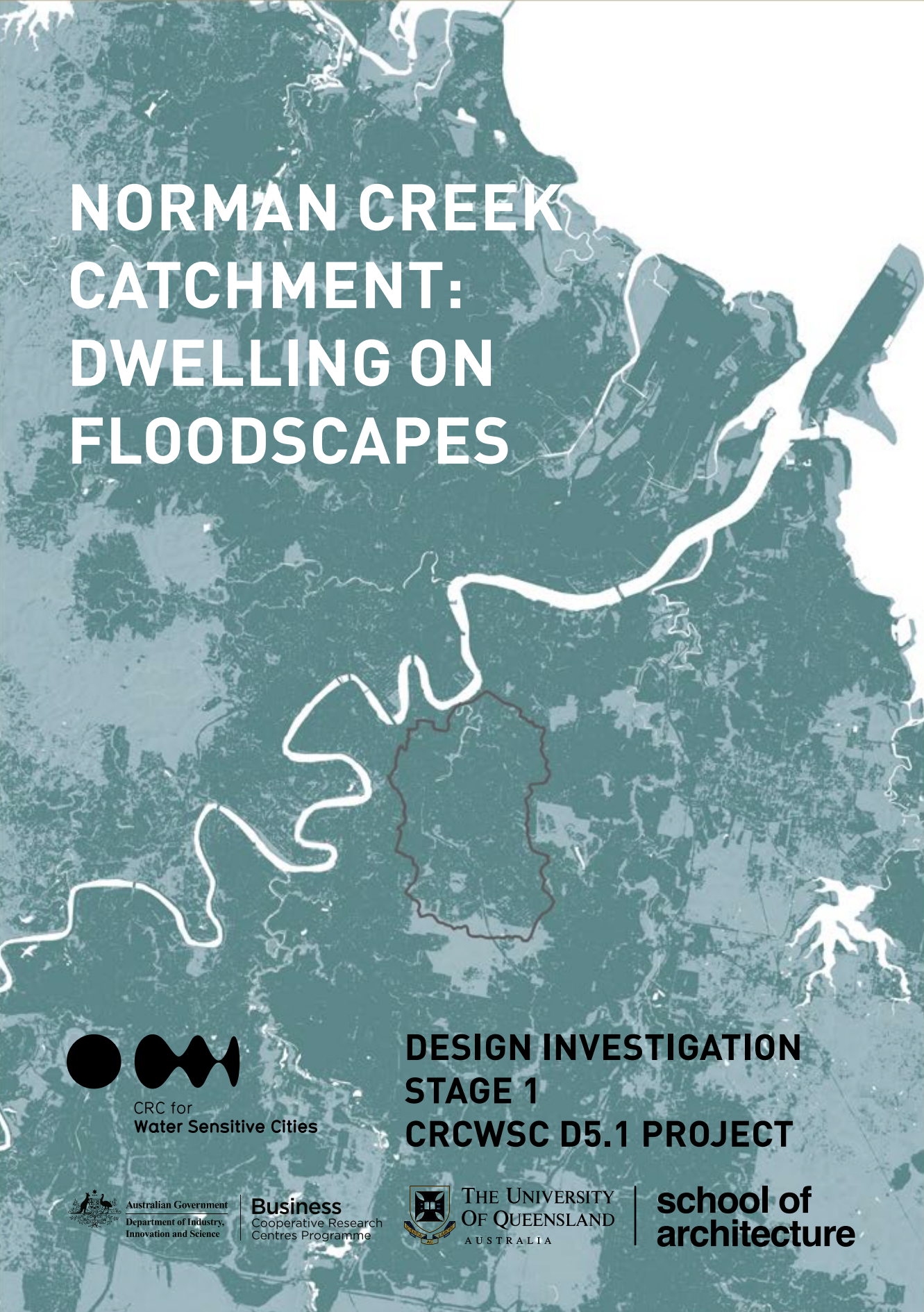
NORMAN CREEK CATCHMENT: DWELLING ON FLOODSCAPES



DESIGN INVESTIGATION STAGE 1 CRCWSC D5.1 PROJECT

CRC for Water Sensitive Cities

Australian Government
Department of Industry, Innovation and Science
Business Cooperative Research Centres Programme

The University Of Queensland
AUSTRALIA
school of architecture

Norman Creek Catchment: Dwelling on Floodscapes
Design Investigation Stage 1. CRCWSC D5.1 Project
Urban intensification and green infrastructure: towards a water sensitive city (Project D5.1)
D5.1 – 1 – 2018

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1. INTRODUCTION

"We have major urban water problems that cannot be solved using conventional, compartmentalized thinking. These problems are becoming more severe as urban populations swell, high-quality source water becomes scarcer, demands for environmental quality increase, and climate change brings new uncertainties (like flood) into play. New thinking is needed to yield solutions that are cheaper, more effective and fairer."[1]

- Lawrence A Baker

The *Norman Creek Project* is one of a suite of projects in Melbourne, Brisbane and Perth which are all undertaken by the Co-operative Research Centre for Water Sensitive Cities (CRCWSC) through its partner Universities, respectfully; Monash University, the University of Queensland and The University of Western Australia. Begun in 2016, the D5.1 Programme is exploring how a design-led approach can synthesise a range of complex issues towards delivering best-practice water sensitive urban design in regions that are undergoing intense redevelopment. By foregrounding water as a primary driver in planning for the future of areas undergoing significant change, the programme is developing a more holistic view of urbanism that unlocks thinking about water systems in place, and reveals processes for developing climate change resiliency in cities as they densify.

As a rapidly densifying area in close proximity to the Brisbane CBD with water management issues, the Norman Creek Catchment is a valuable and important area of study for the following reasons:

- The water management issues of this catchment is a key focus of the Brisbane City Council, namely through the implementation of Brisbane City Council's (BCC) *Norman Creek Catchment Masterplan.*
- In its hydrology and urbanity, the Norman Creek Catchment has been appreciated as a microcosm of the ongoing water management and development issues of the Greater Brisbane Region.
- High density infill development precariously close to the floodplain already underway.

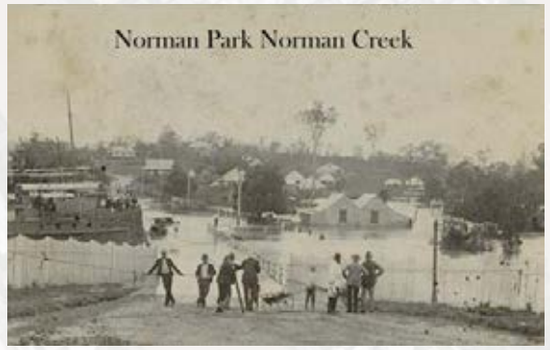


Figure 1: Flooding of Norman Creek in 1893[2]


Figure 2: Flooding of Norman Creek in 2011[3]


Figure 3: From the *South East Queensland Waterfutures Design Charrette*[4]

This booklet records the first stage of the *Norman Creek Catchment Design Investigation*. Multiple activities ran in parallel during this eighteen month period have prospered and provided knowledge, documentation and ideas which will be carried forward in a post-graduate architectural design studio, held in the second semester 2017.

Following an intense documentation and preparation phase, two key workshops took place in July-August 2016: the *South East Queensland Waterfutures* charrette and the CRCWSC synthesis workshop - *Ideas for Norman Creek*. Leveraging knowledge and ideas shaped through the workshops, an architectural design studio with Master of Architecture students (July-October 2016) delivered spatial propositions for water sensitive urban design in three selected precincts within the Norman Creek Catchment (research-driven design); at the same time, postgraduate design-driven research mapped new high-density development in Brisbane's floodplains, capturing its limits and potentials. Research outcomes were then presented to the public including the Norman Creek community, via two exhibitions; *Creek Urbanism* (November 2016, Suncorp Brisbane CBD Headquarters and BCC), and *eMbARCH* (November 2016, UQ School of Architecture). Utilising the knowledge built from these activities and a course dedicated to critically evaluating the geography of the Norman Creek Catchment (in the research selective *Critical GIS and Cartographic Landscapes*), another post-graduate design studio will be held in semester 2, 2017.

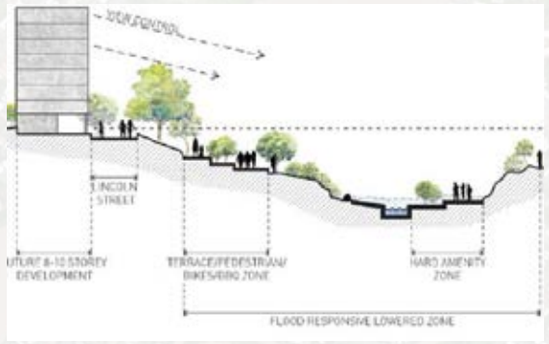


Figure 4: From CRCWSC's *Research Synthesis: Ideas for Norman Creek* workshop[5]


Figure 5: From UQ's *Dwelling in Future Waterscapes* design studio[6]


Figure 6: Photo from one of the programme's exhibitions - *Creek Urbanism*[7]

1.1 BETWEEN FLOOD AND DROUGHT

Blessed by a subtropical climate and the advantageous location as Australia's closest eastern capital to Asia,[8] Brisbane strives to join the international race for the most resilient and liveable city. Like many other cities in the world, Brisbane straddles the floodplains of a major river and is crossed by thousands of overland flow paths that meander along its hilly topography. Its hydrology naturally encompasses cycles of droughts and floods, including riverine floods as well as flash flooding. Its prosperity depends on the correct management of these extremes, which have a significant impact on infrastructures, assets, transport, waterways, parks and community life. The devastating 2011 Queensland floods preceded, and followed by prolonged drought, are an alarming warning of this ever-transient condition of the city.

Brisbane City Council's (BCC) aspirations for a built environment where "flooding is expected, designed and planned for" are well summarised in the recently released *Brisbane's Floodsmart Future Strategy 2012-2031,*[9] which stipulates how the city's built form should be shaped to increase resilience to flooding, and specifies the need to "locate the right land use in the right place" and "new growth areas where there are few flood constraints or where the effects of flooding can be managed", this is also echoed in the *2014 Brisbane City Plan.*[10] Despite these aspirations, Brisbane has seen rampant high-density development occurring well within the floodplain.

This intense infill development in areas at risk of flooding means that Brisbane could serve as a unique laboratory in which to develop and test design solutions for improving quality and performance of public space, green and water infrastructures, and the urban fabric.

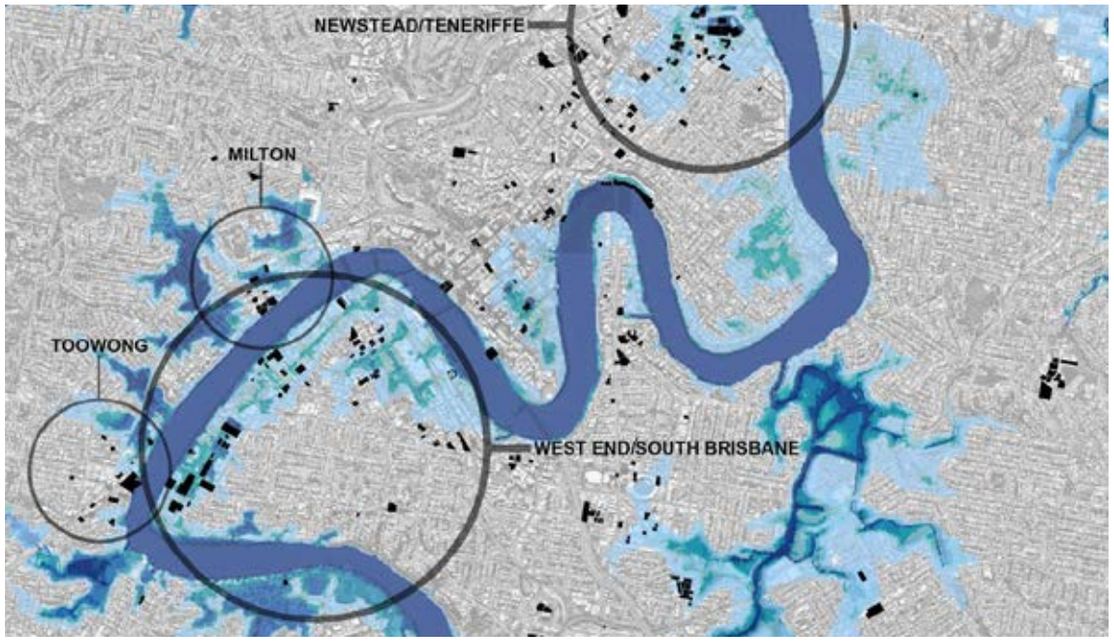
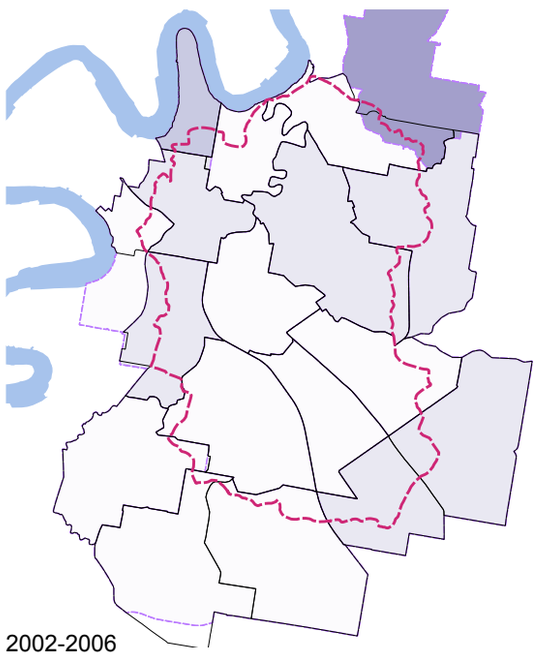
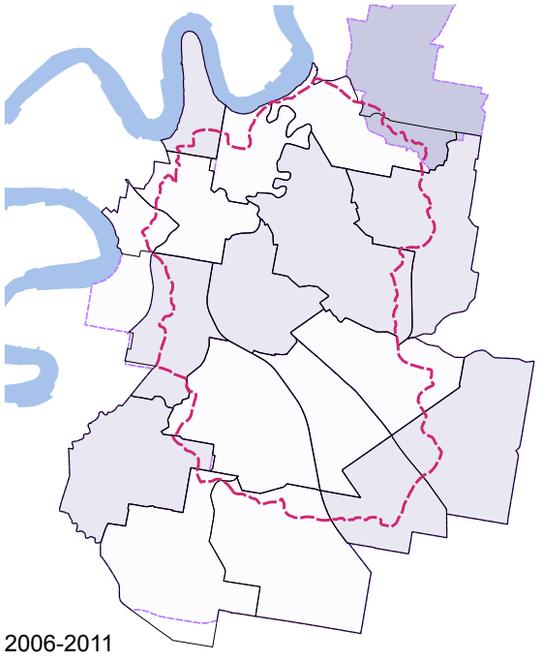
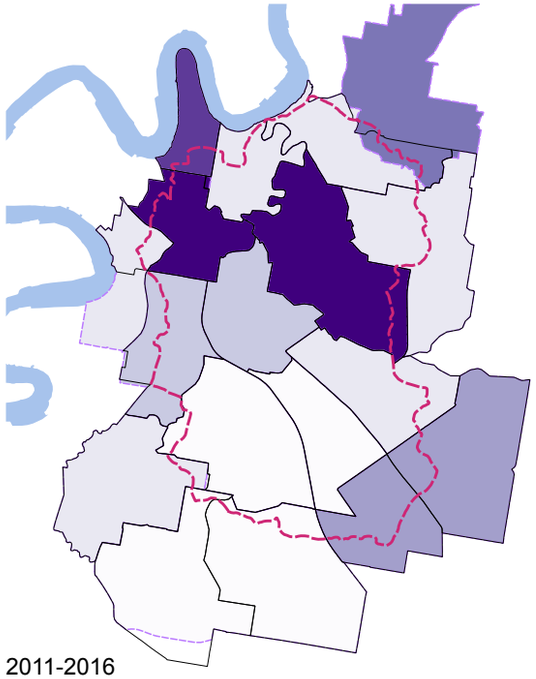


Figure 7: Apartments under construction and approved as of April 2016[11]

Many of these up and coming and recent developments lie within Brisbane's flood risk areas (shown in blue around the Brisbane River and its tributaries)







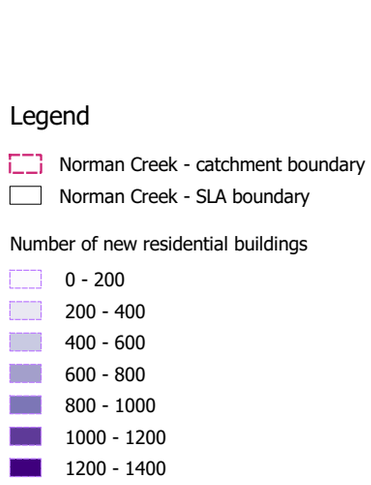


Figure 8: New buildings constructed over time in the Norman Creek Catchment by UQ student, Paul Violett.[12]

Like the broader context, there is a prevalence of infill development within flood prone areas in the Norman Creek Catchment. Coorparoo and Woolloongabba, two suburbs separated only by the flood prone Norman Creek, are growing rapidly with 1000's of new residences being constructed between 2011 and 2016.

2. NORMAN CREEK THROUGH HISTORY

2.1 NORMAN CREEK AS INHABITED FLOODSCAPE

The existence of water catchments within inner city locations can often be obscured by the patterns of urban development that dominate the form and experience of the city. The Norman Creek Catchment situated south-east of Brisbane's CBD is one example, typical of many, where the expansion of a city dominates the presence of earlier landscapes.

Prior to its colonial inhabitation Norman Creek was called Kulpurum by the Jagara people. The indigenous people of the area would use the creek and its surrounding riparian areas for wood gathering, hunting, camp grounds, and, reportedly, Corroborees (Australian Aboriginal dance ceremonies) of up to 300 people.[13] Figure 9 shows the area was part of a broader network of land stretching across the landscapes around the Brisbane river. Hundreds of indigenous people used the camp grounds adjacent the creek until the 1880's,[14] though due to the proximity of an ever-expanding colony they were subject to marginalisation. A key effect of this is the fracturing of their urban network by the boundary roads (Figure 10).

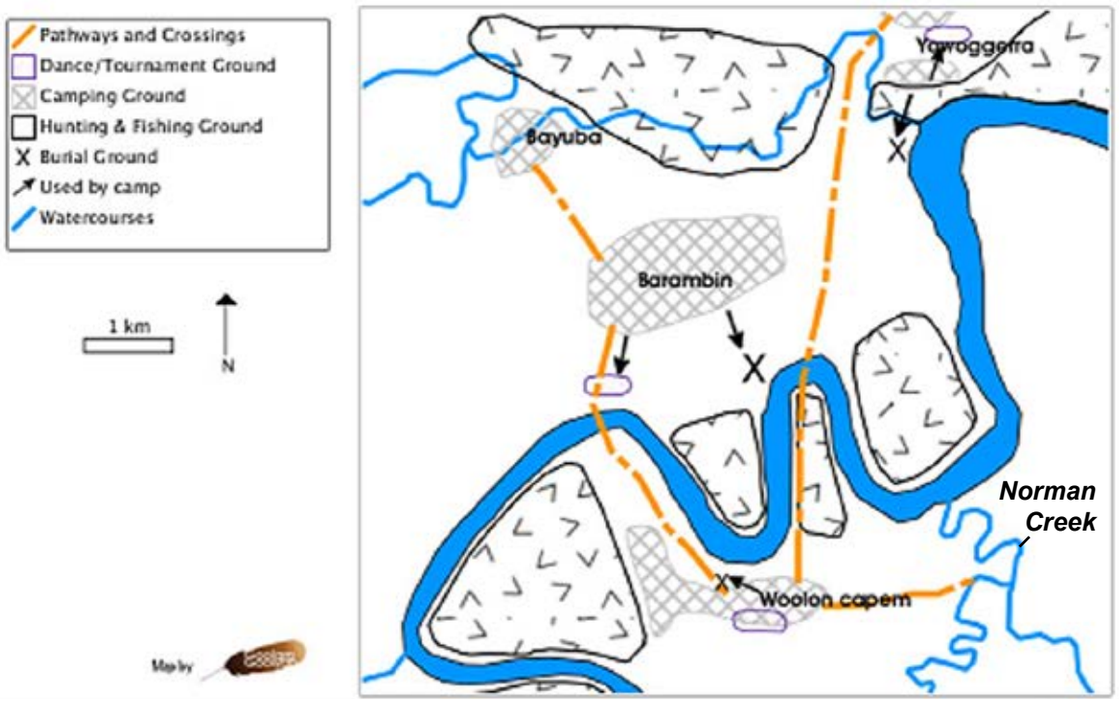


Figure 9: Indigenous land use[15]

This figure shows Norman Creek as part of a large urban network before colonial settlement.

2.2 EARLY EUROPEAN SETTLEMENT

The settlement of the Norman Creek Catchment is relatively recent historically. Even as Brisbane was established in the mid-19th century it remained outside the formal boundaries of the city. It was not until the subdivision of the Parish of Bulimba in 1854 that the landscape began to strongly reflect the presence of European settlement beyond its use by indigenous groups.[16]

Before the construction of a bridge the local population could only cross the creek by boat, or by travelling to and from the northern Hawthorne Road, to Bennetts Road, and finally across to Woolloongabba via Old Cleveland Road. In 1855, a rough road was made to this bridge, which would later become Wynnum Road.[17]

Figure 10. Map of the Environs of Brisbane Town. Map produced by Henry Wade in 1844.[18]

While the boundaries of Brisbane extended into the Norman Creek Catchment, no colonial developments existed near the creek during this period.

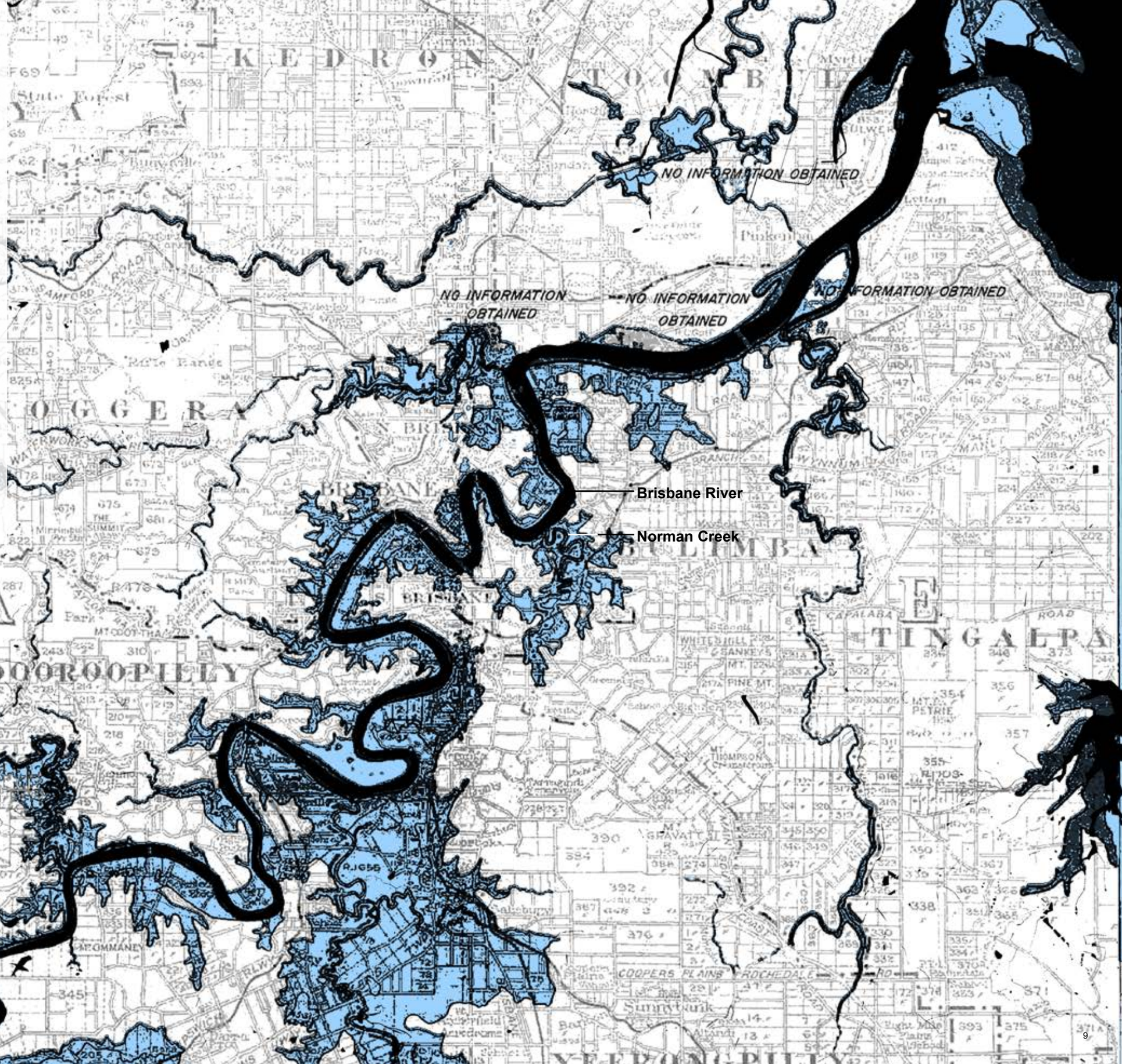
2.3 THE GREAT FLOOD OF 1893.

"In 1893 the Great Flood of Brisbane left a path of destruction in its wake. The total rainfall in Brisbane for over 8 days was about 20 inches (500mm) and the Brisbane River rose 23 feet (7 metres) above its ordinary level – 10 feet (3 metres) higher than the flood of 1890. Brisbane suffered approximately £2,000,000 worth of damages. The Victoria Bridge and the Indooroopilly Railway Bridge were swept away and in Queen Street, the businesses of Finney, Isles and Co, drapers, Perry Brothers, the goldsmiths, Hall Company, H. L. Davies and Gordon and Gotch, all suffered major damage."[19]

This excerpt was written in 2011 by Karen Hind, Librarian of the renown John Oxley Library.

Figure 11. Extent of the 1893 flood.[20]

This figure is a modified version of the Survey Office, Department of Lands Brisbane's map - *Floods: Brisbane River, February 1893 of Brisbane and Suburbs*.



2.4 DEVELOPMENT IN THE EARLY 20TH CENTURY.

Despite the Great Flood of 1893, Brisbane continued to grow precariously along the Brisbane River and its tributaries such as Norman Creek and Breakfast Creek. In fact, developing and densifying on floodplains was preferred over developing on the higher lands of Greenslopes, Mt. Gravatt and Mt Coot-tha.[21]

Figure 12. Extent of the 1893 flood superimposed on 1946 satellite imagery.[22]

2.5 FLOOD OF 1974.

The Brisbane Flood of 1974 was a riverine flood which elevated the water level 5.5 metres, killing 14 people, inundating over 6,700 homes and causing 980 million dollars worth of damage (approximately 8 billion dollars by today's standards). The response of the council to reduce the intensity of future riverine floods was the construction of the Wivenhoe Dam.[23]

Figure 13. Extent of the 1974 flood.[24]

This figure is a modified version of the 1974 *Flood Map of Brisbane and Suburbs* by the Survey Office, Department of Lands Brisbane.

1974 Flood Level

FLOOD MAP
OF
BRISBANE & SUBURBS

Delineating the extent of the January, 1974, Brisbane River Flood and those areas subject to probable inundation for various flood heights on the Port Office Gauge, as indicated on the Bureau of Industry 1933 Flood Map

SCALE 1 : 15 840

Drawn and Published at the Survey Office, Department of Lands, Brisbane. Feb., 1974
Printed at the Govt Printing Office. Price $1.00.

CROWN COPYRIGHT RESERVED

This map was compiled under the direction of the Surveyor General, Queensland, from data obtained from field inspection by Survey Office field staff, supplemented by information from aerial photographs flown on the 29th. and 30th. January, 1974, and information made available from the Brisbane City Council.

The areas of probable inundation by floods rising to various heights on the Port Office Gauge have been obtained from the Bureau of Industry's Flood Map published in 1933.

REFERENCE

Areas that would be inundated by

Blue — Flood rising 10 feet (3.048 m) on Port Office Gauge

2.6 THE 2011 RIVERINE FLOODING OF THE BRISBANE RIVER AND ITS TRIBUTARY - NORMAN CREEK.

While the riverine flood of 2011 was lower than the floods of 1974 and 1893, the densification of the city's riparian zones meant that 20,000 houses were affected. Additionally, the increasingly densified riparian edges around Brisbane River tributaries in the upper catchments (for example Grantham) were devastated. At least 38 people died during this event with 6 others presumed dead, 2 000 000 lives were affected and 2.38 billion dollars of damage was accrued.[25]

Figure 14 (above). Aerial over the mouth of Norman Creek during the floods of 2011.[26]

Figure 15 (spread). Satellite imagery of the 2011 floods over Norman Creek.[27]


BULIMBA
BALMORAL
MERTHYR
EAST
BRISBANE
1974
ORRPAROO
GREENSLOPES

2.7 SEDIMENTARY CITY

Previous Research and Design Project, 2008 - 2010
(Coordinators: Brit Andresen and Mara Francis)

How can we understand pre-existences in the landscape of the city and their potential as cues for urban development?

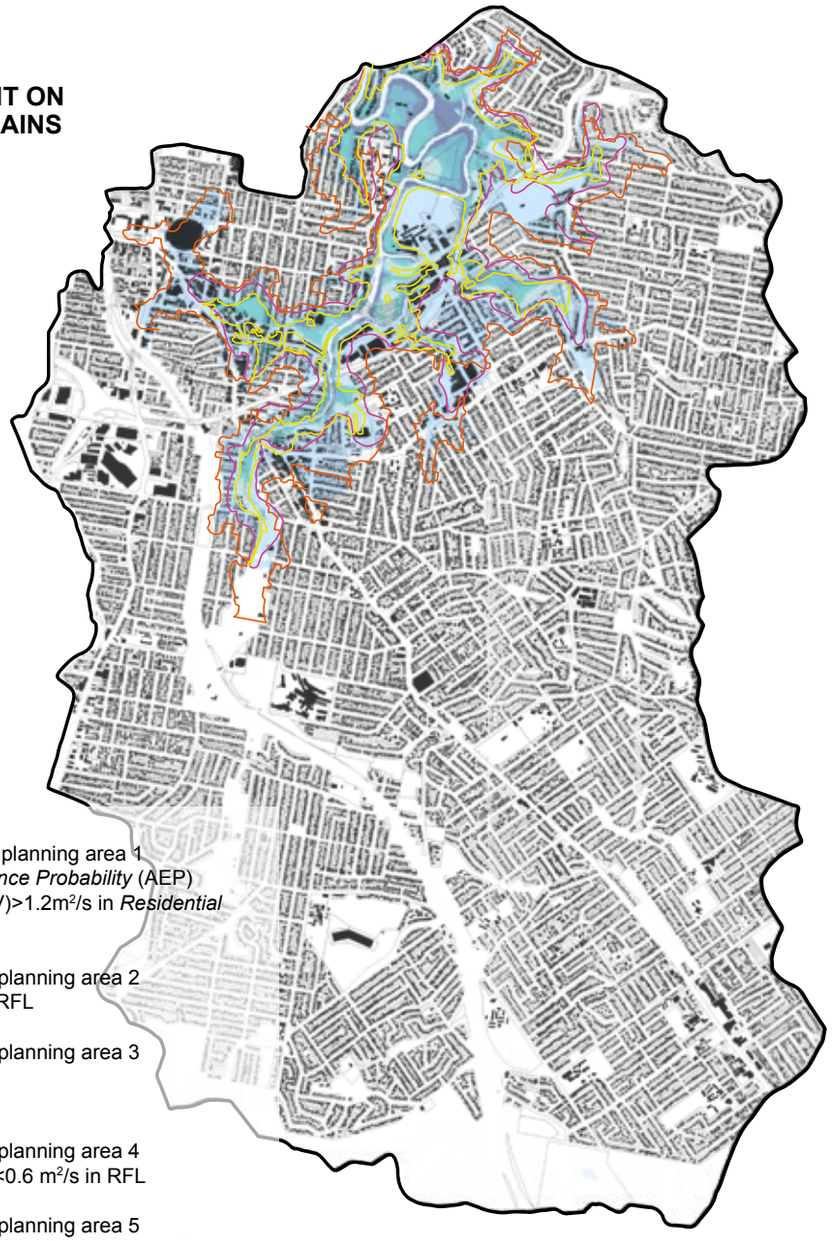
The Sedimentary City project raised such issues in inner Brisbane by exploring scenarios of past and future landscape conditions in relation to human settlement. The study of early European maps and patterns of indigenous occupation were used to establish snapshots through time of the environment. By revealing a picture of the deep structure of the landscape, the Sedimentary City project sought to challenge architects to rethink how they could recover and augment the environment - respecting pre-existing conditions through new urban propositions.

The programme included three post-graduate design courses, three presentations and two publications, all culminating in two exhibitions including the *12th International Architecture Exhibition, La Biennale di Venezia 2010.*

Figure 16: Sedimentary Cities - "First City,"[28]
This collage depicts Brisbane's environment as it was inhabited before European settlement.

Figure 17 (opposite page, right): Scheme for the reclamation of Kinfisher Creek's floodplain by Jonathan Ward.[29]

2.8 NEW DEVELOPMENT ON BRISBANE'S FLOODPLAINS



Legend:

'Brisbane River flood planning area 1
Within the 10% *Annual Excedence Probability* (AEP) extent; and *depth x velocity* (DV)>1.2m²/s in *Residential Flood Level* (RFL)

Brisbane River flood planning area 2
>1.2m deep; or DV>1.2m²/s in RFL

Brisbane River flood planning area 3
0.6–1.2m deep in RFL; or
0.6 m²/s<DV <1.2 m²/s in RFL

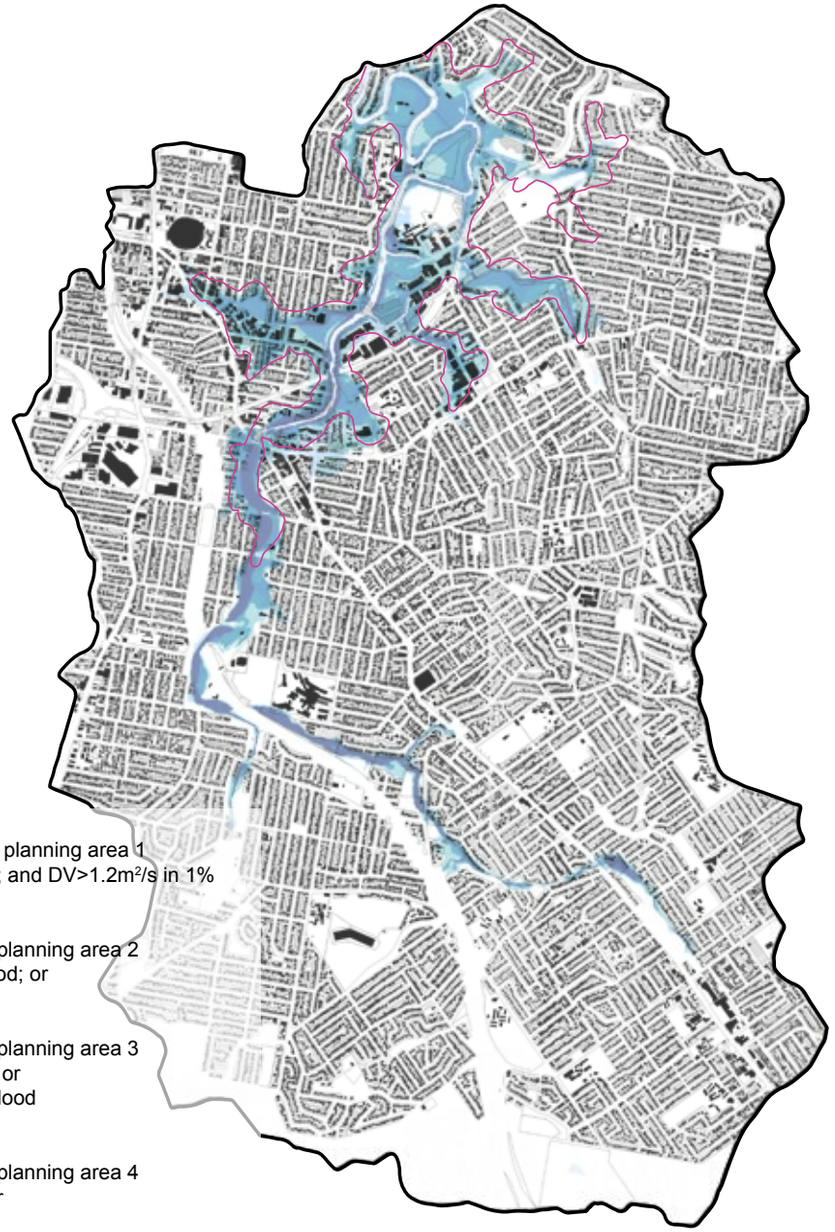
Brisbane River flood planning area 4
0–0.6m deep in RFL; or DV of <0.6 m²/s in RFL

Brisbane River flood planning area 5
From the RFL extent to the 0.2% AEP flood extent.'[30]

Great flood of 1893
Flood of 1974
Flood of 2011

Figure 18: Riverine flood scenarios on the present day urban fabric of the Norman Creek Catchment[31]

The development in risk can be clearly seen by overlapping this development over the council's flood risk areas. The source for the building footprints in this image was created by the students of the *Critical GIS and Cartographic Landscapes* course.



Legend:

"Creek/waterway flood planning area 1
Within the 10% AEP flood extent; and DV>1.2m²/s in 1% AEP flood

Creek/waterway flood planning area 2
Deeper than 1.2m in 1% AEP flood; or
DV>1.2 m²/s in 1% AEP flood

Creek/waterway flood planning area 3
0.6–1.2m deep in 1% AEP flood; or
0.6m s<DV<1.2m²/s in 1% AEP flood

Creek/waterway flood planning area 4
0–0.6m deep in 1% AEP flood; or
DV<0.6 m²/s in 1% AEP flood

Creek/waterway flood planning area 5
1% AEP flood extent to the 0.2% AEP flood extent"[32]

Great flood of 1893
Note that the Great Flood was both a flash/creek/ waterway flood and a riverine flood.

Figure 19: Creek/waterway flood scenarios on the present day urban fabric of the Norman Creek Catchment[33]

The development in risk can be clearly seen by overlapping this development over the council's flood risk areas. The source for the building footprints in this image was created by the students of the *Critical GIS and Cartographic Landscapes* course

3. NORMAN CREEK TODAY

3.1 URBAN ENVIRONMENT AND HYDROLOGY

The Norman Creek Catchment is currently one of the most densely populated areas in Brisbane, with a population of 100,000 living on 3,000 hectares of land.[34] The long history of colonial inhabitation has changed the form of Norman Creek and its tributaries profoundly, but since the floods in 2011, the Brisbane City Council (BCC) has begun to acknowledge the need for a more natural and sustainable creek system to increase resilience to inevitable flooding. The following paragraphs describe three apparent sections of Norman Creek, their transformations, and those of the tributaries, as well as the surrounding urban context.

The treatment of Norman Creek and its tributaries is varied; for the first 5,300 metres from the mouth to the river and through the suburbs of East Brisbane and Coorparoo, Norman Creek isn't canalised. Despite its natural appearance, a few of the pre-existing meandering forms of the creek have been straightened, in order to increase the creek's release of floodwater and so that its riparian terrains could be reduced for burgeoning development. Additionally, the creek's salinity has not been natural since the removal of the rock bar at the mouth of the Brisbane River in 1864. This section of the creek, which is bounded by the river to the North and Logan Road to the South, is mainly surrounded by detached dwellings, though there is a large high-school and several light-industry workshops also nearby. Kingfisher Creek, a tributary of Norman Creek which catches Woolloongabba's stormwater has been canalised and covered almost entirely. Ben's Hole Creek appears partially canalised, Scott's Creek is entirely canalised, and Bridgewater Creek is planned for rejuvenation. Coorparoo Creek has been reopened this year, having been restored to a more natural state (prior to which it was covered like Kingfisher Creek).

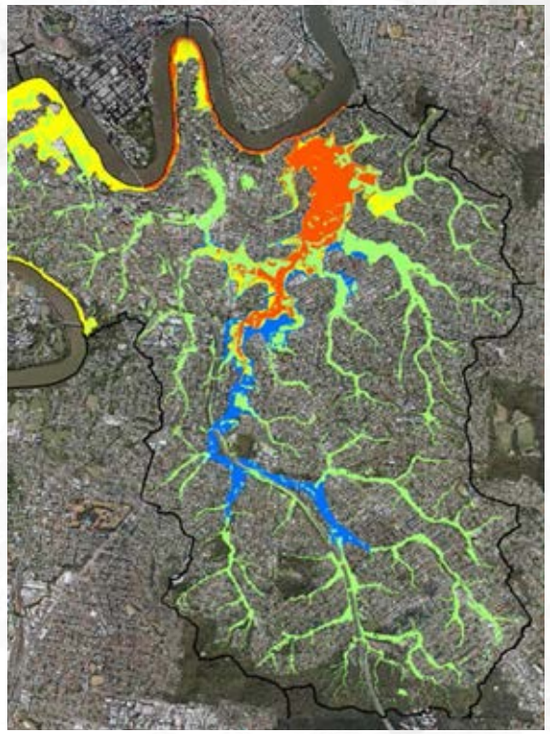


Figure 20: The different kinds of flood risk areas in the Norman Creek Catchment.[35]

Figure 21: North Norman Creek (5,300m).[36]

South from here, the creek is canalised for 1,300 metres. This canal is bordered for the most part by a 100m wide flat floodplain, which is partially privately owned and partially state owned, yet is available to the residents as a continuous parkland. In this section of the creek the large commercial/retail/hospitality district of Stones Corner is located.

Finally, Norman Creek runs for no more than one kilometre, edged by a mix of concrete culverts and earthen riparian before dividing into three tributaries: Sandy Creek, Mott Creek and Glindermann Creek - the latter two running up the South of the catchment. While there are large buildings in the upper regions of the southern half of the catchment, such as the Greenslopes Hospital and Greenslopes Mall, the vast majority of development in this area is characterised by detached residential dwellings on small lots.

Figure 22: Middle Norman Creek (1,300m).[37]

Figure 23: South Norman Creek (1,000m).[38]

3.2 DEMOGRAPHICS

The overall large population and development growth of the Norman Creek Catchment is an expression of the rich and prosperous economy of Brisbane's suburbs. In comparison with the CBD and its surrounding business centres, the suburbs produce over twice as many jobs for the people of Brisbane.[39]

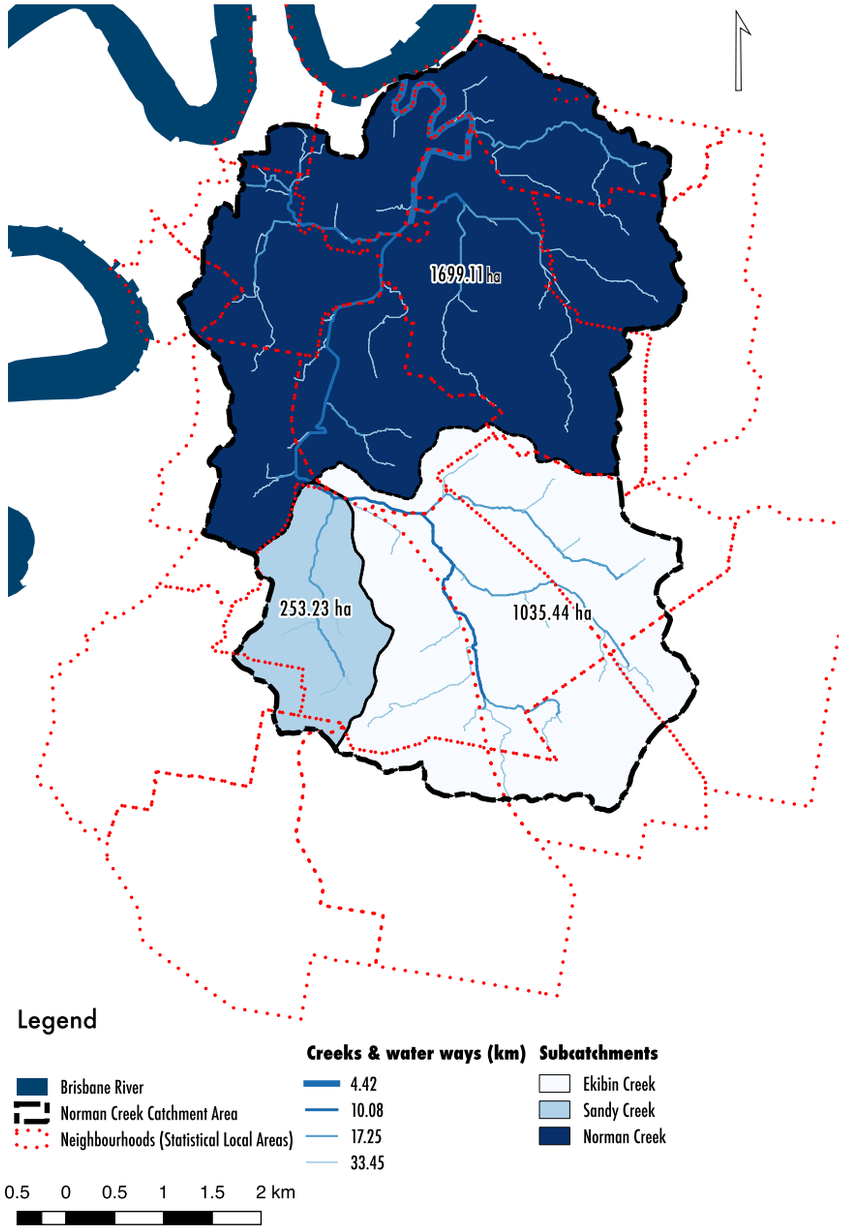
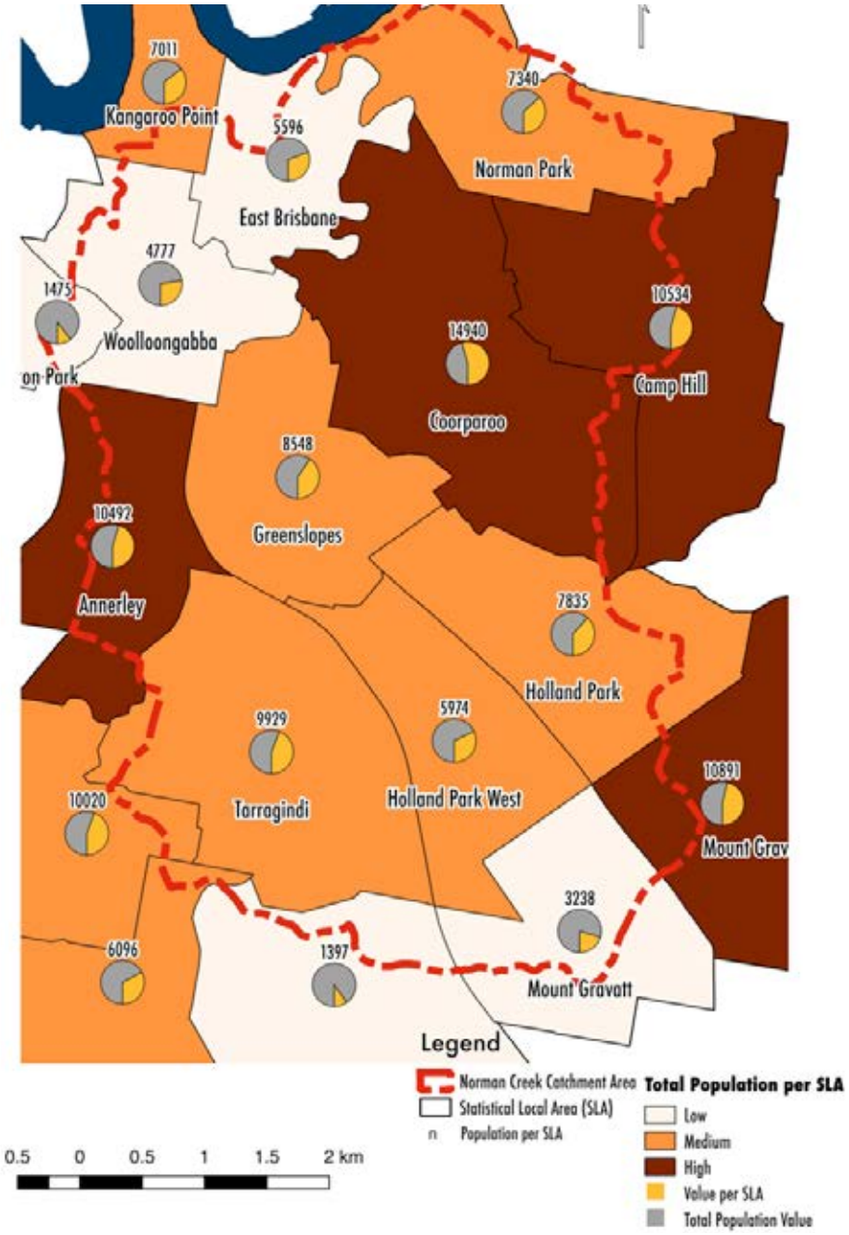


Figure 24 (opposite page): Suburb outlines versus subcatchments[40]
Suburban boundaries are disconnected from its catchment landscape for the most part with only Norman Creek itself partially impacting these boundaries.

Figure 25 (below): Populations of the Norman Creek Catchment[41]
Based on *2011 Australian Census* data, this map demonstrates the distribution of population per neighbourhoods.



4. NORMAN CREEK MASTERPLAN

In 2010, Brisbane City Council (BCC) announced its intention to fund Australia's first masterplan for an entire waterway catchment. This involved a thorough consultation process with local community and various stakeholders, as well as commissioned urban planners, landscape architects, ecologists, flood and civil engineers and other specialists. While the aim of the plan is the regeneration of local waterways and the restoration of green areas bordering them, building development will be the major driver of quality urban environments and smart water usage / flood resilience.

BBC's vision for the catchment is summarised in the following points:

"- A catchment enjoyed for its subtropical open spaces, green transport options and healthy waterways.
- A creek reconnected with the Brisbane River and local waterways, bordered by safe and attractive wildlife corridors.
- An urbanised place that celebrates water and is resilient during times of flood and drought.
- Water smart communities who appreciate water's integral role in sustaining life and manage it sustainably."[42]

Figure 26: Artist's impression of the Coorparoo Creek Project.[43]

As part of the ongoing implementation of the Norman Creek Masterplan, BCC has begun to restore Coorparoo Creek, one of Norman Creek's tributaries, by:

- *"Lowering the ground level in the parkland and returning Coorparoo Creek to the surface.*
- *Constructing a shared path for cyclists and pedestrians through the new park.*
- *Installing park furniture such as tables and benches.*
- *Landscaping the park space."*[44]

Figure 27: Artists impression of the Bridgewater Creek Project.[45]

Included in the Masterplan is the *Concept Plan for the Bridgewater Creek–Wembley Park Landscape*, whose aim is to:

- *"Increase riparian plantings to both sides of Bridgewater Creek along its entire length in this location to 60m width.*
- *Demonstrate an urban ecological system that provides critical habitat and improves water quality through WSUD treatment train through the whole of Wembley Park and develop mechanisms to involve residents, visitors and school groups with the system.*
- *Highlight the need to review and improve the water treatment performance upstream at Bowies Flat Constructed Wetand as part of this system and downstream of Wembley Park.*
- *Remove the concrete channel in Giffin Park and naturalise that section.*
- *Improve safe access, recreation opportunities and connections."*[46]

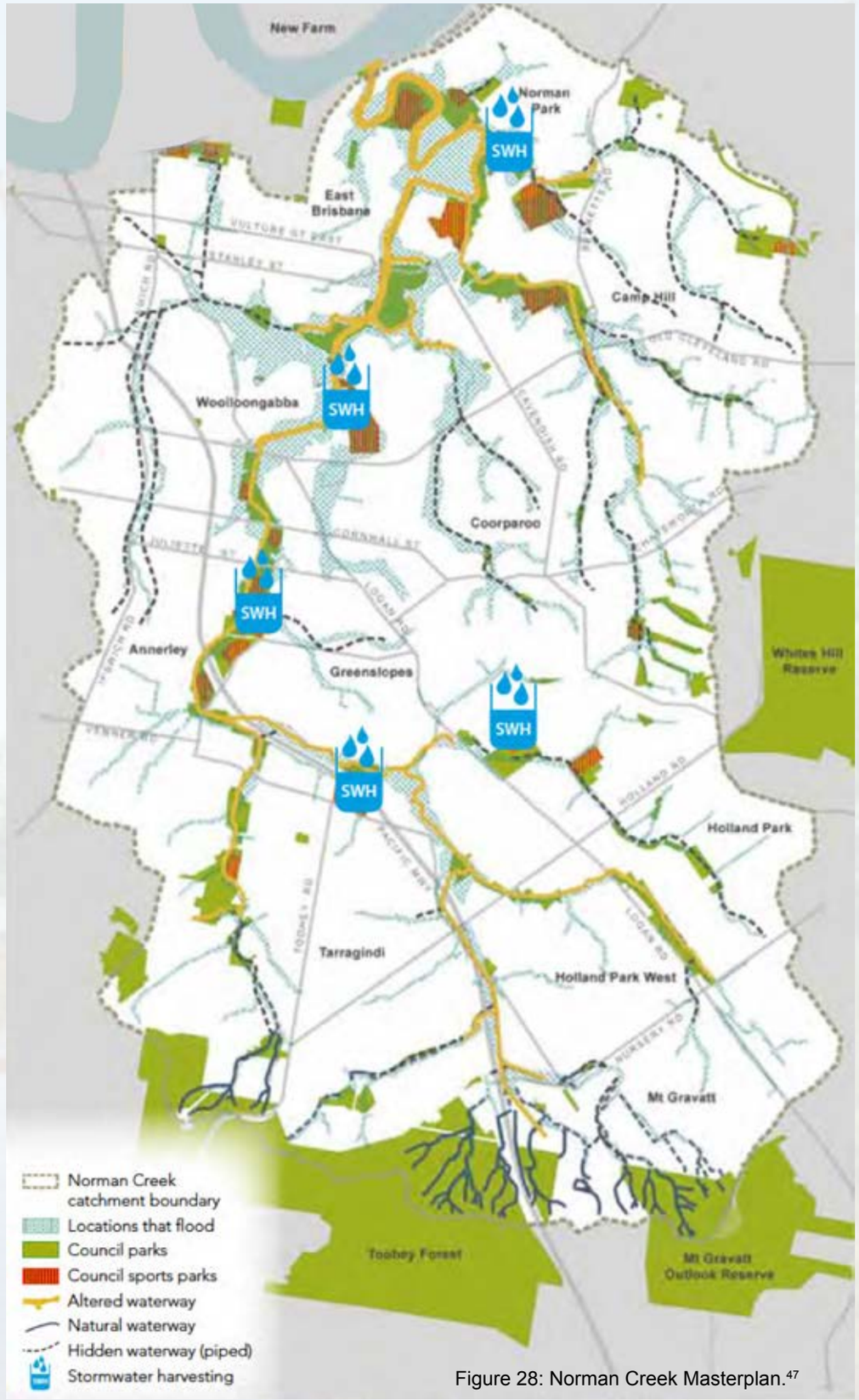
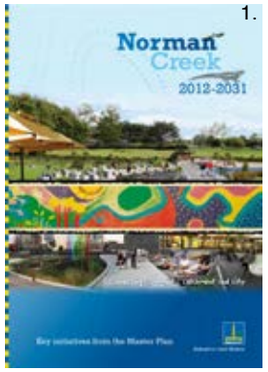


Figure 28: Norman Creek Masterplan.[47]

5. PUBLICATIONS

5.1 PUBLICATIONS ON NORMAN CREEK

1.



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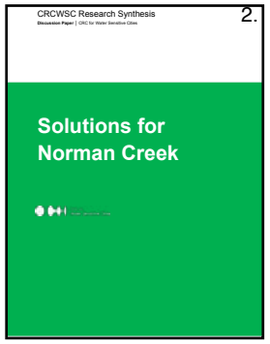


3.

1. Key Initiative of the Norman Creek Masterplan: 2012 -2013[48]

This document describes the key initiatives of the *Norman Creek Masterplan* already being executed, it refers to itself as *"a blueprint to guide long-term investment and coordinate community actions. It shows what is possible and where to focus our efforts"*[49]. This document details the reclamation of riparian zones which have been canalised and covered.

2. Solutions for Norman Creek by the CRCWSC[50]

This document contains *"potential flood resilience initiatives for the Norman Creek catchment in Brisbane... ...It compiles ideas generated by stakeholders during a Norman Creek research synthesis workshop, which was hosted by the Cooperative Research Centre for Water Sensitive Cities and Brisbane City Council."*[51]

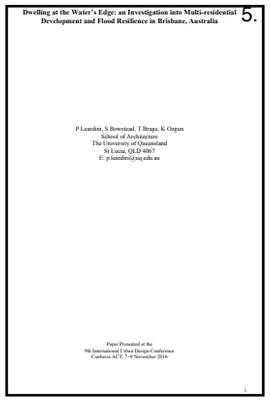
3. Norman Creek Catchment Group[52]

This website is for the Norman Creek Catchment community and contains information on the ecology and history of development in the Norman Creek Catchment. Specifically referenced here are the GIS overlays of historical surveys onto present day satellite imagery, depicting the creek's changes throughout time.

5.2 UNIVSERSITY OF QUEENSLAND'S PUBLICATIONS ON WATER MANAGEMENT IN BRISBANE

4.

5.



6.

4. Amphibious Brisbane: a critical comparison of five post-flood houses in the Brisbane City[53]

This thesis is *"concerned with exploring design strategies that have worked technically, economically and litigiously within their respective flood conditions."*[54]

5. Dwelling at the Water's Edge: an Investigation into Multi-residential Development and Flood Resilience in Brisbane, Australia[55]

"This paper presents a water-potential-mapping methodology that uses Geographic Information Systems (GIS) as a tool to identify new design opportunities in response to Brisbane's increasing population and associated pressure for new urban development."[56]

6. Water-potential-mapping for urban flood/ drought resilience: A holistic approach to sustainable spatial planning and design by augmenting use, reuse and storage capacity of storm water in South East Queensland.[57]

This study aims *"to foster ideas developed and implemented by the SEQ private sector which supports liveable and resilient small-lot infill development."*[58]

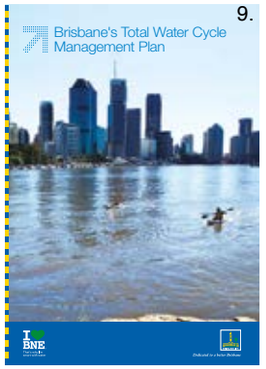
5.3 SUPPORTING EVIDENCE BASED PLANNING

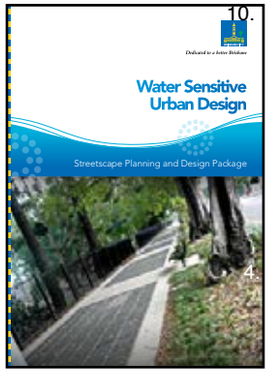
7.

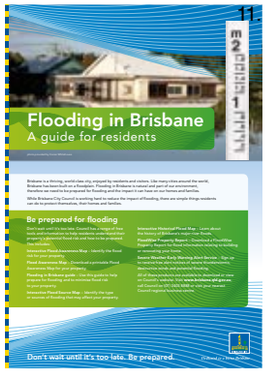
7. Suburban Business Centre Review: Understanding the Role of the Suburban Economy[59]

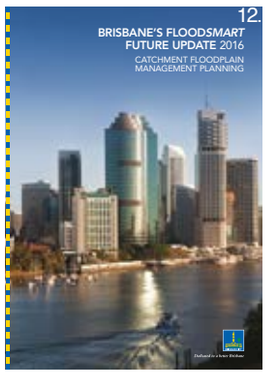
The Suburban Alliance has studied the contribution of suburban economies to regional Queensland. The findings of this study show that despite the state's preference for large-scale infrastructure projects (for example, the CrossRiverRail Project), the business registrations within the suburban business districts have increased dramatically. The same study also highlights the fact that there were a total of 1,276,083 jobs in the Brisbane governorate according to the 2011 census, 52.2% of these jobs were located in suburban areas not identified as business centres.[60] The acknowledgement of Brisbane's rich suburban economy has been a significant driver to the evidence based planning approach documented in section 9.

5.4 BRISBANE CITY COUNCIL PUBLICATIONS ON WATER AND FLOOD.









8. Understanding floods: Questions & Answers.[61]
This document essentially describes how floods occur, and how the state forecasts, broadcasts/ warns of and manages floods.

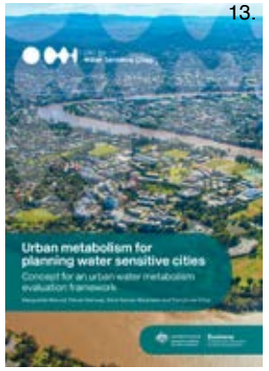
9. Brisbane's Total Water Cycle Management Plan[62]
This is a 20-year implementation plan and framework which guides detailed planning around Brisbane's issues of flood mitigation and flood resilience.[63]

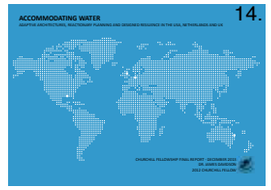
10. Water Sensitive Urban Design: Streetscape Planning and Design Package[64]
A resource designed for civil engineers, landscape architects, urban planners and other professionals seeking guidance on best practice stormwater management techniques.[65]

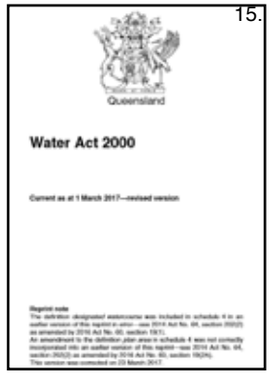
11. Flooding in Brisbane: A guide for residents[66]
This is a public service document detailing how the general public can protect themselves, their homes and their families in times of flood.

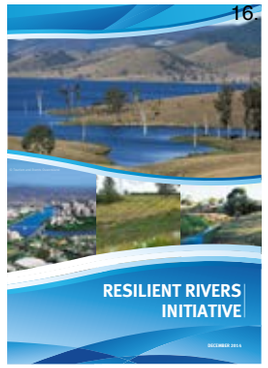
12. Brisbane's Floodsmart Future Update 2016[67]
As an update of *Brisbane's Floodsmart Future Strategy,* this document is based on 4 principles: protecting lives and property, balancing social, economic and environmental objectives, a long-term perspective of flooding and integrated use of the following resources: flood risk management tools, communities and agencies.[68]

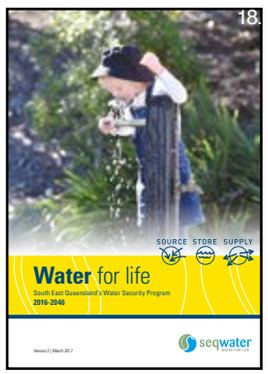
5.5 OTHER PUBLICATIONS ON FLOOD, RESILIENT DESIGN, WATER MANAGEMENT AND / OR THE BRISBANE COMMUNITY.











13. Urban metabolism for planning water sensitive cities.[69]
This document provides an "urban water metabolism evaluation framework, which helps us conceptualise urban water management more holistically and generate information about metabolic efficiencies to inform urban and regional planning."[70]

14. Accommodating Water: Adaptive architectures, reactionary planning and designed resilience in the USA, Netherlands and UK[71]
The international documentation of many case studies which exhibit best practice flood-resilient design principles for mass-produced affordable housing in a range of different contexts.

15. Water Act 2000[72]
The main purposes of this Act is to provide a framework for sustainable management of Queensland's resources, and secure water supply and demand management and the management of impacts on underground water by the exercise of groundwater rights.[73]

16. Resilient Rivers Initiative[74]
This initiative aims to *"improve the health of our waterways and Moreton Bay by delivering more coordinated catchment management to protect our water and keep soil on our land and out of the waterways."*[75]

17. Restoring Ecological Infrastructure for Flood Resilience: The 2011 Southeast Queensland Floods and Beyond[76]
"The basic premise put forward in this (document) is that poor floodplain and environmental management over the past one hundred and fifty years has decreased the environmental resilience of catchments and contributed significantly to the velocity and poor quality of flood waters."[77]

18. Water for life: South East Queensland's Water Security Program[78]
This document *"details the factors... considered to secure South East Queensland's bulk water supply, including our plans for climate extremes."*[79]

6. DIACHRONIC PUBLIC SPACE: PRECEDENTS AND ANALYSIS

Diachronic (adj)
"Of, relating to, or dealing with phenomena as they occur or change over a period of time."[80]
(definition from the Merriam-Webster dictionary)

Diachronic public spaces are those designed to accommodate multiple uses, activities or purposes which change over time. Public space can be generated through a diachronic approach to water management, by shaping places instead of hiding infrastructures. The threat of climate change and extreme weather events brings to question how architecture and urban design can contribute to shaping resilient cities. Meanwhile, in a time of limited funding for public projects, designs that channel alternate sources of capital (infrastructure revenue, capital from selling development) are being sought. In effect, these new typologies are also generating new kinds of public space, which is an important line of investigation for contemporary designers.

6.1 DIACHRONIC PUBLIC SPACE. MAPPING NEW DEVELOPMENTS IN BRISBANE'S FLOODPLAINS

Master of Architecture Research Selective, Sem 2, 2016

(course coordinator: Paola Leardini)

With the aim of analysing the design impact of BCC's policies for flood risk management, selected students of the Master of Architecture Programme at the University of Queensland carried out a comprehensive mapping exercise between July and November 2016. Students surveyed areas of high-density development in Brisbane: West End, South Brisbane, Newstead and Milton to evaluate the provision of public space, ground floor use, street activation and infrastructure, all via the production of maps that illustrate the social and hydrological performance of these diachronic public spaces.

Regulated by the *Development Codes* of the *Brisbane City Plan 2014* and specific *Neighbourhood Plans* (NP), various new residential developments have been built within the study areas since 2011. Interestingly, the purpose of most of these NPs is to guide the transition of the former industrial fabric to medium and high-density residential development, generally emphasising *"site amenity such as deep planting, well-connected and publicly accessible spaces, protection of existing vegetation, landscaping and public art."*[81] Yet, analysis shows that new high-density developments commonly fail to deliver quality public space and amenities.

Figure 29 (opposite page top): New development in Victoria St, West End showing "public" space and the problematic interface with public footpaths[82]

In many cases throughout Brisbane the ground floor is raised on a thick blockwork/concrete podium above the 'defined flood level', having a disconnecting effect between the public and private realms.

Figure 30 (opposite page below): New development in West End, showing carparks under buildings as contributing to an inactive streetscape[83]

6.1.1 CASE STUDIES IN BRISBANE: WEST END

(Students: Yasmin Crawford and Gottlieb Janse van Rensburg)

New high-density development in West End shows lack of quality public space, partially due to the NP's omission of flood resilient design provisions. One of the obvious design consequences of this is the prevalence of carparks and other vehicular areas on the ground floor, with residential spaces sitting above the required *Residential Flood Level* (RFL). This stark separation between private and public realms undermines the potential of high-density development to activate streetscapes through mixed uses requiring ground floor access. With their floor heights set to the *Defined Flood Level* (DFL), commercial spaces in riverfront development cannot be at grade, while carparks occupy street fronts in areas with 10 to 15 storey-high developments. Considering this, outcomes for a *new* master-planned approach of the area are defined, encouraging pedestrian-friendly connections to the river and its adjacent parklands.

Figure 31: Ground Surface Map[84]

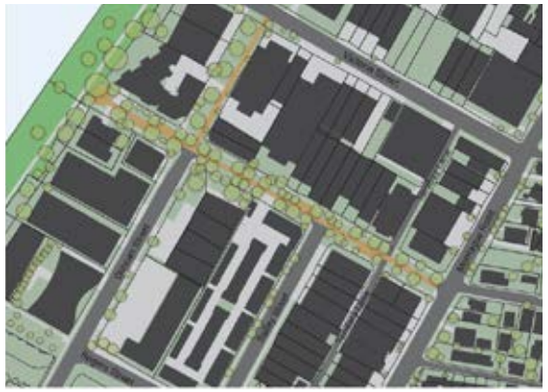


Figure 32: Kurilpa St design proposal masterplan[85]

Figure 33: Kurilpa St & Montague Rd intersection - proposed[86]

6.1.2 CASE STUDIES IN BRISBANE: MILTON

(Students: Laura Ellis and Sarah Batchelor)

New high-density development in Milton presents similar limitations in terms of public space. The suburb is also subject to riverine flooding. The following issues emerged from the site analysis (refer Figure 34):

1. "There are very few permeable surfaces in Milton that are capable of absorbing flash flood and runoff water. The contours also endorse the movement of implementing more permeable surfaces in low lying areas.
2. Park Road and Cribb Street have become high traffic thoroughfares between Milton Road and Coronation Drive. The lack of public space between and around the buildings have created thin sidewalks that need to be much more pedestrian friendly.
3. Park Road is too small for the projected NP development and more public green space needs to be acquired."[87]

Figure 34: Critical analysis of Milton's urban fabric.[88]

Figure 35: Flooding of Milton Road in 2011[89]

Figure 36: Vision for Milton[90]

6.1.3 LOCAL PRECEDENT: SW1 [COX ARCHITECTURE, 2011]

(Students: Jessica Kane and
Bernardo Antonio Ramìrez Fernàndez De Lara)

Cox Architecture's SW1 is, in many regards, a more successful project than those examined in the previous sections. Completed in 2011, this masterplanned precinct presents a variety of flood mitigation solutions, including ample permeable ground surfaces that allow floodwater to seep into the soil rather than contributing to the stress of the existing stormwater system. Permeable urban environments for pedestrian movement promote connection with surrounding urban blocks, while providing protection from the intense vehicular traffic of adjacent roads.[91]

Figure 37 (directly below): Northern Facade of the SW1 Precinct[92]

Figure 38 (far bottom): Northeast corner of the SW1 Precinct[93]

Figure 39 (top left): Site Plan of the SW1 Precinct[94]
The relatively high amount of permeable surfaces in this precinct holds stormwater, reducing stress on stormwater infrastructure and therefore mitigating flash floods.

Figure 40 (top right): Flood Level Overlay on SW1[95]
While much of the site is susceptible to floods, the arrangement of programmes has aimed to protect those who are at most risk (namely residents/residences).

Figure 41 (bottom left) Programmes of the SW1 Precinct[96]

6.2 INTERNATIONAL PRECEDENTS OF FLOOD RESILIENT DESIGN SOLUTIONS.

A number of international case studies provide successful design alternatives to the adverse flood risk policies in Brisbane in relation to floor height, habitable and non-habitable spaces, safe access and escape routes, and neighboring flood impact. Cities in Europe, the US and Asia serve as examples where increased flood resilience not only reduces the physical impact of flood events, but creates public spaces and urban amenity.[97]

Floor Height

New York City Planning has published a series of urban design principles emphasising the need to maintain a liveable streetscape while designing for flood resilience with increased elevation levels, similar to the RFL in Brisbane. In considering the human scale, strategies are proposed to carefully design transitions between levels using stairs, ramps, landscaping and setbacks.[98] In the same vein *Hafen City* in Hamburg mandates that all new buildings stand on artificial “warts” eight meters above sea level, with guidelines on the integration of lower streets and walking levels including infrastructures such as amphitheatres, seating edges and ramps which add to street life.[99] In another case, Parkroyal on Pickering, a hotel by WOHA, in Singapore presents a detailed edge treatment to the building that intentionally designs a three level transition, remarking continuity.

Habitable and non-habitable spaces

Another alternative risk-based strategy is to allow for flexibility in the programming of spaces in areas at risk of flooding, as shown in New York City, Singapore and The Netherlands. This makes an active street level possible while still avoiding sensitive uses and fragile construction and equipment. The adequacy of uses is determined by measuring potential damage to property and safety risks in case of flooding against social as well as economic benefits during the majority of the lifespan of the constructions. In New York City compulsory ground floor[100] activation serves as the clearest counter example to Brisbane´s ground floor neglect, where temporary barriers are permitted in some areas allowing commercial activity on the ground floor. Similarly, street activation is achieved by Singapore’s “void decks”, a standard feature of all high-density public housing developments - in these open ground and intermediate floors activity is not regulated and the space is public, allowing for spontaneous temporary occupation, and therefore encouraging community networking and integration.[101] Dutch examples demonstrate how flexible programming can also be combined with flood mitigation infrastructure giving birth to a hybrid typology, such as the “water square” which serves as a public amphitheatre next to a training school as well as a retention basin.[102]

Neighbouring flood impact

International built examples show how water infrastructure can be included into the urban fabric at the precinct level without compromising the flood resilience of its parts, and increasing its liveability. This is the driver of diachronic public spaces, which serve a social function in times of unexceptional weather but turn into a flood management facility when required. For example, the Dutch water squares have been built to decrease surface water runoff by storing excess rainwater in open sports fields and playgrounds: these are converted into ponds at peak rain times and release water slowly afterwards. The extension of the infrastructure goes beyond the square itself and affects many streets and lots.[103] Houston’s Buffalo Bayou also demonstrates an integrated approach where public parks serve as a network of retention basins allowing development to occur uphill.[104] Similarly, the 7 mile BIG U project for Manhattan uses a series of temporary barriers and berms as an integrated public space infrastructure to protect existing and future New York development from storm surges.[105] [106]

Figure 42 (opposite page): Parkroyal on Pickering, Singapore[107]

Figure 43: The Water Square in Benthemplein, Rotterdam, after a flood event[108]

7. STRATEGY AND VISION

7.1 WORKSHOP 1: SOUTH EAST QUEENSLAND WATERFUTURES

Brisbane 6-10 Aug 2016

UQ School of Architecture and the CRC for Water Sensitive Cities supported James Davidson Architect to convene a five-day workshop investigating holistic and innovative planning approaches to water in the South-East Queensland region.

The initiative brought in facilitators from the USA and the Netherlands who have run similar workshops in New Orleans, St Louis and Rotterdam. Locally, 70 experts from various disciplines in design, planning, engineering and economics contributed to the workshop. The objective was to build on the various post-flood planning and environmental initiatives in a push towards holistic integrated catchment management in the region which will influence urban development, and project SEQ as a true water-sensitive region. The event was also supported by the Flood Community of Practice, Dutch Partners in International Business and Suncorp, who hosted the event. The workshop was joined by Dr Paola Leardini and 25 Master of Architecture students from UQ's School of Architecture (*Design Studio: Dwelling in Future Waterscapes, Sem.2, 2016*), who actively contributed to the debate and used their expertise to visually draw out the discussion between experts.

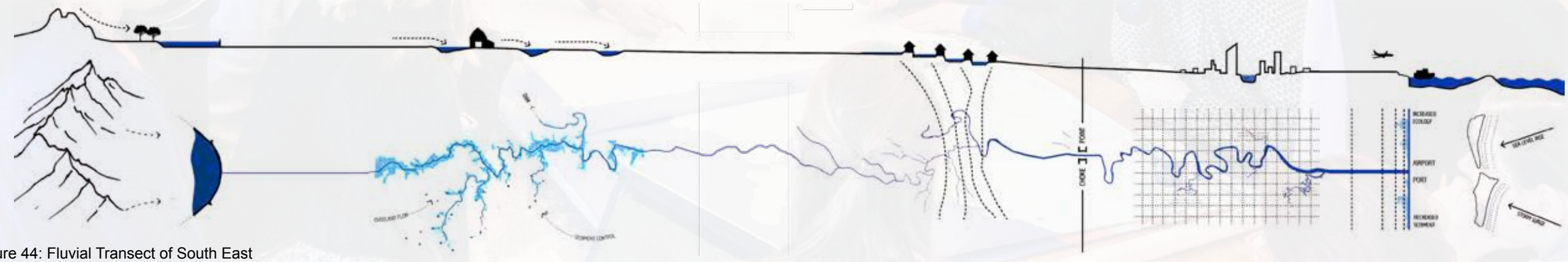


Figure 44: Fluvial Transect of South East Queensland[109]

"Building on the physical properties and community ambitions of the region, the fluvial transect allows water to become a liveability asset, increasing resilience and decreasing risk."[110]

7.1.1 CATCHMENT SCALE

Students and experts worked in four groups at a variety of scales. At the largest scale, students ensured that their schemes not only worked throughout their sub-catchment but also the entire catchment, as well as in synergy with the other charrette/sub-catchment groups. Sub-catchment strategies were developed to respond to both flood and drought via a series of patterned interventions. These interventions acknowledge the reasoning behind status quo developments and hydrological responses to landscape but also sought to improve the current unsustainable traits of such practices.

Figure 45: Sponge Urbanism across SEQ by Charisa Chan Yan Yan, Tammy Junyi Hu and Vismaya Cherian. [111]

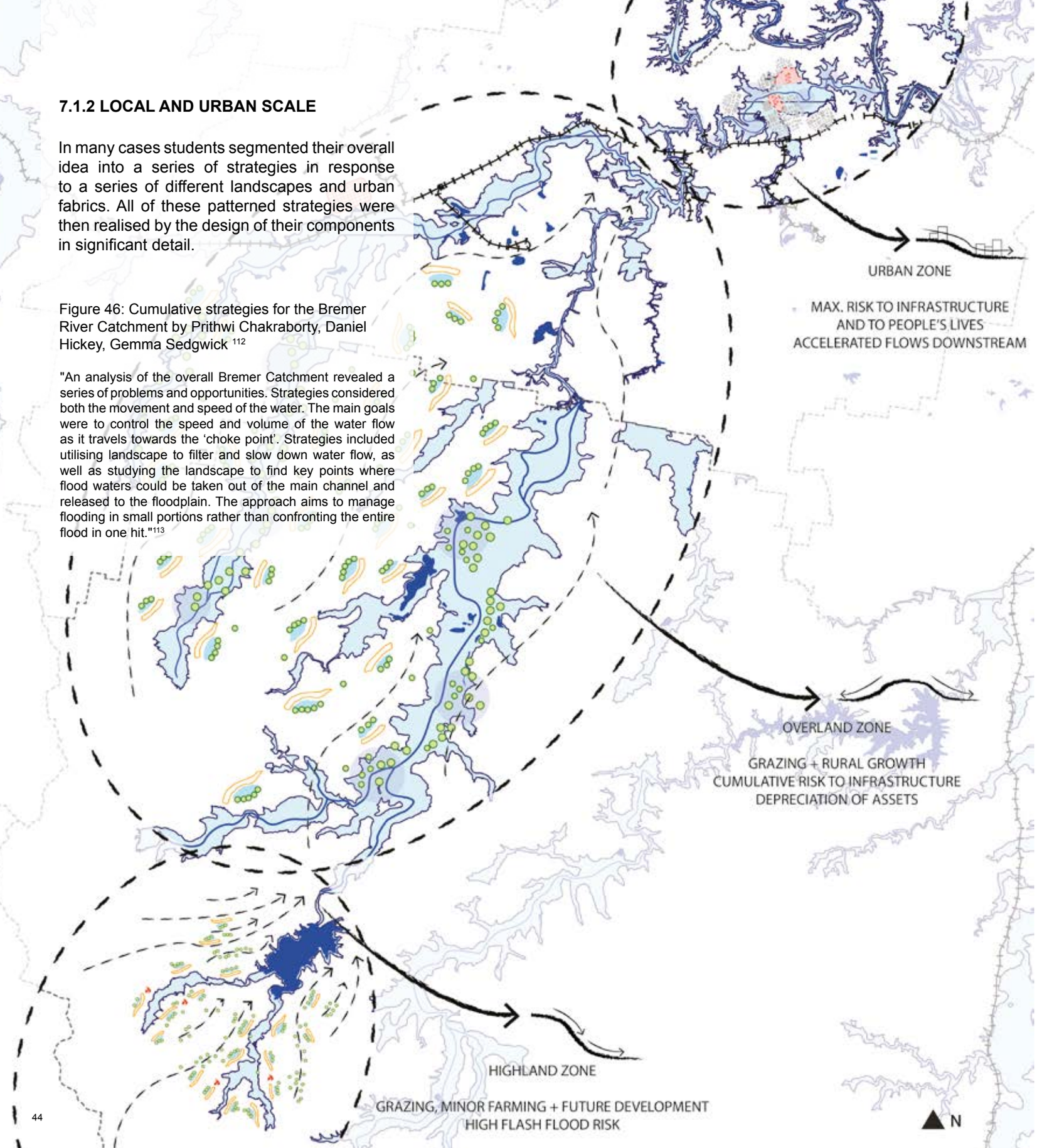
The overarching idea - 'Sponge Urbanism' acknowledged the city's need to respond to both flood and drought. Essentially the city should be able to retain water to be used in dry periods. In absorbing stormwater runoff the interruptions of minor floods which happen at least once a year are mitigated. However in larger events, just like a soaked sponge won't soak water, the city must be able to shed water downstream into the ocean when flooded beyond the capacity of its new blue-green infrastructures.

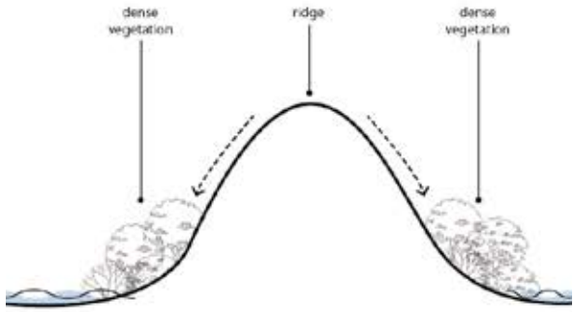
7.1.2 LOCAL AND URBAN SCALE

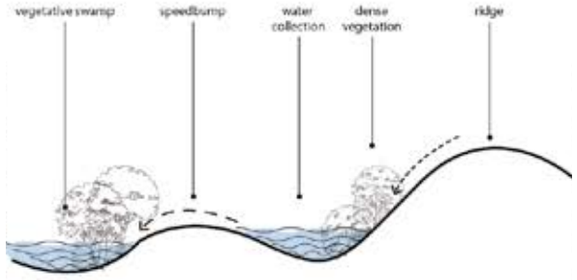
In many cases students segmented their overall idea into a series of strategies in response to a series of different landscapes and urban fabrics. All of these patterned strategies were then realised by the design of their components in significant detail.

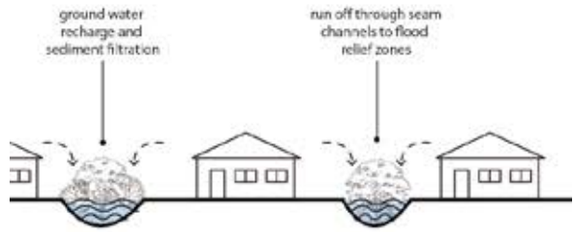
Figure 46: Cumulative strategies for the Bremer River Catchment by Prithwi Chakraborty, Daniel Hickey, Gemma Sedgwick [112]

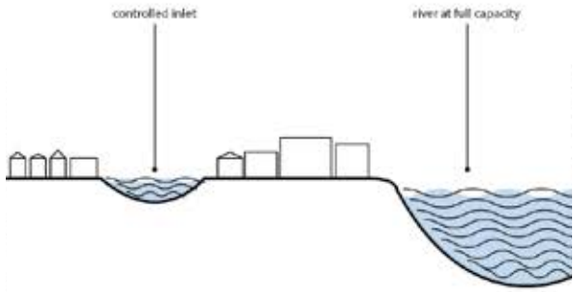
"An analysis of the overall Bremer Catchment revealed a series of problems and opportunities. Strategies considered both the movement and speed of the water. The main goals were to control the speed and volume of the water flow as it travels towards the 'choke point'. Strategies included utilising landscape to filter and slow down water flow, as well as studying the landscape to find key points where flood waters could be taken out of the main channel and released to the floodplain. The approach aims to manage flooding in small portions rather than confronting the entire flood in one hit."[113]











7.2 WORKSHOP 2:
SOLUTIONS FOR NORMAN CREEK

Brisbane 16-17 Aug 2016

The workshop was hosted by the Cooperative Research Centre for Water Sensitive Cities (CRCWSC) and Brisbane City Council. It involved various stakeholders from a variety of disciplines to generate new ideas on potential flood resilient initiatives and solutions for the Norman Creek Catchment.[114]

"The workshop generated ideas and solutions towards a central question: what are the best ways to make Norman Creek and its community flood resilient? To approach this question from a new angle, the workshop engaged with CRCWSC to scope solutions projects that harness the latest water, and sustainable cities research."[115]

The work defined a framework from which a catalogue of economically feasible solutions were developed and tested (Figure 47).

At the urban/precinct scale, solutions incorporated blue-green infrastructure into Norman Creek and its tributaries. These infrastructures do not assume large amounts of privately owned buildings but are instead integrated into the uninhabited riparian zones. These types of solutions would increase ecological quality, provide new recreational areas, improve the groundwater table (mitigating drought), reduce stormwater runoff which contributes to pollution and flash flooding, as well as slow riverine floods of the Brisbane River from travelling upstream the creek (Figure 48).[116]

A catalogue of plans and sections documented how these geographic interventions would simultaneously improve urbanity and hydrology (Figure 49).

… create multiple outcomes: improve liveability, enhance biodiversity and reduce flood risk?	… build flood literacy and a flood resilient community	… make flood resilience commercially attractive and a sought-after outcome by communities	… harness the planning scheme to create flood reliance	… operationalise the aspirations and help Council to deliver them	… make Norman Creek a model for other high density, inner city catchments

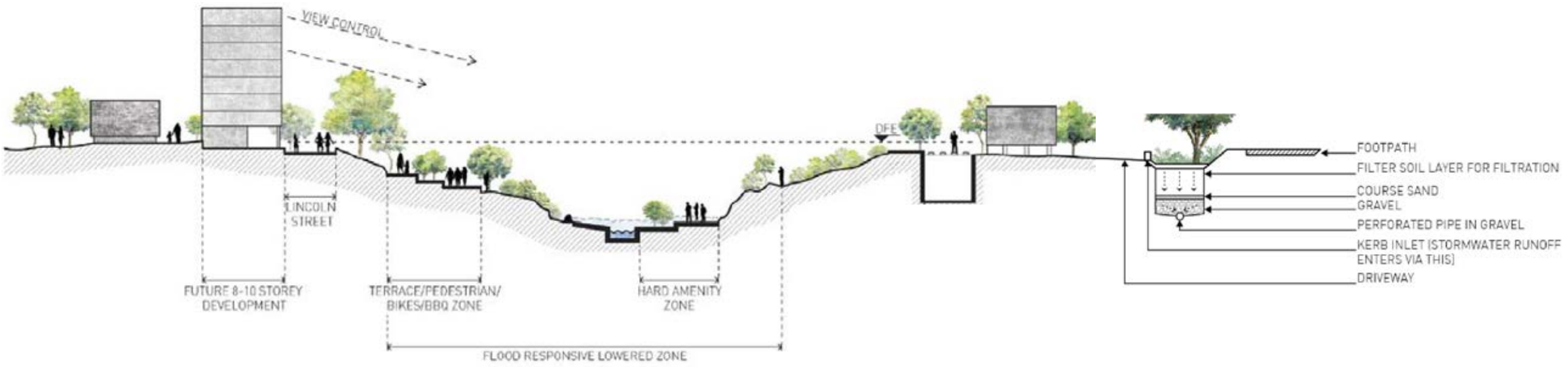


Figure 47 (opposite page, top): The six goals of the workshop[117]

Figure 48 (opposite page, middle): Green-blue infrastructural intervention for Kingfisher Creek[118]

Figure 49 (bottom): Section across Hanlon Park: Infrastructural interventions and scheme.[119]

8. DESIGN SYNTHESIS

DWELLING IN FUTURE WATERSCAPES,
Master of Architectural Design Studio, Sem 2, 2016

(design studio coordinator: Paola Leardini; design tutors: James Davidson and Samuel Bowstead)

8.1 COURSE OUTLINE

This studio used a 'multi-residential cluster on an inner-city flood affected site in Brisbane' to explore the underlying economic, ecological and policy systems of high-density development. Students had undertaken an extensive survey of site constraints, including planning restrictions, flood data and current development characteristics which generated a flood resilient alternative to the status quo, including their informed 'vision' of mixed use and public/open space. The studio started with a 4-day planning and design charrette, which was the key generator of design approaches for the semester. The *SEQ Waterfutures Charrette* brought international facilitators from the USA and Netherlands who have run similar workshops as part of Dutch Dialogues in New Orleans and St Louis, in order to facilitate the generation of urban planning solutions and architectural scale strategies for public space, building codes and infrastructure.

In collaboration with Brisbane City Council and the CRC for Water Sensitive Cities, the studio investigated different flood prone areas within the Norman Creek Catchment. While the existing fabric is mainly made of one or two storey detached houses and isolated examples of 'six-pack' buildings, the current *Neighbourhood Plan* allows new construction up to eight storeys, visioning medium to high density mixed-use precincts. Building in these flood prone areas means rethinking the mutual relationship between landscape and urban fabric, private and public space in the challenging attempt to pursue flood resilience through design at different scales.[120]

8.2 SITE SELECTION

The project sites are located in the Norman Creek's precincts of Woolloongabba, Coorparoo and Stones Corner and feature mixed land use as well as complex green and blue infrastructures.

1. Kingfisher Creek is for the most part canalised and covered. Except for the strip of parks which lie directly over the creek, the area is characterised by industrial developments, raising questions regarding pollution and water quality.

2. The Turbo Drive site occupies a strip of industrial developments that back onto a green strip with a bike path on the riparian edge of Norman Creek.

3. Hanlon Park is set on a drained swamp. Currently adjacent to Stones Corner, this is a well-used green space, surrounded by private land subject to future development. Over the next 20 years, this area is expected to evolve into an exciting 'urban village' with a mix of apartments, offices, shops, cafes and public spaces.[121]

Refer Figure 50 (opposite page): for site locations.

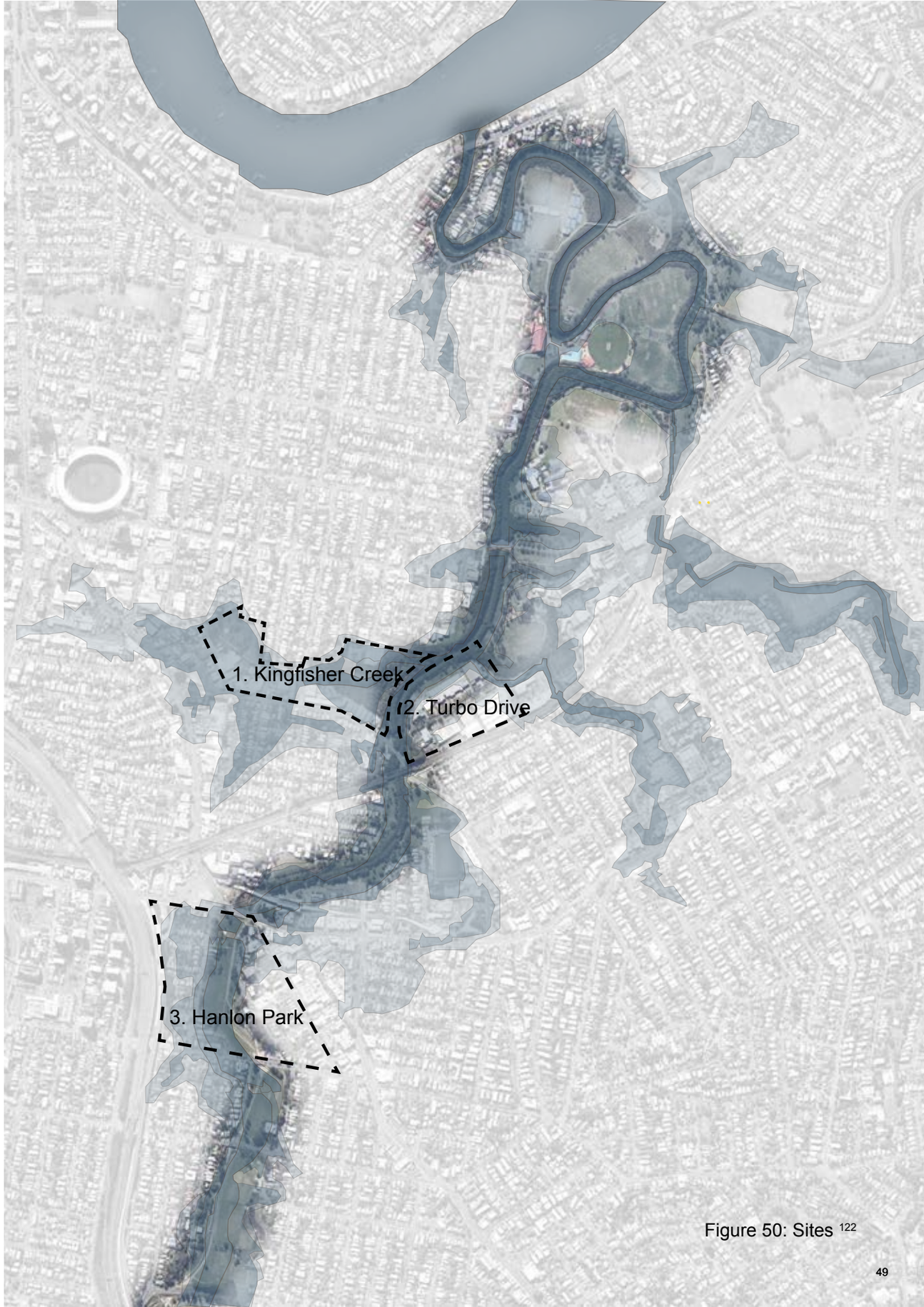
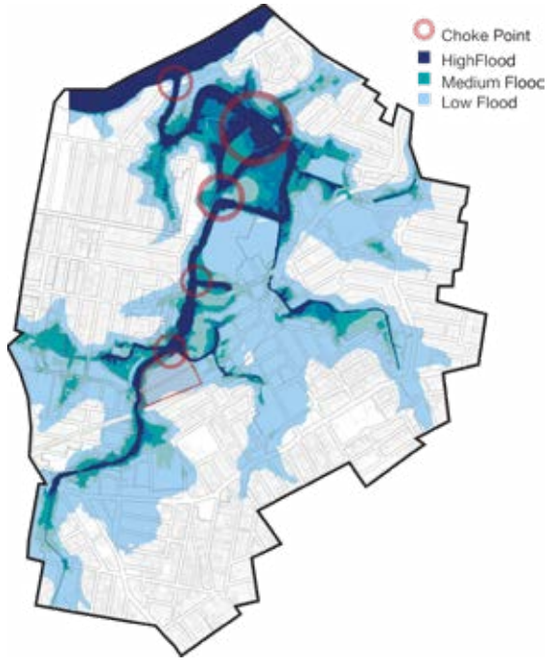


Figure 50: Sites [122]

8.3 SITE ANALYSIS

Before a project strategy could be devised, students comprehensively analysed the Norman Creek Catchment, and the specific sites, building a repertoire of key considerations on the following topics:

- Urban fabric and urban form; how people and water flow through the sites:
- Use of the site and its context: building typologies, arrangements of greenspaces, and densities;
- Key demographics and densities;
- Future prospects, not only of growing populations in South East Queensland but also on the impacts of this growth.



8.4 PHASE 1 - PROJECT STRATEGY

In appreciating that the Norman Creek Catchment is in its urban arrangement and hydrology a microcosm of the Brisbane River Catchment, students innovatively adapted strategies learned during the *SEQ Waterfutures Charrette* in accordance with their analysis of the Norman Creek sites.

In groups of 3, students were assigned a particular site within the Norman Creek area to:

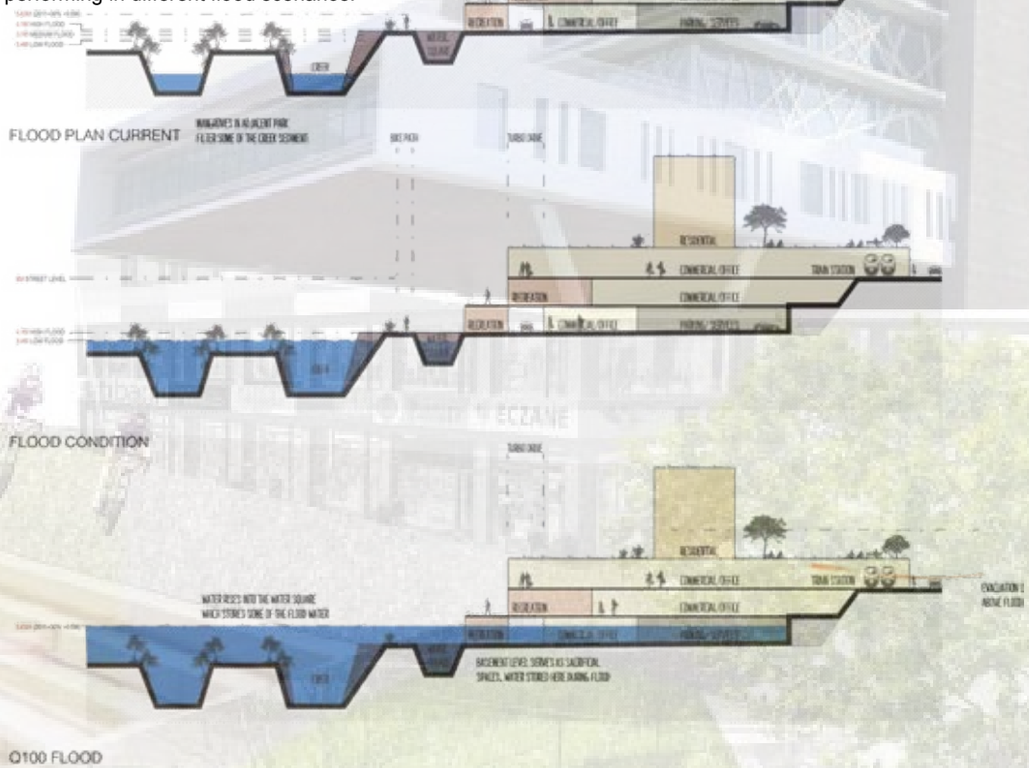
- prepare a relevant catalogue of strategies from the design charrette,
- present a comprehensive site analysis, and
- present conceptual principles and systematic application of identified design strategies across their project site.

Figure 51 (opposite page): 'Choke point' locations by Charisa Chan Yan Yan, Tammy Junyi Hu and Vismaya Cherian.[123]

Identification of 'choke points' which pressure the flood to break its banks.

Figure 52 (below): Strategy for Turbo Drive by Charisa Chan Yan Yan, Tammy Junyi Hu and Vismaya Cherian.[124]

Strategy performing in different flood scenarios.



8.5 PHASE 2 - MASTERPLAN

In groups of 3-4, students investigated site-specific flood issues and identified suitable design strategies through a schematic masterplan for medium to high-density development including mixed-use building clusters and surrounding public spaces for a given site in the Norman Creek Catchment. They identified typologies to be introduced to the assigned flood prone sites based on adjacent urbanities, demographic trends, increasing populations, agriculture and individual aspirations, while acknowledging how (formally) water would interact with their overall proposition. Flood strategies such as 'delay, store, recharge' and 'defend, adapt, retreat' drove design approaches and subsequent masterplans.

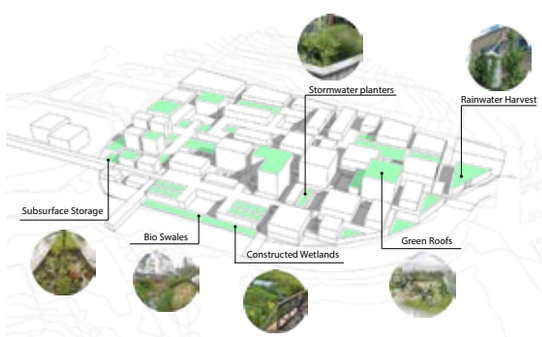


Figure 53: Turbo Drive Masterplan - green infrastructure[125]

Figure 54: Turbo Drive Masterplan - water infrastructure[126]

Figure 55: Turbo Drive Masterplan by Charisa Chan Yan Yan, Tammy Junyi Hu, Jingyi (Erica) Zeng and Vismaya Cherian.[127]

"The project aims to create a resilient community which serves as a transition between the creek, that is nature, and the existing urban grain. The volume is derived from a platform originating at the railway station, which serves as a safe haven above the flood level. The main axes are derived by connecting the existing road networks surrounding the site, filling in the missing links, which also direct the vantage points from the axes towards the creek. In order to retain connectivity between the green and the urban, ‘Urban sponges’ are incorporated which also help to absorb water runoff or in extreme cases, slow down the flow of water."[128]

8.6 PHASE 3/4: CLUSTER AND BUILDING DESIGN

Building on the knowledge and strategies developed in the previous assignments, in these final design phases students individually developed a schematic design proposal for medium to high-density development including a mixed-use building cluster (up to 10,000m²) and surrounding public spaces for a selected area within the given site. In considering Brisbane's ever more problematic centralisation, infill development and increasing densities on floodplains, students developed flood resilient medium to high-density mixed-use projects, aiming for new holistic types of urbanities and architectures.

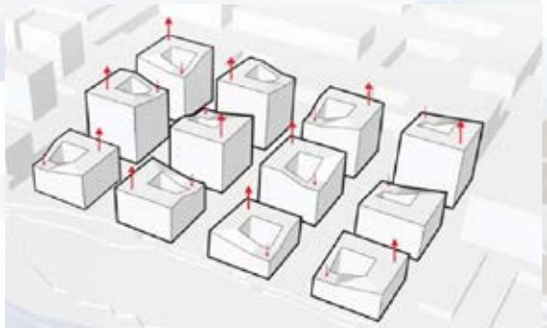


Figure 56: Creating dynamic roof form.[129]

Figure 57: Rooftop as water capacitative skywalk.[130]

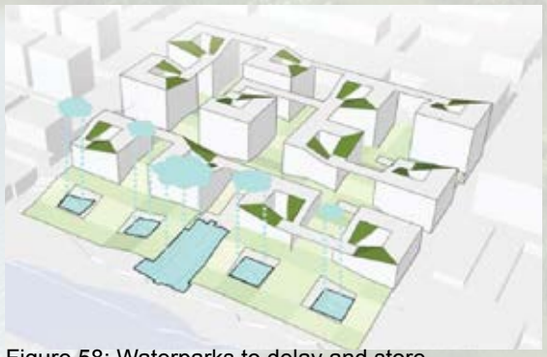


Figure 58: Waterparks to delay and store floodwaters.[131]

Figure 59: Design for an Aging Population by Charisa Chan.[132]

This housing design is purposely developed to create a community lifestyle that will encourage a sense of belonging and engagement between the younger population and the elderly. The idea of turning circulation to destination and creating more public space for the community shapes the entire design. Taking into consideration that the site is adjacent to the creek and at risk of flooding, a good water management strategy is also paramount. The design provides 'creative' urban water management solutions that go beyond protecting lives and property: the goal is to create attractive places for people.[133]

8.7 SITE 1: KINGFISHER CREEK CLUSTER PROPOSALS

Figure 60: The buried Kingfisher Creek.[134]

Figure 61: Flooding of park over creek.[135]

Aggregate Aggregate
Jonus Darr

Aggregate Aggregate is a design that reconsiders the programmatic relationships within urban environments. From the critique of the status quo's unsustainable and growingly unliveable civic system a new kind of urbanity has been developed. This solution is an aggregated urbanity that includes programmes of residence, agriculture, industry, commerce, recreation and parkland.

Kingfisher Grove
Jenny Stedman

This project is a collection of dual-use spaces by way of aggregating issues of the city and turning them to our advantage; integrating recreation and amenities with flood mitigation and a need for urban agriculture.

Green Steps
Michael Pradella

The tiered structure of the residences is achieved by utilising a portion of the unit below to create the terrace spaces. In this manner, each unit has an optimum northeast orientation with ample outdoor space. Each terrace provides large planter boxes and trellis structures, to support growing green screens and any small plants/vegetables the tenant desires.

The Market [Food Bowl]
Phoebe Lau

The Market is responsible for providing a space for locals and visitors from surrounding areas to purchase fresh fruit and vegetables that are produced from on-site farms. It is also a priority to retain some of the current local industries. The aim is to not lose the original meandering quality and character of the site.

In the Green Loop
Morgan Liu

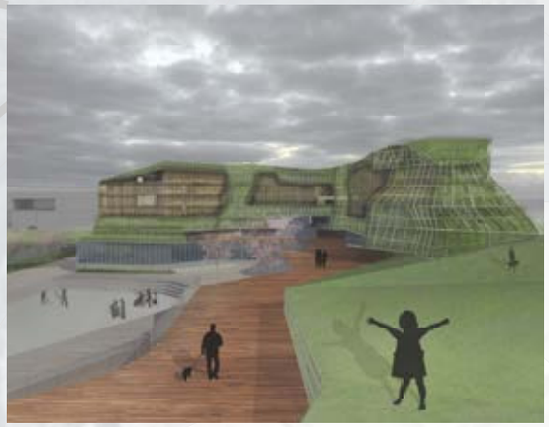
The concept behind the proposed living community is to create an experiential learning environment to teach the residents the importance of sustainable living and water management. Located off a creek overspill zone, the cluster takes advantage of the restored riparian zones along the creek to create a series of bio-detention basins that will both act as a flood defence and a natural park.

Prospect Village
Laura Ellis

Prospect Village's high-density micro-housing responds to the inhabitant's lifestyle and allows for flexibility (growth / downsizing), personalisation (hobbies, careers, interests), and socialisation (connectedness, community, relationships). The building facade is a multi-functional screen used for privacy, balcony drainage, infrastructure, trellis, and a balustrade guardrail.

Living Structure
Hannah Renshaw

The Living Structure provides apartments within the community zone of the Kingfisher Creek Master Plan with a design solution that aims to incorporate the three things humans need to live: water, clean air and food. The green spine that structures the entire masterplan connects to the cluster form, wrapping itself around the watersquare and wetland.



8.7.1: CLUSTER PROPOSAL EXAMPLE: AGGREGATE AGGREGATE

(Student: Jonus Darr)

In critique of the status quo's unsustainable and growingly unliveable civic system a new kind of urbanity has been developed. This solution is an aggregated urbanity that includes programmes of residence, agriculture, industry, commerce, recreation and parkland. By localising these programmes into a multi-use development, a variety of benefits can be achieved; space is saved, roads become relatively obsolete, the functioning of the city, its industries and those who run them become transparent and communities are strengthened through their newfound independence.[136]

Figures 62 (background): Project in fine weather.[137]
The strategy to delay, store and recharge creek water has improved its quality, and reduced its salinity so that it may be used for recreation and agriculture.

Figure 63 (below): Project in nuisance flood event.[138]
Permeable paved surfaces and detention basins which surround the creek reduce stormwater runoff.

Figures 64 (bottom): Project in Q500 flood event.[139]
In this event residential developments are safe from flood and the main arterial road which connects the projects to the city's grid are still useable for emergency vehicles and rescues.

8.7.2: KINGFISHER CREEK CLUSTER PROPOSAL EXAMPLE: IN THE GREEN LOOP

(Student: Morgan Liu)

The concept behind the proposed living community is to create an experiential learning environment to teach the residents the importance of sustainable living and water management. Located off a creek overspill zone, the cluster takes advantage of the restored riparian zones along the creek to create a series of bio-retention basins that will both act as a flood defence and a natural park. Recreational squares that double as water detention devices are then located off the constructed wetlands to take in excess floodwater in extreme flood events. Residential and commercial functions are then planned around the detention basins creating a central public square where the main public activities will occur in support of the medium density residential blocks on the upper floors.[140]

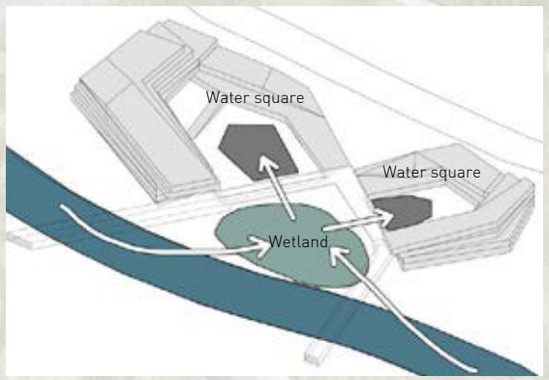
Figures 65: Perspective of scheme (background)[141]:

Figures 66: Creek spill zones (far left)[142]:

Bio-detention basins are designed in the main creek 'spill zone' and act as a first defence for minor floods. Water squares are created off the constructed wetlands to take in fluvial and stormwater in a major flood.

Figures 67: Stormwater collection (centre right)[143]:

The roof garden and terraces are to retain and delay water flow into the water square in an extreme rain event. The flow of stormwater is then directed to a collection point at the bottom of the roofs at the upper ground level and a small water park is created in the plaza facing the existing neighbourhood.



8.8 SITE 2: TURBO DRIVE CLUSTER PROPOSALS

Figure 68: Floodplain riparian.[144]

Figure 69: Industry buildings on a floodplain.[145]

Design for an Ageing Population
Charisa Chan

The number of adults 65 year old and older in Australia will double over the next 25 years. This housing design is purposely developed to create a community lifestyle that will encourage a sense of belonging and interaction between different age demographics.

The Growing Platform
Vismaya Cherian

The design is developed around the idea of a raised platform which aims to create a safe and sustainable community. Residential blocks and public space are both generated by additions to and subtractions from the platform, which defines the safe level according to the predicted future flood levels for the site.

Safety Platform
Tammy Hu

The proposed scheme implements the concept of ‘sponge urbanism’, and a water storage and release system to adapt to the future. The site has been developed in a three dimensional perspective, which facilitates urban farming, hydroponic green houses, community gatherings and the integration of work and life.

Housing Stack
Jingyi (Erica) Zeng

The project is shaped as a stack of wood-clad units that are designed to harmonise with the specific environmental context of Turbo Drive and Norman Creek. The buildings generate the feeling of a small community, bringing many opportunities for 'street scale' interaction. The project updates the relationship between private units and public space and generates a sense of movement and permeability.

Borrowed Living
Rosaria Cho

For Turbo Drive, the term ‘density’ is understood by one phrase: “successful density is about sharing”. The design aims to push the boundaries of shared living, introducing ideas of ‘borrowed living’ while educating the public about alternate living, all in order to fulfil a vision for a more ecological and sustainable future.

Multigenerational Urban Living
Poorvi Mehrotra

The proposed building cluster envisions the next generation of apartment living for families, accommodating both youth and elderly. Blending multi-generational housing with urban farming, this innovative living model integrates on-site farming with mixed-use facilities and high-density housing.

Doing Diversity Together
Peter Edwards

The waterfront is kept open for public thoroughfare, with an ampitheatre constituting the main architectural intervention along the water’s edge. Access is raised well above the waterline to prevent regular disruptions from flash flooding. The residential scheme is raised atop a podium above the longterm range of projected flooding, with carparking beneath.

8.8.1: CLUSTER PROPOSAL EXAMPLE: BORROWED LIVING

Student: Rosaria Cho

The Turbo Drive site is at risk of flooding, regardless of how heavy the rainfall. Furthermore, in the past it has been susceptible to drying out, making the area an unattractive area for residential living. However, the project recognises the site's potential to be a place for 'creek density', whereby the creek, the green spaces and proximity to the city become assets to a future high density development. Turbo Drive's most central cluster envisions a precinct where the ambitions of future generations to create environmental change through alternative living strategies are encompassed and designed for.

Located in the centre of the precinct, the cluster is designed to publicly portray the ambitious lifestyles in which the Turbo Drive Masterplan encourages residents to live. Acting as the 'public face', the building intentionally blurs the boundaries between public and semi-private. In this way the building allows for the public to learn about the Norman Creek vision through interaction with the building and its residents.[146]

Figure 70: Perspective from Norman Creek (background)[147] and Figure 71: Exploded axonometric (bottom right)[148]:

The levels of public and private spaces become more complex and interesting with the concept of sharing. As the public cluster within the masterplan, areas in the building are intentionally mixed to allow for resident and public interaction. Ideas of the 'lounge corridor' are explored as spaces for residents to borrow, or share for living, studying or working. These mixed areas are arranged vertically so that the most vulnerable building typologies are protected from flood.

8.9 SITE 3: HANLON PARK CLUSTER PROPOSALS

Figure 72: Stormwater infrastructure.[149]

Figure 73: Stormwater infrastructure after flooding.[150]

Adaptable Landscapes
Samara Webster

Located on low-lying land adjacent Norman Creek, the cluster layers a series of flood strategies to ensure the buildings are still useable and mitigate floodwaters in surrounding areas during an event. This unique residential living model blends the two hard conditions on either end of the site through folding the surrounding landscape to create intriguing pockets of space.

Hanlon's Edge
by Isaac Vincent

The shapes of the buildings are derived from site-specific factors that include contours, adjacent green fingers, cross-site circulation and public courtyard spaces. Flood risk and the movement of water during periods of heavy rain are also major considerations in the form of the cluster.

rEvolve
Sarah Batchelor

rEVOLVE displays resilient design through the overarching ambition of the masterplan carried through into the building scale, complete with internal swales at ground level, which extend up into the building as green voids.

Market²
by Laura Zumbo

Adjacent to an urban agriculture hub, the project acts as a destination for education, living and playing. The underlying concept of the design is to connect residents to green spaces and the new marketplace, which is an adaptable space aiming to educate inner-city dwellers about agriculture and sustainable living.

Healthy Community, Healthy People
Daniel Hickey

The northern sector of the Hanlon Park master plan is the focus of this design. The vision is to create a vibrant, healthy community, which is sustainable and thoughtful to its public context, as well as resilient to environmental threats. These goals will be achieved through designing an innovative residential typology, and shared public space between formal programmes.

Life by the creek
by Shuai He

This design meets the needs of contemporary and future society and simultaneously responds to issues of shared living and individuality by offering a multiplicity of indoor/outdoor spaces that are specific to the site. The residential cluster is a vibrant interconnected network of living and communal spaces integrated with the natural environment.

Morphological Landscapes
by Prithwi Chakraborty

As the design is located on the highest point of the site along the park, it is able to critically deal with water run-off through the sloping nature of the landscape. Timber based residential blocks are grown from the mounds, evoking the idea of natural growth and extension from the landscape, one that contributes to building a positive, sustainable and flood resistant future for Brisbane.

Higher Ground
Gemma Sedgwick

The driving design objective was to reinterpret the conventional horizontal platform with a focus on adaptable flood techniques, high density living and prioritising green space. The design process was methodical in nature, manipulating the form to achieve specific functions and experiences.

8.9.1: CLUSTER PROPOSAL EXAMPLE: MORPHOLOGICAL LANDSCAPES

(Student: Prithwi Chakraborty)

The design is derived from the original master planning concept of incorporating the idea of platforms – a direct response to dealing with the heavy flooding conditions across the Hanlon Park site. However, this ideology is enhanced further by sloping the platform into a mound, one that is heavily integrated with the surrounding natural terrain. As the design is located on the highest point of the site, it is able to critically deal with water run-off through the sloping nature of the landscape. From this, timber based residential blocks are grown from the mounds, evoking the idea of natural growth and extension from the landscape, one that contributes to building a positive, sustainable and flood resistant future for Brisbane.[151]

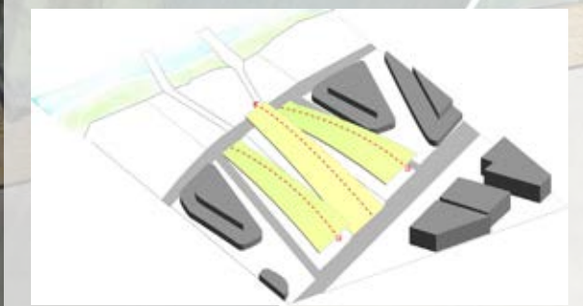
Figure 74 (Background): Perspective view of project from Norman Creek.[152]

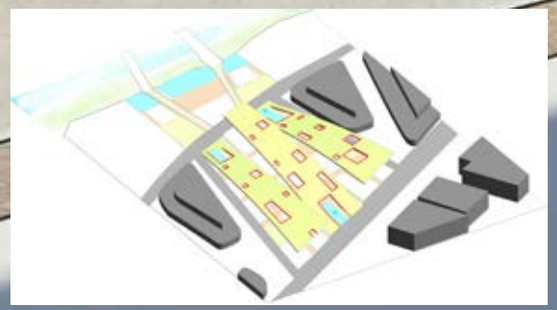
Figures 75 (far left)[153]:
A flood resilient platform is divided by two streets as per the Hanlon Park Masterplan. The resultant three forms are morphed to connect to the ground plain.

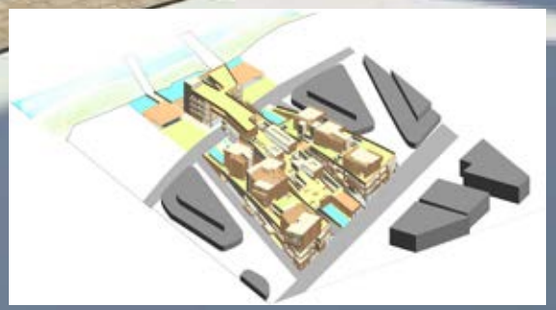
Figures 76 (centre left)[154]:
Stormwater retention pools and underground water storage tanks beneath the social courtyards mitigate flash flooding and provide water for the residents in the project.

Figures 77 (centre right)[155]:
These retention ponds also create 'valleys' in the 'morphological landscape' so that water can be enjoyed as part of the public space that this development provides.

Figures 78 (centre right)[156]:
While commercial and workshop programmes are housed within the created 'morphological landscape' high-density residential typologies sit on-top, well away from almost any flood.







9. EVIDENCE BASED PLANNING

9.1 CRITICAL GIS (GEOGRAPHIC INFORMATION SYSTEMS) AND CARTOGRAPHIC LANDSCAPES

Master of Architecture Research Selective, Sem 1, 2017

(course coordinators: Antony Moulis and Kaan Ozgun)

University of Queensland's post-graduate architecture students employed Geographic Information Systems (GIS) tools to analyse society, urbanity, hydrology and the topography of the Norman Creek Catchment. Socio-economic analysis drove the identification of key 'hotspots' where green-blue infrastructure would thrive. The outcome of this research subject called *Critical GIS and Cartographic Landscapes: Spatial thinking, data and design* will lay advanced analyses as the ground work for future design investigation.

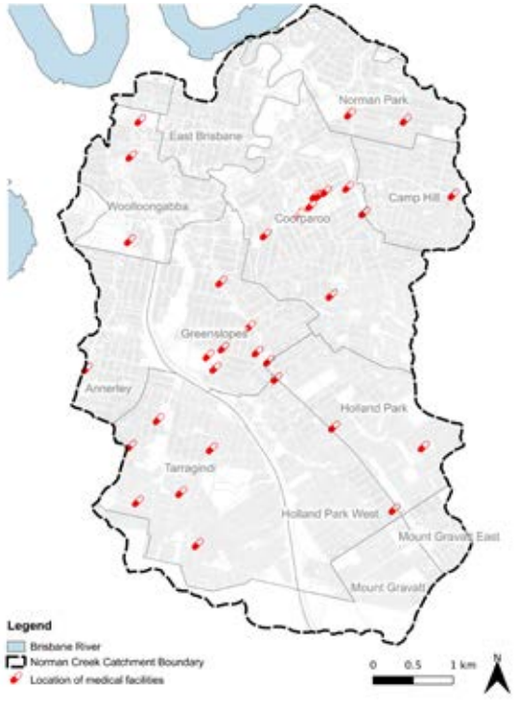


Figure 79: Public transport stops in the Norman Creek Catchment. Map by Callum Gordon.[157]

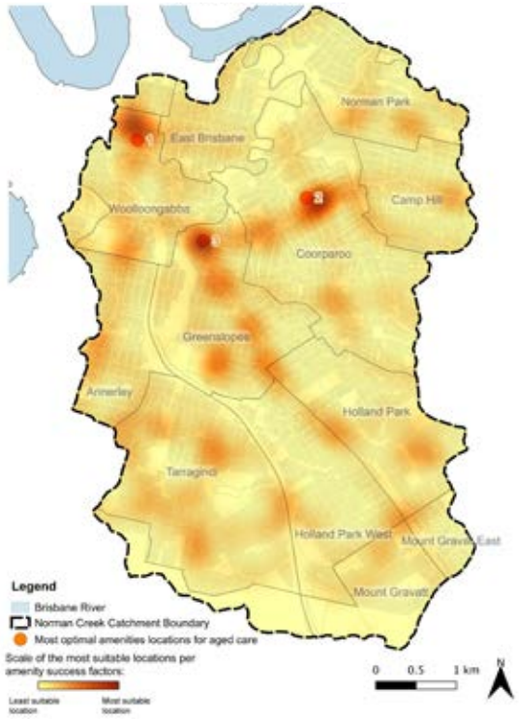
Figure 80: Retail places in the Norman Creek Catchment. Map by Callum Gordon.[158]

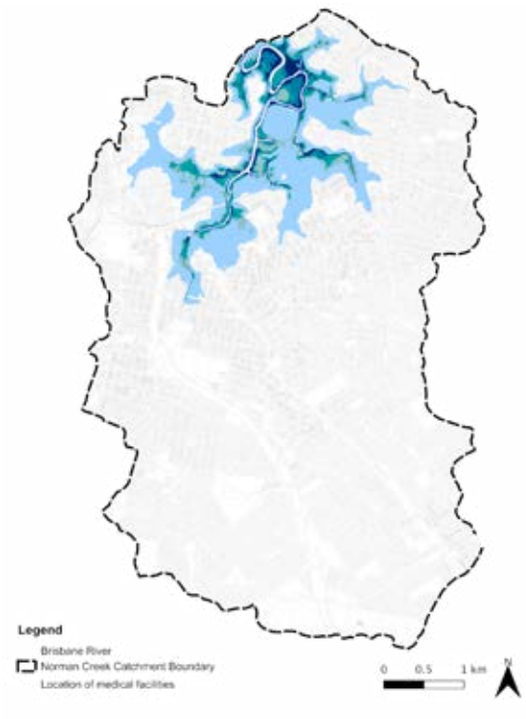
Figure 81: Health services places in the Norman Creek Catchment. Map by Callum Gordon.[159]

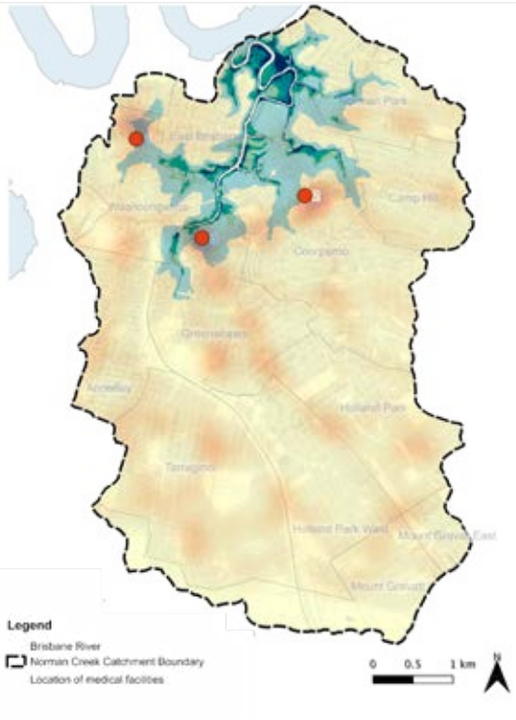
Figure 82: Hotspots were then developed in areas with reasonable access to health services, retail and public transport stops. These three hotspots, called out of a heat map indicate the best locations for residential aged care and housing for the disabled. Map by Callum Gordon.[160]

Figure 83: Flood overlay code.[161]

Figure 84: The hotspots found by spatially correlating the needs of certain demographics are on flood prone land. Therefore, projects situated in ideal locations to service target demographics will need to also integrate flood resilient design.[162]







10. DESIGN EXHIBITIONS

10.1 CREEK URBANISM

The work of the 24 *Dwelling in Future Waterscapes* students reunited the professionals of the CRCWSC and the Norman Creek Community in an open invitation exhibit, held in the very room which hosted the *Southeast Queensland Waterfutures Design Charrette* 5 months earlier.

Figure 85: Photo from *Creek Urbanism* exhibition.[163]

10.2 DWELLING IN FUTURE WATERSCAPES

At the end of Semester 2, 2016 the work of the students was exhibited at the University of Queensland's end-of-year design exhibition - *eMbARCH*. This exhibition is "the most important event in the School's yearly calender, bringing together students, practitioners and academic staff. It provides an opportunity for the Brisbane architectural community to review the work of our graduates in an atmosphere of celebration."[164]

Figure 86-88: Photos from *eMbARCH*[165]

11. WHERE TO NEXT?

This document summarises the multifaceted activities carried out by researchers of UQ School of Architecture, and a number of students involved in the courses they ran in the last eighteen months, all in contribution to the *CRCWSC Program D5.1*. Working collaboratively with BCC on the Norman Creek Catchment – with a focus on pockets of land where green and blue infrastructures meet future medium to high-density developments. This first research stage generated site-specific analytical data together with globally applicable novel methodological approaches. The concept of Evidence Based Planning will inform the next stage, starting in semester 2, 2017, where planning and design methods will be refined to finally connect quantitative analytical tools to creative processes, at both district and building scale. This phase will involve an architectural design studio with Masters students, who will implement tools and ideas to identified "hotspots" within the catchment, with the aim of improving and testing the design method, and producing novel spatial types through design-based research. A public exhibition and a final document will record the design speculations from the studio as well as summarise the entire research journey and its outcomes.

11.1 METALAB,

Master of Architecture Design Studio, Sem 2, 2017

(design studio coordinator: Paola Leardini)

"*A sustainable and resilient future for a city based on one or more (interconnected) Urban Metabolisms is not the result of a single explorative journey but involves the continuous ability to innovate and maintain the capacity for adaptive governance processes to both 'hard' and 'soft' urban disturbances, and to do so by a continuous change of its urban fractals and within these, its smaller components.*"[166]

The *METALAB* design studio looks into the future of Brisbane's medium to high-density built environment, with a strong focus on environmental and social sustainability of responsive spaces and artefacts.

The design investigation will stem from the concept of *Urban Metabolism*, which, looking at the city as a living organism, allows understanding and modelling multiple flows (water, energy, food, and people) as well as information of urban complex systems and their parts. It will interrogate the evolving concept of responsive architecture at different spatial and semantic scales - from the macro scale of the "urban fractal"[167], "integrated neighbourhood"[168] and "pocket neighbourhood"[169], to the micro scale of augmented spaces within buildings.

The first explorative part of the design studio, leading to the definition of individual "pocket neighbourhood's" (clusters of dwellings gathered around a commons) within the Norman Creek Catchment, will include critical reading, background research, site analysis, technology documentation and data gathering. Thematic workshops with experts and local community will help students conceive and design their fractal metabolic systems for circular management of resources.

The final design will unpack the spatial quality of the commons as a social catalyst and shape the proposal for an interpretive centre, where environmental data from the sustainable urban fractal is processed and displayed through responsive or augmented environments.

UQ's School of Architecture is part of an ongoing investigation on water resilience in Brisbane City. Through this studio and allied events within the Cooperative Research Centre for Water Sensitive Cities, students will participate in design-led research generating spatial propositions of diachronic public space and resilient architecture, critically evaluating their social and environmental viability and validity in future high-density urban areas.

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CRCWSC D5.1 Project
Norman Creek Design Investigation
Paola Leardini (research coordinator), Antony Moulis, Kaan Ozgun

Southeast Queensland Waterfutures Charrette
James Davidson Architects (conveyor), Sam Bowstead, Piet Filet
John Hoal, Derek Hoeferlin, Tijs van Loon (International facilitators)

CRCWSC Research Synthesis: Solutions for Norman Creek
Water Sensitive Cities (moderator: Jamie Ewert)
Brisbane City Council

Dwelling in Future Floodscapes - Design Studio
Paola Leardini (course coordinator), James Davidson, Sam Bowstead
Guest Lecturers:
Nick Morgan (Brisbane City Council)
Tijs van Loon (Bosch Slabber)
Cathryn Chatburn (Urban Enquiry)
Peter Kearney (Cityfood Growers)

Diachronic Public Spaces - Research Selective
Paola Leardini (course coordinator)

Critical GIS(Geographical Information Systems) and Cartographic Landscapes - Research Selective
Kaan Ozgun, Antony Moulis (course coordinators)

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