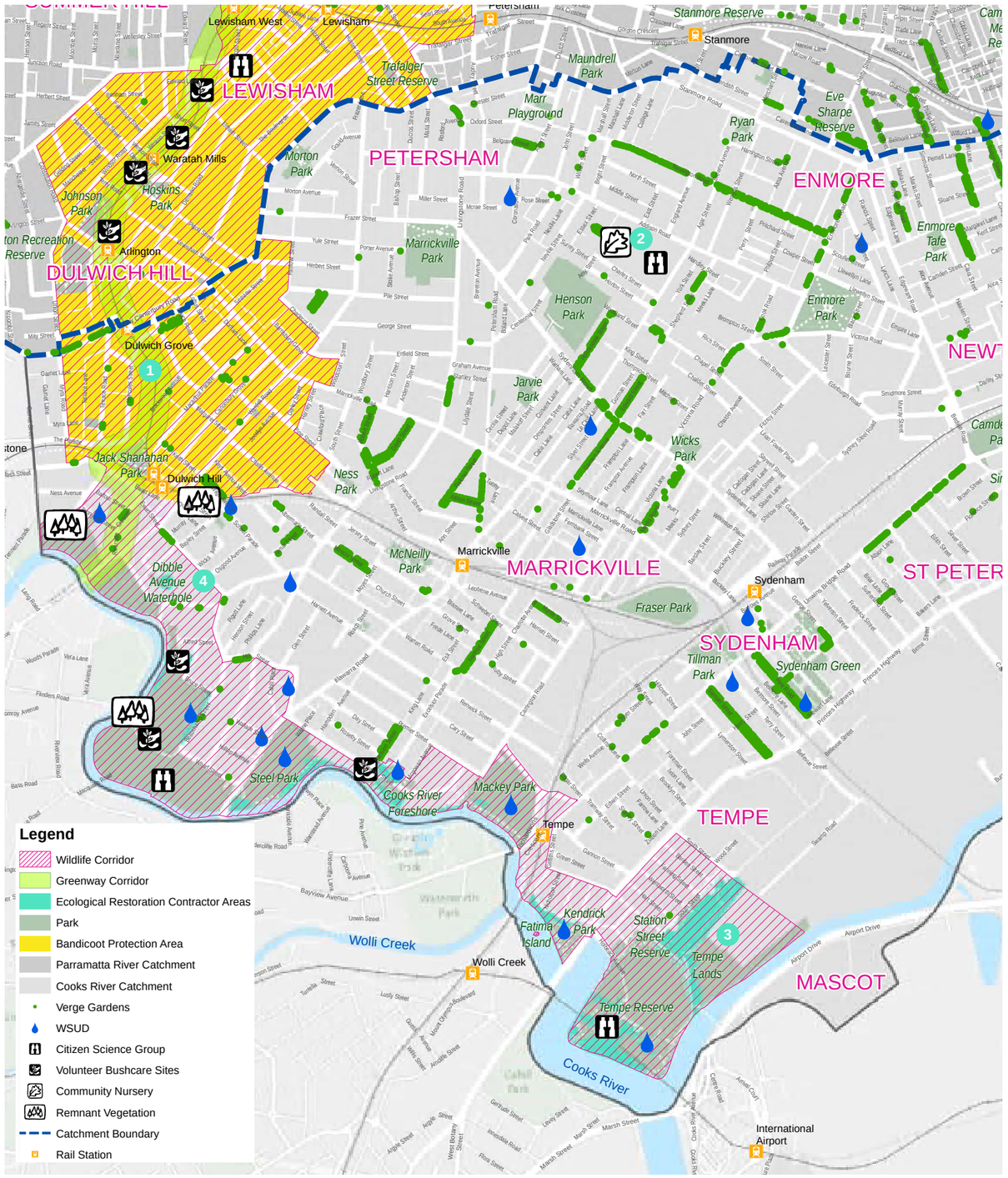


Marrickville Community Native Nursery



Tempe Birdos

Habitat boxes at Dibble Avenue waterhole, Marrickville



Green Infrastructure and Water Sensitive Urban Design (WSUD)

Green infrastructure and water sensitive urban design (WSUD) can provide ecosystem services including creating cooler microclimates, providing thermal benefits, providing habitat, acting as carbon sinks, producing oxygen and improving aesthetics.

1. Rainwater tanks collect rainwater from roofs and hard surfaces. In urban areas, rainwater from tanks is mainly used for watering gardens, laundry and flushing toilets.

2. Bioswales (grassed or vegetated swales) are depressions covered in plants to remove sediment and suspended solids. Their efficiency depends on type and height of vegetation.

3. Rain gardens / biofiltration systems are vegetated basins that slow water down and remove sediments, nutrients and other pollutants by passing water through gravel, sand and plants.

4. Buffer strips are strips of vegetation, such as grasses and shrubs, used to absorb road runoff. They remove pollutants and coarse sediments, such as soil and gravel, from stormwater.

5. Wetlands are natural water filtering systems made up of plants such as grasses and reeds. They remove soil, sediments, nutrients, some chemicals and litter from stormwater. Wetlands use a combination of physical, chemical and biological processes to remove pollutants.

6. Ponds are open bodies of water that settle sediments out of the water. Phytoplankton or other living organisms break down nutrients and sunlight disinfects the water.

7. Permeable paving reduces or eliminates stormwater runoff because water is able to go through the surface and into the ground or storage system. It can help reduce pollution and control erosion while assisting property owners to reduce the impervious surface area.

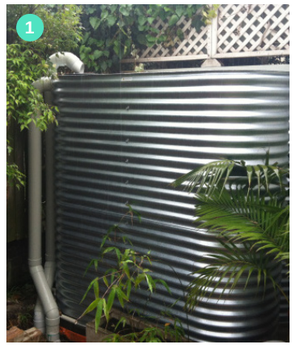
8. 9. 10. Green roofs, walls and facades can be made to suit a variety of building types and are particularly suitable for multistorey flats and apartments. They:

- increase habitat and biodiversity
- increase access to private outdoor green space and support urban food production
- improve air quality and reduce CO2 emissions, and delay stormwater runoff
- insulate buildings, and increase the value of buildings for owners and tenants alike
- create jobs in research, design, construction, gardening, health, and food production

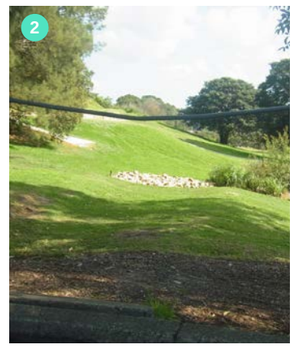
End of pipe solutions include:

11. Gross pollutant traps remove large pollutants such as litter and leaves from stormwater. They include trees, rocks and litter booms and are commonly used in urban areas. They require regular maintenance.

12. Sedimentation basins are large bodies of open water that remove sediment, soil and litter. Water is held for periods of time while pollution settles out of it.



Rainwater Tank

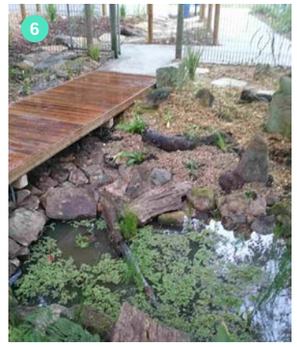


Bruce Street grassed swale, Marrickville

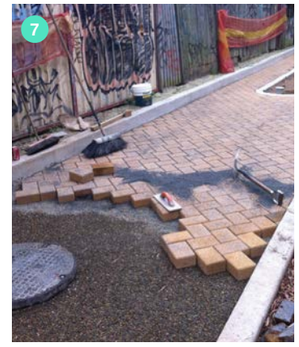
Thornley Street rain garden, Marrickville

Buffer strip, Marrickville

Whites Creek Wetland, Annandale

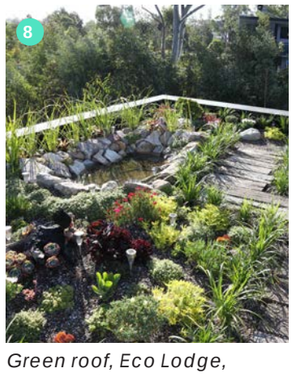


Dulwich Hill Public School frog pond



Permeable paving, Wilford Lane, Enmore

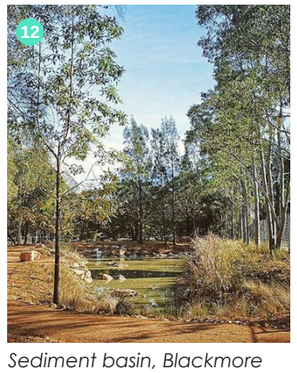
Green roof, Newtown



Green roof, Eco Lodge, Forest Lodge

Green wall, Camperdown

Gross pollutant trap



Sediment basin, Blackmore Oval, Leichhardt

4. Glossary

Biodiversity
Biodiversity is the variety of all living things, from the smallest microbe to the massive Blue Whale.

Climate change
Climate change is a change in the usual weather found in a place (NASA, 2017).

Ecology
Ecology is the scientific study of the processes influencing the distribution and abundance of organisms, the interactions among organisms, and the interactions between organisms and the transformation and flux of energy and matter (Cary Institute of Ecosystem Studies, 2018).

Ecosystem
An ecosystem is a dynamic community comprising populations of plants, animals, microorganisms and the non-living environment interacting together as a functional unit.

Ecosystem services
Ecosystem services are the benefits that plants, animals, water, soil, and air provide, e.g:

- trees acting as carbon sinks and providing oxygen and cooling;
- landscapes providing habitat, food, aesthetic, cultural and mental health benefits;
- fungi and insects supporting the food chain, soil formation and breaking down waste;
- bees, bats and birds pollinating plants

Fauna
Fauna is the animals of a particular region, habitat, or geological period.

Flora
The plants of a particular region, habitat, or geological period.

Green infrastructure
Green infrastructure is the natural and engineered infrastructure that results in the provision of ecosystem services, e.g. trees, parks, wetlands, saltmarsh, roof gardens, habitat; or ecosystem service functions e.g. stormwater harvesting.

Habitat
Habitat is the natural home or environment of an animal, plant, or other organism.

Habitat connectivity
Habitat connectivity at a local scale means appropriately spaced suitable habitat, allowing species to move between areas to breed, shelter and forage.

Habitat mosaic
A habitat mosaic is a collection or patchwork of different types of landscape features across an area which provide habitat. They are ecologically important for protecting and enhancing biodiversity.

Impervious area
Impervious areas are covered by material that significantly reduces and prevents natural infiltration of water into the soil.

Overland flow
Overland flow relates to short duration flooding of backyards, drainage paths, streets and other properties caused by stormwater as it makes its way into rivers and waterways.

Potable water
Drinking quality water. In Sydney, Sydney Water pipes in the water from the catchment area to the west of Sydney. Sydney Water's operating license comes under strict guidelines and reporting requirements to make sure the quality is always safe for human consumption.

Sewage
Sewage is the water entering the sewerage system that combines material flushed down the toilet and greywater (wastewater from washing machines, showers, baths and basins). This water can be thoroughly treated and recycled at a sewage treatment plant. It can then be piped to individual households, as part of a dual-pipe water-supply system (in addition to and separate from the normal tap water supply). It can be used for toilet flushing, garden watering, washing cars and outdoor surfaces, irrigating sports fields and public parks, fire control, sewerage flushing, dust control, or irrigating agricultural crops. A number of such systems exist in Australia, e.g. Rouse Hill.

Stormwater
Stormwater is rain that drains into the stormwater system as 'runoff' from roofs, roads, footpaths and other surfaces. It usually flows untreated directly into local waterways. The water carries pollutants such as rubbish, animal droppings, engine oil, petrol, tyre rubber, soil, pesticides, asbestos and debris. Stormwater from public and private properties is increasingly being used to irrigate local sports fields and parks and provide water for wetlands.

Subcatchment
A subcatchment is a smaller catchment (or area) within a bigger catchment - the area of land which feeds water to the river. All the water enters the receiving waterway at the same point (in this case via the Eastern Channel next to the train line).

Urban ecology
Urban ecology is the interrelationship of all living things with people and the physical built environment including towns and cities.

Urban forest
An urban forest is the totality of trees and shrubs on all public and private land in and around urban areas (including bushland, parkland, gardens and street trees) and is measured as a canopy cover percentage of the total area, and is recognised as a primary component of the urban ecosystem.

Wastewater
Wastewater (sewage) is the used water and sewage that goes down sinks, toilets and inside drains. This enters the sewerage system, which is owned and operated by Sydney Water.

Water sensitive cities
Water sensitive cities are places that:

- serve as a potential water supply catchment, providing a range of different water sources at a range of different scales, and for a range of different uses;
- provide ecosystem services and a healthy natural environment, thereby offering a range of social, ecological, and economic benefits; and
- consist of water sensitive communities where citizens have the knowledge and desire to make wise choices about water, are actively engaged in decision-making, and demonstrate positive behaviours such as conserving water at home. (CRC for Water Sensitive Cities, 2018)

Water Sensitive Urban Design (WSUD)
WSUD is an urban planning, engineering and landscape design approach which integrates urban water cycle management (water supply, stormwater, groundwater, wastewater), with urban design to provide multiple benefits including improving environmental health and supplying ecosystem services.

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