Precinct Structure Plan Response

Croskell Precinct Structure Plan

Date	9 October 2024
Project No.	24030 00 v1.0
Author	Jamie Tainton
Client	Wolfdene c/o Marshal

Project History

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Issued to	Wolfdene c/o Marshal

Document History

Version	Date	Description
1.0	09/10/2024	Submitted for consideration

Acknowledgement of Country

This document was prepared on the land of the Wurundjeri Woi-wurrung people. We acknowledge the Traditional Owners of country and pay our respects to them, their culture and their Elders past, present and emerging.

WaterStudio.

About us

Water Studio Pty Ltd

Water Studio is a creative engineering company focused on effective and efficient stormwater solutions. We work for clients from a variety of industry sectors including land development, local government and authorities like Melbourne Water.

We create integrated water management solutions for the community using established engineering methodologies and natural sciences that protect and enhance our local environment. From the people that use the space, to those that maintain it, and ultimately the biota that call it home, Water Studio will use its creative approach to design amazing solutions and spaces.

Water Studio is a female led business, one of only a few in this industry!

Jamie Tainton

Jamie is the Founder, Managing Director and Principal engineer for Water Studio and has almost 20 years experience working as a civil and environmental drainage engineer. She is well versed in the expectations of the industry and has strengths in the strategy, feasibility, concept design, detailed design and construction/superintending phases of a variety of projects.

When not focused on the design side of the business, Jamie is facilitating multi-stakeholder engagements across sectors to establish truly integrated water projects. She has worked closely with local government, developers, water retailers, and authorities like Melbourne Water to find efficient and economical solutions to many projects.

She is the Immediate Past President of Stormwater Victoria, she sits on the Board for the Association of Land Development Engineers and was recently inducted as a Fellow at Engineers Australia. This is complimented by her presence on the National Engineers Register, Victorian Professional Engineers Register and as a Chartered Professional Engineer.

On behalf of Water Studio we are excited to be part of this project.

Yours Sincerely,

Jamie Tainton
Founder and Principal Engineer

Executive Summary

There are many ways to develop a precinct like the Croskell Precinct Structure Plan (PSP) area. Many of them have merit however it is important that the chosen solution responds to many factors including topography, construction cost, maintainability, community accessibility and ultimately the resulting product or parcels.

Rather than completely reinventing the wheel, we have reviewed the exhibited PSP and associated Ti-Tree Creek Drainage Scheme upgrade, and provided some recommendations and tweaks that should improve the construction cost, resulting physical form and its implementation.

Specifically, we propose:

- To remove the overland flow path above pipeline E in lieu of upgrading the pipeline to a 1% pipe. This will require a diversion structure or basin of some kind to appropriately manage the flows.
- Water Quality should be managed across the PSP area in locations that suit the topography and relevant authority requirements.
- We also recommend the design, costing and blending of integrated water management infrastructure into the DCP/ICP as shared cost items.
- Interim solutions are an essential part of development and need to be available for negotiation. Full downstream construction of assets would certainly impose impossible barriers to development.

This has been summarised graphically in Figure 1.

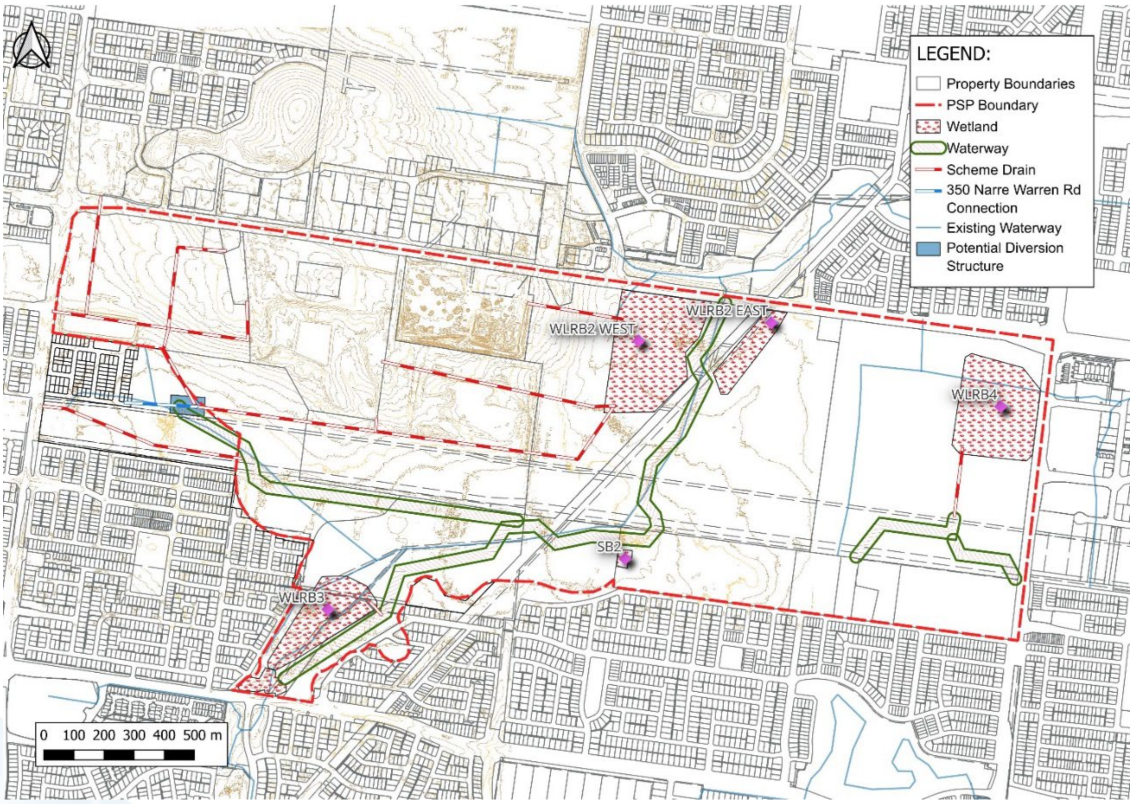

Figure 1: Proposed Drainage Scheme (Scenario 3)

Source: Water Studio (GIS)

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Introduction

1 Background

The Victorian Planning Authority (VPA) has released the Croskell Precinct Structure Plan (PSP) for exhibition and a portion of the Ti Tree Creek Drainage Scheme within the PSP area is being revised to suit the proposed development footprint.

The PSP is located in Cranbourne East and is within Casey Council (Council) municipality. The site is within the Melbourne Water Boundary (MW).

Water Studio have been asked by the developer of 1450 Thompsons Rd, Cranbourne East to provide advice and a response to the VPA's exhibition of the PSP. The focus of this response is centred around the western catchment and relates primarily to the cost effectiveness and constructability (in stages) of the solution.

1.1 Site Location

The proposed development area encompassed by the proposed structure plan area has an odd shape which can roughly be seen below in Figure 1. The critical parcel for the client in this PSP is outlined approximately in red.

Figure 2: Approx. location the proposed precinct structure plan area (client land outlined in red)

Source: Google Maps (July 2024)

1.2 Site Description

The development area is surrounded by residential development with some industrial and commercial sites to the east and a concrete batching plant to the north. The adjacent sites to the east include a quarry and abattoir (and perhaps a broiler farm) which all have larger buffer zones that restrict some types of development. The site to the south has a degraded waterway running north south through the centre of the PSP west area. Along the northwest boundary, the site has a large hill that pushes stormwater west and east. Farm drains have been established to control flows and send them to the central waterway.

The general PSP area is divided by large overhead high voltage cables that run from the eastern to western boundaries. At the northern boundary for the high voltage powerlines, the Victorian Desalination Project (VDP) cable is located underground. This asset is of state significance and is currently under the control of AquaSure. Contractual arrangements with AquaSure make crossing the cable very difficult but not impossible.

1.3 Proposed Development

The layout of the PSP can be seen in Figure 3 and a variety of development types across the development area have been included.

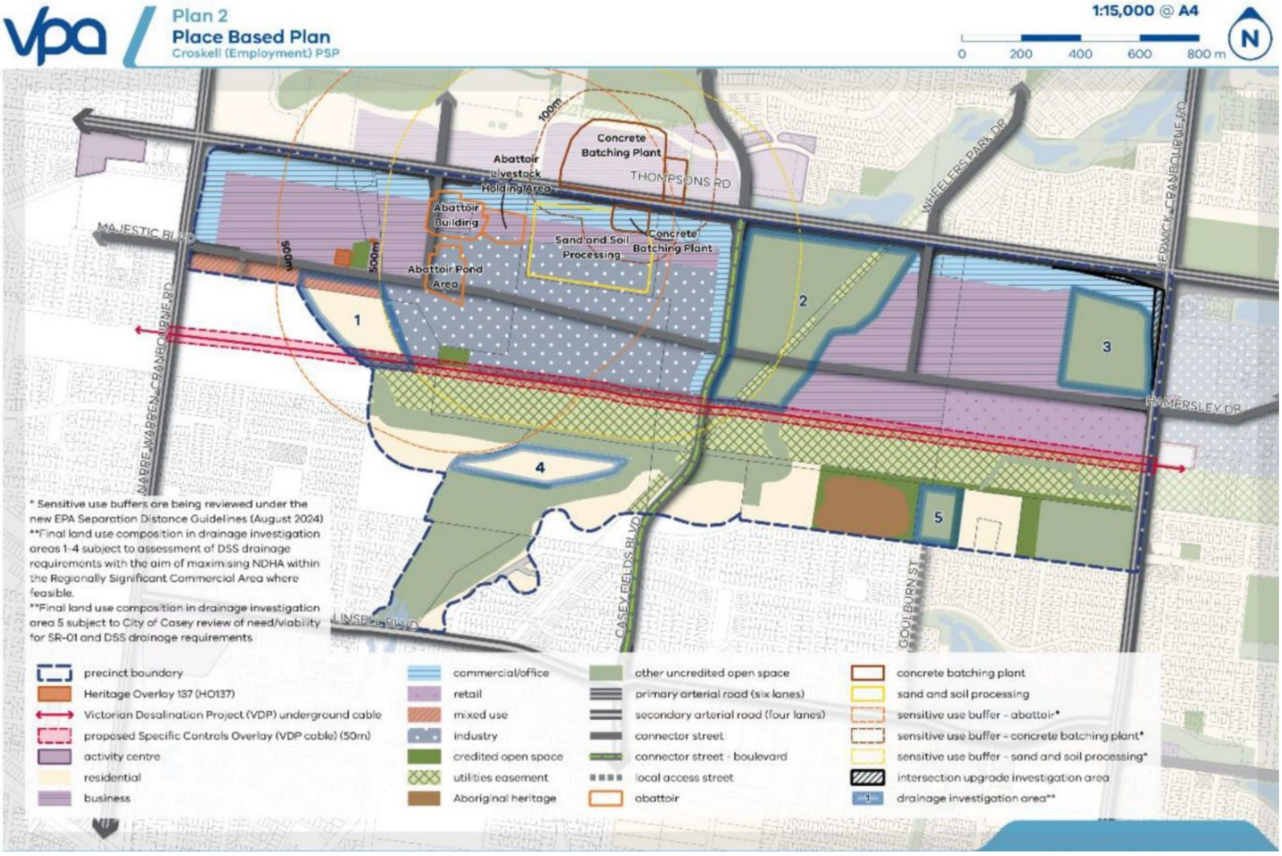

Figure 3: Proposed Development Layout

Source: Victorian Planning Authority (1051 Croskell (Employment) Precinct Structure Plan – September 2024

Whilst the PSP incorporates the drainage scheme requirements that focus on stormwater quality and the hydraulic movement of water, it also extends its reach to include integrated water management objectives that go beyond the drainage scheme. These stem from objectives around establishing a high-quality public realm that is sustainable. The terminology on the PSP is a "must" statement but doesn't specifically provide clear targets but does reference other documents with recommendations. Reference is made to several documents that will require developers to provide on lot works to bolster the drainage scheme assets.

In Plan 7 in the PSP (a copy of which can be seen in Figure 4 overleaf) we can see that several initiatives are proposed including:

- Spongy areas in and around the wetlands and waterways
- Rainwater tanks and/or road irrigation
- Passively irrigated street trees from road runoff
- Potential for Stormwater Harvesting under the scope of "alternative water" for irrigation

There is no clear indication that the initiatives will meet the objectives outlined in various external documents.

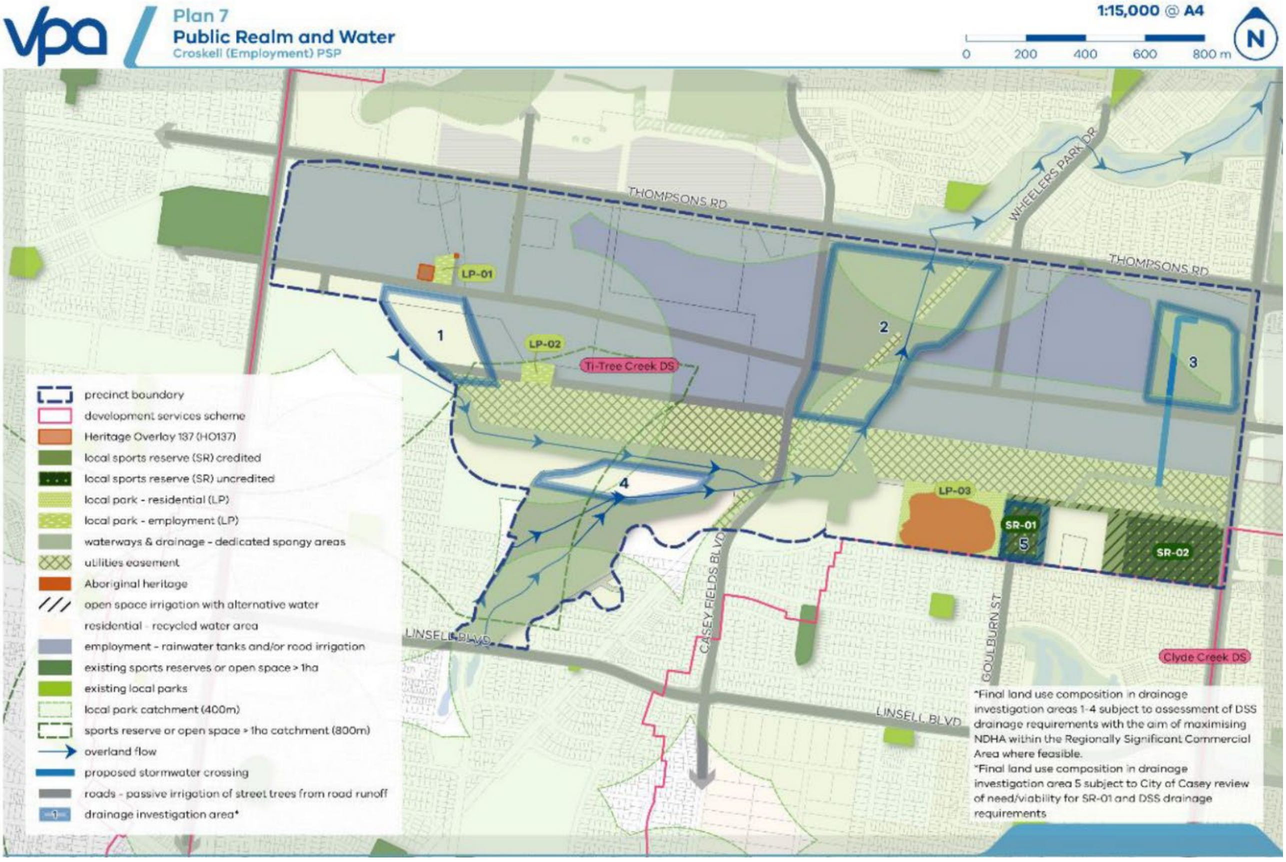

Figure 4: Plan 7 – Public Realm and Water

Source: Croskell Precinct Structure Plan (VPA September 2024)

Factors to be considered for Development

2 General Approach

In developing a site or parcel we have the potential to change the characteristics of the stormwater flow entering and leaving. Development traditionally increases the volume and peak flow rates through increased impervious surfaces. Development also collects contaminants and litter within the stormwater runoff and efficiently delivers it to the outlet. Both outcomes can adversely impact the downstream receiving environment through changes to water quality, stream ecology and capacity constraints (flooding).

To reduce these affects, a series of hydrological and water quality mitigation measures can be used to limit the impact. The following section outlines the legislative mechanisms used to protect our receiving environments.

2.1 Relevant Stakeholders, Authorities and Objectives

2.1.1 State Government

The Victorian State Planning Policy Framework incorporates provisions for stormwater management in its integrated water management clauses. This includes 56.07 for Residential Development and 53.18 for Commercial, Industrial, Townhouse Developments and Capital Works. Casey Council, as part of its planning requirements, enforces these objectives for stormwater runoff.

For this PSP, Clause 53.18 applies.

2.1.1.1 Planning Clause 53.18

Clause 53.18 is a Stormwater Management Clause in the planning scheme with specific stormwater management objectives including:

- To minimise damage to properties and inconvenience to residents from stormwater.
- To ensure that the street operates adequately during major storm events and provides for public safety.
- To minimise increases in stormwater and protect the environmental values and physical characteristics of receiving waters from degradation by stormwater.
- To encourage stormwater management that maximises the retention and reuse of stormwater.
- To encourage stormwater management that contributes to cooling, local habitat improvements and provision of attractive and enjoyable spaces.

2.1.1.2 Water Quality Requirements

In line with the integrated water planning clauses applicable to this development (ie clause 56.07 or 53.18), the quality of stormwater leaving the Site must meet the Victorian EPA Best Practice Environmental Management (BPEM) Guidelines (1999). These guidelines expect:

- 80% Total Suspended Solids (TSS) reduction
- 45% Total Nitrogen reduction
- 45% Total Phosphorus reduction
- 70% Gross Pollutant capture

This is a load-based reduction target compared with the unmitigated developed scenario. These water quality requirements will need to be met as part of this development.

2.1.1.3 General Environmental Duty (GED) - EPA Act 2017

The GED is a proactive rather than reactive based approach to protect our natural environment. The GED describes itself as a:

"Positive duty to proactively identify and manage environmental risk and is a shared responsibility of all Victorians….. The GED states that a person who is engaging in an activity that may give rise to risk of harm to human health or the environment from pollution or waste must minimise those risks, so far as reasonably practicable".

The intention is to provide a system that gives the Environment Protection Authority (EPA) the right to punish non-compliance with the law. So, if anyone were to knowingly or negligibly pollute or risk the natural environment, they can be prosecuted.

This development will ensure design is undertaken in line with Best Practice Environmental Management.

2.1.1.4 Urban Stormwater management (EPA) – Publication 1739.1 (July 2021)

"*Uncontrolled urban stormwater run-off poses a risk to the values of waterways and bays. This guide is intended to help improve the management of urban stormwater in Victoria by recognising current science and the risk of harm from urban stormwater flows. It supports minimising the risk of harm (https://www.epa.vic.gov.au/for-business/how-to/manage-environmental-risk) to human health and the environment through good environmental practice and provides information that will support the planning and design of new urban stormwater management systems. This guide:*

• *highlights the risk to waterways and bays the creation of sealed (impervious) surfaces causes*

• *provides general objectives and information to support risk assessment and minimisation*

• *explains stormwater management for communities in Victoria.*"

The guidance builds on the GED and provides metrics to value the solutions for the site. Given the Mean Annual Rainfall for the area is around 800mm, the area should aim to harvest or evapotranspire 26% of annual impervious runoff and infiltrate or filtrate up to 11% of runoff. In the case studies within the publication, industrial and commercial areas are often managed with wetlands and infiltration sponges.

Recommendation No.1

The PSP should look for opportunities for shared stormwater harvesting, infiltration sponges and passive irrigation. In Plan 7 (as shown in Figure 4 earlier in this document) several initiatives have been outlined that will work towards meeting these targets. There is no confirmation that the ideas presented in Plan 7 meet the requirements set out in this publication.

2.1.1.5 Flood Storage and Protections Requirements

The Guidelines for Development in Flood Affected Areas was released by the Department of Energy, Environment and Climate Action (DEECA previously DELWP) in 2019. The relevant legislation associated with the content in the document includes:

- Planning and Environment Act
- Building Act
- Water Act
- Climate Change Act

All lots within the development will need to be at least 300mm higher than any waterway based 1% AEP flood level (with floors a further 300mm higher). Any local stormwater-based flows will only require a 300mm freeboard to the local 1% overland flow path.

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2.1.2 Local Government – Casey Council

The Casey City Council (Council) is the relevant council for this project.

The population of Council is almost 400,000 and is expected to reach 600,000 in the next 20+ years. Most growth is seen in the greenfields areas of Clyde North, Cranbourne West, Cranbourne North and Cranbourne East where this PSP is situated.

According to the council website…. *Climate change is increasingly threatening communities, infrastructure and biodiversity across the City of Casey. Rising global temperatures are resulting in more intense and frequent heatwaves and storms, as well as long-term impacts like reduced rainfall and sea level rises. Bushfires, flash floods and adverse health impacts associated with extreme heat and thunderstorm asthma will become more severe. The City of Casey is committed to addressing climate change…."*

The Council will utilise planning provision 53.18 as outlined earlier in the document to enforce water quality expectations on this development.

The Council utilises the standards and guidelines established in the Engineering Design and Construction Manual prepared by the Victorian Planning Authority (previously known as the Growth Areas Authority).

2.1.2.1 Land Subject to Inundation and/or Flood Overlay

We note the PSP area is subject to flooding-based overlay known as an Urban Flood zone. The extent of the current flood zone can be seen in Figure 5. Our understanding is that the proposed drainage scheme will better manage flows throughout this area and look to remove the Urban Flood Zone from the area. At the very least, the zone should be reduced to the future water-based assets proposed.

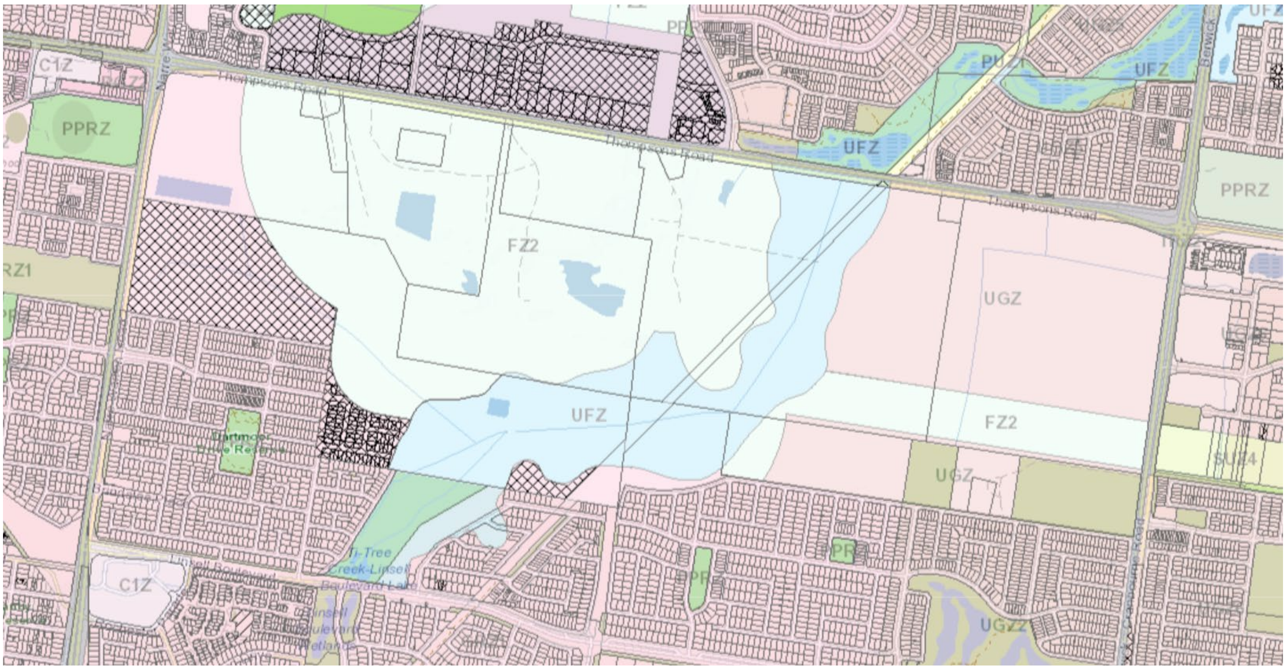


Figure 5: Planning zones

Source: VicPlan (DEECA – August 2024)

2.1.3 Catchment Management – Melbourne Water

According to the "Principles for provision of waterway and drainage services for urban growth 2019":

"Melbourne Water is responsible for regional drainage, flood plain and waterway management, and for contributing to the protection and improvement of waterway health across greater Melbourne. These responsibilities are managed with a focus on sustainable social, environmental and economic outcomes.

In relation to regional drainage, flood plain and waterway management, Melbourne Water is a:

- *Water Corporation and an Authority under the Water Act, with waterway management, regional drainage and floodplain management functions under Divisions 2, 3 and 4 of Part 10 of the Water Act. These functions include:*

- *ensuring that adequate drainage and flood protection standards for development are achieved; and*
- *ensuring that the bed and banks of waterways are protected and enhanced.*

- *Referral authority under the Planning and Environment Act 1987 with the ability to specify conditions pertaining to the use or development of a property.*

Development services schemes are prepared to plan the infrastructure required to ensure new urban development meets appropriate standards for flood protection, water quality, waterway health and amenity. Infrastructure requirements are costed and used to establish contributions under the Water Act that will apply to developers to fund the provision of infrastructure."

2.1.3.1 Drainage Scheme/Strategy

This site is part of the Melbourne Water Ti Tree Creek Drainage Strategy (#0619). The current drainage scheme available from Melbourne Water's website can be seen in Figure 6 below.

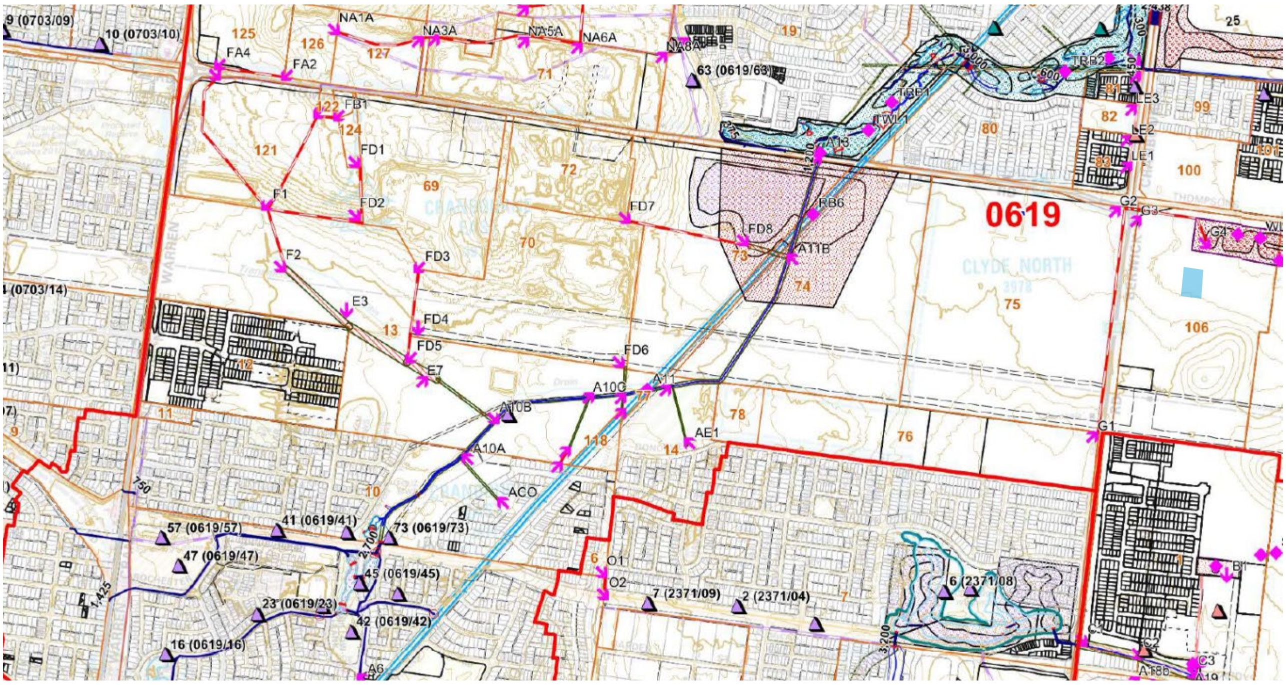


Figure 6: Ti Tree Creek Drainage Scheme

Source: Melbourne Water

Drainage contributions for the DSS can normally be found on Melbourne Water's Land Development website and the rates for the hydraulic and water quality components as of 31/08/2024 were listed as follows:

Table 1: Drainage Services Scheme

No.	Greenfield scheme name	Current base rate (standard residential) ($/ha)				Rate changes		
		Hydraulic	Water Quality	Includes Scheme WQ works	Calculator	Effective date	Hydraulic	Water Quality
6550	Ti Tree Creek Drainage Scheme	$118,534	$28,407	Yes	-			

Source: Melbourne Water website

2.1.3.2 DSS Revision

Through the development of the PSP, Melbourne Water undertook a revision of the Ti Tree Creek DSS within the general PSP development area. Several iterations were made with a final preferred concept introduced to the immediate land holding in May

2024. Formal exhibition and consultation of the DSS Revision have been undertaken through the formal PSP exhibition process commencing on the 11th of September and expected to conclude on October 9th, 2024.

Given our focus on the western catchment, the recommended concept provided by Melbourne Water in May, 2024 can be seen in Figure 7. The new revision proposes to limit flows (peak flows and peak volume) to pre-development levels over a critical desalination power cable forcing the scheme to look for alternative ways to transfer flows in the west to the outlet in the central north of the PSP area. A complex arrangement is proposed that looks to utilise a combined pipe and overland flow path parallel to the desalination cables. This will require large pipes, significant cut and a creative diversion structure on the western end.

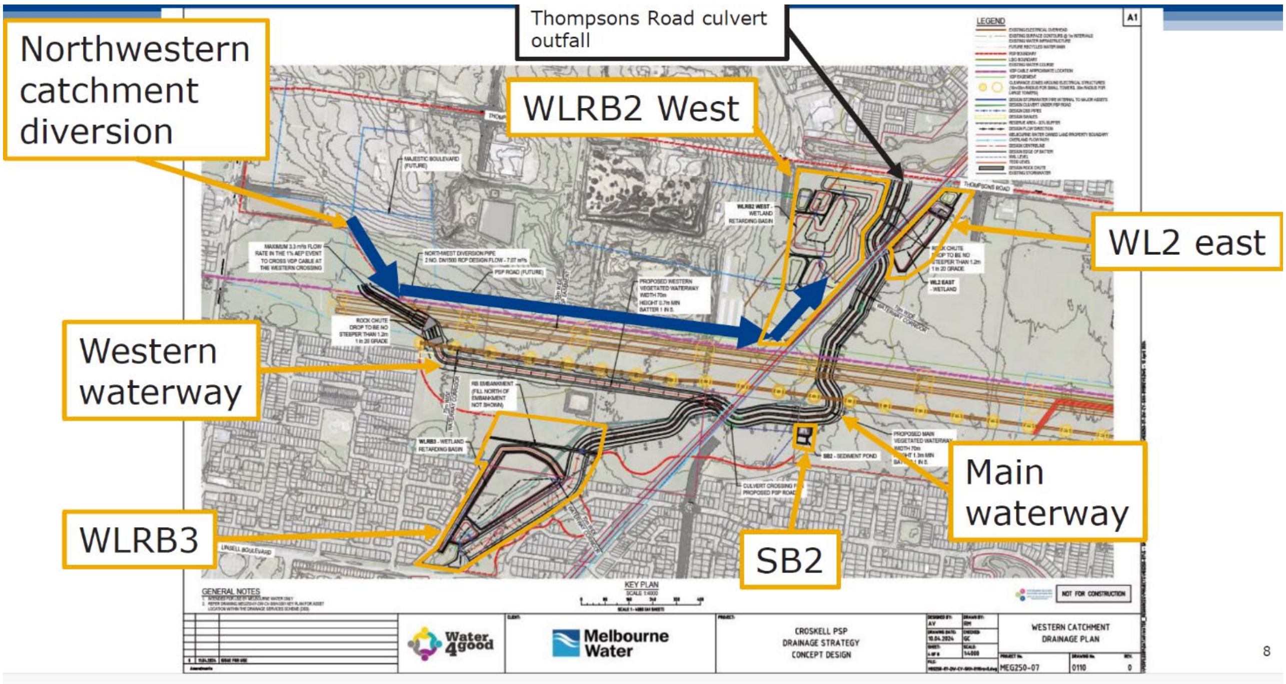


Figure 7: Proposed DSS Concept

Source: Melbourne Water (May 2024)

Melbourne Water provided the following expectations of the Drainage Scheme on the 26th of August, 2024:

- Flood protection is to be provided for properties within the PSP
- New developments are not to further exacerbate existing flooding conditions for downstream/neighbouring properties.
- New developments are to achieve appropriate best practice stormwater quality treatment for flows generated from their property to mitigate impacts on downstream environments
- To optimise drainage land requirements within the existing Urban Floodway Zone area and Melbourne Water owned land
- Proposed constructed waterways to provide safe drainage and flood protection and to incorporate environmental, cultural and amenity values
- Main stem of Ti Tree Ck is to be an open channel
- Western tributary into Ti Tree Ck is to be an open channel
- Climate Change effects to be included in the Development Services Scheme design
- Protect/minimise impacts on existing environmental and waterway values
- Meet critical and other agency asset operational requirements to ensure constructability (i.e. water supply mains, transmission infrastructure and Victorian Desalination Project assets)
  - DEECA advice on VDP assets
  - Minimise works over the cable reserve

- Do not increase volume of stormwater over the cable, unless approved by DEECA
  - Therefore for large catchments in the west and central, flows are to be retarded upstream of VDP assets or diverted elsewhere.
  - A design requirement for the VDP assets is that the post-development peak flow rate and volume across the assets does not exceed the pre-development peak flow rate (stated as 2.75m^3/s) and volume (stated as145ML).
- Achieve the principles as set out in the Melbourne Water Principles for Provision of Waterway and Drainage Services for Urban Growth (i.e. equity, cost/performance balance)
- Other requirements (Need to refer to the Drainage Strategy Concept report for additional information)
- Maximise drainage within existing Urban Floodway Zone
- No detrimental impact to performance, operation, maintenance or access to Melbourne Water supply mains.
- Ongoing asset ownership considerations
  - If an asset is servicing a catchment <60ha, it will be vested to Council
  - If an asset is servicing a catchment >60ha, it will be vested to Melbourne Water
- Consideration of the implementation and delivery of assets post PSP gazettal.
- Melbourne Water will not consider assets that clearly demonstrate a shifting of assets from one property to another without meeting the above objectives.

We requested advice from Melbourne Water over the exhibition and consultation period. A copy of which can be found in the appendix. Within the correspondence and assessment of the data it was identified that:

- 0.93m3/s going over the pipeline only in excess of the pipe to the east.
- The worst case was modelled by Water4Good where all the flows from the western catchment went south over the desalination cable rather than the ultimate solution and intention of flows into the proposed pipe to the east.
- The pre-burst was modelled using a reduction factor in the losses rather than using pre-burst information. Sensitivity analysis was undertaken by the Water4Good team indicating that the impact was negligible and more in line with the known flow rates and water levels. Confirmation of this should be prepared.
- The flow rate limitation over the desalination cable was calculated within 1 catchment in the RORB model despite the RORB manual clearly stating that "*It is recommended that at least 5 sub-areas be placed above any hydrograph printout point to allow sufficient smoothing and attenuation of the rainfall excess hyetographs*." – RORB Manual Section 7.2, Item 11, page 85.

The concept has been assessed in more detail in Section 3 of this document.

2.2 Relevant Information

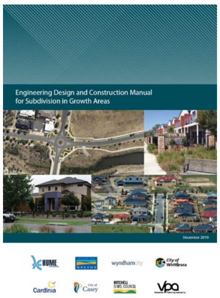
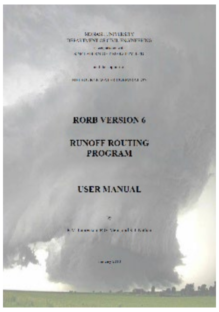
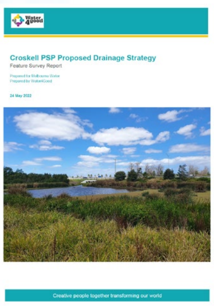
A number of information sources have been used in the formation of this document; these include:

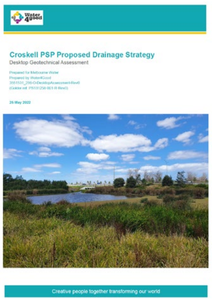
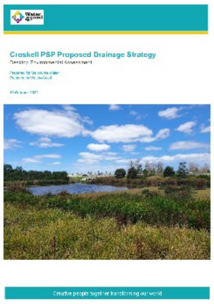
- Site inspection conducted 26th of July 2024
- Nearmap Aerial imagery downloaded in July 2024
- LiDAR commercially obtained 3rd July, 2024 (United Photo and Graphic Services Pty Ltd)
- VicPlan Website (August 2024)
- Melbourne Water DSS Website (August 2024)
- Discussions with the relevant authorities
- Discussions and information as provided by the MW
- Topographic information
- Past models and existing infrastructure information

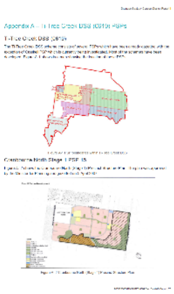
- Various Environmental Planning instruments and Planning Frameworks
- Preliminary plans and Site survey received from client.
- Meeting minutes and notes from discussions with VPA, Melbourne Water and DEECA (in appendix)

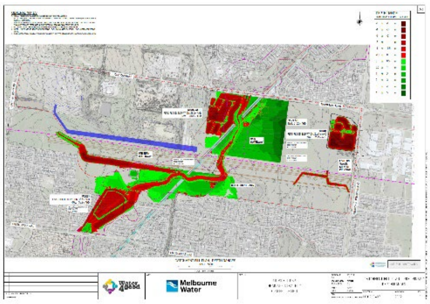
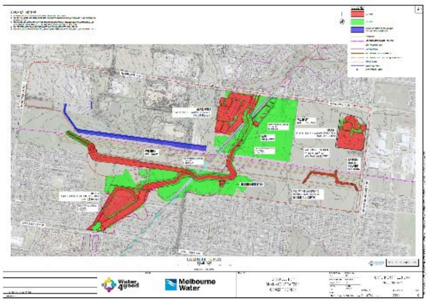
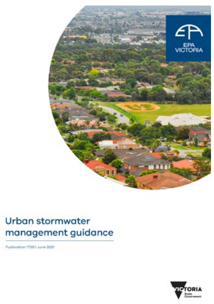
2.3 Relevant Documents

The following table outlines the relevant documents reviewed and used to formulate an opinion and recommendations with regard to the proposed PSP.

	**Engineering Design and Construction Manual** **for Subdivision in Growth Areas** December 2019 This Manual is a product of the Victorian Growth Areas Infrastructure Engineering Standardisation Project, and delivers a set of consistent standardised, best practice documents that outline approval and supporting processes for the planning, design and construction of subdivision infrastructure. The standards, specifications and processes have been developed by collaboration between the Victorian Planning Authority and Councils in Melbourne's growth areas, in consultation with industry representatives.
	**MUSIC (Model for Urban Stormwater Improvement Conceptualisation) Guideline** July 2024 The purpose of this document is to provide guidance on modelling approaches and input parameters for MUSIC models that are submitted to Melbourne Water. This guideline is also useful for building a model. MUSIC is a software that simulates rainfall, stormwater runoff, flows and pollution. It also simulates pollutant removal and flow reduction through stormwater management assets such as sediment ponds, wetlands, bioretention and stormwater harvesting.
	**RORB Version 6** **Runoff Routing Program** January 2010 RORB is a general runoff and streamflow routing program used to calculate flood hydrographs from rainfall and other channel inputs. It subtracts losses from rainfall to produce rainfall-excess and routes this through catchment storage to produce runoff hydrographs at any location. It can also be used to design retarding basins and to route floods through channel networks. The program requires a datafile to describe the particular features of the stream network being modelled and is run interactively. It can be used both for the calculation of design hydrographs and for model calibration by fitting to rainfall and runoff data of recorded events.
	**Croskell PSP Proposed Drainage Strategy** **Feature Survey Report** Prepared by Water4Good 24 May 2022 Melbourne Water commissioned Water4Good to complete a Feature survey for the Croskell Precinct Structure Plan (PSP) Proposed Drainage Strategy Project (hereafter 'the project). The wider project involves completing a drainage concept options assessment and functional design of major drainage assets (retarding basin, wetland and new waterway alignment) for the Croskell PSP. The functional design of the major assets will provide

	greater certainty to the land required for the assets, which will inform the PSP and schemes, and confirm the quantities and cost estimation for the scheme contribution rate.
	**Croskell PSP Proposed Drainage Strategy** **Desktop Geotechnical Assessment** Prepared by Water4Good 25 May 2022 Melbourne Water has commissioned Water4Good to undertake a desktop geotechnical assessment for the Croskell Precinct Structure Plan (PSP) Proposed Drainage Strategy Project (the Project). The Project involves completing a drainage concept options assessment and functional design of major drainage assets (retarding basin, wetland and new waterway alignment) for the Croskell PSP.
	**Croskell PSP Proposed Drainage Strategy** **Desktop Environmental Assessment** Prepared by Water4Good 19 October 2022 Melbourne Water has commissioned Water4Good to complete a Desktop Environmental Assessment for the Croskell Precinct Structure Plan (PSP) Proposed Drainage Strategy Project (hereafter 'the project). The project involves completing a drainage concept options assessment and functional design of major drainage assets (retarding basin, wetland and new waterway alignment) for the Croskell PSP. The functional design of the major assets will provide greater certainty to the land required for the assets, which will inform the PSP and schemes, and confirm the quantities and cost estimation to inform the scheme contribution rate.
	**Croskell PSP Proposed Drainage Strategy** **Growling Grass Frog Survey Report** Prepared by Water4Good 05 April 2023 Melbourne Water has commissioned Water4Good to complete a targeted species survey for the nationally endangered Growling Grass Frog (GGF) (Litoria raniformis) for the Croskell Precinct Structure Plan (PSP) Proposed Drainage Strategy Project (hereafter 'the project'). GGF is listed as 'Vulnerable' under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and 'Threatened' under the Flora and Fauna Guarantee Act 1988 (FFG Act).
	**Croskell PSP Proposed Drainage Strategy** **Preliminary geotechnical site report** Prepared by Water4Good 18 August 2023 Following an initial desktop study (W4G Ref: 3551531-268-RevB, dated 4 April 2022), Melbourne Water has commissioned Water4Good (W4G) to undertake a preliminary geotechnical investigation for the Croskell Precinct Structure Plan (PSP) Proposed Drainage Strategy Project (the Project). The project involves completing a drainage concept options assessment and functional design of major drainage assets (retarding basin, wetland and new waterway alignment) for the Croskell PSP.

	**Croskell PSP Proposed Drainage Strategy** **Feature Survey Report** Prepared by Water4Good 13 September 2023 Melbourne Water commissioned Water4Good to complete a Feature survey for the Croskell Precinct Structure Plan (PSP) Proposed Drainage Strategy Project (hereafter 'the project). The wider project involves completing a drainage concept options assessment and functional design of major drainage assets (retarding basin, wetland and new waterway alignment) for the Croskell PSP. The functional design of the major assets will provide greater certainty to the land required for the assets, which will inform the PSP and schemes, and confirm the quantities and cost estimation for the scheme contribution rate.
	**Croskell PSP Proposed Drainage Strategy** **Drainage Strategy Concept Design Report** Prepared by Water4Good 28 June 2024 Water4Good (W4G) has been engaged by Melbourne Water to complete a comprehensive options assessment and concept design for drainage assets within the Croskell Precinct Structure Plan (PSP). The PSP, situated in Cranbourne East and Clyde North, about 45 km southeast of Melbourne's CBD, covers approximately 317 hectares. It is a part of the Melbourne Water Ti-Tree Creek Development Services Scheme (DSS) (0691). The Ti-Tree Creek DSS discharges into the Greaves Road Retarding Basin and then into the Hallam Valley Contour Drain. The primary purpose of this report is to provide an engineering review, assess various options, and propose a preferred concept design that focuses on water quality, waterway, and flood retardation assets within the Ti-Tree Creek DSS.
	**Drainage Strategy Concept Design Report (Appendix)** Prepared by Water4Good 28 June 2024
	**Croskell PSP Drainage Strategy Concept Design** Prepared by Water4Good 10 April 2024

	**Catchment Fill Plan – Depth Ranges** Prepared by Water4Good 19 June 2024
	**Catchment Fill Plan** Prepared by Water4Good 19 June 2024
	**Croskell Precinct Structure Plan – Integrated Water Management Plan** Prepared by ARUP 21st March 2024 This report summarises the Integrated Water Management (IWM) options assessed for Croskell, and provides recommendations to be incorporated by the VPA as part of the wider Precinct Structure Plan (PSP). This is a concept level IWM investigation, which aims to provide inputs for the development of a PSP, and so further investigation is still necessary at a subdivision or development scale to assess the feasibility of the recommended options, and the associated costs, benefits, and other elements to ensure the best community outcomes can be achieved.
	**Urban Stormwater Management Guidance (Publication 1739.1)** Prepared by EPA Victoria June 2021 Uncontrolled urban stormwater run-off poses a risk to the values of waterways and bays. This guide is intended to help improve the management of urban stormwater in Victoria by recognising current science and the risk of harm from urban stormwater flows. It supports minimising the risk of harm to human health and the environment through good environmental practice and provides information that will support the planning and design of new urban stormwater management systems. This guide: • highlights the risk to waterways and bays the creation of sealed (impervious) surfaces causes • provides general objectives and information to support risk assessment and minimisation • explains stormwater management for communities in Victoria.

Existing Conditions

3 Analysis

3.1 Site Inspection

A site inspection was undertaken on the 26th of July, 2024 to appreciate the site conditions, characteristics of the catchment and any significant features (including any hydraulic controls). The following images highlight key features of the site.

Figure 8: Looking south across 1450 Thompsons Rd

Source: Site inspection 26.07.2024

Figure 9: Looking east across the development area.

Source: Site inspection 26.07.2024

Figure 10: Sample of natural low point.

Source: Site inspection 26.07.2024

Figure 11: Looking west from Narre Warren – Cranbourne Rd through Mormac Development.

Source: Site inspection 26.07.2024

Figure 12: Croskell PSP outlet culverts under Thompsons Rd (Looking North)

Source: Site inspection 26.07.2024

Figure 13: Croskell PSP outlet culverts under Thompsons Rd (Looking South)

Source: Site inspection 26.07.2024

3.2 Undeveloped Catchment

The undeveloped and development area within the PSP can be seen in Figure 14. Flows naturally fall towards the existing waterways and drains highlighted by the blue linework on the plan. It's important to note the existing waterways shown in the west that flow over the Victorian Desalination Project Cable. An external developed catchment comes through the site from the south via an existing channel.

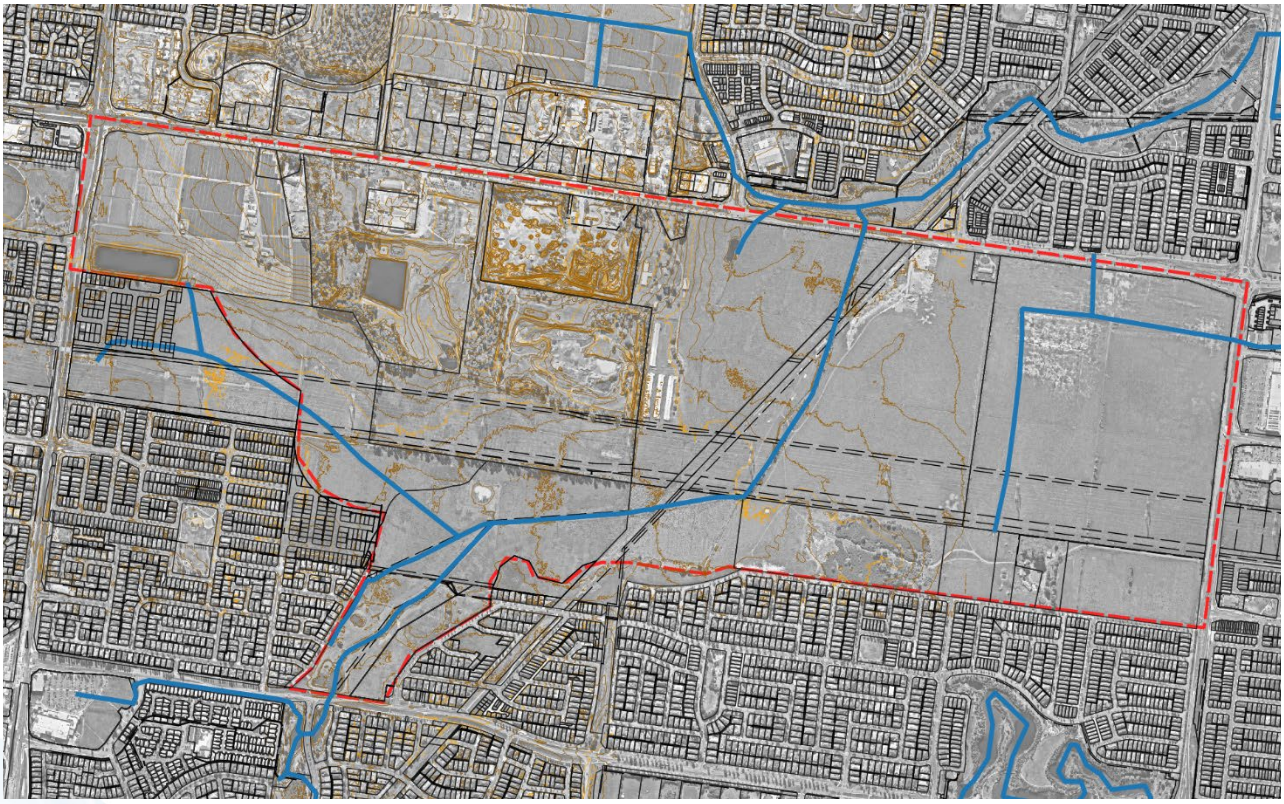


Figure 14: Undeveloped Development Area

Source: QGIS Image (Croskell PSP.qgz)

3.3 Hydrology

3.3.1 Model description

The 1% Annual Exceedance Probabilities (AEP) for the area were estimated using 2019 (ARR19) methodologies.

ARR19 includes 10 temporal patterns for 24 durations (from 10minutes to 7 days) providing 240 Hydrographs to test across the catchment. The key locality information from the ARR Data Hub for this area can be seen as summarised in Table 2. Based on this information, the following sections outline the relevant data obtained.

Table 2: ARR Data Hub

Input Data	Details
River Region	Southeast Coast (Bunyip River)
Latitude	145.330
Longitude	-38.081
Time accessed	07 April 2022 01:22PM

Source: ARR Data Hub – April 2024

3.3.1.1 Rainfall Depths

Rainfall depths were extracted from the Bureau of Meteorology (BoM) and a summary has been included in Appendix C.1 at the end of this document.

3.3.1.2 Temporal Patterns

The relevant rainfall temporal patterns were downloaded from the ARR Data Hub as per the guidelines identifying the location of the site on the temporal patterns map. A sample of the temporal patters map from ARR can be seen in Figure 15.

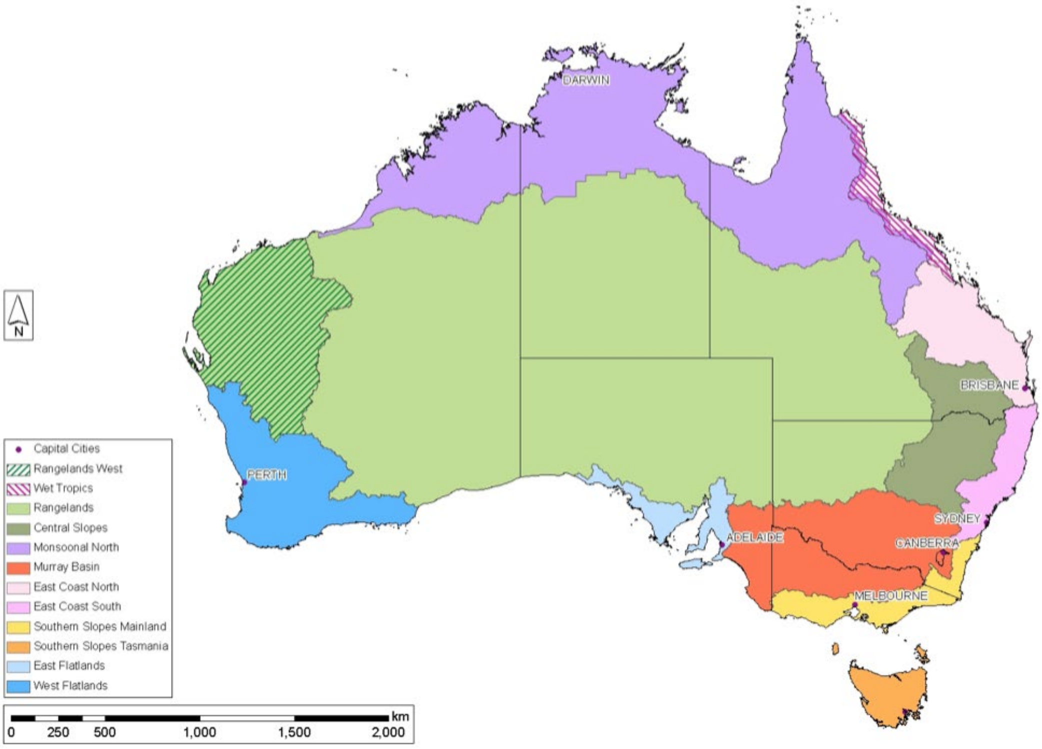


Figure 15: Temporal Patterns Map

Source: Australian Rainfall and Runoff 2016 (Book 2, Figure 2.5.7)

3.3.2 Fraction Impervious

The ratio of fraction impervious provides an agreed break up of hardstand and grassed/vegetated zones within the development. The following table outlines the expected fraction imperviousness for Council as indicated in the Engineering Design and Construction Manual (EDCM).

Table 3: Fraction Imperviousness

Catchment Type	Typical Value	Applied Value
Industrial Zone 1 (0.70 – 0.95)	0.90	0.85
Undeveloped Paddock (0.10 – 0.30)	0.20	0.20
Residential Development (0.70 – 0.90)	0.80	0.70

Source: Engineering Design and Construction Manual (Dec2019) Table 16

Note: MW's consultants have used a pre-developed fraction impervious of 0.10 across the catchment. Given the development north of Thompsons Rd is currently under construction and will be before the PSP is gazetted, it is a flawed approach to consider this area having a 0.10 fraction impervious. If we don't use the current condition, the PSP and DSS area already behind. We also recommend a pre-developed catchment impervious of 0.20 which is more inline with a Rural Living, Rural, Conservation or Resources zone.

Recommendation No. 2

The current condition at the time the PSP is gazetted should be applied in the pre-developed model which includes an upstream catchment (north of Thompsons Rd) being developed with at least a 0.70 fraction impervious.

3.3.2.1 Loss Parameters

Loss Parameters outline how much water doesn't run off during a rainfall event. In an ILCL model (Initial Loss, Continuing Loss) these parameters establish what is the initial loss caught in the grass, rubble, landform and what is the ongoing or "continuing" loss, that seeps into the soils and lost to moisture.

Loss parameters for the pervious catchments for this project were obtained from the ARR Data Hub based on maps from ARR as can be seen in Figure 16 and Figure 17.

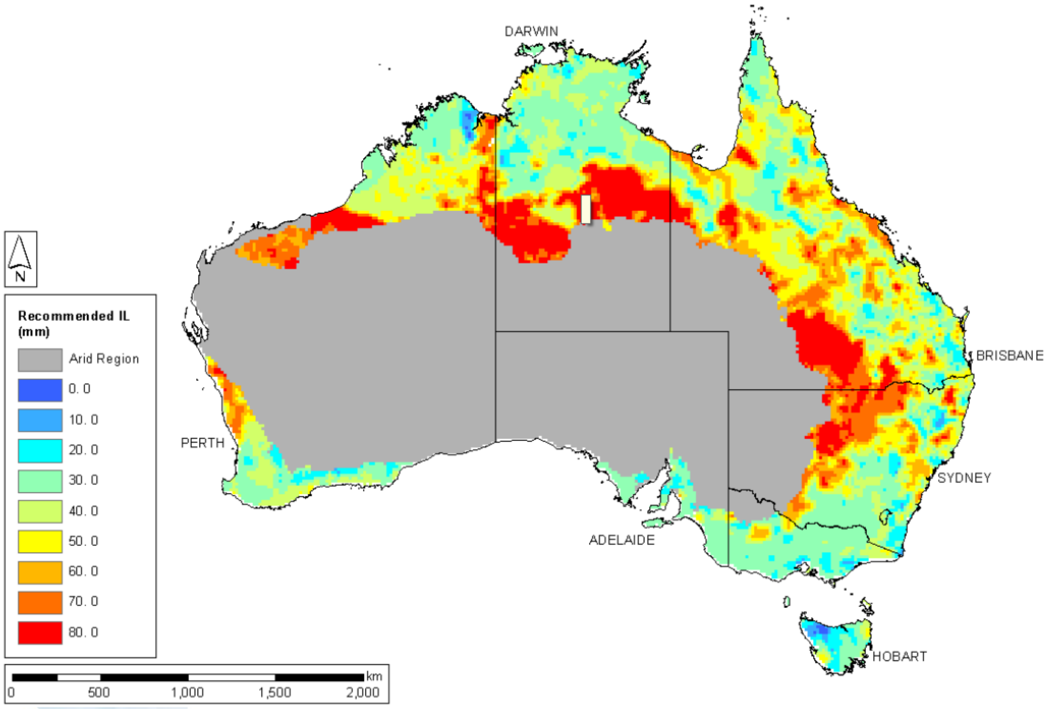


Figure 16: ARR 2016 recommended Initial Loss map

Source: Australian Rainfall and Runoff 2016 (Book 5, Figure 5.3.18)

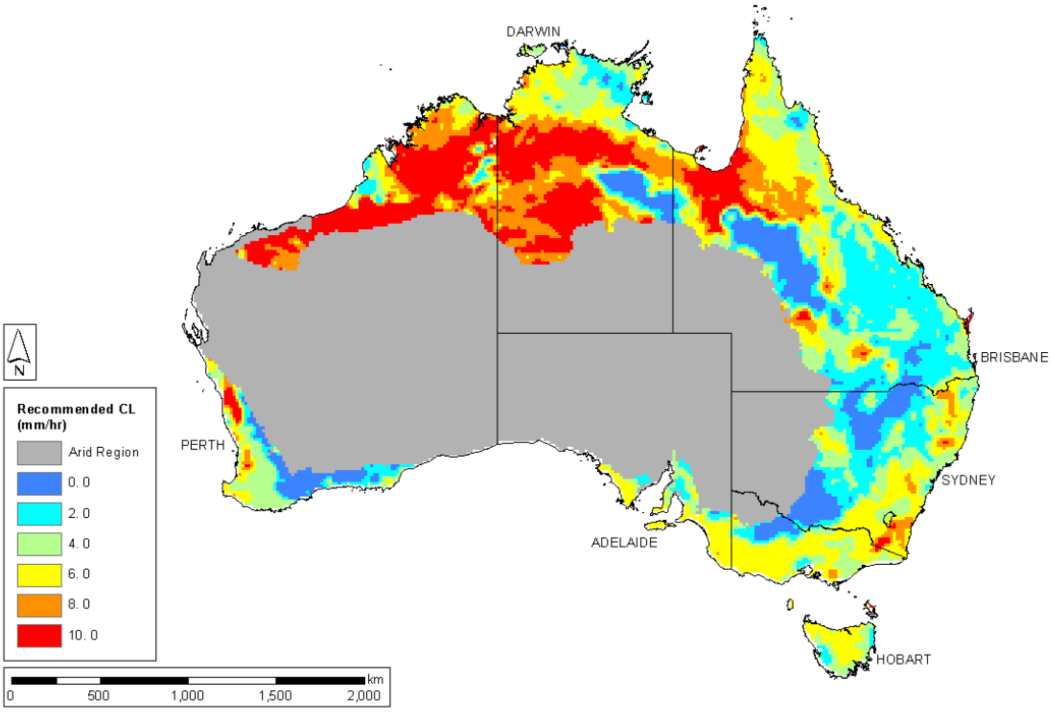


Figure 17: ARR 2016 recommended Continuing Loss map

Source: Australian Rainfall and Runoff 2016 (Book 5, Figure 5.3.19)

The relevant loss parameters issued by ARR are outlined in the table below.

Table 4: Loss Parameters

Loss Type	ARR DataHub Recommended	MW Depth Applied
Pervious Storm Initial Loss	27 mm	25 mm
Pervious Storm Continuing Loss	4.4 mm	2.5 mm
Impervious Storm Initial Loss	1 mm	1 mm
Impervious Storm Continuing Loss	0 mm	0 mm

Source: ARR Data Hub – January 2024

3.3.3 Flow modelling

RORB was used to identify the outflows from the local area. RORB is software used widely in Australia and internationally for design flood hydrologic modelling. The software is based on work undertaken by Prof. Eric Laurenson and Prof. Russell Mein (Monash University) in the late 1970s. More recently the joint probability developments and other enhancements were prepared by Assoc. Prof. Rory Nathan (SKM/Jacobs/Melbourne University).

Melbourne Water had generated a RORB as part of the Ti Tree Creek DSS 6345.

The model was supplied by Melbourne Water on the 15th of July 2024 when requested including the GIS files defining the catchment, nodes and reaches for both the pre-development and developed scenarios. The pre-developed catchment model for RORB can be seen in Figure 18 while the developed catchment model for RORB can be seen in Figure 22 later in this document.

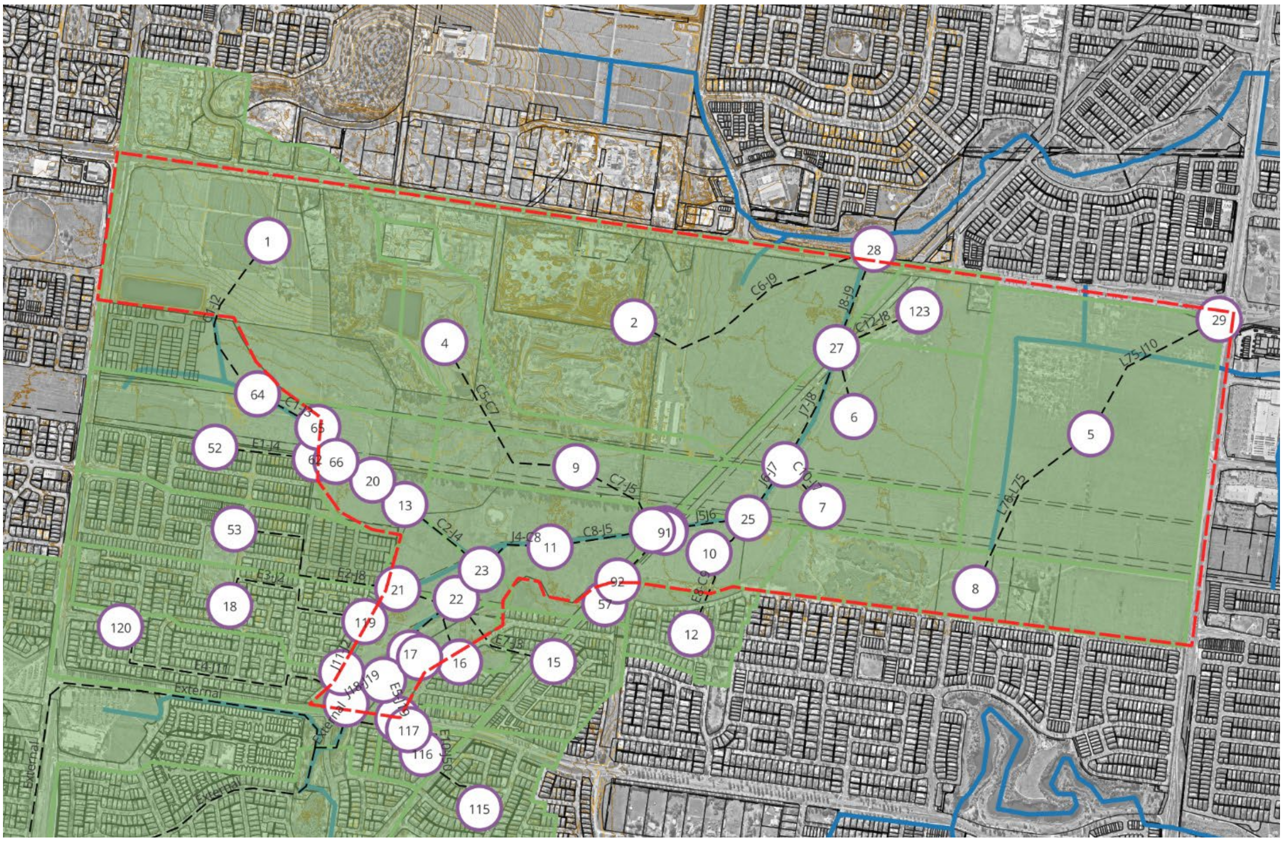


Figure 18: Undeveloped catchment Plan for RORB

Source: QGIS Image (Croskell PSP.qgz)

The corresponding RORB model can be seen in Figure 20 overleaf.

3.3.3.1 Parameters

The model was run using ARR19 methodology based on the parameters shown in the batch file provided. These are shown in Table 5.

Table 5: RORB Model Parameters

Parameter	Value
Kc	11.0
m	0.8

Source: Melbourne Water (TITR16-Croskell-pre-dev-RevB_batch.out)

Variable loss factors were also applied in the following manner

```
Loss factors   : Vary with ARI -      ARI(yr)       1%
               :            InitLoss factors      1.00
               :            ContLoss factors      1.00
               : Vary with Duration - Duration    10 min    15 min    20 min    25 min    30 min    45 min     1 hour  1.5 hour    2 hour    3 hour  4.5 hour    6 hour    9 hour   12 hour
               :              InitLoss factors      0.95      0.95      0.95      0.95      0.95      0.95      0.95      0.92      0.94      0.89      0.84      0.80      0.79      0.78
```

Figure 19: Variable Losses

Source: Melbourne Water (TITR16-Croskell-pre-dev-RevB_batch.out)

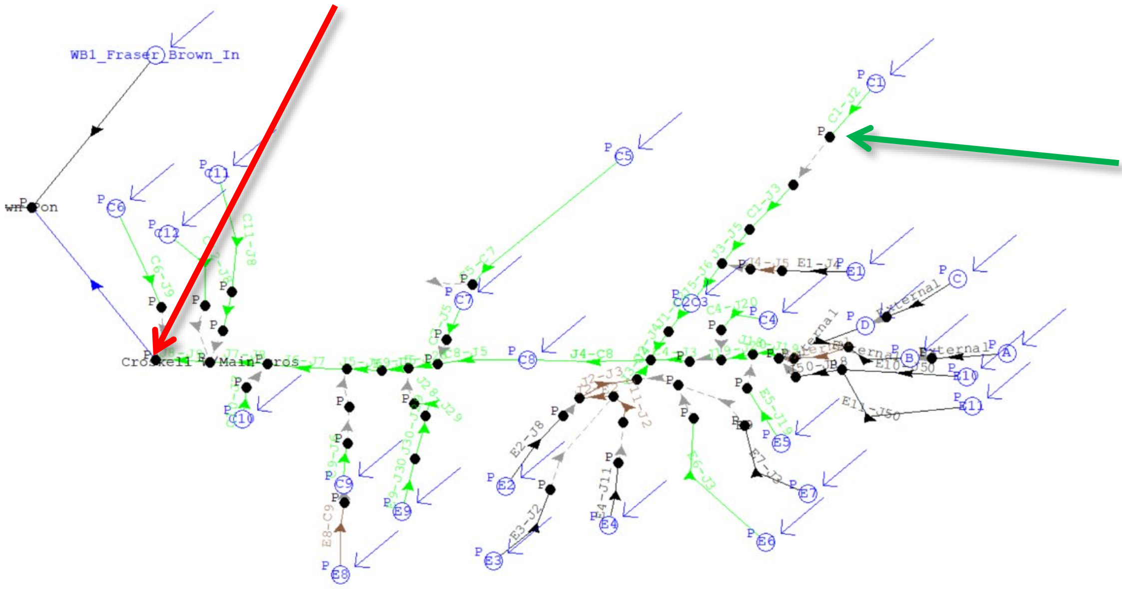


Figure 20: RORB Undeveloped Model Graphical View (original model, VDP West highlighted by green arrow, Thompsons Rd highlighted by red arrow)

Source: Melbourne Water

In the Concept report provided, a key reference point of discussion for the modelling was the desalination cable crossing in the west (labelled C1 in Figure 20 above). The following table outlines the values from the pre-development model provided against a similar model created in DRAINS and when applying the Rational Method. As a future reference point, the flows at the Thompsons Rd crossing have also been included. Given the development north of Thompsons Rd is currently under construction, the assumption in the our modelling is that it is developed and will be before this PSP is gazetted. MW and its consultants have reaffirmed the need to calculate the flows based on a 0.1 Fraction impervious. This forms the new "current" condition.

Table 6: Pre-developed catchment flow estimation

Duration	ARR19 ILCL m3/s (Original RORB Model)	ARR19 ILCL m3/s (RORB with >5 upstream catchments)	ARR19 ILCL m3/s (DRAINS)	2019 Rational Method Check (m^3/s)
1% Desal Crossing	2.75	4.05	4.80	4.10
1% Thompsons Rd Crossing	20.95	not modelled	not modelled	not modelled

Source: Water Studio (RORB)

The tabulated results indicate a large variance in the flow expected at the desal crossing point. As indicated in Section 2.1.3.2 earlier in this document, the existing flow across the VDP Cable is the maximum flow allowable without potentially upsetting AquaSure. With that in mind, calculating the correct value of this crossing is a critical element. The current value is based on a print node immediately down stream of point C1 explained above. Upstream of that print node is one solitary catchment. In the RORB Manual it states:

"*It is recommended that at least 5 sub-areas be placed above any hydrograph printout point to allow sufficient smoothing and attenuation of the rainfall excess hyetographs*." – RORB Manual Section 7.2, Item 11, page 85.

This tends to indicate that the "Original RORB Model" result of 2.75m3/s is most likely inaccurate and in this case, much too low. The RORB model was adapted to include 5 catchments upstream of the reference point and found that current flows over the desal crossing point are more likely in excess of 4m3/s.

Recommendation No.3

When comparing flows against the DRAINS model and a simple Rational check, a conservative approach would be to take 4.05m3/s as the appropriate flowrate to use as the 1% AEP pre-developed at the existing west VDP cable crossing. This assumes a correct fraction impervious representing the current developed context.

Exhibited Solution

4 Analysis

4.1 Development Plan context

In order to the develop this area, formal drainage assets are required to be designed and constructed. MW and the VPA provided details of their preferred solution with an opportunity to explore and discuss it. The proposed drainage layout, as provided by the MW and the VPA can be seen below in Figure 21 and incorporates:

- Wetlands
- Retarding basins
- Scheme Drains
- Overland flow paths
- Waterways

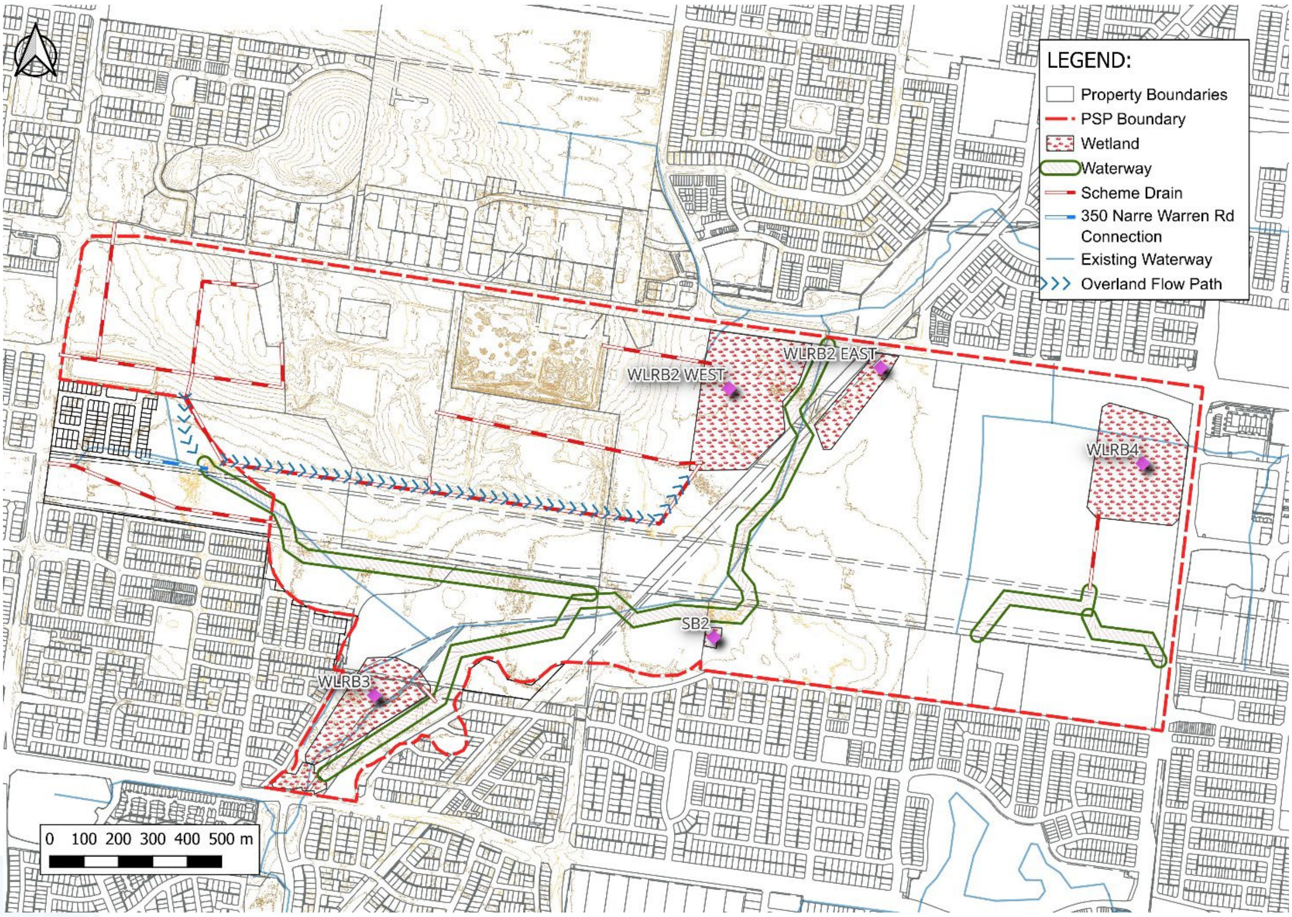


Figure 21: Exhibited Drainage Scheme (Scenario 1)

Source: Melbourne Water

4.2 Hydrology

4.2.1 Model description

As per the pre-developed context the hydrology method used in the exhibited model run is the ARR19 Method. The area has been updated using a fraction impervious of 0.85 or higher as recommended in the EDCM and listed in Table 3 earlier in this document. It appears MW used an automated process to establish the fraction imperviousness as it varies across the PSP.

The rainfall and relevant parameters remain the same as the pre-developed condition. An updated RORB layout has been provide and graphically generated reflecting the parcel ownership and potential connections. This can be seen in Figure 22.

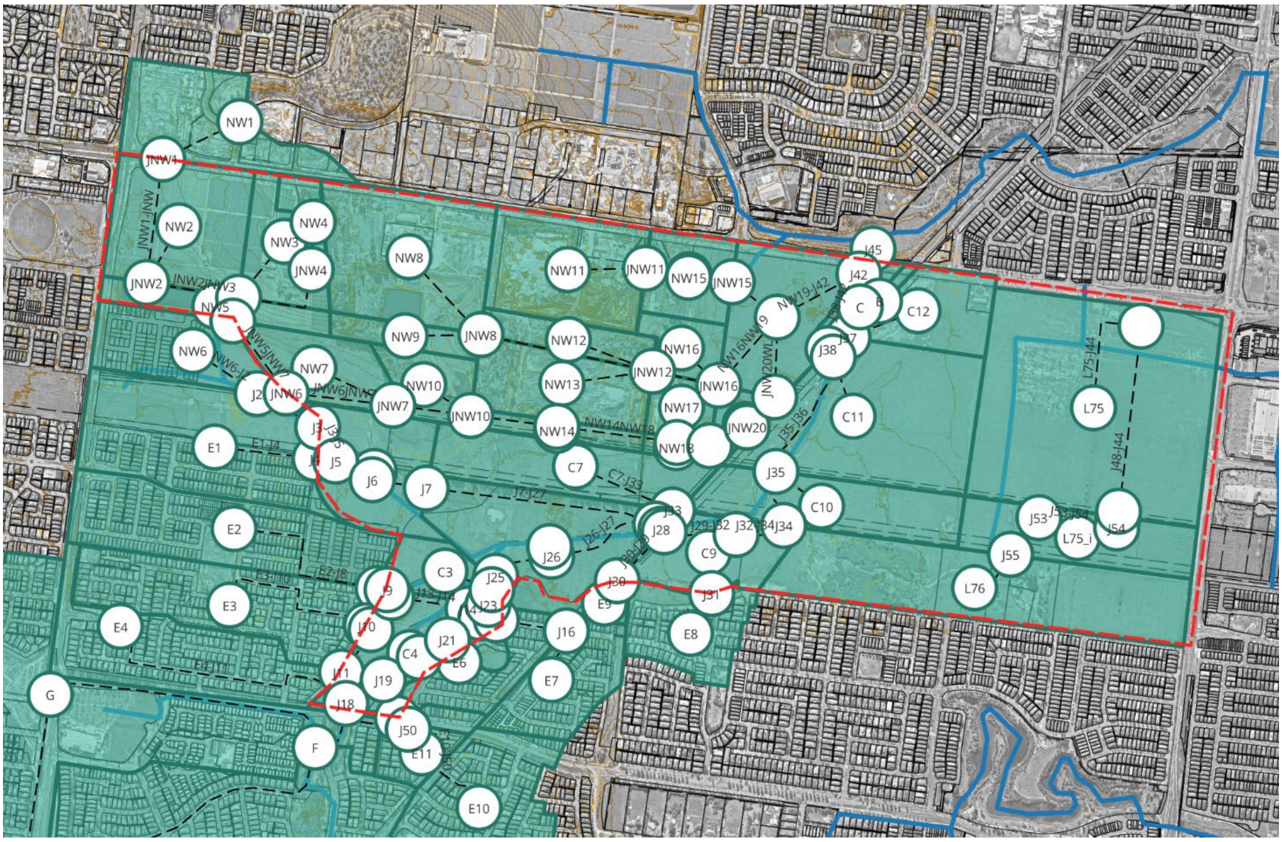


Figure 22: Exhibited Developed RORB Catchment Layout

Source: QGIS Image (Croskell PSP.qgz)

The corresponding RORB mode for the same catchment can be seen in Figure 23.

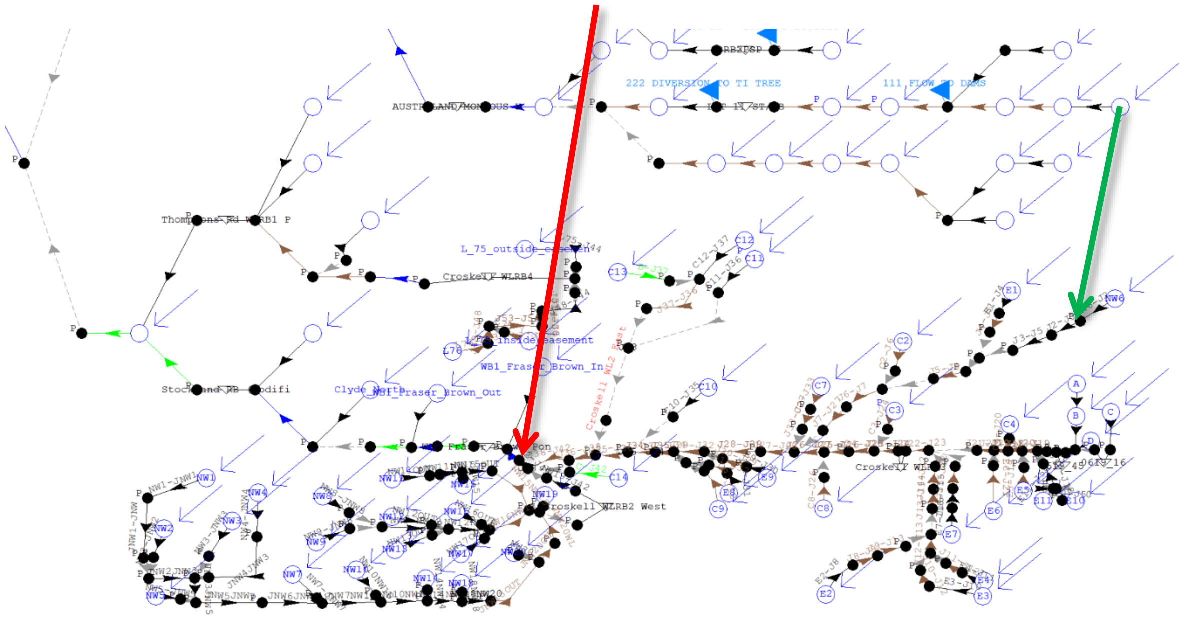


Figure 23: RORB Developed Model Graphical View (exhibited model, VDP West highlighted by green arrow, Thompsons Rd highlighted by red arrow)

Source: Melbourne Water

4.2.2 Expected Outflows from the Developed Site

Scenario 1: Exhibited Modelling

The model was run for the 1% event with the RORB model as provided. The intention of this solution was to use both an east west pipe with an overland flow path over the VDP Cable with flows less than or equal to the pre-developed condition. The model exhibited allowed the entire development from 350 Narre Warren Rd (also known as the Moremac property and as NW6 in the RORB model) and the northern half of property 13 in the original drainage scheme to flow over the desalination cable and into the proposed waterway. MW indicated that this was a “worst case” run to determine what size the waterway would need to be.

The visual representation of this can be seen in Figure 24 where the proposed flow path for the water from the Mormac property can be seen in yellow.

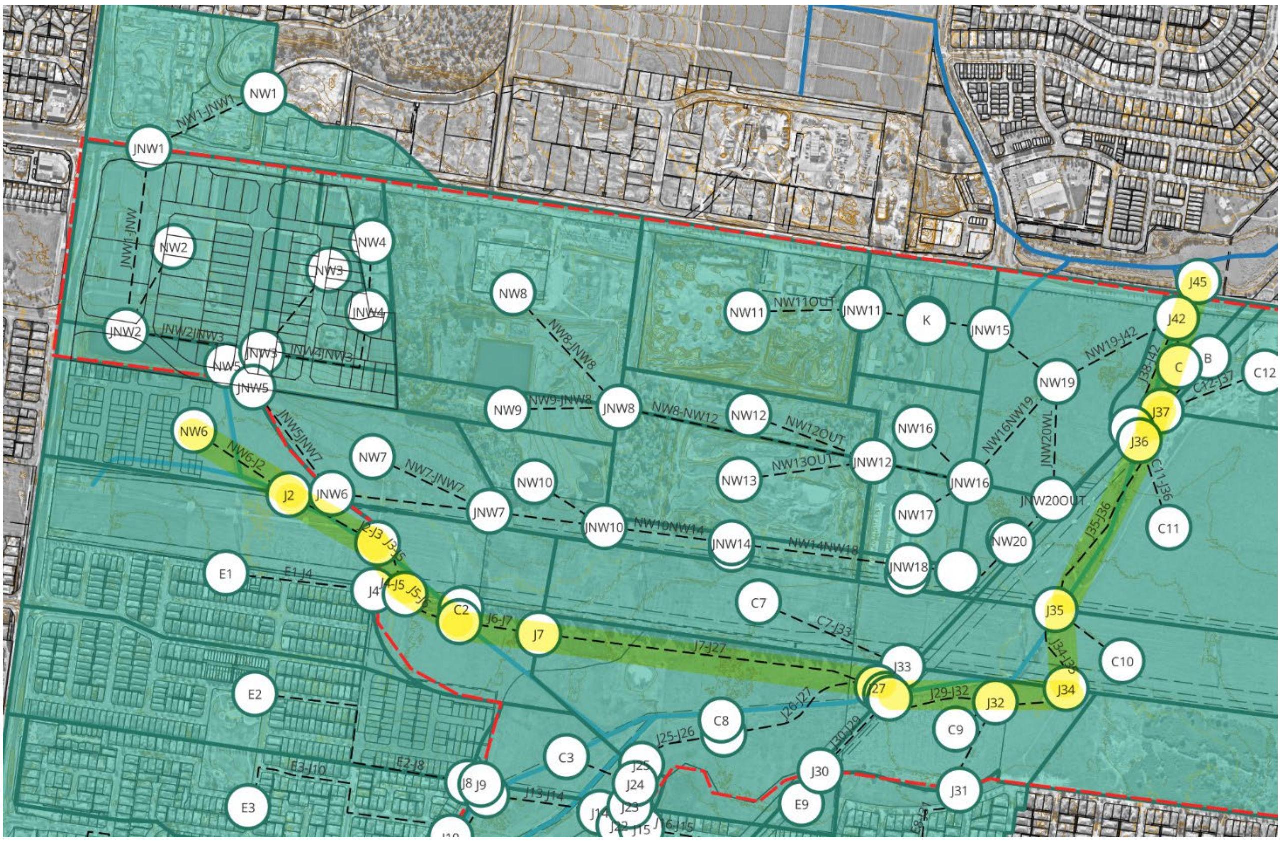


Figure 24: Scenario 1: Original Model Provided by MW

Source: Melbourne Water

The expected developed outflows using the ARR19 Rational Method can be seen in Table 7 below. The results appear to be close to those provided in the report.

Table 7: 1% Flows

Duration	ARR19 ILCL m3/s (Scenario 1: Original RORB Model)
1% 1450 Thompsons Rd Site Boundary (JNW5)	7.55
1% East West Pipe flow (JNW6)	7.35
1% VDP Cable Crossing including 350 Narre Warren Rd	(1.42-1.91)*
1% Inflow in the WLRB2	13.15
1% Outflow from WLRB2	8.65
1% Thompsons Rd Crossing	15.95

* Note: the entirety of 350 Narre Warren Rd is proposed to cross the VDP cable in Scenario 1. Estimate only.

Scenario 2: Exhibited Model with 350 Narre Warren Rd (Mormac land or NW6) connected to the proposed east west pipeline (in line with the Report and graphical Concept)

The model was re-run for the 1% AEP event with the RORB adjusted to divert all flows into the proposed pipeline north of the desalination cable (in line with the concept presented in the documentation exhibited). It was an interesting decision to send a model that did not match the concept. The model now allows for the entire development at 350 Narre Warren Rd (ie Moremac property known as NW6 in the RORB model) and the northern half of property 13 in the original drainage scheme to flow east. This is proposed to include around 7.5m³/s in the pipe and the gap flow overland (over the pipe and within the proposed road reserve).

(Note: We have not allowed for the 0.93m3/s to flow over the VDP cable in this scenario in line with the correspondence from MW during the exhibition period. We expect this twill require significant fill on the 350 Narre Warren Rd development and recommend this be investigated further.)

The visual representation of this scenario can be seen in Figure 25 where the proposed flow path for the water from the 350 Narre Warren Rd development can be seen in yellow. This is the only change to the model.

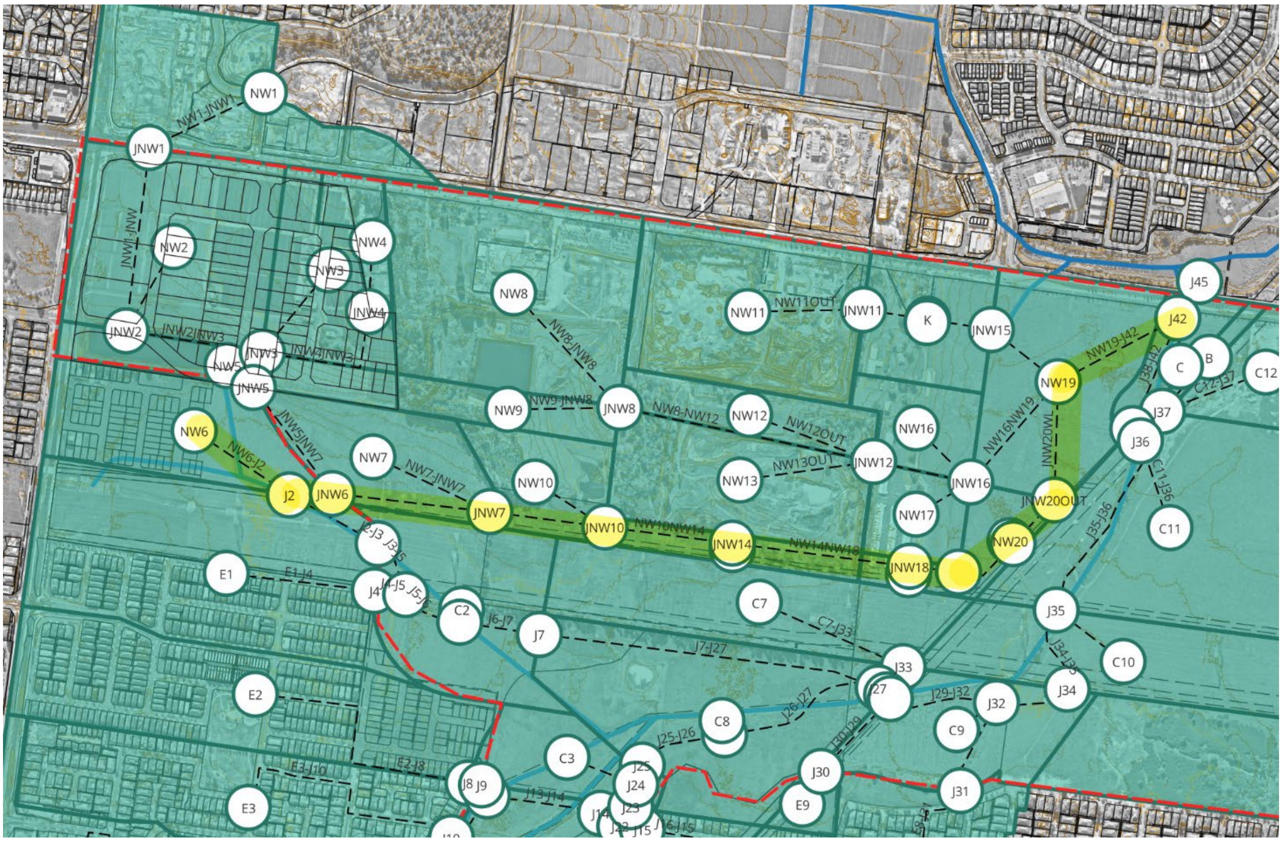


Figure 25: Scenario 2: Original RORB model with 350 Narre Warren Rd (Mormac land - NW6) using proposed pipeline and overland flow path

Source: Melbourne Water + Water Studio adjustment

The corresponding RORB mode for the same catchment area with the 350 Narre Warren Rd connection change can be seen in Figure 26.

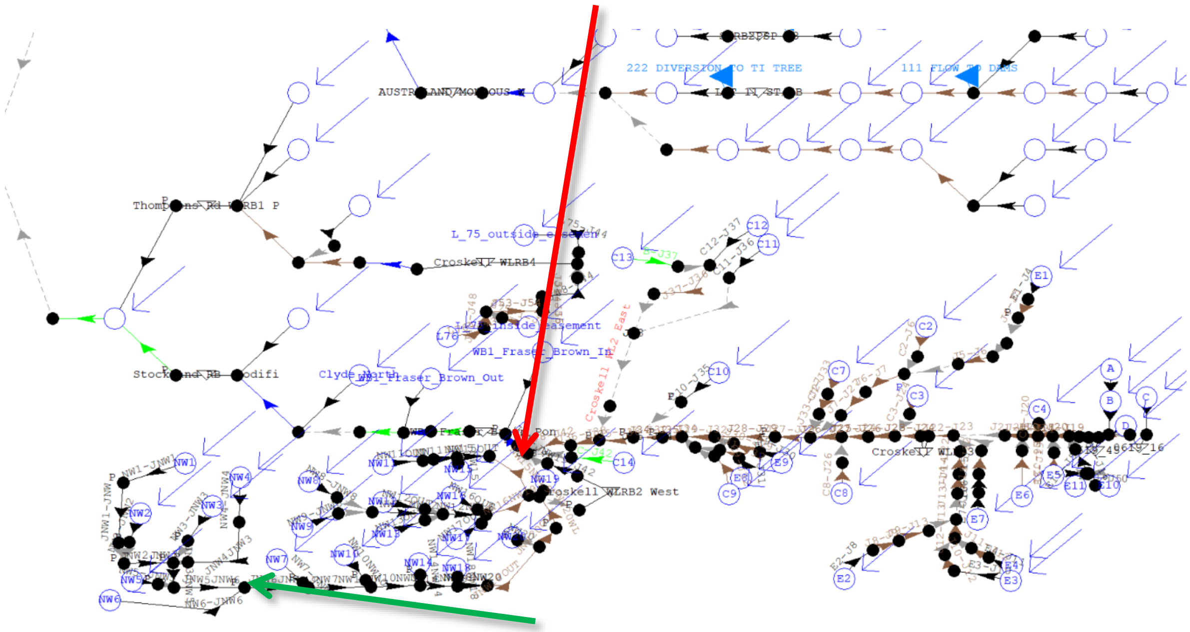


Figure 26: RORB Developed Model Graphical View (exhibited model with 350 Narre Warren Rd Development connected into the east west pipe , 350 Narre Warren Rd development highlighted by green arrow, Thompsons Rd highlighted by red arrow)

Source: Melbourne Water

Graphically this is represented in Figure 27 where the blue connecting pipe from the 350 Narre Warren Rd development now connects to the flow pipe with the road based overland flow arrangement.

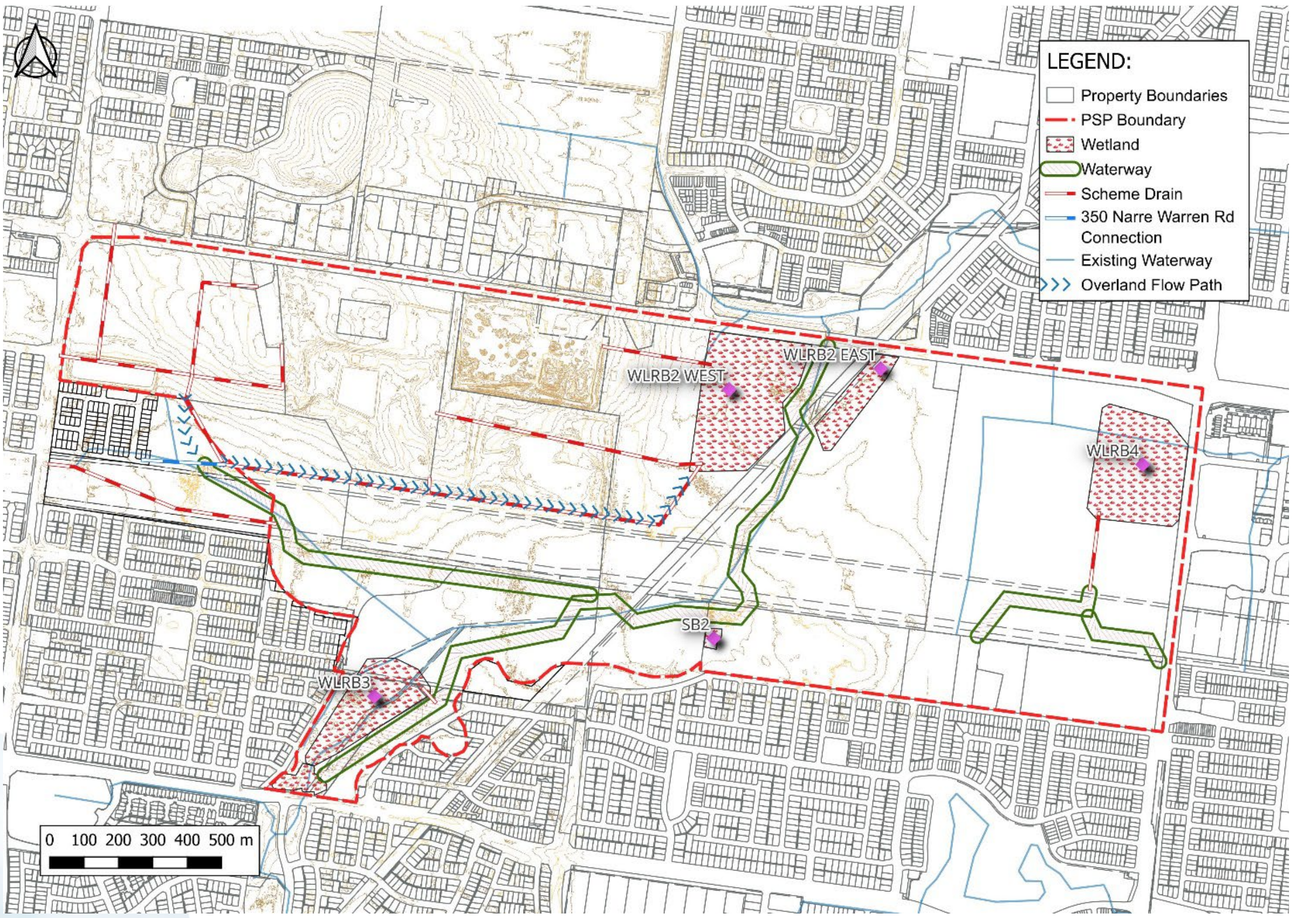


Figure 27: Exhibited Drainage Scheme (Scenario 2 - Concept)

Source: Melbourne Water

4.2.2.1 Flow Modelling

The expected developed outflows using the ARR19 Rational Method can be seen in Table 7 below. We have included the Scenario 1 modelling as a comparison.

Table 8: 1% Flows

Duration	ARR19 ILCL m3/s (Scenario 1: Original RORB Model)	ARR19 ILCL m3/s (Scenario 2: Original model with Moremac site diversion)
1% 1450 Thompsons Rd Site Boundary (JNW5)	7.55	7.55
1% East West Pipe flow (JNW6 including flows from 350 Narre Warren Rd)	7.35	9.45
1% VDP Cable Crossing	(1.42-1.91)*	0
1% Inflow in the WLRB2	13.15	13.90
1% Outflow from WLRB2	8.65	8.75
1% Thompsons Rd Crossing	15.95	15.95

* Note: the entire of 350 Narre Warren Rd is proposed to cross the VDP cable in Scenario 1. Estimate only.

4.3 Design and Construction

The constructability of these scenarios is a major concern.

The proposed alignment of the pipe in the longitudinal section shows the extent of cut required to not only install the pipe, but the overland flow path in the form of a road above it. This would mean the road is constructed up to 5m below the natural surface in order to facilitate an outlet. This solution requires at least two 1650mm pipes at over 1.5km based on our design. We have also identified that the road (at 0.5% grade) cannot adequately carry the gap flow and would evidently require more water into the pipe (an additional pipe may be needed).

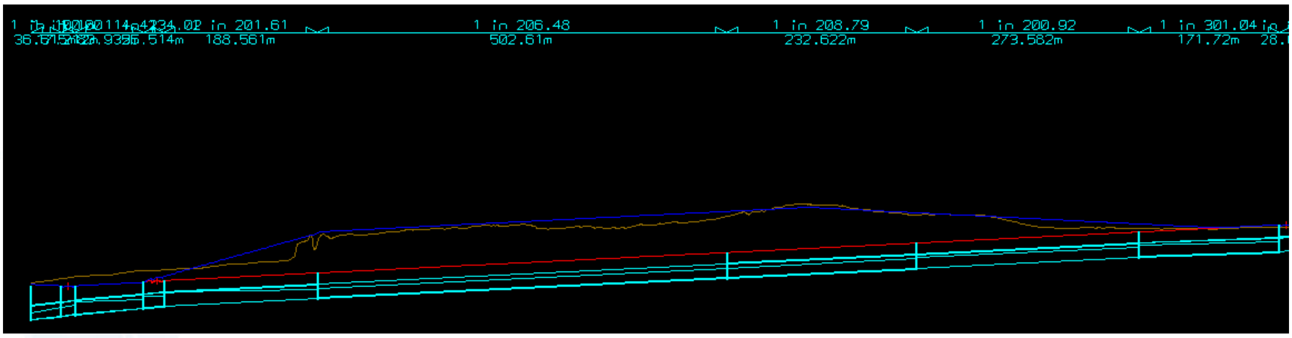


Figure 28: Pipe alignment

Source: Marshal (September 2024)

When we look at this in cross-section we can see the real impact of the overall road depth in this solution against the VDP cable (refer to Figure 29). This section of industrial access road acting as the overland flow path over Pipe E would, at its worst point, be up to 5.0m in cut against the VDP cable easement.

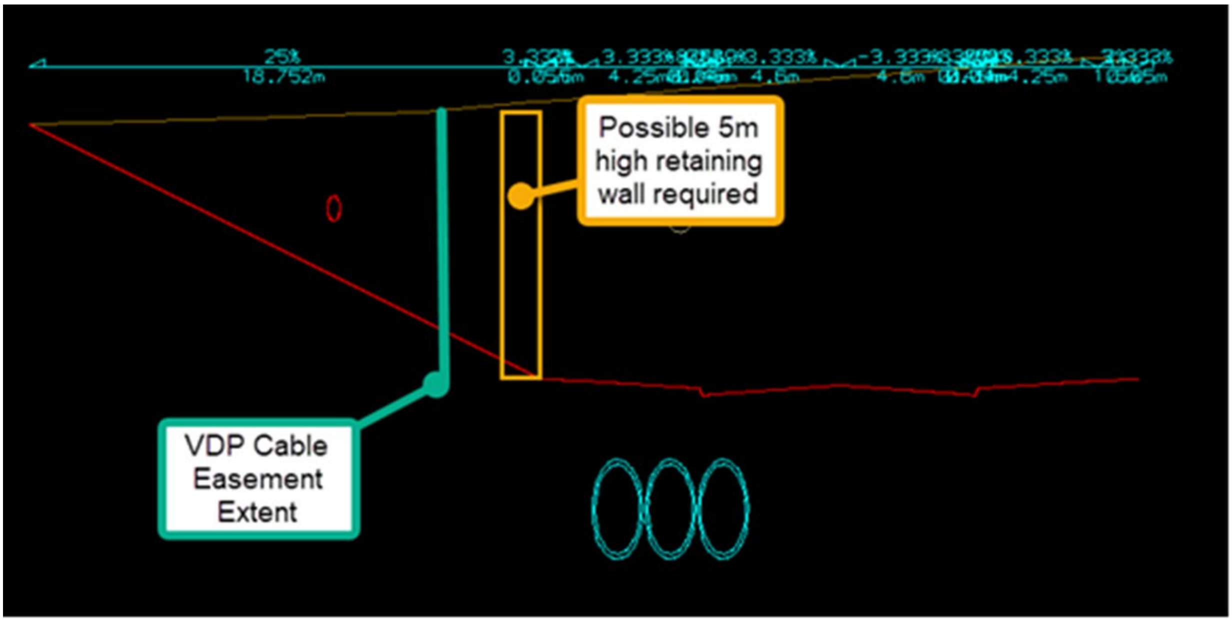


Figure 29: Future overland flow path PSP Road Section (including pipe and proximity to the VDP cable)

Source: Marshal (September 2024)

The extent of the wall construction varying from over 1m high (up to 5m high) can be seen in Figure 30 below. As seen, the Exhibited Solution would require the industrial access road acting as the overland flow path to be in excessive cut for a at least a 1.1km continual length against the VDP cable easement.

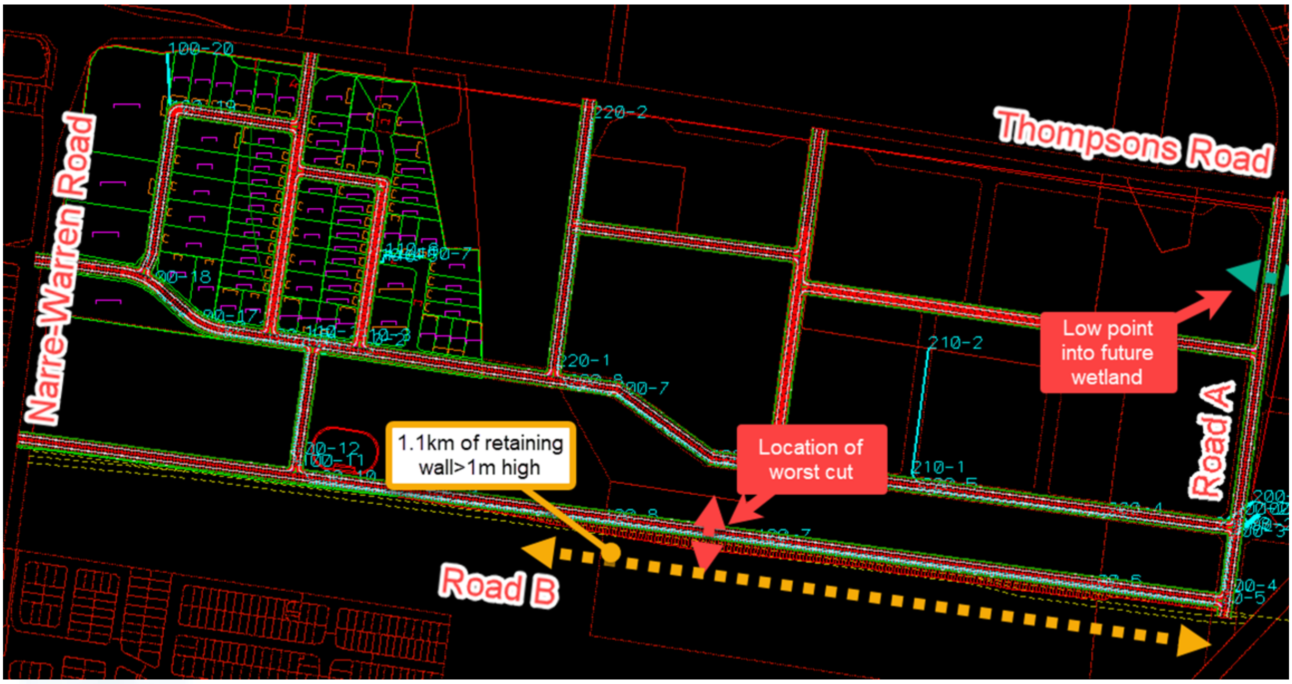


Figure 30: Expected length of wall

Source: Marshal (September 2024)

In our meeting with DEECA on the 23rd of September, they indicated that a road at depth in this area would not meet the requirements of AquaSure in their responsibility to protect the VDP Cable. In the current PSP documentation, a 50m width Special Control Overlay (SCO) off the VDP cable is proposed. This SCO is proposed as part of the GC148 amendment which isn't yet gazetted, however is anticipated to be in effect at the time of this PSP gazettal. The SCO requires a rigorous and thorough approval process prior to approval of any works in the area of the VDP cable, which may not approve this proposed deep road in cut against the easement. This could potentially quarantine a significant amount of the development area by pushing this road further north, this retaining wall would only get higher in that circumstance.

To assess the impact of the southern industrial road depth on the broader PSP, WaterStudio in cooperation with Marshal Melbourne have completed a high-level grading of the entire north-west PSP precinct. This grading exercise seeks to fairly compare the impact of the Exhibited Solution against the next Proposed Solution, to ensure that a holistic impact to the PSP is highlighted. Please note the below assumptions used in this high-level grading:

- LiDAR data used as the existing surface
- Internal roads match into the existing road levels of Thompsons Rd on the north, and Narre-Warren Cranbourne Rd on the west
- Industrial road width of 28m used for Majestic Blvd and William Thwaites Blvd/Casey Field Blvd, and 22m used for other industrial roads.
- Filling of dams and quarries assumed to be part of this exercise.
- No detailed lot pad grading has been completed– we have only graded road levels to each other. We note that the actual earthworks/retaining walls of the southern PSP area (in particular) to facilitate 1 in 100 flat industrial pads could be excessive.
- Minor earthworks into the VPD Cable easement is shown, however we acknowledge that this would not occur in practise and would ideally be replaced with retaining walls.
- Future WLRB2 location in MAB land to the east has been excluded, as it is expected this land will be in cut.

When looking at the earthworks for this Scenarios 1 and 2 in Figure 31, we can see significant cut will be required throughout the area (>2.2mill m^3) and together with the fill, looks like 2.5mil m^3 of earthwork moved around the site (details can be found in Table 9). This excludes the earthworks needed for the large pads expected in an employment area like this.

A 5m high wall along the edge of any road would make access to each parcel extremely difficult and result in the need for ramps and loss of useable space. This could render many parcels or space earmarked for development virtually undevelopable.

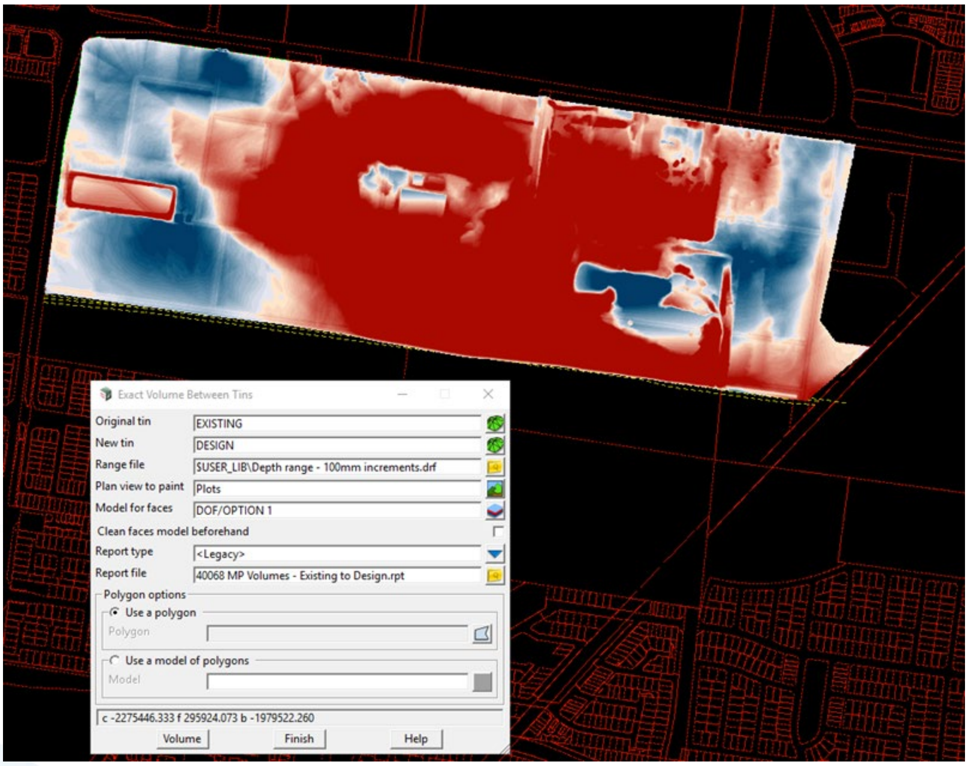


Figure 31: Extent of cut (red) and fill (blue)

Source: Marshal (September 2024)

Table 9: Cut and fill volume summaries

	Volume (m³)
Total Cut	2,275,446
Total Fill	295,924
Balance	**1,979,522**

Source: Marshal

When looking further at the overland flow path along the future local access street above the pipe, we can see in Figure 32 that a local park (LP-02) is proposed part way along its length breaking the "through road" nature. Given the road is going to be 5m+ below the surface and carrying an overland flow path, has the PSP appropriate considered the location of this park? If it were to be located as proposed, 5m+ retaining walls may need to surround the park or perhaps a tiered solution is proposed?

Further consideration needs to be given to the location of the park and overland flow path.

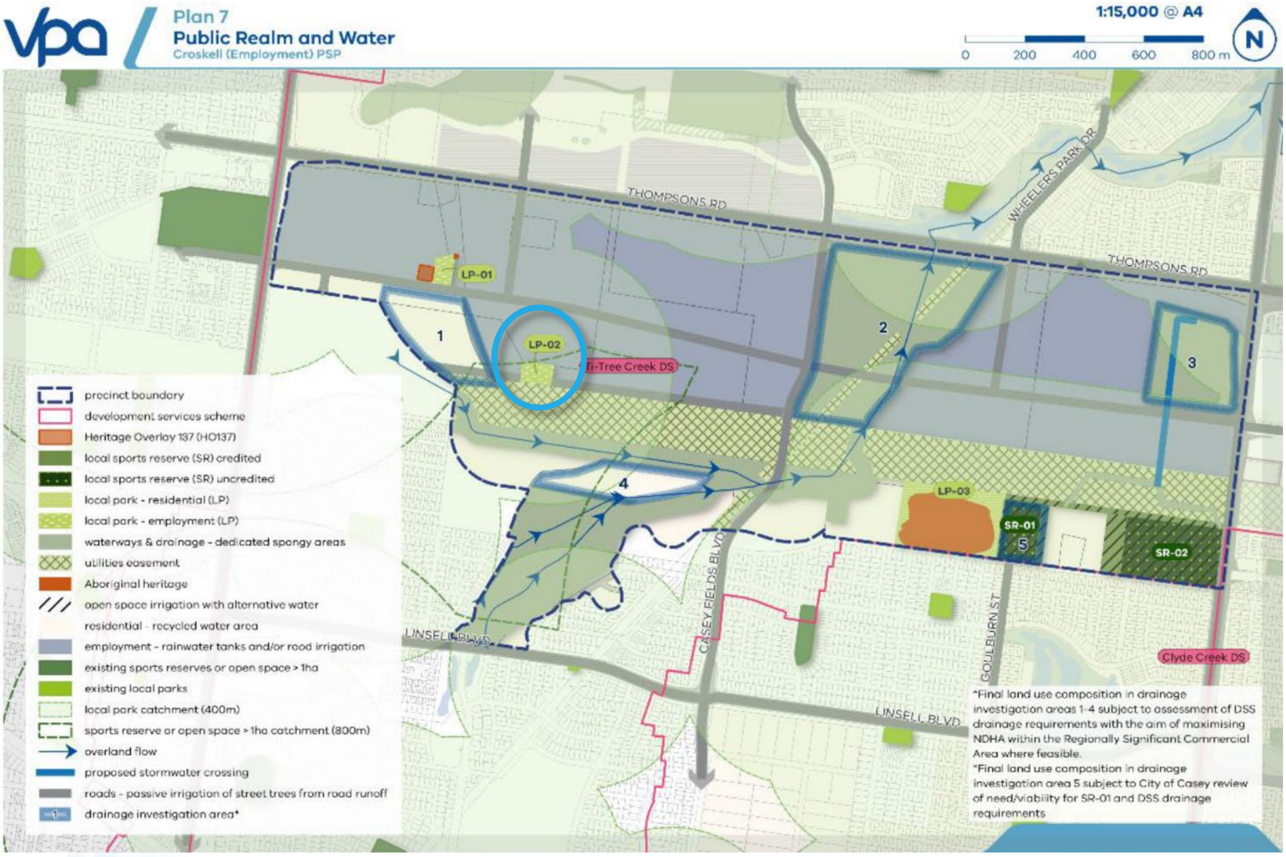


Figure 32: Proposed Park cuts overland flow path

Source: Croskell Precinct Structure Plan (VPA September 2024)

Due to the need for all overland gap flow to free-flow to the east through the overland route at Pipe E, this scenario will also require significant filling of the Moremac Land (350 Narre Warren Rd Development). As per our modelling completed for the Exhibited Solution, at the south-west corner of the Moremac property, there would need to be up to 5m of fill to drain it east. This degree of filling would not be supported by the Moremac Group and ignoring the obvious economic feasibility issues of developing their site, we also do not believe Aquasure/DEECA would be supportive of a 5m high retaining wall in fill against their easement.

4.4 Summary

This scenario is an expensive solution that doesn't respond to the actual topography of the area. Specifically:

- Overland flow path for the east west road over Pipe E will be up to 5m in cut and may not be approved by DEECA / Aquasure as part of the SCO approval process.
- This will isolate a large portion of the PSP area from development.
- The overall earthworks required just to facilitate the functionality of the scheme is excessive and could make development economically unfeasible.
- This will also increase the height of the retaining wall and make any properties fronting that road very difficult to access.
- The proposed Park LP-02 clashes with the overland flow path and doesn't consider its depth.
- This option would require filling of the Moremac land in the far west of up to 5m.

Proposed Solution

5 Analysis

5.1 Development Plan context

The proposed drainage scheme layout, as adapted from the VPA exhibited solution can be seen below in Figure 33. In this Scenario the blue connecting pipe from the 350 Narre Warren Rd development now connects to the east west pipe. The east west pipe is now proposed to take the entire development in a 1% flow arrangement with no overland flow above Pipe E. A back up grassed swale over the VDP cable is proposed to take flows over and above the 1% and as a backup should the 1% pipe block or fail in anyway.

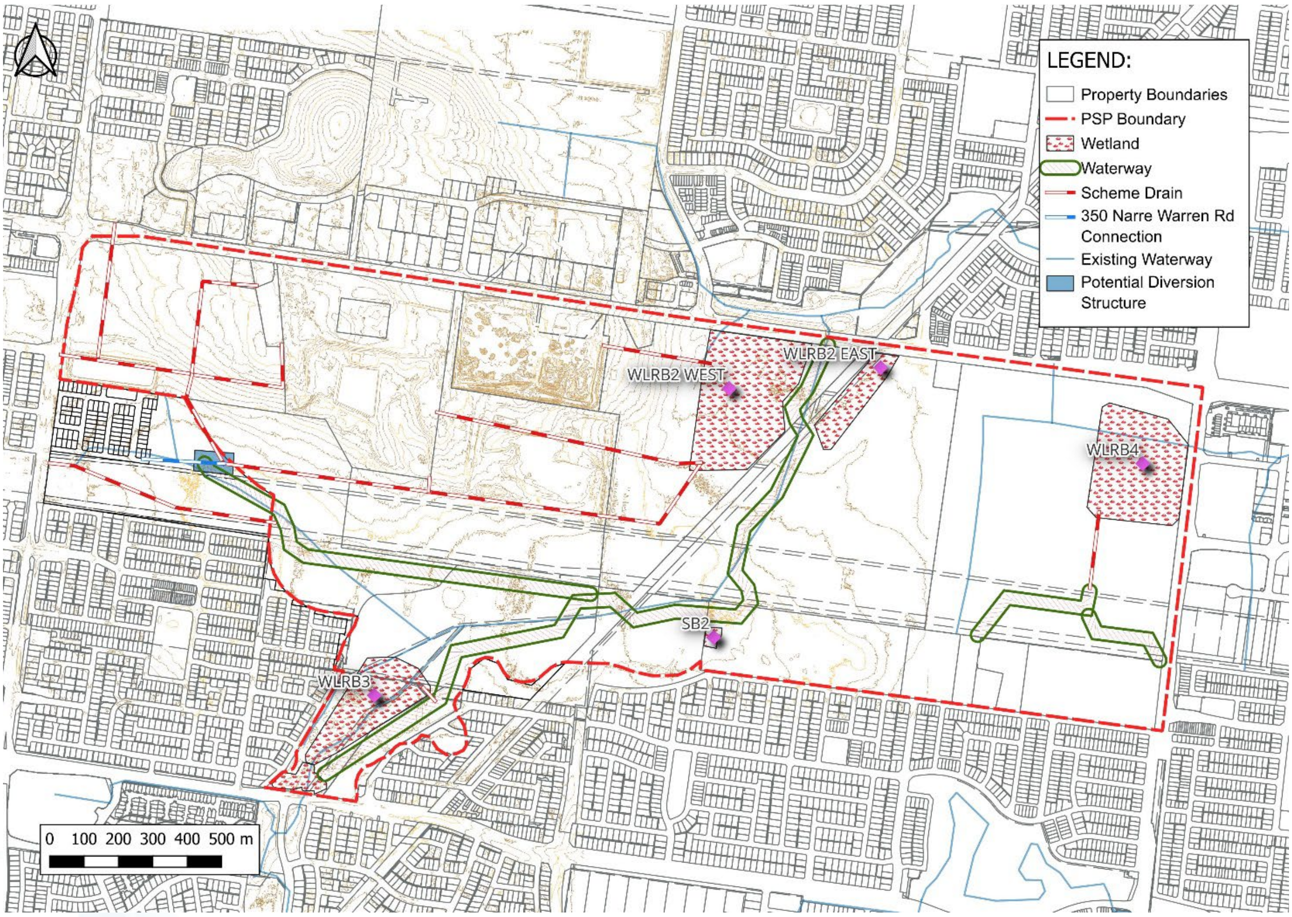


Figure 33: Proposed Drainage Scheme (Scenario 3)

Source: Water Studio (GIS)

5.2 Hydrology

5.2.1 Model description

As per the pre-developed context the hydrology method used in the proposed solution model run is the ARR19 Method. The area has the same fraction impervious details as the exhibited model. The rainfall and relevant parameters remain the same as the pre-developed condition. The RORB catchment layout remains the same as that shown in the Scenario 2 (refer to Figure 22). The only difference being the way water moves to the eastern outfall (ie wholly within the pipe).

5.2.2 Expected Outflows from the Developed Site

Scenario 3: Exhibited Model with 350 Narre Warren Rd (Mormac land - NW6) connected to the proposed east west pipeline with a 1% capacity

Getting flows into a 1% pipe arrangement has its challenges but they are easily overcome given appropriate infrastructure. One solution is to upgrade much of the upstream pipe network to a 1% capacity over a set distance to give the catchment time to enter the pipe earlier. If this solution were to be adopted, a set length of 1% pipe should be included in the DSS for shared cost.

Alternatively, a diversion basin could be constructed at the upstream end to manage flows. The model was re-run for the 1% AEP event with the RORB adjusted to include a diversion (with minor retardation) basin that appropriately conveys flows into the proposed pipeline north of the desalination cable. The benefit of this scenario is its ability to limit flows in the pipeline back to the flows expected in Scenario 1.

In Scenario 3, the model allows for the entire 350 Narre Warren Rd Development (NW6 and property 13 in the DSS) as well as the 1450 Thompsons Rd Development (NW2, NW3, NW4 and NW5 or 121, 122 and 124 in the original DSS) and the development north of Thompsons Rd (known as NW1 in the RORB model and 125 and 126 in the original DSS) to flow into the pipe. In this scenario we have not allowed for the 0.93m3/s flow over the desalination cable either. We expect this will again be problematic with regard to fill on the 350 Narre Warren Rd Development however the diversion basin enables the capture of the overland flows and appropriately diverts it into the pipe in a maintainable format. This solution also creates an opportunity to divert flows over the desalination cable if warranted. This enables a controlled environment to manage flows greater than 1% or even flows below the 1% should pipes be blocked at any stage.

The conceptualised diversion basin is currently designed with a 750mm depth of water and volume of 4000m3. This could be resized to include water quality assets if required. If so, we expect it would be considerably larger to improve water quality for the upstream catchment and much more land would be needed.

The visual representation of this can be seen in Figure 34 where the proposed flow path for the water from the western properties can again be seen in yellow with a diversion basin approximately sized and shown in blue. The RORB model remains the same as shown in Scenario 2 (Figure 26 earlier in the document).

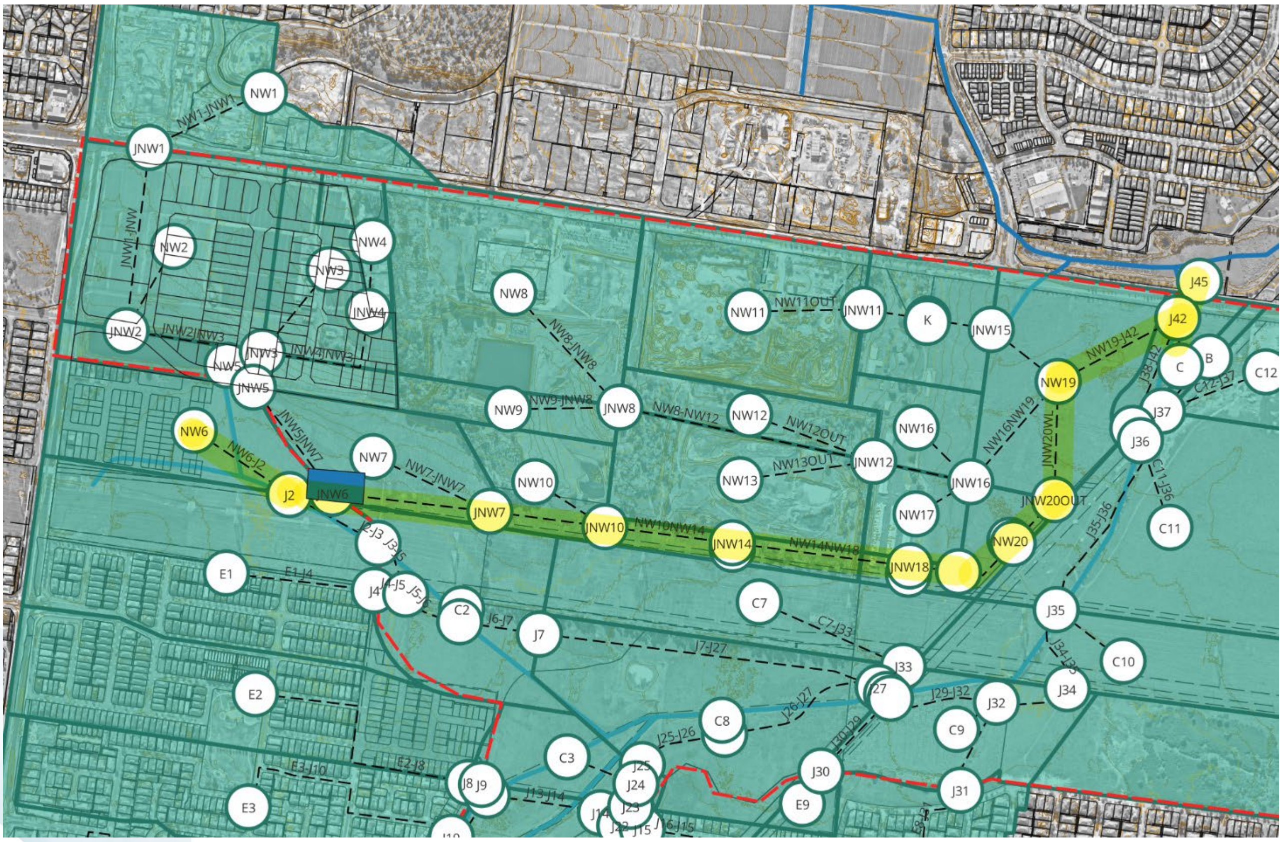


Figure 34: Scenario 3: Original RORB model with 350 Narre Warren Rd (Mormac land - NW6) using proposed pipeline and using a diversion basin to better control flows.

Source: Melbourne Water

5.2.2.1 Flow Modelling

The expected developed outflows using the ARR19 Rational Method can be seen in Table 7 below. We've included all Scenarios in the one table with clear reference points for comparison. We can see that the flows reaching the Thompsons Rd Crossing do not change in any Scenario so the same level of service is met across the catchment.

Table 10: 1% Flows

Duration	ARR19 ILCL m3/s (Scenario 1: Original RORB Model)	ARR19 ILCL m3/s (Scenario 2: Original model with Mormac site diversion)	ARR19 ILCL m3/s (Scenario 3: Original with Mormac site diversion & RB)
1% Wolfdene Site Boundary (JNW5)	7.55	7.55	7.55
1% East West Pipe flow (JNW6)	7.35	9.45	7.45
1% VDP Cable Crossing	(1.42-1.91)*	0	0
1% Inflow in the WLRB2	13.15	13.90	13.20
1% Outflow from WLRB2	8.65	8.75	8.25
1% Thompsons Rd Crossing	15.95	15.95	15.85

*Note: the entire of 350 Narre Warren Rd is proposed to cross the VDP cable in Scenario 1. Estimate only.

5.3 Design and Construction

This scenario includes the same pipe alignment proposed in Scenarios 1 and 2 however the entire 1% flow is contained within the pipe. We expect only 1 extra DN1650 pipe would be required to carry the difference in flows, so at the outfall into WLRB2, there would ultimately be 3x DN1650 pipes. We propose that the pipe alignment carry the 1% flow using today's rainfall data. By carrying the entire current 1% flow in the pipe, this will provide up to 4m³/s of capacity to overflow the VDP cable in the longer term. Given Aquasure will only manage the VDP cable for 12 or 13 years (or so) beyond the date of the PSP gazettal, this provides the relevant authorities plenty of opportunity to upgrade the overflow route in the future if needed.

A 1% pipe requires significant upstream infrastructure to ensure the flow is adequately captured and transferred into pipeline. As discussed, this could either be managed by upgrading the pipe infrastructure for a set distance upstream of the 1% pipe or using a diversion basin as described earlier.

The benefit of a 1% pipe is that we have a reasonable backup overland flow path proposed over the VDP cable if needed at a later stage. In the shorter term, this could be a simple broad grassed swale that can safely deliver flows to the waterway if needed. The downstream environment is already encumbered with services and no developable land should be lost with this backup flow path of this nature.

The alignment of the pipe in the longitudinal section in Figure 35 shows the depth of pipe with respect to the proposed road (shown in dark blue) above it. This would mean the pipe is constructed up to 8m below the natural surface in order to facilitate an outlet.

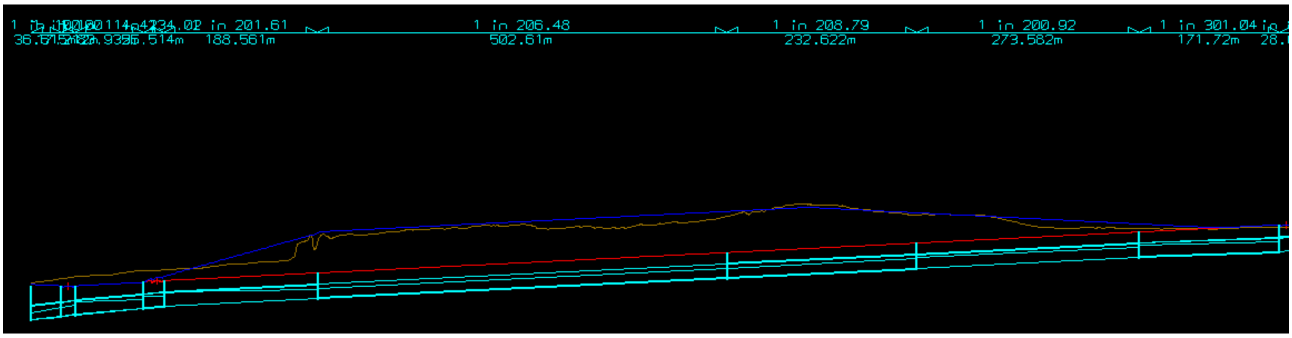


Figure 35: Pipe alignment

Source: Marshal (September 2024)

When we look at this in cross-section we can see the impact of the overall pipe depth in this solution (refer to Figure 29). Further to this we recommend shifting the pipes to the northern side (right of the page) of the road to ensure it is beyond the angle of repose to the VDP cable. This would still be within the 50m SCO zone of the cable but enables full use of land in this area with minimal impact to the cable and its heat dissipation zones.

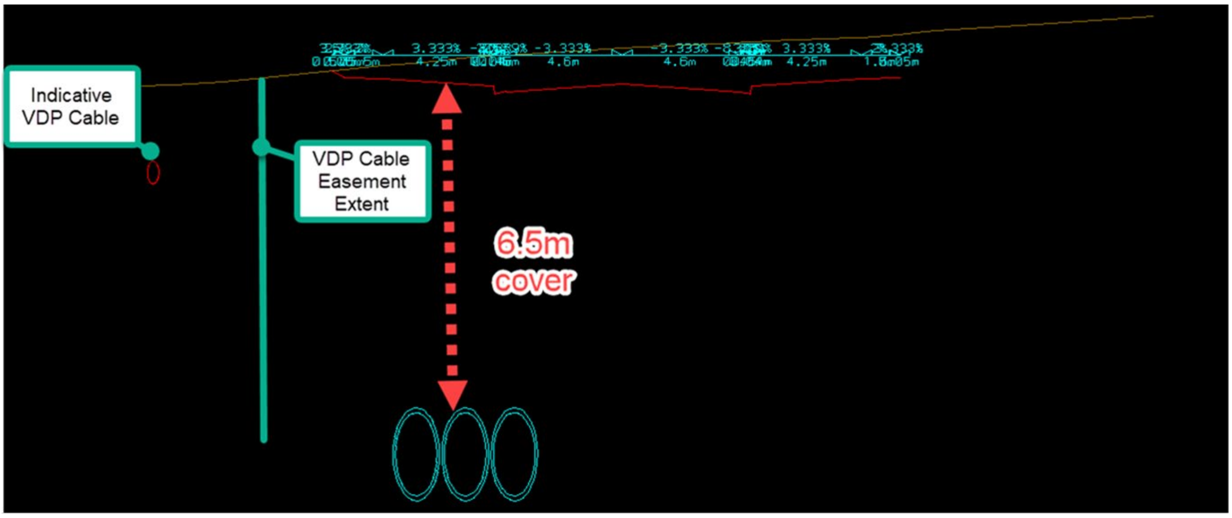


Figure 36: Future overland flow path PSP Road Section (including pipe and proximity to the VDP cable) – Cross-section Cut example

Source: Marshal (September 2024)

Retaining walls are likely to still be required along the interface of the VDP cable easement, however in their highest extent will only be some ~2.0m in fill. We note that localised grading in more detail may completely remove any need for a filled solution as shown in Figure 30 below.

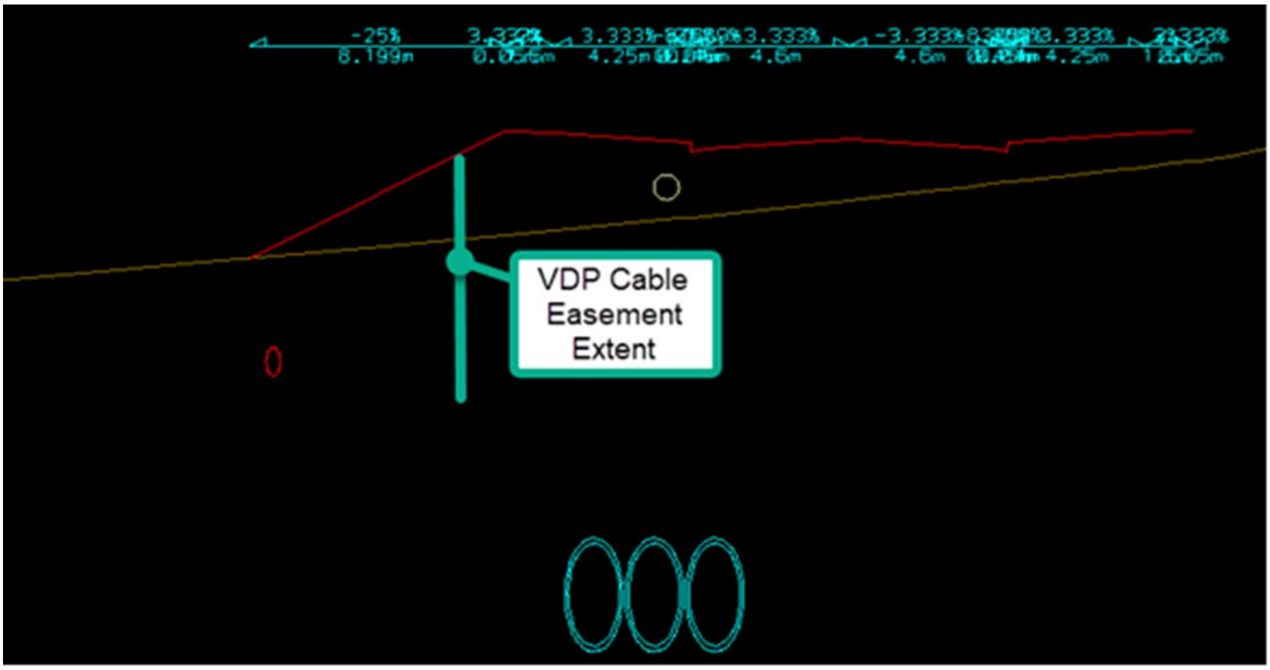


Figure 37: Future overland flow path PSP Road Section (including pipe and proximity to the VDP cable) - Cross-section fill example

Source: Marshal (September 2024)

When looking at the earthworks (refer to Figure 31) for this scenario we can see that the need for cut will be dramatically reduced when compared to the Exhibited Solution. Instead of >2.2mill m^3 we are expecting around 1.4mil m^3 of cut and together with the fill, looks like 1.9mil m^3 instead of 2.5mil m^3 of earthwork moved around the site (details can be found in Table 11). This still excludes the requirements for the large pads expected in an employment area like this.

We note that the below cut and fill volumes use the same design assumptions outlined for the Exhibited Solution to maintain a consistent approach to how the west PSP area would realistically be developed with each drainage solution.

Table 11: Cut and fill volume summaries

	Volume (m^3)
Total Cut	1,392,063
Total Fill	589,945
Balance	**802,117**

Source: Marshal

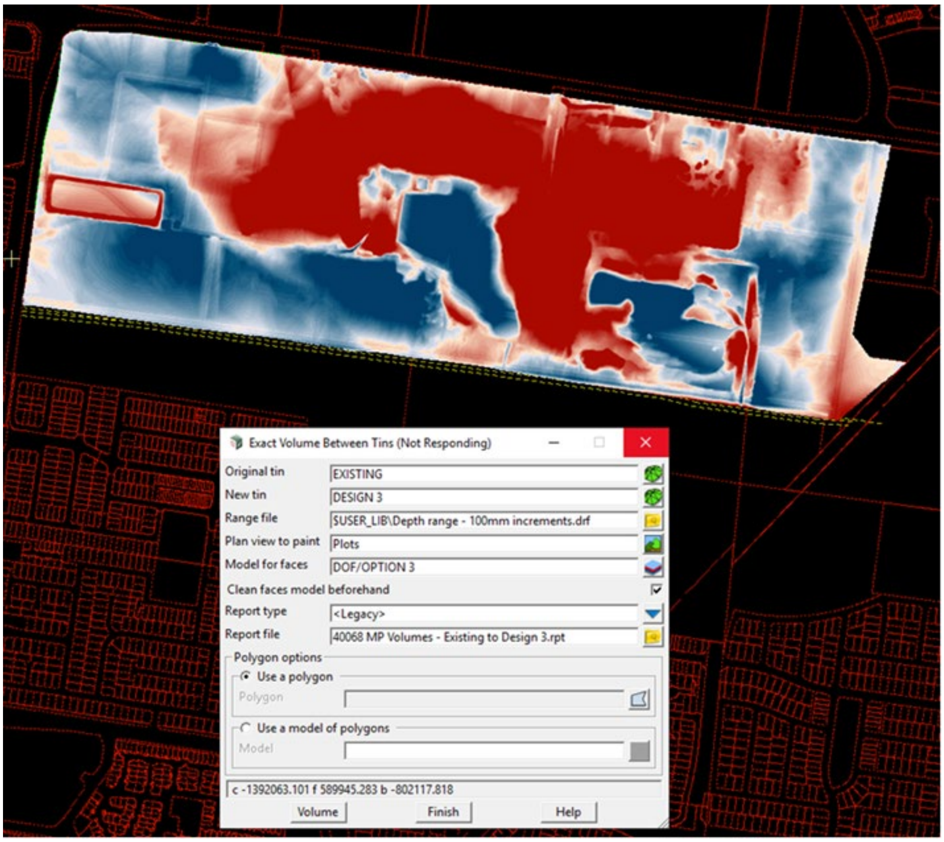


Figure 38: Extent of cut (red) and fill (blue)

Source: Marshal (September 2024)

Another benefit of putting the flows into a pipe is the removal of Swale F as shown in Figure 39. Here we have shown the probable location of the 1% pipe within the road reserve. Depending on the future location of the road, this could unlock more land for development.

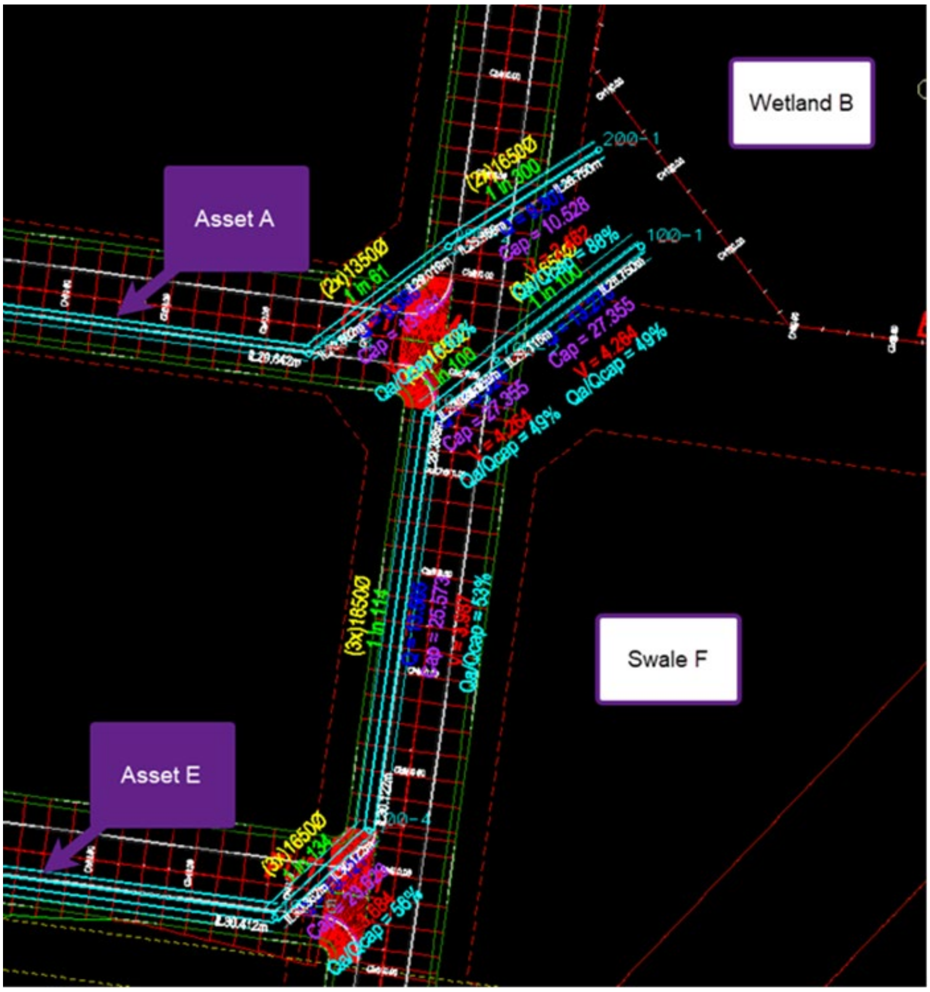


Figure 39: 1% pipe outlet arrangement (no swale)

Source: Marshal

5.4 Summary

This scenario is a more constructable solution that tries to respond to the actual topography of the area. Specifically:

- The overland flow path is removed from above the east west pipe alleviating a large unmanageable road at depth against the VDP cable easement.
- Only one more pipe is required to upgrade the Exhibited Solution to the Proposed Solution.
- Excessive earthworks on the entire PSP area are reduced, and minimal retaining walls are required along the VDP cable easement.
- Placing the 1% AEP flow within the pipe provides a greater overflow capacity over the VDP cable if needed in the longer term.
- Key infrastructure is needed at the upstream end of the pipe to transfer 1% flows into the pipe (upgraded pipe network or a diversion basin).
- This removes the need for a swale at the eastern end of the pipe and provides more developable land to the PSP.
- The proposed Park LP-02 no longer clashes with the overland flow path and could be integrated back into the landscape design

Recommendation No. 4.

Update the DSS for Pipe E to be a 1% pipe diverting flows to the east and around the VDP Cable. A diversion structure or basin will be required to appropriately managed flows into the pipe.

Ideal Solution

6 Site Analysis

6.1 Development Plan context

The ideal drainage scheme layout, as adapted from the VPA exhibited solution can be seen below in Figure 40 and looks to work with the topography instead of fighting it. By allowing the entire western catchment to go over the VDP cable in the west we avoid the unnecessary need for 1% pipes or deep overland flow paths that bring in risk.

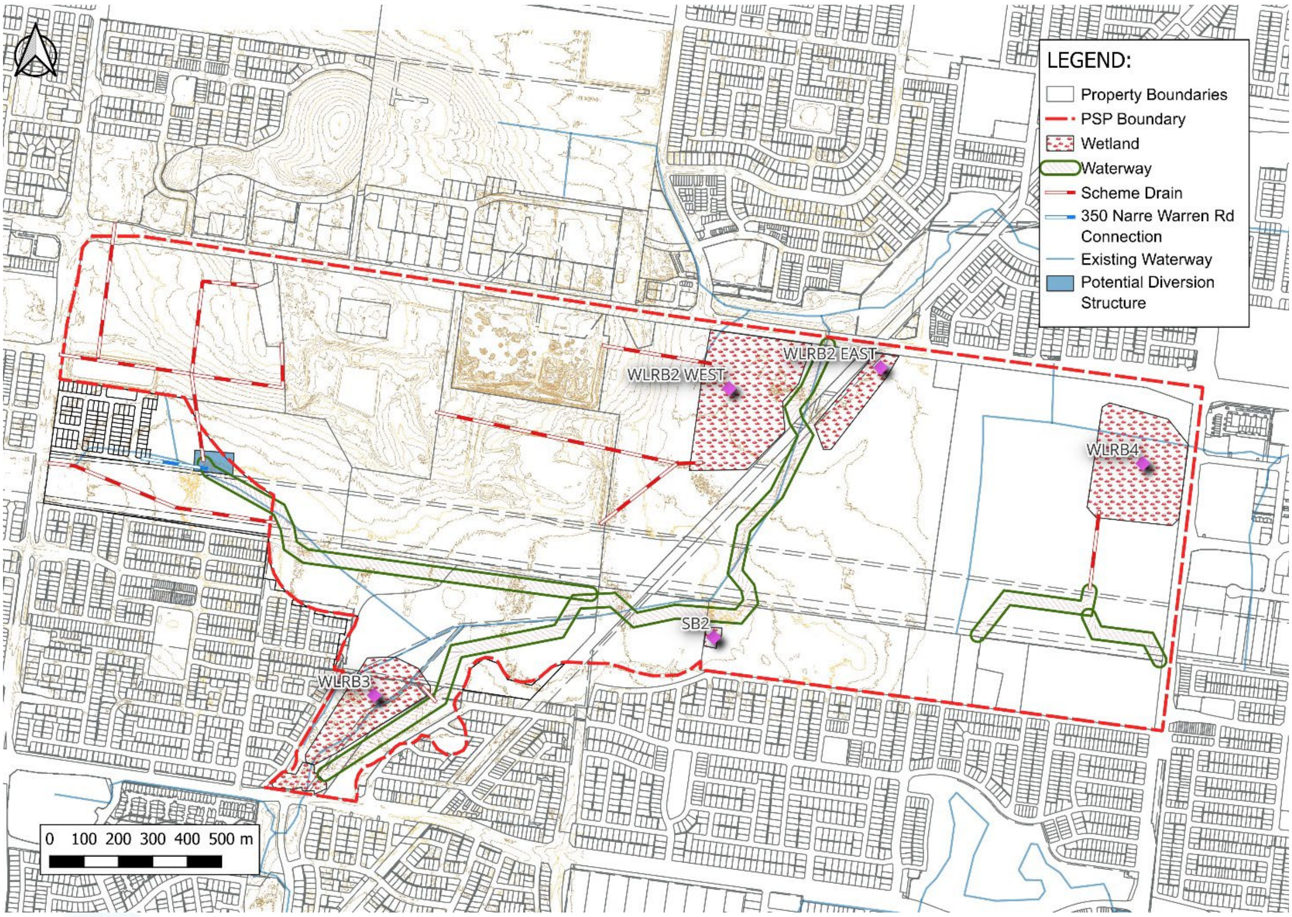


Figure 40: Proposed Drainage Scheme (Ideal Scenario)

Source: Water Studio (GIS)

As outlined further in the costings section later in this report, not only does this Ideal Solution by following existing contours and existing flow paths minimise public risk during large storm events, it also saves the ICP and DSS substantial cost and aids the economic viability of the PSP.

This ideal solution was discussed directly with VPA, DEECA and Melbourne Water on 23rd September 2024.

During this meeting it was admitted by Melbourne Water / DEECA that an application to AquaSure is required for any changes to the existing western crossing regardless of what flow over the cable was identified, and a negotiation with Aquasure will be required for the current Exhibited Solution regardless. With that in mind, we ask VPA / MW that instead of requesting an upgraded overflow crossing for current existing flows, they request permission to construct an upgraded crossing for the fully developed flows. We appreciate that DEECA do not wish to risk the relationship between them and AquaSure when there is an alternative. However, we strongly urge the department to consider the impact of that decision on the quality of the solution and result for the community as a result. We can engineer the required security into the design to alleviate most of the concerns and risks. The result is a lower risk, more manageable solution for everyone. We are aware that this is a PSP of State significance triggering the need to consider how the area is developed.

We note that there have been recently two crossing constructed over this VDP cable immediately to the west of our site, as part of the Narre-Warren Cranbourne Road upgrade works. See Figure 41 below showing the construction of the crossings.

Figure 41: VDP Cable Crossing

Source: Nearmap (downloaded 8.10.2024 – image date 15.02.2024)

We believe this demonstrates that there are engineering solutions available to cross the VDP cable that are acceptable to DEECA / Aquasure. We note and acknowledge that the Casey Fields Blvd crossing is a high-priority crossing for this PSP that will require significant negotiation with Aquasure, and that DEECA want to focus on getting this top-priority crossing approved by Aquasure.

However, we contend that the upgrade of the existing VDP cable drainage crossing in the west is also high priority, and will significantly impact the viability to deliver the entire west area of this PSP.

Further consideration is needed to a full flow crossing in the west.

Cost Comparison

The underlying focus of our submission is the constructability and resulting cost to develop the area. For simplicity we have broken these down into the Exhibited, Proposed and Ideal solutions presented.

7 Exhibited Solution Costs

As outlined earlier in this report, the Exhibited solution requires significant earthworks across the PSP area to facilitate the overland flow path for the west catchment over the pipe (north of the VDP Cable). The following table outlines the various items and their probable (conservative) costs.

Please note the below assumptions used in the below high-level estimate:

- Assumes $18/cu.m for cut and $10/cu.m for fill.
- Up to 5.0m of cut against the VDP cable easement – so excessive retaining walls will be required. We have assumed 1.1km of retaining wall along the easement boundary only at a conservative cost of $2,500/m for retaining wall.
- Pipe upsizing within the road reserve will be required, as the 22m wide industrial access road won't be able to cater for the gap flow. As such, $1,000/m for the 1.5km length of overland flow path has been allocated for pipe upsizing below.

CROSKELL PSP - WEST CATCHMENT - COSTING COMPARISON				
Option	**Description**	**Fill (cu.m)**	**Cut (cu.m)**	**Cost**
Scenario 1/2	*South road as deep as possible to minimise Moremac fill*	295,924	2,275,446	
	Earthworks Cost	$2,959,240	$40,958,028	$43,917,268
	Excessive Retaining Wall Costs (against easement boundary)		$2,750,000	$2,750,000
	Drainage pipe scope (Pipe E only)	over 8m depth	under 8m depth	
	2x 1650 pipes	0	1500	
	Rate	$ 6,000.00	$ 4,000.00	
	Drainage pipe cost	$ -	$ 6,000,000	$ 6,000,000
	Pipe Upsizing to accommodate excessive gap flow		$ 1,500,000	$1,500,000
Scenario 1/2	**TOTAL COST**			**$ 54,167,268**

Figure 42: Exhibited Solution Costs

Source: Marshal

We note that the above costs are a conservative 'base' cost for earthworks grading to facilitate road construction in the west catchment of the PSP, and to deliver the drainage outcome required by the Exhibited Solution.

8 Proposed Solution (1% Pipe) Costs

As outlined earlier in our report, our Proposed Solution removes the overland flow path over the Pipe E, which then means that we can grade most of the internal PSP roads closer to the existing contours. In this exercise we note that our earthworks costs drop dramatically saving the PSP at least $13 million.

Things to note:

- Assumes $18/cu.m for cut and $10/cu.m for fill.
- 1% pipe option only adds one more DN1650 pipe, although it will be much deeper when compared to Scenario 1/2 with an overland flow path directly above it. This has been reflected in the split of the scope between pipes that are under 8m depth (900m length), and pipes over 8m in depth that go through the existing hill (600m length). The extra-depth pipes have attracted a higher construction cost.
- No retaining wall costs are included, as they are not excessive, and will be private development costs.

CROSKELL PSP - WEST CATCHMENT - COSTING COMPARISON				
Option	**Description**	**Fill (cu.m)**	**Cut (cu.m)**	**Cost**
Scenario 1/2	**TOTAL COST**			**$ 54,167,268**
Scenario 3	*Q100 pipe through hill with roads close to ex. contours*	589,945	1,392,063	
	Cost	$5,899,450	$25,057,134	$30,956,584
	Drainage pipe scope (Pipe E only)	over 8m depth	under 8m depth	
	3x 1650 pipes	600	900	
	Rate	$ 8,000.00	$ 6,000.00	
	Drainage pipe cost	$ 4,800,000	$ 5,400,000	$ 10,200,000
	TOTAL COST			**$ 41,156,584**
			Net saving to Scheme/PSP	**-$ 13,010,684**

Figure 43: Proposed Solution Costs

Source: Marshal

The above estimate highlights that there is significant net saving of cost to the overall PSP by adopting our Proposed Solution. When considering that earthworks need to happen regardless within the PSP to facilitate development, we have created this comparison of road gradings and earthworks within the same footprint of the PSP to ensure a fair like-for-like comparison is maintained. We believe this costing demonstrates the adverse impact that occurs when constructing an overland flow path through the hill that the Exhibited Solution requires. Adopting the Proposed Solution and saving a conservative $13 million in construction costs means that the PSP better achieves its aims to be economical. It will increase the feasibility of future projects, meaning a higher likelihood of projects being greenlit and commencing.

We would also like to highlight what would occur if we were to consider removal of spoil off-site. Due to the excessive cut the PSP requires, the balance of Cut over the Fill left-over would need to be removed from site. Applying a rate of $15/cu.m of excess cut to the 1.98 million cu.m in the Exhibited Solution increases that cost by $29 million. Applying the same rate of $15/cu.m of excess cut to the 800,000 cu.m in the Proposed Solution increases that cost by $12 million.

By considering the removal of spoil from site, we can demonstrate a more accurate estimate increases the $13 million saving into a $30 million+ saving. This serves to further highlight the utility of the Proposed Solution.

CROSKELL PSP - WEST CATCHMENT - COSTING COMPARISON				
Option	**Description**	**Fill (cu.m)**	**Cut (cu.m)**	**Cost**
Scenario 1/2	TOTAL COST			**$ 83,860,098**
Scenario 3	*Q100 pipe through hill with roads close to ex. contours*	589,945	1,392,063	
	Cost	$5,899,450	$25,057,134	$30,956,584
	Removal of spoil		$12,031,770	$12,031,770
	Drainage pipe scope (Pipe E only)	over 8m depth	under 8m depth	
	3x 1650 pipes	600	900	
	Rate	$ 8,000.00	$ 6,000.00	
	Drainage pipe cost	$ 4,800,000	$ 5,400,000	$ 10,200,000
	TOTAL COST			**$ 53,188,354**
			Net saving to Scheme/PSP	-$ 30,671,744

Figure 44: Proposed Solution Costs – including removal of spoil off-site

9 Ideal Solution Costs

As outlined earlier in our report, our Ideal Solution removes the east west pipe all together, instead formalising an upgraded crossing over the VDP pipe and upgrading the downstream waterway. This option could save the PSP cost up to $19 million (that's a 35% saving in a State Significant project).

Things to note:

- Assumes $18/cu.m for cut and $10/cu.m for fill.
- No 1% pipe to be constructed.
- Diversion Structure required to congregate flows into the crossing
- All flow goes south over ex. VDP cable crossing in a formalized crossing
- Allowance to bore a low-flow pipe under the VDP cable and to formalise the VDP crossing with floating-pier concrete apron, similar to adjacent crossings in the area.
- With reference to the Exhibited Concept, this costing has upgraded of 'G' channel to a type 'B' channel. We have modelled a net additional 7,000 cu.m of cut required for this option.

CROSKELL PSP - WEST CATCHMENT - COSTING COMPARISON				
Option	**Description**	**Fill (cu.m)**	**Cut (cu.m)**	**Cost**
Scenario 1/2	**TOTAL COST**			**$ 54,167,268**
Ideal Option	*West VDP cable overland crossing, no east Pipe E*	589,945	1,392,063	
	PSP Earthworks Cost	$5,899,450	$25,057,134	$30,956,584
	Diversion Structure		$250,000	$250,000
	Bored low flow pipe		$300,000	$300,000
	Formalising ex. VDP cable crossing		$2,000,000	$2,000,000
	Upgraded G channel (9.44 m^3/s)		7,000.00	
	Cost		$1,171,000	$1,171,000
	TOTAL COST			**$ 34,677,584**
			Net saving to Scheme/PSP	**-$ 19,489,684**

Figure 45: Ideal Solution Costs

Source: Marshal

By considering the removal of spoil from site, we can demonstrate a more accurate estimate increases the $19 million saving into a $37 million+ saving. See below Figure 46.

CROSKELL PSP - WEST CATCHMENT - COSTING COMPARISON				
Option	Description	Fill (cu.m)	Cut (cu.m)	Cost
Scenario 1/2	TOTAL COST			$ 83,860,098
Ideal Option	*West VDP cable overland crossing, no east Pipe E*	589,945	1,392,063	
	PSP Earthworks Cost	$5,899,450	$25,057,134	$30,956,584
	Removal of spoil		$12,031,770	$12,031,770
	Diversion Structure		$250,000	$250,000
	Bored low flow pipe		$300,000	$300,000
	Formalising ex. VDP cable crossing		$2,000,000	$2,000,000
	Upgraded G channel (9.44 m^3/s)		7,000.00	
	Cost		$1,171,000	$1,171,000
	TOTAL COST			$ 46,709,354
			Net saving to Scheme/PSP	-$ 37,150,744

Figure 46: Ideal Solution Costs – including removal of spoil off-site

Source: Marshal

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Discussion

10 Design Considerations

10.1 Drainage Scheme 1% pipeline

The cost of the above ground overland flow path in the exhibited solution is really cost prohibitive and essentially forces us to look for an alternative arrangement. Given the many constraints of the site, the 1% pipeline is the most practical solution. The inclusion of a diversion basin or structure enables the capture of the overland flows and appropriately diverts it into the pipe in a maintainable format. This solution also creates an opportunity to divert flows over the desalination cable if warranted. This solution provides a controlled environment to manage flows greater than 1% or even flows below the 1% should pipes be blocked at any stage.

10.2 Integrated Design

The Melbourne Water Drainage scheme is just one piece of the drainage solution. In order to meet the broad stormater obligations of the PSP, an integrated network of assets that responds to the many policies, guidelines and documents are needed. Ie. the drainage scheme can't be developed in isolation to the integrated water management practices expected in this area. For example, the dedicated spongy areas outlined in Plan 7 should form part of the wetland areas but the land allocation in the scheme doesn't factor them in. The PSP wetlands should be used to irrigate the local sports reserves however there is no clear plan to establish and share the cost across the development area. Individual developments can mandate tanks and utilise passively irrigated trees in the street scapes however a typical cross-section that includes passively irrigated street trees would add value to PSP documents and establish a local character. Consideration should also be given the value of trees in an employment zone where adequately passively watered trees could vastly improve the microclimatic conditions for large impervious expected in areas like this. The removal of a footpath on one side of streets to improve the health of a passively irrigated tree should be considered and included in the typical road profile.

Integrated water aspirations are a necessary part of development but they should not be left up to the individual developer to manage within their parcel. We don't want to progress unaware to permit where we have lofty integrated management obligations to fit within an area that isn't practical and not maintainable. The reduction in flows from parcels with these initiatives may also inhibit the function of downstream wetlands based on reduced flows. We have an opportunity here to break down the silos of responsibilities and look for ways to share asset costs, with assets placed in reasonable locations particularly when we have so much encumbered space that could be used for this purpose.

10.3 Water Quality

We have not discussed water quality in detail throughout this submission as the location and size of the water quality assets, like wetlands, should sit with those responsible for maintaining them. They should be located to treat multiple parcels at a size that suits both Council and Melbourne Water.

10.4 Additional drainage investigation areas

In July, 2024 the VPA issued a plan outlining a further drainage investigation area. This can be seen in Figure 47 and includes a zone extending up into 1450 Thompsons Rd. While we don't object in principle to the inclusion of a retarding basin or water quality treatment in this area, the topography doesn't lend itself to water ponding up that high into the hill. There is a 7m level difference from the south boundary of the investigation area to the southern boundary of 1450 Thompsons Rd which would render construction of a drainage facility in this area unfeasible and impractical to construct. This asset, if required, needs to reflect the topography of the area and not any specific boundaries.

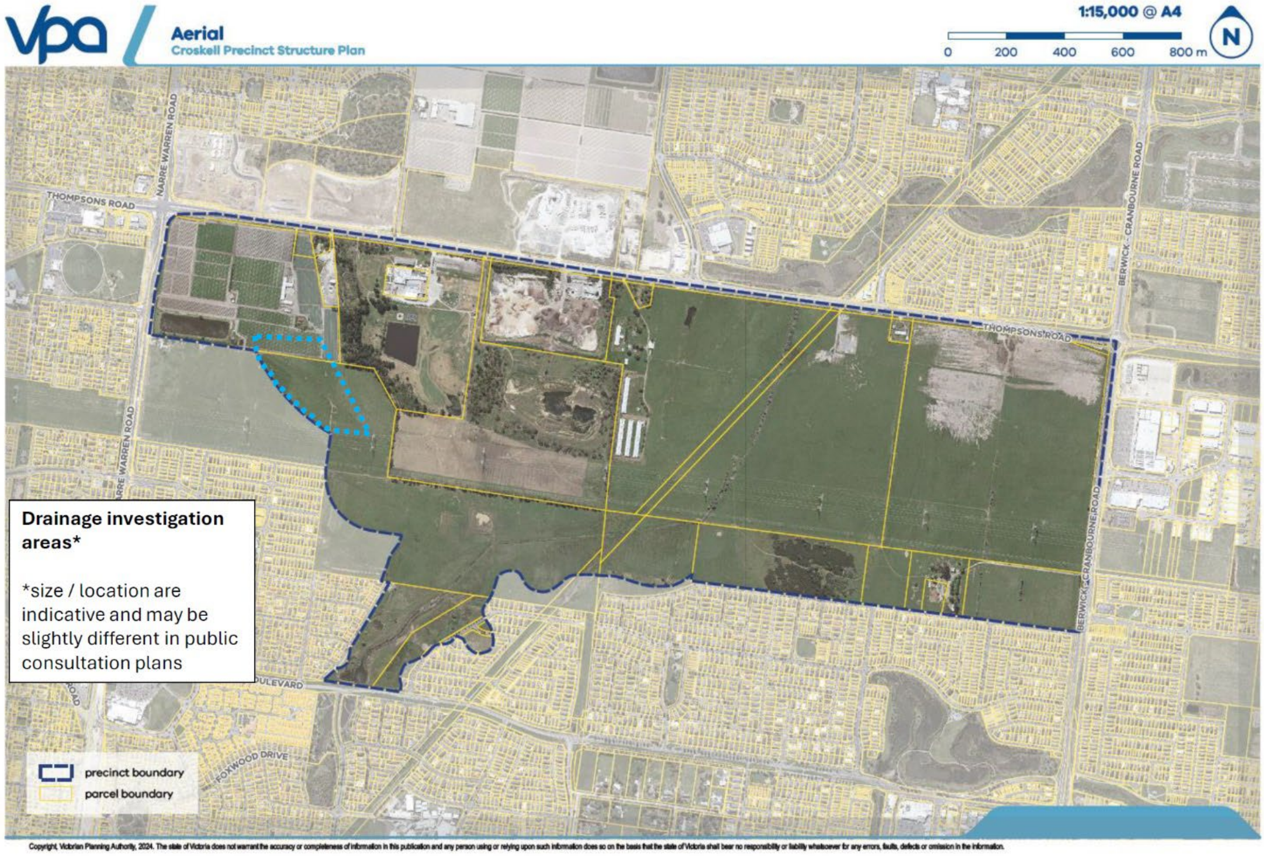

Figure 47: Additional Drainage Investigation Area

Source: VPA (July 2024)

11 Interim Solutions

It is imperative that interim drainage solutions for both stormwater retardation and treatment be facilitated by this PSP. The developer has made it very clear that any significant delays in construction that are a result of downstream complexities would render this area undevelopable in the short term. The idea of abandoning this site is a very real prospect.

We would like the opportunity to provide thorough and practical solutions to manage flows within our site as the broader area develops. Whilst the staged drainage expectations listed in the PSP are important and would of course be the preferred method of development, some flexibility in their application would be essential.

The developer of 1450 Thompsons Rd, is a gateway property to this employment zone, and it would be a real disappointment if they had to wait for the entire downstream flow path be constructed to develop when practical interim solutions could be agreed upon.

Recommendation No.5

We submit that the wording of PSP item G36 is amended to provide assurance to Applicants that interim drainage solutions will be considered and reasonably approved by the Responsible Authority.

Recommendations and Conclusions

12 Recommendations

Throughout this document we have outlined a variety of recommendations that should be integrated into the updated drainage scheme and associated PSP. These are listed below for ease:

Recommendation No.1

The PSP should look for opportunities for shared stormwater harvesting, infiltration sponges and passive irrigation. In Plan 7 (as shown in Figure 4 earlier in this document) several initiatives have been outlined that will work towards meeting these targets. There is no confirmation that the ideas presented in Plan 7 meet the requirements set out in this publication.

Recommendation No. 2

The current condition at the time the PSP is gazetted should be applied in the pre-developed model which includes an upstream catchment (north of Thompsons Rd) being developed with at least a 0.70 fraction impervious.

Recommendation No.3

When comparing flows against the DRAINS model and a simple Rational check, a conservative approach would be to take 4.05m3/s as the appropriate flowrate to use in this area. This assumes a correct fraction impervious representing the current developed context.

Recommendation No. 4.

Update the DSS for Pipe E to be a 1% pipe diverting flows to the east and around the VDP Cable. A diversion structure or basin will be required to appropriately managed flows into the pipe.

Recommendation No.5

We submit that the wording of PSP item G36 is amended to provide assurance to Applicants that interim drainage solutions will be considered and reasonably approved.

13 Conclusions

While we recommend the "Ideal Solution" is adopted by the PSP with all flows conveyed across the VDP Cable, we appreciate that DEECA has no appetite to convince AquaSure that a formal crossing would be the best solution for the entire PSP.

With that in mind we ask that the proposed 1% pipe solution be seriously considered in the next iteration of the Drainage Scheme and PSP documentation.

The 1% pipe solution:

- Generates a better employment zone product with greater access (ie less retaining walls)
- Is cheaper to construct then an overland flow path through a hill alongside high value infrastructure (like the VDP Cable)
- Can better manage the risk of blockage with more allowance for overland flow path over the VDP cable
- Will need a diversion structure or basin to appropriately manage flows into the pipe.

Water Quality should be managed across the PSP area in locations that suit the topography and relevant authority requirements.

We also recommend the design, costing and integration of integrated water management infrastructure into the DCP as shared cost items. This will prevent the generation of independent and isolated assets that Council would need to maintain.

Interim solutions are an essential part of development and need to be available for negotiation. Full downstream construction of assets would certainly impose impossible barriers to development.

Glossary

AEP - Annual Exceedance Probability

ARI – Annual Recurrence Interval

BoM - Bureau of Meteorology

BPEM – Best Practice Environmental Management

CHMP – Cultural Heritage Management Plan

CMA – Catchment Management Authority

DEECA – Department of Energy, Environment and Climate Action

DELWP - Department for Environment, Land Water and Planning

DTP – Department of Transport and Planning

DV - Depth Velocity

EDCM – Engineering Design and Construction Manual

EPA - Environment Protection Authority

GED - General Environmental Duty

IDM - Infrastructure Design Manual

IWM – Integrated Water Management (IWMP – Plan, IWMS – Strategy)

LSIO - Land Subject to Inundation Overlay

MW – Melbourne Water

NCCMA - North Central Catchment Management Authority

OMR – Outer Melbourne Ring Road

OSD – On Site Detention

PAO – Public Acquisition Overlay

PSP – Precinct Structure Plan

SWM – Storm Water Management (SWMP – Plan, SWMS – Strategy)

VPA – Victorian Planning Authority

WSC – Water Sensitive Cities

WSUD - Water Sensitive Urban Design

Appendices

Appendix C: Rainfall depths

C.1 Rainfall Depths mm

Copyright Commonwealth of Australia 2016 Bureau of Meteorology (ABN 92 637 533 532)								
IFD Design Rainfall Depth (mm)								
Issued:	7-Apr-22							
Location Label:								
Requestec	Latitude	-38.0816	Longitude	145.3303				
Nearest gr	Latitude	38.0875 (S	Longitude	145.3375 (E)				
		Annual Exceedance Probability (AEP)						
Duration	Duration ir	63.20%	50%	20%	10%	5%	2%	1%
1 min	1	1.48	1.69	2.39	2.89	3.4	4.11	4.69
2 min	2	2.58	2.92	4.01	4.79	5.54	6.4	7.05
3 min	3	3.46	3.92	5.41	6.48	7.51	8.76	9.72
4 min	4	4.19	4.76	6.62	7.94	9.26	10.9	12.2
5 min	5	4.81	5.48	7.67	9.23	10.8	12.9	14.5
10 min	10	7.05	8.09	11.5	13.9	16.5	20.1	23
15 min	15	8.58	9.85	14	17.1	20.2	24.7	28.4
20 min	20	9.76	11.2	15.9	19.3	22.9	27.9	32.1
25 min	25	10.7	12.3	17.4	21.2	25	30.4	34.8
30 min	30	11.6	13.2	18.7	22.7	26.7	32.4	37
45 min	45	13.6	15.5	21.6	26.1	30.6	36.7	41.5
1 hour	60	15.2	17.2	23.8	28.6	33.3	39.7	44.7
1.5 hour	90	17.7	19.9	27.2	32.3	37.4	44.1	49.3
2 hour	120	19.7	22.1	29.7	35.1	40.5	47.5	52.9
3 hour	180	22.8	25.4	33.8	39.6	45.4	53	58.9
4.5 hour	270	26.3	29.2	38.5	44.8	51.2	59.8	66.5
6 hour	360	29	32.2	42.3	49.1	56	65.6	73.1
9 hour	540	33.1	36.8	48.2	56.1	64	75.5	84.6
12 hour	720	36.3	40.3	53	61.8	70.6	83.9	94.5
18 hour	1080	40.9	45.5	60.4	70.8	81.5	97.6	111
24 hour	1440	44.2	49.3	66	78	90.3	109	124
30 hour	1800	46.9	52.3	70.5	83.8	97.5	118	134
36 hour	2160	49	54.8	74.3	88.7	104	125	143
48 hour	2880	52.5	58.7	80.2	96.4	113	137	156
72 hour	4320	57.5	64.3	88.1	106	126	152	172
96 hour	5760	61.4	68.6	93.4	112	133	159	181
120 hour	7200	64.9	72.1	97.1	116	137	164	185
144 hour	8640	68.1	75.3	99.8	118	139	165	187
168 hour	10080	71.2	78.4	102	119	139	166	188

Thank you

Should you have any questions or require further information we'd be happy to discuss this project with you at any time. Please reach out via the contact information below.

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