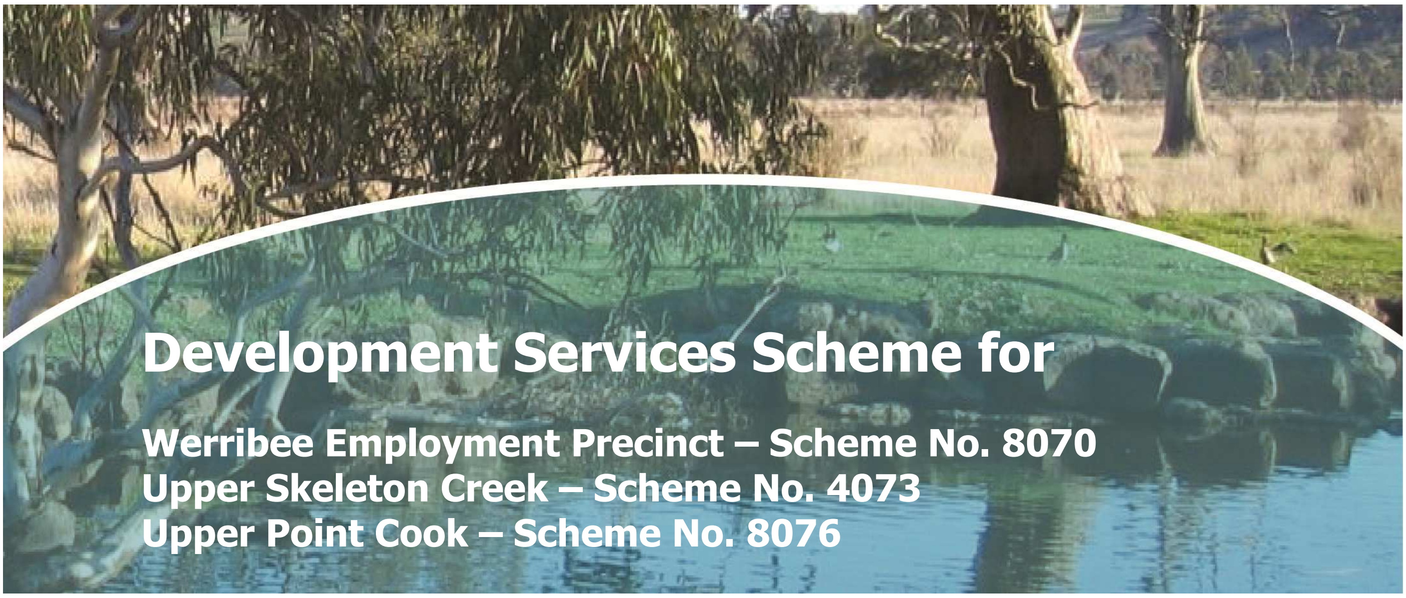

# Development Services Scheme for

## Werribee Employment Precinct – Scheme No. 8070
## Upper Skeleton Creek – Scheme No. 4073
## Upper Point Cook – Scheme No. 8076

**18 February 2011**

**Version 4**


50 Hoddle Street

Abbotsford, Victoria 3067

Telephone: 03 9418 4000

Facsimile: 03 9418 4001



www.bonacciwater.com

**Authors**: Dr. Peter Coombes, Mark Colgate, Nick Ronan and Simon Want

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Sue Holiday: Chair of the Built Environment Industry Innovation Council

Mike Waller: Chair of Sustainability Victoria

Craig Cook: Public finance advisor

Mike Day: Urban Planner – founding partner of Roberts Day

**Version Control**

| Version | Date | Comment |
|---|---|---|
| 1 | 4/09/2010 | Preliminary draft reports for discussion and review |
| 2 | 8/10/2010 | Draft final report for discussion |
| 3 | 14/10/2010 | Draft final report with inclusions from DPCD |
| 4 | 18/02/2011 | DSS Numbers Issued by MWC |

**Bonacci Water's Due Diligence**

**Purpose of the report**

This report sets out the essential requirements for stormwater-related works and infrastructure in the Werribee Employment Precinct to implement the Integrated Water Cycle Management strategy by Bonacci Water with the Multi-Agency Working Group for the Department of Planning and Community Development in 2010.

**Accuracy and Reliability of the Information**

Bonacci Water has used the best available information relating to:

- Detailed forensic inspection of the study area and checking dimensions of all existing stormwater infrastructure
- Ground survey records and as-constructed drawings from the City of Wyndham, Melbourne Water and other organisations
- High resolution LIDAR data from Melbourne Water
- Long term rainfall records from the Commonwealth Bureau of Meteorology
- High-resolution hydrologic and hydraulic models

Except as stated in the report, Bonacci has not verified the accuracy or completeness of the information received, and will not be liable for any discrepancies arising from such inaccuracy.

***Intellectual property***



***Authorisation***

Report prepared by Dr Peter Coombes, Mark Colegate and Simon Want

Signed ..............................

Modeling and designs by Mark Colegate and Dr Peter Coombes:

Signed ..............................

Scientific development and project management by Dr Peter Coombes

Signed ..............................

# Contents

# Executive Summary

## Key findings

- The site is currently subject to large pollutant loads and extents of flooding that are generated from upstream catchments.
- An integrated water cycle management (IWCM) strategy has been proposed to service the proposed Werribee Employment Precinct. The strategy provides for net self sufficiency for water and sewage services whilst mitigating the current stormwater management challenges.
- This report has established objectives and targets for stormwater management within the Precinct that can be used to guide all new development. Urban development within the Precicnt will be required to use water sensitive urban design (WSUD) approaches to meet these objectives.
- This report also provides the stormwater management strategy and associated infrastructure that is required at the Precinct scale to facilitate urban development and the IWCM strategy. This strategy will take the form of a development services scheme (DSS) administered by Melbourne Water Corporation.
- The extent of flooding has been reduced from 230 ha for inundation depths greater than 50 mm to a requirement for 68.4 ha of land for facilities to manage stormwater runoff which creates additional land value of $109.2 million. The value of this increased developable land minimises the net costs of the proposed developer's contribution for Precinct scale infrastructure.
- The stormwater management strategy includes works in the upper catchment and within the Precinct that substancially improve the extents of flooding, stormwater quality and impacts on waterways.
- The strategy includes replacement of the D1 Drain with a waterway that will provide high amenity and improvements in the quality of stormwater.
- The gross cost of the proposed stormwater management strategy is $45,917/ha for the entire Werribee Employment Precinct. However, when the land value is included in the analysis, the net benefit of the strategy is $117,165/ha. Importantly, the value of additional land provided by the stormwater management strategy is more than sufficient to fund both the stormwater management and IWCM strategies

## Introduction

The proposed Werribee Employment Precinct is located near Werribee, 25 km south-west of Melbourne's CBD. It is the largest undeveloped parcel of publicly owned land in metropolitan Melbourne and is located in one of the fastest growing urban areas in Australia.

During 2009, the Department of Planning and Community Development (DPCD) led detailed investigations and preparation of a preliminary Development Strategy involving input from 20 organisations. Twelve background technical studies were undertaken, including preliminary contamination and heritage assessments, and the preparation of transport, stormwater and economic studies.

The investigations highlighted the potential to provide a new 'mixed use' city with a range of civic, educational, employment, recreational and residential uses that coexist in the one area. An Independent Expert Review Panel supported this view.

For the water component, DPCD commissioned Bonacci Water to develop a conceptual integrated water cycle management (IWCM) strategy that incorporated the objectives of a Multi-Agency Working Group and investigated the options for intelligent use of regional stormwater and local rainwater harvesting, district scale aquifer storage and recovery, wastewater reuse within the Precinct and water efficiency.

The proposed IWCM strategy was found to be independent of regional mains water supplies; decrease sewerage discharges from the Precinct; supply surplus treated wastewater to surrounding areas, contribute to restoring the aquifer under the site; and substantially reduce the requirement for water and sewerage infrastructure. This strategy also provided significant reductions in greenhouse gas emissions.

The IWCM strategy is dependent on a stormwater management solution that mitigates the significant legacy of flooding and stormwater pollution at the site and incorporates the principles of water sensitive urban design (WSUD). The stormwater management elements of the proposed IWCM strategy therefore needed to be incorporated into a Development Services Scheme (DSS) administered by Melbourne Water Corporation.

Bonacci Water was commissioned by Department of Planning and Community Development and Melbourne Water Corporation to prepare an innovative integrated stormwater management strategy for the site based on rigorous scientific and economic analysis.

This report outlines the essential stormwater management facilities required to achieve the stormwater flow and quality objectives in the Precinct. It will form the basis a new Development Services Schemes for the Werribee Employment Precinct and additions to the existing schemes for the Skeleton Creek and Upper Point Cook catchments.

## Background

The Werribee Employment Precinct is predominantly crown land used historically for various agricultural and animal research purposes. It is traversed by significant infrastructure assets including the Maltby Bypass section of the Geelong freeway, several minor roads, Melbourne Water's Western Trunk Sewer, and the heritage-classified Western Trunk Sewer (Figure I).

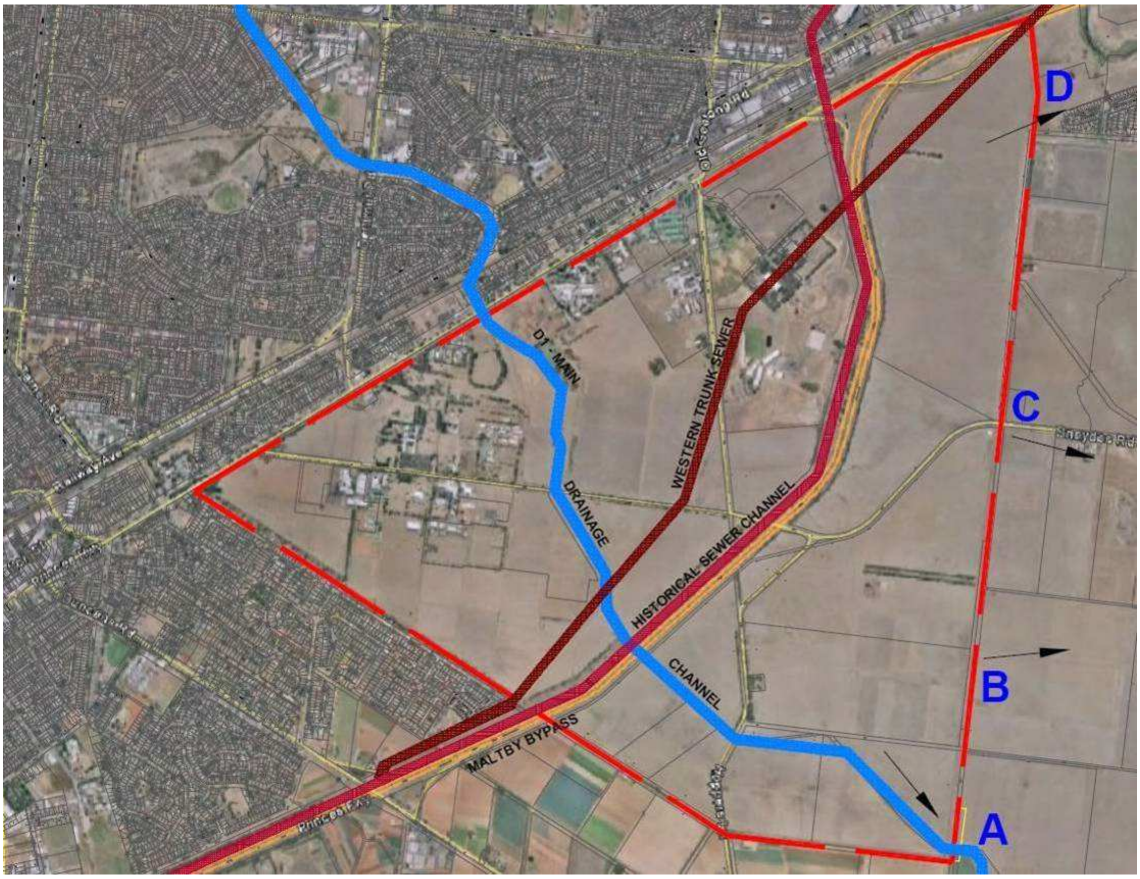



Figure I: Existing development, major infrastructure and natural drainage directions.

Figure I shows the main drainage alignment, the major above ground infrastructure and the existing development. It also shows that stormwater flows out of the Precinct at the main drainage outlet (A) and three other locations (B, C and D). The Princes Highway forms the north-west boundary of the Precinct.

The neighbouring areas north of the Maltby Bypass are mostly urbanised. Irrigated agriculture predominates to the south, and areas to the east and north east are dry land farming transitioning into new urban developments (out of view in Figure I).

The urbanised catchments that drain into the Precinct from north-west of the Princes Highway are shown in Figure II. These catchments total 1,097 ha which is slightly larger than the area of the precinct. The topography across the entire is relatively flat with a fall of less than 20 m in the 9 km downstream of Sayers Road to exit point A in Figure I.

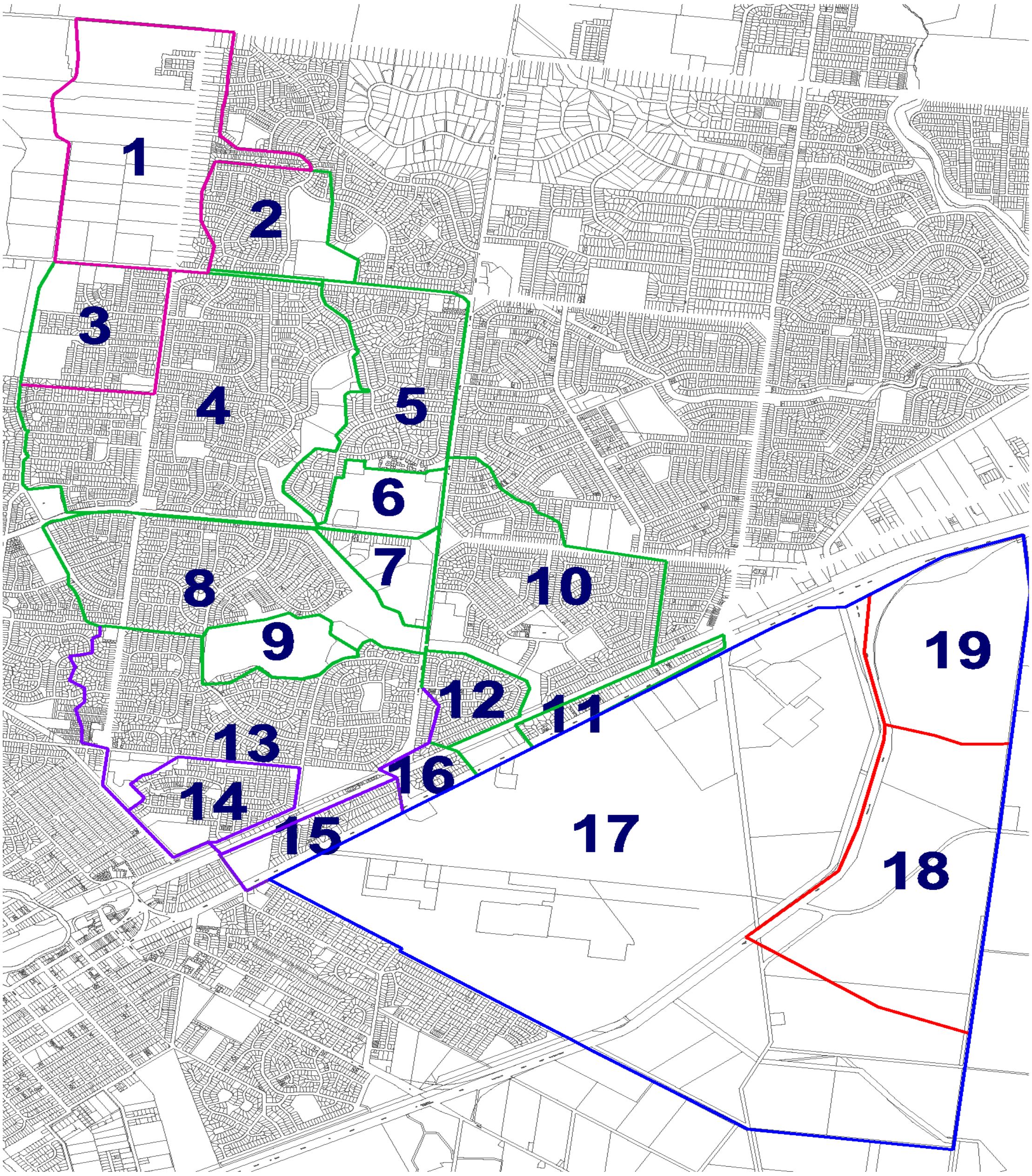



Figure II: Stormwater sub-catchments under existing conditions

## Methods

Objectives for stormwater management and protection of waterways were agreed with the Multi-agency working group. Analysis of the stormwater infrastructure required to support the overall IWCM strategy relied on detailed forensic inspection of the existing drainage lines and facilities and checking the physical dimensions of all culverts, spillways and other flow controls.

Historical rainfall data from representative nearby locations sourced from the Bureau of Meteorology and design rainfall from the national guideline, Australian Rainfall and Runoff, was utilised in this study. Estimates of the impacts of climate change on rainfall intensity by CSIRO and IPCC were incorporated in the analysis.

High resolution digital terrain models representing pre-European, current and future conditions were developed. The hydrological analysis utilised design storms and a state-of-the-art model called WUFS that can compare traditional drainage solutions to water sensitive urban design solutions or analyse combinations of both. A parallel model of the hydrology was also created using the RORB software package to confirm the results of the hydrological analysis. As no stream gages were present at the site, the pre-European hydrology was calibrated to rational method calculations.

The hydraulic analysis utilised the digital terrain model and inputs from the hydrology model in the hydraulic model TUFLOW that incorporates one and two dimensional simulation. The MapInfo geographic information system was used to analyse and present the hydraulic results.

Simulation of stormwater quality was undertaken using the MUSIC model and local rainfall from the Werribee area. All data sets were rigorously inspected for any inconsistencies.

## Stormwater Management Objectives

In accordance with the vision for sustainable development of the Werribee Employment Precinct, objectives and targets for stormwater management were developed to include:

- source controls and rainwater harvesting
- trapping of gross plllutants
- removal of suspended solids and nutrients from stormwater runoff
- achieving current best practice targets for reduction in pollutants below typical urban levels
- enhancing health and amenity of waterway ecosystems
- mitigation of flooding
- optimising opportunities to harvest water for aquifer storage and retrieval

Analysis of pre-European conditions included research into the likely historical stormwater flow paths and catchments to establish natural stormwater runoff regimes. These results were used to inform the targets for stormwater management.

## Existing Conditions

Information from a range of sources was combined with site inspections and detailed analysis to identify the urban stormwater sub-catchments discharging to the Precinct. This was a critical aspect and outcome of the study, as it had never been accurately undertaken before.

The site of the Werribee Employment Precinct is subject to stormwater runoff from a large urbanised catchment (1,097 ha) upstream of the site. Land uses in the upstream sub-catchments include residential housing, shopping centres, schools and road networks within the suburb of Werribee.

Two different urbanised catchments (D1 Drain and P1 Pipe) discharge to the Werribee Employment Precinct from the upstream area. The D1 catchment includes a drainage corridor that discharges to a detention basin located below Werribee Plaza that discharges under Derrimut Road towards the Precinct. This catchment also includes the offline constructed wetland known as Glen Orden that is not directly connected to any of the stormwater sub-catchments.

Existing stormwater management facilities in the upper catchments pre-date current design guidelines and do not achieve required standards for stormwater management. They include nine small detention basins and two large storages identified as the D1 reserve retarding basin and the Glen Orden constructed wetland.

Areas of the upper catchment and substantial parts of the Precinct are subject to flooding to depths of 50 mm of greater during severe rainfall events (Figure III).

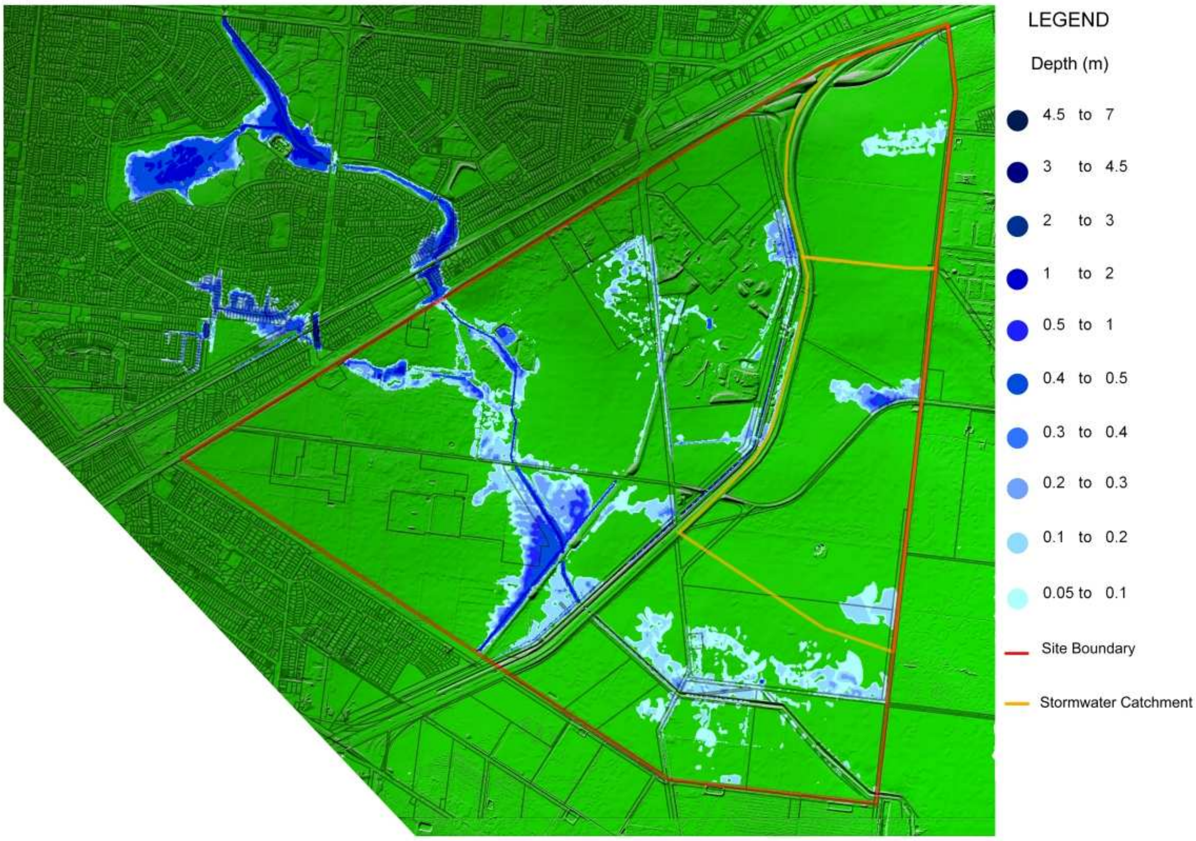



Figure III: Extent of flooding from 100 year ARI storm events under existing conditions

It is expected that inundation from flooding in the Precinct would increase substantially under the proposed development scenarios because of the additional runoff generated by urban development.

## Proposed stormwater infrastructure

The proposed stormwater management infrastructure has been developed to achieve best possible results for:

- Flood mitigation
- Stormwater quality improvement and
- Waterway health and stability

An important underlying objective for the Precinct is that domestic and commercial developments will adopt on-site harvesting and indoor utilisation of roof runoff, and local scale best management practices for water sensitive urban design.

The principal elements of the major infrastructure involve retarding basins, wetlands, gross pollutant traps, culverts, weirs, spillways and re-aligned or re-formed waterways. The predominant features in the upper catchment are shown in Figure IV.

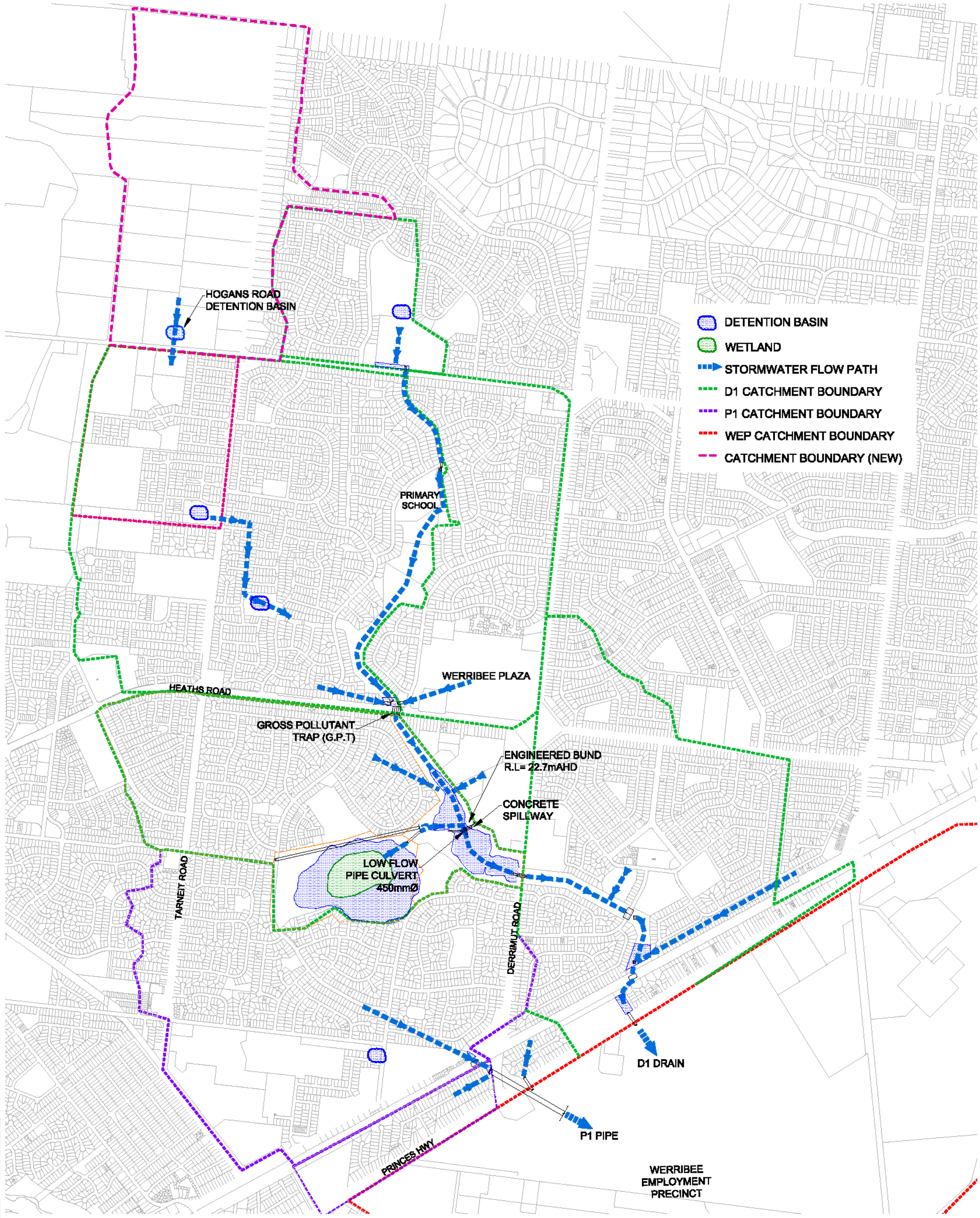



Figure IV: Design Stormwater Infrastructure in Upper Catchment

### Upstream Urbanised Catchment

Key changes in the upper catchment include the proposed new retarding basin upstream of Hogan's Road, a gross pollution trap just upstream of Heaths Road and a new weir and other modifications to better link the retarding basin in the D1 Drain Reserve to the Glen Orden constructed wetland. This will achieve higher utilisation of the storage capacity in Glen Orden at lower flows with significant water quality and flood mitigation benefits. Key elements of the infrastructure proposed to be used, modified or constructed within the Precinct are set out in Figure V.

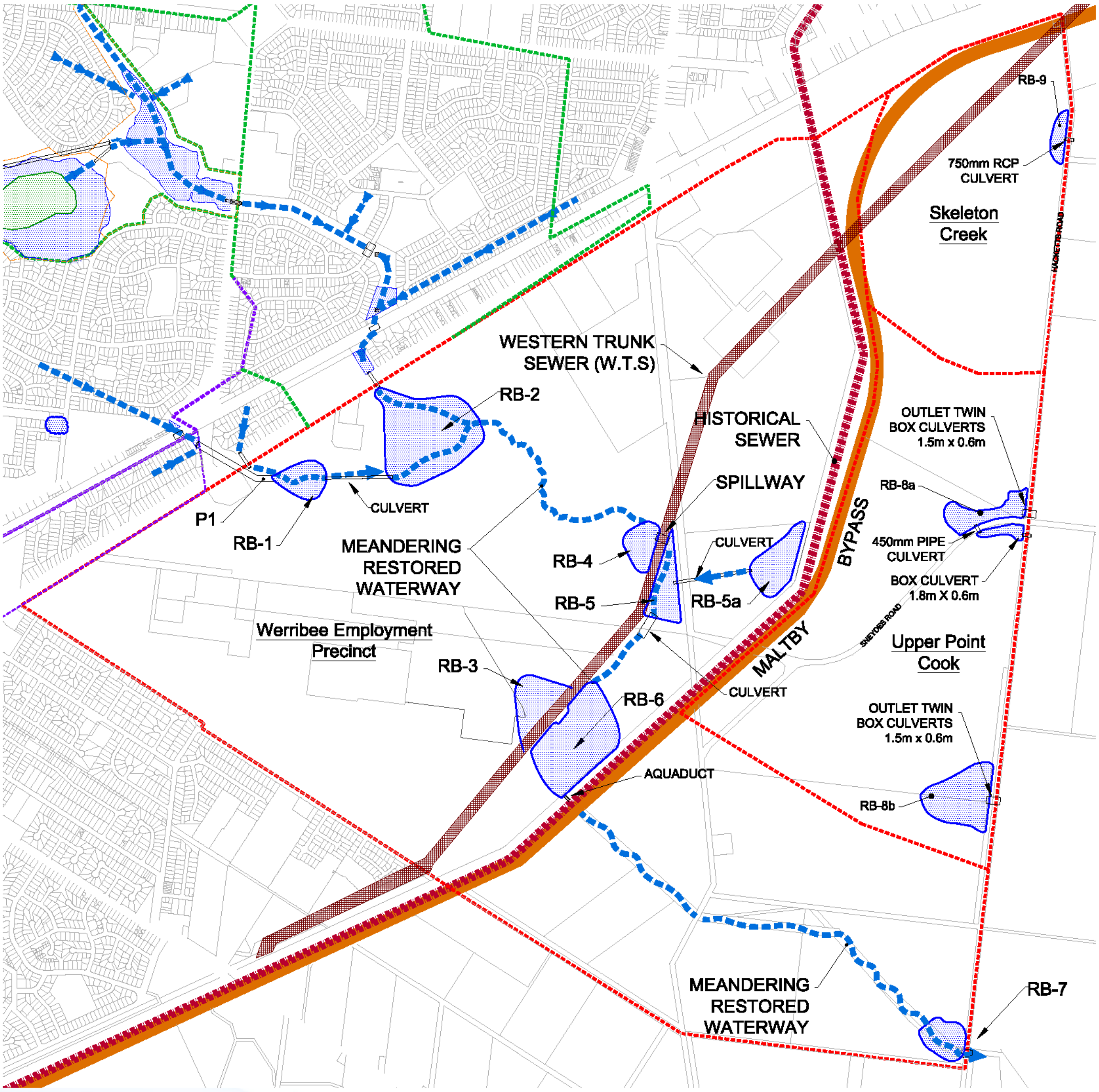



Figure V: Overview of stormwater management infrastructure within the Werribee Employment Precinct

### D1 drainage system within the Precinct

The initiatives developed for works associated with the D1 drainage system within the Precinct include:

- A gross pollutant trap and retarding basin RB1 at the P1 entry to the Precinct;
- A re-formed meandering waterway through the base of RB1 and on to RB2;
- A gross pollution trap and retarding basin RB2 at the entry of the main D1 drain to the Precinct.
- Re-formed meandering waterways through the base of RB2 which also contains a small permanent wetland pond to assist in harvesting water for aquifer storage and recovery;
- A new meandering waterway from RB2 to the new retarding basin RB4. The new alignment meets the Western Trunk Sewer further north than the current D1 drain alignment where the sewer is set lower in the ground permitting easier passage of stormwater flows;
- Filling and stabilising the old alignment of the D1 drain through this portion of the area;
- A permanent pond in the new RB4 for habitat and aquifer storage and recovery;
- A spillway from new RB4 over the Western Trunk Sewer into new RB5 retarding basin;
- A new retarding basin RB5a collects stormwater from the isolated catchment further north between the two sewer alignments;
- A low flow culvert and high flow overland pathway linking retarding basin RB5a to the new RB5;
- High flow spillway and low flow outlet directing flows from new retarding basin RB5 through box culverts under Sneydes Road. A bund to prevent inundation of Sneydes Road at this location during high flow events;
- A new meandering waterway from Sneydes Road south to new retsrding basin RB6 located between the new and old sewers;
- Inclusion of a pond for habitat and aquifer storage extractions in existing retarding basin RB3 which outlets to new retarding basin RB6 via an existing siphon under the Western Trunk Sewer and a high flow spillway over the sewer;
- Modification of the existing twin siphon to increase flows under the Historical Sewer channel from the RB6 retarding basin;
- Construction of an aqueduct from the RB6 retarding basin over the Historical Sewer to carry high flows across the sewer. Stormwater currently spills into the sewer;
- Re-construction of a meandering waterway along the D1 drain alignment between the Maltby Bypass and the south-east limit of the Precinct,
- Construction of a new retarding basin RB7 just inside the Precinct at the outflow location.

### Upper Point Cook drainage system works

Works associated with the stormwater catchment that falls towards the Point Cook drainage system include:

- New RB8a retarding basin which includes an existing reeded billabong likely to have high ecological value. The existing outlets under Sneydes and Hackets Roads will meet outflow requirements, and
- New RB8b retarding basin that utilises the existing twin culverts to pass flows under hackets Road towards Point Cook

### Skeleton Creek drainage system works

A small retarding basin RB9 is proposed for the very north-east corner of the Precinct where the stormwater catchment falls north into the Skeleton Creek system through an existing urban development.

## Results

### Flooding

The extent of areas subject to inundation at depths of 50 mm or greater depth generated by 100 year ARI storm events are shown in Figure IV. This result shows the effect of the proposed stormwater management infrastructure and the eventual full development of the Precinct. It is clear that the surface area has been significantly reduced compared to that shown in Figure III.

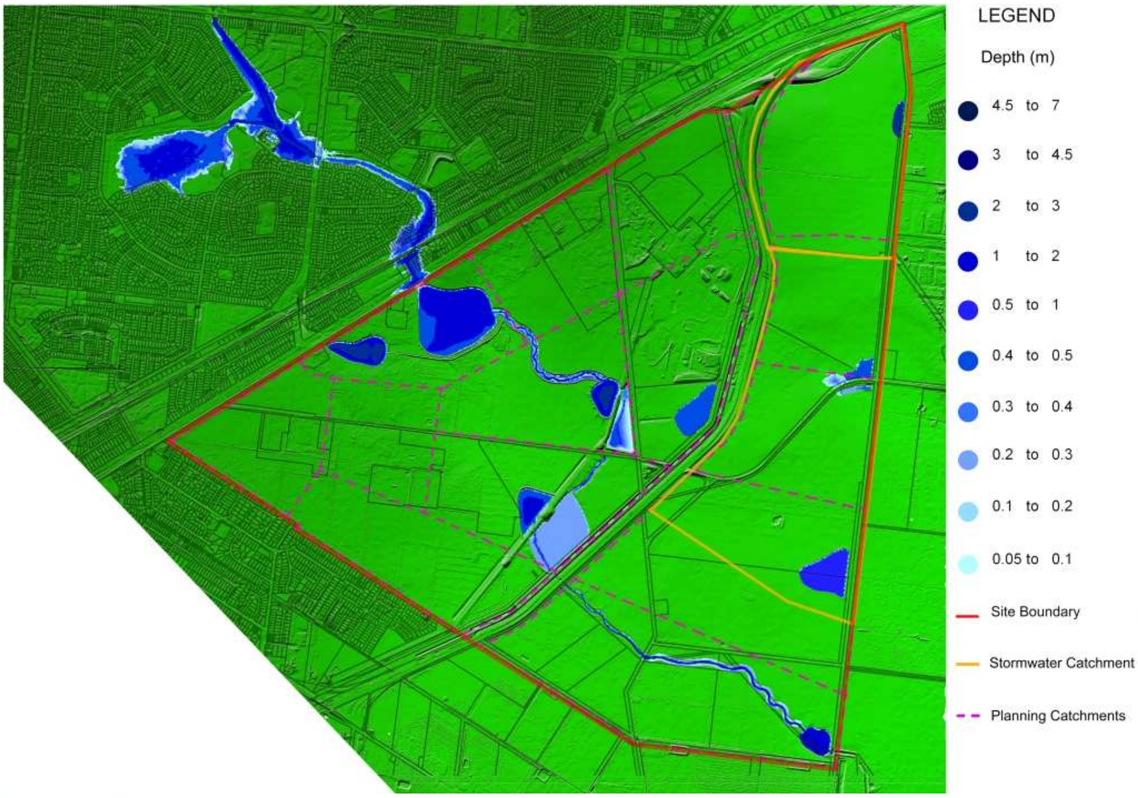



Figure VI: Extent of flooding from 100 year ARI storm events in the developed catchments

### Stormwater Quality

The characteristics of stormwater leaving the Precinct towards the downstream D1 drainage system are shown in Table A. The Table can be interpreted using the following definitions:

- SOURCE represents the cumulative contributions from all areas in the upstream catchments in the fully developed state
- RESIDUAL represents the pollutant that have not been eliminated, removed or otherwise ameliorated by the cumulative action of all the stormwater management measures in the upstream catchments

The reductions in pollutant loads achieved by the stormwater management strategy are very considerable and exceed the best practice objectives identified for the study.

Table A: Stormwater quality discharging from the Precinct outfall to the lower D1 drain

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 4,010 | 1,740 | 56.6 |
| Total Suspended Solids (kg/yr) | 690,000 | 36,100 | 94.8 |
| Total Phosphorus (kg/yr) | 1,440 | 235 | 83.7 |
| Total Nitrogen (kg/yr) | 10,500 | 2,990 | 71.6 |
| Gross Pollutants (kg/yr) | 105,000 | 0 | 100.0 |

The improvements in stormwater quality for the upper Point Cook and Upper Skeleton Creek sections of the Precinct were similarly effective.

### Riparian Habitat

The wetland ponds in most of the retarding basins and the newly formed waterways arranged as meandering low-flow channels between high flow levees or bunds will underpin significant long term improvements in riparian habitat. Careful attention to design, construction and revegetation of these areas will be important.

### Climate Change

The areas estimated to be affected by flooding under current design conditions and with the impacts of climate change are shown in Table B. The high emissions climate change scenario (17% increase in rainfall intensity) would increase the extent of flooding. However, these increases are contained in the stormwater infrastructure designed for the site.

Table B: Land areas estimated to be affected by flooding under current design conditions and with the impacts of climate change

| Inundation at indicated depth | Area of flood (ha) | |
|---|---|---|
| | Design | Climate Change |
| Full extent | 57 | 79 |
| > 50 mm | 55 | 57 |
| > 100 mm | 54 | 56 |

### Land Yield

The area of land available for development across the Precinct is approximately 670 ha. This discounts the areas required for current permanent uses and infrastructure, the heritage reservation at the old research station and the areas required for waterways, retarding basins and other stormwater facilities as shown in Table C.

Table C: Land area available for development

| Land Category | Area (Ha) | Balance (Ha) |
|---|---|---|
| Total Precinct | | 915 |
| Existing Permanent Uses and infrastructure easements | 171.8 | 743.2 |
| Cultural heritage reservation at old research station | 5 | 738.2 |
| Waterways, retarding basins and other stormwater reserves | 69 | 669.8 |

## Conclusions

Rigorous and detailed analysis of stormwater processes in the Precinct and its upstream catchments has provided a sound understanding of the dynamics of stormwater runoff. Existing conditions in the upstream catchments do not meet current stormwater quality or quantity objectives, creating a challenge for stormwater management within the Werribee Employment Precinct.

However, the works proposed are capable of achieving exemplar stormwater objectives for the Precinct and its upstream catchments at a considerable economic benefit. The proposed works will also significantly enhance riparian habitat values, improve amenity and are resilient to potential increases in rainfall intensity associated with climate change.

Development of the Precinct as currently proposed will not be unduly constrained by stormwater requirements. The gross cost of the proposed stormwater management strategy is $45,917/ha and the net benefits are $117,165/ha when the value of land is considered. The gross costs of Precinct scale stormwater infrastructure in the three catchments within the Precinct as shown in Table D.

Table D: Gross cost of Precinct scale stormwater infrastructure

| Location | Developable area (ha) | Cost ($/ha) |
|---|---|---|
| Remainder of Werribee Employment Precinct | 449 | 59,997 |
| Upper Point Cook | 140.1 | 16,404 |
| Upper Skeleton Creek | 80.7 | 10,772 |

Inclusion of the net land values in the analysis provides the net costs of the Precinct scale infrastructure as shown in Table E.

Table E: Net costs of Precinct scale stormwater infrastructure

| Location | Net costs ($) | Cost ($/ha) |
|---|---|---|
| Remainder of Werribee Employment Precinct | 78,294,267 (benefit) | 174,365 (benefit) |
| Upper Point Cook | 646,501 | 4,615 |
| Upper Skeleton Creek | 3,018,513 (benefit) | 37,402 (benefit) |

Table A shows that the value of the land that is made available as a result of the reduced flood inundation generated by the stormwater management strategy has mitigated the costs of the stormwater infrastructure. Although the developers of the land will have to make the contributions listed in Table D, the value of the increased developable land area reduces the net cost of the stormwater management strategy to the values shown in Table E.

Note that the net benefit of the proposed stormwater management scheme for the entire Werribee Employment Precinct is $117,165/ha when the value of the increased developable area is included. The stormwater management strategy has produced sufficient increases in developable land to fund both the proposed stormwater management and the IWCM strategies, and provide considerable surplus in value.

# 1 Introduction

The proposed Werribee Employment Precinct is 25 km south-west of Melbourne's central business district as shown in Figure 1.1. The site is predominantly in public ownership, managed by the Department of Primary Industries, and is fully within Melbourne's Urban Growth Boundary.


Figure 1.1: Location of the Werribee Employment Precinct

This precinct, formerly the Werribee State Research Farm, was designated in Government's metropolitan planning policy *Melbourne 2030,* and its update *Melbourne @ 5 Million,* for employment centred development to provide local jobs and access to community services for the residents of Western Melbourne in order to minimize their journey to work, and to maximize their work opportunities. It is the largest parcel of undeveloped, public-owned land in metropolitan Melbourne and is also designated to be a demonstration of environmentally sustainable design.

*"This will help to reduce congestion on the roads and CBD public transport services. The precinct will showcase sustainable design with an emphasis on water, energy and transport efficiency."*

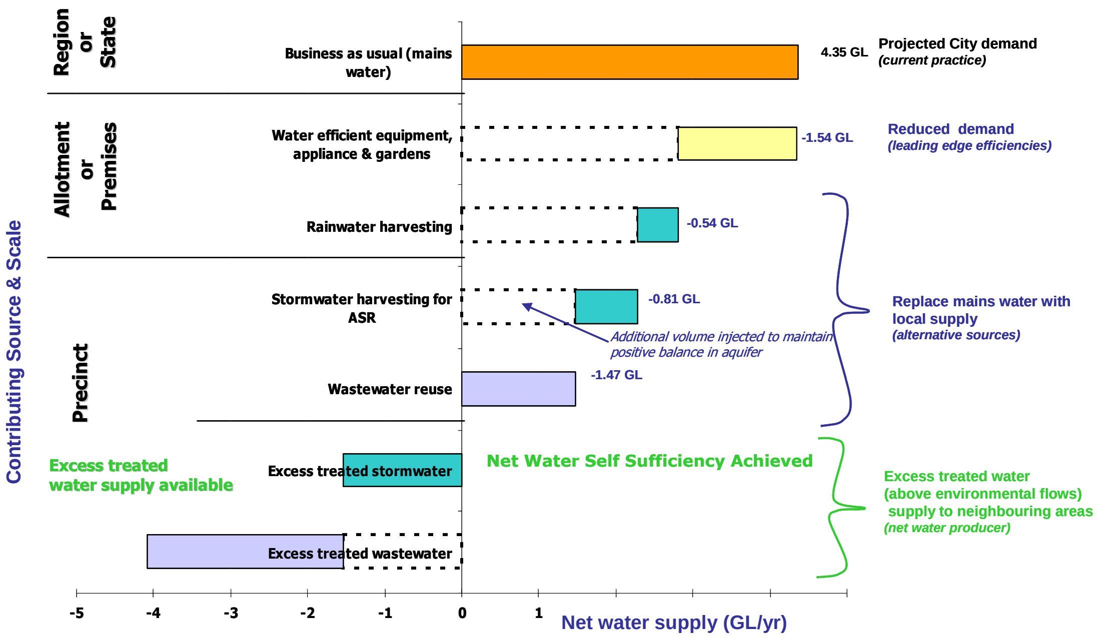
The Department of Planning and Community Development (DPCD) is leading the coordination of multi-agency planning to establish a water positive city at the Werribee Employment Precinct that generates more water than it consumes. The working group comprises the Department of Sustainability and Environment, Melbourne Water, City West Water, Southern Rural Water, Wyndham City Council, Port Phillip and Westernport Catchment Management Authority, EPA, and Sustainability Victoria.

In 2009, DPCD commissioned Bonacci Water to develop a conceptual integrated water cycle management strategy that incorporated the objectives of the Multi-Agency Working Group. The study evaluated an array of options under the guidance of the Multi-Agency Working Group. The selected option included the intelligent use of regional stormwater and local rainwater harvesting, district scale aquifer storage and recovery, wastewater reuse within the Precinct and water efficiency as shown in Table 1.1.

Table 1.1: Summary of the proposed Integrated Water Cycle Management strategy (IWCM)

| Scale | Strategy | Concept |
|---|---|---|
| **Precinct**<br>*Efficiency* | **Productive reuse of treated water** - storm water and treated waste water provide a secure local supply of quality water for the new city, with excess exported to neighbouring areas | 1) **Establish secure supply of reuse water** by integrating amenity enhancing infrastructure into the urban form:<br>(a) Reuse of regional storm water entering the site from upstream:<br>• Replacing the concrete D1 drain and 150 hectare retarding basin with amenity enhancing waterways<br>• Using aquifer storage and retrieval (ASR) with treatment to potable water standards<br>(b) Retrieval, treatment and reuse of local wastewater with timely installation of modular wastewater treatment plants<br>2) R**eticulated supply of reuse water** to all allotments with excess exported for supply to neighbouring areas<br>3) **Open space network with overland flow paths** to increase resilience to the impacts of severe storm events that are projected to occur under a high emissions climate change scenario |
| **Sub-Precincts**<br>Flexibility | **Flexible** development of sub-precincts | Provide developers with maximum flexibility in sub-precinct structure planning to adopt the latest technologies and approaches providing they meet the predetermined objectives and associated standards |
| **Allotments**<br>*Effectiveness* | Developer delivers to Precinct standards | Reduced upfront Precinct Services Scheme charges based on developer delivery of more effective, source based, infrastructure:<br>• Rainwater plumbed into internal laundry, bathroom and non-food preparatory areas<br>• Reticulated wastewater reuse for external purposes<br>• Smart streetscapes that clean rainwater where it falls and integrate with neighbourhood open space and stormwater management systems<br>• Water sensitive urban designed neighbourhoods<br>• Installation of water efficient equipment, processes, appliances |

Table 1.1 shows that the IWCM strategy incorporates solutions that operate across multiple scales that also contribute water the water balance at the site as presented in Figure 1.2.




Notes:
* Excess stormwater is volumes above environmental flows
* DCPD ultimate land use scenario with 50,000 Jobs and 30,000 residents
* Average values shown - Variances due to climate and seasonal variability in demand and supply
• Locally sourced water treated to potable standards for business use
• Each year inject stormwater in excess of that required to build a reservoir as a future buffer/resource

Source: Werribee City Infrastructure Planning - Integrated Water Cycle Management Strategy, Bonacci Water - 2010

Figure 1.2: Water balance from the IWCM strategy – opportunities for the new city to be water positive, generating more water than it uses (local water supply to neighbouring areas)

The proposed IWCM strategy was found to be independent of regional mains water supplies, and to reduce sewerage discharges from the Precinct by 68%. The surplus treated wastewater (low salinity) will be supplied to the surrounding areas at an average rate of 1.5 GL/yr, with considerable reductions in the requirement for financial contributions to regional water and sewerage infrastructure. The strategy also provides a 78% reduction in greenhouse gas emissions and restoration of the aquifer under the site.[1]

Importantly, the IWCM strategy is dependent on a stormwater management solution that mitigates significant impacts of flooding and stormwater pollution at the site and incorporates the principles of water sensitive urban design (WSUD). It is, therefore, important to incorporate the stormwater management elements of the proposed IWCM strategy into a Development Services Scheme (DSS) administered by Melbourne Water Corporation. This report outlines the essential stormwater management policies and infrastructure required for new Development Services Schemes at the Werribee Employment Precinct, Upper Point Cook and Upper Skeleton Creek.

[1] Bonacci Water (2010). Werribee City Infrastructure Planning. Integrated water cycle management – planning for the productive use of stormwater. Report for the Department of Planning and Community Development.

# 2 Background

The Werribee Employment Precinct is the largest undeveloped parcel of publicly owned land in metropolitan Melbourne. It includes 915 hectares of predominantly Crown Land historically managed by the Minister for Agriculture. It is located in Wyndham, one of the fastest growing urban areas in Australia with a population that is expected to reach 400,000 by 2050.

The total area has been identified as a site suitable for development as a major employment hub to the west of Melbourne. Proximity to the Princess Freeway, two railway stations, two airports and two shipping ports mean the area has very considerable commercial potential.

During 2009, the Department of Planning and Community Development, with support from VicUrban, led detailed investigations and preparation of a preliminary Development Strategy. This work involved input from 20 organisations, including relevant Government departments and agencies, such as VicRoads, Melbourne Water, the Growth Areas Authority and Sustainability Victoria and included senior staff from Wyndham City Council. Twelve background technical studies were undertaken, including preliminary contamination and heritage assessments and the preparation of transport, storm water and economic studies.

The work to date clearly confirms that sustainable development of this site has enormous potential and importance for the long term development of Melbourne's West. A new urban centre, just 25 km from Melbourne's CBD, will provide local jobs, reduce journey times to work, provide an urban development that is resilient to the impacts of climate change and deliver exciting business and investment opportunities. It will be a 'mixed use' city with a range of civic, educational, employment, recreational and residential uses that coexist in the one area.

The development strategy has been reviewed by a Government appointed Independent Expert Review Panel who found the site presented a unique opportunity in Victoria, and probably Australia, to deliver a leading example of a mixed use urban centre and that early engagement of the private sector will be critical to delivering the vision for a new 21st century city.

In October 2009, Government endorsed the urban development of the site as a vibrant new city, built to 21st century standards (with low emissions) and a designated "Climate Smart Innovation District" to provide "more job opportunities close to where people live" and to "showcase sustainable design". The project will accelerate economic development of the site to build a city that can eventually accommodate 60,000 jobs and 30,000 residents (in 30 to 50 years time).

The sheer size and complexity of the city scale development is unprecedented in Victoria and has the potential to reshape economic, social and cultural opportunities for Melbourne's south-west, and to become a model for future sustainable urban development.

Bonacci Water was commissioned by Department of Planning and Community Development to prepare an innovative integrated stormwater management strategy for the site based on rigorous scientific and economic analysis that:

- combines surface water and flood risk mitigation with urban form and infrastructure planning to make the new city resilient to the impacts of climate change (a dual focus on managing nuisance flooding in combination with the productive use of storm water as a scarce resource)
- protects the health and amenity of downstream waterway ecosystems

- identifies the requisite district scale storm water infrastructure as a platform for (net) water self sufficiency
- sets objectives for integrated water cycle management, integrated land use, water and transport planning and for climate smart urban growth
- incorporates an objective based planning approach that provides developers with significant flexibility to incorporate the latest approaches and technologies in their Precinct Structure Planning

## 2.1 The Site

The site of the Werribee Employment Precinct is a large triangular area of land bounded by the Pacific Highway to the north-west, Hacketts Road to the east, and Harrison Road and Wattle Avenue to the south-west. Surrounding land uses include:

- Established urban areas to the west and the north-west
- Developing urban areas to the east – in the Skeleton Creek catchment
- Market gardening to the south
- The Point Cook Airforce base 5 km to the south-east

The study area is predominantly within Melbourne Water's D1 Drain catchment, situated between the Werribee River and the Skeleton Creek catchment in Werribee South and comprises about 925 ha of land generally known as the State Research Farm.

### 2.1.1 Existing conditions

The site includes a range of infrastructure assets that will influence future development and stormwater runoff. The Maltby Bypass section of the Princes Freeway traverses the site and the "D1" drain discharges stormwater from Werribee through the site in a north-west to south-east direction to outlet point A as shown in Figure 2.1. Stormwater also drains away from the site into the Point Cook catchment (C and D) and the Skeleton Creek catchment (B). Stormwater flows in the D1 drain are impeded by the Western Trunk Sewer and subsequently the historic, heritage-listed, brick-lined Western Outfall Sewer which runs parallel with the Maltby Bypass.

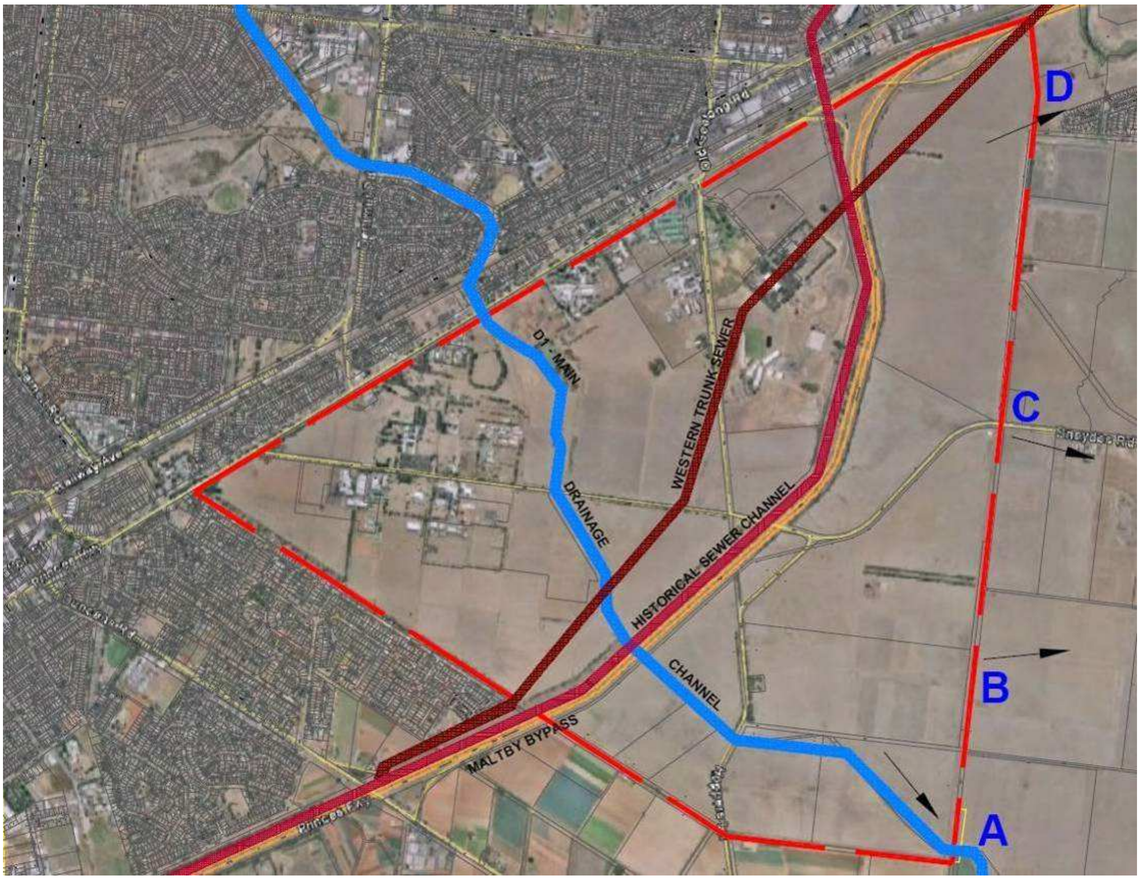



Figure 2.1: Existing major infrastructure and natural drainage directions.

### 2.1.2 Existing land use

Whilst the majority of the Werribee Employment Precinct is broad acre developable land (formerly part of the state research farm) the Precinct is currently home to a number of research and development organisations and a growing community services centre. Facilities within the Werribee Employment Precinct include:

- Werribee Police Station
- Mercy Hospital
- University of Melbourne Veterinary School Campus
- Victoria University – Children's Centre Clinic
- Victoria University – Werribee Sport and Fitness Centre
- Jacaranda Golf Course
- Melbourne Water pumping station
- Department of Primary Industries Animal Research Centre
- CSIRO Food and Nutritional Sciences Division
- Facilities under construction
    - Suzanne Cory Select Entry School (opening in 2011)
    - University of Notre Dame Medical Sciences School

### 2.1.3 Key infrastructure

The site is encumbered by major service infrastructure assets that are unlikely to be relocated and will have significant impact on the way the Precinct may be developed.[2] This infrastructure includes:

- The heritage-listed Historic Sewer which is a brick-lined channel reserved in perpetuity as a historical feature;
- The Federation Trail cycle path located in the linear reserve along the Historic Sewer;
- The Maltby Bypass section of the Princes Freeway, including off and on-lanes for access to Werribee in the northern corner of the study area; (this section of the freeway was constructed immediately adjacent to the alignment of the Historic Sewer)
- The new Western Trunk Sewer which traverses the site on the alignment as shown in Figure 2.1 and a pumping station;
- The Sneydes Road retarding basin immediately upstream of where the Historic Sewer crosses the D1 Drain alignment;
- Potable water supply mains owned by City West Water at several locations;
- A recycled water main owned by City West Water that provides limited distribution of recycled water through the Precinct from a treatment plant located in the south-west to properties north of the Princes Highway;
- Underground telecommunications services owned by Optus, Telstra, and Vernet;
- A local radio station building and two transmission masts in the northern corner of the Precinct;
- Underground oil pipelines owned by Shell Australia;
- Underground natural gas pipelines owned by Tenix and APA GasNet;
- Overhead and underground electricity cables owned by Powercorp.

### 2.1.4 Background studies

The site has been extensively assessed in order to gauge its potential for development as an employment precinct. The available reports are listed in Table 2.1.

[2] Arup (2009). Werribee Employment Precinct – primary services infrastructure. Report for VicUrban

Table 2.1: List of reports into the capability of the site

| Subject | Title | Author |
|---|---|---|
| Aboriginal Heritage | Desktop audit and implications for development | Andrew Long & Associates, March 2009 |
| Potential for Contamination | Phase 1 Environmental Site Assessment | Compass Environmental, March 2009 |
| Economics | Interventions to Boost Werribee Employment Precinct | SGS Economics and Planning, 2009 |
| Economics | The Role of Government Interventions in Boosting Employment | SGS Economics and Planning, 2009 |
| Cultural Heritage | Preliminary European Cultural Heritage Assessment | Lovell Chen, 2009 |
| Fauna and Flora | Preliminary fauna and flora assessment | Ecology Partners, 2009 |
| Geotechnical Assessment | Preliminary Geotechnical Assessment | GeoAust, March 2009 |
| Integrated Water Cycle Management | Integrated Water Cycle Management at the Werribee Employment Precinct | Bonacci Water and Cullen Capital, 2010 |
| Groundwater | Werribee Irrigation District Groundwater Investigations | SKM, March 2005 |
| Existing Infrastructure | Primary Services Infrastructure | ARUP, 2009 |
| Urban Design | Urban Design Background Report | David Lock & Assoc, April 2009 |
| Feasibility Review | Report of the Expert Project Review Panel | Expert panel, August 2009 |

## 2.2 Planning schemes

The proposed Werribee Employment Precinct is subject to a range of local and state planning policies that are discussed below.

### 2.2.1 State Planning Policy

**Melbourne 2030:** When it was released in October 2002, *Melbourne 2030* designated a portion of the current Werribee Employment Precinct as a Specialised Activity Centre (Agriculture and Food Technology Precinct). Under this policy umbrella planning work was carried out by the Wyndham Committee for Smart Growth.

**Melbourne 2030 Update, *Melbourne @ 5 million:*** In December 2008, the Victorian Government updated Melbourne 2030 to incorporate the expected rapid population growth predicted for Victoria in the report "Future 2008". This update signalled a policy shift towards a multi-centred Melbourne and broadened the employment focus for development of the site. The site was renamed the Werribee Employment Precinct and designated for urban development to provide "more job opportunities close to where people live so there is less need to travel into the city for work"; and "showcase sustainable design with an emphasis on water, energy and transport efficiency"[3].

### 2.2.2 Wyndham Growth Area Framework Plan[4]

This ongoing work is carried out by the Growth Area Authority (GAA) and the Department of Planning and Community Development (DPCD) to implement the state government policies of *Melbourne 2030* and more recently *Melbourne@ 5 million*. The Wyndham Growth Area Framework Plan currently identifies the Precinct as a mixed use employment area containing a specialised activity centre consistent with *Melbourne @ 2030*. The Framework Plan has not yet been amended to reflect the changes in planning policy introduced in the updates of Melbourne 2030 to create the *Melbourne @ 5 million* policy.

### 2.2.3 Wyndham Municipal Strategic Statement (MSS)

*Melbourne @ 5 million* is yet to be embedded in the Wyndham MSS which identifies the Werribee Employment Precinct as a technology precinct. It notes that the Precinct is home to nationally significant research and development activities, and has significant capacity for expansion. The MSS promotes the development of the Precinct for integrated research and development and knowledge-based enterprise activity in a campus style form. It also identifies the opportunity for the development of the Precinct to create a high quality gateway entrance to the Werribee centre.

### 2.2.4 The Wyndham Planning Scheme

The Wyndham Planning Scheme shown in Figure 2.2 indicates that most of the area is currently zoned for Special Use (SUZ5) with minor areas of PUZ3 (Public use – Healthy Community), RDZ1 (Road – Category 1) and PUZ1 (Public Use – Service & Utility). There are currently no land management or other overlays, although a significant portion of the study area is known to be subject to flooding.

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[3] Wyndham is one of the fastest growing urban areas in Australia and the population is forecast to double over the next 15 years to around 280,000 residents and reach 400,000 by 2050.

[4] Werribee Employment Precinct Urban Design Background Report by David Lock & Associates, April 2009

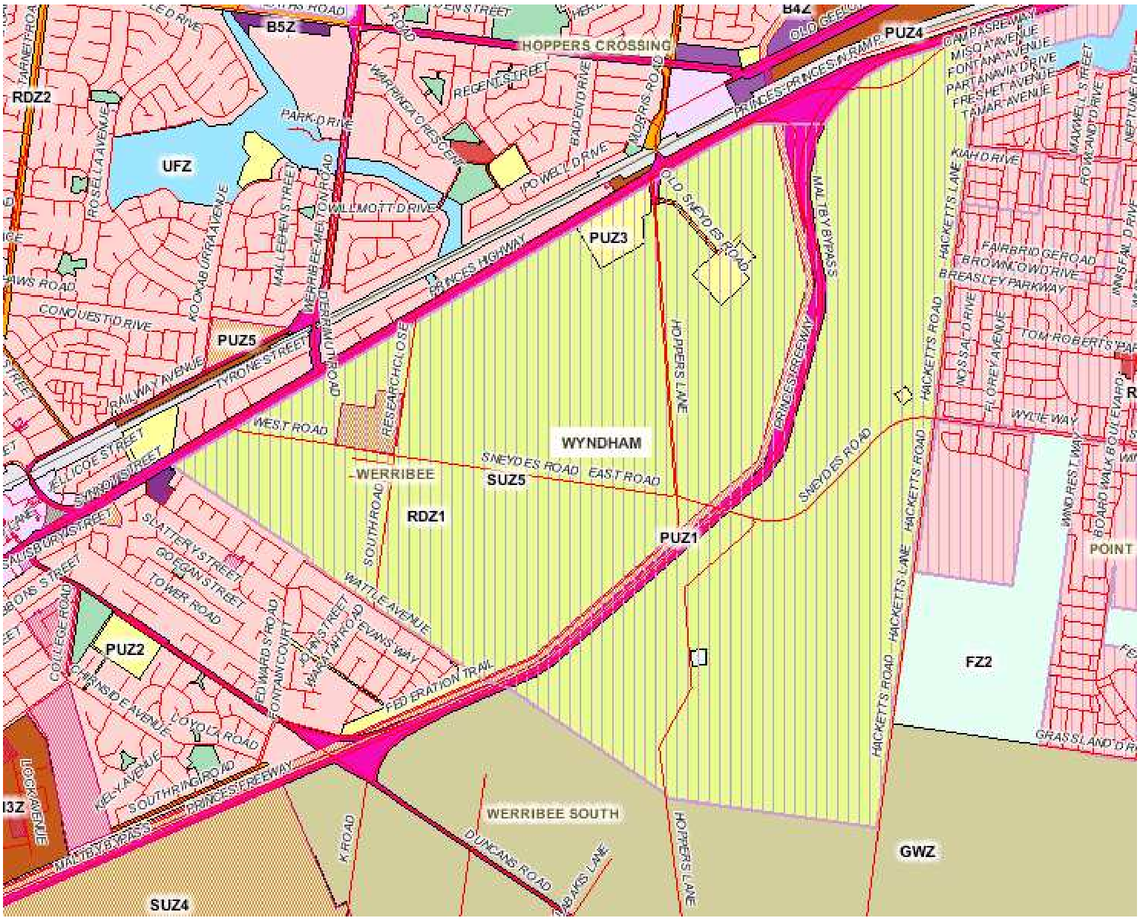


Figure 2.2: Extract from Wyndham Planning Scheme.

The site is not currently subject to planning controls relating to environment and landscape. There is a heritage overlay covering an L-shaped block on the north-east corner of West Road and Research Close (shaded tan in 2.2).

Most of the site is subject to a development plan overlay as shown by vertical hatching in Figure 2.2. The purpose of this planning overlay is to require the form and conditions of future use and development to be shown on a development plan before a permit can be granted to use or develop the land.

## 2.3 Preliminary environmental and cultural assessment

A preliminary assessment of environmental and cultural heritage values was required to assess the feasibility of developing the Precinct and to incorporate the required stormwater management facilities without compromising important environmental and cultural values. An exhaustive approach to these preliminary assessments was adopted in response to the strategic importance of the Precinct.

The preliminary assessments included understanding of flora, fauna, European cultural heritage and aboriginal heritage issues at the site. The flora and fauna assessment included four days of field assessment. The two heritage assessments were desk-top studies that relied on published information and other available records.

### 2.3.1 Flora and fauna

The fauna and flora assessment undertaken by Ecology Partners included a field assessment for flora on the 12th and 13th March 2009, and for fauna on 26th and 27th February 2009.[5] The findings are summarised in Figure 2.3.

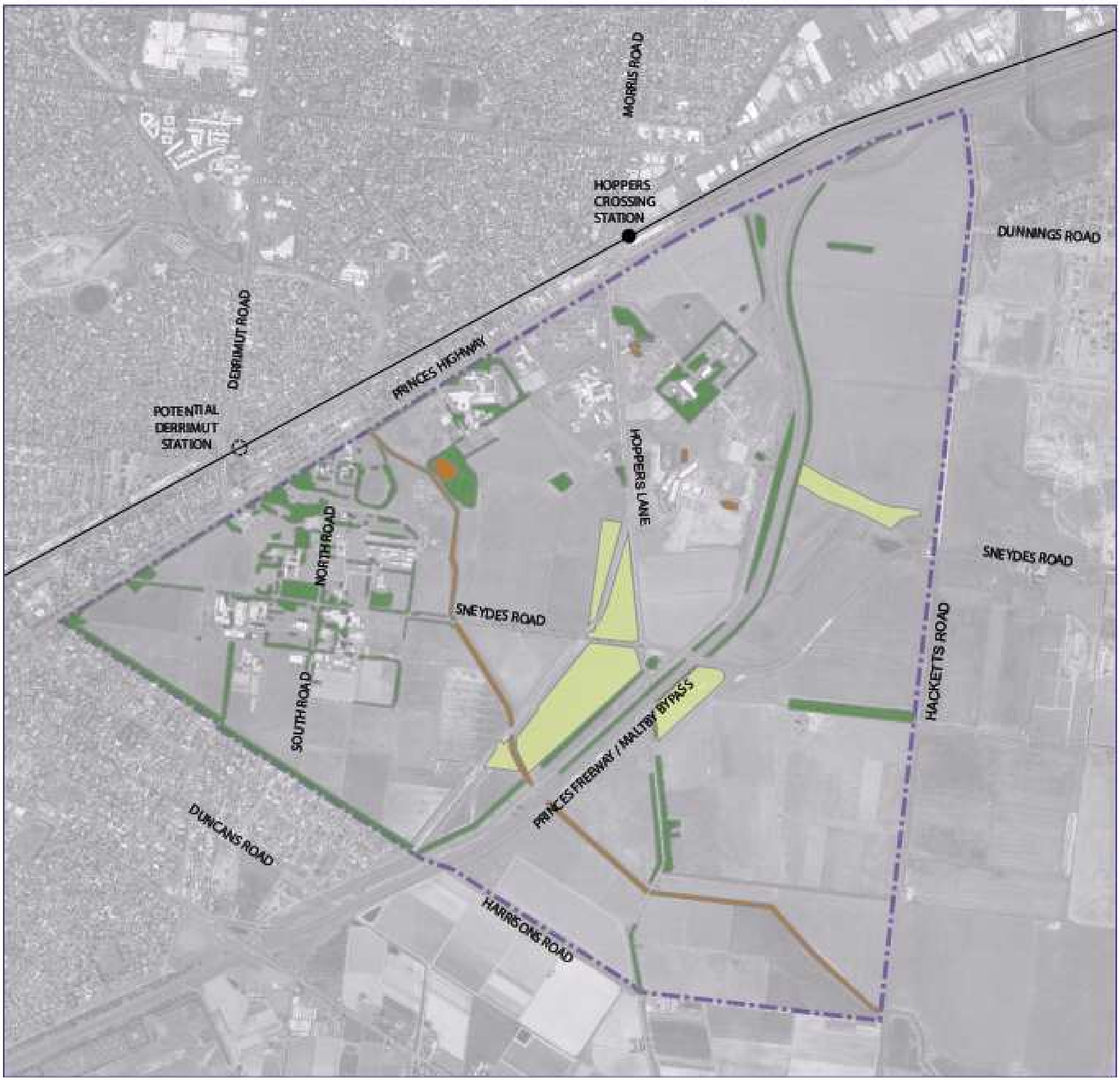


Figure 2.3: Results of preliminary Flora and Fauna Assessment (reproduced from David Lock Associates)

Figure 2.3 shows that the site was generally classified as containing highly modified vegetation with small areas classed as degraded treeless vegetation due to the presence of indigenous plants making up more than the threshold of 25% cover. Areas of exotic trees – mostly linear plantations along roads – were noted for potential arboreal habitat values.

Ecology Partners recommended targeted assessments for significant flora (such as Spiny Rice-flower, Small Scurf-pea and Tough Scurf-Pea) and fauna (such as Growling Grass Frog, Golden Sun Moth

[5] Ecology Partners (2009). Preliminary flora and fauna assessment, Werribee Employment Precinct, Werribee, Victoria

and Fat-tailed Dunnart) as part of the detailed planning and design process. An EPBC Act referral to the Australian Government Federal Environment Minister would be required if any species listed under the EPBC Act were detected.

Importantly, Ecology Partners noted that there will be significant opportunities to re-establish indigenous species and improve habitat values in the area when landscape works are being considered. These considerations will be important in the planning of waterway enhancements, retarding basins and constructed wetlands, consistent with the principles of integrated water cycle management (IWCM) and water sensitive urban design (WSUD).

### 2.3.2 Cultural assessment

A preliminary cultural heritage assessment was undertaken by Lovell Chen. Current heritage classifications cover the brick-lined channel of the Heritage Sewer and the original research precinct as shown in Figure 2.4.

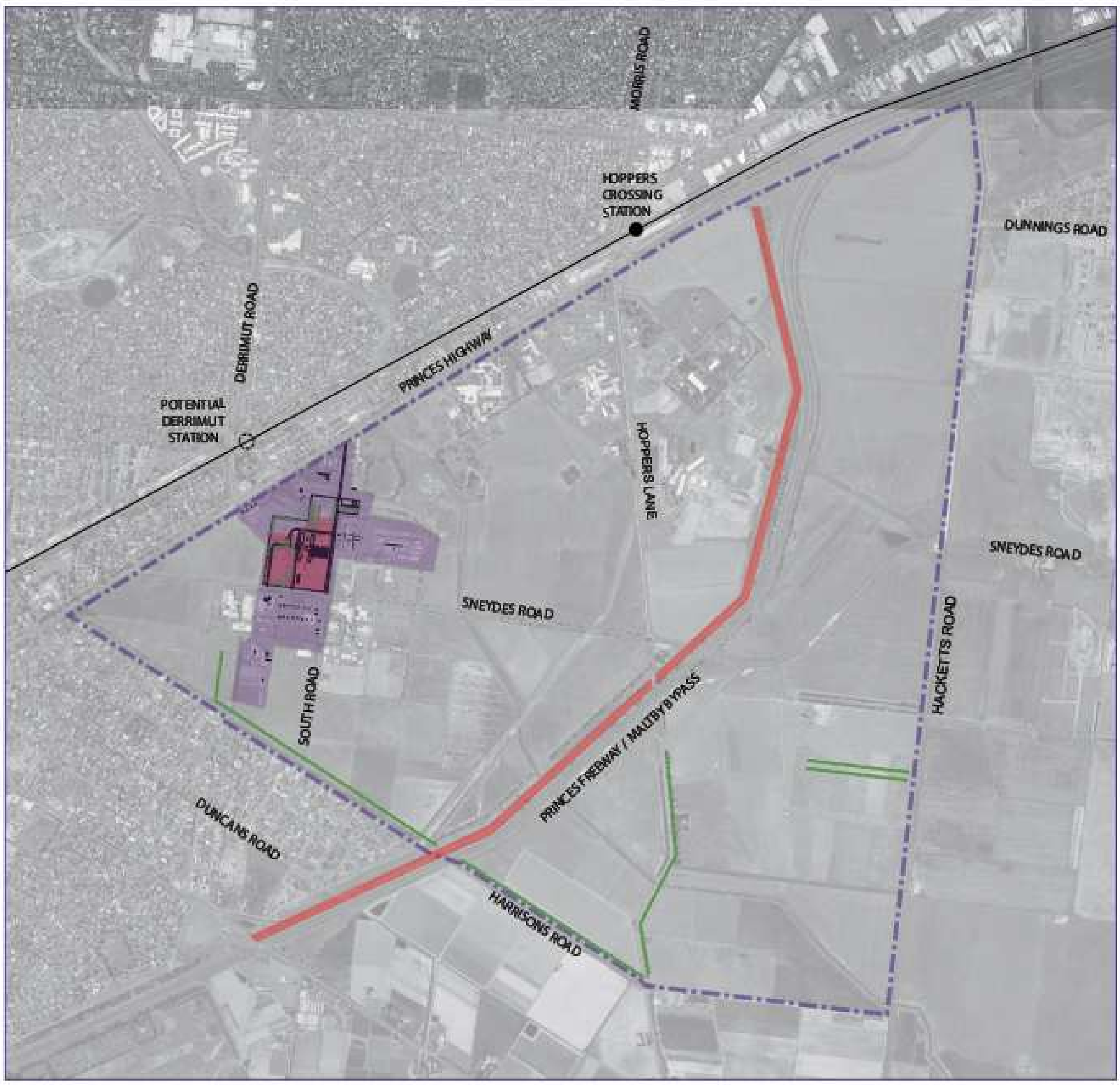


Figure 2.4: Cultural heritage values in the study area (reproduced from David Lock Associates)

It was recommended that a larger area around the research precinct be considered for listing as a heritage site including the woolshed. The potential significance of some of the roadside tree plantations was also highlighted (shown as green on 2.4). The current alignment of the D1 Drain is close to the north-east of the areas identified as having potential heritage value.

### 2.3.3 Aboriginal heritage

The aboriginal heritage assessment was undertaken as a desk-top investigation by Andrew Long and Associates. A search of the existing records provided the following results:

- No listings on the Register of the National Estate
- One registered Aboriginal cultural heritage place on the Victorian Aboriginal Heritage Register:
- Artefact Scatter 7822 1147–SC3 E 298766; N 5804857 – flat basalt plain
- No listings on the Victorian Aboriginal Places Register.

The site of the artefact scatter is shown on Figure 2.5. It is very close to the alignment of the existing Maltby Bypass and should not pose a major constraint on development in the Precinct.

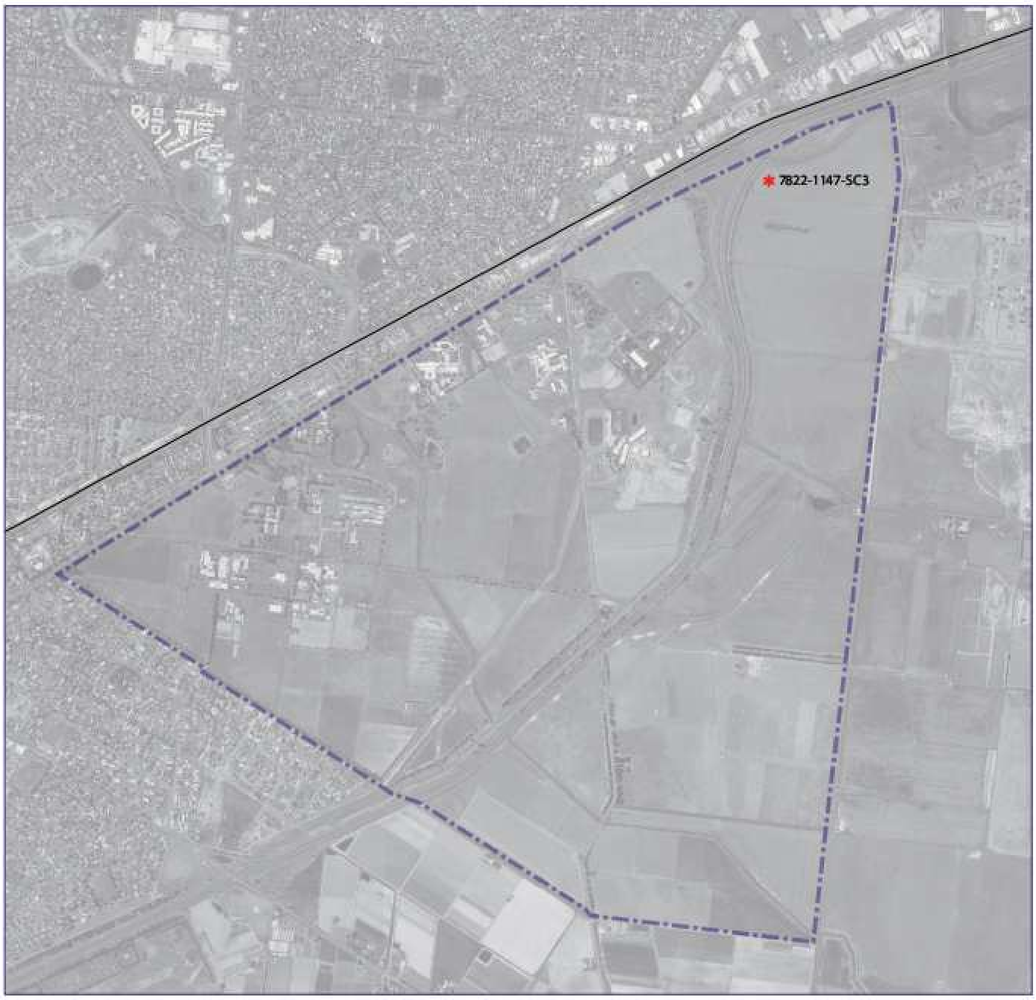


Figure 2.5: Aboriginal heritage assessment results.

## 2.4 Geology

The Werribee Employment Precinct is situated on Werribee River Delta deposits and Newer Volcanic known as the Werribee River Basin[6]. Soil profiles at the site consist of a thin upper layer of windblown and clayey silts (up to 2.1 m thick). A layer of residual basaltic clay (thickness up to 5.2 m) underlays the silt. Weathered basalt is found at depths greater than 0.7 m under the silt and clay layers. Large areas of the site are flat with poor drainage characteristics.

## 2.5 Groundwater

The site is located above a shallow aquifer (0 to 23 m in depth) that is linked to the Werribee Irrigation District (WID)[7]. The aquifer has a surface at about 10 m AHD within the Werribee Employment Precinct and generally flows towards Port Philip Bay and Werribee River. A majority of the aquifer currently has a brackish to saline water quality with total dissolved solids readings ranging from 1,170 to 3,270 mg/L. Groundwater from this aquifer is currently unsuitable for irrigation. The quality and volume of groundwater in the aquifer has declined in recent times – note that the WID is currently subject to zero allocation for irrigation.

The groundwater surface levels and salinity in the three groundwater bores nearest to the Werribee Employment Precinct (59528, 145270 and 59522) are shown in Figure 2.6 and the locations of these bores are shown in Figure 2.7.

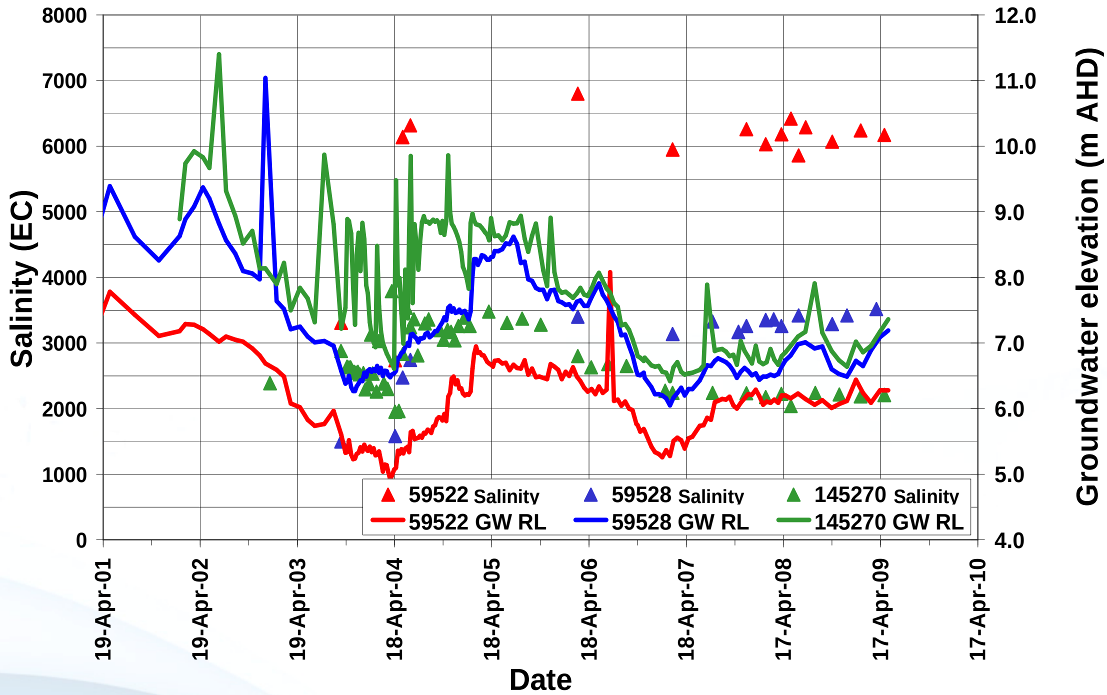


Figure 2.6: Sequence of groundwater surface levels and salinity near the Werribee Employment Precinct – GW RL denotes groundwater surface level

[6] GeoAust (2009). Preliminary geotechnical assessment of the Werribee Employment Precinct
[7] SKM (2005). Werribee Irrigation District groundwater investigations

Figure 2.6 shows that ground water surface levels have declined at all locations since April 2001. The salinity levels (as measured using electrical conductivity) at the bore location 59528, which is a similar distance from the coast as the Werribee Employment Precinct, range from 1,500 ms to 3,520 ms. Ground water surface levels are lower and salinity levels higher at locations closer to Port Phillip Bay as shown for bore 59522.

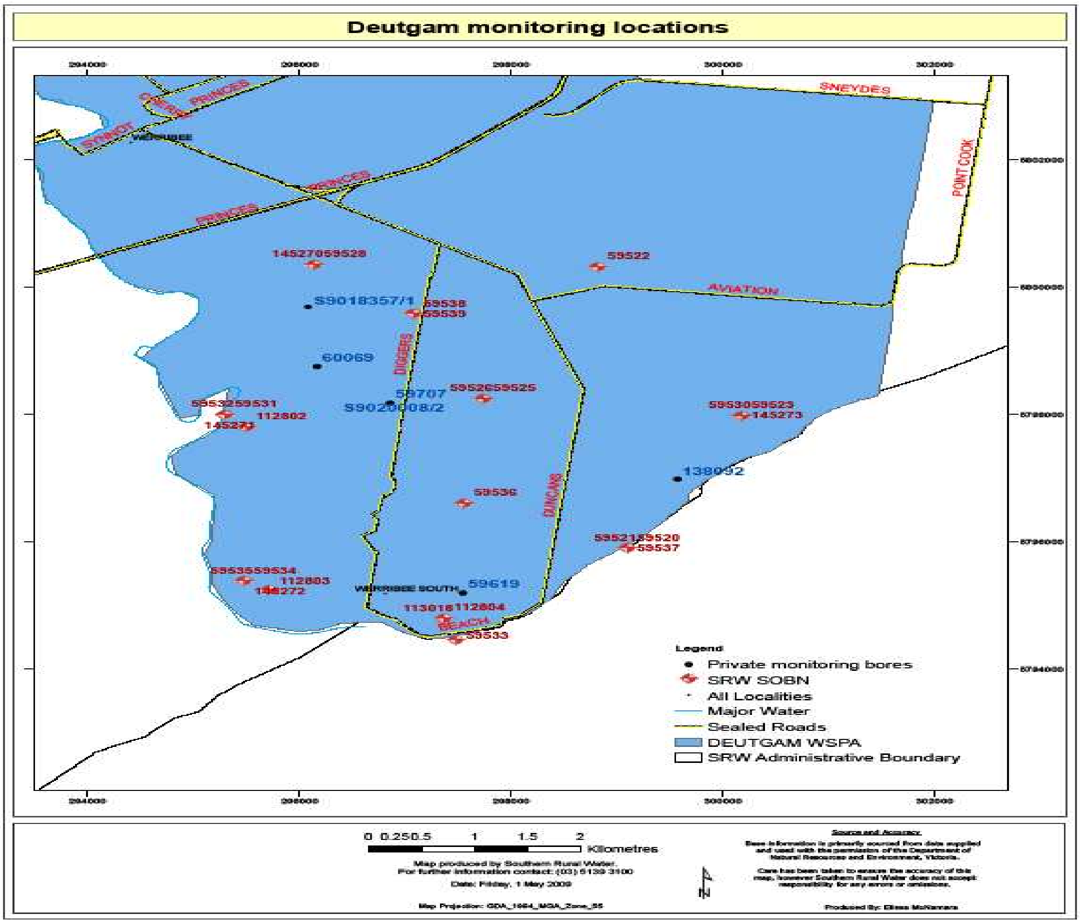


Figure 2.7: Map of bore locations provided by Southern Rural Water

There is potential to inject treated stormwater with lower salinity into the aquifer at the Werribee Employment Precinct in an Aquifer Storage and Recovery (ASR) scheme. This process can improve the salinity levels of the aquifer in the vicinity of the Precinct whilst storing water for use within the Precinct. This process can be successful provided that the balance of recharge to the aquifer and extractions are maintained over a year. Southern Rural Water is responsible for the management of aquifers and licensing of water extractions.

## 2.6 Climate processes

Australia experiences one of the most variable climate regimes on the planet. The extreme natural variation of the continent's climate includes cyclic patterns of droughts and floods throughout recorded history. These variable climatic patterns have resulted in a requirement for very large water storages. For example the capacity of dams supplying Australian cities is more than three times the capacity of dams supplying similar sized cities in Europe and North America.

An understanding of the temporal and spatial variation of climate processes is essential for the development of adequate water cycle management strategies and associated infrastructure. The need to effectively include climate processes in analysis of water resources has increased with the onset of climate change. It is now widely understood that the earth's climate system has been subject to significant warming that will increase the variability of climate processes.[8]

Long term sequences of rainfall at selected locations near Werribee were examined to understand the natural variation of rainfall including the cycle of wet and dry periods which may better describe rainfall processes than speculation about rapid climate change. This phenomenon is known as hydrological persistence.[9] The annual rainfall sequence for Werribee is shown in Figure 2.8.

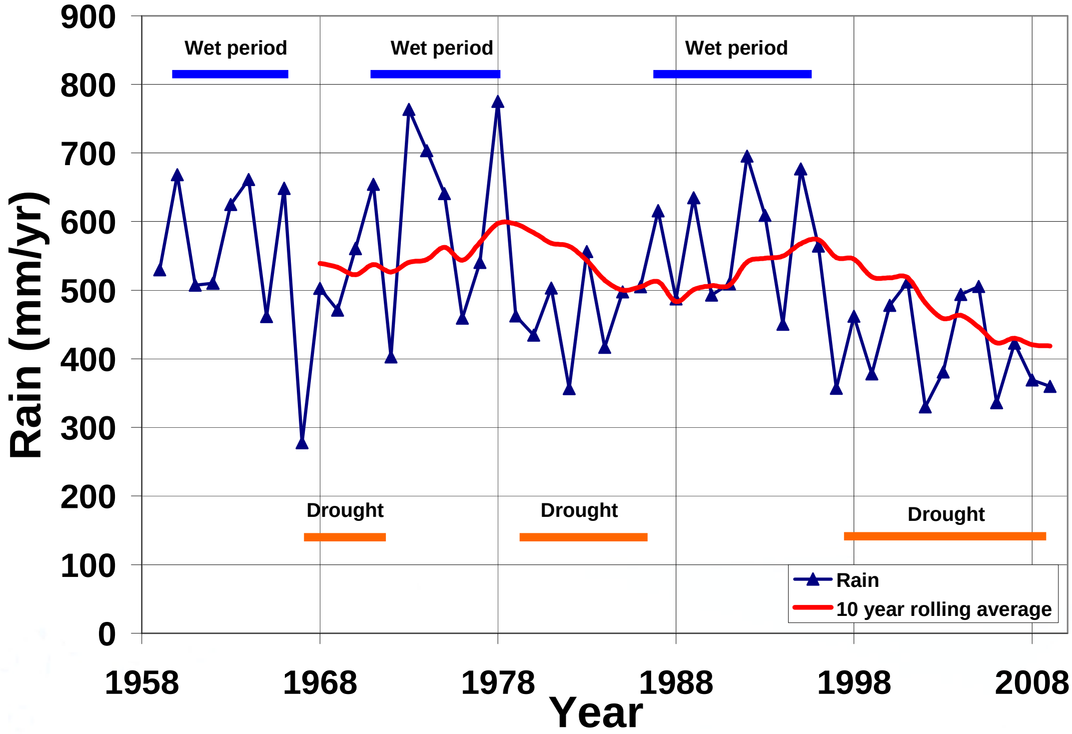


Figure 2.8: Annual sequence of rainfall at Werribee

Figure 2.8 shows that the relatively short rainfall record for Werribee includes three drought periods, including the current drought, and three wet periods. Note that the rainfall record includes the decade of highest rainfall on record (1970s) common to most rainfall locations in Australia which in combination with the current drought creates a perception of declining rainfall. However, this short rainfall record does not provide any certainty about trends in rainfall. The seasonal patterns of rainfall and temperature at Werribee are shown in Figures 2.9 and 2.10 respectively.

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[8] DSE (2008). Climate change in Victoria: 2008 summary – the Victorian climate change adaptation program.
[9] Whiting J., M. Lambert and A. Metcalf (2006). Identifying persistence in rainfall and streamflow extremes and other hydrological variables. 30th Hydrology and Water Resources Symposium. Engineers Australia. Launceston, Australia.

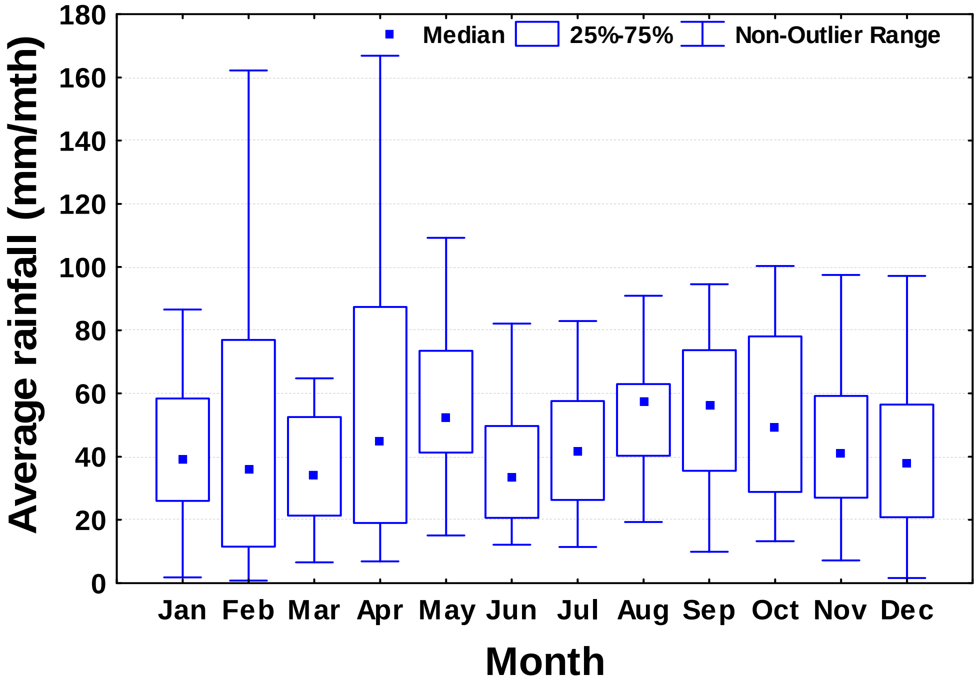


Figure 2.9: Average monthly rainfall at Werribee

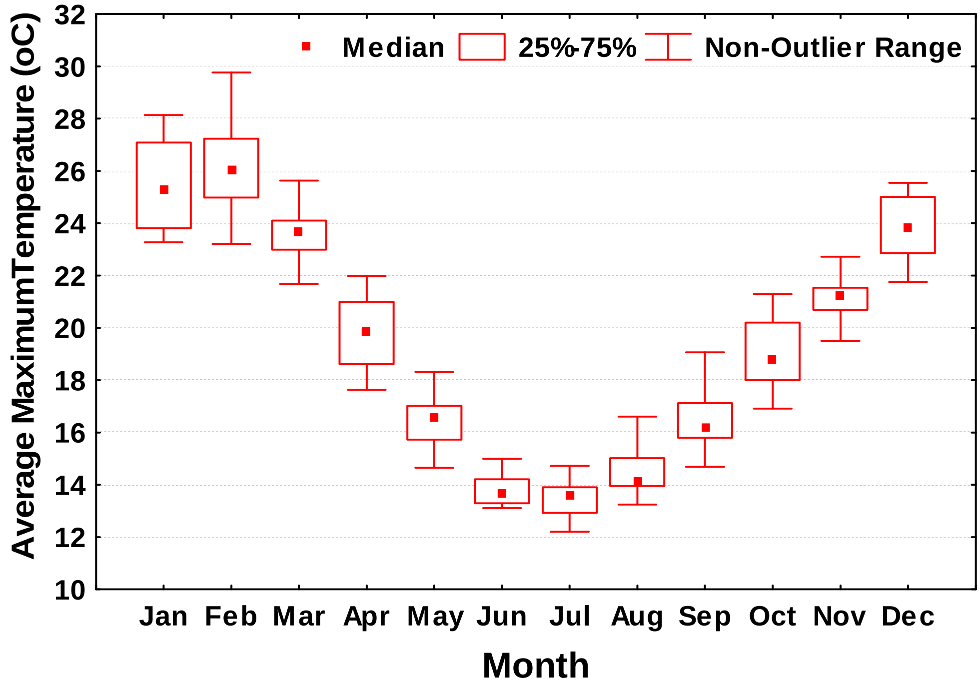


Figure 2.10: Average monthly temperature at Werribee

Figure 2.9 shows that the Werribee area is subject to a relatively even distribution of rainfall throughout the year with higher rainfall during the Spring and Autumn seasons. Figure 2.10 reveals that monthly average temperatures range from greater than 25°C in Summer to less than 14°C in Winter.

The impacts of drought and perhaps climate change on the Werribee area are demonstrated by an increase in temperature of 0.4°C during the last decade (1998 to 2007) in comparison to a thirty year average (1961 to 1990).[10] The region has also been subject to a 14% decrease in annual rainfall during the decade in comparison to the 30 year period (1961 to 1990). However, the 30 year reference period includes the decade of highest rainfall on record. It is likely that the temperature increases in the area represent the impacts of climate change. The longer sequence of annual rainfall at nearby Melton is shown in Figure 2.11 to provide greater certainty about trends in rainfall.

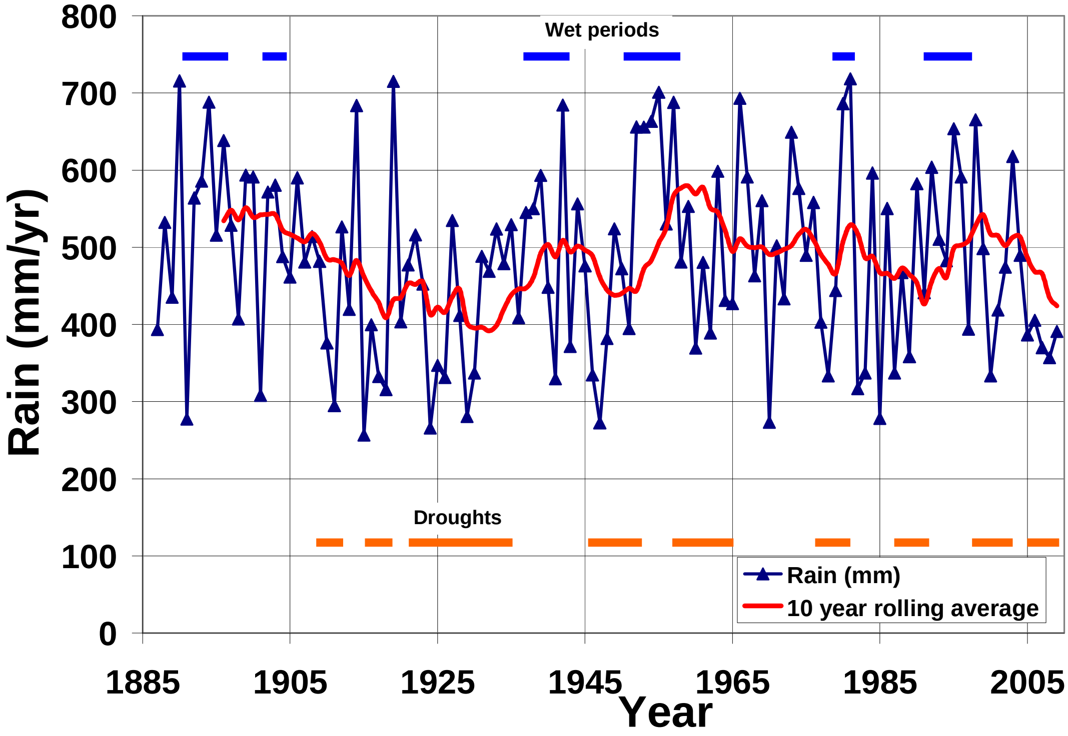


Figure 2.11: The longer annual rainfall sequence at Melton

Figure 2.11 reveals the Melton area has been subject to cycles of higher and lower rainfall over a 124 year period. The lower rainfall periods indicate that the drought around 1925 was more severe than the current one. In addition, the rainfall record does not suggest a recent step change to a lower rainfall regime.

Importantly, there is sufficient rainfall available throughout the record to guarantee significant yields from stormwater and rainwater harvesting. The annual rainfall record at Little River which is 18 km south-west of Werribee is shown in Figure 2.12 for another comparison.

[10] DSE (2008). Climate change in Port Phillip and Western Port. The Victorian climate adaptation program.

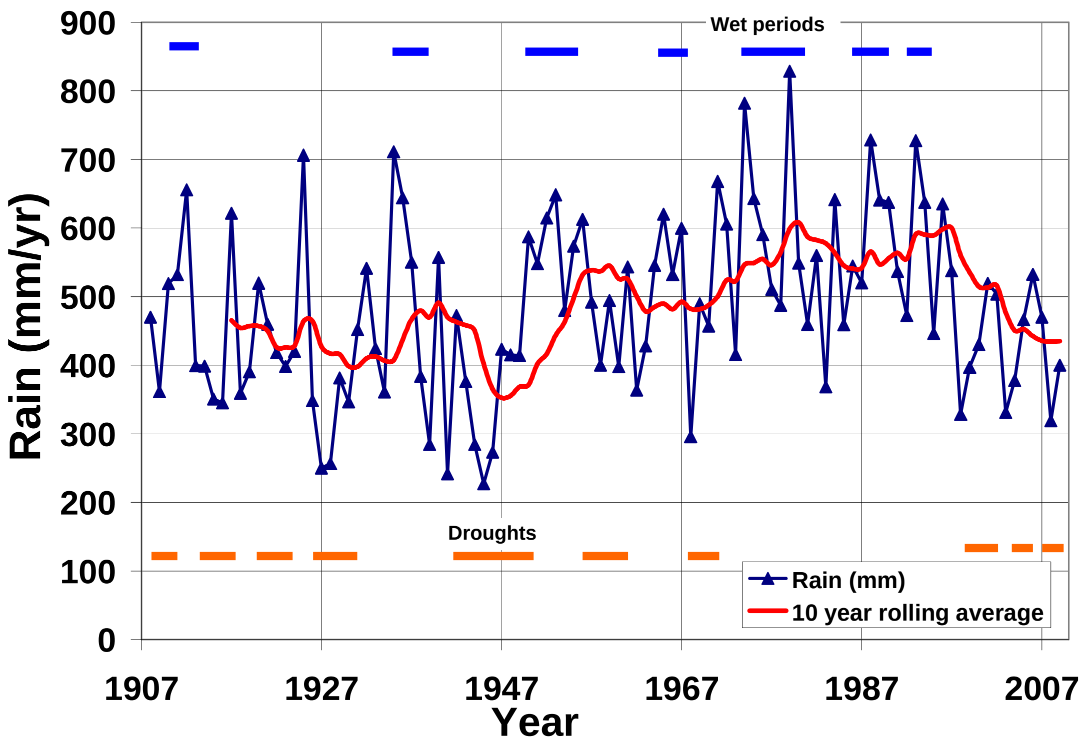


Figure 2.12: The longer sequence of annual rainfall at the Little River

Figure 2.12 reveals the Little River area was also subject to cycles of higher and lower rainfall during the 100 year record. The lower rainfall periods during the 1920s and 1940s indicate that this area has also experienced droughts more severe than the current one. The rainfall record also does not provide evidence of a recent step change to a lower rainfall regime in the record. There is also sufficient rainfall available throughout the record for significant yields for rainwater and stormwater harvesting from urban catchments.

## Climate processes

The longer rainfall records from Little River and Melton demonstrate the inherent natural variability of rainfall in the region. It will be important to incorporate this variability in the analysis of the integrated water cycle management at the Werribee Employment Precinct. This can be achieved by using the most relevant long sequence of rainfall to capture the natural variability of rainfall patterns whilst overlying the expected patterns of climate change.

This approach to analysis of water cycle management strategies for the Werribee Employment Precinct will have the best potential to identify solutions that are resilient to the potential impacts of climate change. The approach captures the uncertainty about the different aspects of climate change and underlying variability – we are fairly certain about increases in temperature but far less certain about impacts on rainfall regimes.

## 2.7 Security of regional water supplies and relative catchment efficiency

Until recently, the majority of water supplied to Australian cities has been runoff collected from inland catchments along with some groundwater. Australia experiences a highly variable climate that has required the construction of large dams to provide a secure water supply to cities. The future reliability of urban water supplies dependent on these traditional centralised sources of water is uncertain due to the combined pressures of population growth, a highly variable climate and the potential for climate change. It is now recognised that more diverse sources of water from centralised and decentralised locations in combination with a diverse range of water conservation strategies can increase the resilience and reliability of a city's water supply.[11]

The water harvest efficiency of the inland water supply catchments is considerably less than from roofs and paved surfaces in urban areas.[12] It has also been shown that in dry years (rainfall < 500 mm) the annual runoff in water supply catchments is often insignificant. In these years water losses to the soil and atmosphere account for most of the rainfall, and as a result water supplies to cities are almost totally dependent on deep seepage and water stored in dams from more bountiful years. In contrast urban catchments, being mostly impervious, only experience small evaporation losses at the commencement of each rain event and the majority of rainfall becomes runoff. This is available for harvest up until storage overflow. As a result, urban catchments can generate highly beneficial volumes of water even during drought years.

This result suggests that rainwater and stormwater harvesting in cities can supplement the performance of hinterland dams providing an overall improvement in the resilience of urban water supplies. The concept of relative catchment efficiency is shown in Figures 2.13 and 2.14 using the Thomson catchment suppling Melbourne as an example.[13]

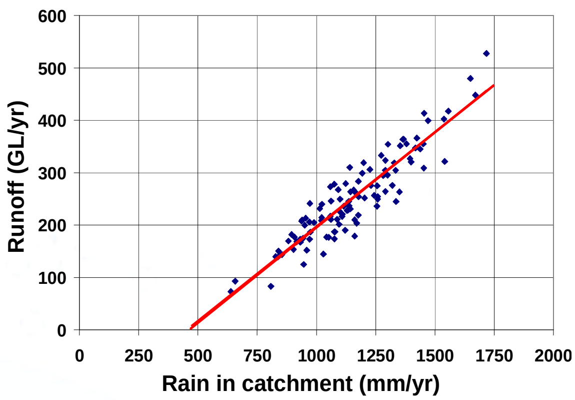


Figure 2.13: Efficiency of Thomson Dam supplying Melbourne

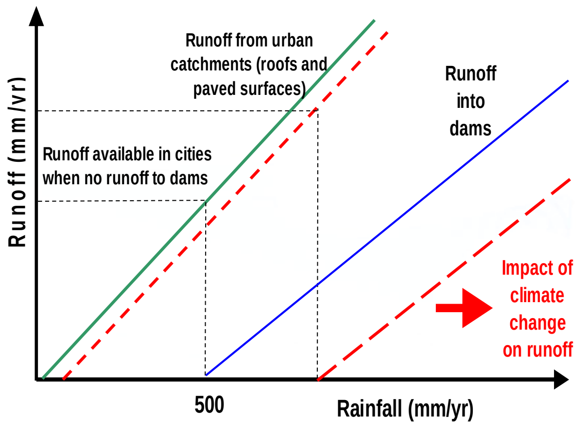


Figure 2.14: Conceptual relative catchment efficiency

[11] PMSIEC (2007). Water for our cities – building resilience in a climate of uncertainty. A report by the Prime Minister's Science, Engineering and Innovation Council working group. The Australian Government. Canberra.
[12] Coombes P.J., and G. Kuczera, (2003). Analysis of the performance of rainwater tanks in Australiancapital cities. Proceedings of the 28th International Hydrology and Water Resources Symposium. Wollongong, Australia.
[13] Coombes P.J. and M.E. Barry (2008). The relative efficiency of water supply catchments and rainwater tanks in cities subject to variable climate and the potential for climate change. Australian Journal of Water Resources. Engineers Australia. 12(2)

Figure 2.13 shows that runoff into Thomson Dam supplying Melbourne diminishes considerably at lower annual rainfall depths to a threshold of no runoff at an annual rainfall of about 500 mm. Figure 2.14 indicates that during years of limited runoff into dams a significant volume of rainwater can still be harvested from urban catchments. Urban catchments are expected to have a high relative efficiency for harvesting rainwater and stormwater in comparison to natural catchments supplying dams. In addition, the impact of climate change is expected to decrease the efficiency of inland water supply catchments relative to catchments within a city because increases in temperature are likely to cause increased evapotranspiration losses.

## 2.8 Greenhouse gas emissions

The planned water future for Greater Melbourne and most Australian capital cities is dependent on high energy strategies including desalination and transport of water across long distances. It is very important to recognise and account for the full energy costs of augmentation strategies for regional water supplies including desalination and long distance transport of water. Our plans to mitigate the impacts of climate change must avoid creating further increases in the causes of climate change by the adoption of high energy strategies.

An accurate comparison of energy impacts must assign green energy to all water strategies or assume that all water strategies do not have access to green energy. In either case the energy profiles must be compared to determine the relative requirement for green energy or the relative greenhouse gas emissions. It is expected that greenhouse gas emissions from Greater Melbourne's planned water future will be greater than 4,900 kg/ML.[14]

## 2.9 Downstream impacts

The Werribee Employment Precinct is situated south of Skeleton Creek and to the north of Werribee River. The majority of stormwater runoff from the site discharges towards Port Philip Bay via the "D1 Drain" and a small proportion of the Precinct discharges towards Skeleton Creek. The "D1 Drain" passes through emerging urban developments and farmlands before discharging to Port Philip Bay near the Point Cook airfield.

Some of the stormwater runoff from the Precinct (discharge points B and C in Figure 2.1) enters the Point Cook drainage scheme which passes through new urban development areas (current being constructed) and remnant brackish wetlands en route to Port Phillip Bay.

Port Philip Bay has been identified as nitrogen limited. Since European settlement the quality of stormwater runoff in waterways discharging to Port Philip Bay has changed significantly due to agricultural, urban and industrial development. Stormwater runoff has been identified as one of the major sources of nitrogen in Port Philip Bay. The Point Cook and Cheetham area of the western shoreline of Port Philip Bay have been identified as a RAMSAR site which supports migratory birds.

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[14] CSIRO (2008). Water – energy futures for Melbourne: the effect of water strategies, water use and urban form. Kenway S.J., Turner, G.M., Cook, S., and Baynes T. Water for a healthy country flagship report.

It is important to manage the quality and quantity regime of stormwater runoff discharging from the Werribee Catchments and from the Werribee Employment Precinct to protect and enhance the values of the western shores of Port Philip Bay.

The regimes of stormwater flows toward Port Philip Bay have been profoundly altered by the Historical Sewer, The Western Trunk Sewer and the Maltby Bypass which act to reduce stormwater discharges to considerably less than pre-European levels. This has restricted the availability of water to downstream areas including the Werribee Irrigation District. Use the remaining water resource by downstream properties that hold licenses to use stormwater from the D1 Drain system is also limited by the poor quality of the water due to pollution from upstream sources.

# 3 Methods

This study has utilised an integrated systems approach to analysing the performance of a range stormwater and water cycle management options for the Werribee Employment Precinct. This type of analysis is dependent on detailed inputs including topography, climate, hydrology, hydraulics and sound urban design principles to create an efficient water cycle management strategy.

The topography of the Werribee area was derived from photogrammetry and LiDar data provided by the Department of Sustainability and Environment, Melbourne Water and augmented with field survey data. The layout, topography and geology of the catchments were incorporated into a digital terrain model (DTM). Information about existing conditions at the site and in the upstream catchments was sourced from Wyndham City Council and Melbourne Water, and verified by field inspections and surveys.

A preliminary conceptual development plan for the Precinct was provided by the Department of Planning and Community Development. This allowed assessment of the density of development, proportions of impervious surfaces and water demands. It is important to have an interactive process between urban planners and the designers of water cycle systems to identify the often hidden benefits of integrated water cycle management (IWCM) and water sensitive urban design (WSUD).

This study used a hydrological model (WUFS) from the University of Newcastle and a two-dimensional hydraulic model (TUFLOW) to analyse the stormwater runoff and flood extents generated by different options. The WUFS model is a variant of ILSAX that utilises the accepted methods and design storm events published in Australian Rainfall and Runoff by Engineers Australia.

This model was chosen because it is the only software package that has the capability for robust analysis of integrated stormwater design strategies such as combinations of WSUD and traditional drainage methods. For comparison purposes, a parallel simulation of the hydrology at the site was undertaken using the RORB hydrology model that is mostly used by Melbourne Water.

Analysis of the extent of flooding generated by 100 year average recurrence interval (ARI) storm events was conducted using the hydraulic model TUFLOW that utilised the digital terrain model (DTM) and stormwater runoff hydrographs for each catchment generated by the WUFS model. The results from the analysis of flooding were mapped using the vertical mapping functionality provided with the geographical information systems (GIS) software Mapinfo. The schematics of the various networks used in this study are shown in Appendix 3A.

## 3.1 Stormwater quality

A comparative analysis of stormwater quality at key locations within the Werribee Employment Precinct was integrated with the hydrological simulations. Four key reference locations at Upper Skeleton Creek (D), Upper Point Cook (B and C) and Werribee Employment precinct (A) were nominated for assessment of stormwater quality targets (see Figure 2.1). The modeled configurations of the stormwater networks used in this analysis are shown in Appendix 3B.

Analysis of the impacts of urban development on waterway ecosystem health was conducted using the continuous simulation model MUSIC from eWater CRC and the hydrological model. The MUSIC model was used to analyse each stormwater management option in regard to:

- Stormwater quality,
    - Total Suspended Solids
    - Total Phosphorus
    - Total Nitrogen
    - Gross Pollutants
- Average annual runoff volumes, and
- Frequency of stormwater runoff as indicated by average annual runoff days.

Stormwater quality measures were designed using MUSIC to meet "best practice" targets described in Section 4. The hydrological model was used to determine a no worsening of stormwater peak discharges for 1 and 2 year ARI storm events to protect waterways from erosion and sedimentation. These design parameters serve the dual purpose of protecting waterway health and improving the amenity of waterways. Two rainfall records were utilised in the analysis of stormwater quality to account for different climate regimes in the area as shown in Table 3.1.

Table 3.1: Rainfall records used in the analysis of stormwater quality and flows

| Record | Start date | End date | Annual rainfall (mm/yr) | Length (years) |
|---|---|---|---|---|
| Werribee | 7/05/1968 | 29/06/1980 | 586 | 12 |
| Drome Paddock | 1/01/1998 | 20/04/2009 | 388 | 10 |

The 6 minute rainfall record from Werribee is normally used in analysis of stormwater management in the Werribee area but this record represents a decade of the highest rainfall on record. In order to capture lower rainfall regimes a 6 minute rainfall from nearby Drome Paddock (see Figure 3.1) provided by Melbourne Water was also used to analysis stormwater management strategies.

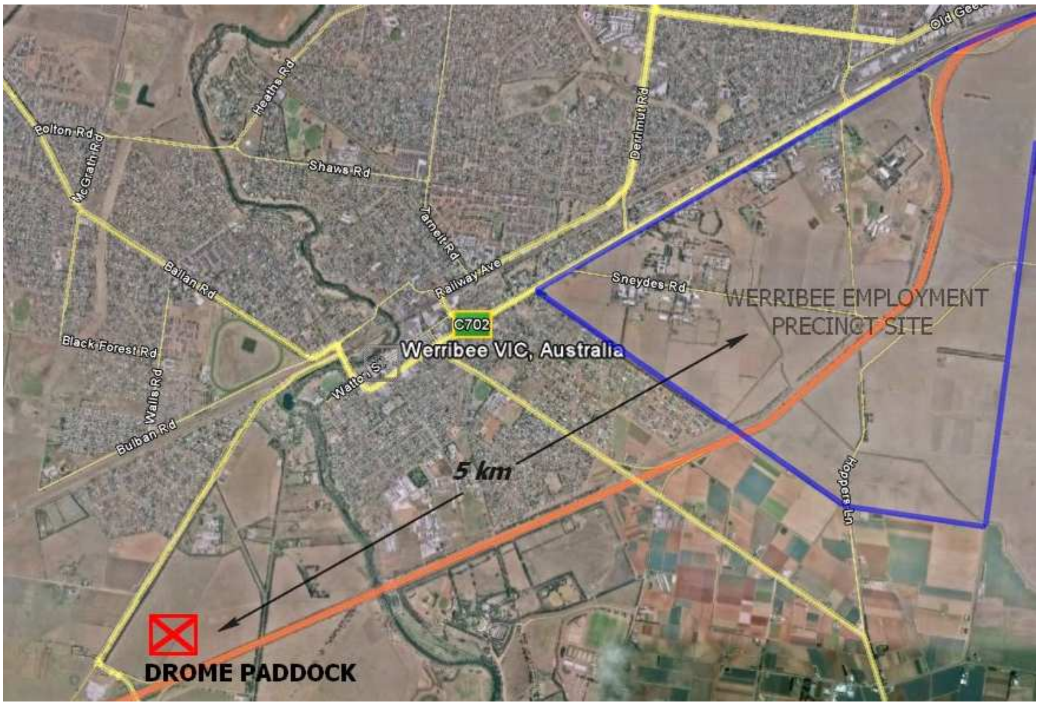


Figure 3.1: Location of Drome Paddock continuous rainfall gauge

## 3.2 Topography and existing infrastructure

The topography of the Werribee area was derived from photogrammetry and LiDar data provided by the Department of Sustainability and Environment, Melbourne Water and augmented with field survey data. The topography, geology and catchments of the area were combined in a digital terrain model (DTM).

This information was analysed using the 12D civil design package and Mapinfo Vertical Mapper to create a DTM with 3 metre grid spacing for the site. A fine grid of topographical information was required to adequately capture the variable terrain and low lying areas. Continuous elevation strings were included in the model to account for significant features including road structures, channels and embankments.

Details of existing stormwater infrastructure (including culverts, wetlands and detention basins) in the Werribee Employment Precinct and in the surrounding Werribee catchments were sourced from Wyndham City Council, the Department of Sustainability and Environment, Melbourne Water and from the infrastructure report prepared by ARUP. Additional information to complete the understanding of existing infrastructure and conditions was obtained from field inspections. The digital terrain model of the Werribee Employment Precinct is shown in Figure 3.2.

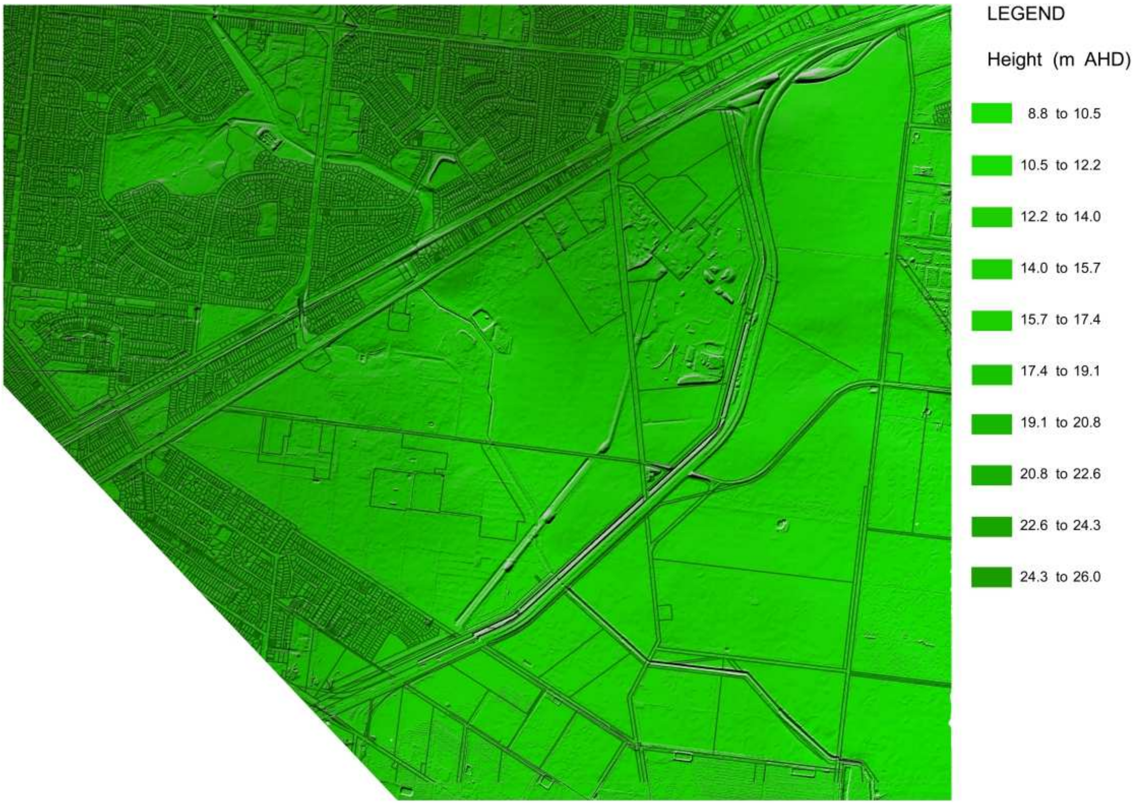


Figure 3.2: Digital terrain model and the cadastre at the Werribee Employment Precinct and surrounding area

## 3.3 Hydrology

It was an objective for this study that the development should not detrimentally affect stormwater runoff volume or quality characteristics. The assessment of the stormwater runoff characteristics of the site in the existing and developed states was undertaken using WUFS (Water Urban Flow Simulator) developed at the University of Newcastle.[15] The stormwater networks utilised in this analysis are shown in Appendix 3C.

The WUFS program is the only reliable analysis tool available to industry that can compare traditional drainage solutions to water sensitive urban design solutions or analyse combinations of both. The WUFS software was until recently freely available to industry from the website www.eng.newcastle.edu.au/~cegak in a similar mode to the availability of ILSAX. Note that both ILSAX and WUFS are freeware that are recommended for research and investigation purposes. WUFS has been developed from the ILSAX algorithms. The more simplistic Rational Method calculations were not employed in this study (other than for calibration purposes) because this type of method does not account for the volumes of rainfall in storm events and the range of initial conditions that impact on stormwater runoff.

[15] Kuczera, G., Williams, B., Binning, P. and Lambert, M., (2000). An education web site for free water engineering software. 3rd International Hydrology and Water Resources Symposium. Institution of Engineers Australia. Perth. Western Australia. 1048 – 1053.

Using the WUFS model, the defined stormwater sub-catchments, and design storm parameters from Australian Rainfall and Runoff,[16] the performance of the stormwater sub-catchments was analysed. The intensity frequency duration (IFD) data used in the hydrology model to simulate the performance is shown in Table 3.2.

Table 3.2: IFD data for the Werribee Employment Precinct

| ARI (years) | Rainfall intensity (mm/hour) for a given duration (hours) | | |
|---|---|---|---|
| | **1** | **12** | **72** |
| **2** | 18 | 3.5 | 0.9 |
| **50** | 38 | 7 | 2 |

The WUFS model was calibrated to peak discharges in the pre-European option derived using the Rational Method at key locations within the Werribee Employment Precinct. The expected changes in rainfall intensity due to climate change have also been included in this analysis. Design storms were generated for all storm durations using a skew of 0.38 and temporal pattern region 1 as defined from Australian Rainfall and Runoff.

## 3.4 Hydraulic analysis

The extent of flooding from the fully developed Precinct was evaluated by employing outputs from the hydrological model in the two dimensional hydraulic model TUFLOW which utilised the digital terrain model (DTM) to analyse stormwater flows throughout the area. Results from the analysis were mapped using the thematic mapping processes in MapInfo.

TUFLOW is a one-dimensional (1d) and two-dimensional (2d) flood and tide simulation package. It simulates the complex hydrodynamics of floods and tides using the full 1d St. Venant equations and the full 2d free-surface shallow water equations. The hydraulic model TUFLOW simulates:

- A range of flooding considerations from major rivers to complex overland and piped urban flows;
- estuarine and coastal tide hydraulics; and
- inundation from storm tides.

TUFLOW combines both 1d and 2d equations within the same analysis. The 1d components include system assets such as streams, culverts and drainage reticulation whilst 2d components primarily include overland flows across the terrain. The inputs and outputs from TUFLOW are specifically linked to GIS systems and can be interfaced with a number of Graphical User Interfaces (GUI's).

[16] IEAust., (2001). Australian rainfall and runoff: a guide to flood estimation. Vols. 1 and 2. The Institution of Engineers, Australia.

## 3.5 Climate change

This study has adopted climate change scenarios derived by CSIRO[17] from recent IPCC[18] summaries of global climate models. The high emissions scenario has been adopted to account for the continuing growth in global emissions. Expected seasonal changes in temperature and rainfall will have a moderate impact on water balances including rainwater and stormwater harvesting, and stormwater quality. The climate change scenarios shown in Table 3.3 were used in the analysis of water balances.

Table 3.3: Estimated changes in temperature from the high emissions scenario

| Season | Change in temperature (°C) | | Change in rainfall (%) | |
|---|---|---|---|---|
| | 2030 | 2070 | 2030 | 2070 |
| Spring | +0.8 | +2.6 | -7 | -21 |
| Summer | +0.9 | +3.0 | -2 | -7 |
| Autumn | +0.8 | +2.6 | -2 | -5 |
| Winter | +0.7 | +2.1 | -4 | -11 |
| Spring | +0.8 | +2.6 | -7 | -21 |

Climate change is expected to increase rainfall intensity and have a significant impact on flooding at the site. The expected seasonal changes in rainfall intensity shown in Table 3.4 have been included in the analysis.

Table 3.4: Estimated changes in rainfall intensity resulting from climate change

| Season | Change in rainfall intensity (%) | |
|---|---|---|
| | 2030 | 2070 |
| Spring | +0.6 | +7.4 |
| Summer | +2.7 | +16.3 |
| Autumn | +1.1 | +7.0 |
| Winter | +2.3 | +17.0 |

The maximum increase in rainfall intensity of 17% in 2070 from Table 3.4 was used in the hydrological analysis of flooding to provide an upper bound approach to estimating the potential impacts of climate change. The minimum height at the site is greater than 8 m above mean sea level

[17] CSIRO (2007). Climate change in Australia. www.climatechangeinaustralia.com.au
[18] IPCC (2007). Fourth assessment report. www.ipcc.ch

and is, therefore, unlikely to be inundated by increased sea levels and stormwater surges resulting from climate change.

# 4 Objectives and Baselines

## 4.1 Objectives

In accordance with the vision for sustainable development of the Werribee Employment Precinct objectives and targets for water management are proposed. These objectives represent current best practice for source control, protection of the health and amenity of waterway ecosystems, mitigation of flooding and minimising the impacts on the water cycle (Table 4.1). The targets aim to mitigate water cycle impacts to pre-European levels where possible.

Table 4.1: Objectives or targets for water cycle management at the Werribee Employment Precinct

| Criteria | Objectives or targets |
|---|---|
| Effective Impervious areas | Not greater than 5% |
| Building form | Greenstar 6 or equivalent |
| Suspended solids | 80% reduction in average annual urban loads |
| Total phosphorus | 60% reduction in average annual urban loads |
| Total nitrogen | 45% reduction in average annual urban loads |
| Litter | No litter discharging to waterways |
| Peak stormwater discharges | Maintain all peak discharges at pre-European levels |
| Stormwater runoff days | Average annual days maintained at Pre-European levels |
| Water demands | Net self sufficiency |
| Sewage discharges | Net self sufficiency |
| Salinity | Return the salinity of waterways and soils to pre_European levels |
| Energy | No increase in energy demands in comparison to BaU |
| Carbon | Carbon neutral |
| Climate change | All water cycle systems resilient when subject to the high emissions scenario for 2070 |

The objectives in Table 4.1 include targets for stormwater flow regimes including average annual runoff days and average annual runoff volumes. Targets for stormwater quality include total suspended solids (TSS), total phosphorus (TP), total nitrogen (TN) and litter. The target for total nitrogen, in particular, is important for managing impacts on Port Philip Bay whilst stormwater quality and flow regime targets aim to protect waterways. Maintenance of 1.5 year average recurrence interval (ARI) storm events at pre-European levels will protect waterways from erosion and sedimentation.

Objectives for managing building form and limiting effective impervious areas are important for managing stormwater impacts and demands for water at source. Reductions in the effective impervious areas at the allotment or sub-precinct scale will mitigate impacts on waterway health[19]. Effective impervious area is defined as the impervious area that is directly connected to waterways via stormwater drainage systems.

It is proposed that flooding can be managed by limiting peak stormwater discharges to pre-European conditions. The ultimate objective for water demands and sewerage discharges is net self sufficiency assessed over a 10 year period. Thus net self sufficiency is attained when mains water demands of the site are balanced by water savings generated by the site.

A salinity target is included to mitigate the increasing salinity of groundwater, soils and waterways in the Werribee region (similar to many other parts of Australia). In particular, urban soil salinity has the potential to limit the amenity of urban areas and cause significant damage to infrastructure. The salinity target also includes the aim to restore the quality of water in the aquifer.

Targets for energy and carbon aim for no net increases in comparison to 2006 levels to mitigate the impact of urban development on future climate. The ultimate aim for a carbon neutral development with no increase in net energy demands embraces the challenge of minimising impacts of climate change. This action will set an example for future human settlements.

It is also proposed that all water cycle systems at the site are resilient when subject to high emissions (ultimate objective) scenarios in 2070. These objectives were endorsed by the members of the Inter-Agency Working Group to provide direction for this study.

## 4.2 Pre-European Baseline

Analysis of pre-European conditions included research into the likely historical surface catchments and stormwater flow paths to establish natural stormwater runoff regimes. These results are used as the basis for identifying "stretch" targets. The pre-European stormwater catchments are shown in Figure 4.1 and their areas are shown in Table 4.2.

[19] Walsh C.J. (2004). Protection of instream biota from urban impacts: minimize catchment imperviousness or improve drainage design? Marine and Freshwater Research. 55, 317-326.

Table 4.2: Areas of pre-European catchments

| Catchment | Area (ha) |
|---|---|
| 1 | 164.3 |
| 2 | 269.4 |
| 3 | 179 |
| 4 | 224.6 |
| 5 | 12.9 |
| 6 | 92.2 |
| 7 | 266.7 |
| 8 | 109 |
| 9 | 433 |

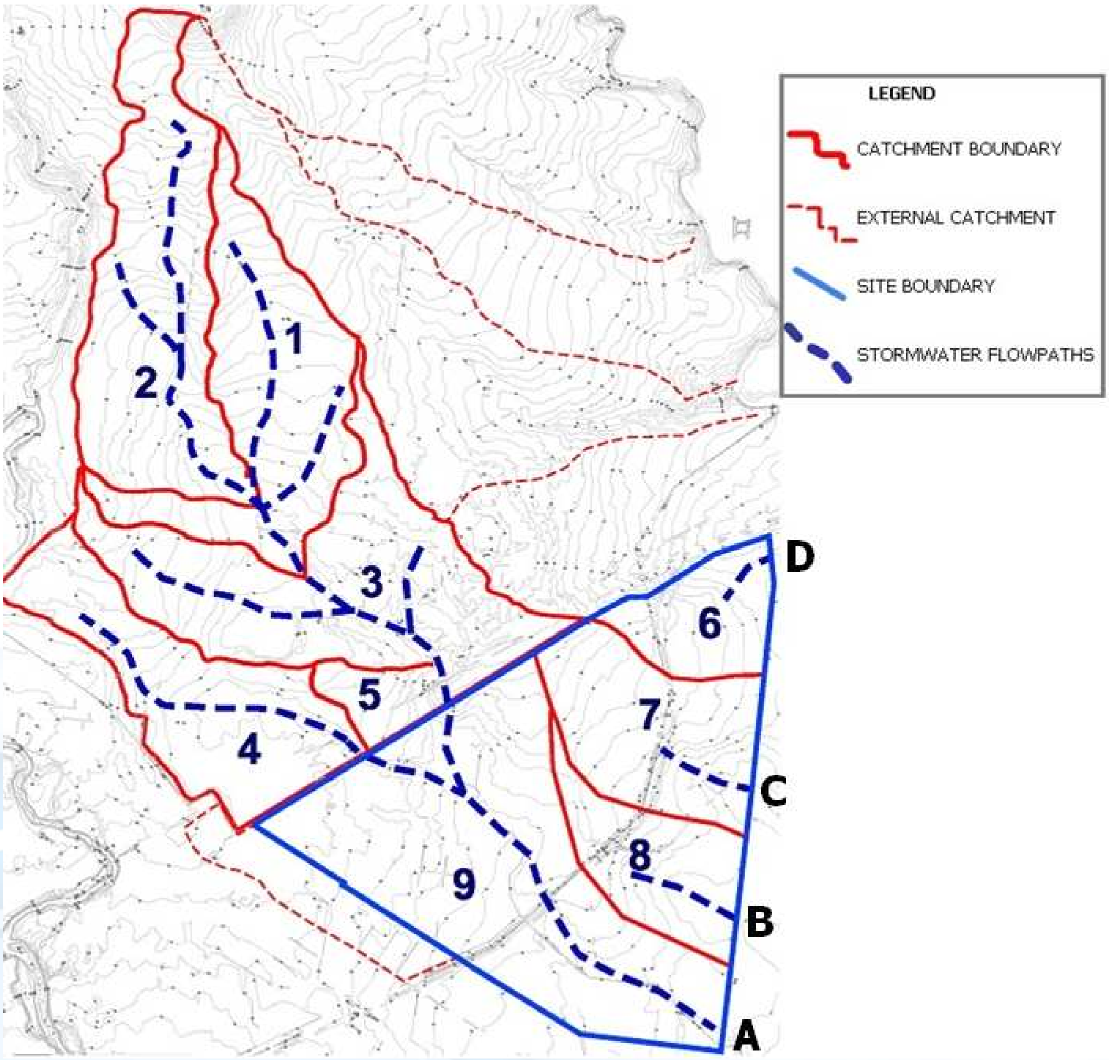


Figure 4.1: Pre-European stormwater catchments used in the analysis

The peak stormwater discharges derived for each of the outlets shown in Figure 2.1 using the Rational Method are shown in Table 4.3.

Table 4.3: Pre-European peak discharges from the Precinct

| ARI (years) | Antecedent Moisture Condition | Peak stormwater discharges at key locations ($m^3/s$) | | | |
|---|---|---|---|---|---|
| | | A | B | C | D |
| 1 | 3.9 | 2.9 | 0.3 | 0.7 | 0.3 |
| 2 | 2.9 | 4.8 | 0.5 | 1.1 | 0.4 |
| 5 | 2.5 | 7.7 | 0.8 | 1.8 | 0.7 |
| 10 | 2.3 | 10.1 | 1.0 | 2.4 | 0.9 |
| 20 | 2 | 13.3 | 1.4 | 3.1 | 1.2 |
| 50 | 1.6 | 17.9 | 1.8 | 4.2 | 1.6 |
| 100 | 1.1 | 22.4 | 2.3 | 5.3 | 2.0 |

Table 4.3 also reveals the antecedent moisture conditions (AMC) used to calibrate the WUFS model to Rational Method calculations for each ARI. Stormwater runoff quality and flow regimes for the pre-European catchments are shown in Tables 4.4 and 4.5.

Table 4.4: Stormwater runoff quality and flow regimes from catchments in pre-European conditions (using Werribee rainfall data)

| Location | Flow (ML/yr) | TSS (kg/yr) | TP (kg/yr) | TN (kg/yr) | GP (kg/yr) |
|---|---|---|---|---|---|
| A | 1,580 | 112,000 | 116 | 1,590 | 0 |
| B | 137 | 10,900 | 11 | 128 | 0 |
| C | 337 | 23,300 | 25 | 318 | 0 |
| D | 116 | 9,150 | 10 | 114 | 0 |

Table 4.4 shows that, using the Werribee rainfall data, the estimated average annual natural stormwater discharges from the Werribee Employment precinct total 2,170 ML/yr.

Table 4.5: Stormwater runoff quality and flow regimes from catchments in pre-European conditions (Drome Paddock rainfall data)

| Location | Flow (ML/yr) | TSS (kg/yr) | TP (kg/yr) | TN (kg/yr) | GP (kg/yr) |
|---|---|---|---|---|---|
| A | 783 | 51,700 | 55 | 726 | 0 |
| B | 68 | 4,390 | 5 | 62 | 0 |
| C | 166 | 11,000 | 12 | 155 | 0 |
| D | 57 | 3,820 | 4 | 53 | 0 |

Table 4.5 shows that, using the Drome Paddock rainfall data, the estimated average annual natural stormwater discharges from the Werribee Employment precinct total 1,014 ML/yr.

# 5 Existing Conditions

The site of the Werribee Employment Precinct is subject to stormwater runoff from a large urbanised catchment (1,097 ha) upstream of the site. Topography provided by Department of Sustainability and Environment (DSE) and Melbourne Water Corporation (MWC), and plans of the extent of drainage infrastructure provided by Wyndham City Council (WCC) enabled identification of the current urban stormwater sub-catchments discharging to the Precinct (Appendix 5A).

This information was combined with details for the Maltby Bypass provided by VicRoads to also identify stormwater sub-catchments within the Werribee Employment Precinct. Stormwater sub-catchments in the upstream area and in the Werribee Employment Precinct are shown in Figure 5.1.

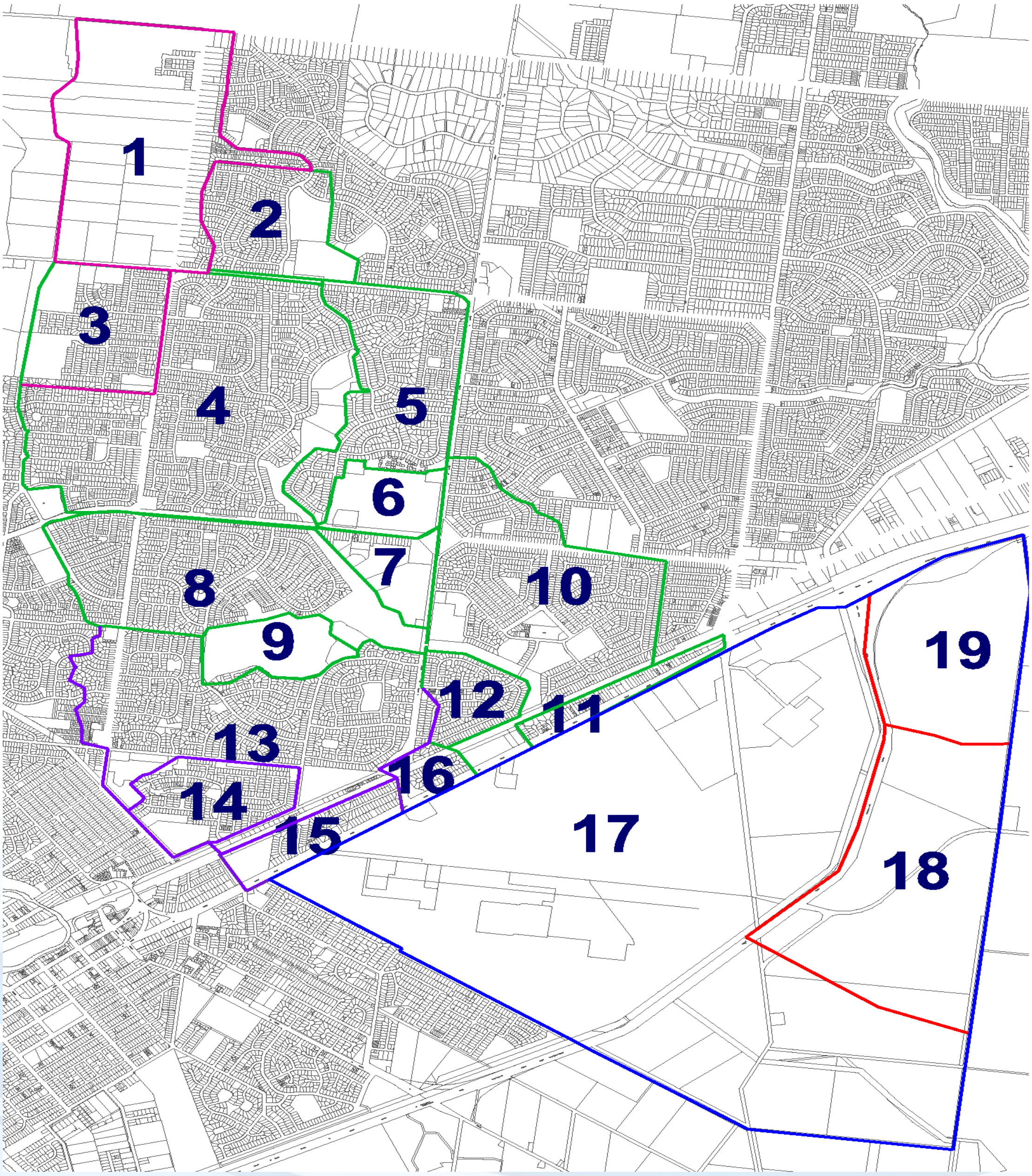


Figure 5.1 Stormwater sub-catchment boundaries under existing conditions

Figure 5.1 shows that the stormwater sub-catchments denoted 1 to 16 discharge to the Precinct and sub-catchments 17 to 19 are included in the Precinct. Sub-catchment 17 forms part of the Werribee Employment Precinct drainage scheme whereas sub-catchments 18 and 19 form part of the Point Cook and Skeleton Creek Schemes respectively (Appendix 5B).

## 5.1 Existing conditions in the upstream sub-catchments

Land uses in the upstream sub-catchments include residential housing, shopping centres, schools and road networks within the suburb of Werribee. The characteristics of these sub-catchments were identified by field inspections, from the Wyndham Planning Scheme and aerial photography as shown in Table 5.1.

Table 5.1: Characteristics of upstream stormwater sub-catchments

| Sub-catchment | Area (ha) | Impervious area (%) | Dominant land use |
|---|---|---|---|
| 1 | 110.4 | 20 | Mostly rural |
| 2 | 51.9 | 57 | Residential with schools |
| 3 | 70 | 60 | Residential |
| 4 | 163.4 | 54.5 | Residential |
| 5 | 89.5 | 60 | Residential |
| 6 | 23.9 | 95 | Werribee Plaza Shopping Centre |
| 7 | 21.7 | 55 | Mixed use development and school |
| 8 | 102 | 60 | Residential and detention basin |
| 9 | 28 | 10 | Glen Orden constructed wetland |
| 10 | 157 | 57 | Residential |
| 11 | 8 | 60 | Residential |
| 12 | 25.3 | 60 | Residential |
| 13 | 166.2 | 60 | Residential |
| 14 | 40.8 | 60 | Residential |
| 15 | 26.4 | 57 | Residential |
| 16 | 12.9 | 70 | Residential |

Table 5.1 shows the areas, proportion of impervious areas and dominant land uses of the sub-catchments as agreed with MWC. The upstream catchment includes shopping centres, mixed use development and schools that can generate significant pollutant loads that include litter and debris

during rain events.[20] In addition, the upstream catchment includes a detention basin located in the D1 Drain, an off-line constructed wetland at Glen Orden and a rural area that will soon be developed as low density urban settlement. The configuration of stormwater management infrastructure in the upstream catchments is shown in Figure 5.2.

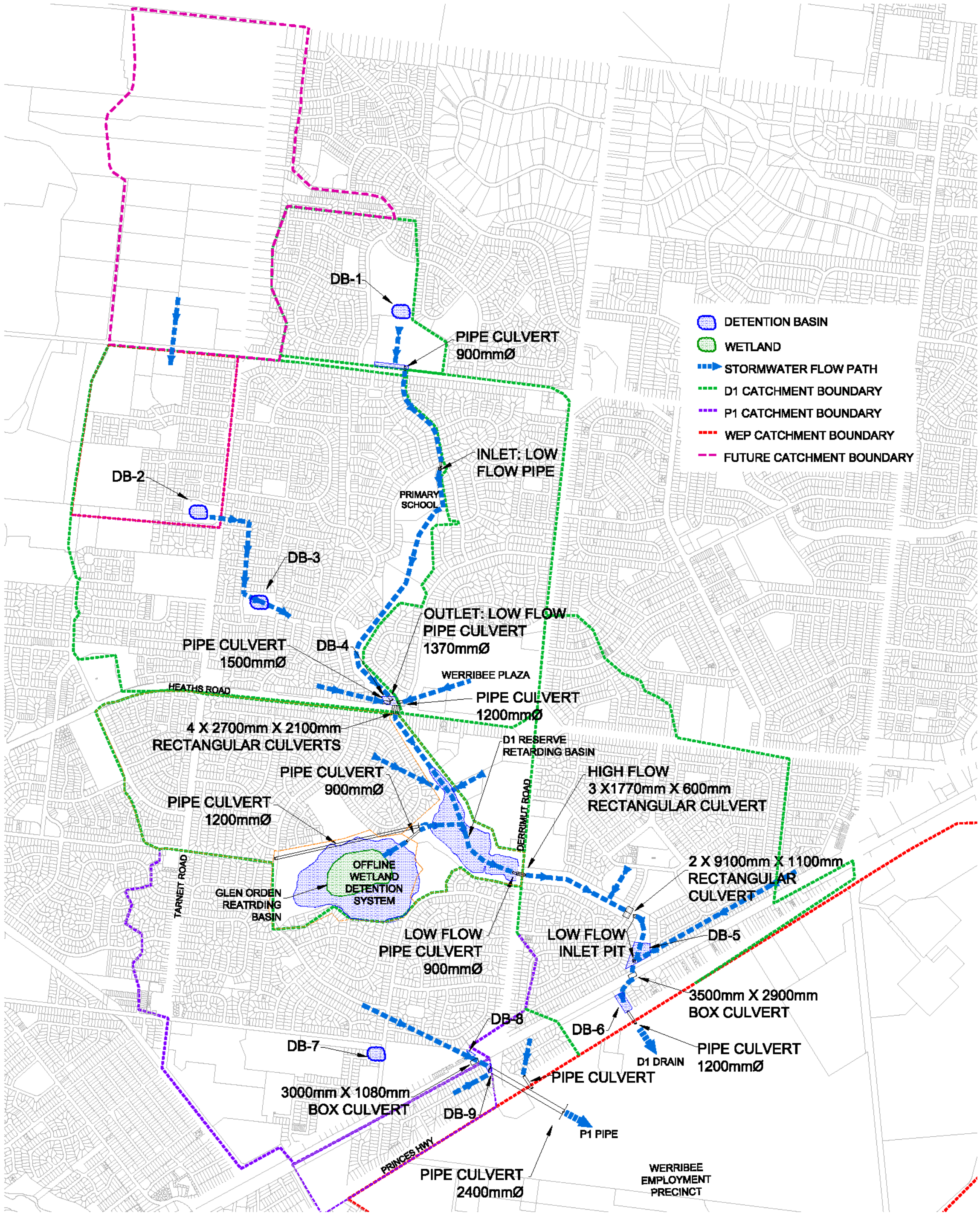


Figure 5.2 The existing stormwater infrastructure in the upper catchment

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20 Engineers Australia (2006). Australian Runoff Quality.

Figure 5.2 shows that two different urbanised catchments (denoted as D1 Drain and P1 Pipe) discharge to the Werribee Employment Precinct from the upstream area.

### 5.1.1 D1 Reserve and Glen Orden Wetland

The D1 catchment includes a drainage corridor that discharges to a detention basin located below Werribee Plaza that discharges under Derrimut Road towards the Precinct. This catchment also includes the offline constructed wetland known as Glen Orden that is not currently directly connected to any of the upstream stormwater sub-catchments.

The combined storage of the retarding basin and constructed wetland does not act to manage all upstream stormwater runoff from the D1 catchment. Field inspections, analysis of the topography and subsequent analysis using two dimensional hydraulic models indicate that the constructed wetland acts as an off-line system from the D1 drainage system that only manages a small part of the catchment. The confluence of the D1 Drain and the swale leading to the Glen Orden constructed wetland is shown in Figure 5.3, and the high flow culverts passing under Derrimut Road at the downstream extent of the D1 Drain Reserve retarding basin is shown in Figure 5.4.

Figure 5.3: Confluence of D1 Drain and swale leading to the Glen Orden constructed wetland

Figure 5.4: Culverts under Derrimut Road allowing high flow outlet from the D1 Drain Reserve

Figure 5.3 shows that the Glen Orden constructed wetland discharges via a grass swale to the online detention basin in the D1 Drain reserve. Thus the majority of the stormwater runoff from upstream catchments passes directly through the smaller online detention basin below Werribee Plaza. Nevertheless, the flat topography of the open space area that contains the retarding basin and constructed wetland systems may allow engineering works to ensure that the combined volumes in the open space is fully utilised to management stormwater runoff.

The storage capacity of the Glen Orden constructed wetland and the retarding basin in the D1 Drain Reserve was determined using detailed survey data provided by MWC and SMEC Urban, and 200 mm contours derived from LiDar provided by MWC (Appendix 5C). Storage volumes corresponding to different water levels are presented in Table 5.2

Table 5.2: Existing offline Wetland and D1 storage characteristics

| Water Level (m AHD) | D1 RESERVE Storage Volume ($m^3$) | WETLAND Storage Volume ($m^3$) | TOTAL Storage Volume ($m^3$) |
|---|---|---|---|
| 19.63 | Discharge under Derrimut Road via low flow pipe | | |
| 20.2 | 776 | | 776 |
| 20.26 | Stormwater enters wetland via 900mm pipe | | |
| 20.4 | 2,080 | 80 | 2,160 |
| 20.6 | 4,017 | 450 | 4,467 |
| 20.8 | 6,638 | 1,107 | 7,745 |
| 21 | 10,047 | 6,637 | 16,684 |
| 21.2 | 14,522 | 17,285 | 31,807 |
| 21.26 | Discharge under Derrimut Road via high flow culvert | | |
| 21.4 | 20,679 | 31,756 | 52,435 |
| 21.6 | 29,527 | 50,682 | 80,209 |
| 21.78 | Stormwater overtops bank at the wetland and D1 interface | | |
| 21.8 | 40,811 | 74,388 | 115,199 |
| 22 | 49,403 | 101,979 | 151,382 |
| 22.2 | 61,912 | 133,817 | 195,729 |
| 22.29 | Stormwater flows over Derrimut Road | | |

Table 5.2 reveals there is a complex relationship between the online detention basin in the D1 Reserve and the offline constructed wetland. Currently, stormwater discharges directly from the D1 reserve to the lower catchment via a low flow pipe until water depths reach an elevation of 20.26 m AHD. Then some of the stormwater surcharges (or backs up) into the Glen Orden constructed wetland via a 900 mm diameter pipe located in a weir.

When water levels reach an elevation of 21.26 m AHD stormwater discharges via the high flow culverts under Derrimut Road and at a depth of 21.78 m AHD stormwater overtops the weir separating the constructed wetland from the retarding basin. If the depth of stormwater exceeds an elevation of 22.29 m AHD stormwater flows over Derrimut Road.

### 5.1.2 Other Existing Retarding basins

The characteristics of the other existing retarding basins in the upstream catchment shown in Figure 5.2 are tabulated in Table 5.3. These are all considerably smaller than the D1 Reserve and the Glen Orden Wetland.

Table 5.3: Existing retarding basins in the upstream catchment

| Retarding basin | Surface area (m²) | Volume (m³) | Depth (m) |
|---|---|---|---|
| DB-1 | 2,172 | 1,955 | 0.9 |
| DB-2 | 13,133 | 9,850 | 0.75 |
| DB-3 | 13,133 | 9,850 | 0.75 |
| DB-4 | 4,048 | 8,500 | 2.1 |
| DB-5 | 9,455 | 10,400 | 1.1 |
| DB-6 | 3,009 | 3,310 | 1.1 |
| DB-7 | 2,398 | 4,100 | 1.71 |
| DB-8 | 803 | 1,790 | 2.23 |
| DB-9 | 1,810 | 3,981 | 2.2 |

The increasing impervious areas in the upper catchment have resulted in significant increases in stormwater runoff volumes and peak discharges to the Werribee Employment Precinct over time. The upper catchment was also expected to contribute considerable contaminant loads such as suspended solids, phosphorus, nitrogen and litter to the Precinct.

It is expected that infill development will further increase the imperviousness of the upper catchment resulting in larger stormwater runoff volumes and contaminant loads discharging to the site. There is a need for the application of a stormwater management policy in the upper catchments that does not permit increases in peak discharges and contaminant loads.

Responsibility for stormwater management in these catchments has recently passed from WCC to MWC. It is expected the MWC will act as the catchment and waterway manager, whilst WCC will continue to manage land use and local drainage systems within the catchments.

## 5.2 Existing conditions in the D1 Drain catchment within the Werribee Employment Precinct

The "D1" drain currently discharges stormwater from the upper catchment in Werribee through sub-catchment 17 within the Werribee Employment Precinct in a north south direction towards Port Philip Bay (Figure 5.5).

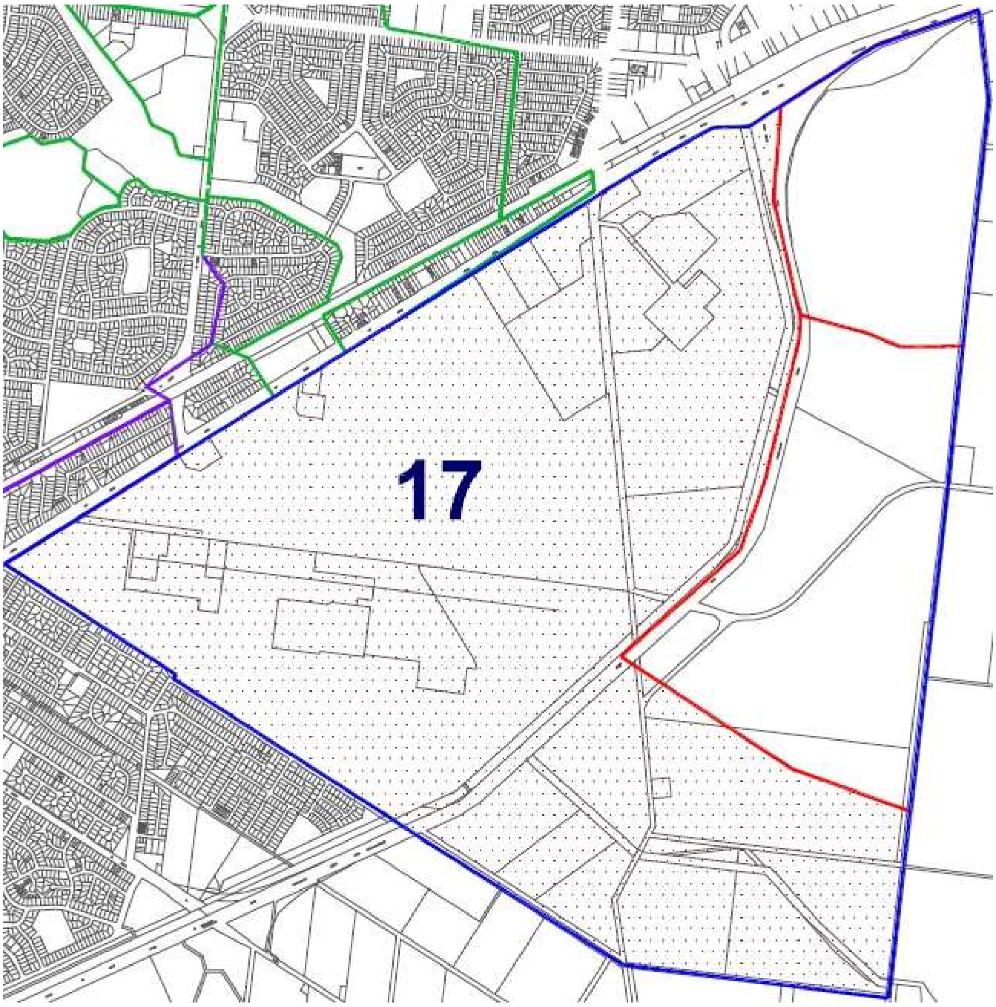


Figure 5.5: The existing sub-catchment of the D1 Drain within the Werribee Employment Precinct

Figure 5.5 shows that the boundaries of the stormwater sub-catchment contributing to the existing D1 Drain within the Werribee Employment Precinct include the western side of the Maltby Bypass, the southern border of the site and a ridge on the eastern side of the Maltby Bypass. The attributes of the D1 Drain sub-catchment within the Werribee Employment Precinct are listed in Table 5.4.

Table 5.4: Attributes of stormwater sub-catchment 17 under existing conditions

| Catchment | Area (ha) | Impervious area (%) |
|---|---|---|
| 17 | 680 | 16.25 |

Stormwater management and related infrastructure located in the Werribee Employment Precinct is shown in Figure 5.6. The Western Trunk Sewer and subsequently the historical sewer channel parallel to the Maltby Bypass both significantly impede stormwater flows in the D1 drain (see Appendix 5D).[21],[22]

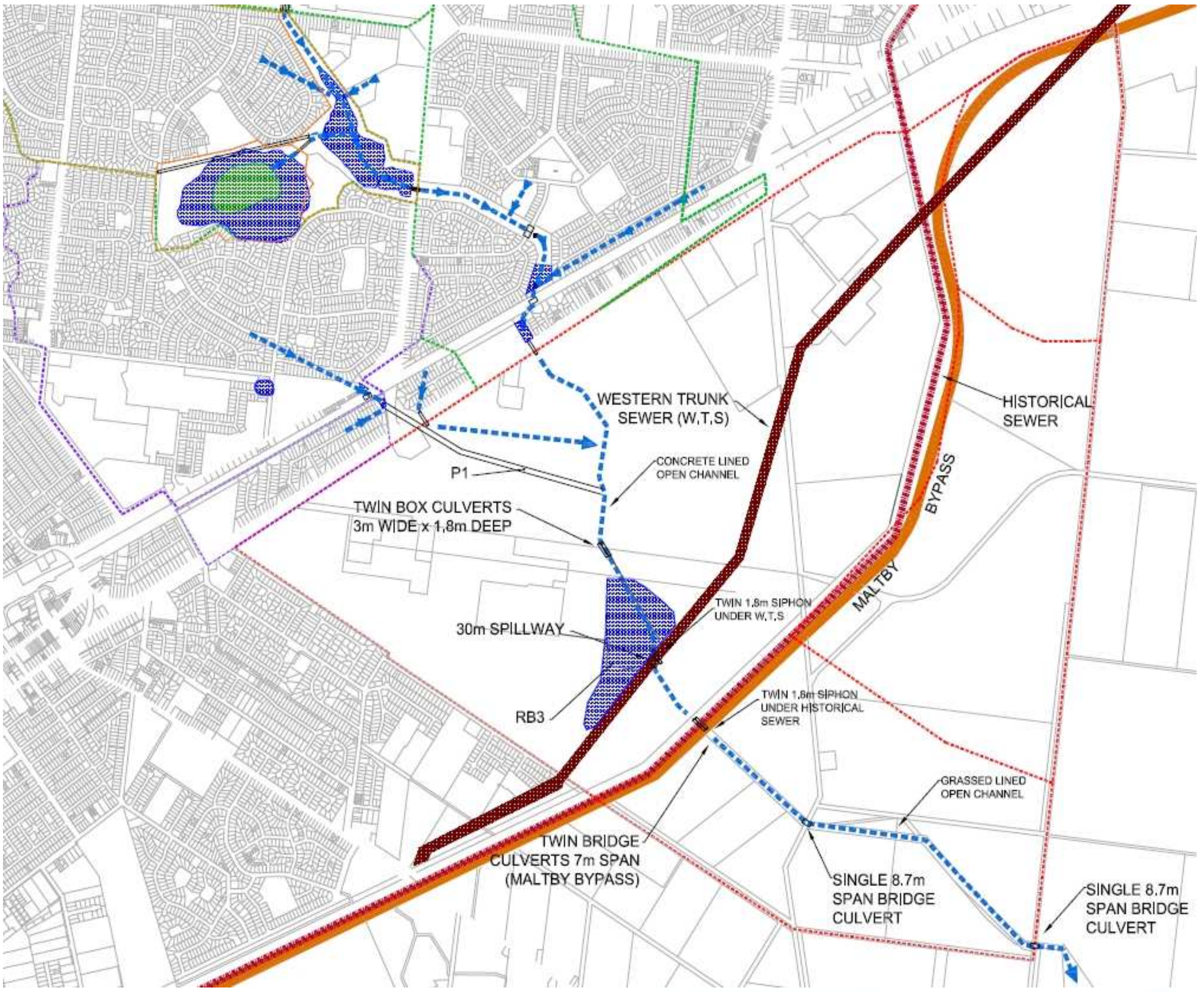


Figure 5.6 : Existing stormwater management and related infrastructure in the Werribee Employment Precinct

Figure 5.6 shows the existing D1 Drain passing through the Werribee Employment Precinct and significant infrastructure that shapes the response of the stormwater system. The "RB3" detention basin is formed at the intersection of the Western Trunk Sewer and the "D1" drain. At that point the obvert of the sewer conduit is above ground level at an elevation of about 16 m AHD and the invert of the "D1" drain is at an elevation of 14 m AHD.[23,24] Clearly the Western Trunk Sewer is a major impediment to stormwater flows. A siphon (twin 1,800 mm pipes - one sealed and one with a

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[21] ARUP (2009). Werribee Employment Precinct – primary services infrastructure. Report for VicUrban and DPCD

[22] Bonacci Water (2010). Werribee City Infrastructure Planning – Integrated Water Cycle Management: planning for the productive use of stormwater. Report for Department of Planning and Community Development (DPCD).

[23] Kilinski (1992) D1 Drain – investigation of RB3 at Western Trunk Sewer. Report for City of Werribee.

[24] Melbourne Metropolitan Board of Works (1988). Western Trunk Sewer – Section 3C. Drawing number C 3.250.03.160. Major Design and Construction Division.

restricted opening of 1.2m) and a broad crested weir (height of 16.34 m AHD and width of 30 m) located at this point allow passage of stormwater to downstream areas.[25]

Similarly, an embankment along the historical western outfall sewer channel impedes stormwater flows in the "D1" drain downstream of the "RB3" detention basin. Another siphon allows stormwater to pass under the historical sewer channel (peak discharges of up to 5.8 $m^3/s$) and then under the Maltby Bypass via a culvert with a maximum capacity of 20.5 $m^3/s$. Stormwater surcharges from the storage area upstream of the historical sewer channel are likely to enter the channel. Details of the existing infrastructure are shown in Appendix 5E.

South east of the Maltby Bypass, the D1 drain is a formed earth trapezoidal channel that was designed to accommodate stormwater flows from upstream areas and receive drainage from the neighbouring irrigation areas. However, during storm events, stormwater from the adjacent surrounding catchments is unable to discharge into the waterway and is impounded by bunds, ranging from 0.4 m to 1 m in height, that run the length of the channel on either bank. The original design details of the bunds in D1 Drain below the Maltby Bypass are shown in Figure 5.7.

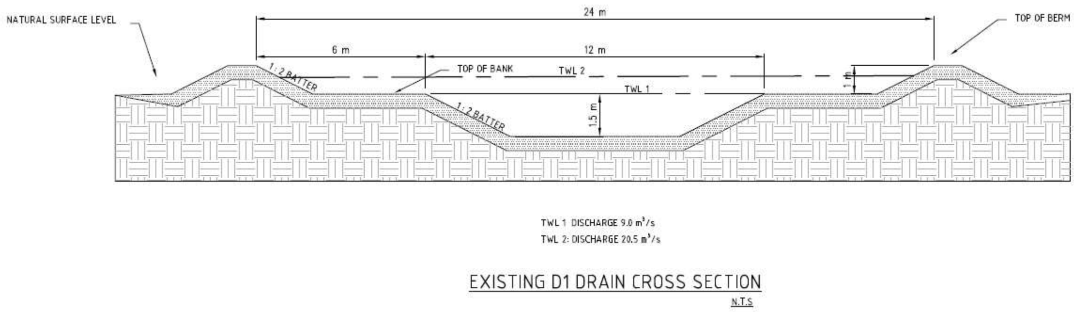


Figure 5.7: Design cross-section of the existing D1 Drain

Figure 5.7 shows that the D1 Drain was designed as a trapezoidal channel with a maximum width of 24 m and a maximum depth of 2.5 m to the top of the bunds. The D1 Drain is surrounded by bunds (or berms) with a height of 1 m above the surrounding natural surface levels. Stormwater pollution from the upper catchment that accumulates at the siphon under the Western Trunk sewer is shown in Figure 5.8. Views of the D1 Drain upstream of Sneydes and Hacketts Roads are shown Figures 5.9 and Figure 5.10 respectively.

[25] Melbourne Metropolitan Board of Works (1988) Western Trunk Sewer – Section 3C: Floodway and siphon arrangements. Drawing numbers C 8070/03/001 – 003. Major Design and Construction Division.

Figure 5.8: Stormwater pollution accumulating in the D1 Drain

Figure 5.9: The D1 Drain upstream of Sneydes Road

Figure 5.10: The D1 Drain upstream of Hacketts Road

As seen in Figure 5.9, a section of the D1 Drain upstream of Sneydes Road is lined with concrete whilst the remainder of the drain is an earth channel as shown in Figure Figure 5.8. The D1 Drain discharges under Sneydes Road via twin box culverts (3 m wide by 1.8 m deep). In addition, the D1 Drain passes under both Hoppers Lane and Hacketts Road using single span bridge culverts (8.7 m wide). The D1 Drain discharges under the Western Trunk Sewer and the Historical Western Sewer using siphons as shown in Figure 5.11 and Figure 5.12 respectively.

Figure 5.11: The siphon allowing the D1 Drain to flow under the Western Trunk Sewer

Figure 5.12: The siphon allowing the D1 Drain to flow under the Historical Western Outfall Sewer

Figure 5.11 shows that the siphon allowing stormwater to discharge from the RB3 basin under the Western Trunk Sewer is partially blocked and creates significant retention of stormwater in the basin. In any event, the siphon does not operate until water levels in the basin reach the top of the concrete headwall shown in Figure 5.11.

Similarly, Figure 5.12 shows that the older siphon passing under the Historical Western Outfall Sewer has two clear inlets to accommodate stormwater flows. Nevertheless, this siphon does not begin to operate until water levels reach the top of the levee (and bicycle track) behind the inlet. This explains why a proportion of stormwater flows in the D1 Drain surcharge into the Historical Western Outfall Sewer.

## 5.3 Existing conditions within the Upper Point Cook Catchment

There are currently two development services schemes managed by MWC in the vicinity of the Werribee Employment precinct. The Point Cook Development Services Scheme (DSS) 8075 receives stormwater to drain from sub-catchment 18 in the Precinct (Figure 5.13).

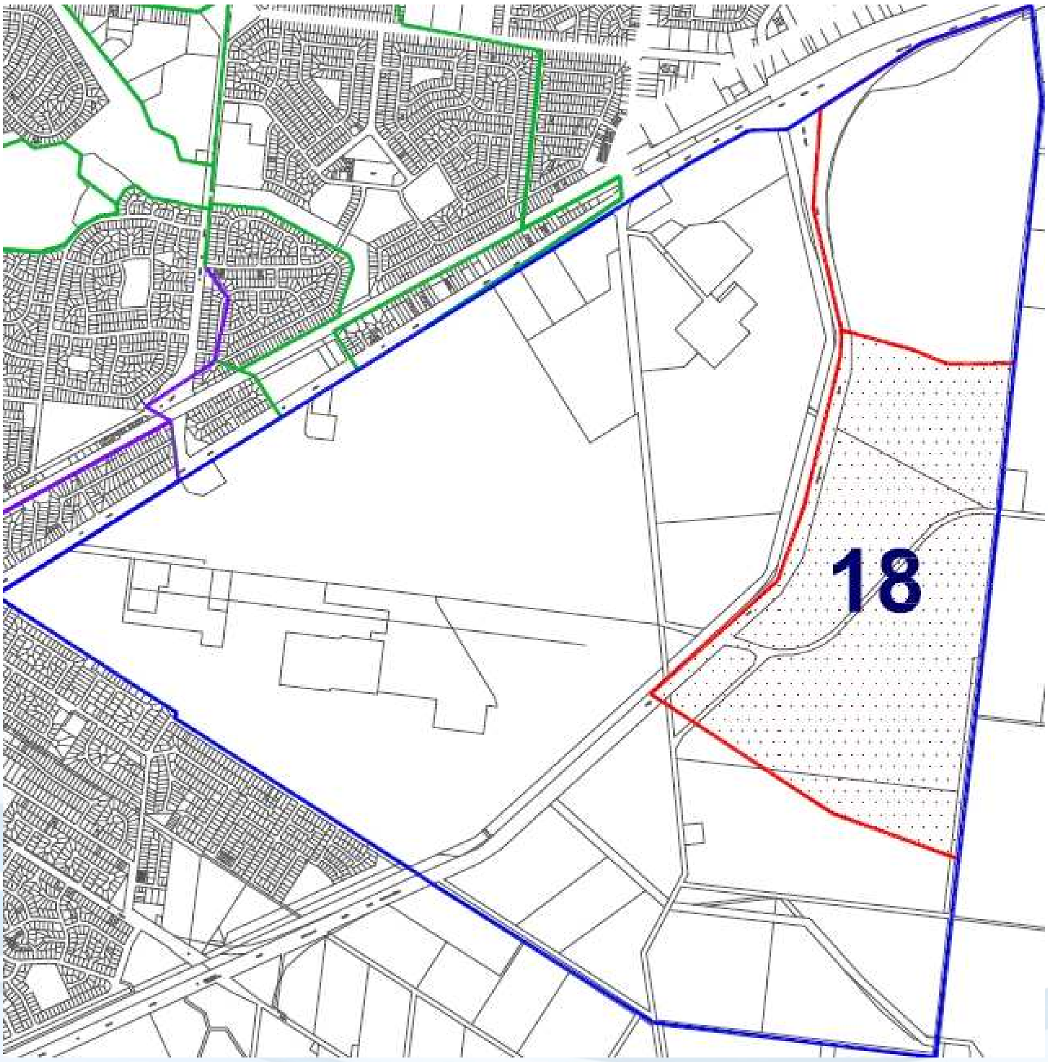


Figure 5.13: The existing sub-catchment of the Point Cook catchment within the Werribee Employment Precinct

Figure 5.13 reveals that the Maltby Bypass forms a barrier to upstream stormwater flows that prevents stormwater generated within the upper catchments from following the natural fall of the land towards the Point Cook catchment. The existing stormwater catchment downstream of the Maltby Bypass is defined by existing topography with the characteristics shown in Table 5.5. Note that half of the adjacent section of the Maltby Bypass also discharges stormwater to this sub-catchment.

Table 5.5: The upper Point Cook stormwater catchment under existing conditions

| Sub-catchment | Area (ha) | Impervious area (%) |
|---|---|---|
| 18 | 155 | 5 |

The upper Point Cook catchment is currently undeveloped, dissected by Sneydes road and contains minimal stormwater infrastructure as shown in Figure 5.14.

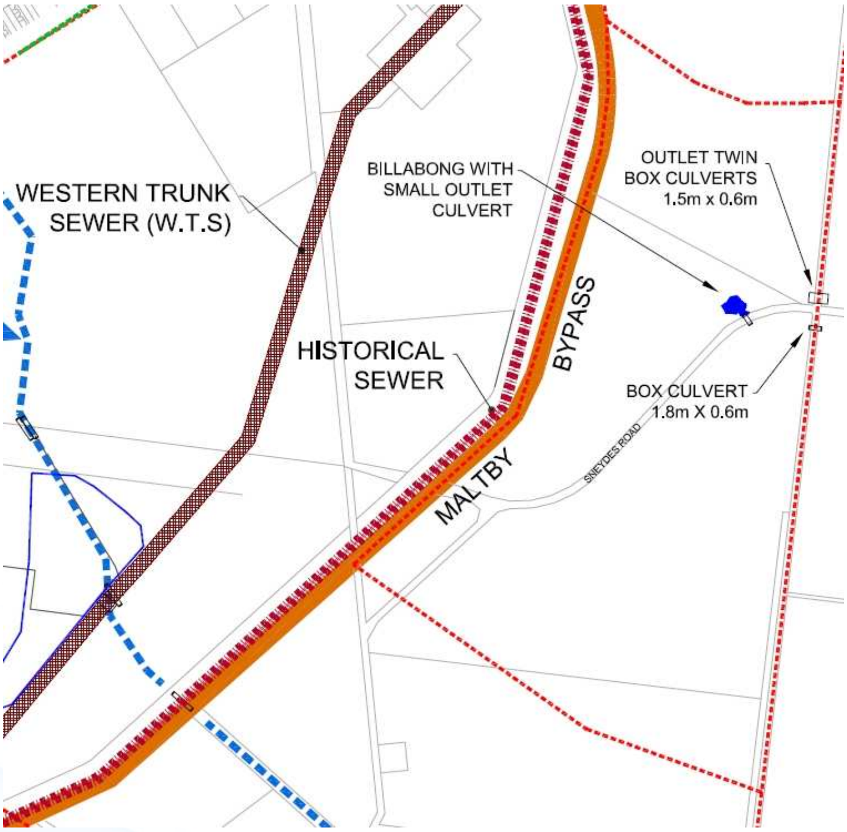


Figure 5.14: Stormwater and related infrastructure located in the upper Point Cook Catchment within the Werribee Employment Precinct

Figure 5.14 shows that this sub-catchment contains a small billabong west of Sneydes Road that surcharges via a small culvert under Sneydes Road. In addition, box culverts located north and south of Sneydes Road at the Precinct boundary allow stormwater to enter the downstream Point Cook catchment.

## 5.4 Existing conditions within the upper Skeleton Creek Catchment

There are currently two MWC development services schemes in the vicinity of the Werribee Employment precinct. The Skeleton Creek Development Services Scheme (DSS 135) discharges stormwater towards Skeleton Creek from sub-catchment 19 in the Werribee Employment Precinct. Sub-catchment 19 is bordered by the Maltby Bypass and a low ridgeline to the south and is currently undeveloped. This sub-catchment shown in Figure 5.15 discharges stormwater into Skeleton Creek via the Water Haven urban development which is detailed in Appendix 5F.

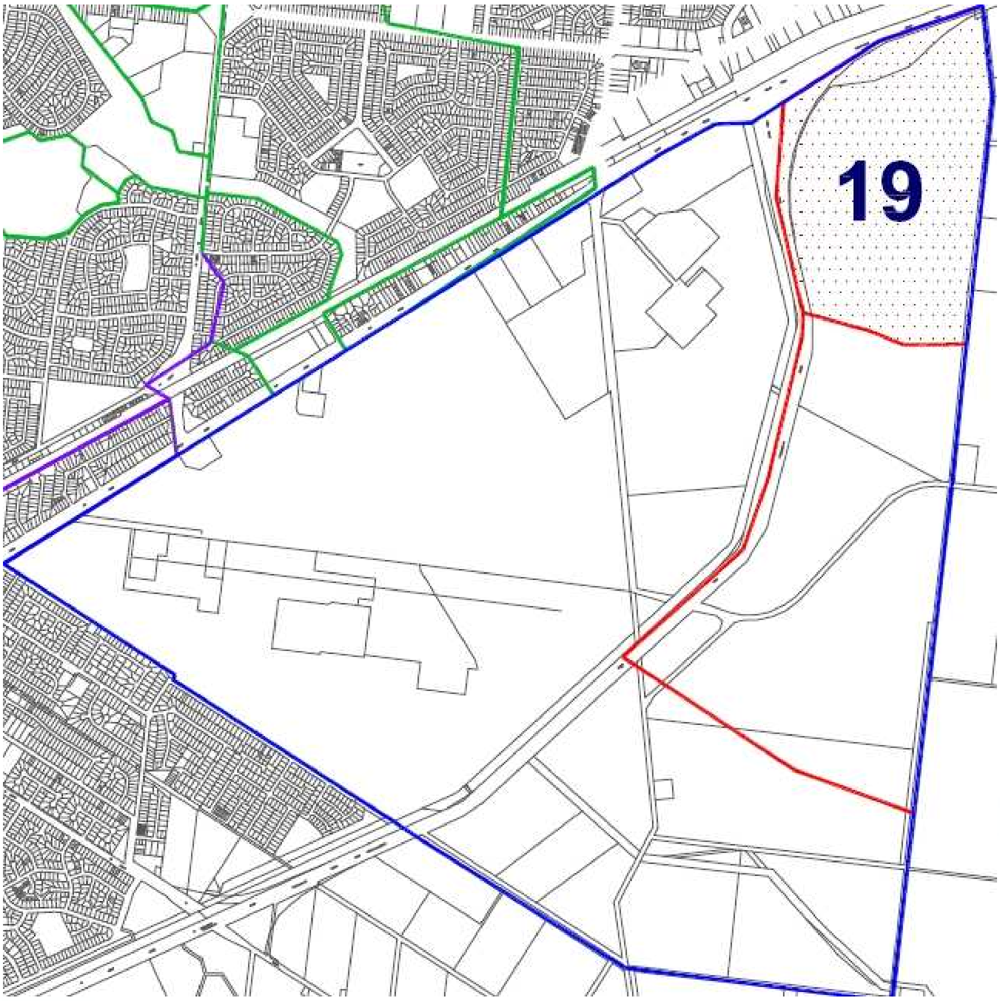


Figure 5.15: The existing sub-catchment of the Skeleton Creek catchment within the Werribee Employment Precinct

Table 5.6: Stormwater catchment areas under existing conditions

| Sub-catchment | Area (ha) | Impervious area (%) |
| --- | --- | --- |
| 19 | 90 | 5 |

Stormwater flows in this sub-catchment follow the natural fall of the land towards Skeleton Creek. The downstream Water Haven development contains constructued stormwater infrastructure to cope with peak discharges from the upper Skeleton Creek Catchment as shown in Figure 5.16.

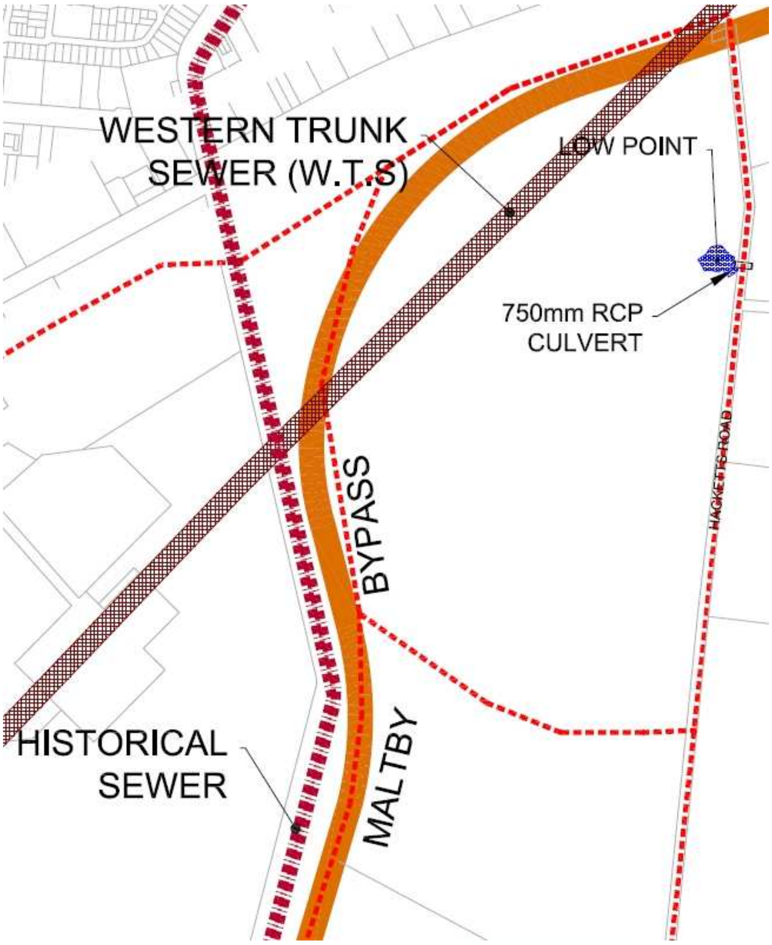


Figure 5.16: Stormwater and related infrastructure located in the upper Skeleton Creek Catchment within the Werribee Employment Precinct

Figure 5.16 shows that the sub-catchment discharges via a low point adjacent to Hacketts Road into a 750 mm diameter culvert towards the Water Haven development.

## 5.5 Hydrology

The hydrology of the catchments upstream and within the Werribee Employment Precinct was determined by the addition of infrastructure and various urban land uses to the calibrated models of pre-European conditions. For additional validation, Bonacci's hydrology model (WUFS) was also compared with results obtained using RORB which is Melbourne Water's preferred hydrology model.

### 5.5.1 Upstream catchment

The hydrology at key locations in the upper catchment is presented in Table 5.7.

Table 5.7: Existing hydrology at key locations in the upper catchments

| ARI (years) | Peak discharge (m3/s) at location | | | |
|---|---|---|---|---|
| | Heaths Road | Derrimut Road | D1 to WEP | P1 to WEP |
| 1 | 9.61 | 2.7 | 7.02 | 6.13 |
| 2 | 14.32 | 4.18 | 8.82 | 8.56 |
| 5 | 20.03 | 7.48 | 11.32 | 11.97 |
| 10 | 24.86 | 10.14 | 13.08 | 14.87 |
| 20 | 30.97 | 15.88 | 19.4 | 18.26 |
| 50 | 38.69 | 29.88 | 34.74 | 23.09 |
| 100 | 44.96 | 39.86 | 46.72 | 26.74 |

Table 5.7 shows that the online detention basin in the D1 Reserve and the offline constructed wetland provide significant mitigation of peak discharges for frequent stormwater events and moderate impacts for rarer events. The Heaths Road location represents the input to the D1 reserve and offline Glen Orden wetland, and the Derrimut Road location is the outlet from these facilities. The D1 drain and P1 pipe inputs to WEP represent all the inputs from the upper catchments to the Werribee Employment Precinct as illustrated in Figure 5.2. These results indicate a significant opportunity to optimise the performance of the online basin and offline constructed wetland in the upper catchment.

### 5.5.2 D1 Drain catchment within Werribee Employment Precinct

Stormwater from the upper catchments flows in the D1 Drain through the Werribee Employment Precinct towards the RB3 basin adjacent to the Western Trunk Sewer and then under the Maltby Bypass. The hydrology at key locations in this flow path is shown in Table 5.8.

Table 5.8: Existing hydrology in the D1 catchment within the Werribee Employment Precinct

| | Peak Discharge ($m^3/s$) at each location | | |
|---|---|---|---|
| ARI (years) | Overflow to Historical Sewer | Flow Under Maltby Bypass | D1 drain leaving WEP |
| 1 | 3.62 | 3.62 | 7.12 |
| 2 | 5.03 | 4.86 | 7.58 |
| 5 | 6.86 | 5.82 | 8.02 |
| 10 | 8.89 | 5.87 | 8.58 |
| 20 | 13.03 | 5.98 | 9.21 |
| 50 | 19.57 | 5.98 | 10.16 |
| 100 | 24 | 5.98 | 10.23 |

Table 5.8 reveals that the stormwater flow under the Maltby Bypass is attenuated by overflows into the Historical Western Sewer due to the RB3 basin reaching capacity for all storm events with ARIs of one year or greater. Hence most of the peak flows spill into the Historical Western Outfall Sewer. The result is that peak discharges from the D1 Drain catchments to the downstream environment are currently significantly less than pre-European discharges.

### 5.5.3 Upper Point Cook catchment

The hydrology in the upper Point Cook catchment at the exit from the Werribee Employment Precinct is shown in Table 5.9.

Table 5.9: Hydrology at the exit of the upper Point Cook Catchment

| | Peak discharge (m3/s) |
|---|---|
| ARI (years) | Point Cook |
| 1 | 1.4 |
| 2 | 1.95 |
| 5 | 2.53 |
| 10 | 3.21 |
| 20 | 4.15 |
| 50 | 5.63 |
| 100 | 6.53 |

The upper Point Cook catchment includes a proportion of the surface runoff from the Maltby Bypass.

### 5.5.4 Upper Skeleton Creek Catchment

The hydrology in the upper Skeleton Creek catchment at the exit from the Werribee Employment Precinct is shown in Table 5.10. This catchment receives a proportion of the surface runoff generated by the Maltby Bypass.

Table 5.10: Hydrology at the exit of the upper Skeleton Creek Catchment

| | Peak discharge (m3/s) |
|---|---|
| ARI (years) | Skeleton Creek |
| 1 | 1.04 |
| 2 | 1.41 |
| 5 | 1.89 |
| 10 | 2.36 |
| 20 | 2.98 |
| 50 | 4.09 |
| 100 | 4.99 |

## 5.6 Flood Extents

The extent of flooding to 50mm or greater depth from 100 year ARI storm events in the existing catchments is shown in Figure 5.17.

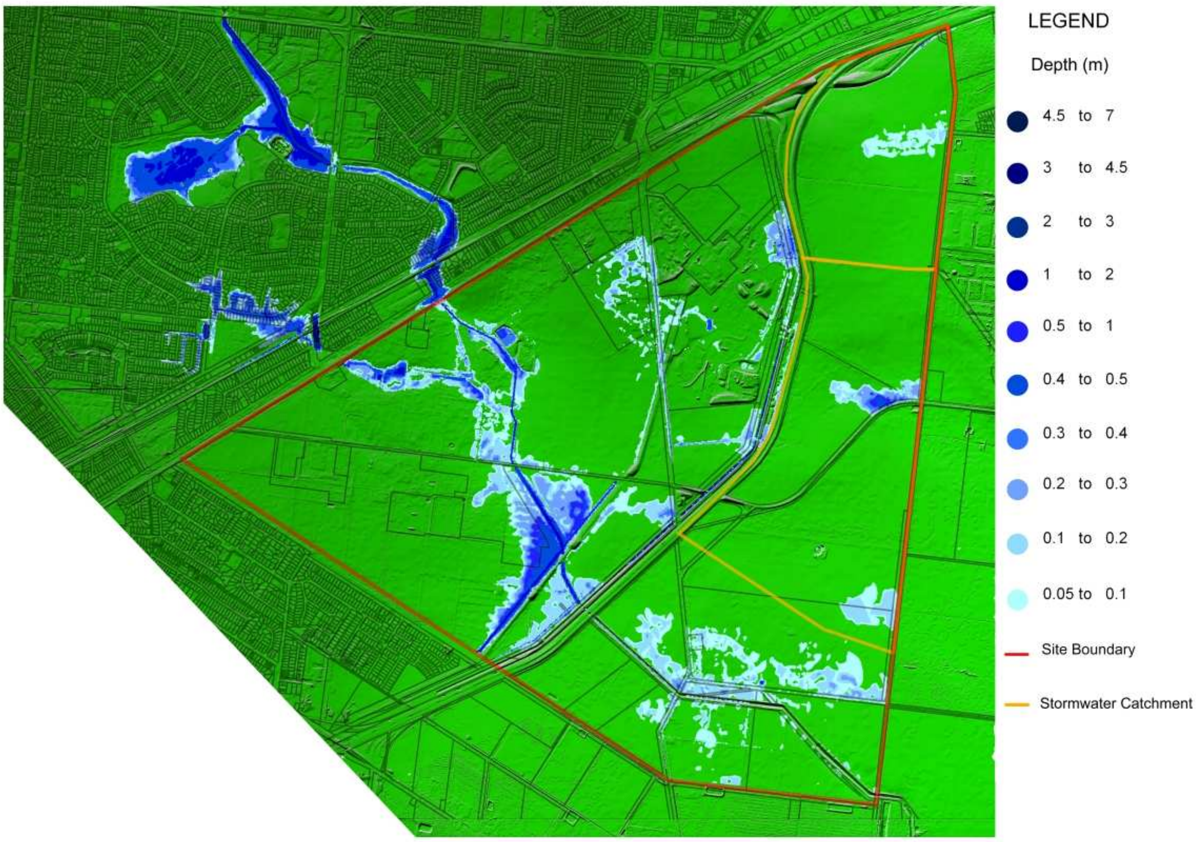


Figure 5.17: Extent of flooding from 100 year ARI storm events in the existing catchments

Figure 5.17 reveals that the detention basin and constructed wetland in the upper catchment, and the RB3 basin within Werribee Employment Precinct provide significant storage along the D1 Drain alignment. The extent of inundation from flooding to 50mm and 100mm depth is shown in Table 5.11.

Table 5.11: Extent of inundation within the Werribee Employment Precinct

| Inundation at depth | Area of flood (ha) |
|---|---|
| Full extent | 391 |
| > 50 mm | 230 |
| > 100 mm | 172 |

The results of the hydraulic model were verified by comparing of simulated flood overlays to aerial photographs of flood extents following after a significant (> 50 yr ARI) storm event in 2005. The image shown in Figure 5.16 was used as a comparative base for the hydraulic simulations shown in Figure 5.18.

Figure 5.18: Oblique aerial photo of the 2005 flood extent showing extensive inundation between Sneydes Road and the Western Trunk Sewer alignment. (Photo courtesy of WCC)

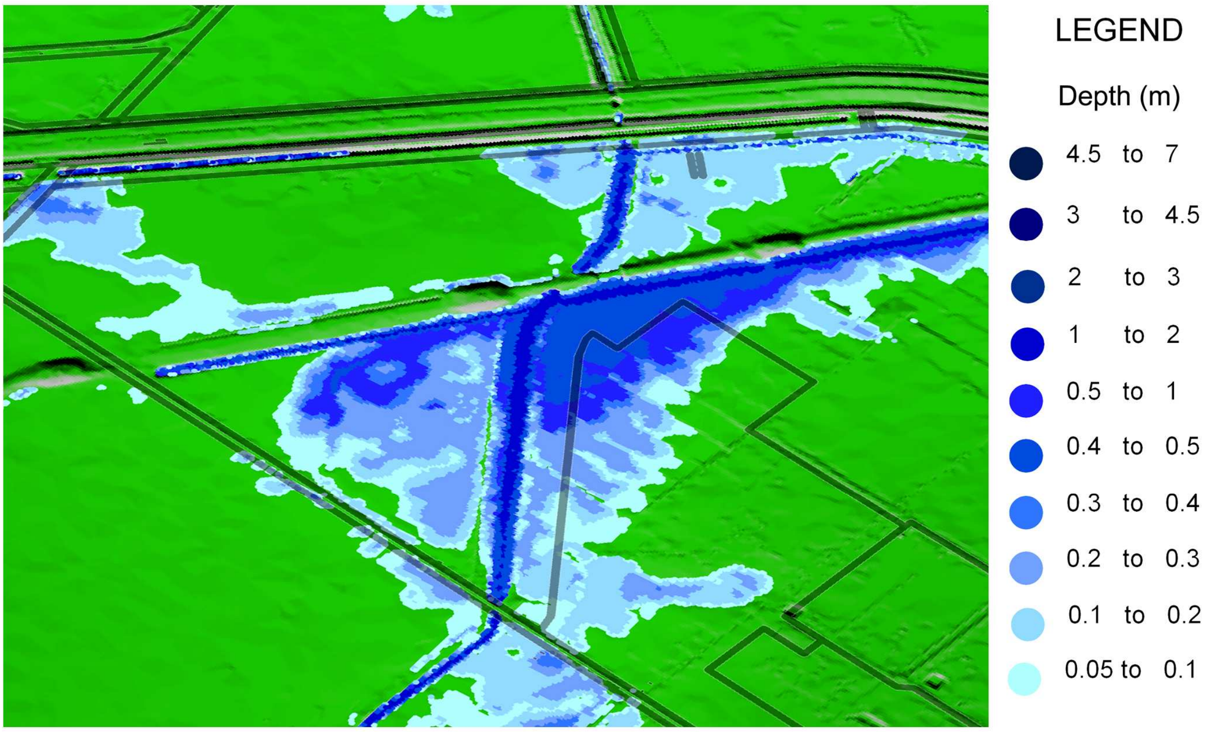


Figure 5.19: Extent of flooding derived from the hydraulic analysis for 100 year ARI storm events

Figure 5.19 shows the simulated flood extents greater than 50mm depth for 100 year ARI events are comparable to the photographed flood behaviour for the 2005 event. Note that the timing of the aerial photography relative to the peak flood heights during 2005 is uncertain but the photography clearly shows inundation and the extent of previous inundation as dark staining of the earth. The storm event recorded at the Drome rainfall gage adjacent to the site during the 2nd and 3rd of February 2005 is shown in Figure 5.20.

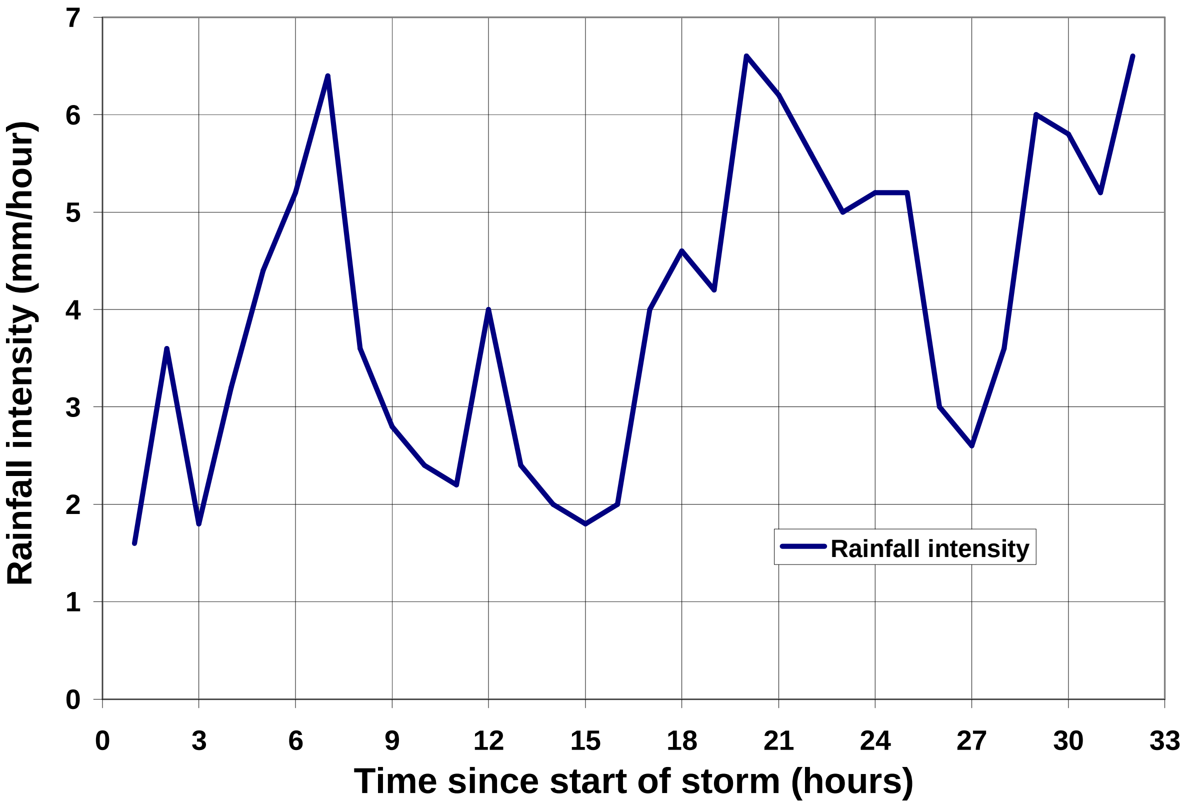


Figure 5.20: Rainfall intensity during the storm event on the 2nd and 3rd of February 2005 at the Drome rainfall gage

Figure 5.20 reveals that the average rainfall intensity ranges from 1.6 mm/hour to 6.7 mm/hour during a storm event with a length of 32 hours. The average rainfall intensity of the entire storm is 4.025 mm/hour which equates to a storm event with an ARI of about 55 years. In the absence of streamflow observations this verification against historical observations and calibration to rational method inputs allows confidence with the determination of the hydrology and hydraulics at the site.

## 5.7 Stormwater quality

The stormwater quality discharging from the upstream catchments and within the Werribee Employment Precinct was determined by analysing the infrastructure and land uses in the catchments using the MUSIC model.

In the following discussion, results are presented in accordance with the tyerminology conventions used in MUSIC. The SOURCE values represent the estimated aggregate of all flows and pollutant loads generated in the catchments upstream of the identified location. The RESIDUAL values represent the flows and lows remaining after the estimated cumulative effect of all amelioration measures and processes in the stormwater train upstream of the identified location.

### 5.7.1 Upper catchment

The characteristics of stormwater quality discharging to the D1 Drain Reserve at Heaths Road are shown in Table 5.12.

Table 5.12: Stormwater quality at Heaths Road

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 1,120 | 1,100 | 1.7 |
| Total Suspended Solids (kg/yr) | 227,000 | 166,000 | 26.7 |
| Total Phosphorus (kg/yr) | 477 | 376 | 21.1 |
| Total Nitrogen (kg/yr) | 3,310 | 3,030 | 8.3 |
| Gross Pollutants (kg/yr) | 41,900 | 29,000 | 30.8 |

Table 5.12 reveals that significant pollutant loads are expected to discharge into the D1 Drain reserve below Heaths Road. A proportion of gross pollutants are likely to originate from schools and shopping centres in the upstream catchments. The quality of stormwater discharging from the D1 Drain Reserve including the Glen Orden constructed wetland at Derrimut Road is presented in Table 5.13.

Table 5.13: Stormwater quality at Derrimut Road

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 1,490 | 1,470 | 1.7 |
| Total Suspended Solids (kg/yr) | 303,000 | 235,000 | 22.4 |
| Total Phosphorus (kg/yr) | 632 | 518 | 18 |
| Total Nitrogen (kg/yr) | 4,400 | 4.070 | 7.3 |
| Gross Pollutants (kg/yr) | 56,900 | 43,200 | 24.1 |

Table 5.13 shows that the quality of stormwater discharging from the D1 Drain Reserve at Derrimut Road does not meet stormwater best practice guidelines. The configuration of the stormwater system within the D1 Drain Reserve results in the majority of frequent flows bypassing the Glen Orden constructed wetland. Indeed, the offline Glen Orden constructed wetland only receives stormwater when the online detention system is partially inundated by larger runoff events. As a consequence the improvements to stormwater quality are limited.

The quality of stormwater entering the Werribee Employment Precinct from all of the upper D1 Drain catchments is shown in Table 5.14.

Table 5.14: Stormwater quality at D1 Drain entering Werribee Employment Precinct

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 1,940 | 1,920 | 1.3 |
| Total Suspended Solids (kg/yr) | 394,000 | 298,000 | 24.4 |
| Total Phosphorus (kg/yr) | 815 | 662 | 18.8 |
| Total Nitrogen (kg/yr) | 5,680 | 5,290 | 6.8 |
| Gross Pollutants (kg/yr) | 74,900 | 53,300 | 28.8 |

Table 5.14 reveals that the quality of stormwater entering the Werribee Employment Precinct is not compliant with stormwater best practice guidelines with considerable pollutant loads discharging to the Precinct. The quality stormwater discharging from the other upstream "P1" catchment into the Werribee Employment Precinct is presented in Table 5.15.

Table 5.15: Stormwater quality at P1 entering Werribee Employment Precinct

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 588 | 588 | 0.0 |
| Total Suspended Solids (kg/yr) | 120,000 | 119,000 | 1.1 |
| Total Phosphorus (kg/yr) | 244 | 242 | 0.8 |
| Total Nitrogen (kg/yr) | 1,680 | 1,680 | 0.3 |
| Gross Pollutants (kg/yr) | 23,500 | 23,200 | 1.0 |

Table 5.15 shows that stormwater discharges into the Precinct also do not meet stormwater best practice guidelines.

### 5.7.2 D1 Drain catchment within Werribee Employment Precinct

The characteristics of stormwater discharging under the Maltby Bypass in the D1 drain are presented in Table 5.16.

Table 5.16: Stormwater quality at the Maltby Bypass

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 3,070 | 2,792 | 9.06 |
| Total Suspended Solids (kg/yr) | 547,000 | 60,800 | 88.9 |
| Total Phosphorus (kg/yr) | 1,170 | 374 | 68 |
| Total Nitrogen (kg/yr) | 8,900 | 5,056 | 43.2 |
| Gross Pollutants (kg/yr) | 91,200 | 0 | 100 |

Table 5.16 reveals significant improvements in the quality of stormwater discharging under the Maltby Bypass including substantial improvements in loads of Total Suspended Solids and Gross Pollutants. A combination of the RB3 basin and the barrier created by the Western Trunk Sewer act to impound most of the stormwater flows with only limited discharge via a siphon under the Historical sewer. As a result, a large proportion of pollutant loads are trapped within the RB3 basin as highlighted in Figure 5.6 earlier in this Section. The characteristics of stormwater in the D1 drain discharging from the Werribee Employment Precinct are presented in Table 5.17.

Table 5.17: Stormwater quality at the Maltby Bypass

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 3,101 | 2,871 | 7.4 |
| Total Suspended Solids (kg/yr) | 546,590 | 70,390 | 87.1 |
| Total Phosphorus (kg/yr) | 1,186 | 402 | 66.1 |
| Total Nitrogen (kg/yr) | 9,016 | 5,266 | 41.6 |
| Gross Pollutants (kg/yr) | 90,400 | 0 | 100 |

Table 5.17 shows that the quality of stormwater discharging in the D1 Drain from the Werribee Employment Precinct is not compliant with stormwater best practice guidelines.

### 5.7.2 Upper Point Cook catchment

The quality of stormwater discharging from the upper Point Cook catchment is shown in Table 5.18.

Table 5.18: Stormwater quality at the Maltby Bypass

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 226 | 226 | 0.00 |
| Total Suspended Solids (kg/yr) | 70,000 | 70,000 | 0.00 |
| Total Phosphorus (kg/yr) | 84 | 84 | 0.00 |
| Total Nitrogen (kg/yr) | 722 | 722 | 0.00 |
| Gross Pollutants (kg/yr) | 5,820 | 5,820 | 0.00 |

Table 5.18 reveals that the quality of stormwater discharging from the upper Point Cook catchment is not compliant with stormwater best practice guidelines.

### 5.7.3 Upper Skeleton Creek catchment

The quality of stormwater discharging from upper Skeleton Creek catchment is shown in Table 5.19.

Table 5.19: Stormwater quality discharging from the Upper Skeleton Creek catchment

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 68 | 68 | 0.00 |
| Total Suspended Solids (kg/yr) | 17,000 | 17,000 | 0.00 |
| Total Phosphorus (kg/yr) | 30 | 30 | 0.00 |
| Total Nitrogen (kg/yr) | 227 | 227 | 0.00 |
| Gross Pollutants (kg/yr) | 931 | 931 | 0.00 |

Table 5.19 reveals that the quality of stormwater discharging from the upper Skeleton Creek catchment is not compliant with stormwater best practice guidelines.

# 6 Developed Stormwater Catchments and design infrastructure

The Werribee Employment Precinct is subject to stormwater runoff from a large urbanised catchment (1,097 ha) upstream of the site. It is expected the density of urban development in the upper catchment will increase over time due to infill development processes. Stormwater sub-catchments in the upstream and Werribee Employment Precinct are shown in Figure 6.1.

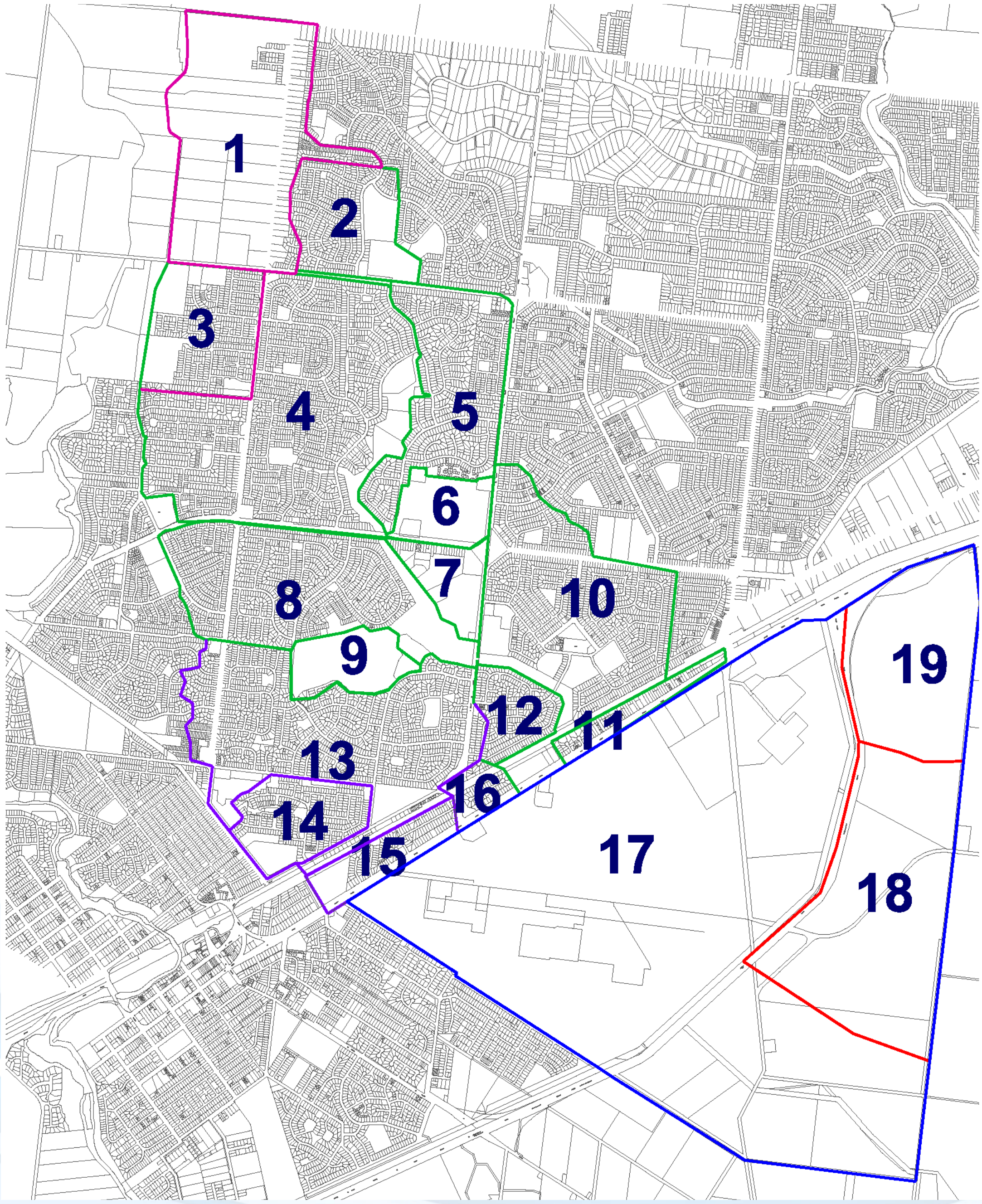


Figure 6.1: Stormwater sub-catchment boundaries under existing conditions

Figure 6.1 shows that the stormwater sub-catchments denoted 1 to 16 discharge to Werribee Employment Precinct and sub-catchments 17 to 19 are included in the Precinct. Sub-catchment 17 forms part of the Werribee Employment Precinct scheme whereas sub-catchments 18 and 19 form part of the Point Cook and Skeleton Creek Schemes respectively.

## 6.1 Developed conditions in the upstream catchments

It is expected that land uses in the upstream catchments will remain largely unchanged in comparison to the existing situation with the exception of sub-catchment 1. This previously rural sub-catchment will be subject to urban development which will increase the proportion of impervious surfaces in the up stream catchments. The characteristics of the upstream sub-catchment are shown in Table 6.1.

Table 6.1: Characteristics of the upstream stormwater sub-catchments

| Sub-catchment | Area (ha) | Impervious area (%) | Dominant land use |
|---|---|---|---|
| 1 | 110.4 | 60 | Residential |
| 2 | 51.9 | 57 | Residential with schools |
| 3 | 70 | 60 | Residential |
| 4 | 163.4 | 54.5 | Residential |
| 5 | 89.5 | 60 | Residential |
| 6 | 23.9 | 95 | Werribee Plaza Shopping Centre |
| 7 | 21.7 | 55 | Mixed use development and school |
| 8 | 102 | 60 | Residential and retarding basin |
| 9 | 28 | 10 | Glen Orden constructed wetland |
| 10 | 157 | 57 | Residential |
| 11 | 8 | 60 | Residential |
| 12 | 25.3 | 60 | Residential |
| 13 | 166.2 | 60 | Residential |
| 14 | 40.8 | 60 | Residential |
| 15 | 26.4 | 57 | Residential |
| 16 | 12.9 | 70 | Residential |

The development of sub-catchment 1 will increase the area of impervious surfaces in the upper catchment by 44.16 ha. A retarding basin that was commissioned and designed by others will be constructed at Hogans Road to mitigate stormwater peak discharges from sub-catchment 1 (see Appendix 6A).

The characteristics of the existing retarding basins in the upstream catchment including the proposed Hogans Road basin are shown in Table 6.2.

Table 6.2: Characteristics of retarding basins located in the upstream catchment

| Retarding basin | Surface area ($m^2$) | Volume ($m^3$) | Depth (m) |
|---|---|---|---|
| DB-1 | 2,172 | 1,955 | 0.9 |
| DB-2 | 13,133 | 9,850 | 0.75 |
| DB-3 | 13,133 | 9,850 | 0.75 |
| DB-4 | 4,048 | 8,500 | 2.1 |
| DB-5 | 9,455 | 10,400 | 1.1 |
| DB-6 | 3,009 | 3,310 | 1.1 |
| DB-7 | 2,398 | 4,100 | 1.71 |
| DB-8 | 803 | 1,790 | 2.23 |
| DB-9 | 1,810 | 3,981 | 2.2 |
| Hogans Rd | ~ 8,000 | 21,600 | 2.75 |

The analysis of existing conditions (see Section 5) reveals the stormwater infrastructure in the upper catchment does not mitigate stormwater peak discharges into the Werribee Employment Precinct to a no worsening as compared to pre-European conditions. In addition, the quality and 1.5 year ARI peak discharges of stormwater entering the Werribee Employment Precinct do not meet stormwater best practice guidelines.

Stormwater discharging from the Werribee Plaza shopping centre and schools in the upper catchment can contribute significant pollution loads to the D1 drain reserve and constructed wetland. It was also shown in Section 5 that the upstream catchments are contributing significant pollution loads to the Werribee Employment Precinct.

To better control gross pollutants above the D1 reserve and Glen Orden wetland, the existing stormwater infrastructure will be augmented to direct stormwater flows through an appropriately sized GPT just upstream of Heaths Road. All stormwater flows with peak discharges less or equal to 1 year ARI will be diverted through the GPT and stormwater flows with larger ARIs will bypass the GPT. A suitable location for the GPT is in the D1 Drain reserve above Heaths Road is shown in Figure 6.2.


Figure 6.2: Location of the proposed gross pollutant trap (GPT)

A schematic of the infrastructure in the upstream catchments is shown in Figure 6.3, which indicates that the Hogans Road retarding basin has been added to the existing assets in the upstream catchment.

A redesign of the D1 Drain Reserve between Heaths and Derrimut Roads was also undertaken to achieve better online performance of the Glen Orden constructed wetland to mitigate stormwater peak discharges and improve quality outcomes. As discussed in detail below, a new weir across the D1 Drain will cause stormwater back up into the Glen Ormond wetland and later flow back into the D1 drain reserve when water levels recede.

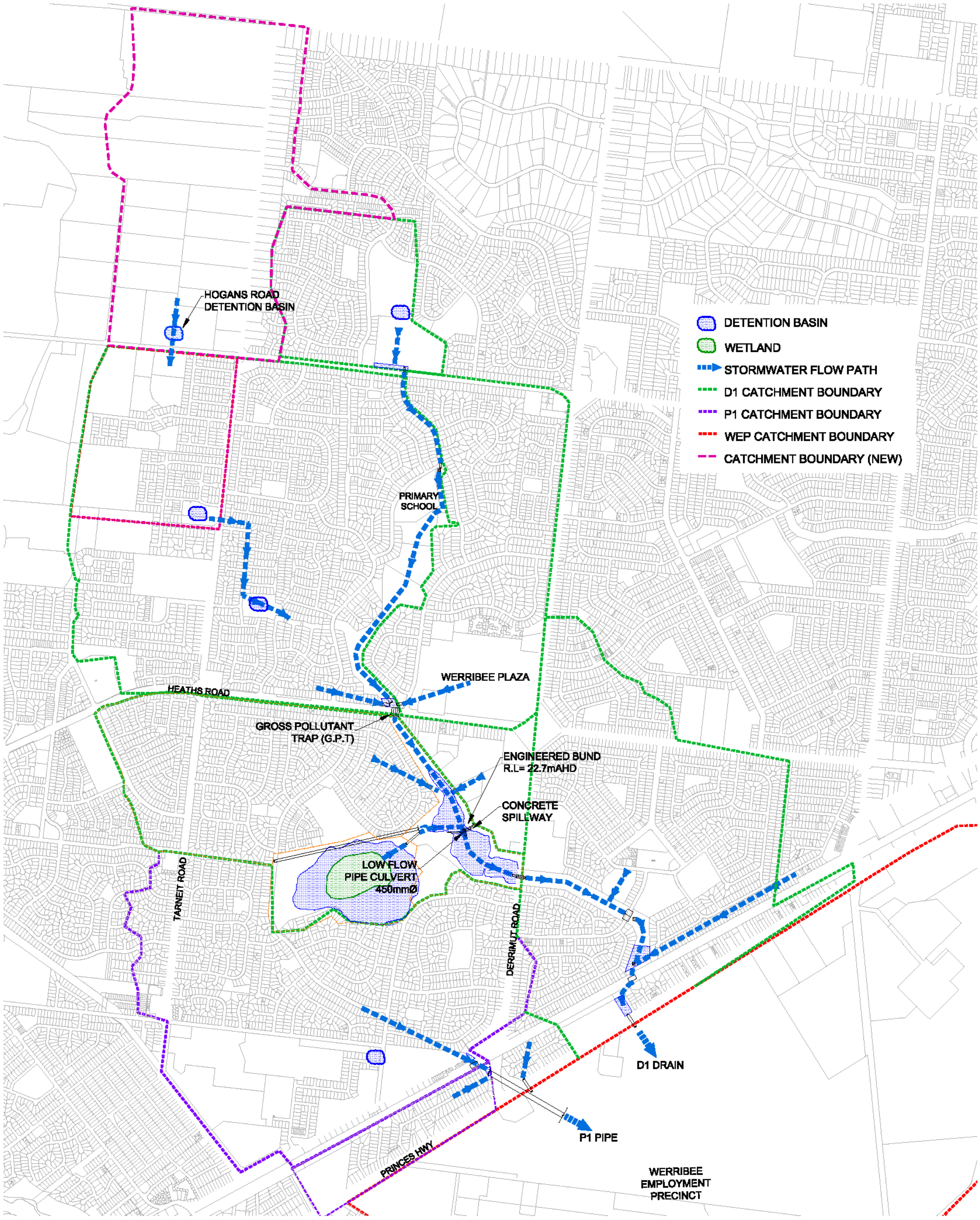


Figure 6.3: Design Stormwater Infrastructure in Upper Catchment

The small weir across the D1 drain is shown in Figure 6.4. It will be constructed as a contour bank with a low flow pipe at the invert of the D1 Drain and a spillway. The top of the contour bank will be at an elevation of 22.7 m AHD and the invert of the spillway will be at an elevation of 21.75 m AHD. Design plans of this strategy are shown in Appendix 6B.

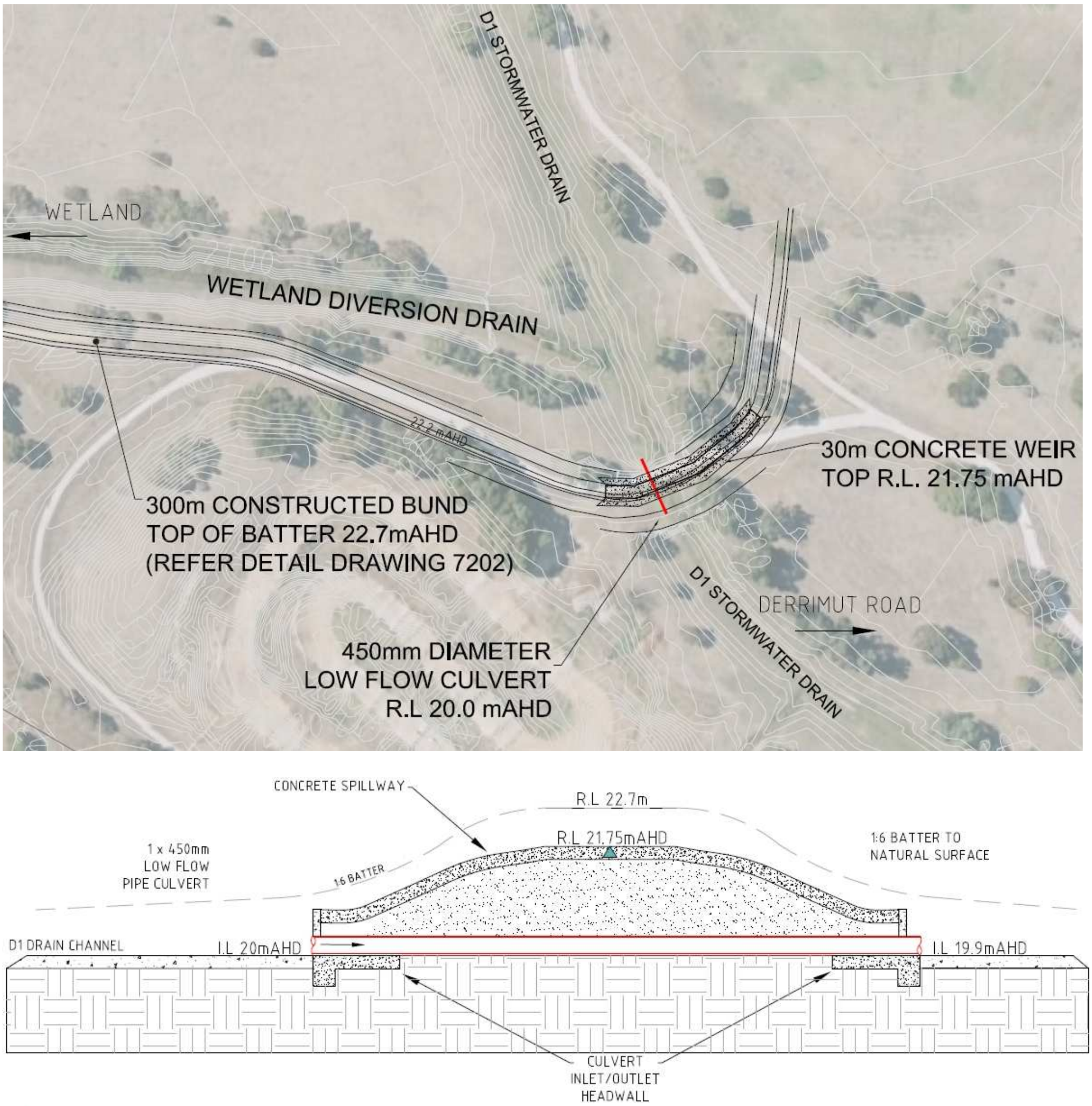


Figure 6.4: Details of the proposed weir to allow diversion of stormwater to the Glen Orden constructed Wetland

The characteristics of the modified retarding basin in the D1 Drain Reserve and connectivity to the Glen Orden constructed wetland are shown in Table 6.3.

Table 6.3: Storage characteristics of the diversion weir, Glen Orden constructed wetland and the D1 Drain Reserve

| Elevation (m AHD) | Wetland and upper D1 Reserve Volume (m³) | Lower D1 Reserve Volume (m³) | Total Volume (m³) |
|---|---|---|---|
| 19.63 | Discharge under Derrimut Road via low flow pipe | | |
| 20 | Discharge under diversion weir via low flow pipe | | |
| 20.2 | 306 | 470 | 776 |
| 20.26 | Stormwater enters wetland via pipe with 900 mm diameter | | |
| 20.4 | 864 | 1,296 | 2,160 |
| 20.6 | 1,680 | 2,787 | 4,467 |
| 20.8 | 3,884 | 3,861 | 7,745 |
| 21 | 12,222 | 4,462 | 16,684 |
| 21.2 | 26,297 | 5,510 | 31,807 |
| 21.26 | Discharge under Derrimut Road via high flow culvert | | |
| 21.4 | 45,006 | 7,429 | 52,435 |
| 21.6 | 69,548 | 10,661 | 80,209 |
| 21.75 | Stormwater Discharges into downstream D1 Drain via high flow spillway | | |
| 21.78 | Stormwater overtops bank at the wetland and D1 interface | | |
| 21.8 | 99,532 | 15,667 | 115,199 |
| 22 | 133,672 | 17,710 | 151,382 |
| 22.2 | 171,416 | 24,313 | 195,729 |
| 22.29 | | Stormwater flows over Derrimut Road | |
| 22.3 | 200,780 | 24,313 | 225,093 |
| 22.4 | 224,770 | 24,313 | 249,083 |
| 22.5 | 250,260 | 24,313 | 274,573 |
| 22.6 | 277,095 | 24,313 | 301,408 |
| 22.7 | 306,600 | 24,313 | 330,913 |

Table 6.3 indicates that the diversion weir will impound most of the stormwater entering the D1 Reserve allowing flows to back up into the Glen Orden constructed wetland until the level and volume of impounded stormwater exceed 21.75 m AHD and 92,036 m$^3$ respectively. Stormwater then surcharges via a spillway into the downstream section of the D1 Drain reserve and the low flow pipe ultimately allows impounded stormwater to discharge from the weir. This ensures slow release of stormwater to downstream catchments and that the weir does not retain stormwater between storm events.

The diversion weir and the Glen Orden constructed wetland also provide up to 306,600 m3 retarding storage upstream of the proposed bund that has an elevation of 22.7 m AHD.

## 6.2 Developed conditions in the D1 Drain catchments within the Werribee Employment Precinct

The preliminary concept plan shown in Figure 6.5 describes one potential land use scenario for mixed use development of the site (with 60,000 jobs and 30,000 residents) as provided by the Department of Planning and Community Development to inform modelling work at the sub-precinct level in advance of the master planning for the new city. This was utilised to inform the development of options for the Werribee Employment Precinct. Note that this preliminary concept plan is indicative only and will not be the final planning outcome for the site and is only utilised as an indicative plan for water cycle management (see Appendix 6C for the draft report).

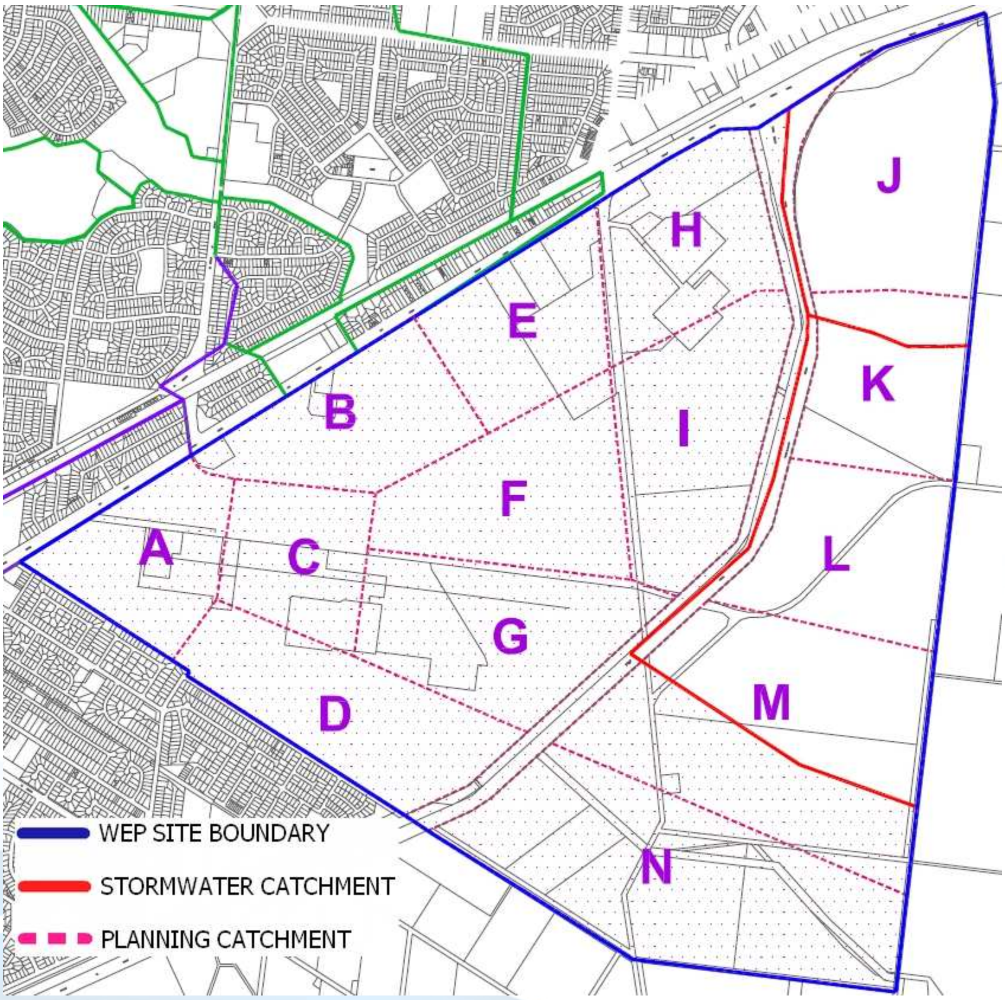


Figure 6.5: Indicative draft Precinct Structure Plan used in the analysis

Although the structure plan shown in Figure 6.5 is only an indication of the final development it does indicate locations for the Sub-Precincts (A to N) that are consistent with the topography and existing infrastructure at the site.

Development of the proposed Werribee Employment Precinct will increase the proportion of impervious surfaces within the site and the magnitude of stormwater discharges from each of the 14 Sub-Precincts shown in Figure 6.5. The proportions of impervious surfaces for each land use shown in Table 6.4 were adopted for this study.

Table 6.4: Proportions of impervious surfaces versus land use

| Land use | Proportion of impervious surfaces (%) |
|---|---|
| Commercial | 80 |
| Health | 80 |
| Education | 50 |
| Industrial | 90 |
| Public Open Space | 10 |
| Conventional housing | 70 |
| Mix use development | 80 |
| Medium density housing | 80 |
| High density housing | 90 |

The analysis has not utilised all of the estimations of the proportions of impervious surfaces for each land use provided by Melbourne Water. These estimates of fraction imperviousness appear to be low in the context of a trend in reduced lot sizes, national practice and seem to have been derived from the practice of using discrete Rational Method assumptions for design of urban drainage systems. The use of Rational Method estimations for design of stormwater management facilities is not recommended for the Werribee Employment Precinct due to the complex nature of the stormwater processes which are dependent on the volumes of stormwater runoff.

Analysis using the Sub-Precincts shown in Figure 6.5 provides a reasonable indication of potential land uses that allows evaluation of various water cycle management strategies. The land use categories and areas of each Sub-Precinct analysed in this report are shown in Table 6.5.

Table 6.5: Indicative land uses and areas for each Sub-Precinct in the Werribee Employment Precinct

| Sub-precinct | Land area (ha) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Commerce | Mixed Use | Health | Education | Industry | Residential | Open Space |
| A | 16.7 | 24 | - | - | - | - | 6.2 |
| B | 7.4 | 22.9 | - | 7.5 | - | - | 15.7 |
| C | 14 | 4.3 | 13.1 | - | - | - | 4.9 |
| D | - | 10.7 | - | - | - | 40 | 2.2 |
| E | - | 2.4 | 13 | 30.5 | - | 2.8 | 2.8 |
| F | 2 | 44.5 | - | - | - | - | 9.9 |
| G | 2 | 21.1 | - | 11.3 | - | 15.9 | 7.7 |
| H | 42.1 | - | - | 8 | - | - | 1.8 |
| I | - | 6.5 | - | - | 43 | - | 15.1 |
| J | - | 29.3 | - | - | - | 31.7 | 11.2 |
| K | - | 21.7 | - | - | - | 22 | 5.1 |
| L | - | 13 | 13.4 | 13.7 | - | - | 14 |
| M | - | 26.6 | - | 5.9 | - | 75.7 | 3 |
| N | - | 3 | - | - | 66.7 | 8.7 | 30.5 |
| **Total** | **84.2** | **230** | **39.5** | **76.9** | **109.7** | **196.8** | **130.1** |

The data listed Table 6.5 were used to determine stormwater runoff and design stormwater management infrastructure within the Werribee Employment Precinct as shown in Figure 6.6.

All development within the Werribee Employment Precinct will adopt a WSUD strategy to meet the stormwater management objectives for the Precinct. Use of rainwater storages of 50 $m^3$/ha connected to roof areas that are 20% of impervious areas to supply an indoor water demand and use of bio-retention storages of 40 $m^3$/ha has been assumed as a "deemed to comply" development condition for this analysis.

An overview of the stormwater management infrastructure proposed for the D1 Drain catchment within the Werribee Employment Precinct is provided in Figure 6.6.

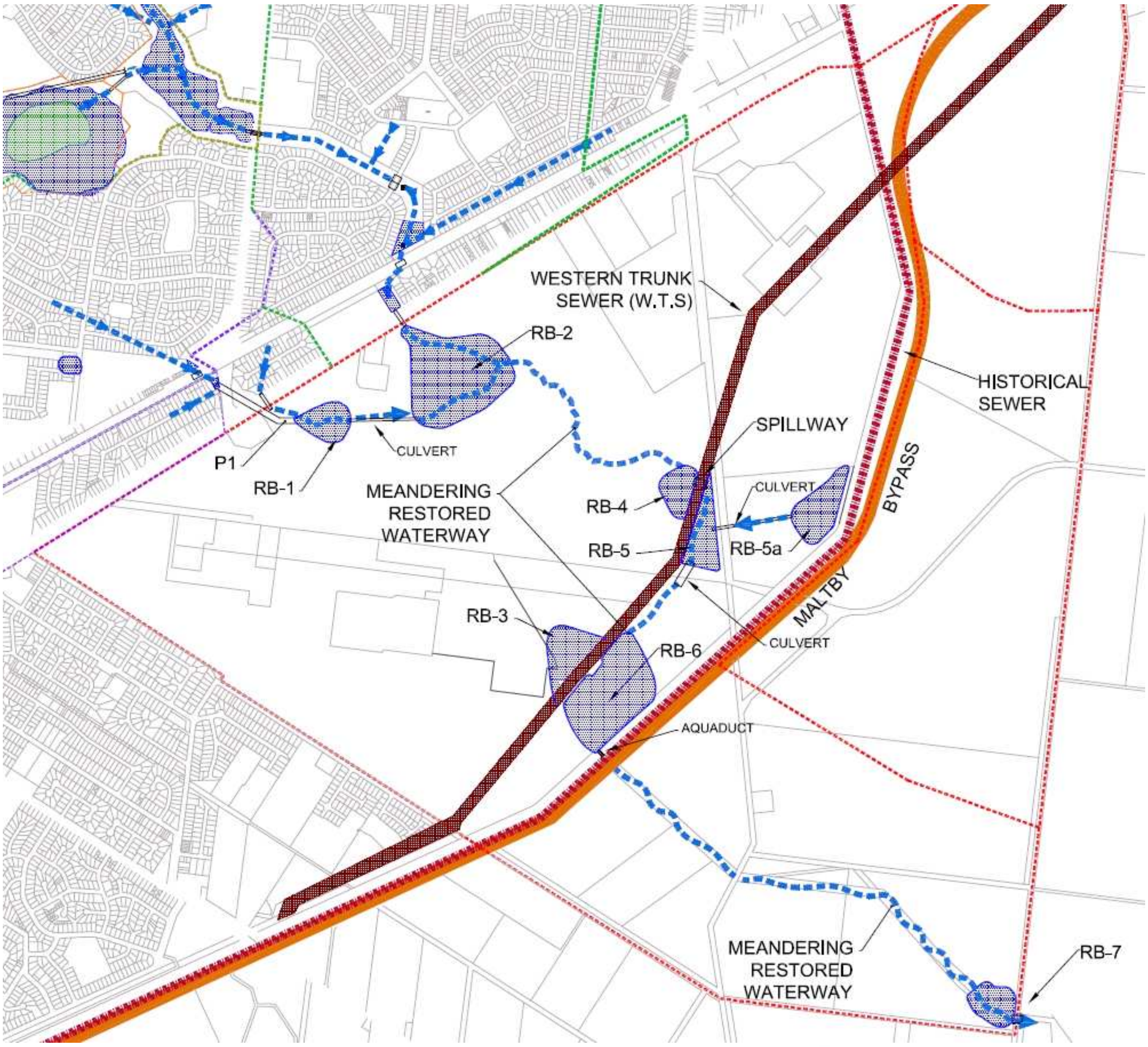


Figure 6.6: Overview of stormwater management infrastructure within the Werribee Employment Precinct

Figure 6.6 shows that the trunk stormwater infrastructure proposed for the Werribee Employment Precinct includes restoration of the D1 Drain as a waterway and inclusion of the retarding basins RB1 to RB7. The alignment of the D1 Drain was also changed to mitigate the barrier to the waterway created by the Western Trunk Sewer and the extent of the existing RB3 basin is reduced. Retarding basins RB1 – RB4 also contain ponds that facilitate extraction of stormwater for use in the ASR scheme. A summary of retarding basins within the Precinct is provided in Table 6.6.

Table 6.6: Summary of retarding basins within Werribee Employment Precinct

| Retarding basin | Surface area (m²) | Storage volume (m³) | Invert (m AHD) | Top (m AHD) |
|---|---|---|---|---|
| RB-1 | 36,000 | 80,500 | 16.9 | 19.2 |
| RB-2 | 119,500 | 397,220 | 16.5 | 19.2 |
| RB-3 | 20,000 | 69,500 | 14.2 | 16.8 |
| RB-4 | 25,000 | 80,600 | 15.0 | 19.2 |
| RB-5a | 50,000 | 50,000 | 15.8 | 16.8 |
| RB-5 | 30,800 | 135,950 | 15.0 | 19.2 |
| RB-6 | 99,000 | 198,000 | 14.8 | 16.8 |
| RB-7 | 20,770 | 41,546 | 8.8 | 10.8 |

Table 6.6 reveals that the proposed retention basins occupy a land area of 40.1 Ha and provide a total storage of 1,053,316 m$^3$ within the D1 Drain catchment in the Werribee Employment Precinct. Additional storage is also provided in the restored waterways. It is proposed to install a gross pollutant trap (GPT) at each of the two inlets to the Werribee Employment Precinct to improve the quality of stormwater entering the Precinct. The proposed location of the GPT in the D1 Drain prior to RB2 is shown in Figure 6.7.


Figure 6.7: Location of the proposed gross pollutant trap in the D1 Drain entry to the Werribee Employment Precinct

Figure 6.7 shows that the GPT in the D1 Drain entrance to the Werribee Employment Precinct should be designed to cope with peak stormwater discharges up to 1.81 $m^3/s$. The proposed location of the GPT in the P1 location prior to RB1 is shown in Figure 6.8.


Figure 6.8 Location of the gross pollutant trap at the P1 entry to the Werribee Employment Precinct

Figure 6.8 shows that the GPT in the P1 entrance to the Werribee Employment Precinct should be designed to cope with peak stormwater discharges up to 3.62 $m^3/s$. The design of this GPT will incorporate the existing buried and surface stormwater infrastructure at the inlet to the Precinct. The design of the retarding basin RB1 to mitigate inflows to the Precinct from the P1 upper catchment is shown in Figure 6.9.

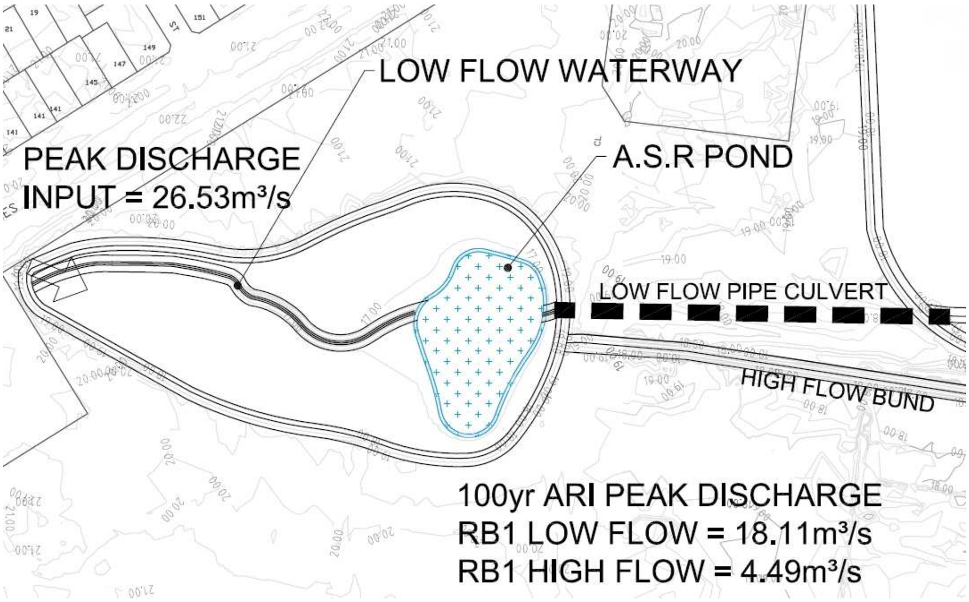


Figure 6.9 Details of the RB1 retarding basin

Figure 6.9 show that the proposed retarding basin includes a low flow waterway and a pond that facilitates extractions for the ASR scheme. Low stormwater flows discharge from the RB1 basin to the RB2 basin via twin 1,350 diameter pipes and an emergency spillway is provided that surcharges via an overland flow path into the waterway below the RB2 basin. Details of the RB1 basin are provided in Table 6.7.

Table 6.7: Details of the RB1 retarding basin

| Elevation (m AHD) | Storage ($m^3$) | Pipe discharge ($m^3/s$) | Weir discharge ($m^3/s$) | Comments |
|---|---|---|---|---|
| 16.3 | 0 | 0 | 0 | Base elevation |
| 16.9 | 12,600 | 0 | 0 | IL of twin 1,675 mm diameter pipes |
| 17 | 14,800 | 0.12 | 0 | |
| 17.5 | 30,800 | 4.35 | 0 | |
| 18 | 47,800 | 11.68 | 0 | |
| 18.4 | 58,252 | 15.19 | 0 | IL of weir (8 m wide) |
| 18.8 | 65,700 | 18.02 | 3.45 | |
| 19 | 72,000 | 19.35 | 6.34 | |
| 19.2 | 80,500 | 20.68 | 9.76 | |

Table 6.7 reveals that the majority of peak discharges from the RB1 basin are conveyed via the low flow pipe system and the surcharges to the overland flow path only occur as the basin reaches capacity. Frequent stormwater runoff events will be conveyed in the low flow waterways and pipe system to the RB2 basin. Details of the RB2 retarding basin are shown in Figure 6.10.

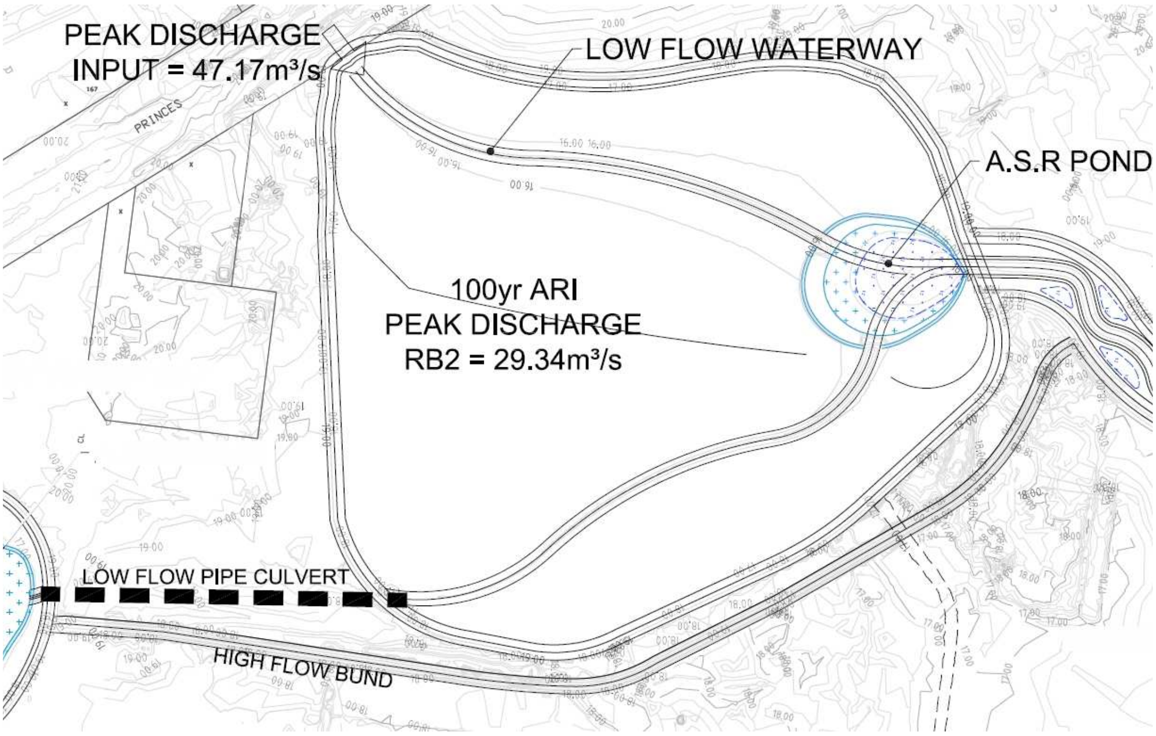


Figure 6.10 Details of the RB2 retarding basin

Figure 6.10 shows that the RB2 retarding basin receives stormwater from the upper catchment of the D1 Drain and low flows from the RB1 basin. Low flow waterways are provided to convey low flows to a pond that will facilitate extractions for the ASR scheme. Overflows from the RB1 basin pass below the RB2 basin in the overland flow path created by a high flow bund and the wall of the RB2 basin. Stormwater discharges from the RB2 basin via twin box culverts and surcharges over a spillway when the capacity of the basin is reached. Details of the RB2 basin are provided in Table 6.8.

Table 6.8: Details of the RB2 retarding basin

| Elevation (m AHD) | Storage (m³) | Culvert discharge (m³/s) | Weir discharge (m³/s) | Comments |
|---|---|---|---|---|
| 15.4 | 0 | 0 | 0 | |
| 16 | 4,000 | 0 | 0 | |
| 16.5 | 28,000 | 0 | 0 | IL of twin box culverts (2.1 m x 1.8 m) |
| 17 | 82,000 | 12.73 | 0 | |
| 17.5 | 150,000 | 18 | 0 | |
| 18 | 218,000 | 22.05 | 0 | |
| 18.5 | 290,000 | 25.46 | 0 | |
| 18.8 | 338,900 | 27.3 | 0 | IL of weir (30 m wide) |
| 18.9 | 353,400 | 28.46 | 1.62 | |
| 19 | 360,100 | 29.62 | 4.57 | |
| 19.2 | 397,215 | 30.76 | 12.93 | |

Table 6.8 reveals that the majority of discharges from the RB2 basin are conveyed via the low flow box culvert system and surcharges to the downstream waterway only occur via a 30 m wide spillway as the basin reaches capacity. Frequent stormwater runoff events will be conveyed in the low flow waterways and culverts in the RB2 basin to the downstream waterway. The downstream waterway is shown in Figure 6.11.

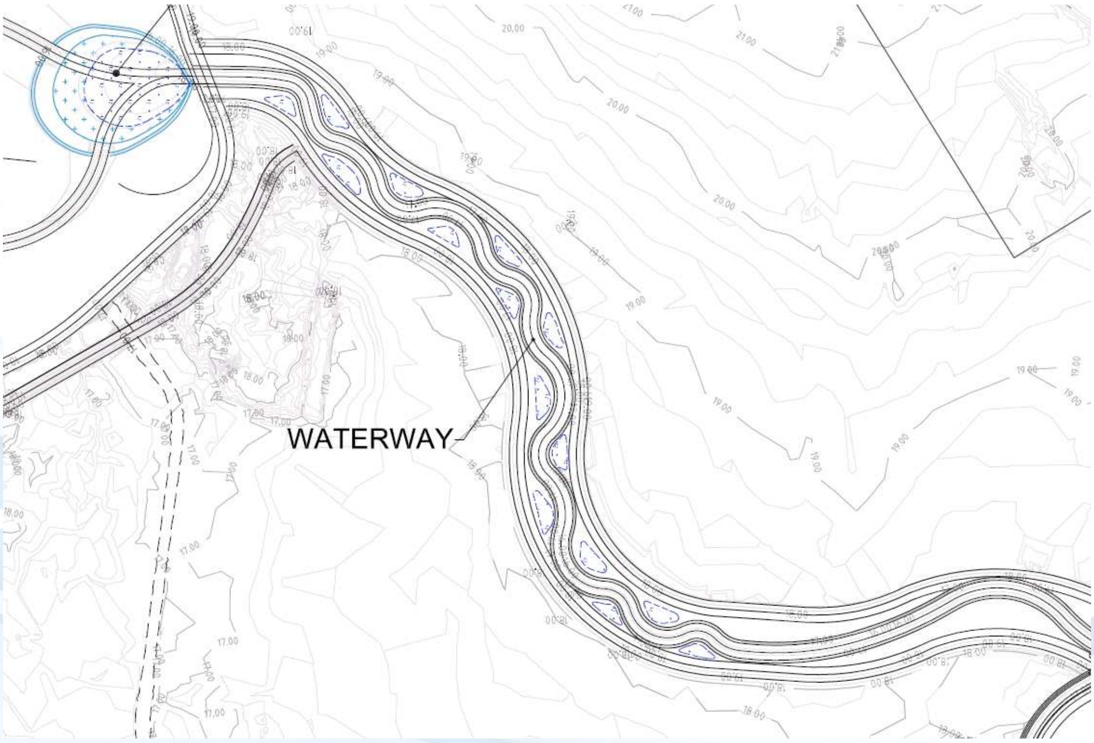


Figure 6.11: Details of the waterway downstream of the RB2 retarding basin

Figure 6.11 shows that a meandering waterway is proposed that operates within high flow banks that contain the 100 year ARI flood events. This system replaces the existing D1 Drain and underground drainage system. A typical cross-section of the waterway is presented in Figure 6.12.

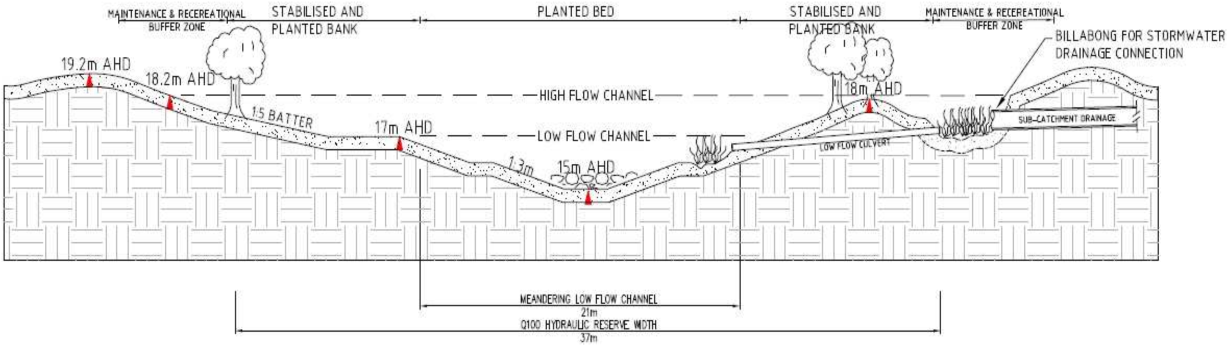


Figure 6.12: Typical cross-section of the waterway

Figure 6.12 reveals that the waterway includes a low flow channel, an over bank floodway and allows connection of stormwater systems within the Werribee Employment Precinct via billabongs in the floodway. Details of the waterway are shown in Table 6.9.

The Werribee Employment Precinct is situated on low lying terrain that requires innovative stormwater management strategies that endeavour to manage stormwater close to or at the ground surface. This constraint can be managed by use of WSUD approaches that retain or convey stormwater in this manner. A typical strategy for connection of Precinct stormwater management systems to regional stormwater facilities is shown in Figure 6.12 that utilise billabongs within a floodway or retarding basin to facilitate discharge of stormwater to the regional scheme.

Table 6.9: Retarding storage provided in the waterway

| Elevation (m AHD) | Storage ($m^3$) | Surface discharge ($m^3/s$) | Comments |
|---|---|---|---|
| 15.5 | 0 | 0 | IL of RB4 pond |
| 16.5 | 5,100 | 0 | IL of low flow culvert at RB2 |
| 17.5 | 21,700 | 9.34 | IL of weir in RB4 |
| 18.5 | 58,650 | 24.65 | |
| 18.7 | 63,315 | 30.25 | |
| 18.8 | 65,648 | 32 | IL of weir in RB2 |
| 19 | 81,975 | 35 | |
| 19.2 | 90,630 | 40 | |

Table 6.9 highlights that the interposed waterway provides storage additional to Basin RB2 and the downstream RB4 basin. At high flows, the RB2 and RB4 retarding basins interact with the waterway to create a larger combined flood storage. The modified RB3 retarding basin is shown in Figure 6.13.

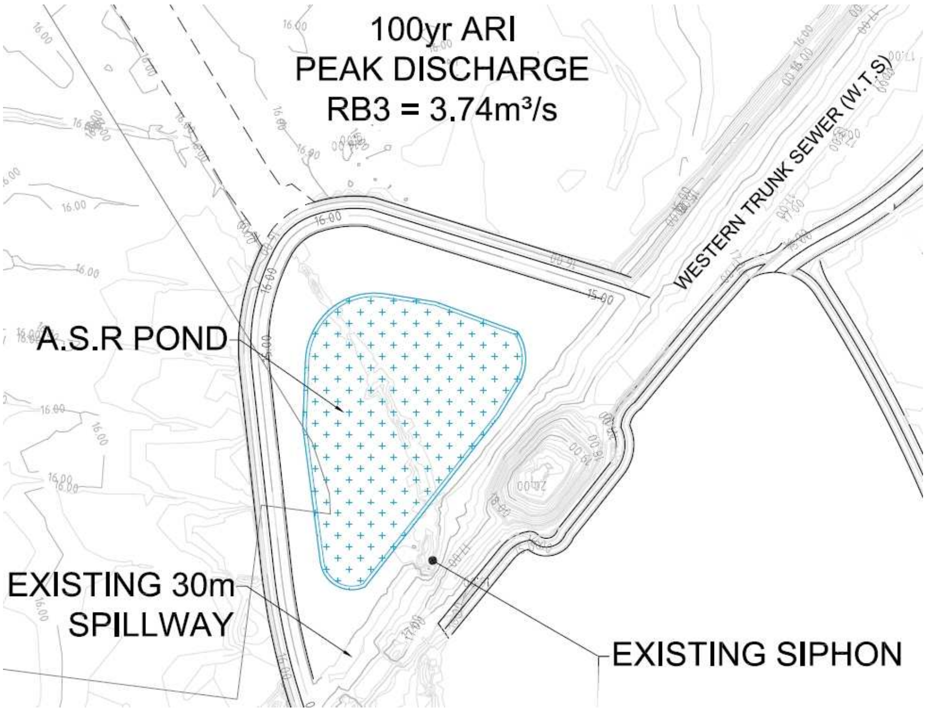


Figure 6.13: The modified RB3 retarding basin on the former D1 Drain

Figure 6.13 shows that the modified RB3 retarding basin retains the single siphon arrangement with 1.2 m orifice and the 30 m wide spillway that allows stormwater to pass under and then spill over the Western Trunk Sewer. The modified RB3 basin includes a pond to facilitate extractions for ASR and is surrounded by bunds that are integrated with the Western Trunk Sewer bund. This modified system also includes filling of the existing D1 Drain. Details of the RB3 basin are provided in Table 6.10.

Table 6.10: Details of the modified RB3 retarding basin

| Elevation (m AHD) | Storage ($m^3$) | Siphon discharge ($m^3/s$) | Weir discharge ($m^3/s$) | Comments |
|---|---|---|---|---|
| 14.2 | 0 | 0 | 0 | IL of single siphon with 1.2 m orifice |
| 15 | 13,500 | 0.91 | 0 | |
| 15.5 | 27,400 | 2.03 | 0 | |
| 16 | 42,610 | 4.83 | 0 | |
| 16.34 | 48200 | 5.4 | 0 | IL of weir (30 m wide) |
| 16.5 | 59,100 | 5.8 | 3.273 | |
| 16.8 | 69,500 | 5.98 | 15.95 | |

The proposed RB4 retarding basin at the crossing of the new waterway over the Western Trunk Sewer is shown in Figure 6.14.

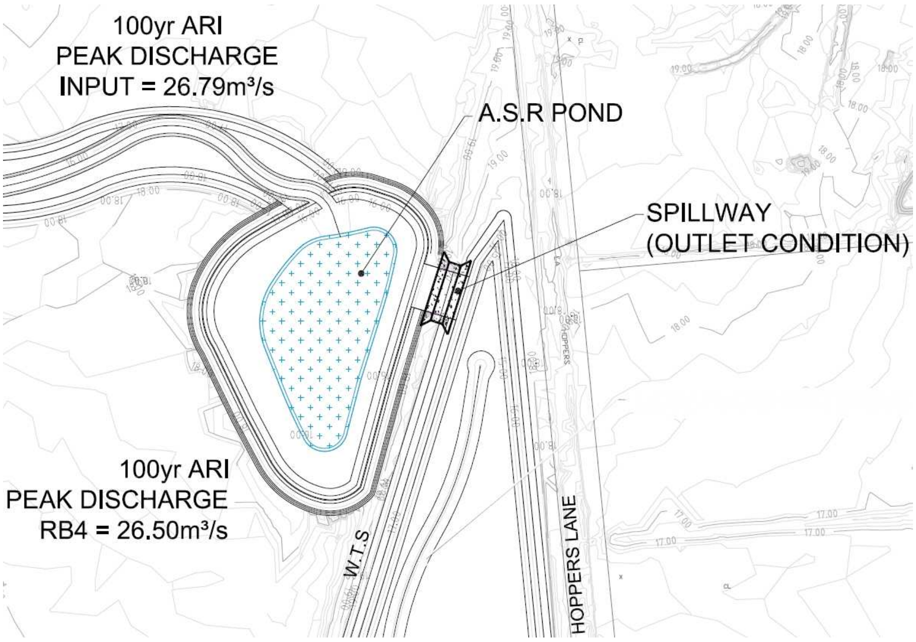


Figure 6.14: The proposed RB4 retarding basin at the intersection of the new waterway and the Western Trunk Sewer

Figure 6.14 shows that the RB4 retarding basin includes a pond to facilitate extractions for the ASR scheme and discharges via a spillway over the Western Trunk Sewer. Details of the spillway over the Western Trunk Sewer are provided in Figure 6.15.

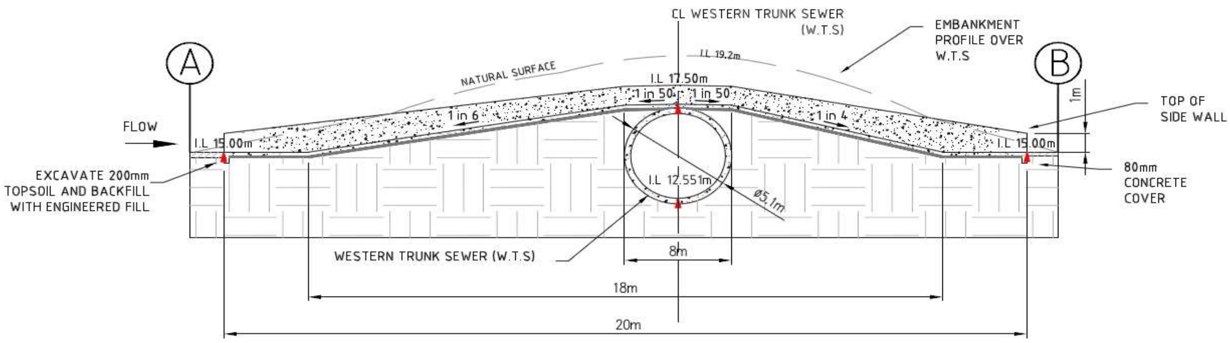


Figure 6.15: Spillway from the RB4 basin at the Western Trunk Sewer

Details of the RB4 retarding basin and the spillway are provided in Table 6.11.

Table 6.11: Details of the RB4 retarding basin

| Elevation (m AHD) | Storage ($m^3$) | Weir discharge ($m^3/s$) | Comments |
|---|---|---|---|
| 15.5 | 0 | 0 | IL of pond |
| 16 | 4,400 | 0 | |
| 16.5 | 16,850 | 0 | |
| 17 | 24,000 | 0 | |
| 17.5 | 40,700 | 0 | IL of weir (9 m wide) |
| 18 | 46,400 | 5.424 | |
| 18.5 | 58,700 | 15.34 | |
| 19 | 71,700 | 28.18 | |
| 19.2 | 80,600 | 34.01 | |

Table 6.11 shows that stormwater can only discharge to the lower catchment when water depths in the RB4 basin reach a height of 17.5 m AHD. This allows the provision of a substantial pond for ASR at this location. Extraction of stormwater from this pond for injection to the aquifer will assist with stormwater management at this location.

The proposed RB5 retarding basin that will be located adjacent to Hoppers Lane and Sneydes Road is shown in Figure 6.16.

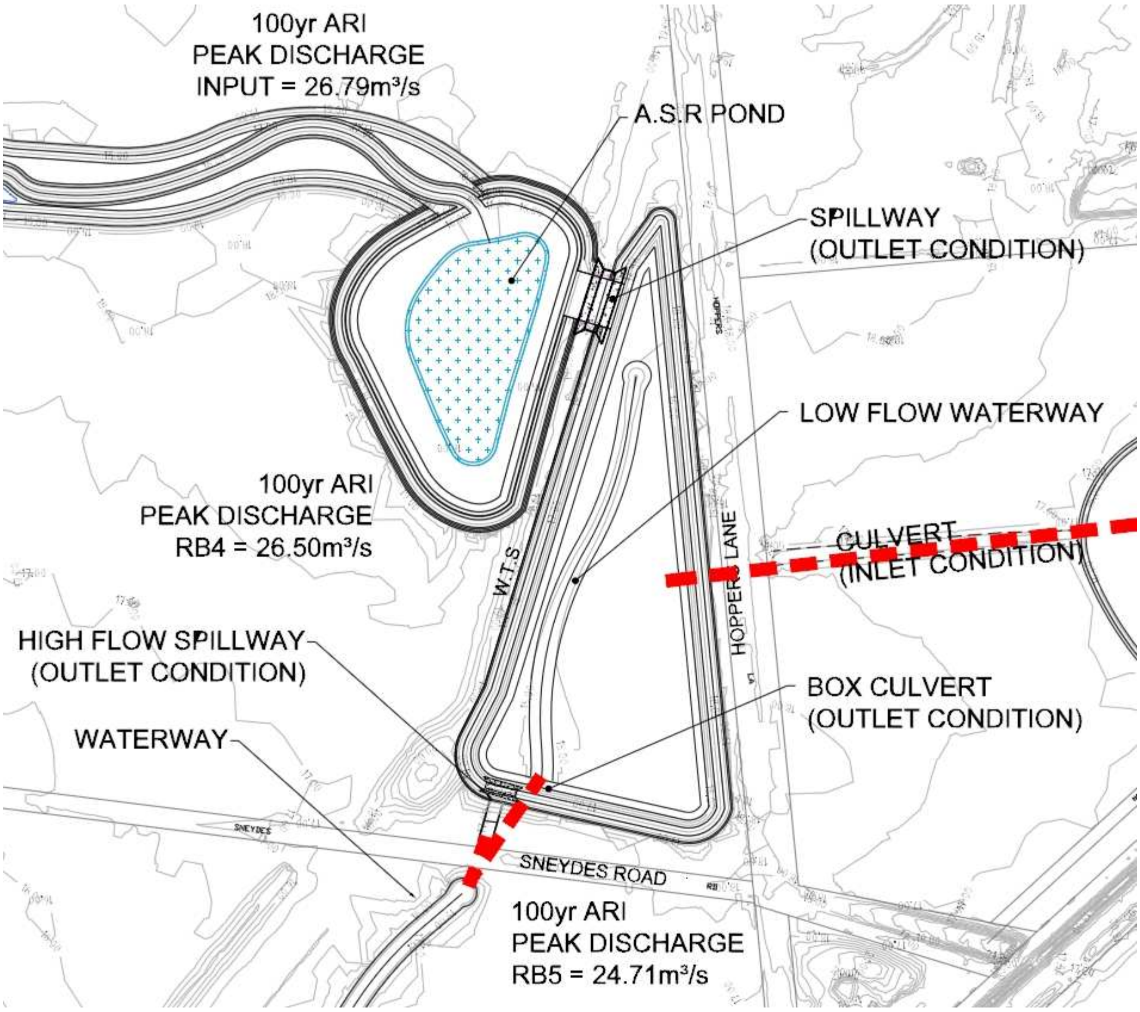


Figure 6.16: The proposed RB5 retarding basin near Hoppers Lane and Sneydes Road

Figure 6.16 shows that the RB5 basin accepts stormwater from the RB4 and RB5a basins and includes a low flow waterway. It discharges to the south under Sneydes Road via a box culvert as presented in Figure 6.17.

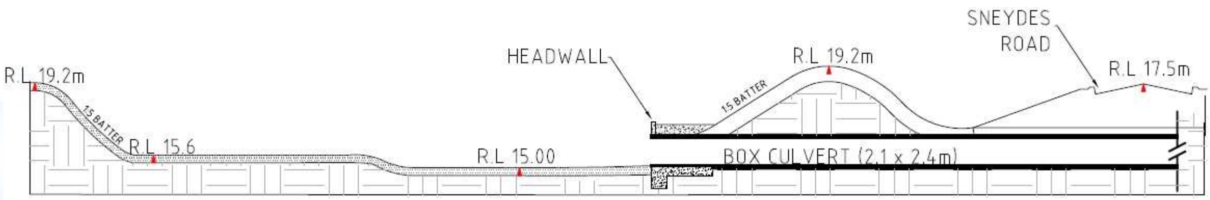


Figure 6.17: Long section of the RB5 retarding basin showing culvert under Sneydes Road

Figure 6.17 shows that the RB5 basin will discharge via a box culvert under Sneydes Road and Sneydes Road is protected from inundation by a bund. Details of the RB5 basin are shown in Table 6.12.

Table 6.12: Details of the RB5 retarding basin

| Elevation (m AHD) | Storage ($m^3$) | Culvert discharge ($m^3/s$) | Culvert discharge ($m^3/s$) | Comments |
|---|---|---|---|---|
| 15.0 | 0 | 0 | 0 | IL of box culvert (2.1 m x 2.4 m) |
| 16.0 | 14,625 | 14 | 0 | |
| 17.0 | 44,515 | 19.83 | 0 | |
| 18.0 | 78,975 | 24.25 | 3.7 | |
| 18.4 | | | | IL of high flow spillway |
| 19.0 | 97,377 | 25.8 | 6.3 | |
| 19.2 | 135,950 | 27.4 | 9.8 | |

Table 6.12 shows that most stormwater outflows from the RB5 basin pass under Sneydes Road via the box culvert to a low flow channel (Figure 6.16) which leads to the RB6 basin. A second high flow culvert is provided to account for larger events such as the climate change scenario. The RB5a retarding basin is shown in Figure 6.18.

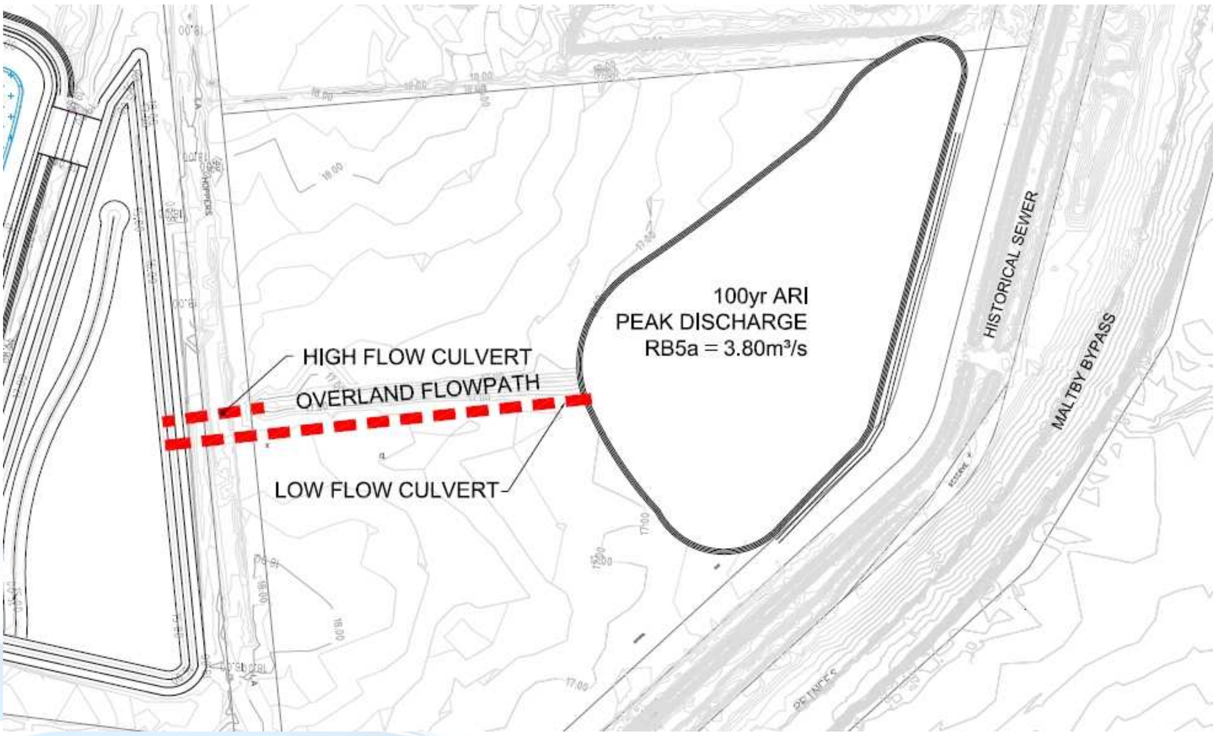


Figure 6.18: The proposed RB5a retarding basin between Hoppers land and the historical sewer

Figure 6.18 shows that the RB5a basin collects stormwater runoff from the isolated area between the Historical Sewer and the Western Trunk Sewer upstream of Sneydes Road. The B5a basin discharges via a low flow culvert (0.6 m x 1.2 m) into the RB5 basin and surcharges via a 3 m wide spillway into an overland flow path when the capacity of the basin is exceeded. A culvert under

Hoppers Lane is required to allow overland flows into the RB5 basin. Details of the RB5a basin are shown in Table 6.13.

Table 6.13: Details of the RB5a retarding basin

| Elevation (m AHD) | Storage ($m^3$) | Culvert discharge ($m^3/s$) | Spillway discharge ($m^3/s$) | Comments |
|---|---|---|---|---|
| 15.8 | 0 | 0 | 0 | IL of box culvert (0.6 m x 1.2 m) |
| 16.0 | 11,200 | 0.59 | 0 | |
| 16.2 | 20,600 | 1.41 | 0 | |
| 16.4 | 30,800 | 2.39 | 0 | |
| 16.6 | 40,000 | 2.64 | 0.46 | Spillway (3 m wide) |
| 16.8 | 50,000 | 2.87 | 1.29 | |

The RB6 retarding basin is shown in Figure 6.19.

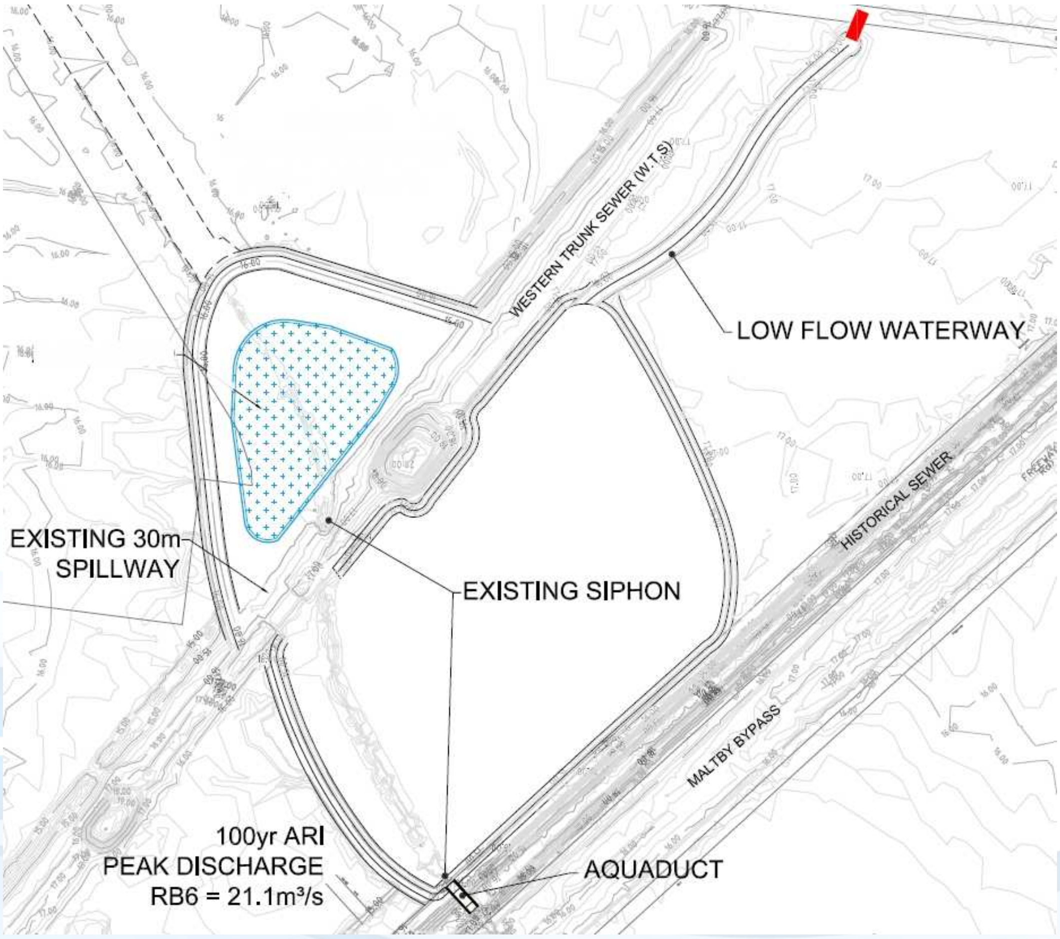


Figure 6.19: The proposed RB6 retarding basin between the Western Trunk Sewer and the Maltby Bypass.

Figure 6.19 shows that the RB3 basin discharges to the RB6 basin via an existing siphon(under) and spillway (over) the Western Trunk Sewer. The RB5 basin also discharges to the RB6 basin via a low flow waterway that can also cope with greater than 100 year ARI peak discharges. The RB6 retarding basin discharges under the historical sewer via the existing twin siphon that is modified to allow both elements to operate. In addition, the basin surcharges over the historical sewer via a proposed aqueduct that is 7 m wide as shown in Figure 6.20.

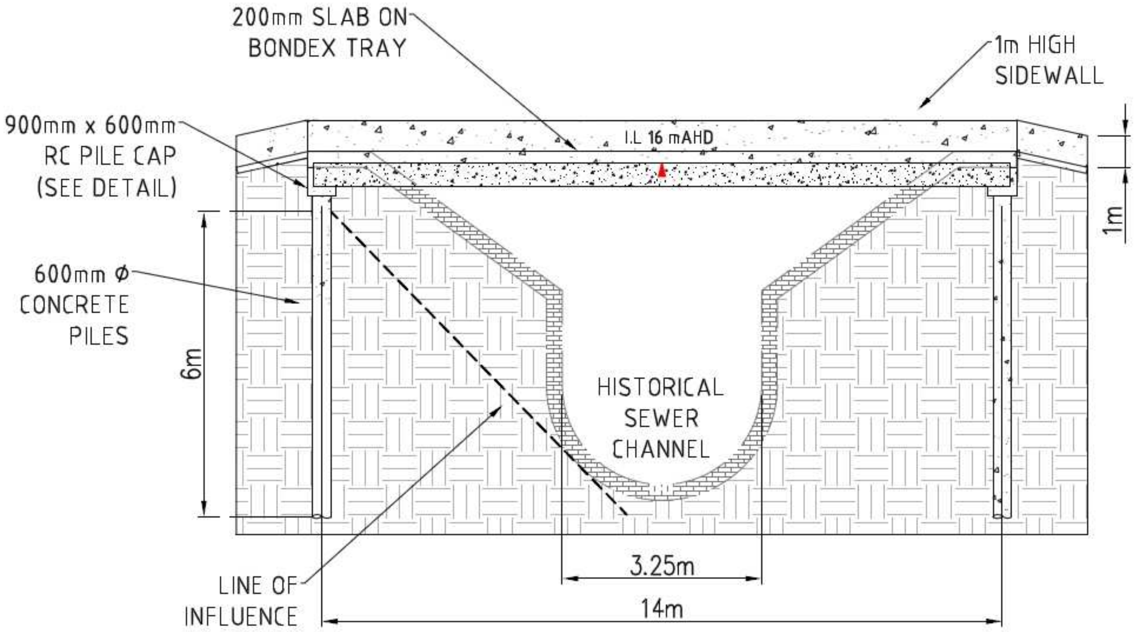


Figure 6.20: Long section of the proposed aqueduct over the historical sewer

Figure 6.20 reveals that the aqueduct bridges the historical sewer using a concrete slab with side walls that are 1 m high. The aqueduct will be supported by concrete piles and will have an invert at 16.0 m AHD as shown in Table 6.14.

Table 6.14: Details of the RB6 retarding basin

| Elevation (m AHD) | Storage (m³) | Siphon discharge (m³/s) | Weir discharge (m³/s) | Comments |
|---|---|---|---|---|
| 14.8 | 0 | 0 | 0 | Twin siphons with 1.2 m orifices |
| 15 | 17,300 | 1.81 | 0 | |
| 15.5 | 60,000 | 4.06 | 0 | |
| 16 | 103,000 | 9.07 | 0 | IL of aqueduct |
| 16.5 | 175,500 | 11.6 | 3.616 | |
| 16.8 | 192,000 | 11.96 | 7.319 | |
| 17 | 198,000 | 14.0 | 9.8 | |

Table 6.14 shows that the twin siphons with 1.2 m orifices facilitates low flow discharges from RB6 and the aqueduct allows the basin to surcharge over the Historical sewer and thence flow under the Maltby Bypass. Previous reports have identified that the bridge under the Maltby Bypass can accept peak discharges of about 20.5 $m^3$/s. Our investigations reveal that peak stormwater discharges of up to 22 $m^3$/s can pass under the bridge. Stormwater discharging from the RB6 basin passes under the Maltby Bypass into the restored waterway to the RB7 retarding basin. Stormwater peak discharges that exceed the capacity of the RB6 Basin, the siphon and the aqueduct will surcharge to the Historical Sewer. It is proposed to modify the D1 Drain to create a restored waterway as shown in Figure 6.21.

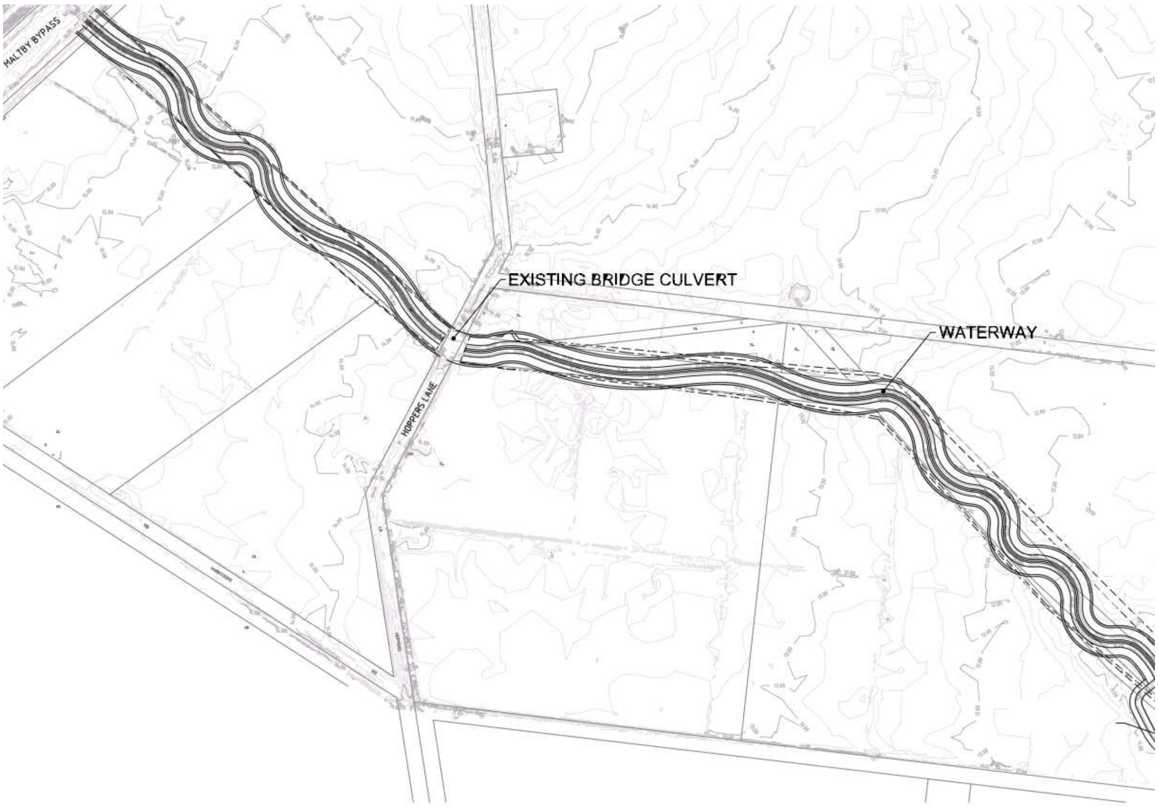


Figure 6.21: The restoration of the D1 Drain as a waterway downstream from the Maltby Bypass

Figure 6.21 show that the restoration of the D1 Drain as a meandering waterway will utilise a similar flow path as the existing D1 Drain. The waterway incorporates the existing bridges at Hoppers Lane and Hacketts Road. A typical cross-section of the waterway is shown in Figure 6.22.

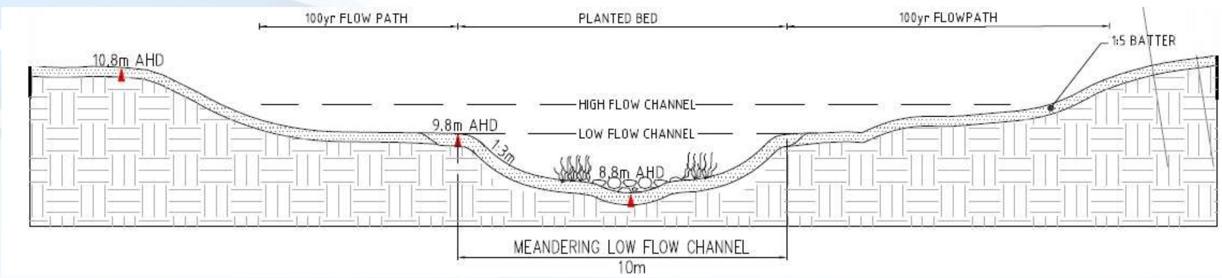


Figure 6.22: Cross section of the waterway downstream of the Maltby Bypass

Figure 6.22 highlights that the restored waterway will incorporate a low flow channel that meanders within a high flow floodway towards the retarding basin RB7 at the boundary of the Werribee Employment Precinct. The RB7 retarding basin is shown in Figure 6.23.

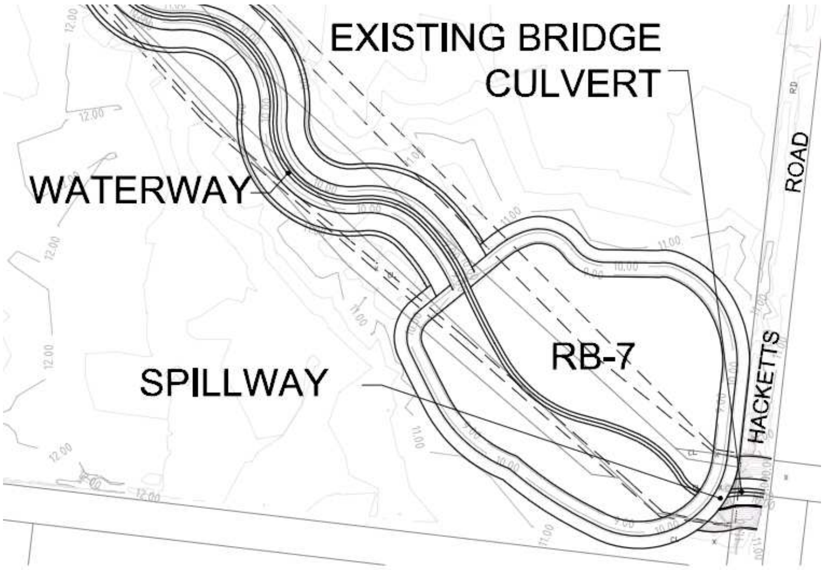


Figure 6.23: The proposed RB7 retarding basin at the exit of the D1 drain catchment from the Werribee Employment Precinct

Figure 6.23 reveals that the RB7 retarding basin will be located at the lowest point of the D1 Drain catchment within the Werribee Employment Precinct as the final step in management of stormwater peak discharges from the Precinct. The basin includes a low flow waterway with an outlet via a 900 mm diameter pipe and surcharges via a spillway with a width of 8 m. Details of the RB7 basin are provided in Table 6.15.

Table 6.15: Details of the RB7 retarding basin

| Elevation (m AHD) | Storage ($m^3$) | Pipe discharge ($m^3/s$) | Spillway discharge ($m^3/s$) | Comments |
|---|---|---|---|---|
| 8.8 | 0 | 0 | 0 | IL of 900 mm diameter pipe |
| 9 | 3,680 | 0.2 | 0 | |
| 9.5 | 13,315 | 1.72 | 0 | IL of weir (8 m wide) |
| 10 | 23,600 | 2.1 | 4.8 | |
| 10.5 | 34,600 | 2.67 | 13.63 | |
| 10.8 | 41,546 | 2.98 | 20.21 | |

Table 6.15 reveals that the RB7 basin manages peak stormwater discharges from the D1 Drain catchment using an 8 m wide spillway.  Total outflow is well below the capacity of the existing bridge at Hacketts Road.

## 6.3 Upper Point Cook catchment

All development within the upper Point Cook catchment must meet the integrated water cycle management objectives for the Werribee Employment precinct which includes provision of a WSUD strategy to manage stormwater runoff. The stormwater management infrastructure proposed for the upper Point Cook catchment is shown in Figure 6.24.

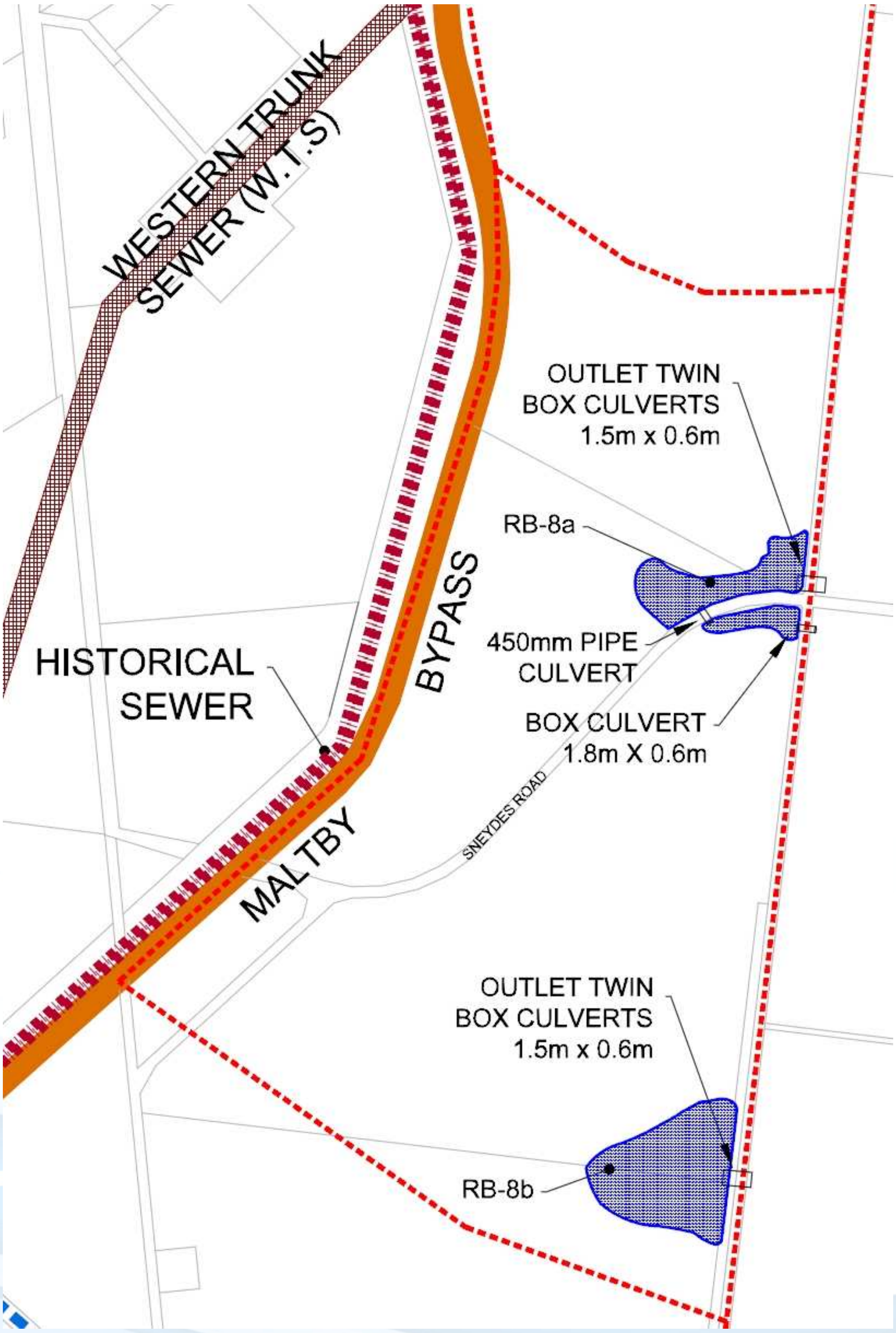


Figure 6.24: Overview of stormwater management infrastructure proposed for the upper Point Cook catchment

Figure 6.24 shows that two retarding basins, namely RB8a and RB8b, are proposed to manage stormwater peak discharges from the upper Point Cook catchment. Note that the RB8a basin includes an existing outlet under Sneydes and two outlets under Hacketts Road.

The proposed RB8a basin as presented in Figure 6.25 includes a culvert outlet under Hacketts road from the main storage and a small "high level" culvert outlet under Sneydes Road that discharges from the existing billabong. Stormwater flows from the second outlet travels parallel to Sneydes Road and ultimately discharge under Hacketts Road. This discharge point is shown as location C7 on drawing number 4043/01/001 by MWC.

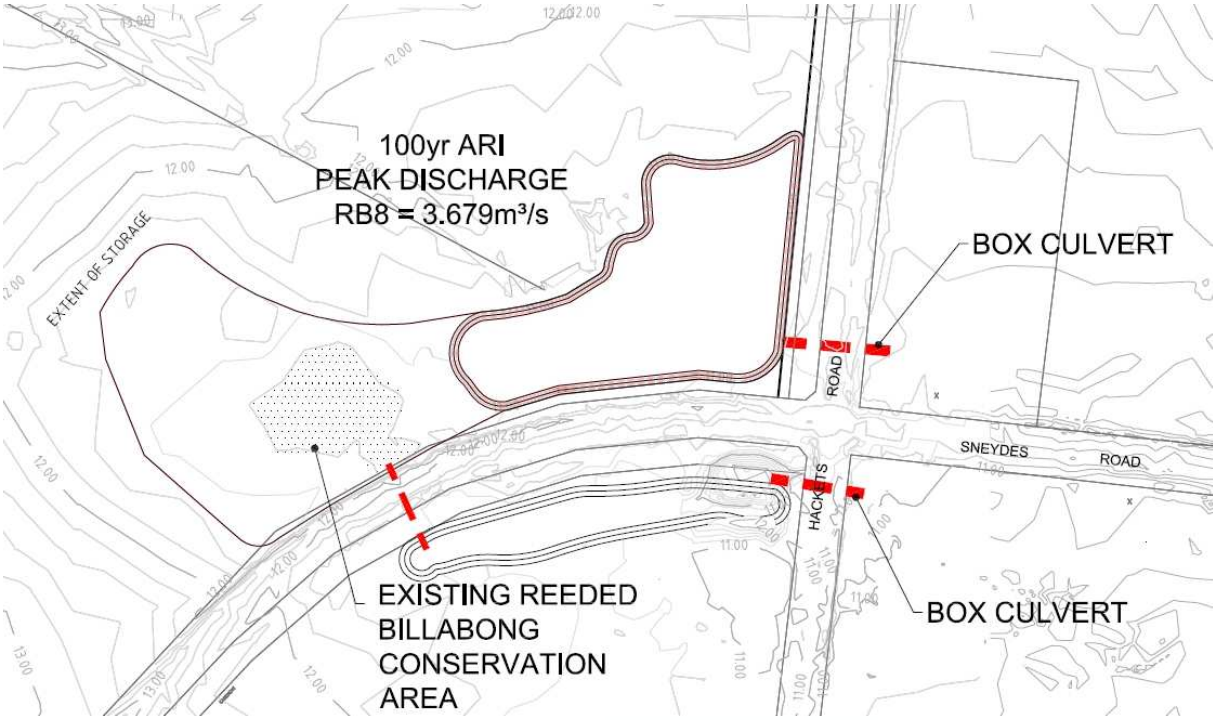


Figure 6.25: Details of the RB8a retarding basin

The details in Figure 6.25 highlight that the footprint of the proposed RB8a retarding basin incorporates the existing reeded billabong and outlet culverts. It is proposed to preserve the existing reeded area within the proposed retarding basin and provide a swale on the south side of Sneydes Road to accommodate high level overflows from the billabong. Details of the RB8a basin are shown in Table 6.16.

Table 6.16: Details of the RB8a retarding basin

| Elevation (m AHD) | Storage ($m^3$) | Culvert ($m^3/s$) | Comments |
|---|---|---|---|
| 10.61 | 0 | 0 | IL of twin box culverts (1.5 m x 0.6 m) |
| 10.8 | 3,680 | 2.18 | |
| 11 | 13,315 | 3.12 | |
| 11.2 | 23,600 | 3.84 | IL of high flow outlet |
| 11.4 | 17,000 | 4.44 | |
| 11.53 | 18,000 | 4.8 | |

Table 6.16 reveals that the proposed retarding basin and the existing outlet culverts have sufficient capacity to manage inflows from the Upper Point Cook Catchment. The proposed RB8b retarding basin illustrated in Figure 6.26 provides retarding storage in an area currently subject to flooding. It releases water via a culvert outlet under Hacketts Road. This basin discharges to the location F4 as shown on drawing number 4043/01/001 by MWC.

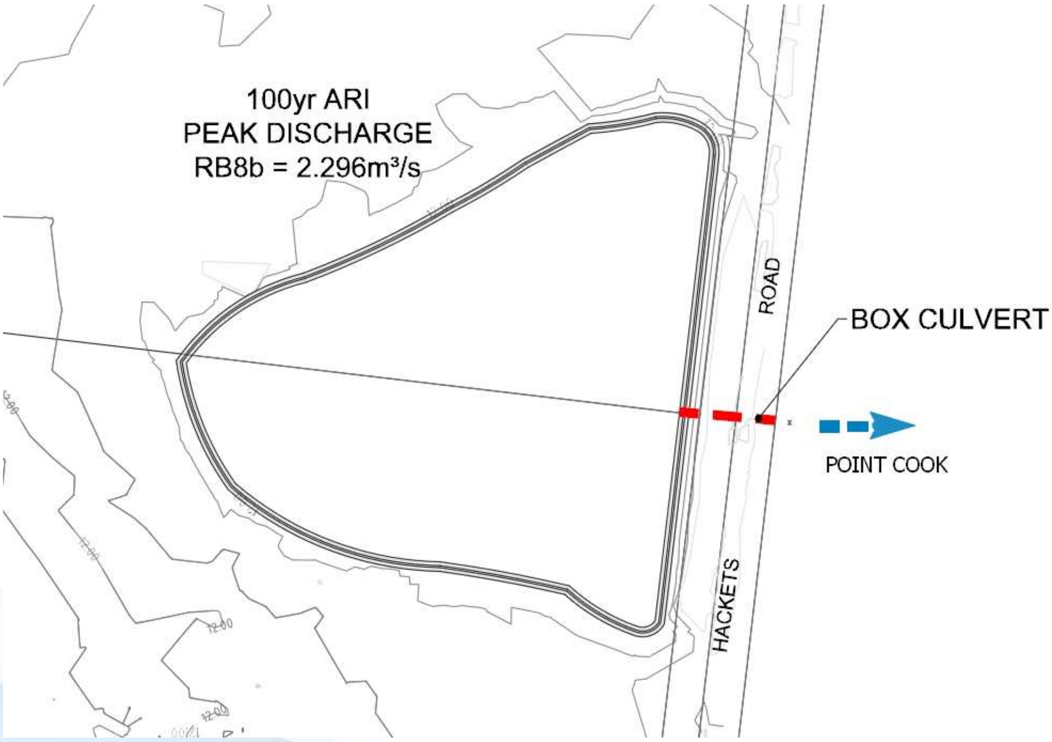


Figure 6.26: Details of the RB8b retarding basin

Figure 6.26 reveals that the footprint of the proposed RB8b retarding basin incorporates the existing area subject to inundation and provides twin box culverts to facilitate discharge under Hacketts Road. Details of the RB8b retarding basin are provided in Table 6.17.

Table 6.17: Details of the RB8b retarding basin

| Elevation (m AHD) | Storage ($m^3$) | Culvert ($m^3/s$) | Comments |
|---|---|---|---|
| 11 | 0 | 0 | IL of twin box culverts (1.5 m x 0.3m) |
| 11.2 | 9,400 | 1.24 | |
| 11.4 | 18,900 | 1.76 | |
| 11.6 | 28,600 | 2.15 | |
| 11.8 | 38,500 | 2.48 | |

Table 6.17 shows that the twin box culverts under Hacketts Road allow the basin to discharge to the downstream Point Cook catchment and that the proposed basin has sufficient capacity to manage stormwater peak discharges from the upstream catchment.

## 6.4 Upper Skeleton Creek catchment

All development within the upper Skeleton Creek catchment must meet the integrated water cycle management objectives for the Werribee Employment Precinct which includes provision of a WSUD strategy to manage stormwater runoff. The stormwater management infrastructure proposed for the upper Skeleton Creek catchment is shown in Figure 6.27.

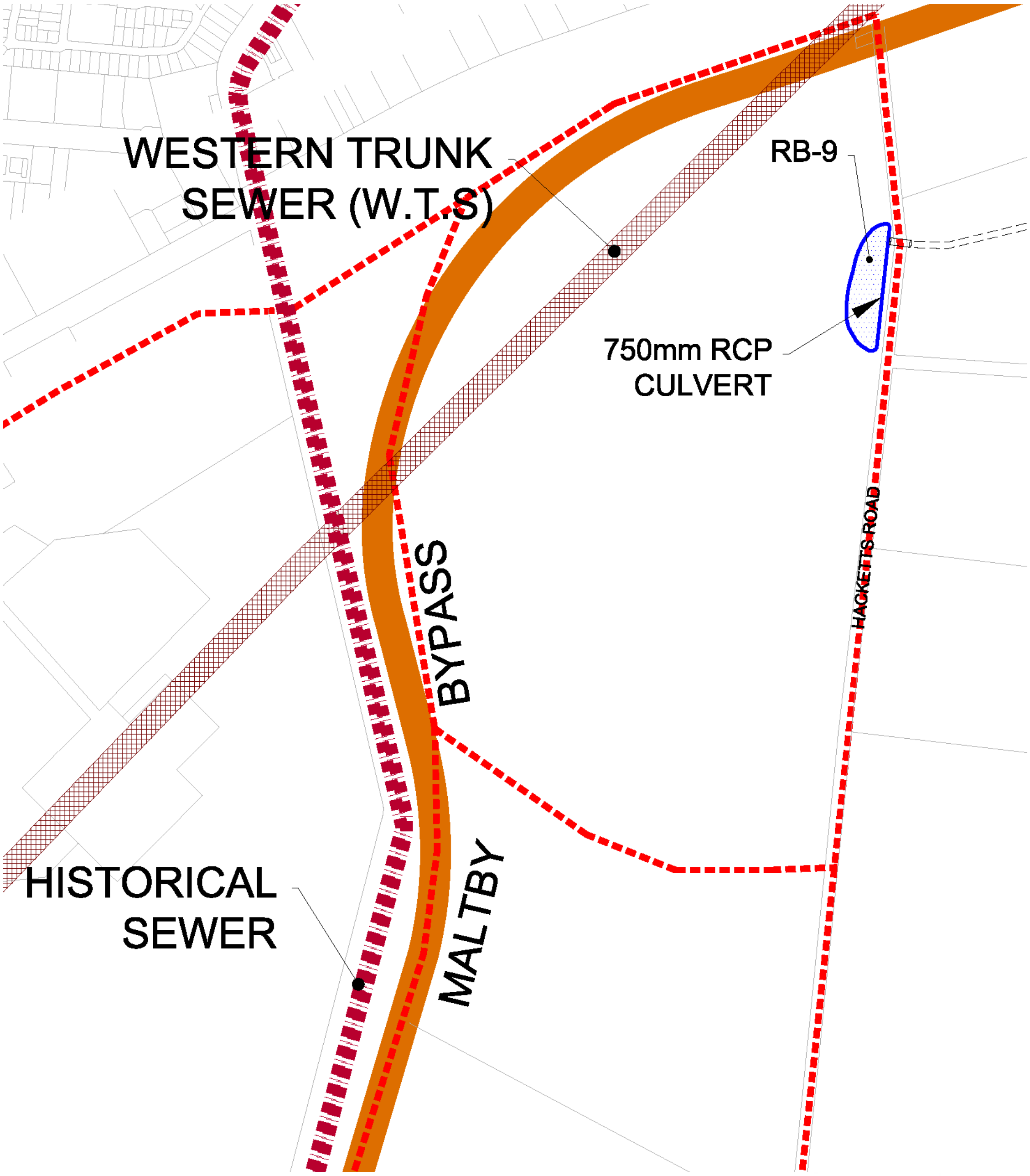


Figure 6.27: Overview of stormwater management infrastructure proposed for the upper Skeleton Creek catchment

The proposed RB9 retarding basin as presented in Figure 6.28 includes a pipe culvert outlet under Hacketts road from the main storage that discharges via the existing infrastructure in the Water Haven development towards Skeleton Creek.

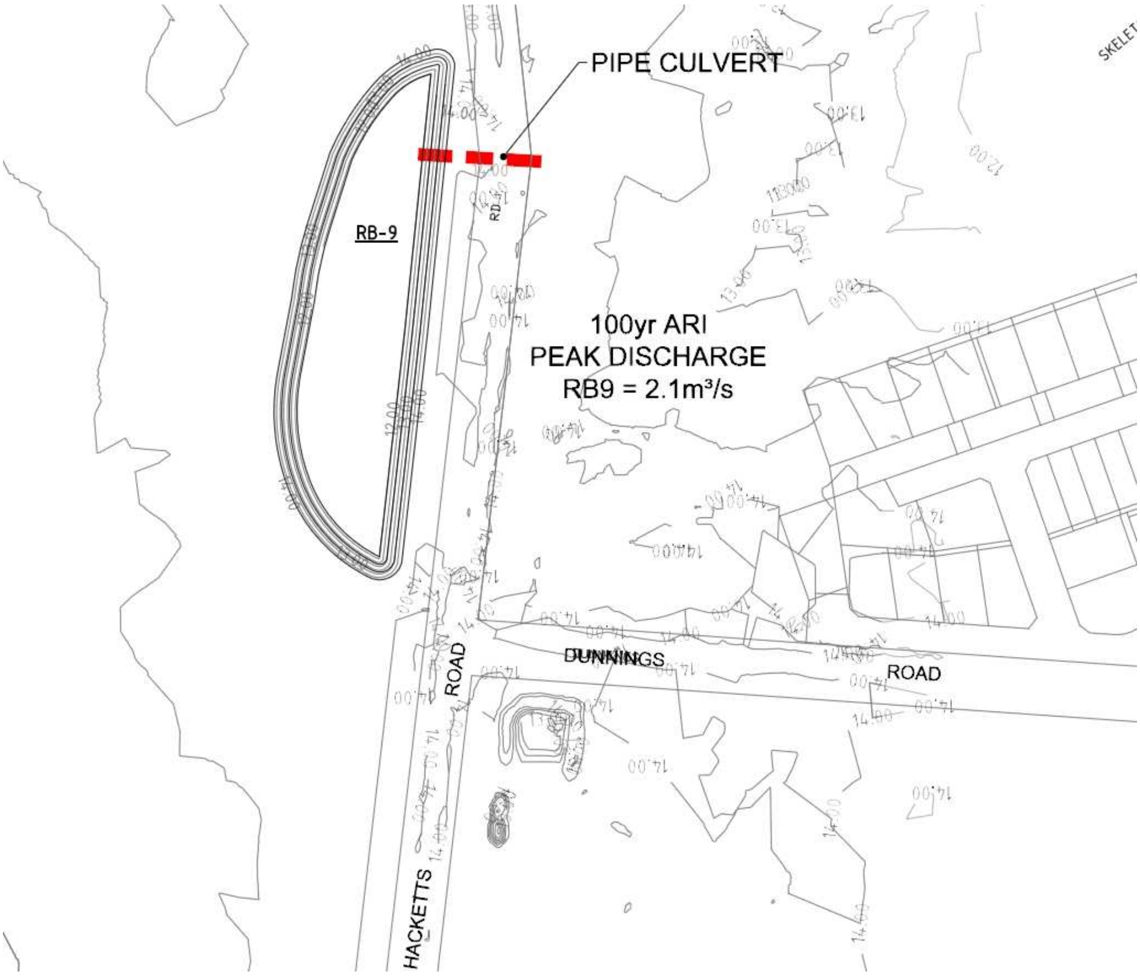


Figure 6.28: Details of the RB9 retarding basin

Details of the RB9 retarding basin are shown in Table 6.18.

Table 6.18: Details of RB9 retarding basin

| Elevation (m AHD) | Storage ($m^3$) | Pipe discharge ($m^3/s$) | Spillway discharge ($m^3/s$) | Comments |
|---|---|---|---|---|
| 11.32 | 0 | 0 | 0 | IL of 750 mm diameter pipe |
| 11.82 | 5,000 | 0.92 | 0 | |
| 12.32 | 8,600 | 1.76 | 0 | |
| 12.82 | 12,500 | 2.07 | 0 | IL of emergency spillway |
| 13.32 | 16,700 | 2.35 | 2.6 | |

Table 6.18 shows that the 750 mm diameter pipe under Hacketts Road allows the basin to discharge to the existing infrastructure in the downstream Water Haven development and that the proposed basin has sufficient capacity to manage stormwater peak discharges from the upstream catchment. Nevertheless, an emergency spillway is provided that will discharge via Freshet Avenue towards

Skeleton Creek. The maximum acceptable peak discharge of surface flows along Freshet Avenue is 2.6 $m^3/s$ to meet safety requirements as defined by velocity – depth product (VD) of less than 0.4.

## 6.5 Hydrology

The hydrology of the upstream catchments and within the Werribee Employment Precinct was determined by the addition of infrastructure and various urban land uses to the calibrated models of pre-European conditions. Our hydrology model (WUFS) was also compared to the MWC's preferred model for completeness (RORB).

### 6.5.1 Upstream catchment

The hydrology at key locations in the upstream catchments is presented in Table 6.19.

Table 6.19: The hydrology at key locations in the upstream catchments

| ARI (years) | Peak discharge ($m^3/s$) at location | | | |
|---|---|---|---|---|
| | Heaths Road | Derrimut Road | D1 to WEP | P1 to WEP |
| 1 | 8.73 | 0.4 | 1.81 | 3.45 |
| 2 | 14.02 | 2.55 | 4.76 | 6.26 |
| 5 | 20.29 | 11.0 | 14.21 | 10.03 |
| 10 | 25.62 | 13.23 | 16.84 | 12.56 |
| 20 | 32.3 | 24.13 | 29.26 | 15.98 |
| 50 | 40.81 | 31.84 | 39.95 | 20.55 |
| 100 | 47.51 | 36.92 | 47.17 | 23.91 |

Table 6.19 shows that the modified stormwater retarding strategy within the D1 Drain Reserve mitigates increased development in the upper catchment to generate a no worsening of peak discharges and reduced frequent peak discharges to the Werribee Employment Precinct. The impact of expected climate change on the hydrology at key locations in the upstream catchments is presented in Table 6.20.

Table 6.20: The impact of climate change on the hydrology at key locations in the upstream catchments

| ARI (years) | Peak discharge ($m^3/s$) at location | | | |
|---|---|---|---|---|
| | Heaths Road | Derrimut Road | D1 to WEP | P1 to WEP |
| 1 | 11.88 | 0.56 | 3.15 | 5.13 |
| 2 | 17.88 | 7.14 | 8.44 | 8.91 |
| 5 | 26.29 | 12.51 | 15.57 | 13.08 |
| 10 | 32.35 | 20.41 | 24.1 | 16.18 |
| 20 | 40.35 | 26.57 | 31.8 | 20.12 |
| 50 | 50.07 | 32.85 | 40.08 | 25.68 |
| 100 | 57.89 | 38.3 | 46.72 | 30.11 |

Table 6.20 shows that the impacts of climate change include higher peak discharges from the upstream catchments into the Werribee Employment Precinct. The modified retarding basin and constructed wetland system in the D1 Drain Reserve has served to mitigate a proportion of the increased stormwater peak discharges from the D1 Drain catchment.

### 6.5.1 D1 Drain catchment within Werribee Employment Precinct

Stormwater from the upper catchments flows in the D1 Drain through the Werribee Employment Precinct towards the RB3 basin adjacent to the Western Trunk Sewer and under the Maltby Bypass. The hydrology at key locations in this flow path is shown in Table 6.21.

Table 6.21: The hydrology in the D1 catchment within the Werribee Employment Precinct

| ARI (years) | Peak discharge ($m^3/s$) at location | |
|---|---|---|
| | Maltby Bypass | D1 From WEP |
| 1 | 2.35 | 1.79 |
| 2 | 5.17 | 4.62 |
| 5 | 11.94 | 11.39 |
| 10 | 15.84 | 15.34 |
| 20 | 20.05 | 19.53 |
| 50 | 20.9 | 20.6 |
| 100 | 21.1 | 21.18 |

Table 6.21 shows that the peak discharges under the Maltby Bypass are compliant with capacity of bridge culvert (about 22 $m^3/s$) and peak discharges from the Werribee Employment Precinct are similar to the pre-European case.

The impact of climate change on the hydrology at key locations in this flow path is shown in Table 6.22.

Table 6.22: The hydrology in the D1 catchment within the Werribee Employment Precinct

| ARI (years) | Peak discharge ($m^3/s$) at location | | |
|---|---|---|---|
| | Maltby Bypass | D1 From WEP | Historical Sewer |
| 1 | 2.68 | 1.97 | 0 |
| 2 | 8.97 | 7.92 | 0 |
| 5 | 18.6 | 16.9 | 0 |
| 10 | 22 | 21.15 | 3.38 |
| 20 | 22 | 21.86 | 5.91 |
| 50 | 22 | 23.2 | 9.62 |
| 100 | 22 | 25.38 | 10 |

Table 6.22 shows that the peak discharges under the Maltby Bypass are compliant with capacity of bridge culvert and peak discharges from the Werribee Employment Precinct are similar to the pre-European case. However, the increases in peak stormwater discharges resulting by climate change have resulted in surcharges to the Historical Sewer. The magnitudes of surcharges to the Historical Sewer are considerably reduced in comparison to existing conditions. It is also possible to store the excess stormwater runoff created by climate change in and adjacent to the RB6 basin.

### 6.5.3 Upper Point Cook catchment

The hydrology in the upper Point Cook catchment at the exit from the Werribee Employment Precinct is shown in Table 6.23.

Table 6.23: Hydrology at the exit of the upper Point Cook Catchment

| ARI (years) | Peak discharge ($m^3/s$) | |
|---|---|---|
| | A | B |
| 1 | 0.64 | 0.74 |
| 2 | 1.19 | 0.97 |
| 5 | 2.02 | 1.28 |
| 10 | 2.68 | 1.52 |
| 20 | 3.5 | 1.82 |
| 50 | 3.59 | 2.12 |
| 100 | 3.68 | 2.3 |

Table 6.23 shows that peak discharges from the upper Point Cook catchment are not worse than existing conditions and are similar to pre-European discharges. The proposed stormwater management strategy that includes WSUD within the catchment provides the acceptable management of stormwater. The impacts of climate change on the hydrology in the upper Point Cook catchment at the exit from the Werribee Employment Precinct are shown in Table 6.24.

Table 6.24: Hydrology at the exit of the upper Point Cook Catchment

| ARI (years) | Peak discharge ($m^3/s$) | |
|---|---|---|
| | A | B |
| 1 | 1.01 | 0.9 |
| 2 | 1.73 | 1.2 |
| 5 | 2.81 | 1.59 |
| 10 | 3.51 | 1.88 |
| 20 | 3.59 | 2.13 |
| 50 | 3.7 | 2.43 |
| 100 | 3.71 | 2.65 |

Table 6.24 shows that the climate change scenario increases peak discharges from the upper Point Cook catchment.

### 6.5.4 Upper Skeleton Creek Catchment

The hydrology in the upper Skeleton Creek catchment at the exit from the Werribee Employment Precinct is shown in Table 6.25.

Table 6.25: Hydrology at the exit of the upper Skeleton Creek Catchment

| ARI (years) | Peak discharge ($m^3/s$) Skeleton Creek |
|---|---|
| 1 | 0.62 |
| 2 | 0.76 |
| 5 | 0.84 |
| 10 | 0.84 |
| 20 | 0.93 |
| 50 | 1.64 |
| 100 | 2.1 |

Table 6.25 shows that peak discharges from the upper Skeleton Creek catchment are not worse than

existing conditions and are similar to pre-European discharges. The proposed stormwater management strategy meets the objectives for the Precinct. The impacts of climate change on the hydrology in the upper Skeleton Creek catchment at the exit from the Werribee Employment Precinct is shown in Table 6.26.

Table 6.26: Impact of climate change on the Hydrology at the exit of the upper Skeleton Creek Catchment

| ARI (years) | Peak discharge ($m^3/s$) Skeleton Creek |
|---|---|
| 1 | 0.71 |
| 2 | 0.84 |
| 5 | 0.84 |
| 10 | 1.05 |
| 20 | 1.77 |
| 50 | 2.67 |
| 100 | 3.29 |

Table 6.25 shows that the climate change scenario increases peak discharges from the upper Skeleton Creek catchment. This increase in peak discharges will result in a surcharge of 2.47 $m^3/s$ over the emergency spillway in the RB9 basin into the overland flow path at the centre of Freshet Avenue in the Water Haven development. However, this overland flow is compliant with the safety criteria of a velocity-depth product less than 0.4.

## 6.6 Hydraulics

The extent of flooding from 100 year ARI storm events in the developed catchments is shown in Figure 6.29.

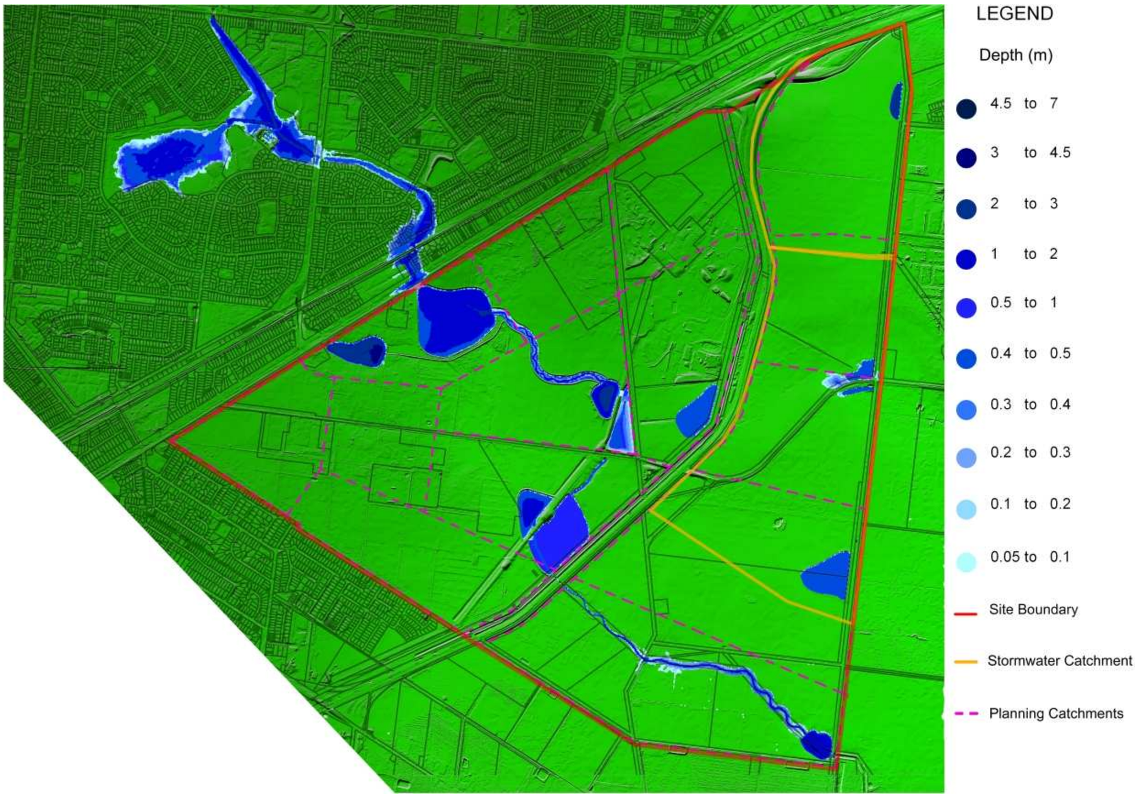


Figure 6.29: Extent of flooding from 100 year ARI storm events in the developed catchments

Figure 6.29 reveals that the amended retarding basin and constructed wetland in the upper catchment, and the restored waterways and new retarding basins within Werribee Employment Precinct provides significant mitigation of flooding in the D1 Drain catchment. The extent of inundation from flooding is shown in Table 6.27.

Table 6.27: Extent of inundation within the Werribee Employment Precinct

| Inundation at depth | Area of flood (ha) | |
|---|---|---|
| | Design | Existing |
| Full extent | 57 | 391 |
| > 50 mm | 55 | 230 |
| > 100 mm | 54 | 172 |

Table 6.27 reveals that stormwater management strategy has significantly reduced the extent of inundation from 100 year ARI flood events in comparison to existing conditions. The reduction in inundation results from more effective mitigation of stormwater runoff from the urbanised upstream catchments, and the use of a formal stormwater management system (WSUD) and optimised waterway strategy including retarding basins within the Werribee Employment Precinct. The extent of flooding from 100 year ARI storm events as altered by expected climate change in the developed catchments is shown in Figure 6.30.

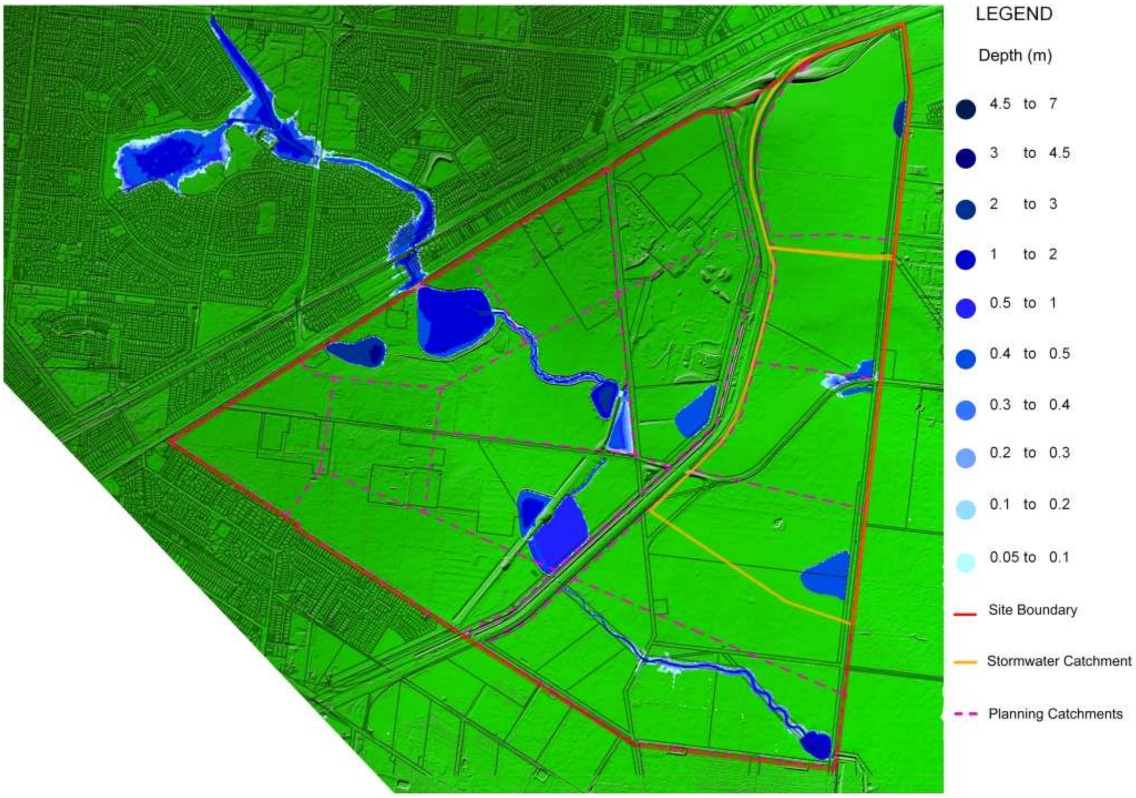


Figure 6.30: Extent of flooding from 100 year ARI storm events with impacts of climate change in the developed catchments

Figure 6.30 reveals that the stormwater management strategy is resilient to the expected impacts of climate change generated by the high emissions scenario in 2070. The extent of inundation from flooding under the expected impacts of climate change is shown in Table 6.28.

Table 6.28: Extent of inundation with impacts of climate change within the Werribee Employment Precinct

| Inundation at depth | Area of flood (ha) | |
|---|---|---|
| | Design | Climate Change |
| Full extent | 57 | 79 |
| > 50 mm | 55 | 57 |
| > 100 mm | 54 | 56 |

Table 6.28 confirms that the proposed stormwater management strategy is resilient to the impacts of climate change. Small increases in the area of inundation are generated by the climate change scenario.

## 6.7 Stormwater quality

The land uses in the interim development plan from the Department of Planning and Community Development and infrastructure within the catchments was utilised in the analysis of stormwater quality. The MUSIC model was utilised to analyse the performance of the catchments.

### 6.7.1 Upper catchment

The characteristics of stormwater quality discharging to the D1 Drain Reserve at Heaths Road are shown in Table 6.29.

Table 6.29: Stormwater quality at Heaths Road

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 1,210 | 1,180 | 2.2 |
| Total Suspended Solids (kg/yr) | 242,000 | 51,200 | 78.9 |
| Total Phosphorus (kg/yr) | 495 | 292 | 41.0 |
| Total Nitrogen (kg/yr) | 3,440 | 2,480 | 27.8 |
| Gross Pollutants (kg/yr) | 47,600 | 808 | 98.3 |

Table 6.29 reveals that the installation of a GPT downstream of the Werribee Plaza and schools generates considerable improvements in the quality of stormwater discharging into the D1 Drain reserve and ultimately the Glen Orden constructed wetland. The characteristics of stormwater quality discharging from the D1 Drain Reserve at Derrimut Road are shown in Table 6.30.

Table 6.30: Stormwater quality at Derrimut Road

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 1,580 | 1,420 | 10.5 |
| Total Suspended Solids (kg/yr) | 319,000 | 48,900 | 84.7 |
| Total Phosphorus (kg/yr) | 651 | 243 | 62.6 |
| Total Nitrogen (kg/yr) | 4,520 | 2,650 | 41.3 |
| Gross Pollutants (kg/yr) | 62,700 | 4,330 | 93.1 |

Table 6.30 shows that the diversion of stormwater flows from the D1 Drain into the Glen Orden constructed wetland will significantly improve the quality of stormwater discharging towards the Werribee Employment Precinct. The characteristics of stormwater entering the Werribee Employment Precinct from the D1 Drain catchments are presented in Table 6.31.

Table 6.31: Stormwater quality at D1 Drain entering Werribee Employment Precinct

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 2,030 | 1,870 | 8.2 |
| Total Suspended Solids (kg/yr) | 409,000 | 135,000 | 67.0 |
| Total Phosphorus (kg/yr) | 834 | 421 | 49.6 |
| Total Nitrogen (kg/yr) | 5,810 | 3,930 | 32.4 |
| Gross Pollutants (kg/yr) | 80,700 | 21,400 | 73.4 |

Table 6.31 reveals significant improvement in the quality of stormwater entering the Precinct. However, the reductions in loads of stormwater pollutants are not compliant with the stormwater best practice targets for reductions relative to normal urban development. The characteristics of stormwater entering the Werribee Employment Precinct from the other upstream catchments are presented in Table 6.32.

Table 6.32: Stormwater quality at P1 entering Werribee Employment Precinct

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 862 | 861 | 0.0 |
| Total Suspended Solids (kg/yr) | 177,000 | 8,170 | 95.4 |
| Total Phosphorus (kg/yr) | 362 | 221 | 39.1 |
| Total Nitrogen (kg/yr) | 2,510 | 2,110 | 16.1 |
| Gross Pollutants (kg/yr) | 31,600 | 626 | 98.0 |

Table 6.32 shows that the quality of stormwater entering the Precinct at P1 is not compliant with stormwater best practice guidelines for the nutrients phosphorus and nitrogen. Installation of a GPT at the entry of the P1 stormwater drains to the Werribee Employment Precinct produces acceptable improvement in pollutant loads of total suspended solids and litter (gross pollutants).

### 6.7.2 D1 Drain catchment within Werribee Employment Precinct

The characteristics of stormwater discharging under the Maltby Bypass in the restored waterway that was the D1 drain are presented in Table 6.33.

Table 6.33: Stormwater quality at the Maltby Bypass in the restored waterway that was the D1 Drain

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 3,690 | 1,870 | 49.2 |
| Total Suspended Solids (kg/yr) | 614,000 | 45,300 | 92.6 |
| Total Phosphorus (kg/yr) | 1,300 | 289 | 77.8 |
| Total Nitrogen (kg/yr) | 9,690 | 3,700 | 61.9 |
| Gross Pollutants (kg/yr) | 94,200 | 0 | 100.0 |

Table 6.33 reveals that the quality of stormwater discharging under Maltby Bypass is compliant with the stormwater best practice guidelines. This improvement in the quality of stormwater is achieved by the restored waterway and the use of retarding basins that include some retention storage. The retention storages at the base of the retarding basins will facilitate injection of stormwater into the aquifer as part of the proposed aquifer storage and recovery (ASR) scheme. The characteristics of stormwater discharging from the Werribee Employment Precinct in the restored waterway that was the D1 drain are presented in Table 6.34.

Table 6.34: Stormwater quality discharging from restored waterway that was the D1 Drain

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 4,010 | 1,740 | 56.6 |
| Total Suspended Solids (kg/yr) | 690,000 | 36,100 | 94.8 |
| Total Phosphorus (kg/yr) | 1,440 | 235 | 83.7 |
| Total Nitrogen (kg/yr) | 10,500 | 2,990 | 71.6 |
| Gross Pollutants (kg/yr) | 105,000 | 0 | 100.0 |

Table 6.34 reveals that the quality of stormwater discharging from the Werribee Employment Precinct into the D1 Drain is better than the stormwater best practice guidelines. Note that the average annual volume of stormwater discharging into downstream D1 Drain catchment is similar to pre-European volumes due to the use of stormwater retention facilities and ASR within the Werribee Employment Precinct.

### 6.7.3 Upper Point Cook catchment

The quality of stormwater discharging from the upper Point Cook catchment is shown in Table 6.35.

Table 6.35: Stormwater quality discharging from the Upper Point Cook catchment

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 791 | 698 | 11.8 |
| Total Suspended Solids (kg/yr) | 159,200 | 9,450 | 94.1 |
| Total Phosphorus (kg/yr) | 308 | 72 | 76.8 |
| Total Nitrogen (kg/yr) | 2,227 | 1,223 | 45.0 |
| Gross Pollutants (kg/yr) | 27,930 | 0 | 100.0 |

Table 6.35 reveals that use of WSUD strategies in the catchment ensures that the quality of stormwater discharging from the upper Point Cook catchment is compliant with stormwater best practice guidelines.

### 6.7.4 Upper Skeleton Creek catchment

The quality of stormwater discharging from the upper Skeleton Creek catchment is shown in Table 6.36.

Table 6.36: Stormwater quality discharging from the Upper Skeleton Creek catchment

| Criteria | Source | Residual | Reduction (%) |
|---|---|---|---|
| Flow (ML/yr) | 280 | 238 | 15.0 |
| Total Suspended Solids (kg/yr) | 58,800 | 3,880 | 93.4 |
| Total Phosphorus (kg/yr) | 107 | 30 | 72.2 |
| Total Nitrogen (kg/yr) | 794 | 420 | 47.1 |
| Gross Pollutants (kg/yr) | 9,730 | 0 | 100.0 |

Table 6.36 reveals that the use of WSUD strategies ensures that the quality of stormwater discharging from the upper Skeleton Creek catchment is compliant with stormwater best practice guidelines.

# 7 Economics

The costs of the proposed Development Services Schemes (DSS) were evaluated using the DSS Costing Economics spreadsheet provided by Melbourne Water Corporation (see Appendix 7A), analysis of developable land area provided by Department of Planning and Community Development (see Appendix 7B) and the proposed stormwater management strategy. The estimated developable land area is shown in Table 7.1.

Table 7.1: Estimated developable land area

| Location | Land area (ha) |
|---|---|
| Werribee Employment Precinct | 915 |
| Sneydes Road and Hoppers Lane | -21.2 |
| Maltby Bypass and Historical Sewer | -48.9 |
| Western Trunk Sewer Easement | -6.7 |
| Sewage Pumping Station | -6.7 |
| Existing land uses | -76 |
| Committed developments | -7 |
| Heritage | -5 |
| Natural gas easement | -5.3 |
| **Developable area** | **738.2** |

Table 7.1 shows that the developable land area within the Werribee Employment Precinct is reduced by the land used by roads, easements for trunk sewage and other existing facilities. The total land area required for the Precinct scale stormwater management facilities considered in this analysis is presented in Table 7.2.

Table 7.2: Land required for the Precinct scale stormwater management strategy

| Stormwater infrastructure | Land area (ha) |
|---|---|
| RB1 | -3.7 |
| Overland flow path | -1.7 |
| RB2 | -14.6 |
| Waterway | -4.76 |
| RB3 | -3.6 |
| RB4 | -2.7 |
| RB5 | -4.16 |
| RB5a | -5.06 |
| RB6 | -9.7 |
| Waterway | -7.05 |
| RB7 | -2.6 |
| RB8a | -2.73 |
| RB8b | -5.07 |
| RB9 | -0.98 |
| **Total** | **-68.41** |

Table 7.2 reveals that the proposed stormwater management strategy will occupy about 68.41 ha of the land within the Werribee Employment Precinct. Thus the total developable land area is about 669.8 ha. Note that the stormwater management strategy also requires the use of rainwater harvesting and bio-retention within the sub-precincts to meet the management objectives for the Precinct which includes mitigation of stormwater quality and flow regimes. The estimated costs of the stormwater infrastructure are shown in Table 7.3

Table 7.3: Summary of the stormwater infrastructure costs

| Stormwater infrastructure | Cost ($) |
|---|---|
| Waterways | 5,248,308 |
| Decommission D1 Drain and 2,250 mm pipe | 228,776 |
| RB1, pipeline and overland flow path | 2,330,933 |
| RB2 | 3,613,441 |
| RB3 | 442,817 |
| RB4 | 946,696 |
| RB5, spillway and culverts | 1,679,917 |
| RB5a, overland flow path and culvert | 741,146 |
| RB6, aqueduct and overland flow path | 2,732,419 |
| RB7 | 685,542 |
| RB8a | 307,225 |
| RB8b | 1,015,267 |
| RB9 | 307,406 |
| Alterations to Glen Orden wetland | 83,891 |
| GPTs | 229,500 |
| Engineering (15%) | 2,612,707 |
| Administration (9%) | 1,802,768 |
| Contingency | 870,500 |
| **Total** | **25,755,382** |

The total cost of the development services scheme was estimated to be $25,755,382 and the total developable area was calculated to be 669.8 ha. Thus the total cost of the proposed DSS for the entire Werribee Employment Precinct is $38,452/ha. Inclusion of the injection and extraction infrastructure to facilitate use of water from the ASR scheme increases this total cost to $45,917/ha.

This analysis has assumed that additional water treatment and distribution infrastructure will be resourced as part of the water supply strategy that will utilise treated stormwater extracted from the aquifer. The costs of stormwater infrastructure are distributed in the three catchments as provided in Table 7.4.

Table 7.4: Distribution of the costs of stormwater infrastructure in the three catchments

| Location | Developable area (ha) | Cost ($) | Cost ($/ha) | Comments |
|---|---|---|---|---|
| Upstream | | 313,391 | | Alterations to Glen Orden wetland and GPTs |
| Remainder of Werribee Employment Precinct | 449 | 23,812,083 | 53,033 | Including decommissioning of D1 drain and 2,250 diameter pipe |
| Upper Point Cook | 140.1 | 1,322,501 | 9,440 | |
| Upper Skeleton Creek | 80.7 | 307,407 | 3,808 | |

Table 7.4 shows that the majority of infrastructure and associated costs are attributed to the current D1 Drain catchment within the Werribee Employment Precinct. This infrastructure is required to manage the significant inputs from the upstream catchment. The Upper Point Cook and Upper Skeleton Creek catchments do not include inputs from upstream catchments and require considerably less stormwater management infrastructure. The costs of the including the injection and extraction facilities for the ASR scheme are included for each of the catchments in Table 7.5.

Table 7.5: Distribution of the costs of stormwater and ASR infrastructure in the three catchments

| Location | Developable area (ha) | Cost ($/ha) |
|---|---|---|
| Remainder of Werribee Employment Precinct | 449 | 59,997 |
| Upper Point Cook | 140.1 | 16,404 |
| Upper Skeleton Creek | 80.7 | 10,772 |

Although the residual catchment for the Werribee Employment Precinct is subject to the majority of the costs for the proposed stormwater strategy, the catchment also experienced the greatest benefit from reduced area of inundation from flooding. The land inundated by flooding or required for stormwater management within the catchment has reduced from 230 ha to 68.4 ha.

The value of land at this site was estimated by the Valuer General (see Appendix 7C) to be $676,000/ha. The value of the additional developable land made available by the stormwater management scheme is shown in Table 7.6.

Table 7.6: Determination of the value of additional developable land created by the stormwater management strategy

| Location | Existing flood (ha) | Requirement for stormwater management (ha) | Land saved (ha) | Value ($ m) |
|---|---|---|---|---|
| Remainder of Werribee Employment Precinct | 215.3 | 59.6 | 155.7 | 105.2 |
| Upper Point Cook | 8.8 | 7.8 | 1 | 0.68 |
| Upper Skeleton Creek | 5.9 | 0.98 | 4.9 | 3.3 |
| **Total** | **230** | **68.4** | **162.6** | **109.2** |

Table 7.6 highlights that the proposed stormwater management strategy has made available an additional 162.6 Ha of developable land which has a total value of $109.2 million. The net costs of the proposed stormwater management strategies in each catchment are shown in Table 7.7.

Table 7.7: Net costs (or benefits) of the stormwater management schemes

| Location | Net costs ($) | Cost ($/ha) |
|---|---|---|
| Remainder of Werribee Employment Precinct | 78,294,267 (benefit) | 174,365 (benefit) |
| Upper Point Cook | 646,501 | 4,615 |
| Upper Skeleton Creek | 3,018,513 (benefit) | 37,402 (benefit) |

Table 7.7 shows that the value of the land that is made available as a result of the reduced flood inundation generated by the stormwater management strategy has mitigated the costs of the stormwater infrastructure. Although the developers of the land will have to make the contributions listed in Table 7.5 the value of the increased developable land area reduces the net cost of the stormwater management strategy to the values shown in Table 7.7.

Note that the net benefit of the proposed stormwater management scheme for the entire Werribee Employment Precinct is $117,165/ha when the value of the increased developable area is included. The stormwater management strategy has produced sufficient increases in developable land to fund both the proposed stormwater management and the IWCM strategies, and provide considerable surplus in value.

# 8 Key Recommendations

Development Services Schemes (DSS) are proposed from the Werribee Employment Precinct that is the basis of an integrated water cycle management (IWCM) strategy that includes aquifer storage and retrieval (ASR). The three Development Services Schemes proposed for the Werribee Employment Precinct are Upper Skeleton Creek, Upper Point Cook and residual Werribee Employment Precinct.

The proposed DSS includes restorations of waterways, alteration of the Glen Orden constructed wetland in the upstream catchment, hydrologic and hydraulic elements. This report also includes objectives and deemed to comply provisions in the DSS that requires water sensitive urban design (WSUD) strategies within each development in the Precinct to mitigate stormwater quality and flow regimes. The following measures are proposed:

- Alteration of the Glen Orden constructed wetland and the D1 Drain Reserve in the upstream catchment to more efficiently manage peak stormwater discharges generated by 100 year ARI storm events and to cope with increases in peak discharges created by the high emmision climate change scenario
- Provide three gross pollutation traps at key locations, at Heaths Road and at the interface of inputs to the Werribee Employment Precinct, to mitigate stormwater pollution entering the site from upstream catchments
- Eleven retarding basins that are designed to mitigate peak stormwater runoff generated by 100 year ARI stormwater events and to cope with increases in those peak discharges caused by the high emmisions climate change scenario
- Replacement of the D1 Drain with two waterways within the Werribee Employment Precinct
- All development within the Precicnt must comply with the objectives specified within this report.

The proposed stormwater management strategy reduces the land subject to inundation from flooding from 230 ha to a requirement for a land area of 68.4 ha for stormwater management at a total value of $109.2 million. This significant increase in the expected developable land offsets that costs of providing the stormwater management infrastructure and allows the inclusion of measures that facilitate the IWCM strategy such as ponds to facilitate capture of stormwater for ultimate injection to the aquifer.

# Appendix 3A

## GIS network arrangement: Glen Orden Wetland & Werribee Employment Precinct

# Appendix 3B

## Water Quality Network

# Appendix 3C

## Stormwater Quantity Network: Hydrology

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# *Appendix 5A*

## Wyndham Drainage Infrastructure Plan

# Appendix 5B

## Existing Site Drainage Schemes [Melbourne Water]

# Appendix 5C

## Survey Data: Lidar generate contours & Glen Orden Wetland

# Appendix 5D

## Primary Infrastructure Services Plan [ARUP]

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# Appendix 5E

## Existing Infrastructure Design Drawings [Melbourne & Metropolitan Board of Works]

# Appendix 5F

## Waterhaven Estate Staging Plan [Breese, Pitt & Dixon]

# Appendix 5G

## Existing flood overlay

# Appendix 6A

## Hogans Road Retarding Basin
## [Stormwater Solutions]

# *Appendix 6B*

## Glen Orden Wetland and Retarding Basin Redesign Plans

# Appendix 6C

## Integrated Stormwater Management at the Werribee Employment Precinct: October 2009

## [Bonacci Water & Cullen Capital]

# *Appendix 6D*

## Werribee Employment Precinct Stormwater Mitigation: Design Plans

# *Appendix 6E*

## Upper Point Cook Stormwater Mitigation: Design Plans

# Appendix 6F

## Skeleton Creek Stormwater Mitigation: Design Plan

# Appendix 6G

## Flood Overlay: Developed Conditions 100yr ARI >50mm

# Appendix 6H

## Flood Overlay: Developed Conditions 100yr ARI >50mm Climate Change Scenario

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# *Appendix 7A*

## Summary of MWC DSS costing spreadsheet

# *Appendix 7B*

## Developable land area from DPCD

# *Appendix 7C*

## Land valuation