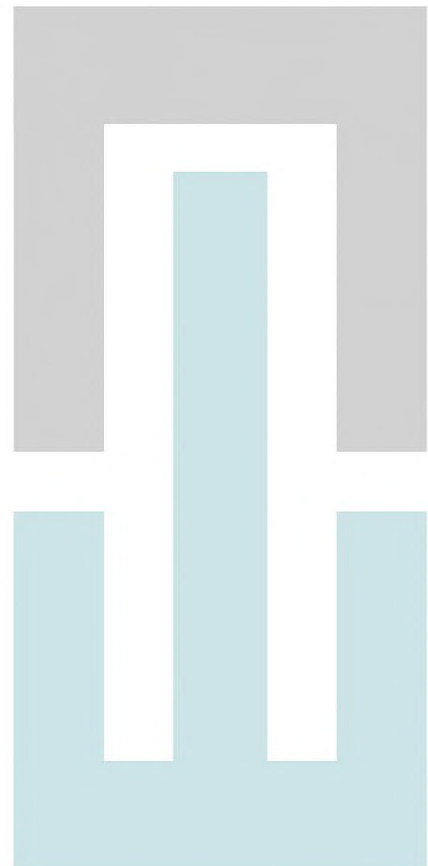


Conceptual Stormwater Management Report

836-842 Waterworks
Road, The Gap

Client: The Trustee for The DP
Gap Holdings Trust
Date: 1/05/2026
Revision: 02



Approval Status

Rev #	Author	RPEQ Reviewer	Signature	RPEQ No.	Date
01	A.lervese	D.Curran			
02	A.lervese	D.Curran		26353	1/05/2026

Revision History

Rev #	Status	Distributed To	Date
01	Draft	The Trustee for The DP Gap Holdings Trust	15/04/2026
02	Approval	The Trustee for The DP Gap Holdings Trust	1/05/2026

This report has been prepared for the client in accordance with the terms and conditions of appointment for the proposed development. Create Engineers Pty Ltd (ABN 52 691 211 453) cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

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1.0. Introduction

1.1. Background and Scope

Create Engineers has been commissioned by The Trustee for The DP Gap Holdings Trust to prepare a Conceptual Stormwater Management Plan for the proposed development at 836-842 Waterworks Road, The Gap. This report will support the development application lodged for the development.

This report aims to address the stormwater management (quality and quantity treatment systems), during the construction and operational phase of the proposed development. It also demonstrates that the stormwater runoff is conveyed to a Lawful Point of Discharge (LPOD) and the post-development stormwater runoff does not adversely affect the ecological values of downstream networks.

This report has been prepared in accordance with Queensland Urban Drainage Manual Fourth Edition 2016 - Provisional (QUDM, 2016), the State Planning Policy (SPP, 2017), IEAust Australian Runoff Quality: Guide to Water Sensitive Urban Design and Brisbane City Council's City Plan (2014).

Throughout this report the proposed development area is referred to as the 'site' which is Lot 1-4 on RP91310 and has a total site area of 5,394m².

2.0. Site Information

2.1. Location

The site is located at 836-842 Waterworks Road, The Gap and which was bounded Waterworks Road to the north, residential properties to the west, Council parkland to the south and a petrol station to the west. The total site area is 5,394m² and is located within the District Centre zone under Brisbane City Council's mapped zones. The site has been summarised in Table 1 and located as per Figure 1.

Table 1: Site Description

Client	Street Address	Lot and Property Description
The Trustee for The DP Gap Holdings Trust	836-842 Waterworks Road, The Gap	Lot 1-4 on RP91310



Figure 1 – Proposed Site Location (Source: Queensland Globe, Accessed April 2026)

2.2. Site Topography

The subject site currently consists of a two-storey residential dwelling. Driveway access is gained from the north from an existing crossover made to Waterworks Road.

The existing site generally falls towards the east with spot levels on-site ranging from RL 42.20m to 36.70m.

For further information refer to the site survey provided by Project Urban, *Contour & Detail Survey* (Ref: 25348-01-CD), included within Appendix A.

3.0. Proposed Development

It is proposed to remove the existing dwelling and access driveway and construct the proposed development which consists of a storage facility and 17 storages units. It is proposed to have a shared access driveway which runs through the middle of the property, with a minor section of land dedicated back to Council along Barkala Street, as shown below in Figure 2 below.

For further information refer to the site layout plan provided by McDougall Roberts Architecture and Consulting (MRAC), *Ground Floor Plan* (Ref: 2520-PP_DA2.01), included within Appendix B.

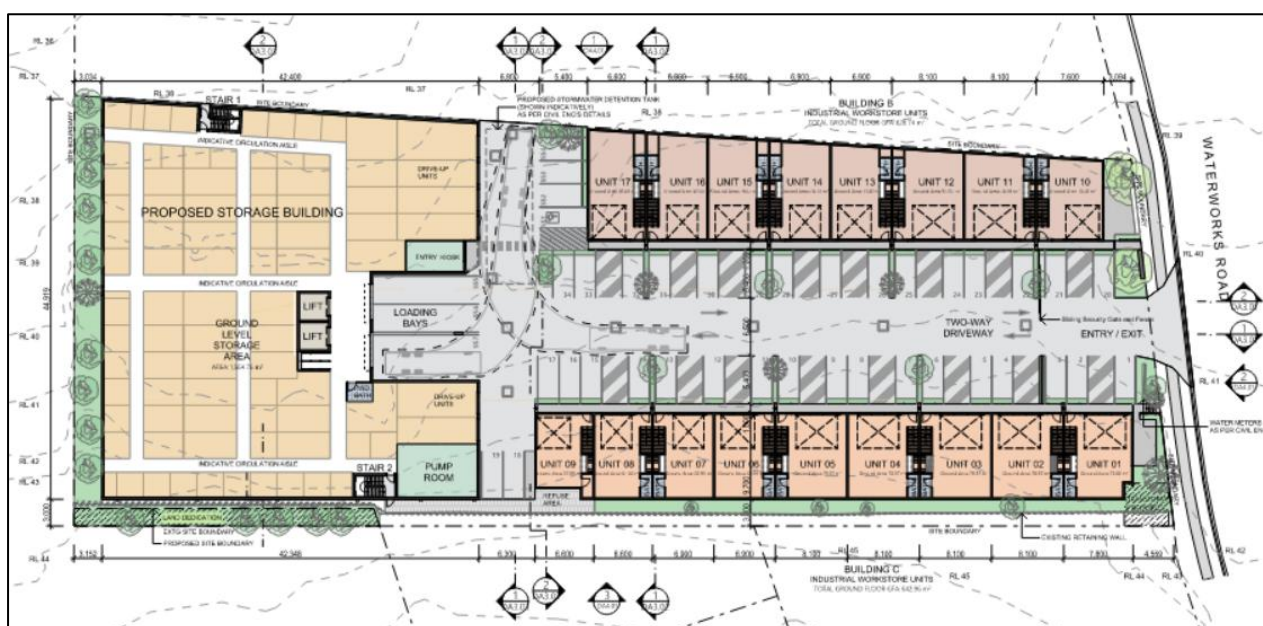


Figure 2 Error! No text of specified style in document.– Proposed Development Layout (Source: MRAC)

4.0. Stormwater Quantity

This section outlines the key elements of the stormwater quantity management strategy for the site and an overview of the existing stormwater catchments currently influencing the site.

This will be addressed under the following sections:

1. Pre-Development Stormwater Catchments
2. Post-Development Stormwater Catchments
3. Stormwater Runoff Analysis
4. Proposed Stormwater Strategy
5. Stormwater Detention Modelling - DRAINS

The hydrologic objectives have been set in accordance with QUDM (2016) and BCC City Plan (2014), including but not limited to:

- The proposed development shall ensure that all stormwater drainage is directed to a lawful point of discharge in accordance with QUDM Section 3.9 (2016).
- No adverse impact on adjoining or downstream properties.

4.1. Pre-Development Stormwater Catchments

4.1.1. Lawful Point of Discharge

The pre-development scenario is considered to be when the subject site was wholly in use, being pre-on-site demolition/ basement excavation works in approximately 2008 (which was part of a previous DA approval – Council Reference: A001645460), refer to image shown in Figure 3 below. An analysis of this pre-developed catchment indicates that the complete site can be considered within a single catchment, with a fraction impervious of 60%. These assumptions are aligned with the initial DA approval for the site (Council Reference: A001645460) with the approved Stormwater Quantity & Quality Assessment Report prepared by Storm Water Consulting being included within Appendix E.



Figure 3 – Pre-Development Catchment Plan (Source: Queensland Globe, Image Dated April 2007)

Stormwater captured on the existing roof is conveyed via downpipes and discharged directly to ground. Any stormwater on ground surfaces is conveyed as sheet flow through the subject site and ultimately discharges across the southern boundary into Alan Willing Place Park (Council's Parkland).

The existing Lawful Point of Discharge (LPOD) for the subject site, is the existing creek/waterway within Alan Willing Place Park.

4.1.2. Pre-Development Catchment Runoff

The pre-development site has been investigated as a singular internal catchment and has a contributing area of 5,394m². The total fraction impervious of the existing catchment is 60%.

The pre-development peak flows for the site are shown in Table 2.

Table 2: Pre-Development Peak Flows – Rational Method

Parameters	Units	Annual Exceedance Probability (AEP)					
		39%	18%	10%	5%	2%	1%
Area of Catchment	ha	0.5394					
Time of Concentration	min	12.0					
Runoff Coefficient		0.66	0.74	0.78	0.82	0.90	0.94
Rainfall Intensity	mm/hr	106.4	132.7	152.8	174.7	203.1	224.4
Peak Flow Rate	L/s	106	147	179	215	273	315

4.2. Post-Development Stormwater Catchments

4.2.1. Lawful Point of Discharge

Stormwater collected from the roof areas (up to the 1% AEP event) shall be conveyed via the hydraulic roof water system to the proposed internal stormwater network within the driveway, in which the captured flows will discharge into the stormwater management tank. The entirety of the site's stormwater flows (minor and major events) will wholly be conveyed via the stormwater network under the proposed storage facility and discharge across the rear property boundary.

As per the existing DA approval for the site (Council Reference: A006345436), the Lawful Point of Discharge (LPOD) for the subject site will ultimately be the existing creek/waterway within Alan Willing Place Park. For further details on Council's previous acceptance of this LPOD location, refer to Council's email correspondence which is included within Appendix F.

4.2.2. Post-Development Catchment Runoff

The post-development site has been investigated as a singular internal catchment and has a contributing area of 5,157m². The land along Barkala Street which is to be dedicated back to Council has been not considered within the post-development flows. The total fraction impervious of the proposed catchment is 90%.

The post-development peak flows for the site are shown in Table 3.

Table 3: Post-Development Peak Flows – Rational Method

Parameters	Units	Annual Exceedance Probability (AEP)					
		39%	18%	10%	5%	2%	1%
Area of Catchment	ha	0.5394					
Time of Concentration	min	6.0					
Runoff Coefficient		0.74	0.83	0.87	0.91	1.00	1.00
Rainfall Intensity	mm/hr	133.0	166.1	191.8	219.8	256.5	284.4
Peak Flow Rate	L/s	146	203	247	297	380	421

4.3. Stormwater Runoff Analysis

The difference between peak flow rates from the pre and post-developed site as per the Rational Method calculations are shown in Table 4.

Table 4: Pre and Post-Developed Peak Flow Rate Comparisons

LPOD 1 – Council Road Reserve							
Annual Exceedance Probability	AEP	39%	18%	10%	5%	2%	1%
Pre-Developed Peak Flow Rate	L/s	106	147	179	215	273	315
Post-Developed Peak Flow Rate	L/s	146	203	247	297	380	421
Change in Peak Flow Rate	L/s	40	56	68	83	107	106

The Rational Method assessment has demonstrated that an increase in peak flow rates discharging to the existing LPOD due to the proposed development. Therefore, On-Site Detention (OSD) will be required to mitigate flows to the pre-development rates.

4.4. Proposed Stormwater Strategy

To mitigate the post development flow rates to those evident in the pre-development case, it is proposed to construct an underground detention tank within the internal driveway. The underground tank will consist of an outlet arrangement that will mitigate flows back to the existing scenario flows. The whole site stormwater will discharge through the tank and be conveyed via a single stormwater pipe under the proposed storage facility. The single stormwater pipe outlet will be sized to convey the complete Q100 stormwater event (including an appropriate blockage factor).

The development is considered to be in compliance with the BCC's Stormwater Code with responses included within Appendix D.

For further details on the general stormwater layout and detention tank arrangement, refer to Create Engineers, Preliminary Services Plan (Ref: CE26010-P040), which is included in Appendix C.

4.5. Stormwater Detention Modelling - DRAINS

DRAINS runoff-routing software was used to estimate the flow rates from the pre and post developed scenarios and to create volumetric hydrographs for the applicable internal catchments. Separate models were developed for each catchment with applicable stormwater management mitigation provisions implemented for each.

The Time of Concentration values calculated in the Rational Method calculations were adopted as applicable within the ILSAX runoff routing method. The 39% and 1% AEP design storm events were analyzed for all standard durations ranging from 5 minutes to 2 hours. The following sections denote the pre and post development peak discharge rates calculated in the DRAINS model as well as the model setup and other detention parameters utilised.

4.5.1. DRAINS Model

The DRAINS model setup for development site has been shown below for both minor and major scenarios.

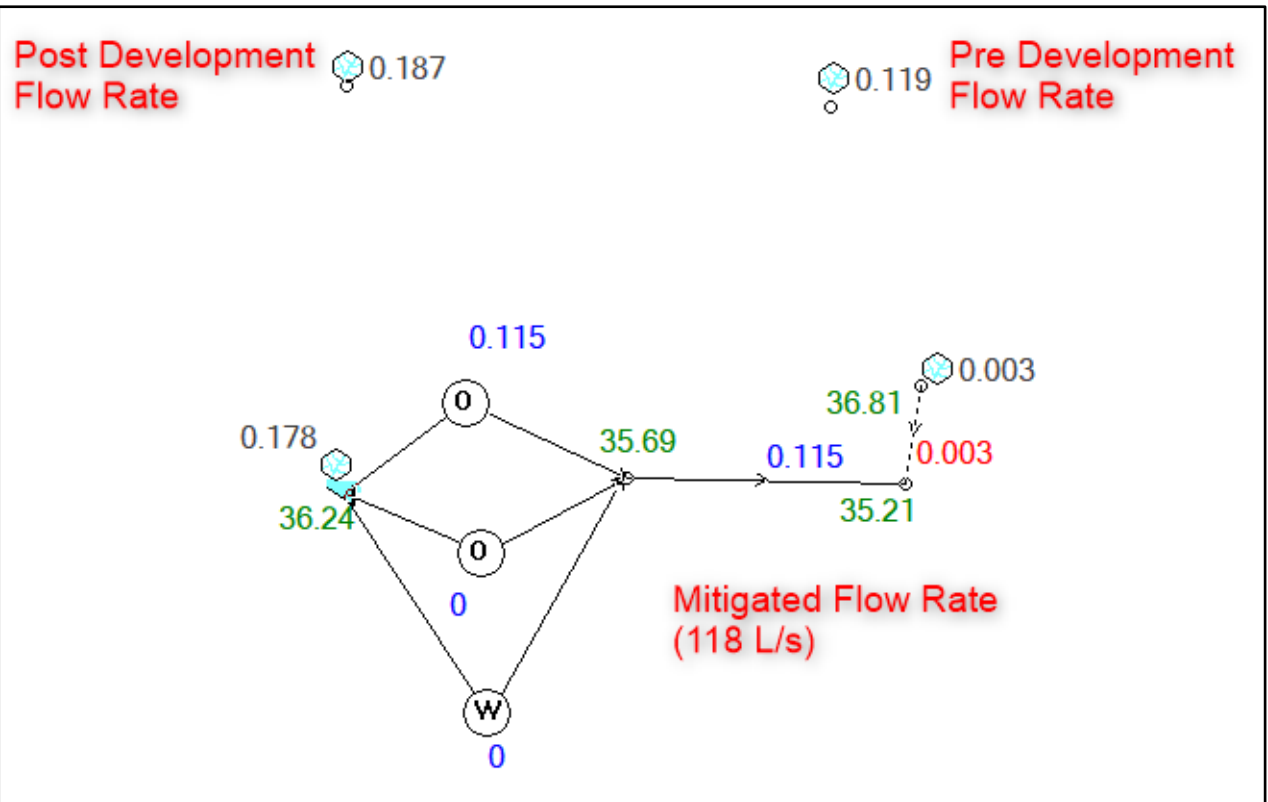


Figure 4 – Development Site Model Setup and Minor (39% AEP) Flow Rates

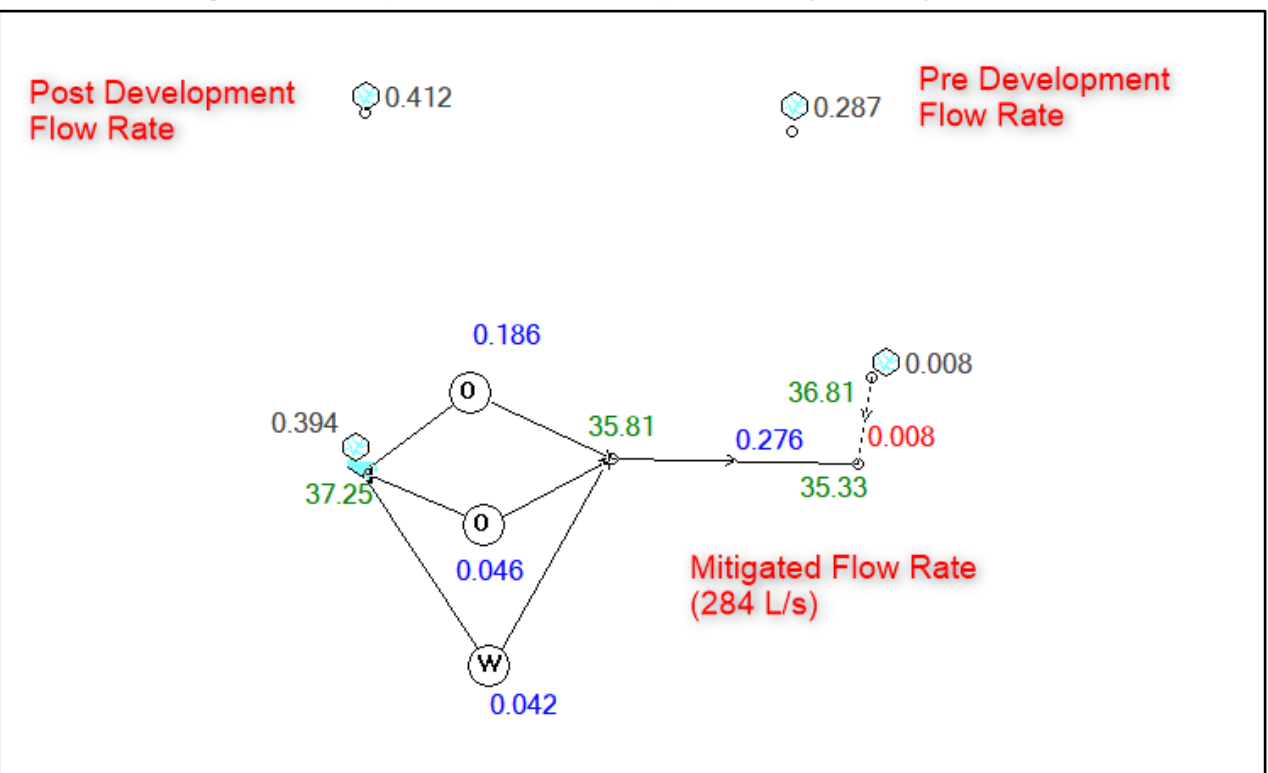


Figure 5 – Development Site Model Setup and Major (1% AEP) Flow Rates

The arrangement utilized for the detention basin within the model to achieve the mitigated flow rates are shown in Table 5 below.

Table 5: Underground Detention Tank Parameters

Tank Surface Area	45m ²
Total Tank Volume	81m ³
Invert Depth (m AHD)	1.80
Invert (m AHD)	35.51
Low Flow Orifice @ Base of Tank	Ø270
Mid Flow Orifice @ 800mm Above Base of Tank	Ø150
High Flow Weir @ 1650mm Above Base of Tank	1m

A comparison of the pre-development and mitigated flow rates based on the above arrangement are shown in Table 6 below.

Table 6: Pre and Post-Developed Peak Flow Rate Comparisons – DRAINS

	AEP	39%	18%	10%	5%	2%	1%
Pre-Developed Peak Flow Rate	L/s	119	155	188	218	255	287
Post-Developed Peak Flow Rate (unmitigated)	L/s	187	235	274	314	370	412
Post-Developed Peak Flow Rate (mitigated)	L/s	118	156	178	200	226	284
Comparison of Pre and Post Peak Flow Rate	L/s	1	-1	10	18	29	3

The results validate that the proposed stormwater quantity strategy mitigate the post-development flows back to the pre-development flows. The minor increase of 1 L/s within the 18% AEP stormwater event is considered to be in the acceptable tolerance range of the DRAINS modelling software capabilities.

5.0. Stormwater Quality

This section outlines the key elements of the stormwater quality objectives during the construction phase and operational phase of the development in accordance with the State Planning Policy (2017).

During the construction phase of the development, disturbances to the existing ground have the potential to significantly increase sediment loads entering downstream drainage systems and watercourses. The operational phase of the development will potentially increase the amount of sediments and nutrients washing from the site.

The following sections describe the construction and operational phase controls and water quality modelling of the proposed treatment train in compliance with Council guidelines.

The operational phase of the management plan focuses on appropriate consideration of Stormwater Quality Improvement Devices and Water Sensitive Urban Design (WSUD) principles to be incorporated into the total water cycle management of the developed site.

5.1. Construction Design Objectives

5.1.1. Pollutants

Throughout the construction phase there was an increased risk that stormwater pollution will occur from site due to construction works disturbing the site and exposing natural soils to direct environmental elements.

Pollutants typically generated throughout the construction phase of this development have been identified below.

Table 7: Construction Phase Pollutants

Pollutant	Sources
Litter	Paper, construction packaging, food packaging, cement bags, material offcuts.
Sediment	Exposed soils and stockpiles during earthworks and building works.
Hydrocarbons	Fuel and oil spills, leaks from construction equipment and temporary car park areas.
pH altering substances	Acid sulphate soils, cement slurry and wash waters.
Toxic Materials	Cement slurry, asphalt primer, solvents, cleaning agents, and wash waters (e.g., from tile works).

5.1.2. Erosion and Sediment Control Measures

Erosion and Sediment Control devices (ESC) employed on the site shall be designed and constructed in accordance with the International Erosion Control Association (IECA) Best Practice ESC Document.

5.1.2.1. Pre-Construction Phase

- Set out transport routes to ensure minimal vegetation disturbance;
- Construct entry/exit areas that comprise a designed gravel pad or hardwood logs in accordance with the IECA document;
- Install sediment fences around the proposed bulk earthworks site;
- Install dust control fences adjacent to the proposed bulk earthworks site; and
- Educate site personnel to the necessities of the Erosion and Sediment Control Plan.

5.1.2.2. Bulk Earthworks Phase

- Maintain construction access/exit, sediment fencing, dust fences, etc as required;
- Implement diversion drains to be provided at upstream catchments to reduce runoff impacting the earthworks;
- Implement diversion drains to convey runoff from disturbed areas to the relevant sediment measures; and
- Stockpile and construction material are not permitted to be stored within the road reserve.

5.1.2.3. Post Bulk Earthworks Phase

- Sediment fences to be erected at the base of all stockpile and batters to prevent sediment transportation off site;
- Progressively revegetate of all disturbed areas;
- Grass filter strips to be placed along all road verges;
- All sediment control structures to be maintained in an effective manner and inspected after each storm event;
- No sediment structure is to accumulate sediment above 40% of its capacity;
- Dust producing areas to be swept to remove silt/dust and wetting of roads is only permitted where sweeping has failed; and
- At least one bin or litter trap is to be provided for hydrocarbons, litter, toxic materials or waste material.

During the maintenance period, all silt fences are to remain on-site during the maintenance period until relevant landscaping has been established.

5.2. Operational Phase

5.2.1. Stormwater Quality Objectives

The State Planning Policy (2017) set out the following water quality load reduction targets that must be achieved when assessing the post-development treatment:

- Total Suspended Sediment (TSS) - 80% reduction
- Total Phosphorus (TP) - 60% reduction
- Total Nitrogen (TN) - 45% reduction
- Gross Pollutant (>5mm) - 90% reduction

The percent reductions listed above are the target reductions for comparing mitigated site annual pollutant loads with unmitigated site annual pollutant loads. The proposed treatment strategy selected for the development will ensure these objectives are met for all pollutants.

Best Management Practices (BMP) are required to be demonstrated for all Development Applications within Southeast Queensland (SEQ) and are recommended to be implemented by the developer. Where practicable, methods such as first flush devices, and discharging stormwater to landscaped/grassed areas prior to discharge to the LPOD, are to be incorporated into the site's stormwater strategy, where the opportunity is available.

5.2.2. Stormwater Quality MUSIC Modelling

To evaluate the quantities of pollutants anticipated to be discharged from the development, the proposed treatment strategy has been modelled using MUSIC version 6.1. Rainfall, catchment properties and pollutant characteristics have been sourced from Water By Design's 'MUSIC Modelling Guidelines' (2010).

The rainfall data uses rainfall station 40223 (Brisbane Airport), using a 6-minute time step from 01/01/1981 to 31/12/1990.

The site has been split into the following MUSIC catchment areas for the purpose of modelling the proposed treatment strategy:

Table 8: MUSIC Catchment Areas

Catchment	Area (m ²)	Fraction Impervious (%)
Roof (Commercial)	2,981	100
Road (Commercial)	1,567	100
Ground (Commercial)	609	30
Ground Bypass (Commercial)	237	0
Total Site Area	5,394	

An underground propriety Stormwater Quality Improvement Device (SQID) will be utilised to treat stormwater runoff from the site as it is deemed more suitable for the proposed site use. An Ocean Protect system comprising of a series of Ocean Guards fitted in the inlet pits and 10 x 690 PSorb Ocean Protect Stormwater Cartridges within an 8.00m² filter chamber will be incorporated into the operational phase development layout.

The proposed SQID has been provided for modelling purposes only and is subject to Council approval. Accordingly, similar alternative devices may be adopted with Council review and approval.

Stormwater runoff from the roof areas will be directly conveyed via the building hydraulics network to the proposed internal pit and pipe network upstream of the underground tank. Runoff generated from the road and ground areas will be conveyed to a series of inlet pits fitted with OceanGuards prior to draining into the underground tank. Runoff generated from the rear landscape bypass area along the southern boundary will bypass the proposed tank and discharge directly to the LPOD.

An illustration of the MUSIC model of the adopted operational treatment train for the post-development site has been provided in Figure 6 below.

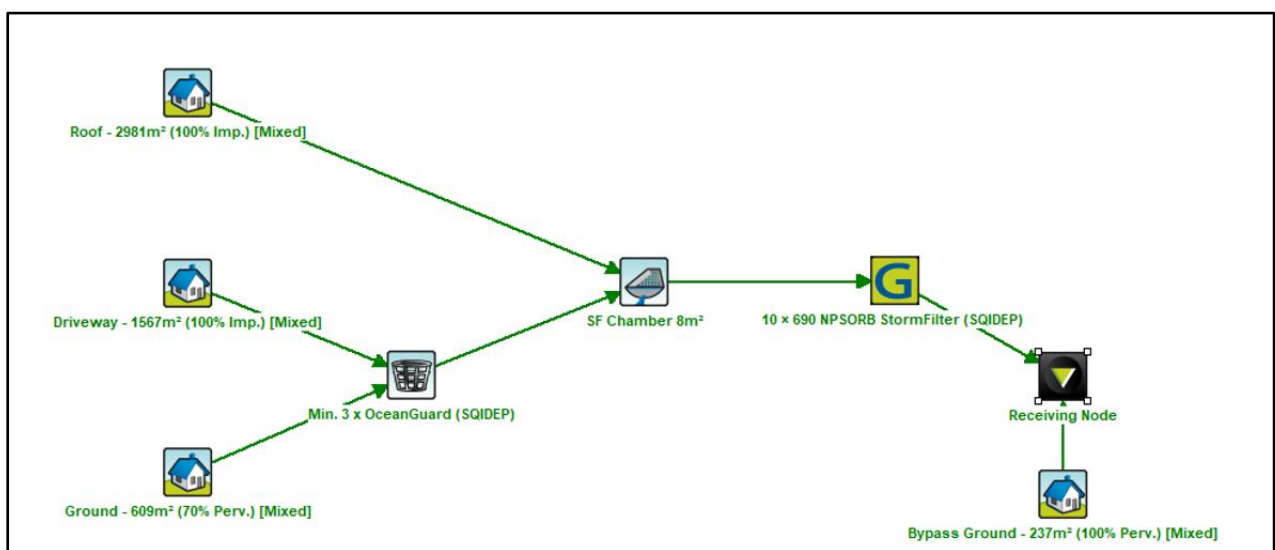


Figure 6 – MUSIC Model Configuration

The post-developed modelled stormwater quality results have been tabulated and shown within Table 9 below.

Table 9: Treatment Train Effectiveness

Parameter	Sources	Post Mitigated	Reduction (%)
TSS (kg/yr)	893	174	80.50
TP (kg/yr)	2.05	0.544	73.50
TN (kg/yr)	17.3	7.77	55.20
Gross Pollutants (kg/yr)	122	0	100

The results validate that the proposed stormwater quality strategy meet the required Water Quality Objectives in accordance with the State Planning Policy (2017).

6.0. Conclusion

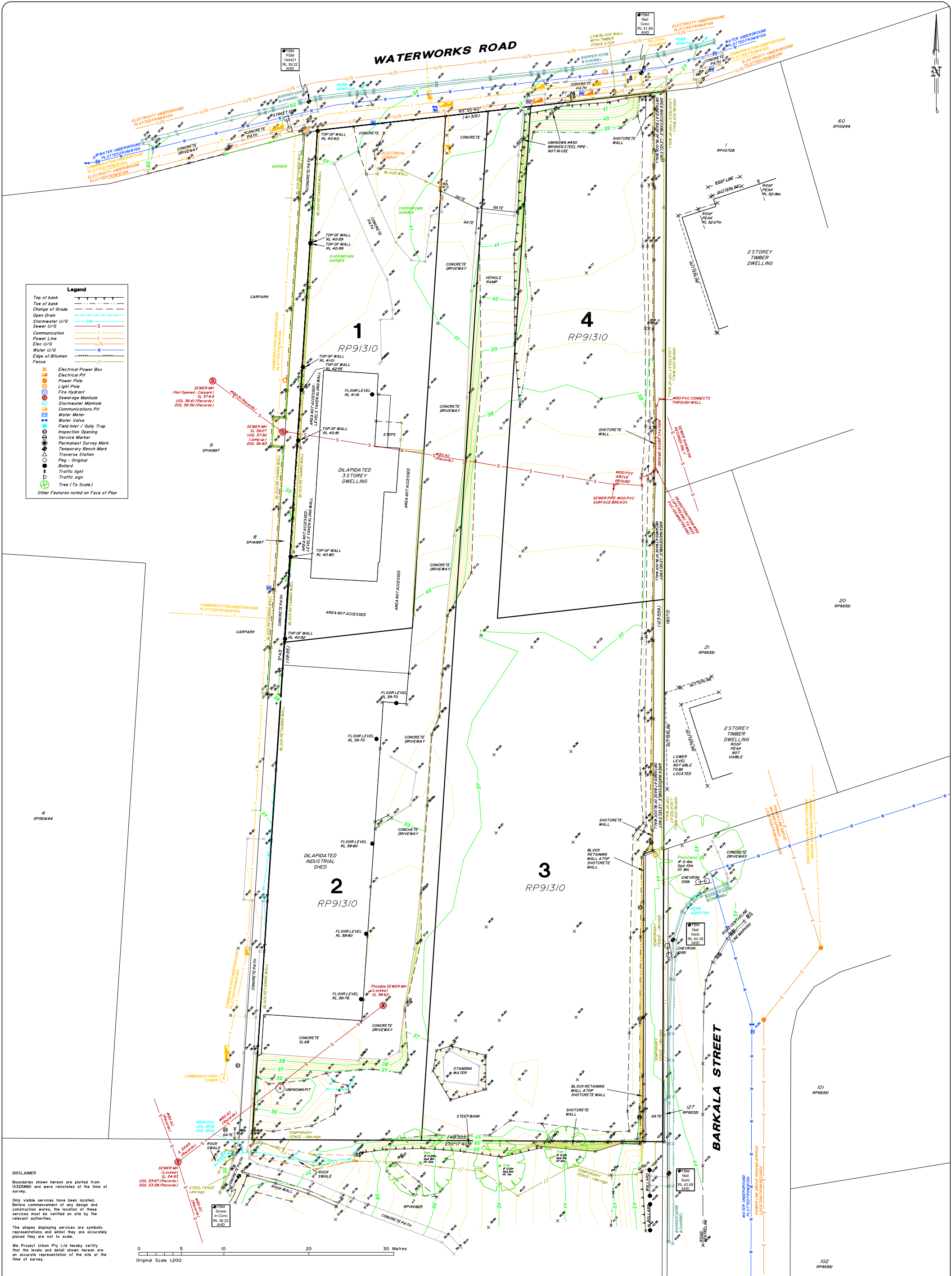
This Conceptual Stormwater Management Report has assessed the stormwater management, for the proposed townhouse development at 836-842 Waterworks Road, The Gap.

The stormwater management strategy has implemented the following components:

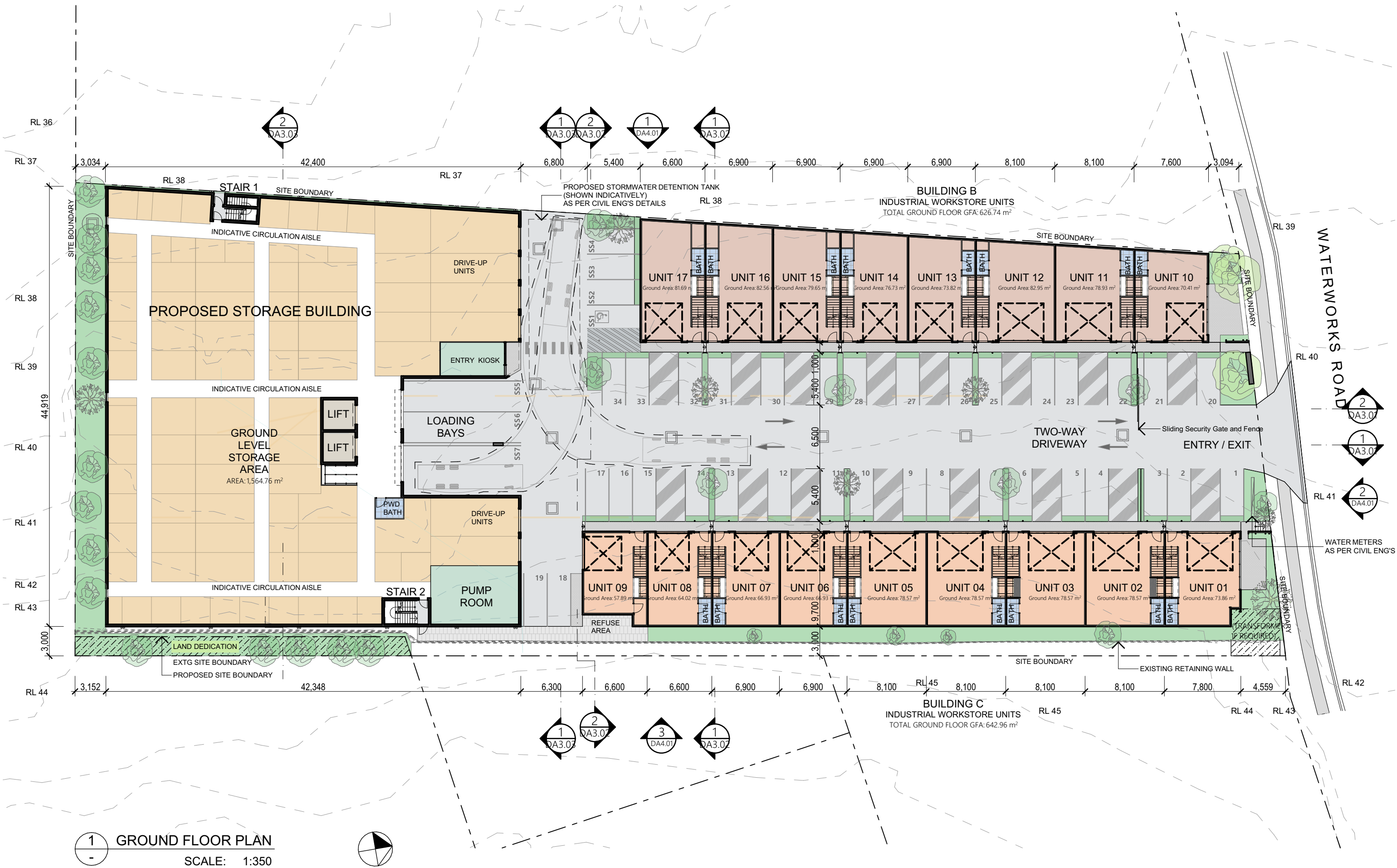
- The nominated Lawful Point of Discharge for the proposed development is Alan Willing Place Park.
- A combined stormwater quantity and quality underground tank with the following parameters:
 - Total Tank Volume 81m³ (45m² @ 1.8m Internal Height).
 - 10 x 690 PSorb Ocean Protect Stormwater Cartridges (8.00m² Filter Chamber)
 - Minimum 3 Ocean Guard inlet pit protectors.

This report has demonstrated that the proposed development proposal provides an acceptable solution for stormwater management and has been designed to comply with Queensland Urban Drainage Manual Fourth Edition 2017 - Provisional (QUDM, 2017), the State Planning Policy (SPP, 2017), IEAust Australian Runoff Quality: Guide to Water Sensitive Urban Design and Brisbane City Council City Plan (BCC, 2014).

Appendix A – Site Survey Files



Appendix B – Architectural Site Plan



1 GROUND FLOOR PLAN
SCALE: 1:350

M R A C
McDougall Roberts Architecture and Consulting

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email: nathan@mcdougallroberts.com.au
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P3 REVISED PRELIMINARY
P4 DA ISSUE

INT DATE
NR 05/03/2025
NR 20/03/2026
NR 27/03/2026
NR 30/04/2026

**PRADELLA
PROPERTY**
StoreLocal

PROJECT STORELOCAL THE GAP + WORKSTORES
842 WATERWORKS ROAD, THE GAP QLD 4061
CLIENT PRADELLA PROPERTY
JOB No. 2520-PP
DRAWING TITLE: GROUND FLOOR PLAN
SCALE: 1:350@A3
DRAWN: NR
DATE: 30/04/2026
DWG No. DA2.01
ISSUE P4

Appendix C – Civil Engineering Drawings

LEGEND

	PROPOSED SITE BOUNDARY
	PROPOSED EASEMENT
	DESIGN SURFACE CONTOURS (0.10m INTERVAL)
	EXISTING SURFACE CONTOURS (0.20m INTERVAL)
	PROPOSED RETAINING WALL
	FINISHED SURFACE SPOT LEVEL
	EXISTING SURFACE SPOT LEVEL
	PROPOSED RETAINING WALL HEIGHTS
	PROPOSED FINISHED FLOOR LEVEL
	EXISTING RETAINING WALL
	EXISTING STORMWATER PIPE
	EXISTING SEWER MAIN
	EXISTING WATER MAIN
	EXISTING OVERHEAD ELECTRICAL
	EXISTING UNDERGROUND ELECTRICAL
	EXISTING TELSTRA
	EXISTING GAS MAIN

BULK EARTHWORKS VOLUMES
(NET EXCL. BULKING)

ITEM	VOLUME (m³)
CUT	1279
FILL	5241
BALANCE	+3962 (+IMPORT)

CUT & FILL LEGEND

EXCAVATION

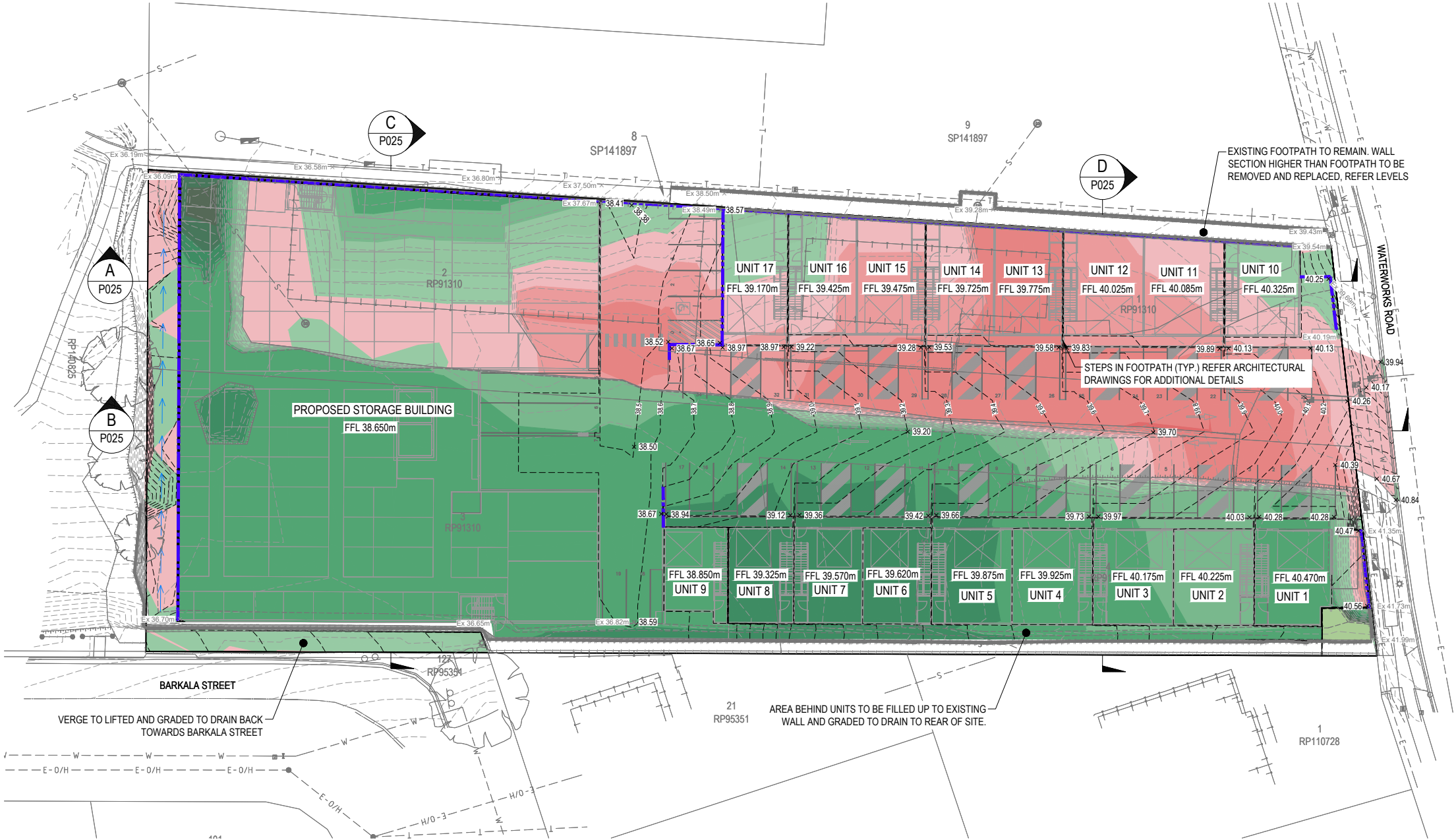
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FILLING

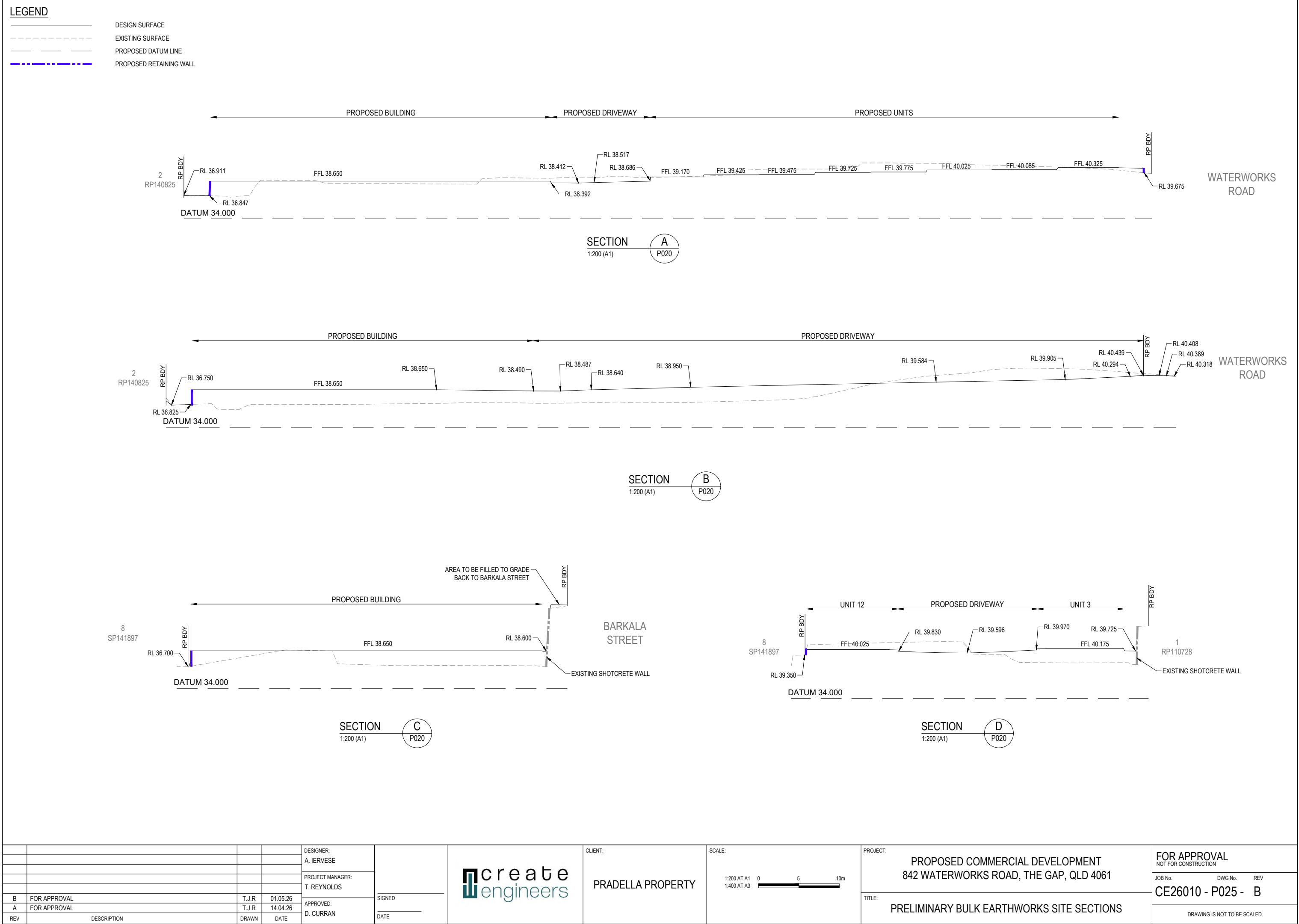
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NOTE:

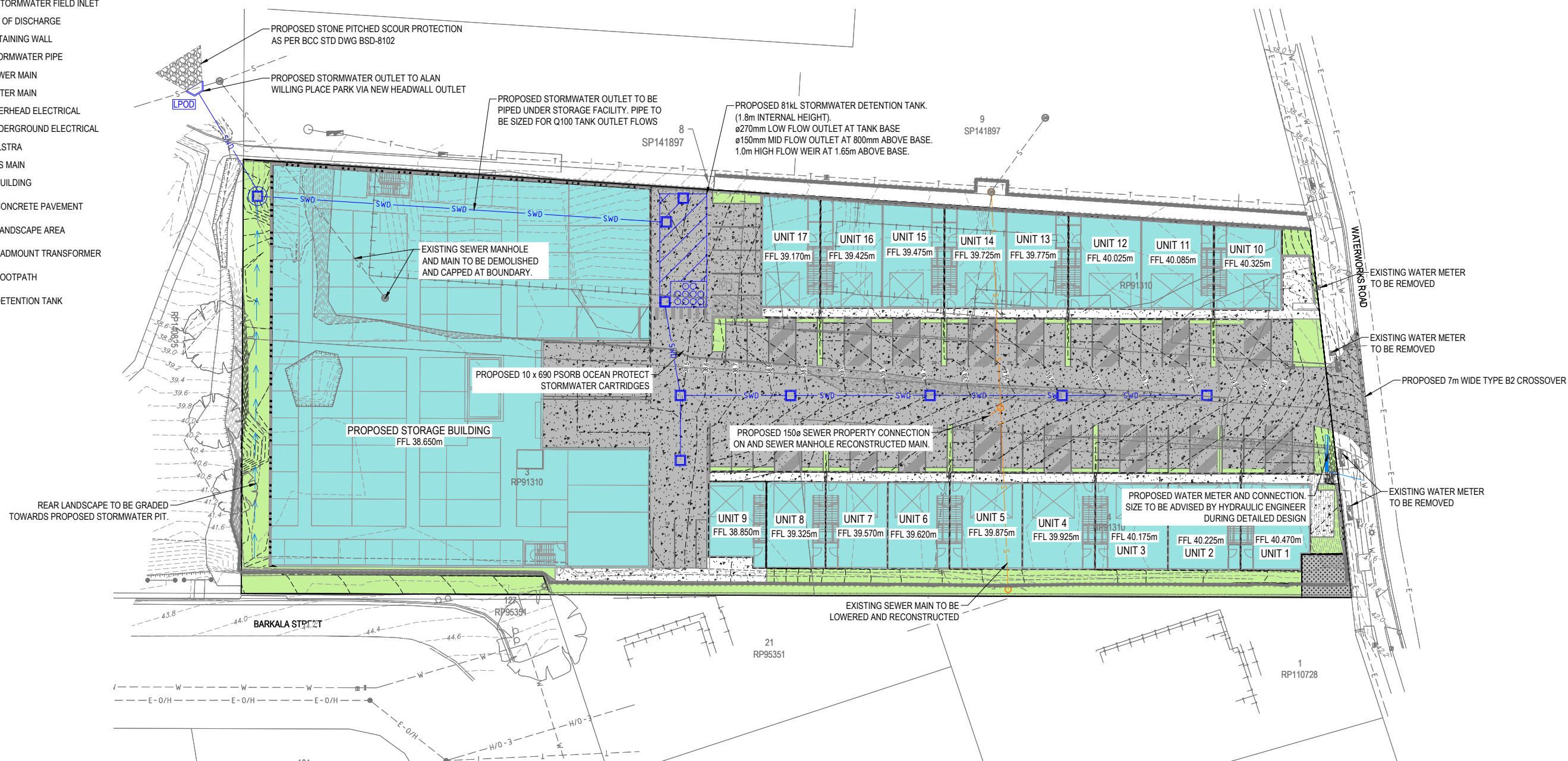
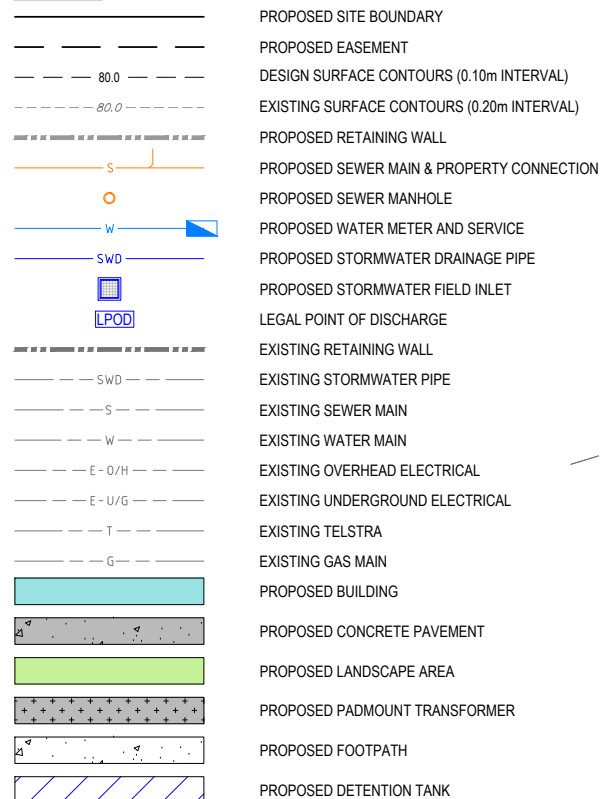
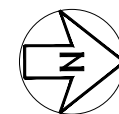
- CUT AND FILL IS PROVIDED FOR GUIDANCE ONLY AND DENOTES DIFFERENCE BETWEEN FINISHED SURFACE AND EXISTING SURFACE.
- FINAL EXTENTS OF CUT/FILL ARE TO BE DETERMINED BY THE CONTRACTOR ON SITE IN CONJUNCTION WITH THE EARTHWORKS DESIGN.
- EARTHWORKS DESIGN AND QUANTITIES SUBJECT TO FURTHER CHANGE FOLLOWING RECEIPT OF GEOTECHNICAL INFORMATION.



				DESIGNER: A. IERVESE			CLIENT: PRADELLA PROPERTY	SCALE: 1:250 AT A1 1:500 AT A3 	PROJECT: PROPOSED COMMERCIAL DEVELOPMENT 842 WATERWORKS ROAD, THE GAP, QLD 4061	FOR APPROVAL NOT FOR CONSTRUCTION
				PROJECT MANAGER: T. REYNOLDS						JOB No. DWG No. REV CE26010 - P020 - B
				APPROVED: D. CURRAN	SIGNED DATE				TITLE: PRELIMINARY BULK EARTHWORKS PLAN	DRAWING IS NOT TO BE SCALED
B	FOR APPROVAL	T.J.R	01.05.26							
A	FOR APPROVAL	T.J.R	14.04.26							
REV	DESCRIPTION	DRAWN	DATE							



LEGEND



				DESIGNER: A. IERVESE		CLIENT:	SCALE:	PROJECT:	FOR APPROVAL NOT FOR CONSTRUCTION					
				PROJECT MANAGER: T. REYNOLDS			PRADELLA PROPERTY	1:250 AT A1 1:500 AT A3	PROPOSED COMMERCIAL DEVELOPMENT 842 WATERWORKS ROAD, THE GAP, QLD 4061	JOB No.	DWG No.	REV		
B	FOR APPROVAL	T.J.R	01.05.26	APPROVED:						TITLE:	PRELIMINARY SERVICES PLAN	CE26010 - P040 - B		
A	FOR APPROVAL	T.J.R	14.04.26	D. CURRAN								DRAWING IS NOT TO BE SCALED		
REV	DESCRIPTION	DRAWN	DATE											

Appendix D – BCC Overlay Codes

9.4.9 Stormwater code

9.4.9.3 Performance outcomes and acceptable outcomes

Table 9.4.9.3.A—Performance outcomes and acceptable outcomes

Performance outcomes	Acceptable outcomes	Comments
Section A—If for a material change of use, reconfiguring a lot, operational work or building work Note—Compliance with the performance outcomes and acceptable outcomes in this section should be demonstrated by the submission of a site-based stormwater management plan for high risk development only.		
PO1 Development provides a stormwater management system which achieves the integrated management of stormwater to: a. minimise flooding; b. protect environmental values of receiving waters; c. maximise the use of water sensitive urban design; d. minimise safety risk to all persons; e. maximise the use of natural waterway corridors and natural channel design principles. Editor's note—The stormwater management system to be developed to address PO1 is not intended to require management of stormwater quality.	AO1 Development provides a stormwater management system designed in compliance with the Infrastructure design planning scheme policy.	The development complies with this performance outcome as the stormwater management strategy has been designed in accordance with the Infrastructure design planning scheme policy.
PO2 Development ensures that the stormwater management system and site work does not adversely impact flooding or drainage characteristics of premises which are up slope, down slope or adjacent to the site.	AO2.1 Development does not result in an increase in flood level or flood hazard on up slope, down slope or adjacent premises. AO2.2 Development provides a stormwater management system which is designed in compliance with the standards in the Infrastructure design planning scheme	The development complies with this performance outcome as the stormwater management strategy has been designed in accordance with the Infrastructure design planning scheme policy, and will not increase any flood levels or hazard on surrounding properties.

	policy.	
PO3 Development ensures that the stormwater management system does not direct stormwater run-off through existing or proposed lots and property where it is likely to adversely affect the safety of, or cause nuisance to properties.	AO3.1 Development ensures that the location of the stormwater drainage system is contained within a road reserve, drainage reserve, public pathway, park or waterway corridor. AO3.2 Development provides a stormwater management system which is designed in compliance with the standards in the Infrastructure design planning scheme policy. AO3.3 Development obtains a lawful point of discharge in compliance with the standards in the Infrastructure design planning scheme policy. AO3.4 Where on private land, all underground stormwater infrastructure is secured by a drainage easement.	The development complies with this acceptable outcome as the proposed lawful point of discharge (LPOD) location is in accordance with the Infrastructure design planning scheme policy.
PO4 Development provides a stormwater management system which has sufficient capacity to safely convey run-off taking into account increased run-off from impervious surfaces and flooding in local catchments.	AO4.1 Development provides a stormwater conveyance system which is designed to safely convey flows in compliance with the standards in the Infrastructure design planning scheme policy. AO4.2 Development provides sufficient area to convey run-off which will comply with the standards in the Infrastructure design planning scheme policy.	The development complies with this performance outcome as the stormwater conveyance strategy has been designed in accordance with the Infrastructure design planning scheme policy.
PO5 Development designs stormwater channels, creek modification works, bridges, culverts and major drains to protect and enhance the value of the waterway corridor	AO5 Development ensures the design of stormwater channels, creek modifications or other infrastructure, permits terrestrial and aquatic fauna movement.	NA

or drainage path for fauna movement.		
PO6 Development ensures that location and design of stormwater detention and water quality treatment: a. minimises risk to people and property; b. provides for safe access and maintenance; c. minimises ecological impacts to creeks and waterways.	AO6.1 Development locates stormwater detention and water quality treatment: a. outside of a waterway corridor; b. offline to any catchment not contained within the development. AO6.2 Development providing for stormwater detention and water quality treatment devices are designed in compliance with the standards in the Infrastructure design planning scheme policy.	The development complies with this performance outcome as the stormwater detention and water quality treatment devices are designed in compliance with the standards in the Infrastructure design planning scheme policy.
PO7 Development is designed, including any car parking areas and channel works to: a. reduce property damage; b. provide safe access to the site during the defined flood event.	AO7.1 Development (including any ancillary structures and car parking areas) is located above minimum flood immunity levels in Table 9.4.9.3.B, Table 9.4.9.3.C, Table 9.4.9.3.D, Table 9.4.9.3.E and Table 9.4.9.3.F. Note—Compliance with this acceptable outcome can be demonstrated by the submission of a hydraulic and hydrology report identifying flood levels and development design levels (as part of a site-based stormwater management plan). AO7.2 Development including the road network provides a stormwater management system that provides safe pedestrian and vehicle access in accordance with the standards in the Infrastructure design planning scheme policy.	All development will be located above the minimum flood immunity levels and driveway access provided in accordance with the standards in the Infrastructure design planning scheme policy.
PO8 Development designs stormwater channels, creek modification works and the drainage network to protect and enhance the environmental values of the waterway corridor or drainage path.	AO8.1 Development ensures natural waterway corridors and drainage paths are retained. AO8.2 Development provides the required hydraulic	NA

	conveyance of the drainage channel and floodway, while maximising its potential to maximise environmental benefits and minimise scour. Editor's note—Guidance on natural channel design principles can be found in the Council's publication Natural channel design guidelines.	
	AO8.3 Development provides stormwater outlets into waterways, creeks, wetlands and overland flow paths with energy dissipation to minimise scour in compliance with the standards in the Infrastructure design planning scheme policy.	
	AO8.4 Development ensures that the design of modifications to the existing design of new stormwater channels, creeks and major drains is in compliance with the standards in the Infrastructure design planning scheme policy.	
PO9 Development is designed to manage run-off and peak flows by minimising large areas of impervious material and maximising opportunities for capture and re-use.	AO9 No acceptable outcome is prescribed.	The development complies with this performance outcome as the site layouts incorporates landscaping where appropriate to minimize the total impervious area.
PO10 Development ensures that there is sufficient site area to accommodate an effective stormwater management system. Note—Compliance with the performance outcome should be demonstrated by the submission of a site-based stormwater management plan for high-risk development only.	AO10 No acceptable outcome is prescribed.	The development complies with this performance outcome as there was sufficient site area to convey the internal stormwater network to the LPOD.
PO11 Development provides for the orderly development of stormwater infrastructure within a catchment, having regard to the: a. existing capacity of stormwater infrastructure	AO11.1 Development with up-slope external catchment areas provides a drainage connection sized for ultimate catchment conditions that is directed to a lawful point of discharge.	NA

within and external to the site, and any planned stormwater infrastructure upgrades; b. safe management of stormwater discharge from existing and future up-slope development; c. implication for adjacent and down-slope development.	AO11.2 Development ensures that existing stormwater infrastructure that is undersized is upgraded in compliance with the Infrastructure design planning scheme policy.	
PO12 Development provides stormwater infrastructure which: a. remains fit for purpose for the life of the development and maintains full functionality in the design flood event; b. can be safely accessed and maintained cost effectively; c. ensures no structural damage to existing stormwater infrastructure.	AO12.1 The stormwater management system is designed in compliance with the Infrastructure design planning scheme policy. AO12.2 Development provides a clear area with a minimum of 2m radius from the centre of an existing manhole cover and with a minimum height clearance of 2.5m.	The development complies with this performance outcome as the proposed stormwater network has been designed in accordance with the Infrastructure design planning scheme policy.
PO13 Development ensures that all reasonable and practicable measures are taken to manage the impacts of erosion, turbidity and sedimentation, both within and external to the development site from construction activities, including vegetation clearing, earthworks, civil construction, installation of services, rehabilitation, revegetation and landscaping to protect: a. the environmental values and water quality objectives of waters; b. waterway hydrology; c. the maintenance and serviceability of stormwater infrastructure. Note—The Infrastructure design planning scheme policy outlines the appropriate measures to be taken into account to achieve the performance outcome.	AO13 No acceptable outcome is prescribed.	The development complies with this performance outcome as an erosion and sediment control plan will be designed at the detailed design stage, which will incorporate industry best practice methods.
PO14 Development ensures that: a. unnecessary disturbance to soil, waterways or	AO14 No acceptable outcome is prescribed.	The proposed development complies with this performance outcomes as all landscaped surfaces will remain stabilized against erosion in the short and long

drainage channels is avoided; b. all soil surfaces remain effectively stabilised against erosion in the short and long term.		term.
PO15 Development does not increase: a. the concentration of total suspended solids or other contaminants in stormwater flows during site construction; b. run-off which causes erosion either on site or off site.	AO15 No acceptable outcome is prescribed.	The development will comply with this performance outcome by ensuring adequate erosion and sediment control measures are implemented during on-site construction works.
Section B—Additional performance outcomes and acceptable outcomes which apply to high-risk development, being one or more of the following: a. a material change of use for an urban purpose which involves greater than 2,500m ² of land that: i. will result in an impervious area greater than 25% of the net developable area; or ii. will result in 6 or more dwellings. b. reconfiguring a lot for an urban purpose that involves greater than 2,500m ² of land and will result in 6 or more lots; c. operational work for an urban purpose which involves disturbing greater than 2,500m ² of land.		
PO16 Development ensures that the entry and transport of contaminants into stormwater is avoided or minimised to protect receiving water environmental values. Note—Prescribed water contaminants are defined in the <i>Environmental Protection Act 1994</i> . Note—Compliance with the performance outcome should be demonstrated by the submission of a site-based stormwater management plan for high-risk development only.	AO16 Development provides a stormwater management system which is designed in compliance with the standards in the Infrastructure design planning scheme policy.	A Conceptual Stormwater Management Plan (CSWMP) has been prepared and submitted as part of this Development Application for all major and minor stormwater management measures. Refer to Create Engineers, <i>Conceptual Stormwater Management Plan</i> (Ref: CE26010 – 836-842 Waterworks Road–CSWMP-0002).
PO17 Development ensures that: a. the discharge of wastewater to a waterway or external to the site is avoided; or b. if the discharge cannot practicably be avoided, the development minimises wastewater discharge through re-use, recycling, recovery and treatment.	AO17 No acceptable outcome is prescribed.	NA

Note—The preparation of a wastewater management plan can assist in demonstrating achievement of this performance outcome. Editor's note—This code does not deal with sewerage which is the subject of the Wastewater code.		
Section C—Additional performance outcomes and acceptable outcomes for assessable development for a material change of use or reconfiguring a lot		
PO18 Development protects stormwater infrastructure to ensure the following are not compromised: a. the long term infrastructure for the stormwater network in the Long term infrastructure plans; b. the existing and planned infrastructure for the stormwater network in the Local government infrastructure plan; c. the provision of long term, existing and planned infrastructure for the stormwater network which: i. is required to service the development or an existing and future urban development in the planning scheme area; or ii. is in the interests of rational development or the efficient and orderly planning of the general area in which the site is situated. Editor's note—A condition which requires a proposed development to keep permanent improvements and structures associated with the approved development clear of the area of long term infrastructure, may be imposed.	AO18 Development protects stormwater infrastructure in compliance with the following: a. for long term infrastructure for the stormwater network, the Long term infrastructure plans; b. for existing and planned infrastructure for the stormwater network, the Local government infrastructure plan; c. the standards for stormwater drainage in the Infrastructure design planning scheme policy.	The development complies with this performance outcome by ensuring compliance with the Infrastructure design planning scheme policy, and will not adversely impact any existing or future stormwater infrastructure.
PO19 Development provides for the payment of extra trunk infrastructure costs for the following: a. for development completely or partly outside the priority infrastructure area in the Local government infrastructure plan; b. for development completely inside the priority infrastructure area in the Local government	AO19 No acceptable outcome is prescribed.	NA

infrastructure plan involving: i. trunk infrastructure that is to be provided earlier than planned in the Local government infrastructure plan; ii. long term infrastructure for the stormwater network which is made necessary by development that is not assumed future urban development; iii. other infrastructure for the stormwater network associated with development that is not assumed future urban development which is made necessary by the development. Editor's note—The payment of extra trunk infrastructure costs for development completely inside the priority infrastructure area in the Local government infrastructure plan is to be worked out in accordance with the Charges Resolution. Editor's note—See section 130 Imposing Development conditions (Conditions for extra trunk infrastructure costs) of the <i>Planning Act 2016</i>.		
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Appendix E – Approved Stormwater Quantity & Quality Assessment Report (Council Reference: A001645460)

SCRUTINY

1406-963127

**836-842 WATERWORKS ROAD,
THE GAP**

**STORMWATER QUANTITY &
QUALITY ASSESSMENT REPORT**

6 March 2007

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Council Ref No.

Report Name	Date	Report No.
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836-842 Waterworks Road, The Gap

Stormwater Quantity & Quality Assessment Report

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1.0 INTRODUCTION

Storm Water Consulting Pty Ltd was commissioned by PGF Property Group Pty Ltd and Pasadevia Holdings Pty Ltd to investigate the stormwater quantity and quality issues for the proposed residential development at 836-842 Waterworks Road, The Gap (the subject site).

The site has road frontage to Waterworks Road along the northern boundary and Barkala Street on the eastern boundary. The subject site currently contains a variety of buildings, including residential and light industry.

A well-defined gully directs overland flow to the west of the subject site before entering a stormwater pipe system.

2.0 SITE CONDITIONS

2.1. EXISTING SITE

The 5500m² subject site currently contains three residential homes, a large carport, and a number of small businesses. The site is generally developed with some small areas of grass and gardens (see Photo 1, Appendix B). The land generally falls toward the gully to the west, although some of the site is graded toward Waterworks Road.

The catchment for the subject site extends approximately 800m upstream of the subject site, as illustrated on Figure 1, Appendix A. The overland flow path passes through the public park (which adjoins the upstream property boundary of the site) before entering a stormwater pipe system. Downstream of the inlet to the pipe system, the overland flow path is blocked by the Waterworks Road road embankment (see Figure 2, Appendix A).

No stormwater pipes are laid within the site. A single 1050mm diameter pipe provides drainage for the upstream catchment (see Figure 3, Appendix A). Flood waters will build up to the level of Waterworks Road before spilling over and continuing on to Enoggera Creek (approximately 150m downstream).

2.2. DEVELOPED SITE

The proposed development of the subject site involves the removal of all existing buildings and constructing two mixed use buildings. These buildings will accommodate retail, office and residential use. The proposed development layout is presented in Appendix A, Holgar Architects Dwg No Z0610 – SK01.

The percentage of impervious area will be increased from existing conditions due to the proposed development, the result being an increase of flow from the site. The impact of this increase on the flows from the total catchment is relatively small. As a better indication of the impact of development, the volume of runoff from the site was used.

The calculated impact from development, as detailed in Section 4.1, is to increase the volume of site runoff during a Q₅₀ storm event by 21m³. If this increase is spread across the area that currently becomes inundated (see Figure 2), the development of the subject site will increase the flood level by 3.8mm (see Section 5.2).

A rainwater tank will be constructed in-situ in the basement car park of the development, to be used for internal uses such as flushing toilets and washing machines and external uses such as watering gardens, washing cars and hosing footpaths. The drawdown effect within the rainwater tank, caused by these uses will be used to mitigate the effects of development.

3.0 METHODOLOGY

It is the objective of this report to demonstrate no increase in site runoff volume and that water quality objectives are achieved.

Development of the subject site will increase runoff from the site due to the increase in impervious area (paving of pervious areas, construction of buildings, etc) which will reduce infiltration of stormwater into the groundwater system.

The time of concentration for the catchment is governed by flow through the park adjacent to the subject site. The change in site conditions due to development will not impact on the time of concentration for the catchment.

The result of the increase in impervious area on the site has little impact on the peak flow from the catchment (less than 1%), however the volume of flow that discharges from the developed site is increased by 21m³ when compared with the existing site.

As part of the proposed development of the subject site, a 30kL rainwater tank will be constructed. This tank will be used for domestic use such as watering gardens and flushing toilets. The tank forms part of the stormwater quantity and quality management for the site, as detailed in Sections 6 and 7 of this report.

When the AR&R temporal pattern methodology is used, it is typically assumed that rainwater tanks are full at the beginning of a storm event. This assumption would not give the full attenuation benefits provided by a tank with a reuse drawdown effect. To overcome this limitation, a model was set up using historic rainfall data and daily drawdown from the rainwater tanks (for use in the garden, flushing toilets etc.).

A model of the catchment was set up, with the appropriate land zoning used to define each contributing area. The MUSIC software package was used for this modelling. It is noted that MUSIC is generally used to model the effect of stormwater quality improvement devices. However, as documented on the MUSIC website*, the model is also designed to perform stormwater quantity analysis.

Using the available historic rainfall data appropriate for the area, the catchment was modelled to represent the existing and developed scenarios. The results from the MUSIC models were analysed, and the peak flow and volume for each rainfall event was listed. From these results, a series of flood frequency analysis were completed, using the log Pearson III distribution method (AR&R Vol 1, Book IV, Section 2).

Further details regarding the calibration and modelling of the scenarios are described in full within this report.

* <http://www.toolkit.net.au>

4.0 HYDROLOGIC ANALYSIS

The peak stormwater discharges from the site and upstream catchment have been calculated using the Rational Method. These Rational Method calculations have been completed in accordance with the parameters recommended in the Queensland Urban Drainage Manual (QUDM, 1992) and the BCC's Subdivision and Development Guidelines, (2000).

Calculations were performed for three catchments, as detailed in the following paragraphs. The results of the Rational Method calculations for each location are presented in Tables 4.1 and 4.3 to 4.5. The full Rational Method calculations are presented in Appendix C.

4.1. CATCHMENT 1

Catchment 1 includes the subject site and the full catchment upstream of the site (Catchment A, Figure 1). Catchment A includes an area of Low Density Residential, and Conservation area, as delineated on BCC BiMap. Appropriate fractions impervious were used for these areas.

Calculations were completed assuming ultimate developed conditions for the upstream catchment.

The existing site C_{10} value was determined by calculating the percentage of impervious area from an aerial photo of the site (see Figure 4, Appendix A), giving 60% of the site as impervious. The developed condition fraction impervious for the site was determined using the Architectural plans (see Appendix A), totalling 85% of the site.

Table 4.1 – Comparison of Peak Flows at Point 1

ARI years	Existing Catchment Flow m^3/s	Developed Catchment Flow m^3/s	Increase m^3/s
1	2.769	2.774	0.005
2	3.798	3.804	0.006
5	5.453	5.462	0.009
10	6.510	6.520	0.010
20	7.910	7.923	0.013
50	10.244	10.260	0.016
100	11.975	11.980	0.005

As shown in Table 4.1, the increase due to development of the site will have a relatively minor impact on total flow from the catchment. As another indicator of the impact, the volume of runoff from the site was determined. This was completed by the following calculation:

Equation 1 – Calculation of Volume of Runoff

$$Vol = \frac{4}{3} Q * t_c$$

$$Q = Q_{50} flow$$

$$t_c (sec) = 15.5 min * 60$$

The results of this calculation are presented in Table 4.2. The results indicate the impact on total volume due to development of the subject site.

Table 4.2 – Results of Eqn 1 for Catchment A Q₅₀ Flow (Results in m³)

Existing Site	Developed Site	Increase
12702.2	12722.8	20.7

4.2. CATCHMENT 2

The Rational Method was used to determine the peak flows from the southern part of the subject site. The catchment directs site runoff toward the overland flow path to the west, as shown in Figure 5, Appendix A.

The existing site conditions C₁₀ value was altered for the developed site condition to represent the extent of development within this catchment, as described in Section 4.1.

Table 4.3 – Comparison of Peak Flows at Point 2 (Site Only)

ARI years	Existing Catchment Flow m ³ /s	Developed Catchment Flow m ³ /s	Increase m ³ /s
1	0.074	0.079	0.005
2	0.101	0.108	0.007
5	0.145	0.153	0.008
10	0.172	0.182	0.010
20	0.208	0.221	0.013
50	0.269	0.285	0.016
100	0.313	0.319	0.006

4.3. CATCHMENT 3

Rational Method calculations were completed for the northern part of the site that discharges site runoff toward Waterworks Road (see Figure 5). The development of the site will not increase the percentage impervious for this catchment, as this catchment is currently 80% impervious.

The results of the Rational Method calculations are shown in Table 4.3.

Table 4.4 - Peak Flows at Point 3 (Site Only)

ARI years	Existing Catchment Flow m ³ /s	Developed Catchment Flow m ³ /s	Increase m ³ /s
1	0.018	0.018	0.000
2	0.024	0.024	0.000
5	0.034	0.034	0.000
10	0.041	0.041	0.000
20	0.049	0.049	0.000
50	0.064	0.064	0.000
100	0.071	0.071	0.000

4.4. CATCHMENT 4

The Rational Method was used to determine the peak flows from the catchment to the east of the subject site. This catchment discharges stormwater on to the site along the eastern boundary, as shown on Figure ..., Appendix A.

The catchment was considered to be fully developed. The results of the Rational Method calculations are presented in Table 4.4

Table 4.5 – Peak Flow entering Site from the East

ARI years	Developed Catchment Flow m ³ /s
1	0.056
2	0.076
5	0.109
10	0.130
20	0.157
50	0.202
100	0.236

5.0 HYDRAULIC ANALYSIS

5.1. EXISTING CHARACTERISTICS

A search was done of the plans available from the BCC Plan Custodian, in regards to the current or proposed pipe systems in the immediate area of the subject site. The result of this search is presented as Figure 3, Appendix A.

A site inspection (conducted 5 February 2007) revealed that these plans were not accurate in detailing the pipe systems in the area. A pipe was identified as an inlet to a pipe system (see Photo 2, Appendix B) in the adjoining lot to the subject site, as shown on Figure 3. This pipe was determined to be a 1050mm diameter pipe.

As shown in Photo 2, development has taken place directly downstream of the pipe inlet (854 Waterworks Rd, a Landscape Supply Centre). It was estimated that the invert of the pipe was 2m below the ground level of the development at 854 Waterworks Rd.

Further inspection downstream of the Landscape Supply Centre indicated that Waterworks Road was creating the major blockage to overland flow from the catchment. It was determined that the 1050mm diameter pipe mentioned above is the only outlet for the catchment.

Using the pipe inlet as the controlling factor for this pipe flow, it was calculated that the pipe has a capacity of $3.2\text{m}^3/\text{s}$ (see Graph C.5, Appendix C).

Waterworks Road has been constructed at approximately RL 36.0m AHD (BCC BiMap, see Figure 2, Appendix A). Figure 2 also indicates that the Landscape Supply Centre is at approximately RL 35.5m AHD. This indicates that flood waters could exceed a depth of 500mm across the Landscape Supply Centre.

When flow from the catchment exceeds $3.2\text{m}^3/\text{s}$, flood waters will fill the area delineated on Figure 2 until becoming high enough to weir flow across Waterworks Rd. Therefore, flood levels for the land upstream are determined by the minimum crown level of Waterworks Road.

Allowing for 300mm of flow across Waterworks Rd, the Q50 flood level at the subject site will be approximately RL 36.3m AHD.

5.2. DEVELOPED SITE CONDITIONS

Flows from the developed subject site will discharge into the gully to the west. The 1050mm diameter stormwater pipe will provide drainage until the inlet of the system is at capacity (approximately 3.2m³/s). When flows are in excess of the inlet capacity, flooding will occur across the Landscape Supply Centre.

As shown in Section 4.1, the subject site would increase the Q₅₀ volume of runoff by 21m³ if no mitigation works were installed. This increase would be spread across the area of inundation upstream of Waterworks Road (5560m²). Using Equation 2, the increase in flood level within this area would be 0.0038m or 3.8mm.

Equation 2 – Increase in Flood Level

$$\text{Increase}(m) = \frac{\text{Volume}(m^3)}{\text{SurfaceArea}(m^2)}$$

To ensure that the proposed development does not cause an adverse impact on neighbouring properties, this increase in volume runoff would need to be collected and discharged over time.

It was determined that a reduction in the volume of runoff, from the developed site to exiting conditions, during the times that catchment flow exceed the capacity of the pipe system will cause no increase in flood levels for neighbouring properties.

Development of the site can continue to direct toward Waterworks Rd. The total area discharging toward Waterworks Road should not exceed 930m² (existing catchment).

Development of the site includes basement car parking. Preliminary architectural sketches indicate a floor level of RL 36m AHD. As stated in Section 5.1, flood levels across the subject site are estimated to be at RL 36.3m AHD (based on the assumed minimum crown level of Waterworks Road). Any openings for this basement car park should be a further 200mm above this. ie. 0.5m above the minimum crown level along Waterworks Rd

Consideration will need to be given to the overland flow coming from the property to the east (Catchment 4, see Section 4.4). The detailed design of the development will need to ensure that no obstruction is placed across the existing flow path, and that drainage is provided within the site.

6.0 STORAGE MODELLING

An analysis of the impact of development has been completed using the MUSIC software. Three models were prepared in MUSIC, the results of which were analysed and compared. The three models are as follows:

- Existing Site Conditions – referred to as 001
- Developed Site Conditions (without a rainwater tank) – referred to as 002
- Developed Site Conditions (with a rainwater tank) – referred to as 003.

Historic 6 minute interval rainfall data for Brisbane Regional Office (040214) was supplied by the Bureau of Meteorology, for the period January 1940 through to June 1994. Evaporation data for the model used the average monthly evapo-transpiration data for Brisbane.

6.1. EXISTING SITE CONDITIONS (001)

A representation of the existing site (and developed catchment) was modelled in MUSIC. The 001 model was set up to represent the total catchment, using the same fractions impervious used in the Rational Method calculations. The source nodes, and their parameters, used in the 001 model are defined in Tables 6.1 and 6.2. A schematic of the 001 model is shown in Figure 6, Appendix A.

Table 6.1 – Definition of Catchments for 001 Model

Catchment Type	Area	Fraction Impervious
Conservation	8.08ha	0%
Low Density Res	13.68ha	40%
Subject Site	0.55ha	60%
Total	22.30ha	26.0%

Table 6.2 – Source Node Parameters for 001 Model

Parameter		Forest	Urban
Impervious Area Properties	Rainfall threshold (mm/day)	1	1
	Soil storage capacity (mm)	120	120
Pervious Area Properties	Initial storage (% of capacity)	25	25
	Field Capacity (mm)	80	80
	Infiltration Capacity Coefficient – a	200	50
	Infiltration Capacity Exponent – b	1	1
Groundwater Properties	Initial depth (mm)	50	50
	Daily recharge rate (%)	25	25
	Daily base flow rate (%)	5	5
	Daily deep seepage rate (%)	0	0

A summary runoff discharge file was created for the total catchment and for the site from the 001 MUSIC model. These results were analysed, extracting the peak discharge and volume of runoff for each rainfall event. An annual summary of this data was also prepared.

A flood frequency analysis of the peak annual flows was performed using the log Pearson III distribution method, also presented in Appendix D. When graphed against the Rational Method results, the 001 model results are shown to be lower than, but consistent with the Rational Method (see Graph D.1).

Flooding of 854 Waterworks Rd occurs when the total catchment flows exceed approximately $3.2\text{m}^3/\text{s}$. It is therefore important for the development not to increase runoff volumes during periods of flooding of 854 Waterworks Rd. In other words, runoff volumes from the site should not be increased during periods when the total catchment flows are greater than $3.2\text{m}^3/\text{s}$.

The volume of runoff during the period when the total catchment flows are greater than $3.2\text{m}^3/\text{s}$ was determined. This process is described in Appendix D. The cumulative volume discharging from the subject site when total flows exceed $3.2\text{m}^3/\text{s}$ was calculated and graphed (see Graphs D.3.a and D.3.b).

6.2. UNMITIGATED DEVELOPED SITE (002)

The 001 model was modified to represent the developed subject site, as summarised in Table 6.3. The use of a rainwater tank for storm flow mitigation was not modelled in this scenario. The schematic of the 002 MUSIC model is presented in Figure 6, Appendix A.

Table 6.3 - Catchment Sizing for 002 Model

Catchment Type		Area	Fraction Impervious
Upstream Catchment	Conservation	8.08ha	0%
	Low Density Res	13.68ha	40%
Site Catchment	Roof Area	0.23ha	100%
	Hardstand Area	0.24ha	100%
	Grass Area	0.07ha	0%
Total		22.30ha	26.7%[†]

A summary file was created for the total catchment and site discharge from the 002 MUSIC model. These results were analysed, extracting the peak discharge and volume of runoff for each rainfall event. An annual summary of this data was also prepared.

The site summary file was compared against the total catchment results to determine when site runoff contributed to flooding (flows in excess of 3.2m³/s). The sum of the volume from the subject site for each event during the historic data series was extracted. This data was used to illustrate the effects of unmitigated development of the subject site, as shown in Graphs D.3.a and D.3.b, Appendix D.

[†] Compared to 26.0% in Table 6.1 (001 Model)

6.3. MITIGATED DEVELOPED SITE (003)

The developed site model was modified to include a 30kL rainwater tank, with the roof area as the catchment. The tank will be custom built in the basement car park. The tank will be 5m x 5m x 2m, with a 90mm diameter outlet pipe 1.2m from the bottom of the tank. This provides a permanent rainwater storage of 30kL and a potential flood storage of 25kL.

The rainwater tank was assumed to be connected to the plumbing for the toilets (30 total) and washing machines (19 total) throughout the proposed development. The tanks would also provide water to hose the garden, wash cars and other external uses. Re-use of the collected rainwater was assumed to total 1100kL/year for the site, as detailed in Table 6.4.

Table 6.4 - Water Re-Use Calculation[‡]

Location	Usage	Daily Usage L/day	Annual Usage kL/year
Toilets	49L/day	1470	537
Laundry	42L/day	798	291
Hosing Garden	10L/min	400	146
Hosing Driveway	10L/min	200	73
Washing Cars	10L/min	150	55
Total			1101.57 kL

The rainwater tank was also assumed to be connected to town water to maintain supply during dry weather periods. A valve would be fitted to open at 10% capacity, filling the rainwater tank to 20%. Thus the maximum available storage for storm attenuation during extended periods of dry weather is the remaining 80% of the 30kL tank capacity.

The properties of the rainwater tank (for the MUSIC model) are outlined in Table 6.5.

[‡] Taken from Pine Rivers Shire Council *Water Demand Management Plan*

Table 6.5 - Rainwater Tank Properties for MUSIC Model

Rainwater Tank	
Inlet Properties	
Low-flow bypass rate (m ³ /s)	0
High-flow bypass rate (m ³ /s)	100
Storage Properties	
Permanent pool volume (m ³)	24.0
Area (m ²)	25
Extended detention depth (m)	0.8
Outlet Properties	
Equivalent pipe diameter (mm)	90
Re-use Properties	
Annual Re-use Demand - scaled by daily PET (ML)	1.10

The summary of the 003 model result file is presented in Appendix D. A summary was prepared of all events in the 003 model when runoff from the catchment exceeded 3.2m³/s. The sum of the volume from the subject site for each event during the historic data series was extracted.

A flood frequency analysis of these site discharges was performed using the log Pearson III distribution method, also presented in Appendix D. These were compared with the 001 site runoff, and plotted on a logarithmic graph (see Graph D.2). These results indicate that the use of a rainwater tank will provide the necessary attenuation of volume runoff to ensure no adverse impact on neighbouring properties.

7.0 WATER QUALITY

7.1. RISK STATUS OF DEVELOPMENT

The determination of whether the proposed development is a High Risk Development or Low Risk Development depends upon a number of criteria that are listed in Section 4.3 of Chapter 5 of the *Brisbane City Plan 2000 Volume 1*, and Appendix 1 of *Council's Guideline on Identifying and Applying Water Quality Objectives in Brisbane City (version 1)*. These are summarised in Table 7.1.

Table 7.1 – Determination of Risk Status of Development

Criteria	Development of Subject Site
Any development in a waterway corridor, the Brisbane River Corridor or a wetland area as indicated on Council Planning Maps	The criterion is not met for this development.
Multi-unit dwellings or commercial uses with an impermeable surface (not including roofing area) in excess of 2,500m ²	Total impermeable surface area is 2370m ² ; therefore the criterion is not met for this development.
Subdivision where at least six lots are involved.	The criterion is not met for this development.
Industrial activities that are not impact assessable (under Council's City Plan) and that have at least 1,000m ² in uncovered storage/working space.	The criterion is not met for this development.
Uncovered car parks with at least 100 spaces	The criterion is not met for this development.

Given that none of the criteria are met, the proposed development is classified as 'low risk'. Therefore, water quality treatment is based on best-management practices.

7.2. STORMWATER QUALITY OBJECTIVES

Council's *Guideline on Identifying and Applying Water Quality Objectives in Brisbane City* show the subject site within Planning Unit E/050. For this planning unit the waterway type is *Fresh* and the category is *High*. The adopted set of environmental values are Set A, B and C.

The water quality objectives for Environmental Values Sets A, B and C for Fresh waterways are summarised in Table 7.2

Table 7.2 – Water Quality Objectives for Environmental Values Set A for Fresh Waters (Abbreviated)

Indicator	Concentration	Notes
Total phosphorous	0.07mg/L	
Total Nitrogen	0.65mg/L	
Suspended Solids	15mg/L 100mg/L	For combined wet and dry periods 90%ile for wet weather periods
Oils and grease	No visible films or odour	
Litter/gross pollutants	No anthropogenic (man made) material greater than 5mm in any dimension	
Riparian vegetation and habitat	Protect and restore consistent with Council policy and plans	
Cultural heritage	Protect and restore consistent with Council policy and plans	

Notes:

Levels are upper limits for median values or ranges in which medians should lie, unless otherwise stated.

A wet weather period is defined as any period where stormwater runoff leaves the site.

7.3. WATER QUALITY – CONSTRUCTION PHASE

During the construction phase of a development, the pollutants listed in Table 7.3 are typically generated. Measures are required during the construction phase to manage each of these pollutants. These measures may include but are not limited to; bins and mini-skips, erosion and sediment control measures (discussed below), wash down and spill containment areas, bunds, spill clean-up kits, street sweeping and chemical agents.

Table 7.3 – Pollutants Generated during the Construction Phase

Pollutant	Source
Litter	Paper, construction packaging, food packaging, cement bags, off-cuts
Sediment	Unprotected exposed soils and stockpiles during earthworks and building operations
Hydrocarbons	Fuel and oil spills, leaks from construction equipment
Toxic materials	Cement slurry, asphalt primer, solvents, cleaning agents, wash waters (eg from tile works)
pH altering substances	Acid sulphate soils, cement slurry and wash waters

7.3.1. Erosion and Sediment Control

During the construction phase of the development, an Erosion and Sediment Control Program (E&SCP) is required to minimise water quality impacts. Such an E&SCP should provide complete and detailed instructions on the following procedures;

1. Before construction activities begin, sediment fences should be constructed on the downstream site boundaries and at the base of all proposed soil stockpiles;
2. Areas for plant and construction material storage should be designated. Runoff from these areas should be directed to small holding ponds in case of spillages;
3. Catch drains at the downstream boundary of construction activities should also be created to ensure that any sediment-laden runoff is contained and directed into a sediment basin and not permitted to flow unmitigated to downstream areas;
4. Sediment basins should be constructed at appropriate locations to collect sediment at the downstream ends of the catch drains that convey runoff from exposed areas;
5. Site personnel should be educated on the sediment and control measures implemented on site; and
6. Following rainfall events greater than 20mm, inspection of silt fences, sedimentation basins and other erosion control measures should be carried out. Where necessary, collected material should be removed and damaged equipment should be replaced immediately.

7.4. WATER QUALITY – OPERATIONAL PHASE

The proposed development will include a stormwater quality treatment train consisting of a grass swale and the rainwater tank (see Figure 7, Appendix A). The grass swale will treat flows from the hardstand and grassed areas prior to discharging into the gully. The rainwater tank will treat the flow coming from the roof catchment.

7.4.1. Treatment Device – Grass Swale

The proposed grass swale is designed to treat the $Q_{3\text{month}}$ flow from the hardstand area.

The grass swale will provide some above-ground storage (40%) of the volume of the $Q_{3\text{month}}$ flow prior to passing through the filter media. The $Q_{3\text{month}}$ flow calculations are presented in Table 6.7.

Table 7.4 - Estimated Volume of $Q_{3\text{month}}$ Storm

Time of Concentration	Q_1 Flow	$Q_{3\text{month}}$ Flow	Total Volume
	see Table C.4	$Q_1 / 2$	$Q_{3\text{month}} * t_c$
5min	$0.06\text{m}^3/\text{s}$	$0.03\text{m}^3/\text{s}$	11m^3

The volume of stormwater to be retained is 11m^3 . The dimensions of the grass swale are summarised in Table 7.5. The location and detail of the proposed grass swale is presented in Figure 7, Appendix A.

Table 7.5 - Dimensions of Bio-Retention System

Parameter		Value
Total Length		40.2m
Width		1.2m
Top Area		48m ²
Bottom Area		40m ²
Filter media depth	Gravel	0.5m
	Top soil transition layer	0.1m
Drainage		90mm Ag Pipe
Above-ground storage depth		0.1m

The Ag Pipe under the grass swale will discharge directly into the gully to the west of the site (as per existing conditions).

7.4.2. Treatment Device – Rainwater Tank

The rainwater tank used on the subject site for stormwater storage will also provide some water quality treatment for the rainwater which falls on the roof catchment.

7.5. MAINTENANCE PLAN

During the operational stage of the development the grass swale should be maintained by periodically replacing the filter media. This should be undertaken when the media becomes completely blocked and stormwater ponds for extended periods after storm events.

8.0 CONCLUSIONS

Development of the site will reduce the volume of site runoff during times of flooding entering the overland flow path located to the west of the subject site.

Any openings to the basement carpark should have a minimum level of 0.5m above the minimum crown level of Waterworks Road.

A rainwater tank will be constructed as outlined in Section 6.3. The tank will be connected to the internal plumbing to provide water for flushing toilets and washing machines, and provide water for outdoor use.

The proposed development includes best management practice stormwater quality improvement devices.



Darren Rogers
BE Civil (Hons), MIE Aust, RPEQ
Director

LIST OF APPENDICES

APPENDIX A – Figures

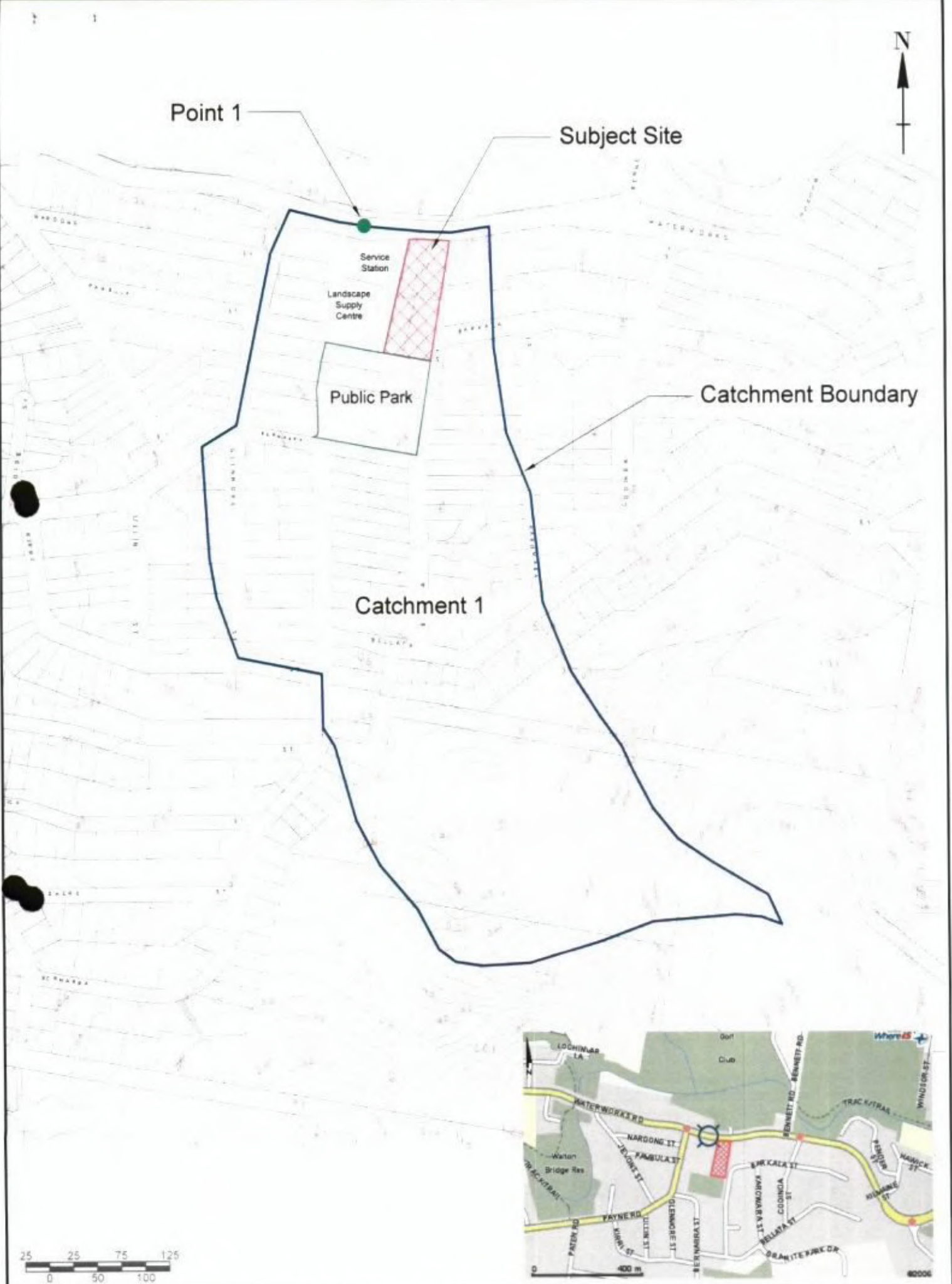
APPENDIX B – Photos of Site

APPENDIX C – Calculations

APPENDIX D – MUSIC Storage Model Data

APPENDIX A

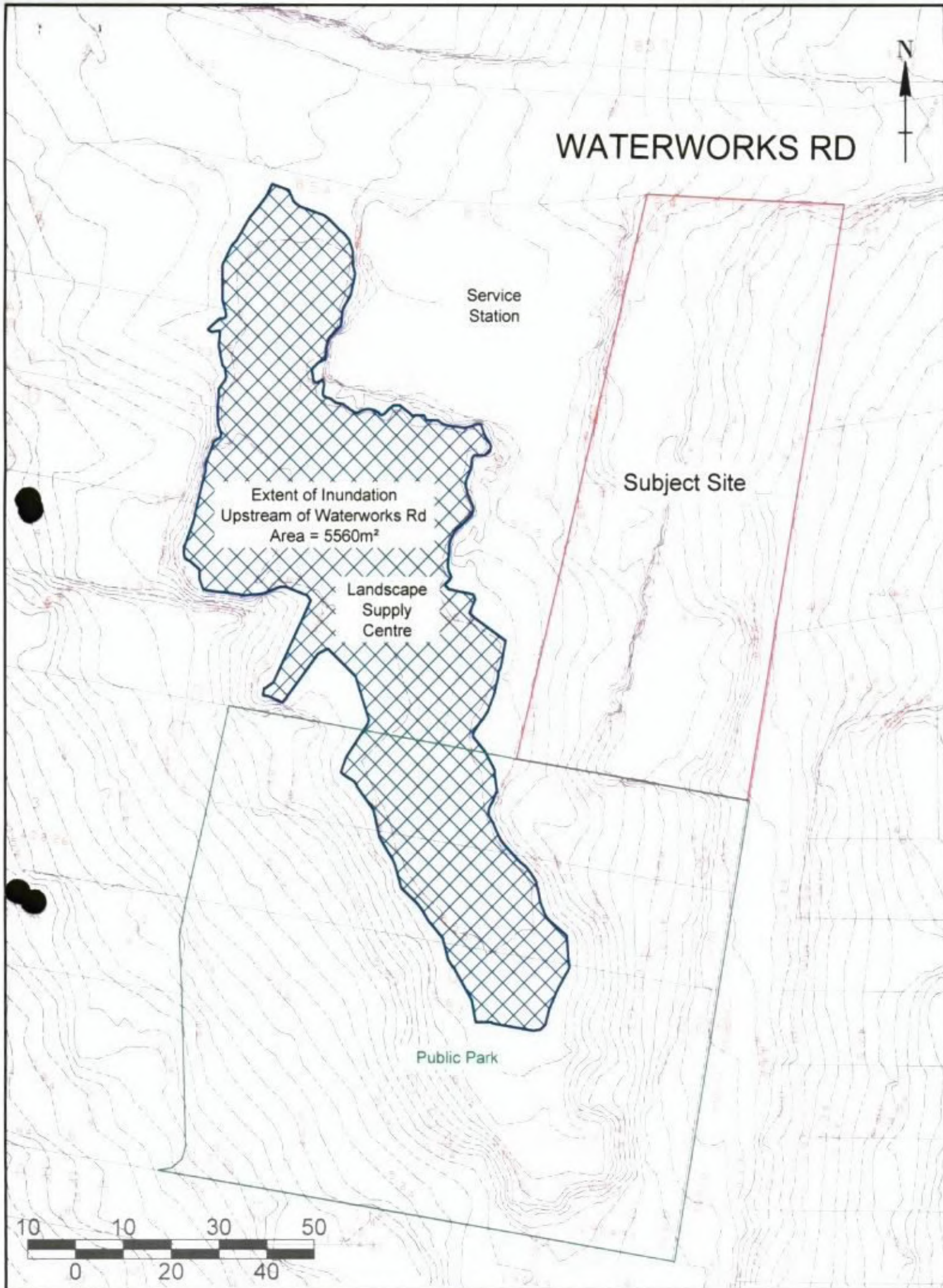
Figures



Job No.	J2712
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Checked	dwr
Date	22-02-07
Scale	1:5,000

Phone (07) 3398 4992
 Fax (07) 3398 4993

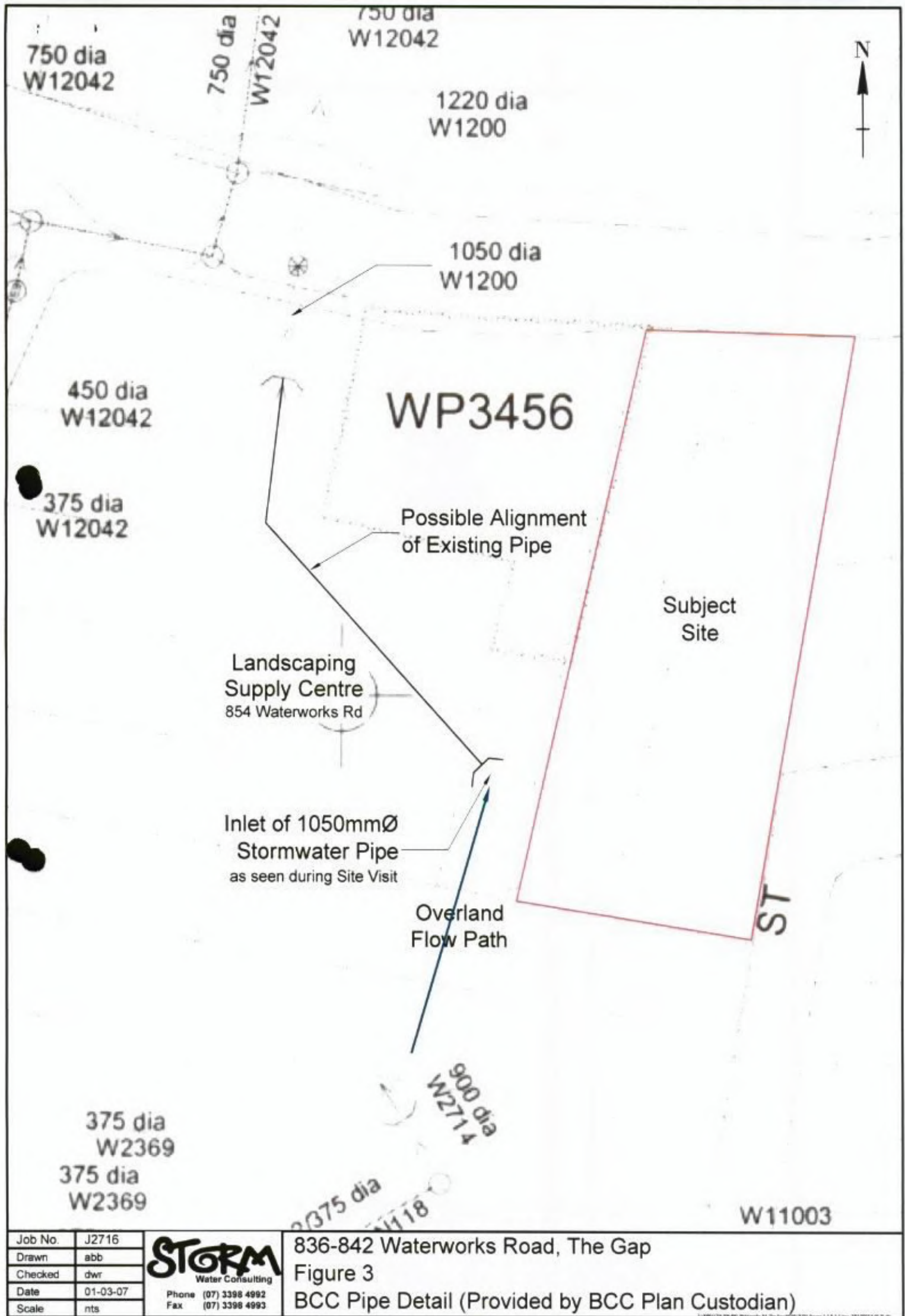
836-842 Waterworks Road, The Gap
 Figure 1
 Location of Site and Catchment Boundary



Job No.	J2716
Drawn	abb
Checked	dwr
Date	02-03-07
Scale	1:1,000

STORM
Water Consulting
Phone (07) 3398 4992
Fax (07) 3398 4993

836-842 Waterworks Road, The Gap
Figure 2
Extent of Inundation Due to Waterworks Road



Job No.	J2716
Drawn	abb
Checked	dwr
Date	01-03-07
Scale	nts

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Water Consulting
Phone (07) 3398 4992
Fax (07) 3398 4993

836-842 Waterworks Road, The Gap

Figure 3

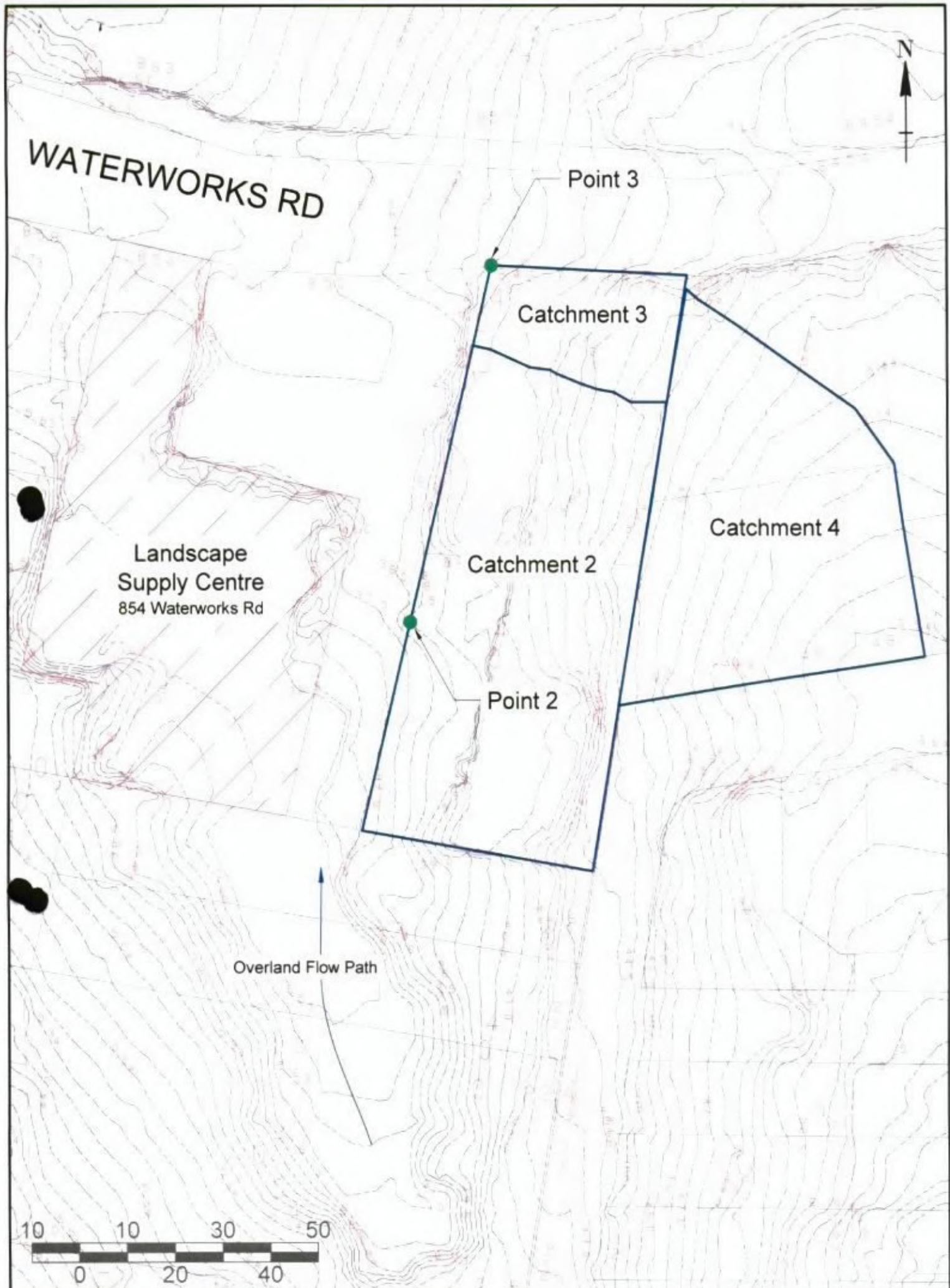
BCC Pipe Detail (Provided by BCC Plan Custodian)



Job No.	J2716
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Checked	dwr
Date	06-02-07
Scale	1:1000

STORM
Water Consulting
Phone (07) 3398 4992
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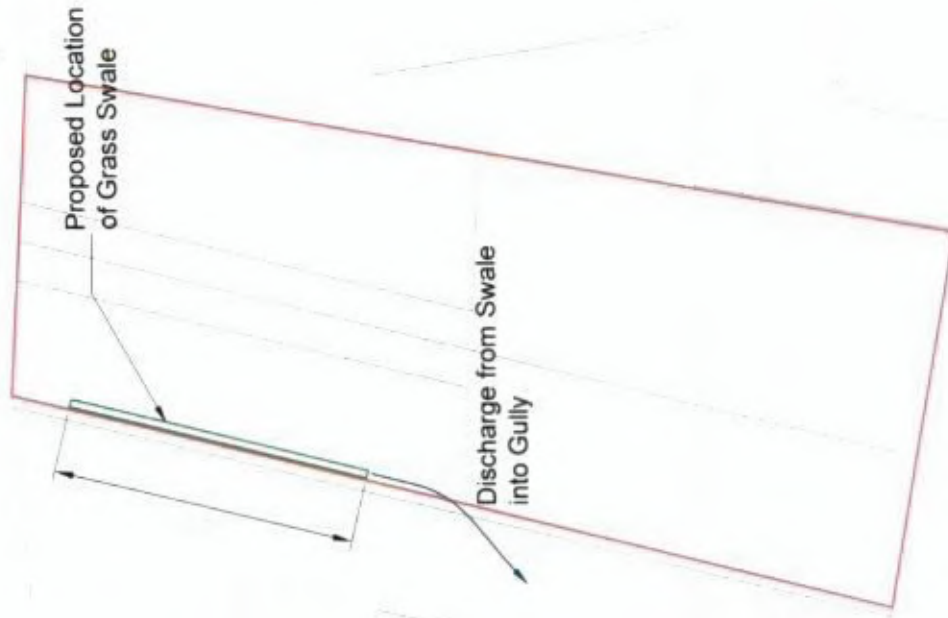
836-842 Waterworks Road, The Gap
Figure 4
Aerial Photograph of Subject Site



Job No.	J2716
Drawn	abb
Checked	dwr
Date	01-03-07
Scale	1:1,000

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836-842 Waterworks Road, The Gap
Figure 5
Detail of Subject Site and Local Catchments



Location of Grass Swale

Scale 1:1,000

Wheel Stops

Driveway

Geo-fabric

Property Boundary

Wall

Section Detail of Grass Swale

Scale 1:10

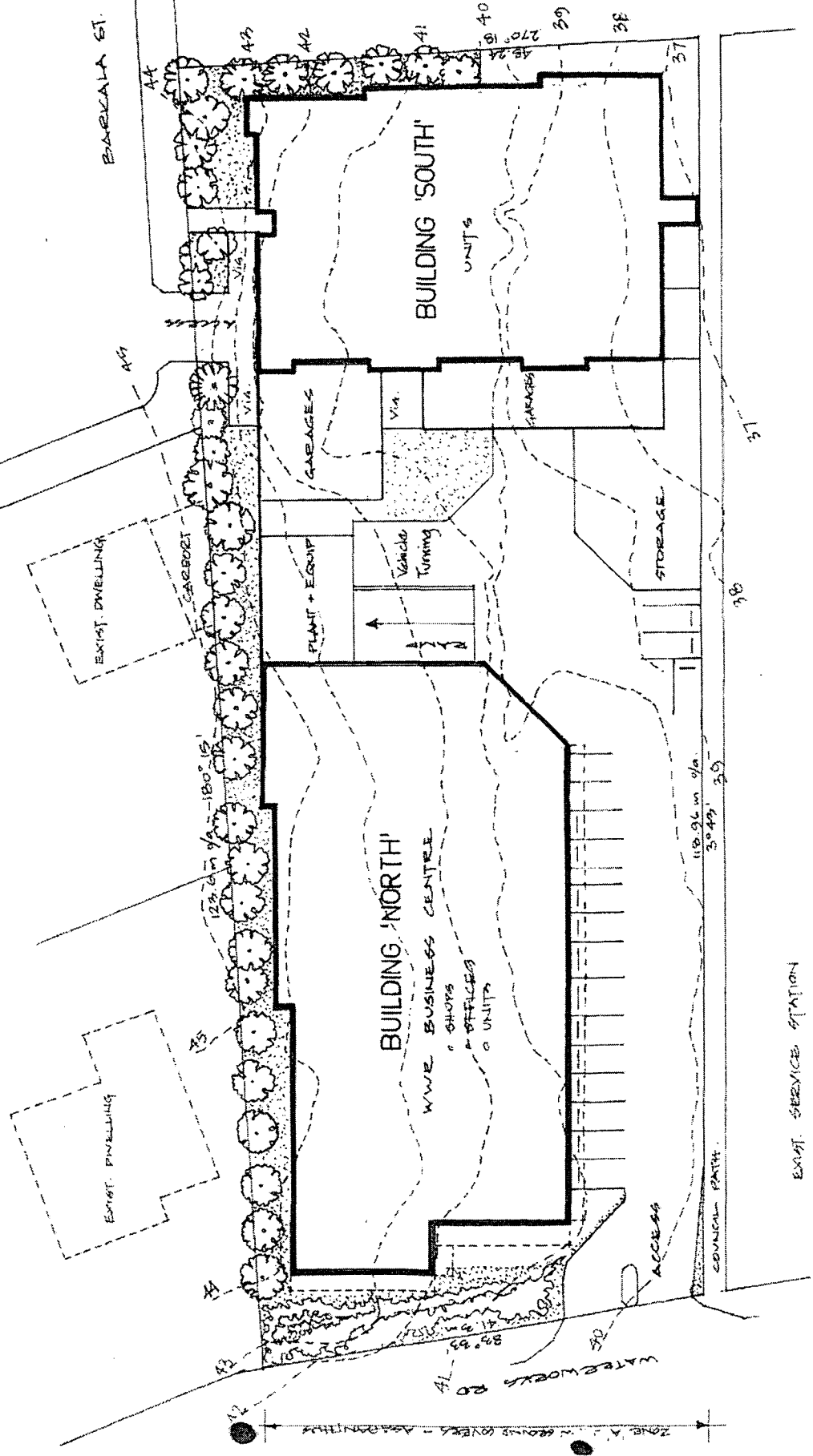
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Checked	dwr
Date	01-03-07
Scale	see above

STORM
Water Consulting
Phone (07) 3386 4992
Fax (07) 3386 4993

836-842 Waterworks Road, The Gap
Stormwater Management Plan

Figure 7
Grass Swale Location and Detail

ZONE 'B' - RESILIENT, SCREEN TREES AND SHADE TOLERANT GROUND COVERS
 B1 BUCKINGHAMIA CELSISSIMA
 B2 BUCKINGHAMIA CELSISSIMA
 B3 BUCKINGHAMIA CELSISSIMA
 ZONE 'C' - FRUIT TREES MAINTAINED FROM
 EXISTING SITE (NO. 842) - MANGO
 AVOCADO, PEACH, APPLE, PEARLIMON,
 LYCHEE



SITE PLAN



EXIST. SERVICES STATION

ARCHITECT
HOLGAR ARCHITECTS
 63 McMillan Rd BROOKFIELD Q 4069
 PH 374 3746 FAX 374 3745
 MOBILE 0414 919 694
 EMAIL holgararchitects.com.au

CLIENT
ZANUTTINI

PROJECT
 MIXED USE DEVELOPMENT AT
 836-842 WATERWORKS ROAD
 THE GAP

TITLE
**SITE PLAN & LANDSCAPE
 CONCEPT PLAN**

Scale	Job No
1:200	70610
Date	Drawn
27.11.06	SK 01
Checked	

COUNCIL PARK

APPENDIX B

Photos of Site



Photo 1 – View of the type of ground cover and vegetation across the site. Photo taken from Waterworks Rd, looking south.



Photo 2 – The inlet works for the 1050mm diameter pipe constructed below 854 Waterworks Rd.

APPENDIX C

Calculations

RATIONAL METHOD CALCULATIONS

Table C 1 a

Project: 836 - 842 Waterworks Rd, The Gap

Location: Point 1 - Total Flow - DS

Comments: Existing Site / Developed Catchment

J2716

Time of Concentration

Upper Catchment Slope

32.0%

50m sheet flow across average grass

8 min

Travel Length

950 metres

Fall

95

Travel Time (Aque)

5 min

Delta for

1.5 min

Time of Concentration

15.5 min

Rainfall Data:

Rainfall Intensity Frequency Duration data for Brisbane City Council

Sub-Areas and Runoff Coefficients									
Areas Included in Calculations									
Area	ha	Exist	Dev	Condition	C10	C10 x A	C10 x A	C10 x A	Area
Site	0.55	0.82	0.87	Existing	0.82	0.45	0.45	0.55	0.55
LR Catchment	13.68	0.78	0.78	Developed	13.68	10.67	10.67	13.68	13.68
Cons Catchment	8.08	0.70	0.70	Developed	8.08	5.65	5.65	8.08	8.08
Site North	0.09	0.87	0.87	Developed	0.70	0.06	0.06	0.09	0.09
Site South	0.45	0.82	0.87	Developed	0.70	0.32	0.32	0.45	0.45
Hardstand	0.24	0.90	0.90	Developed	0.70	0.17	0.17	0.24	0.24
Eastern	0.35	0.78	0.78	Developed	0.70	0.25	0.25	0.35	0.35
Sum	22.30								
Total									
Individual									

Discharge Calculations									
tc									
C100>1		Average		c10	0.000		15.5		
		Area (ha)		0.00					
C100<1		c10 - 2		Average		0.752			
		Area (ha)		22.30					
Total Catchment 22.3 ha									
Depth	ARI	years	Py	Runoff Coefficients		Rainfall (mm/hr)	Discharge		%
				C100>1	C100<1		1	2	
19	1	1	0.80	0.00	0.60	74.3	0.00	2.77	2.77
25	2	2	0.85	0.00	0.64	95.9	0.00	3.80	3.80
32	5	5	0.95	0.00	0.71	123.2	0.00	5.45	5.45
36	10	10	1.00	0.00	0.75	139.7	0.00	6.51	6.51
42	20	20	1.05	0.00	0.79	161.7	0.00	7.91	7.91
49	50	50	1.15	0.00	0.86	191.2	0.00	10.24	10.24
55	100	100	1.20	0.00	0.90	214.2	0.00	11.97	11.97

RATIONAL METHOD CALCULATIONS

Table C 2 a

Project: 836 - 842 Waterworks Rd, The Gap

Location: Point 2 - Total Flow - DS

J2716

Existing Site

Comments:

Time of Concentration

Upper Catchment Slope

8.6%

70m direct flow across poorly grassed

10 min

Travel Length

70 metres

Fall

6 metres

Travel Time (Ague)

6 min

Delta for

10.0 min

Sub-Areas and Runoff Coefficients		Areas Included in Calculations				Separate c100 > 1.0 and c100 < 1.0			
Area	ha	Exist	Dev	Condition	Area	C10	C10 x A	C10 x A	Area
Site	0.45	0.82	0.87						
Site North	0.09	0.70	0.70						
Site South	0.45	0.82	0.87	Existing	0.45	0.82	0.37	0.37	0.45
Handstand	0.24	0.90	0.90						
Eastern	0.35	0.78	0.78						
					0.45				
					Sum		0.37	0.00	0.45
					Total		0.820	0.371	0.453
					Individual		0.820	0.371	0.453

Discharge Calculations			
tc	10.0		
C100>1	Average	c10	0.000
		Area (ha)	0.45
C100<1	c10 - 2	Average	0.820
		Area (ha)	0.45

Depth	mm	ARI	Py	Runoff Coefficients	Rainfall	Discharge	
						1	2
15	1	0.80	0.00	0.66	89.7	0.00	0.07
19	2	0.85	0.00	0.70	115.5	0.00	0.10
25	5	0.95	0.00	0.78	147.5	0.00	0.14
28	10	1.00	0.00	0.82	166.6	0.00	0.17
32	20	1.05	0.00	0.86	192.1	0.00	0.21
38	50	1.15	0.00	0.94	226.6	0.00	0.27
42	100	1.20	0.00	0.98	253.2	0.00	0.31

Discharge		%	
ARI's	m ³ /s	1st	2nd
1st	0.019	25%	
2nd	0.030	40%	
3rd	0.037	50%	
4th	0.044	60%	
6th	0.056	75%	
9th	0.067	90%	
12th	0.074	100%	

RATIONAL METHOD CALCULATIONS

Table C 2 b

Project: 836 - 842 Waterworks Rd, The Gap

Location: Point 2 - Total Flow - DS

J2716

Developed Site

Comments:

Time of Concentration

Upper Catchment Slope

8.6%

10m direct flow across poorly grassed

10 min

Travel Length

70 metres

Fall

6 metres

Travel Time (Ague)

6 min

Delta for

10.0 min

Sub-Areas and Runoff Coefficients		Areas Included in Calculations				Separate c100 > 1.0 and c100 < 1.0			
Area	ha	Exist	Dev	Condition	Area	C10	C10 x A	C10 x A	Area
Site	0.55	0.82	0.87						
Site North	0.08	0.70	0.70						
Site South	0.45	0.82	0.87	Developed	0.45	0.87	0.39	0.39	0.45
Handstand	0.24	0.90	0.90						
Eastern	0.35	0.78	0.78						
					0.45				
					Sum		0.00	0.39	0.45
					Total		0.870	0.394	0.453
					Individual		0.870	0.394	0.453

Discharge Calculations			
tc	10.0		
C100>1	Average	c10	0.870
		Area (ha)	0.45
C100<1	c10 - 2	Average	0.000
		Area (ha)	0.00

Depth	mm	ARI	Py	Runoff Coefficients	Rainfall	Discharge	
						1	2
15	1	0.80	0.70	0.00	89.7	0.08	0.08
19	2	0.85	0.74	0.00	115.5	0.11	0.11
25	5	0.95	0.83	0.00	147.5	0.15	0.15
28	10	1.00	0.87	0.00	166.6	0.18	0.18
32	20	1.05	0.91	0.00	192.1	0.22	0.22
38	50	1.15	1.00	0.00	226.6	0.29	0.29
42	100	1.20	1.00	0.00	253.2	0.32	0.32

Discharge		%	
ARI's	m ³ /s	1st	2nd
1st	0.020	25%	
2nd	0.031	40%	
3rd	0.039	50%	
4th	0.047	60%	
6th	0.059	75%	
9th	0.071	90%	
12th	0.079	100%	

Preliminary Detention Basin Calculations

Table C 2 c									
Developed Catchment Time of Concentration									
ARI	Target	ARI	Target	ARI	Target	ARI	Target	ARI	Target
years	0.07	0.10	0.14	0.17	0.21	0.27	0.31	0.37	0.45
1	0.07	0.10	0.14	0.17	0.21	0.27	0.31	0.37	0.45
2	0.10	0.14	0.17	0.21	0.27	0.31	0.37	0.45	0.55
5	0.14	0.17	0.21	0.27	0.31	0.37	0.45	0.55	0.65
10	0.17	0.21	0.27	0.31	0.37	0.45	0.55	0.65	0.75
20	0.21	0.27	0.31	0.37	0.45	0.55	0.65	0.75	0.85
50	0.27	0.31	0.37	0.45	0.55	0.65	0.75	0.85	0.95
100	0.31	0.37	0.45	0.55	0.65	0.75	0.85	0.95	1.05

Project: 836 - 842 Waterworks Rd, The Gap	
Location: Hardstand Areas Flowing Toward Grass Sw	
Comments:	Developed Site - Southern Part

J2716

Time of Concentration

Upper Catchment Slope	2.0%	
70m sheet flow across poorly grassed	10	min
Travel Length	70	metres
Fall	1	metres
Travel Time (Argue)		min
Delta for		
Time of Concentration	5.0	min

Rainfall Data:

Rainfall Intensity Frequency Duration data for; Brisbane City Council

Sub-Areas and Runoff Coefficients

	Area	C10		Areas included in Calculations				Separate c100 > 1.0 and c100 < 1.0					
	ha	Exist	Dev	Condition	Area	C10	C10 x A	C10	C10	C10 x A	C10 x A	Area	Area
Site	0.45	0.82	0.87										
Cons Catchment	8.08	0.70	0.70										
Site North	0.09	0.87	0.87										
Site South	0.45	0.82	0.87										
Hardstand	0.24	0.90	0.90	Developed	0.24	0.90	0.21		0.90		0.21		0.24
Eastern	0.35	0.78	0.78										
					0.24		Sum			0.00	0.21	0.00	0.24
							Total		0.900		0.212		0.235
							Individual	0.000	0.900	0.000	0.212	0.000	0.235

Discharge Calculations

tc		5.0
C100>1	Average	c10 0.900
	Area (ha)	0.24
C100<1 c10 - 2	Average	0.000
	Area (ha)	0.00

Total Catchment
0.24 ha

Depth mm	ARI years	Fy	Runoff Coefficients		Rainfall (mm/hr)	Discharge m³/s		
			C100>1	C100<1		1	2	Total
10	1	0.80	0.72	0.00	117.4	0.06	0.00	0.06
13	2	0.85	0.77	0.00	150.9	0.08	0.00	0.08
16	5	0.95	0.86	0.00	191.3	0.11	0.00	0.11
18	10	1.00	0.90	0.00	215.3	0.13	0.00	0.13
21	20	1.05	0.95	0.00	246.4	0.15	0.00	0.15
24	50	1.15	1.00	0.00	291.0	0.19	0.00	0.19
27	100	1.20	1.00	0.00	324.5	0.21	0.00	0.21

Frequent ARI's	Discharge m ³ /s	% of Q _i
1mth	0.014	25%
2mth	0.022	40%
3mth	0.028	50%
4mth	0.033	60%
6mth	0.041	75%
9mth	0.050	90%
12mth	0.055	100%

Project: 836 - 842 Waterworks Rd, The Gap

J2716

Location: Catchment Flowing Toward Eastern Site Bdr

Comments:

Developed Catchment

Time of Concentration

Upper Catchment Slope	6.0%	
50m sheet flow across poorly grassed	9	min
Travel Length	20	metres
Fall	1.5	metres
Travel Time (Argue)	0.5	min
Delta for	1.0	
Time of Concentration	9.5	min

Rainfall Data:

Rainfall Intensity Frequency Duration data for; Brisbane City Council

Sub-Areas and Runoff Coefficients

	Area	C10		Areas included in Calculations				Separate c100 > 1.0 and c100 < 1.0					
	ha	Exist	Dev	Condition	Area	C10	C10 x A	C10	C10	C10 x A	C10 x A	Area	Area
Site	0.45	0.82	0.87										
Cons Catchment	8.08	0.70	0.70										
Site North	0.09	0.87	0.87										
Site South	0.45	0.82	0.87										
Hardstand	0.24	0.90	0.90										
Eastern	0.35	0.78	0.78	Developed	0.35	0.78	0.27	0.78		0.27		0.35	
					0.35		Sum			0.27	0.00	0.35	0.00
							Total		0.780		0.274		0.352
							Individual	0.780	0.000	0.274	0.000	0.352	0.000

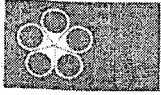
Discharge Calculations

tc		9.5
C100>1	Average	c10 0.000
	Area (ha)	0.00
C100<1	c10 - 2 Average	0.780
	Area (ha)	0.35

Total Catchment
0.35 ha

Depth mm	ARI years	Fy	Runoff Coefficients		Rainfall (mm/hr)	Discharge m³/s		
			C100>1	C100<1		1	2	Total
15	1	0.80	0.00	0.62	91.6	0.00	0.06	0.06
19	2	0.85	0.00	0.66	118.0	0.00	0.08	0.08
24	5	0.95	0.00	0.74	150.4	0.00	0.11	0.11
27	10	1.00	0.00	0.78	169.9	0.00	0.13	0.13
31	20	1.05	0.00	0.82	195.8	0.00	0.16	0.16
37	50	1.15	0.00	0.90	230.9	0.00	0.20	0.20
41	100	1.20	0.00	0.94	258.0	0.00	0.24	0.24

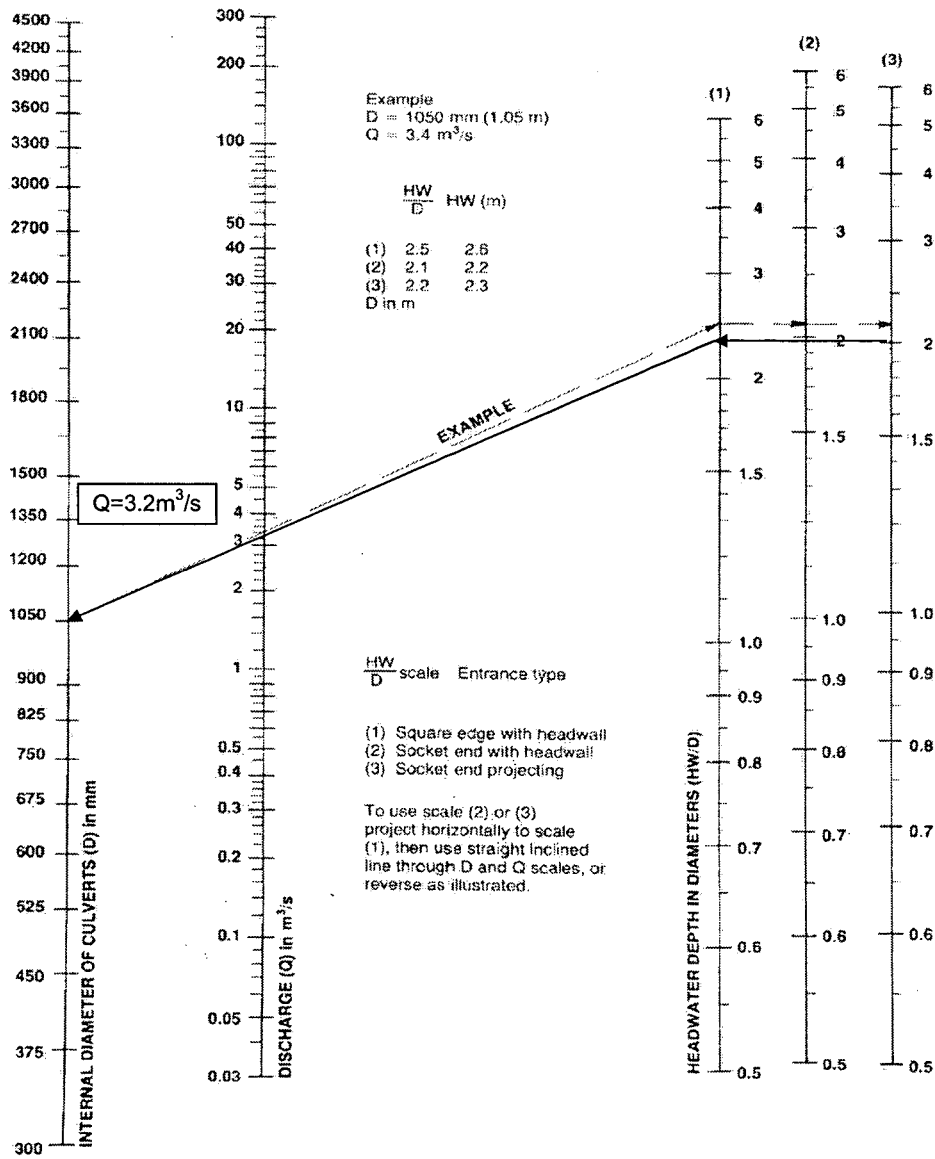
Frequent ARI's	Discharge m ³ /s	% of Q ₁
1mth	0.014	25%
2mth	0.022	40%
3mth	0.028	50%
4mth	0.034	60%
6mth	0.042	75%
9mth	0.050	90%
12mth	0.056	100%



Graph C.1

HYDRAULICS OF PRECAST CONCRETE CONDUITS

SECTION 3



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS
WITH INLET CONTROL

FIGURE 3.3
ADAPTED FROM [3.4]

APPENDIX D

MUSIC Storage Model Data

Site Runoff While Exceeding Pipe Capacity

Flooding occurs when the catchment runoff exceeds the capacity of the 1050mm diameter pipe, shown in Figure 1 as the Threshold ($3.2\text{m}^3/\text{s}$).

The method used to determine the site's contribution is to look at the runoff from the Total Runoff and from the Site Runoff. The MUSIC models used to calculate runoff (001 to 003) are summarised to identify the flooding events. This is done in two steps, as described below.

Step 1

Isolate the time periods when the flow exceeds the pipe capacity (6:18 till 6:24)

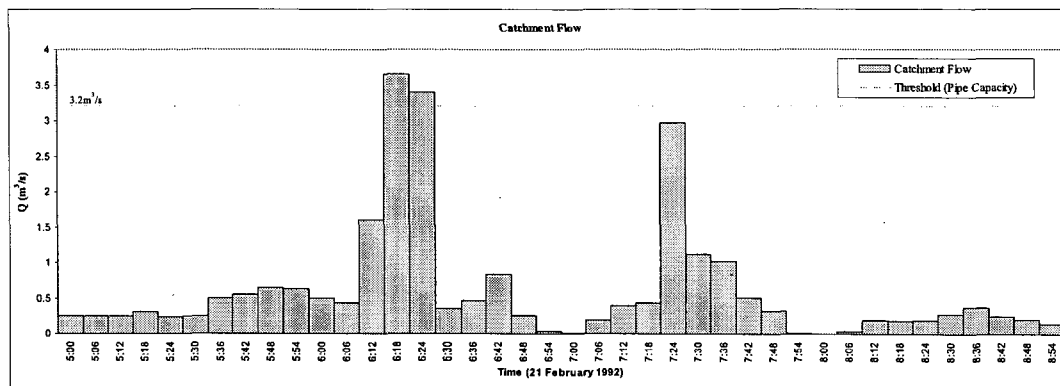


Figure 1 - Total Catchment Flow

Step 2

For each of the time periods from Step 1, the sum of the volume of site runoff is calculated ($0.562 + 0.525 = 1.087$).

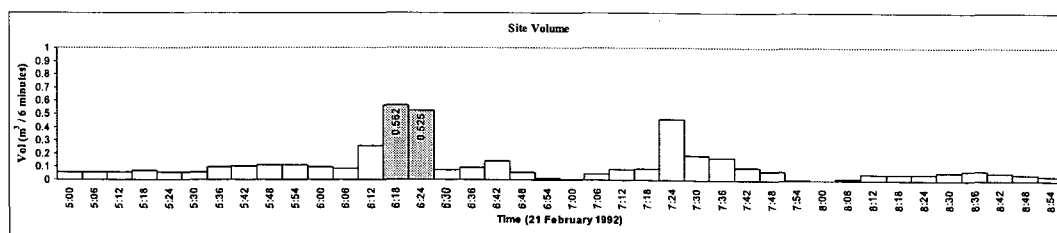
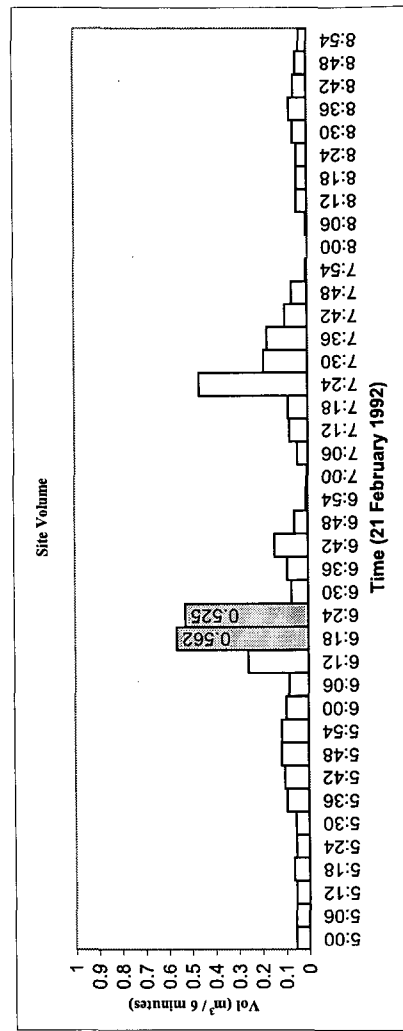
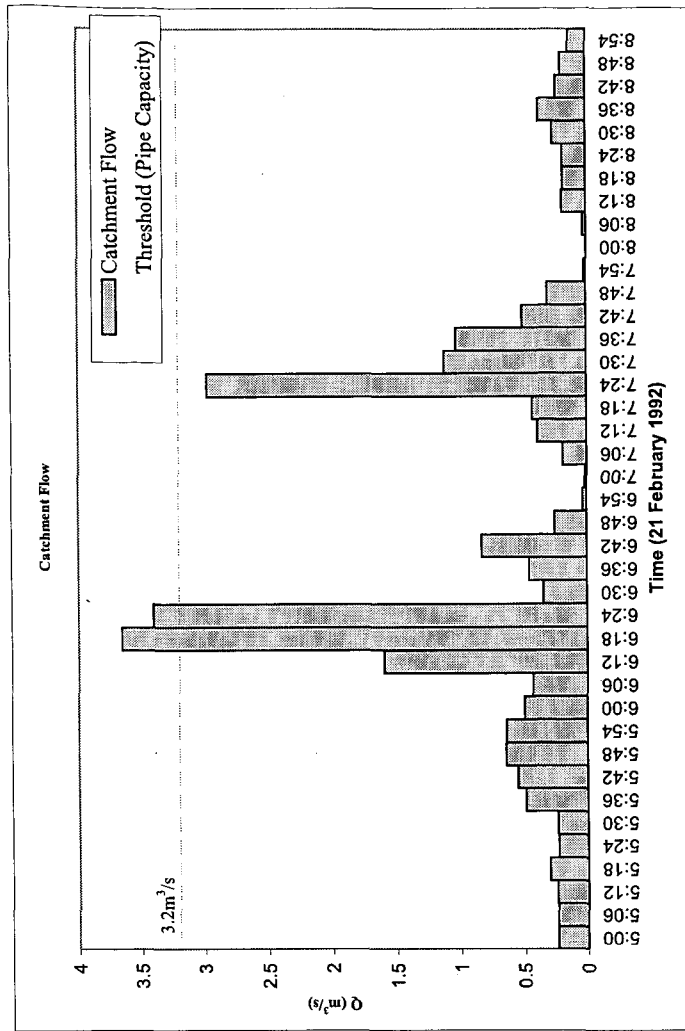


Figure 2 - Site Catchment Volume

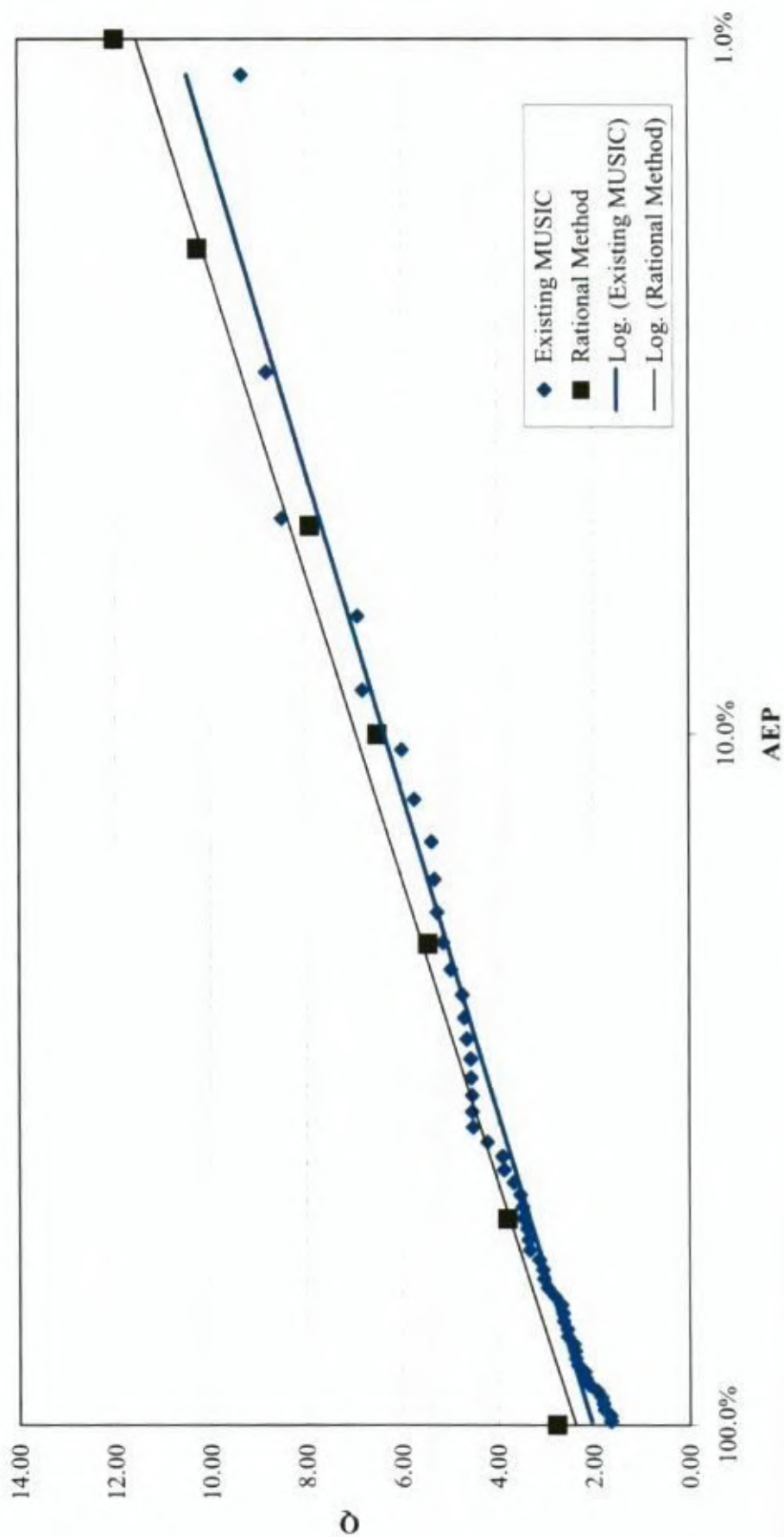
The summary events are correlated and presented in Graphs D.2 and D.3.a to D.3.b.

21-Feb-92	Catchment Flow	Catchment Volume	Threshold (Pipe Capacity)	Site Flow	Site Volume
5:00	0.238401	1.430407	3.2	0.009382	0.056290
5:06	0.238401	1.430407	3.2	0.009382	0.056290
5:12	0.244596	1.467575	3.2	0.009535	0.057209
5:18	0.306543	1.839258	3.2	0.011065	0.066392
5:24	0.232206	1.393239	3.2	0.009229	0.056372
5:30	0.238401	1.430407	3.2	0.009382	0.056290
5:36	0.492385	2.954308	3.2	0.015657	0.093942
5:42	0.548137	3.288823	3.2	0.017034	0.102207
5:48	0.641058	3.846348	3.2	0.019330	0.115982
5:54	0.634863	3.809180	3.2	0.019177	0.115064
6:00	0.498579	2.991477	3.2	0.015810	0.094860
6:06	0.430438	2.582625	3.2	0.014126	0.084759
6:12	1.595045	9.570271	3.2	0.042901	0.257405
6:18	3.651693	21.910157	3.2	0.093715	0.562292
6:24	3.397709	20.386257	3.2	0.087440	0.524640
6:30	0.349906	2.099437	3.2	0.012137	0.072820
6:36	0.461411	2.768466	3.2	0.014892	0.089350
6:42	0.826900	4.961398	3.2	0.023922	0.143532
6:48	0.256985	1.541911	3.2	0.009841	0.059045
6:54	0.031079	0.186474	3.2	0.001576	0.009455
7:00	0.014166	0.084994	3.2	0.000736	0.004416
7:06	0.189146	1.134874	3.2	0.007698	0.046188
7:12	0.387074	2.322447	3.2	0.013055	0.078330
7:18	0.430438	2.582625	3.2	0.014126	0.084759
7:24	2.970274	17.821642	3.2	0.076879	0.461275
7:30	1.118052	6.708310	3.2	0.031116	0.186693
7:36	1.025131	6.150785	3.2	0.028820	0.172919
7:42	0.504774	3.028645	3.2	0.015963	0.095778
7:48	0.312738	1.876427	3.2	0.011218	0.067310
7:54	0.015777	0.094862	3.2	0.000828	0.004967
8:00	0.001275	0.007653	3.2	0.000001	0.000008
8:06	0.027127	0.162764	3.2	0.001423	0.008537
8:12	0.189146	1.134874	3.2	0.007698	0.046188
8:18	0.181242	1.087454	3.2	0.007392	0.044352
8:24	0.185194	1.111164	3.2	0.007545	0.045270
8:30	0.269375	1.616249	3.2	0.010147	0.060882
8:36	0.368490	2.210942	3.2	0.012596	0.075575
8:42	0.238401	1.430407	3.2	0.009382	0.056290
8:48	0.197049	1.182294	3.2	0.008004	0.048025
8:54	0.137774	0.826644	3.2	0.005708	0.034250

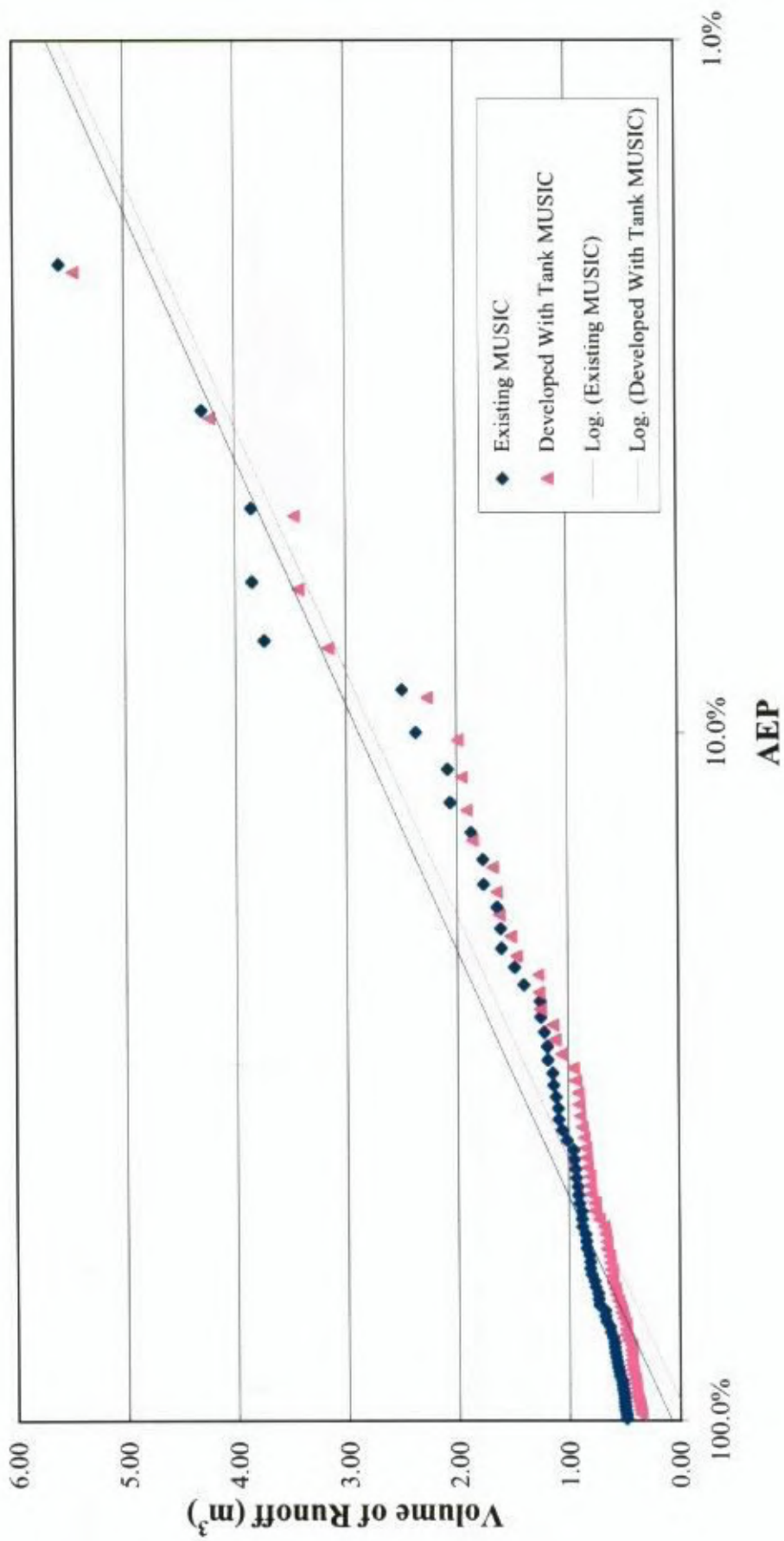


ID	Start Date	Exceeds Threshold Date	End Date	Mins Exceeds Threshold	Pre Threshold Site Volume	Post Threshold Site Volume	Total Site Volume	Peak Date	Peak Flow	Financial Year
75	10 Feb 92 00:36	21 Feb 92 06:18	21 Feb 92 06:24	12	9.114905	1.086932	10.201837	21 Feb 92 06:18	3.651693	1992

Flood Frequency Analysis
Annual Peak Flows
Graph D.1

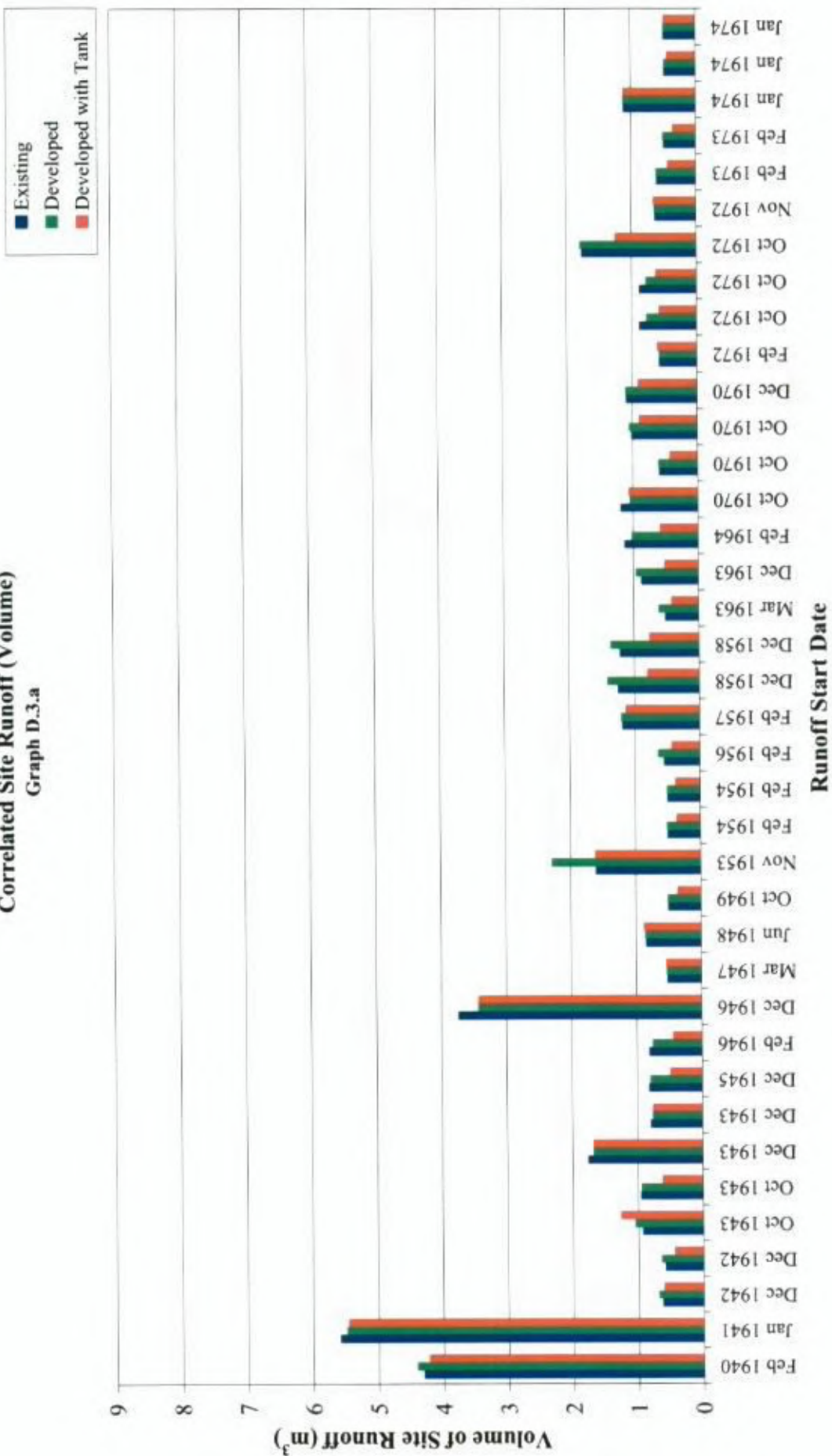


Flood Frequency Analysis
 Site Volume per Event
 Graph D.2

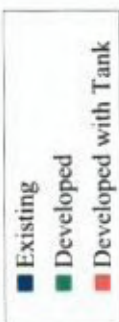


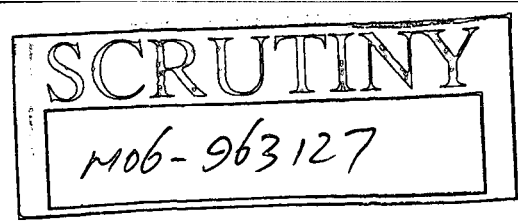
Correlated Site Runoff (Volume)

Graph D.3.a



Graph D.3.b





**PROPOSED MIXED USE DEVELOPMENT AT 836 – 842 WATERWORKS ROAD, THE GAP.
COMPLIANCE WITH BRISBANE CITY COUNCIL LANDSCAPE CODE.**

STREETSCAPE, CHARACTER & PLANTING

PERFORMANCE CRITERIA	PROPOSED SOLUTION
P1 Landscaping work must create a sense of place or specific character , ensure functionality and provide long term visual impact .	A1.1 Suggested plants will provide visual interest through form, texture and mix. A1.2 Existing Street has mix of Commercial, retail and residential dwellings. Selected plants species will be similar, to blend into streetscape.
P2 Landscaping must be consistent with the established landscape character of the area and accommodate the retention of existing vegetation , including street trees	A2.1 Several significant Eucalypts of maximum 16m height and 8m spread require removal to accommodate new buildings (refer Plan) Several Fruit trees and ornamentals including a Pony Tail Plant and several mature Dracaenas will be transplanted to alternative positions on the site (refer Plan) A2.2 There are no existing street trees to the site's frontage. A2.3 Proposed plants will blend into existing character of area.
P3 Landscaping along residential site boundaries must maintain privacy between the adjoining residences and enhance the visual appearance of the development	A3.1 Side boundaries are landscaped with screen planting , columnar trees and palms for added height. A3.2 Landscaping along street frontage consists of shade trees where suitable, screening shrubs and extensive native ground covers. A3.3 Landscaping to rear boundary (adjacent to bush/park land) consists of a row of large screening shrubs and columnar trees, plus small shrubs and ground covers.

P4 Landscaping along non-residential site boundaries must screen incompatible activities and enhance the visual appearance of the development.	A4.1 All boundaries are landscaped with a mix of shade trees, columnar trees and screen shrubs where room permits. Appropriate screening is provided to all residential boundaries.
P5 Landscaping within landscape and recreation areas must be usable and well designed .	A5.1 Columnar trees with under planting have been provided in common recreational areas. Planting is in large square planters in order to facilitate appropriate growth while maximizing recreational space. A5.2 Screen and tree planting in private courtyards will enhance visual amenity and encourage use of outdoor areas.
P6 Adequate shading must be provided for car parking areas , driveways and internal roadways through landscaping	A6.1 Driveway entries are landscaped with shade trees and under story planting.
P7 Plant selection must address the functional issues of the development including : -screening and buffering -street presentation -shading	P7.1 Species are selected in accordance with the Planting Species Planning Policy.

SCREENING AND BUFFERING

PERFORMANCE CRITERIA	PROPOSED SOLUTION
P8 Overlooking into private courtyards and neighbouring residential dwellings must be minimised	P8.1 Decorative awnings and screens overlooking windows and suggested potted plants. P8.2 Landscaped areas to boundaries as per A3.1, A3.2 and A3.3 .
P9 Acoustic barriers and long fences along frontages within the development must be screened	A9.1 N/A
P10 The amenity of a development must be enhanced through the screening of undesirable features	P10.1 Fences are planted with screen planting.
P11 The ecological values of a site adjoining land must be enhanced	P11.1 Adjacent property to rear of site is bush/ park land and selected species within the site include natives and complimentary species to enhance ecological value.

MAINTENANCE AND DRAINAGE

PERFORMANCE CRITERIA	PROPOSED SOLUTION
P12 Stormwater harvesting must be maximised and any adverse impacts of stormwater minimised	P12.1 Terraced gardens, plant selection and the use of field gullies and ag drains limit stormwater runoff .
P13 Landscaping work must be capable of efficient and effective maintenance	P13.1 Full access to both sides of site . P13.2 Provision of irrigation system to all gardens. P13.3 Hose cock provision to each courtyard . P13.4 Paver mowing / garden edge to turf areas P13.5 No use of annuals or perennials . P13.6 Use of clean trunked palms .

SAFETY

PERFORMANCE CRITERIA	PROPOSED SOLUTION
P14 Tree location and species selection must accommodate vehicle and pedestrian sight lines	P14.1 position of large trees do not impede sight lines .
P15 The landscape design must enhance personal safety and reduce the potential for and fear of crime and vandalism	P15.1 Restricted access through fences and gates. P15.2 Main paths are hard surfaces and usable with out fear of slip or trip. P15.3 Raised balconies and windows allow visibility to all garden areas.

UTILITIES AND SERVICES

PERFORMANCE CRITERIA	PROPOSED SOLUTION
P16 The location and type of planting must not compromise the function and accessibility of services and facilities	P16.1 Access to both sides boundaries and position of plants enables this.

Appendix F – BCC Confirmation of Stormwater LPD Route

Oliver Suter | Aspect Architects & Project Managers

From: Jason Dang <J.Dang@bornhorstward.com.au>
Sent: Wednesday, 22 November 2023 9:11 AM
To: Oliver Suter | Aspect Architects & Project Managers; Mark McErvale | Aspect Architects & Project Managers
Subject: FW: 842 Waterworks Road The Gap - A006345436
Attachments: RFI DRAWINGS FLTNreduced.pdf

Hi Oliver,

See below confirmation of the stormwater outcome.

Regards,

Jason Dang
Associate

**BORNHORST
+ WARD**

Bornhorst+Ward

D. +61 (07) 3013 4636
A. L14, 133 Mary Street, Brisbane City, QLD 4000
E. J.Dang@bornhorstward.com.au

From: Timothy Wrafter <Timothy.Wrafter@brisbane.qld.gov.au>
Sent: Tuesday, November 21, 2023 4:51 PM
To: Jason Dang <J.Dang@bornhorstward.com.au>
Cc: Richard Welch <Richard.Welch@brisbane.qld.gov.au>; Leanne Green <Leanne.Green@brisbane.qld.gov.au>
Subject: RE: 842 Waterworks Road The Gap - A006345436

Hi Jason,

Your proposal for LPD is supported in principle.

Regards
Tim.

Tim Wrafter
Engineer
Specialist Services | Development Services
City Planning and Sustainability | **BRISBANE CITY COUNCIL**

Brisbane Square | Level 13, 266 George Street, Brisbane, Qld 4000
Phone: +61-7-3403 8888
Email: tim.wrafter@brisbane.qld.gov.au



SECURITY LABEL: OFFICIAL

From: Jason Dang <J.Dang@bornhorstward.com.au>
Sent: Friday, 17 November 2023 10:36 AM
To: Timothy Wrafter <Timothy.Wrafter@brisbane.qld.gov.au>
Cc: Leanne Green <Leanne.Green@brisbane.qld.gov.au>; Khai Nguyen <kh.nguyen@bornhorstward.com.au>
Subject: RE: 842 Waterworks Road The Gap - A006345436

This email originates from outside of Brisbane City Council.

Hi Tim,

Please see attached sketch of the stormwater outlet location.

Could we get email confirmation from you that this is agreed in principle, and we will organise survey of the area to produce more detailed plans.

Thanks,

Jason Dang
Associate

**BORNHORST
+ WARD**

Bornhorst+Ward

D. +61 (07) 3013 4636
A. L14, 133 Mary Street, Brisbane City, QLD 4000
E. J.Dang@bornhorstward.com.au

From: Timothy Wrafter <Timothy.Wrafter@brisbane.qld.gov.au>
Sent: Wednesday, November 8, 2023 1:25 PM
To: Jason Dang <J.Dang@bornhorstward.com.au>
Cc: Leanne Green <Leanne.Green@brisbane.qld.gov.au>
Subject: 842 Waterworks Road The Gap - A006345436

Hi Jason,

As discussed, a possible location for the discharge is adjacent to the headwall under the footpath through the park as discussed.

Please refer to the attached photo.

If you could prepare a sketch along those lines, we could take it to the asset section of Council to see if it meets their approval.

Regards
Tim

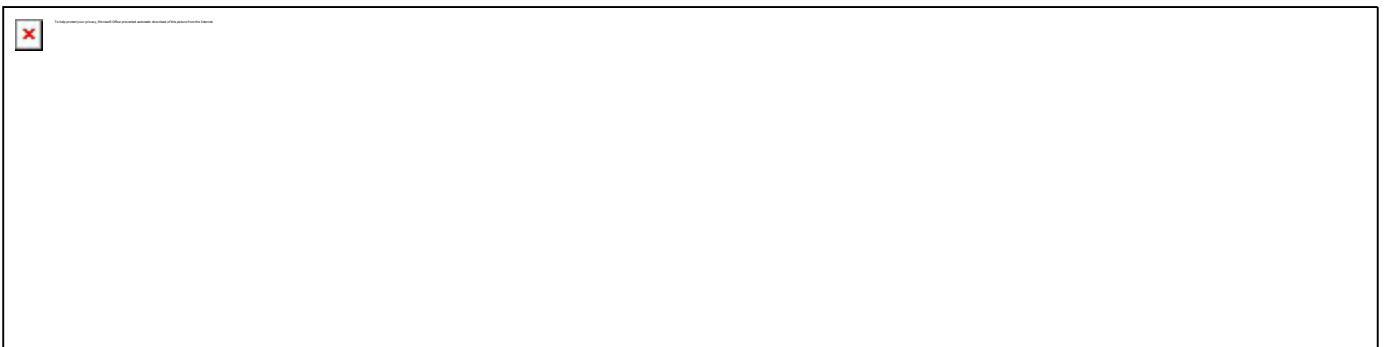
Tim Wrafter
Engineer
Specialist Services | Development Services
City Planning and Sustainability | **BRISBANE CITY COUNCIL**

Brisbane Square | Level 13, 266 George Street, Brisbane, Qld 4000
Phone: +61-7-3403 8888
Email: tim.wrafter@brisbane.qld.gov.au



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OUTLET STORMWATER
PIPE FROM THE SITE

STONE PITCHED
SCOUR PROTECTION
AS PER BCC STD DRG
BSD-8102

**BORNHORST
+WARD**

+61 (7) 3013 4699 www.bornhorstward.com.au

PROJECT

840 WATERWORKS ROAD
THE GAP

SUBJECT

STORMWATER OUTLET

PROJECT No.

22119

DRAWING No.

SK-001

REVISION

A

0 10 20 30 40 50

ORIGINAL SIZE A3