Gilead

Stormwater Management Strategy

Prepared for Lendlease Communities (Figtree Hill)

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Document Information

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Executive Summary

Greater Macarthur has been identified as Growth Area by the NSW Government and will provide for 15,000 new homes to the broader south Campbelltown region. Lendlease's landholding at Gilead has been identified as a Priority Precinct and will make the first contribution to housing supply in the region of approximately 3,300 new homes, retail centre and education facilities.

Importantly, it will secure key conservation outcomes including the establishment of linked koala and fauna corridors between the Georges River and Nepean River.

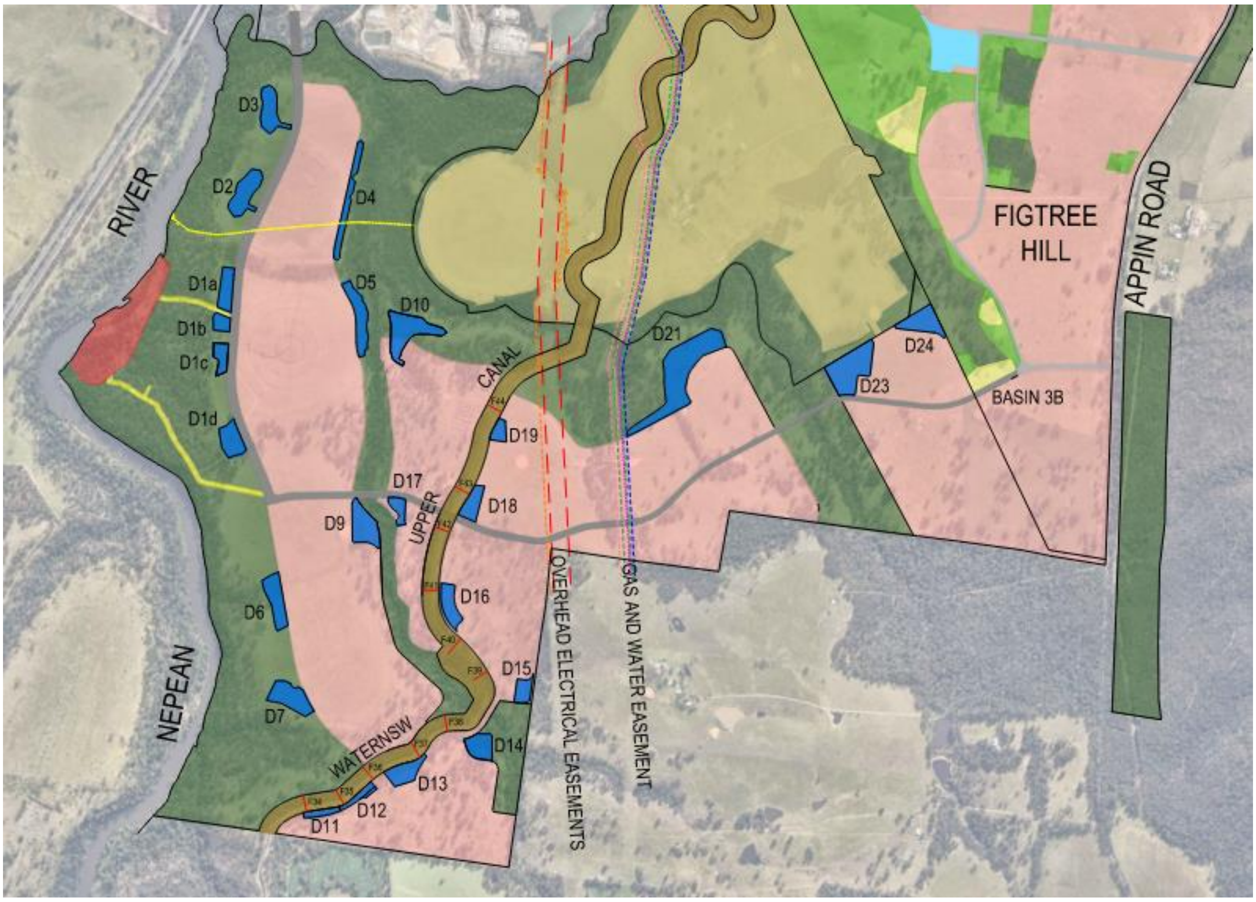
To facilitate both the housing and conservation outcomes for the site, a Planning Proposal is being prepared to rezone a portion of the site known as Gilead under the State Environmental Planning Policy (Precincts – Western Parkland City) 2021. The Planning Proposal will establish the Urban Development Zone for land capable of development and introduce a C2 Environmental Conservation zone for land containing key fauna habitat to be retained as well as land that native bushland is to be reconstructed. This report specifically addresses the stormwater management strategy and has been used to shape and inform the Planning Proposal and associated development outcomes.

The table below summarises the outcomes of this Strategy and demonstrates that surface areas nominated for stormwater management infrastructure at this strategic planning phase is capable of supporting the Gilead development.

This infrastructure is proposed to be located within land identified for urban development and in areas marked for conservation that are currently clear of any significant vegetation due to previous agricultural uses. Where the infrastructure is located within conservation areas, an appropriate level of revegetation is to occur to ensure that it provides a stormwater management function as well as a contribution towards the conservation outcomes in Gilead.

Basin ID	Modelled Surface Area (Bio-retention + OSD) (m^2)	Total Infrastructure Area Required (Modelled Surface Area + 50%) (m^2)	Surface Area Provided for Capability Assessment (m^2)
Basin D1a	2,990	4,500	7,000
Basin D1b	2,120	3,180	3,400
Basin D1c	2,780	4,170	4,650
Basin D1d	3,525	5,300	8,150
Basin D2	3,690	5,600	11,150
Basin D3	4,730	7,100	9,320
Basin D4	260	400	N/A
Basin D5	5,150	7,800	10,700
Basin D6	3,345	5,100	10,090
Basin D7	5,885	8,900	11,300
Basin D9	5,420	8,200	11,590
Basin D10	8,455	12,700	16,120
Basin D11	630	1,000	2,830
Basin D12	1,965	3,000	3,440
Basin D13	3,350	5,100	8,040
Basin D14	4,625	7,000	7,640
Basin D15	3,625	5,500	5,600

Basin D16	6,030	9,100	9,100
Basin D17	450	700	3,870
Basin D18	2,750	4,200	6,500
Basin D19	1,250	1,900	3,530
Basin D21	13,120	19,700	34,460
Basin D23	8,610	13,000	19,230
Basin D24	2,390	3,600	10,170
Total	**97,145**	**146,750**	**217,880**



This stormwater management strategy report demonstrates that the Gilead development can be supported by stormwater control infrastructure to adequately achieve statutory performance targets to facilitate the development.

The proposed development is positioned above existing 1% AEP flood extents and generally above the PMF event such that additional flood mitigation works beyond stormwater peak flow management up to the 1% AEP will not be necessary. In addition, due to landform constraints, bridge crossings are likely to be elevated above the PMF event. A flood evacuation strategy is unlikely to be necessary for The Site due to its elevation above flood risks.

Control of post-development peak flows is to be managed through detention basins, and water quality improvements are to be controlled through a system of rainwater tanks, gross pollutant traps and bio-retention basins. Specifically, the performance requirements of the WaterNSW

Upper Canal (which traverses part of Gilead) will be achieved with refined performance checks to be undertaken at detail design.

Based on the stormwater quantity and quality modelling, approximate land use requirements have been calculated and compared to plan areas reserved in the masterplan which confirms that spatially the stormwater management strategy can be accommodated.

The following opportunities have been identified to improve the fundamental strategy detailed in this report. It is recommended that these opportunities be investigated as part of detailed design to ensure high amenity development outcomes are achieved and should form part of the Development Control Plan to be adopted for the land and inform a local Planning Agreement with Council to confirm delivery.

- An Urban Development land use zoning is recommended to provide flexibility in stormwater infrastructure positioning and size which will allow infrastructure to be designed in detail that responds to the site-specific constraints of the infrastructure.

- The Figtree Hill Basin 3B design could be updated to include part of the Gilead development that naturally falls toward this basin.

- Alternative water sensitive urban design solutions could be considered that may be more beneficial than standard practice such as:
    - Roadside planter beds (with or without bio-filtration media)
    - Roadside swales (with or without bio-filtration media)
    - Large scale vegetation regeneration of previous agricultural land offsetting net development pollutant generation.
    - Proprietary filtration tree pits
    - On-lot raingardens
    - Complimentary pressurised systems (e.g. recirculation or harvesting).

- The impact of a reduced detention strategy should be investigated to determine if detention of environmental impact flows (e.g. 50% AEP event only) will have detrimental impacts on existing waterways and downstream lands. A reduced detention basin strategy has potential to minimise net environmental impact through reduced land disturbance, vegetation clearing and rock excavation.

1 Introduction

Greater Macarthur has been identified as Growth Area by the NSW Government and will provide for 15,000 new homes to the broader south Campbelltown region. Lendlease's landholding at Gilead has been identified as a Priority Precinct and will make the first contribution to housing supply in the region of approximately 3,300 new homes, retail centre and education facilities.

Importantly, it will secure key conservation outcomes including the establishment of linked koala and fauna corridors between the Georges River and Nepean River.

To facilitate both the housing and conservation outcomes for the site, a Planning Proposal is being prepared to rezone a portion of the site known as Gilead (The Site) under the State Environmental Planning Policy (Precincts – Western Parkland City) 2021. The Planning Proposal will establish the Urban Development Zone for land capable of development and introduce a C2 Environmental Conservation zone for land containing key fauna habitat to be retained as well as land that native bushland is to be reconstructed. This report specifically addresses the stormwater management strategy and has been used to shape and inform the Planning Proposal and associated development outcomes.

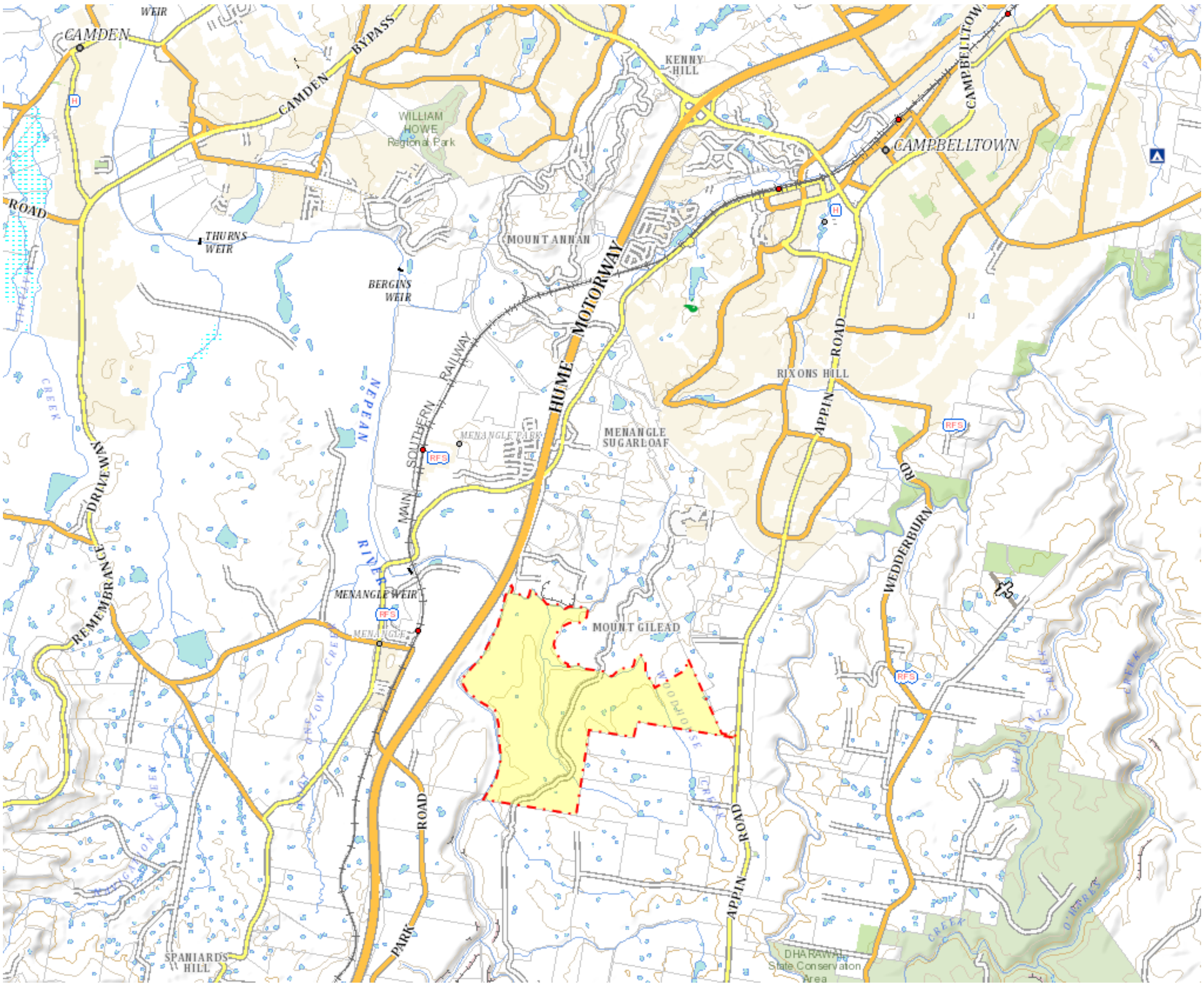


Figure 1 – Gilead Locality Plan

Gilead site highlighted yellow.

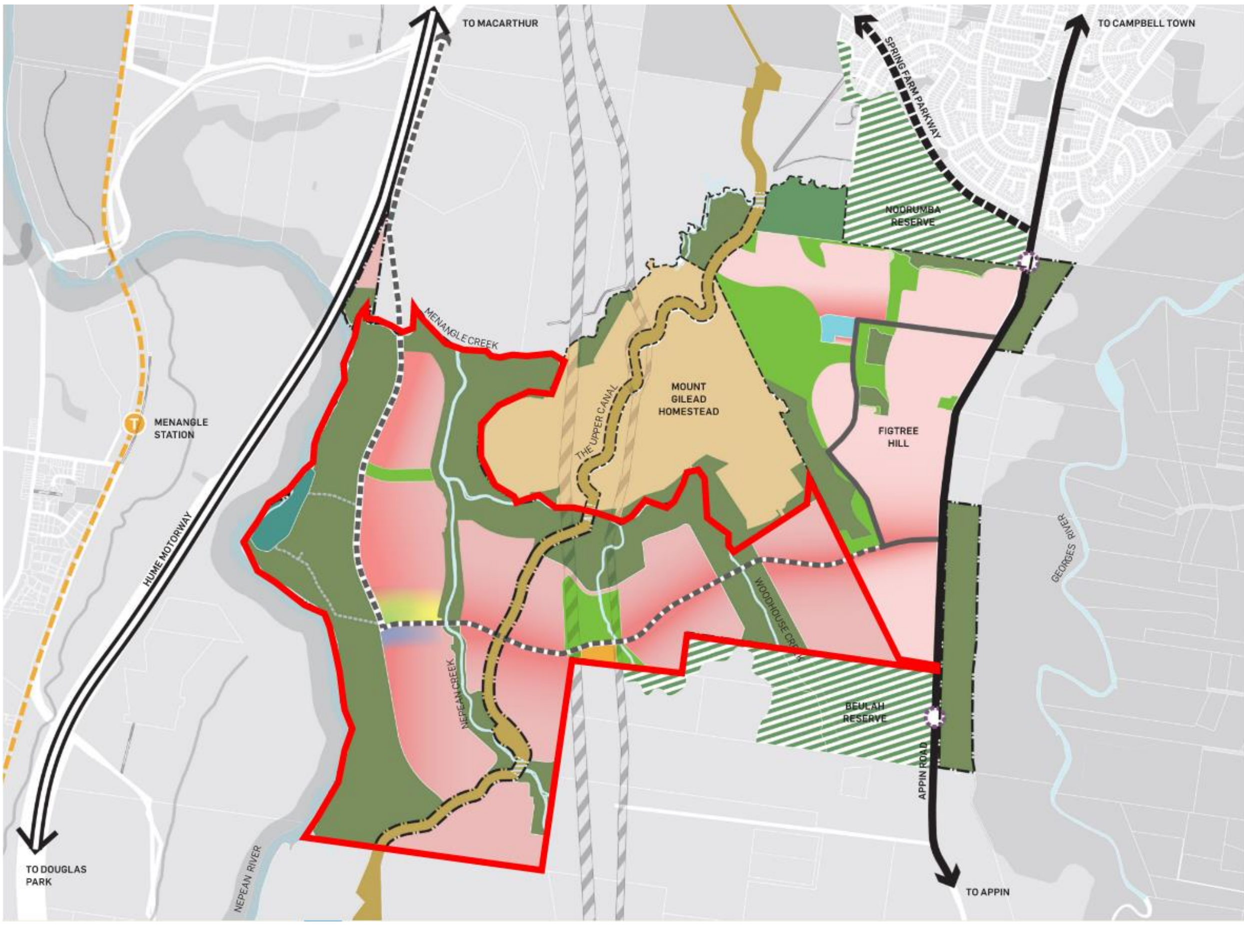


Figure 2 – Gilead Development Masterplan

Source: Gilead Structure Plan, 23 May 2022, Urbis.

The Site consists of five properties including Lot 2 in DP 1218887, Lot 2 in DP 249393, Lot 1 DP603675, Lot 2 DP603674 and part of Lot 5 in DP 1240836 that have a combined area of 495ha.

The Site has been subject to significant clearing and used for cattle grazing. Intact stands of vegetation are generally contained within the creek lines that traverse the Site including the Menangle Creek, Nepean Creek and Woodhouse Creek and along the Nepean River. Outside of these areas, vegetation consists of pastureland and scattered paddock trees.

The Upper Canal is a State Heritage Item that traverses The Site from South to North and there are a series of electrical transmission line, water and gas pipeline easements that traverse the central park of the Site from North to South.

The Site sits to the south and west of the Mt Gilead Homestead complex that is a State Heritage Item.

1.1 Existing Site Conditions

The Gilead site is currently in use for agriculture purposes and is best described as a site with four key zones. The definition of each zone is based on consistent features with unique features between zones and are shown in **Figure 3** and described below. Aspects of the Gilead site that are consistent throughout and are defining characteristics include:

- Generous Koala corridor protection zones surrounding the east, north and west perimeters of development.
- Generally incised creek lines with heavily vegetated banks and rock outcrops providing a unique habitat for native flora and fauna. Refer **Table 1** for water course summary.
- Relatively small farm dams dispersed throughout the site.
- Large tracts of cleared paddocks associated with historic agricultural uses of the land.

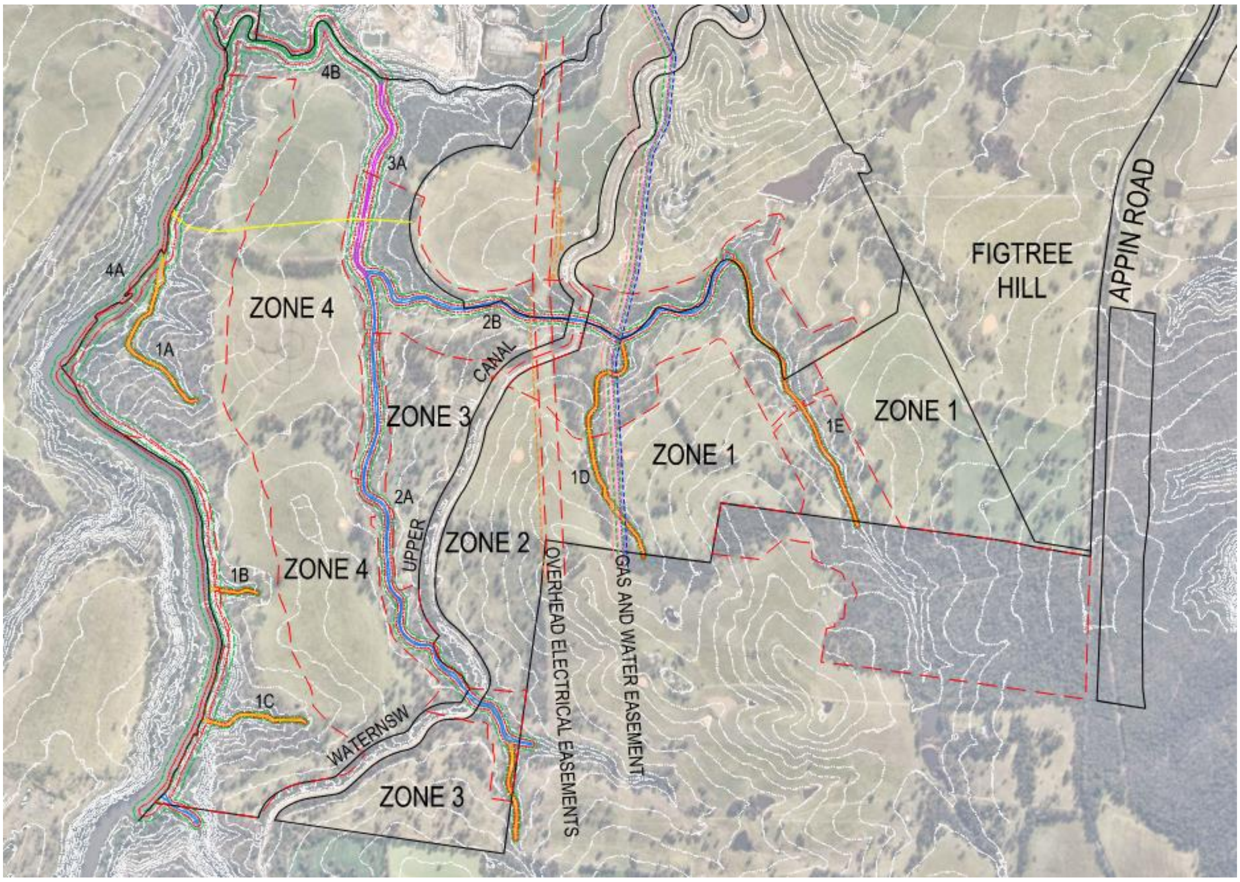


Figure 3 – Gilead Existing Conditions Plan

Table 1 – Existing Watercourse Summary

Watercourse ID (Refer Figure 3)	Watercourse Name (If Applicable)	Stream Order	Comments
4A	Nepean River	Fourth	To be retained
4B	Menangle Creek	Fourth	To be retained
3A	Woodhouse Creek	Third	To be retained
2A	Nepean Creek	Second	To be retained
2B	Woodhouse Creek	Second	To be retained
1A	N/A	First	To be retained
1B	N/A	First	To be retained
1C	N/A	First	To be retained
1D	N/A	First	To be retained and embellished
1E	Woodhouse Creek	First	To be retained

Stream order classifications as per NRAR Guidelines for Controlled Activities on Waterfront Land.

Zone 1 is located either side of Woodhouse Creek directly adjacent Figtree Hill and consists of open pastureland with isolated and scattered vegetation within, and generally heavily vegetated creek lines surrounding the zone extent. The topography consists of two key ridge lines with stormwater runoff directed generally east and west toward existing waterways. The existing gradients within Zone 1 range from 3% up to 10% and the existing soils are typically clay with underlying rock. An existing high-pressure gas main and watermain traverse Zone 1 from south to north. **Figure 4** provides a photo of the typical conditions within Zone 1.

Figure 4 – Zone 1 Typical Existing Conditions

Zone 2 is bound by two existing overhead electrical transmission lines within its east bounds and the existing WaterNSW Upper Canal to its west. The northern half of Zone 2 is generally clear of vegetation while the southern half consists of scattered trees throughout. A ridge line is located generally along the alignment of the overhead electrical transmission lines with existing gradients between the transmission easement and Upper Canal ranging from 5% up to 14%. The existing soils are typically clay with underlying rock. **Figure 5** provides a photo of the typical conditions within Zone 2.

Figure 5 – Zone 2 Typical Existing Conditions

Zone 3 describes two separate areas which are both bound by the existing WaterNSW Upper Canal and existing major creek lines. Zone 3 typically consists of relatively dense pockets of vegetation with existing gradients from 5% up to 14%. A clear defining feature of Zone 3 is the relatively shallow depth of rock and in many cases existing rock is exposed with no soil cover. Exposed rock is generally located in proximity to existing creek lines but also in discrete areas throughout. **Figure 6** provides a photo of the typical conditions within Zone 3.

Figure 6 – Zone 3 Typical Existing Conditions

Zone 4 is located on the west most extent of The Site and consists of cleared agricultural lands incorporating four irrigation pivots. Each irrigation pivot is approximately 500m in diameter. The topography consists of one key ridge line that runs south to north bisecting the zone with stormwater runoff directed generally east and west toward Nepean Creek and Nepean River. The existing gradients within Zone 4 range from 2% up to 6% and the existing soils are typically clay with shallow underlying rock. **Figure 7** provides a photo of the typical conditions within Zone 4.

Figure 7 – Zone 4 Typical Existing Conditions

2 Proposed Stormwater Management Strategy

The Gilead Stormwater Management Strategy (**The Strategy**) is grounded on an overarching philosophy of connecting manmade and natural environments that respects the needs of both. To this effect, The Strategy aims to provide maximum flexibility in stormwater management options such that design to accommodate site specific constraints at a micro design level (e.g. at Development Application stage) does not compromise on the balance of needs for the project.

The needs of development have been defined based on the following control documentation that outline key objectives to generally meet minimum statutory requirements:

- Campbelltown (Sustainable City) Development Control Plan 2015 (**Council DCP**):
  - Campbelltown (Sustainable City) Development Control Plan 2015 Volume 1 Part 2 Requirements Applying to All Types of Development.
  - Campbelltown (Sustainable City) Development Control Plan 2015 Volume 2 Part 7 Mount Gilead DCP.
  - Engineering Design Guide for Development, June 2009 (**EDGD**).
- Guideline for Development Adjacent to the Upper Canal and Warragamba Pipelines, September 2021, WaterNSW (**Upper Canal Guidelines**).
- NSW MUSIC Modelling Guidelines, August 2015, BMT WBM.
- Mount Gilead MDP Lands Water Cycle Management Strategy, 20 November 2017, Cardno (**Figtree Hill WCMS**).
- Greater Macarthur Water Management Report, August 2015, GHD.

Key statutory outcomes from the above can be summarised as the need to:

- Maximise safety of public spaces during storm events up to the 1% AEP event.
- Maximise safe passage of Probable Maximum Flood (PMF) flows.
- Minimise the erosion of existing waterways.
- Minimise the discharge of pollutants from operation of development sites.
- Minimise maintenance of stormwater management systems.
- Eliminate or minimise impact on the existing WaterNSW Upper Canal.

The needs of the environment have been defined by the project team in consultation with ecology and aboriginal groups and may be summarised as the need to:

- Protect and preserve existing waterways and the habitats they support.
- Protect, preserve, and integrate the existing character of remnant natural environments.
- Protect and celebrate the historical artefacts of First Nations people both tangible and intangible.
- Minimise land disturbance as much as practical.

The Strategy proposed adopts a typical management system to demonstrate a functional outcome against the project needs with suggestions and recommendations to be considered as part of future design submissions (e.g. Development Control Documents, Master Planning and Development Applications) that aim to promote better practice design that responds to stage specific constraints and opportunities. This is considered appropriate for rezoning purposes as the desired outcomes, performance targets, standard infrastructure solutions and alternative opportunities are adequately defined in this Strategy to guide the proposed development. The typical management system incorporates a water quality treatment train consisting rainwater tanks, gross pollutant traps and bio-retention basins, and water quantity control infrastructure consisting of dry detention basins.

To support the success of The Strategy, an Urban Development zoning across the Gilead site is recommended to ensure flexibility in infrastructure positioning, size, and range of available techniques both present and those that may be potentially available in future. Without a flexible zoning (i.e. implementing traditional SP2 zoning) opportunities to develop innovative stormwater solutions that respond well to stage specific site constraints will be significantly limited.

Following the submission of the Planning Proposal, Lendlease intend to commence working with Campbelltown City Council to refine the detailed masterplan for Gilead and preparation of the Development Control Plan. As part of this process, we expect there to be refinement to the Stormwater Management Strategy and subsequent establishment of appropriate development controls to inform future development applications.

3 Flooding

3.1 Assessment Scope

Due to the incised creek banks that generally surround development zones within The Site, the location of The Site relative to the Upper Nepean River catchment, and the proposed adoption of detention basins in the post-development scenario, local pre-development flood conditions have been assessed only.

Nepean River flooding has not been modelled and flood modelling outcomes from the Greater Macarthur Water Management Report, August 2015, GHD has been adopted to inform flood potential and flood risk for The Site as part of This Strategy.

The local flood assessment has been undertaken by Rhelm Pty Ltd (**Rhelm**) with details provided in **Appendix A** and summarised in the following sections.

3.2 Modelling Approach

Catchments have been represented using the XP-RAFTS modelling software while hydraulic modelling has been undertaken in TUFLOW software. LiDAR surface data has been adopted in the TUFLOW model noting that while this may not capture nuances within existing creek lines, the surface representation within creek lines will generally be higher in elevation than a detailed survey will provide due to the presence of dense vegetation and tree canopy cover. That is, adopting LiDAR surface data within creek lines generally provides a more conservative estimation of flood levels.

3.3 Hydrology

The local flooding assessment has been undertaken adopting Australian Rainfall and Runoff 2019 procedures.

3.3.1 Rainfall and Losses

Rainfall data and loss parameters have been sourced from the ARR DataHub and summarised in **Table 2**.

Table 2 – ARR Datahub Metadata

Parameter	Value
Storm Initial Losses (mm)	18 (NSW adjusted loss)
Storm Continuing Losses (mm/hr)	2.4 (NSW adjusted loss)
River Region – Division	South East Coast (NSW)
River Region	Hawkesbury River
Point Temporal Pattern Label	East Coast South
Version	2016_v2

3.3.2 Catchment Representation

Catchment areas and slope have been based on LiDAR surface data. Land uses have been based on NearMap 2022 imagery with impervious percentages applied based on typical industry modelling practice (refer **Appendix A**).

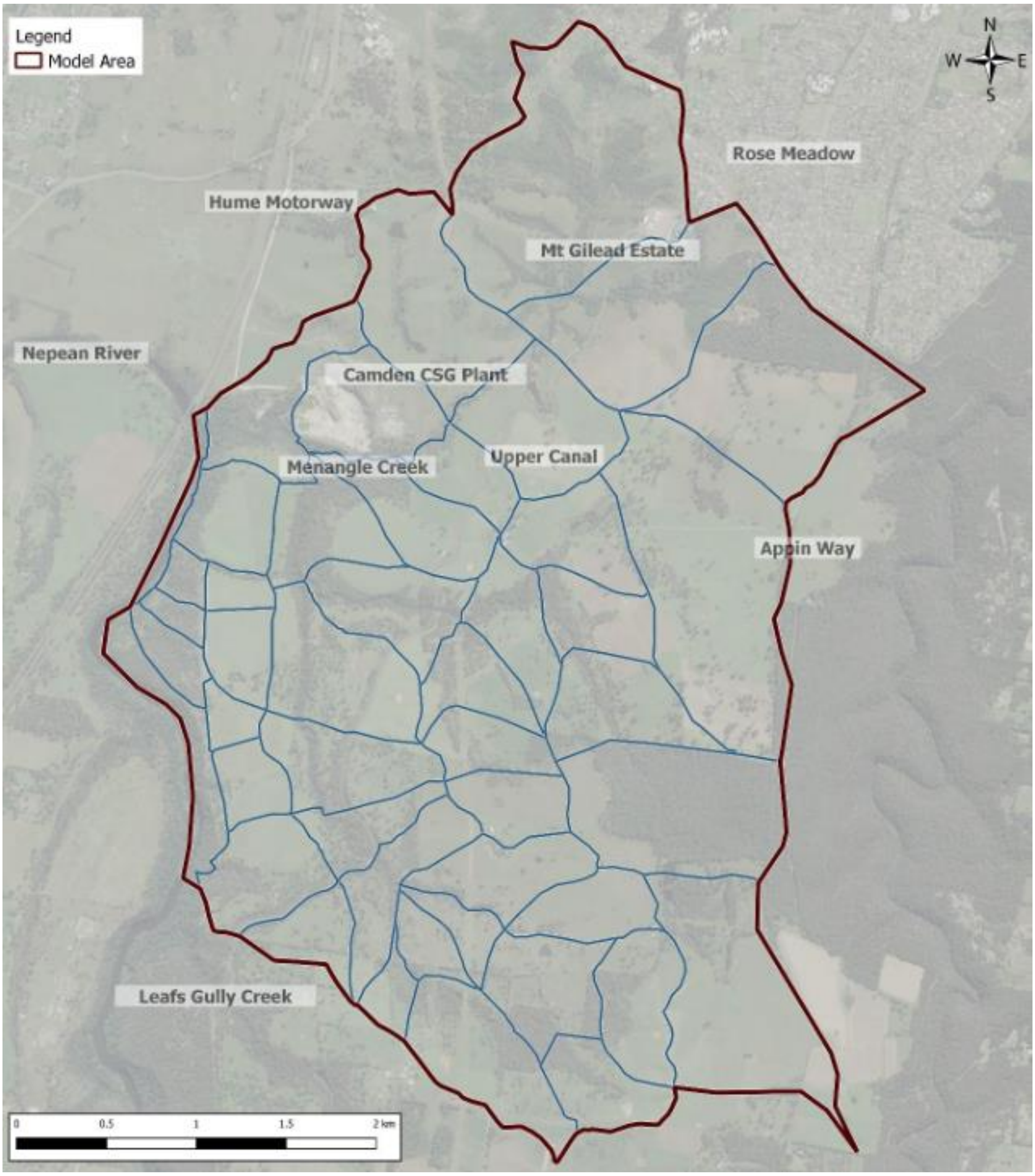


Figure 8 – Existing Catchment Plan

Source: Mount Gilead Preliminary Flood Modelling, June 2022, Rhelm

3.3.3 Existing Farm Dams

There are no existing farm dams with significant volume to meaningfully impact flood behaviour. The impact of existing farm dams has therefore not been considered.

3.4 Hydraulics

Catchment runoff hydrographs from XP-RAFTS have subsequently been applied in TUFLOW to model hydraulic outcomes of the flood assessment.

LiDAR surface data has been adopted at a 3m x 3m grid with roughness coefficients applied based on land use. No 1D elements have been modelled within existing creek lines.

3.5 Results and Discussion

Figure 9 provides an overlay of the existing 1% AEP and PMF extent based on the above methodology against the Gilead development masterplan. **Figure 10** provides an overlay of the existing 1% AEP and PMF extent based on the Greater Macarthur Water Management Report. As demonstrated the proposed development is positioned adequately above existing flood hazards and the proposed development with post-development stormwater detention control is very unlikely to generate meaningful impacts on existing flood behaviour. Further assessment of post-development flood behaviour may be necessary at detail design depending on whether a reduced stormwater detention strategy is adopted. On this basis, the proposed Gilead development is capable of meeting statutory flood planning requirements and a flood evacuation strategy is unlikely to be necessary.

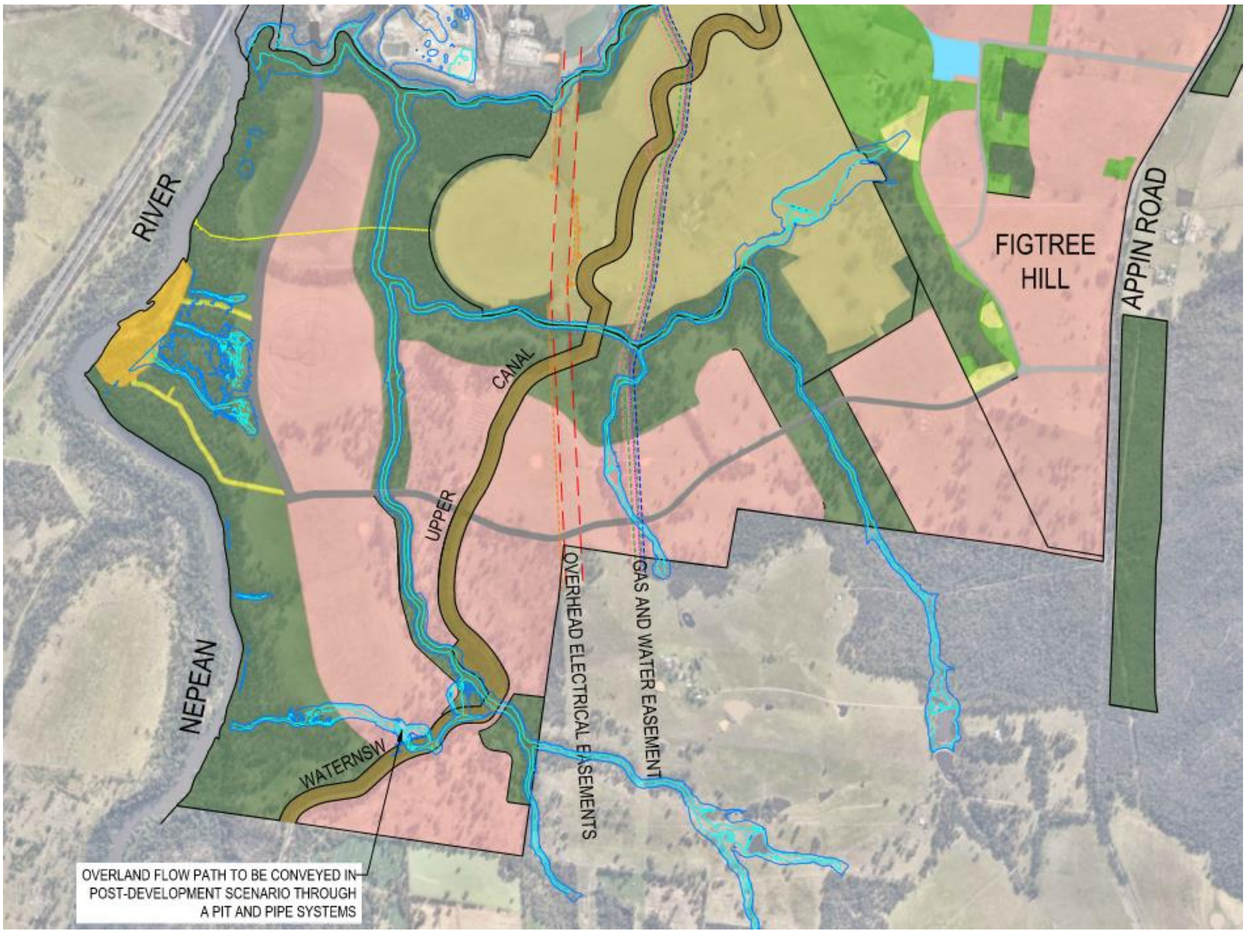


Figure 9 – Existing Local 1% AEP and PMF Extent

Source: Mount Gilead Preliminary Flood Modelling, June 2022, Rhelm

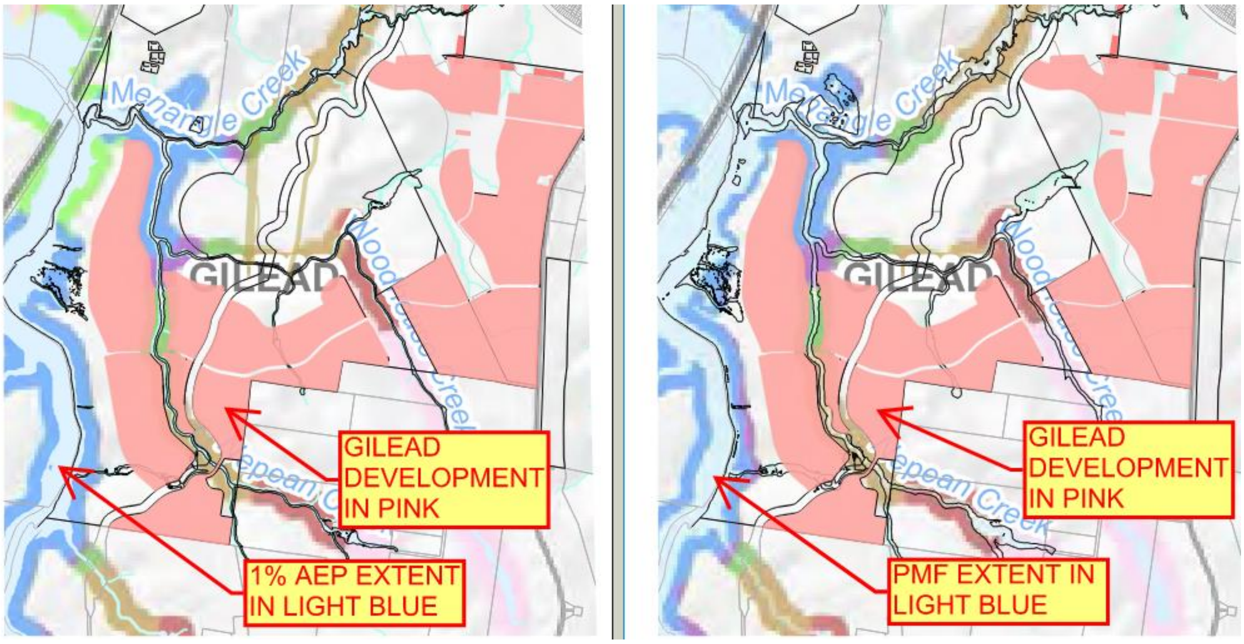


Figure 10 – Existing Nepean River 1% AEP and PMF Extent

Source: Greater Macarthur Water Management Report, August 2015, GHD

4 Stormwater Quantity Controls

4.1 Performance Criteria

The stormwater quantity management strategy has been developed to meet the following objectives at discharge points into existing waterways:

- Post-development discharge flow rates are to be controlled to not exceed pre-development discharge flow rates for typical storm events between the 50% AEP to 1% AEP events.
- Maximise safe passage of Probable Maximum Flood (PMF) flows.
- Minimise the erosion of existing waterways.

Where development is to discharge toward an existing WaterNSW Upper Canal flume The Strategy aims to meet the requirements of the Upper Canal Guidelines namely:

- Post-development discharge flow rates and velocities are to be controlled to not exceed pre-development discharge flow rates and velocities for typical storm events between the 1EY (1 year ARI) to 1% AEP events.

4.2 Stormwater Quantity Management Strategy

The stormwater quantity management strategy adopts detention basins as the primary control of post-development discharge rates and velocities. Basin outlet configurations are assumed to consist of a piped discharge control for very frequent storm events and overtopping weir control for frequent to infrequent storm events. It is intended to adopt relatively wide overtopping weirs to control depth and velocities given the generally vulnerable conditions downstream of most basins in the Gilead development.

This Strategy should not preclude the investigation and/or adoption of alternative management techniques as part of future design development that may better serve the needs of the project as defined in **Section 2**.

This infrastructure is proposed to be located within land identified for urban development and in areas marked for conservation that are currently clear of any significant vegetation due to previous agricultural uses. Where the infrastructure is located within conservation areas, an appropriate level of revegetation is to occur to ensure that it provides a stormwater management function as well as a contribution towards the conservation outcomes in Gilead.

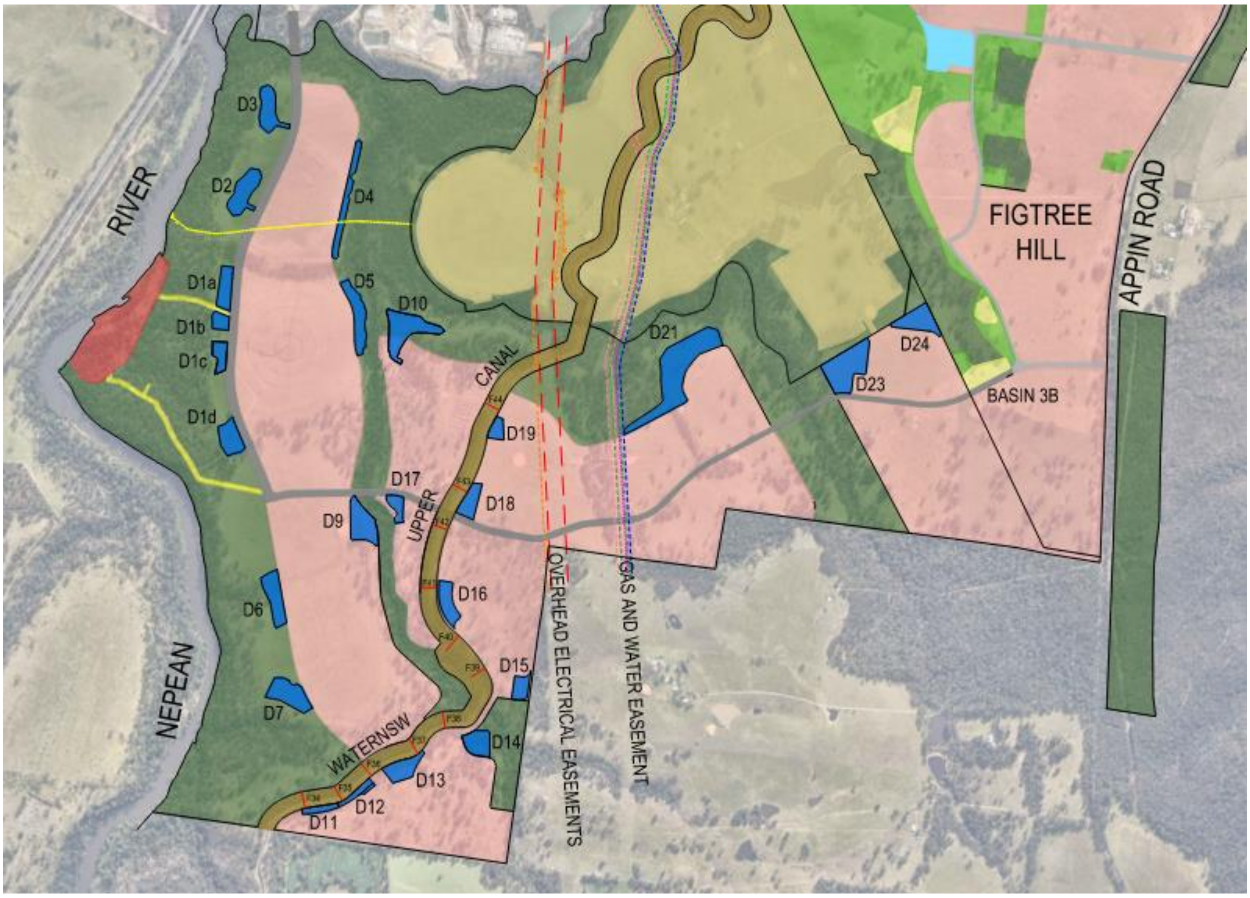


Figure 11 – Stormwater Quantity Infrastructure Plan

Locations and arrangement subject to detail design.

4.3 Modelling Methodology

The stormwater quantity management strategy has been modelled using the DRAINS v2022.01 software package adopting a RAFTS storage routing hydrological model. RAFTS hydrological modelling allows for the more accurate estimation of stormwater runoff from moderate to large catchment sizes (particularly rural catchments) while the DRAINS hydraulics calculations allow for more accurate estimations of basin performance. Australian Rainfall and Runoff 1987 procedures have been adopted due to the scale of the assessment and the urban typologies to be assessed which are better represented in the NSW context adopting ARR1987 hydrology compared to ARR2019 hydrology as implied through the Review of ARR Design Inputs for NSW Report, February 2019, NSW Office of Environment and Heritage.

To determine performance of The Strategy against the performance criteria the following methodology has been implemented:

1. Pre-development catchments have been determined adopting LiDAR contour data.
2. Pre-development catchments have then been modelled in DRAINS adopting a RAFTS hydrology model adopting parameters representative of each catchment's natural typography.

a. For catchments discharging to existing watercourses, existing flow rates for 50%AEP and 1%AEP have been assessed only.

b. For catchments discharging toward the WaterNSW Upper Canal flumes, existing flow rates and velocities for 1EY and 1%AEP have been generated and compared against estimates from data provided by WaterNSW (refer **Appendix B**)

3. Post-development catchments have been determined based on a preliminary design surface for the Gilead site.

4. Post-development catchments have then been modelled in DRAINS adopting a RAFTS hydrology model adopting parameters representative of each catchment's urban typography.

5. Detention basins have been added to the model prior to discharge nodes and designed to not exceed pre-development flow rates and/or velocities.

Modelling of the 1EY/50%AEP and 1%AEP storm events only has been undertaken to inform this Strategy. This is adequate for the purpose of positioning and sizing of stormwater infrastructure at a strategic level and design to cater for all storm events between these will form part of future design development and is not anticipated to impact The Strategy.

4.4 Catchment Hydrology

Catchment hydrology for the Gilead locality has been represented through the Intensity Frequency Duration coefficients defined in **Table 3**. These coefficients are consistent with those adopted for the Figtree Hill WCMS.

Table 3 – Intensity Frequency Duration Coefficients

	2 Year ARI	50 Year ARI
1-hour	32.79	62.60
12-hour	6.36	12.82
72-hour	1.85	4.03
Skew (G)	0	
F2	4.29	
F50	15.8	

Based on Figtree Hill WCMS Coefficients

Table 4 defines the adopted loss and surface roughness parameters to estimate catchment runoff. Similarly, these parameters are consistent with those adopted for the Figtree Hill WCMS.

Table 4 – Initial Loss – Continuous Loss Hydrology Parameters

	Previous Catchment	Impervious Catchment
Initial Loss	15mm	1.5mm
Continuing Loss	2.5mm/hour	0mm/hour
Manning's 'n'		
Pre-Development	0.05	0.015
Post-Development	0.035	0.015

Based on Figtree Hill WCMS Coefficients

4.5 Catchment Representation

Table 5 summarises the properties adopted to represent catchments in the pre-development and post-development scenarios. Key assumptions and clarifications that have informed these parameters include:

- Due to the abundance of rock at or near surface level a pre-development impervious percentage of 5% has been adopted.
- Pre-development catchments for Upper Canal flumes have been represented on plan only and have not been modelled. The flow rates defined in **Appendix B** are assumed to prevail.
- Post-development total impervious percentages include external un-developed catchments.

A catchment plan for stormwater quantity modelling is provided in **Appendix C**.

Table 5 – Catchment Properties

	Area (ha)		Average Slope (%)		Impervious Area (%)	
Catchment	**Pre-Dev**	**Post-Dev**	**Pre-Dev**	**Post-Dev**	**Pre-Dev**	**Post-Dev**
Basin D1a	6.86	7.74	4.4	4.2	5%	70%
Basin D1b	2.65	4.75	4.4	4.8	5%	82%
Basin D1c	10.48	7.51	4.4	4.8	5%	82%
Basin D1d	7.28	7.86	4.6	4.2	5%	84%
Basin D2	9.00	8.36	4.7	4.6	5%	84%
Basin D3	5.09	6.84	4.5	4.0	5%	81%
Basin D4	2.12	2.20	3.3	3.4	5%	84%
Basin D5	10.16	10.38	4.0	4.5	5%	82%
Basin D6	7.73	7.24	5.0	3.2	5%	85%
Basin D7	13.13	12.96	6.6	5.4	5%	74%
Basin D9	10.02	11.67	5.5	2.5	5%	71%
Basin D10	17.94	19.36	5.8	5.8	5%	69%
Basin D11[1]	-	2.62	-	8.0	-	29%
Basin D12[1,2]	-	5.73	-	7.0	-	57%
Basin D13[1]	-	9.34	-	6.5	-	61%
Basin D14[3]	12.38	13.04	5.2	4.8	5%	46%
Basin D15[3]	7.98	13.77	8.4	6.2	5%	44%
Basin D16[1]	-	14.37	-	7.2	-	64%
Basin D17	1.32	1.46	6.6	6.3	5%	62%
Basin D18[1]	-	7.66	-	8.7	-	75%
Basin D19[1]	-	4.52	-	7.0	-	71%
Basin D21	31.06	31.69	4.2	5.7	5%	76%
Basin D23	19.65	20.07	5.9	4.7	5%	83%
Basin D24	5.94	5.28	3.0	3.7	5%	77%

1. *Discharges to an existing WaterNSW flume.*
2. *Proposed stormwater network/basin outlet to split flow to utilise multiple adjacent existing flumes.*
3. *Catchment diversion to eliminate impact on an existing flume. Ultimate confluence point remains similar between pre-development and post-development condition.*

4.6 Results and Discussion

Estimated pre-development and post-development peak flow rates and estimated storage requirement are summarised in **Table 6** based on the modelling methodology described in the preceding Sections. Basins have been modelled with typically 1.5m to 2.0m depth of storage to account for effects of water level on outflow rates. The estimated volumes represent minimum storage requirements for land use planning purposes and is discussed in further detail in **Section 6**.

As demonstrated, the proposed stormwater quantity management strategy is capable of achieving performance criteria for the development, and with refinement as part of future detailed design has potential to create high amenity infrastructure connecting development and adjacent natural vegetation.

Table 6 – Detention Basin Volumes

	1EY/50% AEP		1% AEP		
Basin ID	**Pre-Dev (m3/s)**	**Post-Dev (m3/s)**	**Pre-Dev (m3/s)**	**Post-Dev (m3/s)**	**Estimated Storage (m3)**
Basin D1a	0.399	0.368	1.500	1.417	2,800
Basin D1b	0.171	0.142	0.706	0.691	2,150
Basin D1c	0.577	0.501	2.07	1.773	2,650
Basin D1d	0.425	0.367	1.610	1.470	3,100
Basin D2	0.504	0.382	1.880	1.860	3,300
Basin D3[1]	0.306	0.305	1.19	1.11	4,100
Basin D4	N/A	N/A	N/A	N/A	N/A
Basin D5	0.543	0.462	1.92	1.89	4,200
Basin D6	0.456	0.356	1.74	1.56	2,850
Basin D7	0.762	0.479	2.96	2.85	4,700
Basin D9	0.588	0.416	2.23	2.08	3,850
Basin D10	1.666	1.610	5.734	5.570	6,450
Basin D11[2]	0.194	0.096	0.663	0.622	700
Basin D12[2,3]	0.336	0.332	0.939	0.818	1,950
Basin D13[1]	0.378	0.317	1.223	1.161	3,500
Basin D14	0.701	0.431	2.560	2.205	4,150
Basin D15	0.541	0.538	2.260	2.170	4,400
Basin D16[2,3]	0.468	0.288	1.537	1.518	6,700
Basin D17	0.121	0.11	0.463	0.345	450
Basin D18[2]	0.295	0.200	0.841	0.814	3,700
Basin D19[2]	0.376	0.183	1.303	0.822	1,550
Basin D21	1.360	1.170	4.90	4.72	12,550
Basin D23	1.08	0.730	3.88	3.80	7,900
Basin D24	0.314	0.257	1.1	0.991	2,000

1. *Basin includes flow from basin D4 water quality only*
2. *Pre-development flows based off existing WaterNSW flume data.*
3. *Proposed stormwater network/basin outlet to split flow to utilise multiple adjacent existing flumes.*

4.6.1 Basin D4

Basin D4 is intended to perform a water quality treatment function only that integrates water sensitive urban design and landscape at the fringe between urban development and existing native vegetation. Basin D4 is envisaged to consist of a series of raingardens adjacent a meandering shared path running parallel to the adjacent creek with complimentary planting beds throughout. As part of future design development, it may be necessary for Basin D4 to provide a detention function however this will need to be considered against the performance targets of this Strategy and the vision for the project at the time of development.

Basin D4 is effectively a proof of concept for the implementation of best practice water sensitive urban design that prioritises landscape over efficiency and may be implemented in other parts of Gilead at detail design.

4.6.2 Basin D10

Basin D10 is unique in that this basin will be receiving post-development stormwater from upstream WaterNSW flumes. The design of Basin D10 has assumed that stormwater discharge from these flumes will be at pre-development flow rates considering detention is to be provided upstream of these flumes through Basin D18 and Basin D19.

4.6.3 Basin D16

Basin D16 in its current arrangement will be consolidating stormwater runoff approaching three WaterNSW flumes through one existing flume in the post-development scenario. The design of Basin D16 is a proof of concept for consolidating infrastructure along the WaterNSW Upper Canal however as part of detail design, it may be necessary to split Basin D16 or its discharge routes toward all three existing flumes as opposed to a single flume.

4.6.4 Basin D24 and Figtree Hill Interface

Basin D24 and the interface with the Figtree Hill development are to be designed in consideration of the performance targets of the Figtree Hill WCMS. There is opportunity as part of the Figtree Hill development to amend the design of Figtree Hill Basin 3B to detain part of the Gilead development that naturally falls toward this basin. Likewise, the discharge behaviour of Basin D24 is to be considered in relation to the Figtree Hill post-development control point which is understood to be located downstream at a confluence point for basins on the west side of Figtree Hill. **Appendix D** provides an initial assessment of the revised Figtree Hill stormwater strategy where Basin D24 and Figtree Hill Basin 3B form part of the post development condition.

5 Stormwater Quality Controls

5.1 Performance Criteria

The stormwater quality management strategy has been developed to meet the following objectives at discharge points into existing waterways which are consistent with the Figtree Hill WCMS post-development discharge pollutant removal targets:

- 90% reduction in average annual gross pollutant (GP) loads.
- 85% reduction in average annual total suspended solid (TSS) loads.
- 70% reduction in average annual total phosphorus (TP) loads.
- 55% reduction in average annual total nitrogen (TN) loads.

It is noted that the proposed targets exceed the minimum thresholds for new developments as specified in the Campbelltown Engineering Design Guide for Development which are as follows:

- Undefined reduction in average annual GP loads.
- 80% reduction in average annual TSS loads.
- 45% reduction in average annual TP loads.
- 45% reduction in average annual TN loads.

The higher pollutant removal targets proposed for Gilead aim to minimise the impact on the Hawkesbury-Nepean River and its tributaries and minimise the impact on waterways and the habitats they support. The proposed targets are envisaged to not only provide enhanced environmental benefits but contribute toward the Lendlease Communities vision of happy, healthy, and sustainable living for the residential community.

For sub-catchments that will discharge toward the existing WaterNSW Upper Canal, The Upper Canal Guidelines do not provide specific targets and the following performance criteria has been adopted for discharge toward existing flumes:

Where a flume outlet discharges stormwater through Gilead development.

- 90% reduction in average annual GP loads.
- 40% reduction in average annual TSS loads.

Where a flume outlet discharges stormwater directly to an existing waterway.

- As per above waterway discharge targets.

The targets where a flume outlet discharges stormwater through subsequent Gilead development are considered appropriate as they aim to minimise blockage potential of the flume as a priority while remaining suspended solids and dissolved nutrients will be removed as part of consolidated water quality basins downstream of the flume, thereby reducing stormwater basin maintenance burden, and improving sustainability of the stormwater quality system.

5.2 Stormwater Quality Management Strategy

The stormwater quantity management strategy adopts a typical treatment train to demonstrate a functional outcome that does not rely on a rigid scheme to be effective. It is intended that the treatment train will be further optimised as part of Development Applications adopting this strategy as a guide and supplementing where appropriate, alternative treatment options to meet performance targets. It is noted that the higher pollutant removal targets to be adopted will directly translate into a treatment train that is more robust than a typical business as usual approach even where a typical treatment train is adopted.

The typical treatment strategy incorporates rainwater re-use tanks on every residential lot, gross pollutant traps at each stormwater discharge point and tertiary treatment via vegetated bio-retention basins. To protect water quality infrastructure and minimise the size of proprietary treatment devices, it will be necessary to install splitter pits upstream of the treatment train to divert high flows directly to detention storages.

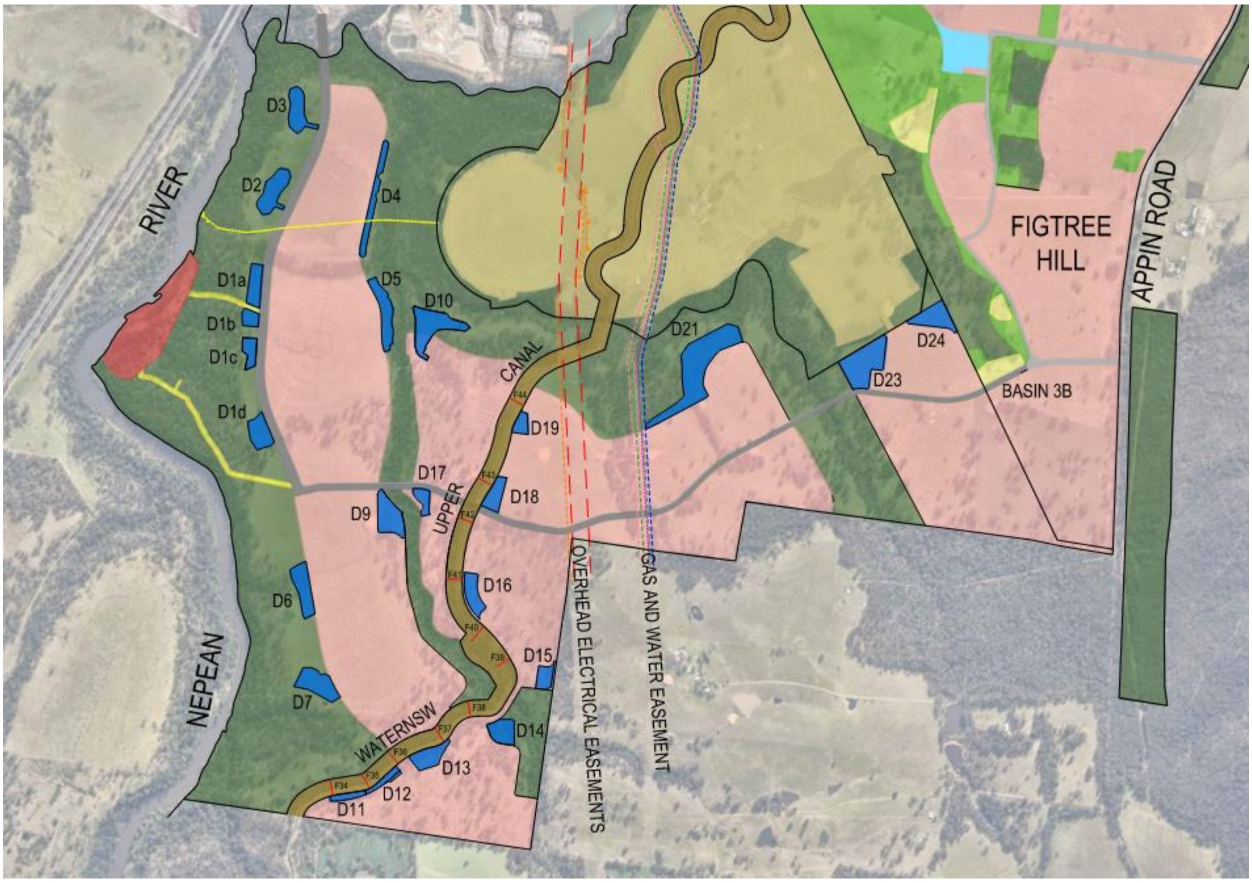


Figure 12 – Stormwater Quality Infrastructure Plan

Locations and arrangement subject to detail design.

5.3 Modelling Methodology

The stormwater quality management strategy has been assessed using the MUSIC v6.3 software package which is the industry standard software for modelling water quality and water sensitive urban design outcomes.

Post-development catchment boundaries adopted for modelling are like those that have been adopted for stormwater quantity modelling but have been further broken down into land use categories to appropriately model pollutant quantities and the proposed treatment train.

Catchment hydrology, pollutant generation and treatment device parameters adopted are detailed in the following sections and have been developed based on:

- Figtree Hill WCMS.
- NSW MUSIC Modelling Guidelines.
- Third party data where applicable.

It is noted that Campbelltown City Council has not released a MUSIC modelling guideline or MUSIC Link file to standardise modelling in the LGA and a first principles approach to modelling has been adopted for this strategy.

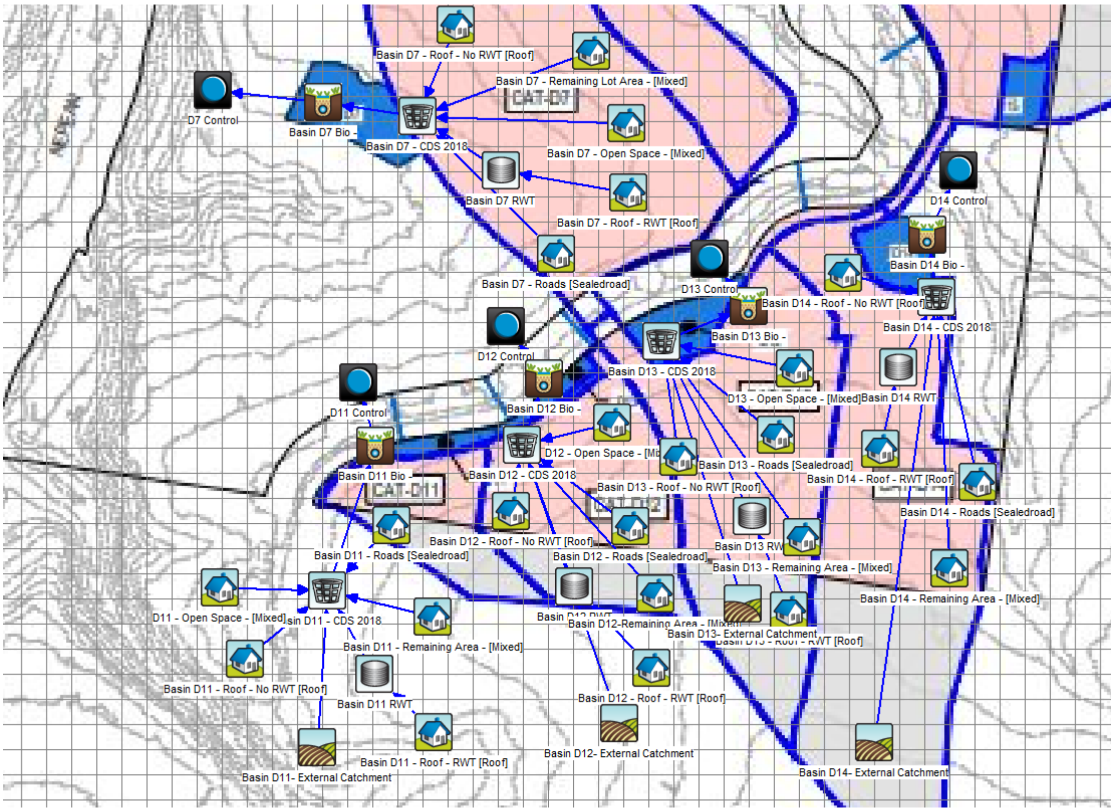


Figure 13 – Sample Extract of MUSIC Modelling Layout

5.3.1 Catchment Hydrology

Rainfall data across numerous weather stations has been assessed with the rainfall data detailed in **Table 7** and monthly Potential Evapotranspiration (PET) data in **Table 8** adopted for modelling purposes. These rainfall parameters have been assessed based on:

- Proximity to the subject site (the closer the more relevant).
- Completeness of data (minimal to no data gaps)
- Period of data collection (ideally 40 years or more)
- Period appropriate for modelling typical climate conditions (generally a 10-year period with no extreme dry or wet conditions)
- Appropriate timestep for modelling evaporation and infiltration effects accurately (industry standard for water quality modelling is 6-minute).

Table 7 – MUSIC Model Rainfall Data

Variable	Adopted Value
Weather Station	Liverpool (Whitlam Centre 67035)
Rainfall Period	1967-1977
Timestep	6-minute

Table 8 – MUSIC Model Monthly PET

Month	Protect PET (mm)
January	165
February	125
March	115
April	65
May	55
June	45
July	45
August	60
September	85
October	120
November	145
December	155

Catchment rainfall-runoff and groundwater properties for all catchment types has adopted the parameters in **Table 9** which have taken into consideration to the typical soil profiles within Gilead which are a mix of silty clays, sandy clays, shaly clays, weathered sandstone, and shale.

Table 9 – MUSIC Catchment Rainfall-Runoff Parameters

Parameter	Adopted Value
Impervious Areas	
Rainfall Threshold	1.4mm
Pervious Areas	
Soil Storage Capacity (mm)	90
Initial Storage (% of capacity)	25
Field Capacity (mm)	70
Infiltration Capacity Coefficient – a	150
Infiltration Capacity Coefficient – b	3.5
Groundwater	
Initial Depth (mm)	10
Daily Recharge Rate (%)	25
Daily Baseflow Rate (%)	10
Daily Deep Seepage Rate (%)	0

5.3.2 Catchment Representation

Post development catchments have been defined by the following general urban typologies:

- Roads
- Low Density
- Medium Density
- Open Space
- External (Rural)

It is recognised that there will be other land uses dispersed throughout the site such as schools, town centre and infrastructure sites however the location of such land uses may be subject to change and will not vary significantly in impervious area compared to Low Density as modelled in this strategy to meaningfully affect feasibility of the strategy. Further, such land uses may adopt on lot stormwater management which will be an improvement on this Strategy. In addition, post-development open space has been sub-categorised into active and naturalised open space which has defined whether open space has additional pollutant generation potential and therefore whether the open space has been modelled as Open Space or Rural category. It is envisaged that naturalised open space will retain vegetation and existing soils with minimal construction works and, in most cases, will passively provide water quality improvement through the removal of existing agriculture as a land use. **Figure 14** and **Figure 15** provide samples of the delineation between active open space and naturalised open space respectively.

Figure 14 – Example of Active Open Space

Figure 15 – Example of Naturalised Open Space

Table 10 details a typical development land use breakdown adopted to generate nodes suitable for MUSIC modelling. The proportions of each land use per basin catchment have been based on an initial development masterplan reflective of a typical residential development. While there may be changes in land use proportions and areas in future, such changes are unlikely to be significant to meaningfully impact This Strategy, especially where an Urban Development zoning is adopted.

Table 10 – MUSIC Node Details Summary

Land Use	Sub Catchment	Adopted Impervious	Comments
Roads	N/A	90%	
Low Density	Roof (to rainwater tank)	100%	Roof assumed to represent 60% of total land use area. 50% of roof assumed to contribute to a rainwater tank.
	Roof (bypass)	100%	Roof assumed to represent 60% of total land use area. 50% of roof assumed to contribute to a rainwater tank.
	Remaining Lot Area	50%	Total percentage of low-density land use imperviousness equates to 80%
Medium Density	Roof (to rainwater tank)	100%	Roof assumed to represent 80% of total land use area. 50% of roof assumed to contribute to a rainwater tank.
	Roof (bypass)	100%	Roof assumed to represent 80% of total land use area. 50% of roof assumed to contribute to a rainwater tank.
	Remaining Lot Area	50%	Total percentage of low-density land use imperviousness equates to 90%
Open Space	N/A	20%	Reduced imperviousness adopted on the basis that most of the open space is to incorporate natural bushland features augmented with walking trails.
External (Rural)	N/A	0%	

5.3.3 Catchment Pollutant Generation

Catchment pollutant generation estimates have been based on **Table 11** base flow and storm flow parameters adopting stochastic generation.

Table 11 – MUSIC Catchment Pollutant Generation Parameters

		Total Suspended Solids (mg/L-log10)		Total Phosphorus (mg/L-log10)		Total Nitrogen (mg/L-log10)	
Land Use	**Mean / Standard Deviation**	**Base Flow**	**Storm Flow**	**Base Flow**	**Storm Flow**	**Base Flow**	**Storm Flow**
Rural	Mean	1.15	1.95	-1.22	-0.66	-0.05	0.30
	Standard Deviation	0.17	0.32	0.19	0.25	0.12	0.19
Road	Mean	1.20	2.43	-0.85	-0.30	0.11	0.34
	Standard Deviation	0.17	0.32	0.19	0.25	0.12	0.19
Roof	Mean	N/A	1.30	N/A	-0.89	N/A	0.30
	Standard Deviation	N/A	0.32	N/A	0.25	N/A	0.19
Residential	Mean	1.20	2.15	-0.85	-0.60	0.11	0.30
	Standard Deviation	0.17	0.32	0.19	0.25	0.12	0.19
Open Space	Mean	1.20	2.15	-0.85	-0.60	0.11	0.30
	Standard Deviation	0.17	0.32	0.19	0.25	0.12	0.19

5.3.4 Treatment Node Properties

5.3.4.1 Rainwater Tanks

Rainwater tanks have been modelled assuming the installation of a 2.5kL tank on each development lot but modelled in MUSIC with 2.0kL capacity taking into consideration storage inefficiencies.

Rainwater tank re-use rates adopted assume 0.1kL/day internal use and 25.0kL/year as PET-Rain.

5.3.4.2 Gross Pollutant Traps

Vortex type gross pollutant traps have been assumed to be adopted allowing for treatment up to the 3-month storm event. Larger storm events are assumed to bypass via splitter pit and be directed to detention basins. Given the range of proprietary products available this strategy has adopted the following treatment effectiveness for gross pollutant traps which is typical for industry leading units available in the market.

- 98% GP removal.
- 70% TSS removal for inflow concentrations greater than 75mg/L.
- 30% TP removal for inflow concentrations greater than 0.5mg/L.
- 0% TN removal.

While not a performance target, it is part of this strategy that oil pillows will be installed in GPTs to capture hydrocarbon pollutants.

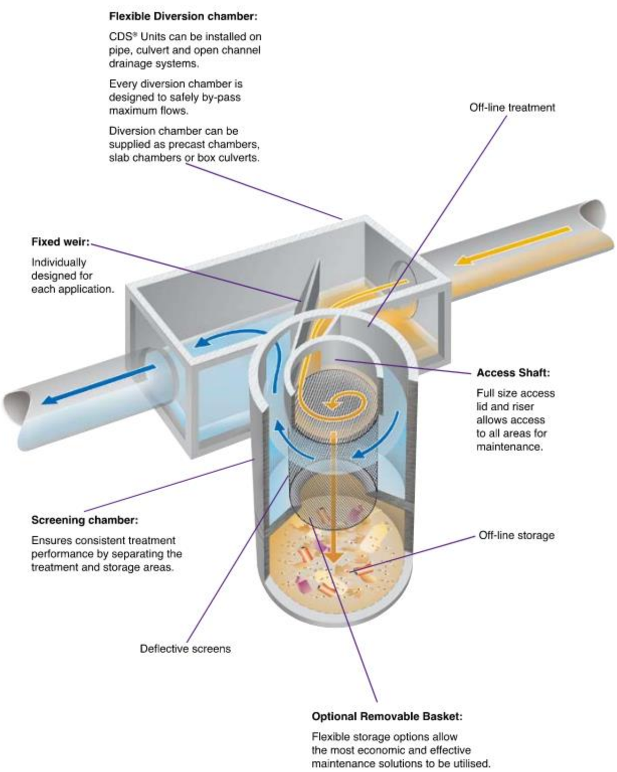


Figure 16 – Typical Vortex Type GPT Concept

Source: Rocla CDS Unit Technical Summary

5.3.4.3 Bio-Retention Basins

The predominant means of suspended solids and nutrient removal is to be through the construction of bio-retention basins. Bio-retention basins are considered most appropriate for the Gilead site due to constraints in the existing topography and shallow depth of rock that render the implementation of wetlands or ponds unfeasible. Bio-retention basins are to incorporate an engineered filtration media that promotes nutrient removal when appropriately vegetated. Bio-retention basins have been modelled in MUSIC adopting the parameters detailed in **Table 12**. A typical bio-retention basin arrangement is presented in **Figure 17**.

Table 12 – Bio-Retention Basin Parameters

Parameter	Adopted Value
High Flow Bypass	3-month flow rate
Extended Detention Depth	300mm
Saturated Hydraulic Conductivity	125mm/hr
Filter Depth	500mm
TN Content of Filter Media	800mg/kg
Orthophosphate Content	40mg/kg
Exfiltration Rate	0mm/hr
Base liner	Yes
Vegetation	Effective nutrient removing plants assumed

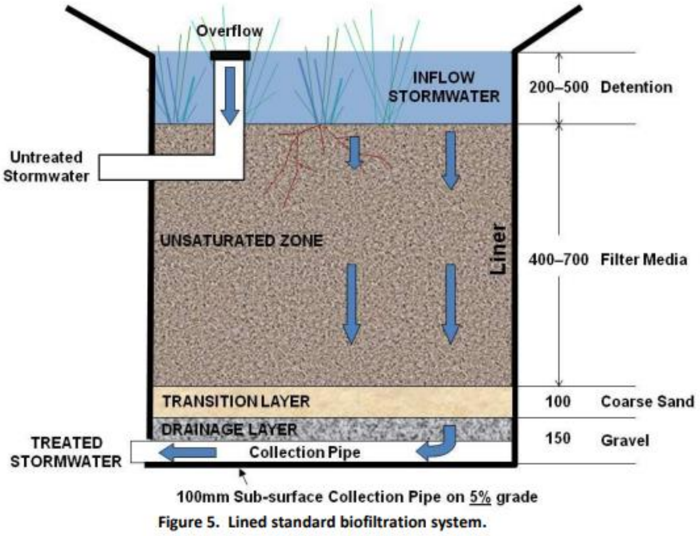


Figure 17 – Typical Bio-Retention Basin Arrangement

Source: Stormwater Biofiltration systems Adoption Guidelines, June 2009, FAWB.

5.3.4.4 Alternative Treatment Options

The Strategy provided adopts a typical water quality treatment train to demonstrate that a functional outcome to meet performance targets can be achieved. This should not preclude the adoption of alternative treatment options that may be of benefit to the project and should be considered as part of a Development Application process for suitability within the site-specific catchment properties. Some current technologies that may be considered in future as part of detail design include but are not limited to:

Roadside planter beds (with or without bio-filtration media)

Such systems differ from traditional verge planting by occupying parts of the road carriageway allowing for larger deep soil zones and generally increased canopy cover. As these systems have a direct connection to gutter stormwater flows, there is the increased opportunity for vegetation to benefit from passive irrigation leading to increased vegetation health and visual amenity. Such systems however generally require increased maintenance compared to positioning vegetation within the verge and have greater potential to accelerate road pavement failure.

Roadside planter beds can incorporate bio-filtration media as part of the soil system however the effectiveness and cost benefit of this initiative is not as efficient as a centralised water quality basin and generally does not lead to better vegetation outcomes overall.

Deep soil zones may also not be practical for The Site due to the shallow depth of rock throughout.

Figure 18 – Example Roadside Planter Concept

Source: Western Sydney Aerotropolis (Initial Precincts) Stormwater and Water Cycle Management Study, December 2021, Sydney Water Corporation

Roadside swales (with or without bio-filtration media)

Such systems are like roadside planter beds but are applied for longer sections of a road and perform a greater stormwater flow conveyance function. As these systems occupy more of the road carriageway than planter beds, they cannot easily be accommodated between parking modules and are therefore typically positioned between the parking lane and verge or to replace the road verge along roads directly adjacent open spaces. These systems provide the same benefits and risks as roadside planter beds but are also more difficult to apply in coordination with pedestrian pathways and vehicle driveways.

Roadside swales can also incorporate bio-filtration media as part of the soil system and due to their relative mass, they may provide more efficient and cost-effective water quality treatment compared to planter beds.

Figure 19 – Example Roadside Swale Concept

Source: Sanctuary Drive, Rouse Hill, Google Street View.

Large scale vegetation regeneration of previous agricultural land offsetting net development pollutant generation.

As part of the Gilead development, large portions of agricultural land are to be revegetated and repurposed as naturalised open space. While on a small scale such improvements may be negligible in water quality improvements, at a larger scale such as is proposed, the reductions in agriculture pollutants and the increased passive water quality improvement potential of the revegetated land can facilitate on its own improved water way health.

This Strategy does not suggest that revegetation alone can wholly compensate for the increase in development generated pollutants or that such land can be used for the sole purpose of water quality treatment, however there is opportunity for revegetation initiatives to partially contribute to water quality and environmental improvements e.g. revegetation of land may provide greater net benefit than the land disturbance and import or foreign material to construct traditional entire water quality systems.

Figure 20 – Example Revegetation Environmental Improvements

Source: Greening Australia, River Torrens Revegetation, Adelaide

Proprietary filtration tree pits.

Such systems are similar in principle to roadside planter beds but are provided as a packaged system by private enterprise. These systems can provide better treatment performance and convenience but are generally more costly to implement and can be more costly to maintain in the long term. The growth potential of vegetation is also limited by the practical limitations of the concrete containers that these systems typically adopt.

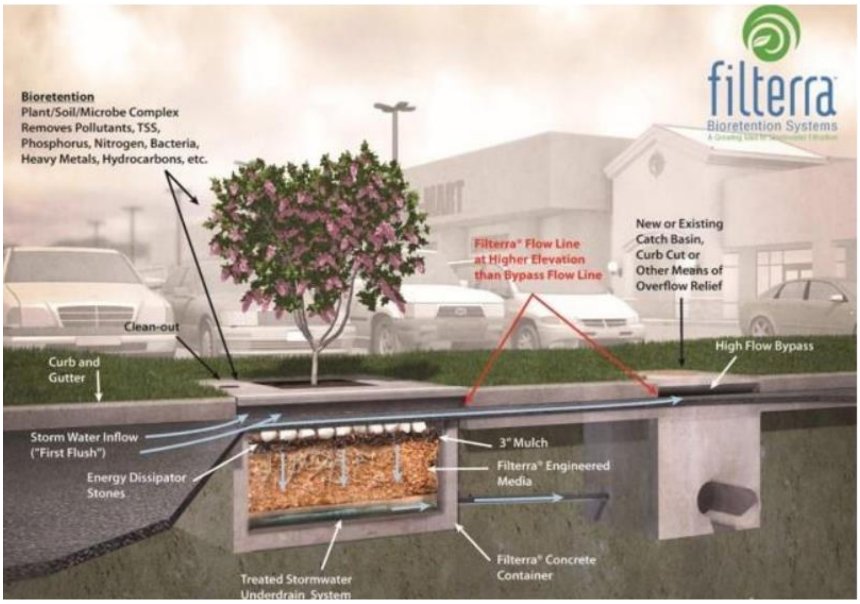


Figure 21 – Example Proprietary Tree Pit Concept

Source: Filterra Technical Design Guide, Ocean Protect

On-lot raingardens.

On-lot raingardens are like the bio-retention basins proposed but are implemented on a smaller scale at each individual land holding. The primary benefits are the capture of pollutants close to the source and reduced burden on public assets. These systems however are reliant on adequate maintenance by numerous private owners and where a water quality system is reliant on their use, requires burdens on the title of land to ensure their implementation.

Generally, the inability to control the implementation of such systems on a broad scale leads to these assets not forming part of a masterplan development strategy.

Complimentary pressurised systems (e.g. harvesting or recirculation).

Pumped systems accompanied by storage can be adopted to improve the performance of a passive system through either the extraction of treated stormwater for reuse or recirculating treated stormwater through the water quality system.

In the case of stormwater harvesting, this typically requires relatively large stormwater retention basins or tanks which for The Site may not be appropriate due to the presence of shallow rock. Such systems also require a pressurised reticulation network to transport harvested rainwater to the point of use which can be cost prohibitive.

With respect to recirculation systems, these have potential to allow for reduced basin footprints but are more expensive to maintain and have reduced reliability due to requiring a pump to function. Adoption of a pumped system however generally allows for reduced excavation.

Due to the broad scope of this strategy, the variability in catchment properties throughout the site and the relative unknown sub surface conditions in general it is not reasonable to rely on alternative treatment options at this stage of development planning.

Following the lodgement of the Planning Proposal, Lendlease intend to work with Campbelltown Council explore opportunities for alternative treatment options that achieve both the necessary performance outcomes and Council's maintenance requirements. Following resolution on preferred alternative strategies with Council, it is expected that appropriate controls can be incorporated within the Development Control Plan that will support the detailed masterplan to be established for Gilead.

5.4 Results and Discussion

Estimated post-development pollutant reductions and estimated bio-retention basin filter area requirement are summarised in **Table 13** based on the modelling methodology described in the preceding Sections. The estimated treatment areas represent minimum area requirements for land use planning purposes and is discussed in further detail in **Section 6**.

As demonstrated, the proposed stormwater quality management strategy is capable of achieving performance criteria for the development and with refinement as part of future detailed design has potential to create high amenity infrastructure connecting development and adjacent natural vegetation.

Table 13 – MUSIC Modelling Results

Control Node	GP Removal (%)	TSS Removal (%)	TP Removal (%)	TN Removal (%)	Bio – Retention System Filter Area (m^2)
Performance Target	**90.0**	**85.0**	**70.0**	**55.0**	
Basin D1a	99.6	90.9	71.8	55.7	890
Basin D1b	99.9	91.4	70.0	56.0	620
Basin D1c	99.6	91.3	72.2	55.9	980
Basin D1d	99.5	90.7	71.4	55.5	1,025
Basin D2	99.5	89.7	70.4	55.4	1,090
Basin D3	99.7	91.6	73.1	55.9	930
Basin D4	100.0	93.2	74.2	56.9	260
Basin D5	99.8	90.5	70.2	55.5	1,350
Basin D6	99.9	91.6	71.8	55.7	945
Basin D7	98.7	88.8	70.0	56.0	1,685
Basin D9	99.0	89.7	71.4	56.3	1,520
Basin D10 [1,3]	99.1	90.4	71.0	56.3	3,555
Basin D11 [1]	100.0	99.6	74.7	55.6	130
Basin D12 [1]	100.0	95.8	72.9	56	465
Basin D13 [1]	99.5	95.3	71.5	55.3	850
Basin D14 [1]	99.3	94.9	71.9	56	825
Basin D15 [1]	99.3	99.0	74.9	56.9	625
Basin D16 [1]	99.8	93.3	71.4	55.0	1,330
Basin D17 [1]	100.0	93.9	71.0	55.2	100
Basin D18 [2]	97.7	N/A	46.1	N/A	N/A
Basin D19 [2]	98.3	N/A	46.5	N/A	N/A

Basin D21	98.4	88.1	70.5	55.8	4,120
Basin D23	99.4	90.1	71.1	55.3	2,610
Basin D24	99.9	92	71.9	56.4	690

1. *Bio-retention basin with external un-developed catchment.*
2. *Basin discharging to an existing WaterNSW flume and subsequently to a downstream consolidated bio-retention basin.*
3. *Bio-retention basin receiving upstream post-development flow from existing WaterNSW flume(s).*
4. *Sizing of basins to be confirmed during detail design*

5.4.1 Basin D24 and Figtree Hill Interface

Basin D24 and the interface with the Figtree Hill development are to be designed in consideration of the performance targets of the Figtree Hill WCMS. There is opportunity as part of the Figtree Hill development to amend the design of Figtree Hill Basin 3B to provide treatment of part of the Gilead development that naturally falls toward this basin. **Appendix D** provides an initial assessment of the revised Figtree Hill stormwater strategy where Basin D24 and Figtree Hill Basin 3B form part of the post development condition.

6 Stormwater Infrastructure Land Use Planning

A key outcome of this Strategy is to define a functional stormwater management strategy that is capable of supporting the proposed Gilead development. Due to numerous site constraints it is likely stormwater infrastructure will shift as part of detailed design to respond to these constraints and this Strategy will form a guide on the overarching objectives to be achieved as part of such refinements. **Table 14** summarises the estimated land requirements to implement this Strategy which demonstrates that the plan areas provided contain sufficient area for the estimated infrastructure footprints plus contingency.

This infrastructure is proposed to be located within land identified for urban development and in areas marked for conservation that are currently clear of any significant vegetation due to previous agricultural uses. Where the infrastructure is located within conservation areas, an appropriate level of revegetation is to occur to ensure that it provides a stormwater management function as well as a contribution towards the conservation outcomes in Gilead.

Table 14 – Stormwater Infrastructure Land Use Summary

Basin ID	Modelled Surface Area (Bio-retention + OSD) (m^2)	Total Infrastructure Area Required (Modelled Surface Area + 50%) (m^2)	Surface Area Provided for Capability Assessment (m^2)
Basin D1a	2,990	4,500	7,000
Basin D1b	2,120	3,180	3,400
Basin D1c	2,780	4,170	4,650
Basin D1d	3,525	5,300	8,150
Basin D2	3,690	5,600	11,150
Basin D3	4,730	7,100	9,320
Basin D4	260	400	N/A
Basin D5	5,150	7,800	10,700
Basin D6	3,345	5,100	10,090
Basin D7	5,885	8,900	11,300
Basin D9	5,420	8,200	11,590
Basin D10	8,455	12,700	16,120
Basin D11	630	1,000	2,830
Basin D12	1,965	3,000	3,440
Basin D13	3,350	5,100	8,040
Basin D14	4,625	7,000	7,640
Basin D15	3,625	5,500	5,600
Basin D16	6,030	9,100	9,100
Basin D17	450	700	3,870
Basin D18	2,750	4,200	6,500
Basin D19	1,250	1,900	3,530
Basin D21	13,120	19,700	34,460
Basin D23	8,610	13,000	19,230
Basin D24	2,390	3,600	10,170
Total	**97,145**	**146,750**	**217,880**

1. *The additional 50% area allowance is to account for batters, maintenance tracks and the like to create functional infrastructure.*

7 Stream Erosion Index

To estimate potential impact on existing waterways due to changes in flow frequency behaviour, an assessment of Stream Erosion Index (**SEI**) has been undertaken. The following methodology has been adopted to calculate post-development SEI with a target SEI value of 1.0 or less (no impact).

- Critical stream forming flow has been estimated based on calculated pre-development 50% AEP flow rate multiplied by 50%. Critical stream forming flow indicates the threshold at which mobilisation of bed material and erosion of banks begins to occur.
- Mean pre-development annual runoff volume that exceeds the estimated critical flow has been determined through MUSIC software. With a SEI target of 1.0, this mean annual volume becomes the target in the post-development scenario.
- Mean post-development annual runoff volume that exceeds the estimated critical flow has been determined through MUSIC software. Detention and water quality improvement infrastructure has been modelled as part of the post-development scenario.
- SEI has been determined by dividing post-development mean annual runoff volume by pre-development mean annual runoff volume from the above steps.

Table 15 – Stream Erosion Index Assessment with Detention

Waterway	Calculated 50%AEP Pre-Development Peak Flow Rate (m^3/s)	Estimated Critical Stream Forming Flow Rate (m^3/s)	Mean Annual Runoff Volume Above Critical Flow (ML/year)		SEI
			Pre-Development	Post-Development	
4A	0.81	0.405	5.04	4.69	0.93
3A	0.13	0.065	0.71	0.00	0.00
2A	6.85	3.426	29.80	17.30	0.58
1A	1.57	0.786	9.73	5.75	0.59
1B	0.46	0.228	2.70	1.38	0.51
1C	1.67	0.835	12.40	6.14	0.50
1D	1.36	0.680	14.20	11.00	0.77
1E	1.37	0.683	9.80	8.52	0.87

Waterway IDs and locations as per Figure 3.

As demonstrated in **Table 15** the implementation of the proposed stormwater management strategy will achieve an SEI of less than 1.0 for all existing watercourses indicating that it is very unlikely the Gilead development will generate accelerated changes in the geomorphology of these watercourses where this Strategy is in place.

7.1 Reduced Detention Storage Sensitivity

As part of detail design there is opportunity to adopt a reduced detention strategy that aims to detain environmental impact flows (e.g. 50% AEP) only while runoff from greater storm events is permitted to bypass. Typically a reduced detention strategy would result in 50% less storage volume than traditional detention strategies and this outcome has been modelled as a sensitivity scenario to estimate potential geomorphology impacts in frequent storm events. Results of this sensitivity is provided in **Table 16** and indicates that a reduced basin strategy may have an impact on some existing waterways (above an SEI of 1.0) but a minor impact only (SEI less than 3.5). On this basis, a reduced detention strategy may be justified provided safety criteria can be achieved. Further, a reduced detention storage requirement would improve the feasibility of implementing a distributed stormwater discharge regime along edge roads that may provide improvements to the passive irrigation of adjacent natural waterways and minimise the localised impact of concentrated discharge.

Table 16 – Stream Erosion Index Assessment with Reduced Detention

Waterway	Calculated 50%AEP Pre-Development Peak Flow Rate (m^3/s)	Estimated Critical Stream Forming Flow Rate (m^3/s)	Mean Annual Runoff Volume Above Critical Flow (ML/year)		SEI
			Pre-Development	Post-Development	
4A	0.81	0.405	5.04	6.54	1.30
3A	0.13	0.065	0.71	0.00	0.00
2A	6.85	3.426	29.80	24.60	0.83
1A	1.57	0.786	9.73	8.45	0.87
1B	0.46	0.228	2.70	2.12	0.79
1C	1.67	0.835	12.40	8.62	0.70
1D	1.36	0.680	14.20	14.10	0.99
1E	1.81	0.905	9.80	9.64	0.98

Waterway IDs and locations as per Figure 3.

8 Conclusions and Recommendations

This stormwater management strategy report has demonstrated that the Gilead development can be supported by stormwater control infrastructure to adequately achieve statutory performance targets to facilitate the development.

The proposed development is positioned above existing 1% AEP flood extents and generally above the PMF event such that additional flood mitigation works beyond stormwater peak flow management up to the 1% AEP will not be necessary. In addition, due to landform constraints, bridge crossings are likely to be elevated above the PMF event. A flood evacuation strategy is unlikely to be necessary for The Site due to its elevation above flood risks.

Control of post-development peak flows is to be managed through detention basins, and water quality improvements are to be controlled through a system of rainwater tanks, gross pollutant traps and bio-retention basins. Specifically, the performance requirements of the WaterNSW Upper Canal can be achieved with refined performance checks to be undertaken at detail design.

Based on the stormwater quantity and quality modelling, approximate land use requirements have been calculated and compared to plan areas reserved in the masterplan which confirms that spatially the stormwater management strategy can be accommodated.

The following opportunities have been identified to improve the fundamental strategy detailed in this report. It is recommended that these opportunities be investigated as part of detailed design to ensure high amenity development outcomes are achieved and should form part of the Development Control Plan to be adopted for the land and inform a local Planning Agreement with Council to confirm delivery.

- An Urban Development land use zoning is recommended to provide flexibility in stormwater infrastructure positioning and size which will allow infrastructure to be designed that responds to the site-specific constraints of the infrastructure.
- The Figtree Hill Basin 3B design could be updated to include part of the Gilead development that naturally falls toward this basin.
- Alternative water sensitive urban design solutions could be considered that may be more beneficial than standard practice such as:
    - Roadside planter beds (with or without bio-filtration media)
    - Roadside swales (with or without bio-filtration media)
    - Large scale vegetation regeneration of previous agricultural land offsetting net development pollutant generation.
    - Proprietary filtration tree pits
    - On-lot raingardens
    - Complimentary pressurised systems (e.g. recirculation or harvesting).
- The impact of a reduced detention strategy should be investigated to determine if detention of environmental impact flows (e.g. 50% AEP event) only will have detrimental impacts on existing waterways and downstream lands. A reduced detention basin strategy has potential to minimise net environmental impact through reduced land disturbance, vegetation clearing and rock excavation.

Appendix A Flood Assessment

Rhelm Pty Ltd

ABN : 55 616 964 517
Level 1, 50 Yeo Street
Neutral Bay NSW 2089
Australia
contact@rhelm.com.au

9 June 2022

Our ref: J1649

Lauren Connors
Enspire Solutons Pty Ltd
1302/83 Mount Street
North Sydney NSW 2060

Dear Lauren,

RE: Mount Gilead Preliminary Flood Modelling

Preliminary flood modelling has been undertaken for Mount Gilead to provide an understanding of the constraints and opportunities associated with development of the site with respect to flooding.

This letter report details the following elements of this preliminary study:

- Background:
- Methodology:
- Outputs; and,
- Limitations and Assumptions.

Background

Rhelm Pty Ltd (Rhelm) has been engaged by Enspire Solutions Pty Ltd (Enspire) on behalf of Lendlease Communities (Lendlease) to develop a flood constraints study to inform part of a Stormwater Management Strategy. The Stormwater Management Strategy forms part of a documentation package that will facilitate a Planning Proposal to rezone land within Lendlease's landholding at Gilead.

The objective of this study is to provide a high level understanding of the constraints and opportunities associated with development of the site with respect to flooding from the local upstream catchment as well as the Nepean River.

Study Area

The site is generally bounded by Appin Road to the east, the Nepean River in the west, Menangle Creek to the north and approximately Leafs Gully to the south. Several watercourses run through the site, discharging north into Menangle Creek and eventually the Nepean River. This includes Woodhouse Creek, Nepean Creek as well as other minor unnamed watercourses. The WaterNSW Upper Canal roughly bisects the site and would remain untouched within its cadastral boundaries.

The current site is largely cleared open space, with remnant pockets of denser vegetation, typically adjacent to creeks and watercourses.

It is noted that in general the watercourses within the study area have steep incised banks with relatively dense vegetation.

The study area is shown **Figure 1** below.

Data Review

The primary data inputs / sources for this study were:

- LiDAR data provided by Lendlease dated 2020 which covered the study area at a 3m resolution (provided as part of the previous study).
- Indicative Masterplan supplied by Enspire 8 June 2022.
- ARR Data Hub, which was used to source rainfall intensity and temporal pattern data.
- Australian Rainfall and Runoff 2019 (ARR2019) Guidelines, which were used to inform the selection of appropriate hydrological and hydraulic model parameters.
- NearMap aerial imagery, which was used to determine subcatchment impervious areas and to delineate land uses (for the purposes of applying model roughness).

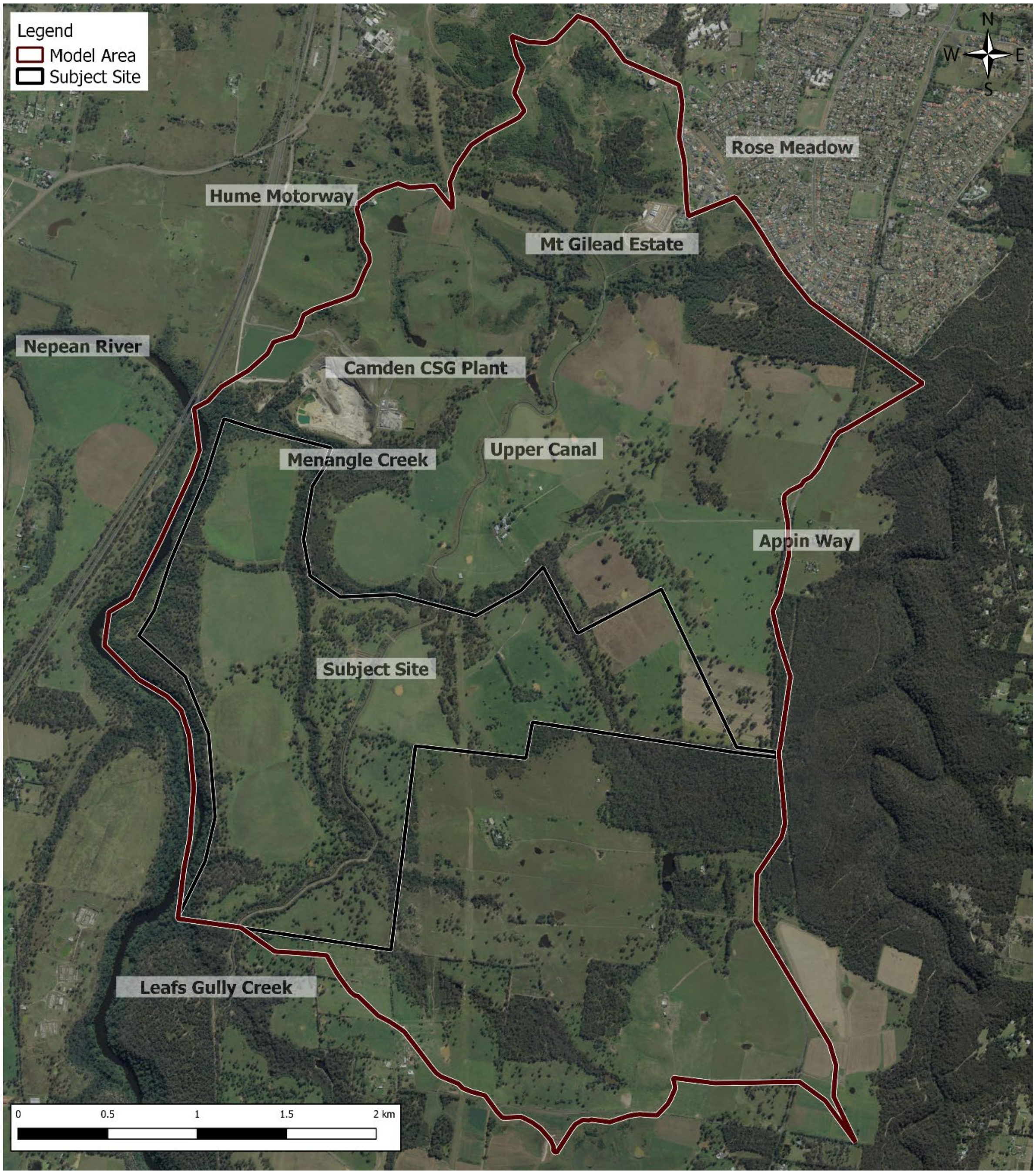


Figure 1 –Study Area

Hydrological Model Development

The hydrological modelling has been completed using the hydrological model in XP-RAFTS. The hydrology has been based on Australian Rainfall and Runoff 2019 (ARR2019) with the parameters extracted from the ARR DataHub shown in **Table 1** and inputs to the model and the data sources for those inputs are summarised in **Table 2**.

The subcatchment delineation is shown in **Figure 2**.

Table 1 – ARR DataHub Metadata

Parameter	Value
Storm Initial Losses (mm)	18 (NSW adjusted loss)
Storm Continuing Losses (mm/h)	2.4 (NSW adjusted loss)
River Region - Division	South East Coast (NSW)
River Region	Hawkesbury River
Point Temporal Pattern Label	East Coast South
Version	2016_v2

Table 2 – Hydrological Model Input Data

Parameter	Data Source
Area and slope	LiDAR data is available for full catchment and was used for this mapping.
Percentage impervious	Percentage impervious areas are largely a factor of development intensity and were determined from aerial imagery (NearMap, March, 2022). Adopted values were: • Open Space 2% • Light Vegetation 1% • Medium Vegetation 0% • Medium Density Residential 80% • Infrastructure 40%
Roughness	Values have been determined from an examination of aerial imagery and have been largely dependent on land use. Roughness values adopted were as per the hydraulic model (see **Table 3**).
Runoff routing	Routing refers to the transfer of flows from one sub-catchment to another. This routing can be done in XP-RAFTS through either specifying a lag time between sub-catchments (10 minutes for example) or inputting a typical cross section, roughness and length and allowing XP-RAFTS to compute the lag time based on the flow volume. For this model, the lag approach has been adopted.
Rainfall losses	Under ARR2019, rainfall parameters for hydrological modelling are all available from the ARR Data Hub have been downloaded directly from this website. Probability neutral losses have been adopted, and in the absence of calibrated site losses, the NSW adjusted losses from the Data Hub have been adopted as noted in **Table 1**.

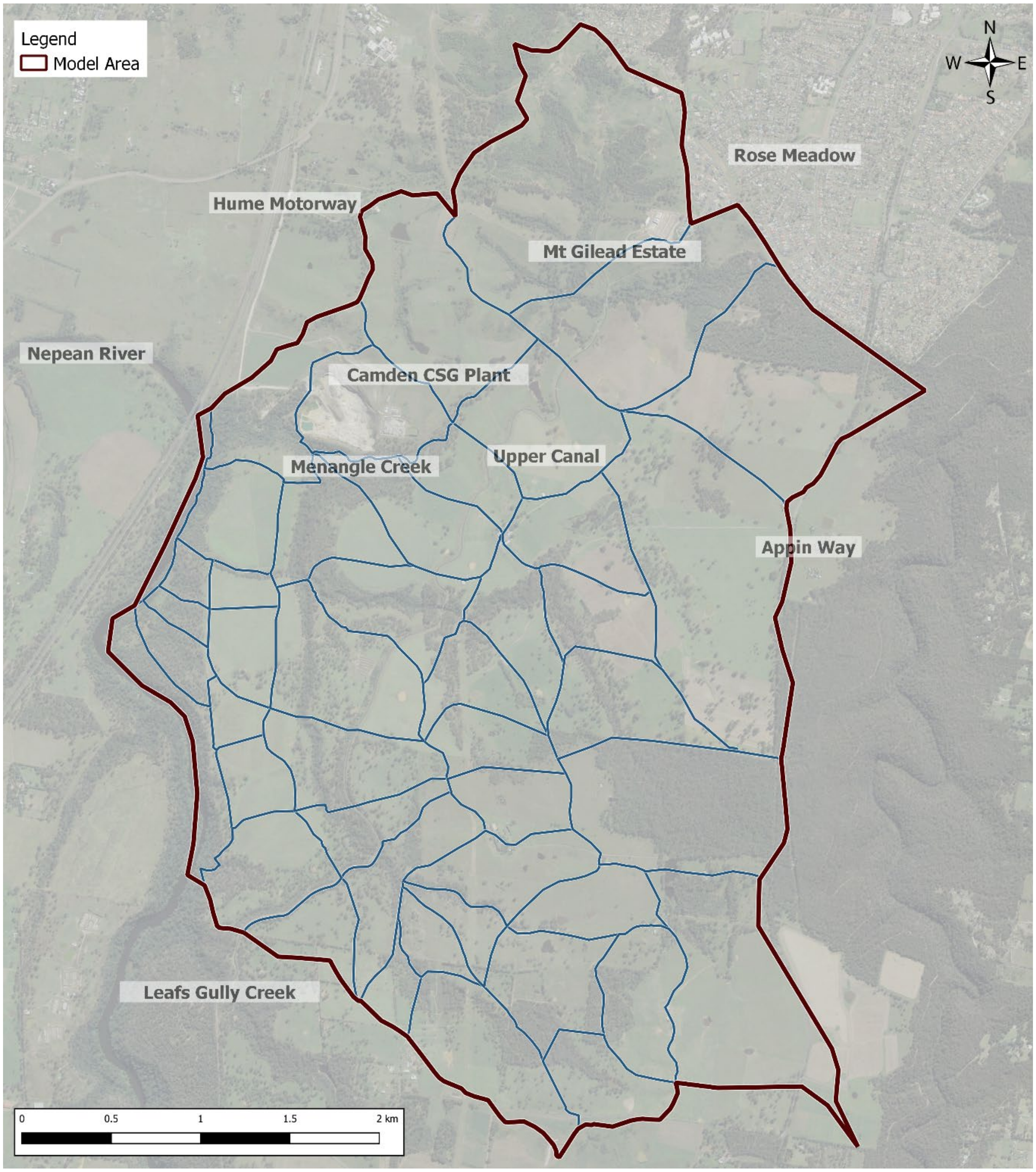


Figure 2 – Subcatchment Delineation

Hydraulic Model Development

The hydraulic modelling has been completed using TUFLOW. The TUFLOW model details are shown in **Figure 3**.

Inputs to the model and the data sources for those inputs are summarised in **Table 3**.

Table 3 - Hydraulic Model Input Data

Parameter	**Data Source**
Model Area	The full upstream catchment area has been included in the hydraulic model. This was feasible due to the relatively small size of the catchment, and allows for the full extent of the various creeks and channels to be included.
DEM	The LiDAR data provided by LendLease in 2020 was utilised as the DEM. This data was supplied in a post-processed format at a 3m grid cell resolution.
Grid Cell Resolution	The variety of creeks and channels within the study area require a grid cell resolution fine enough to appropriately their conveyance. A grid cell of 3x3 metres was adopted for this preliminary modelling which provided a reasonable balance between run times and terrain representation.
Roughness	Roughness values extents were determined based on land use mapping and aerial photography, with reference made to ARR Project 15. The Manning's 'n' values adopted were: • Open Space 0.035 • Light Vegetation 0.045 • Medium Vegetation 0.065 • Medium Density Residential 0.350 • Infrastructure 0.025 A lot averaged high roughness value has been adopted for residential (and to a lesser extent, infrastructure) to allow for buildings, structures and fences onsite that have not been explicitly mapped and accounted for in the model.
1D elements	The model is a pure 2D model and does not contain any 1D elements.
Inflows	Inflows were applied to the hydraulic model via SA polygons utilising standard SA polygons, whereby flows are applied to the lowest cell within the polygon. The SA polygons mirrored the subcatchment breakdown shown in **Figure 2**.
Downstream Boundary	The downstream boundary of the model is the Nepean River. No allowance for Nepean River flooding has been made. The downstream boundary incorporates some nominal level of flow in the Nepean River (that is, the river is not assumed to be dry), by adding 0.1m to the DEM heights. The DEM levels represent the river surface at the time the LiDAR was flown. This flow is fully contained within the riverbanks, and does not influence upstream flood behaviour.

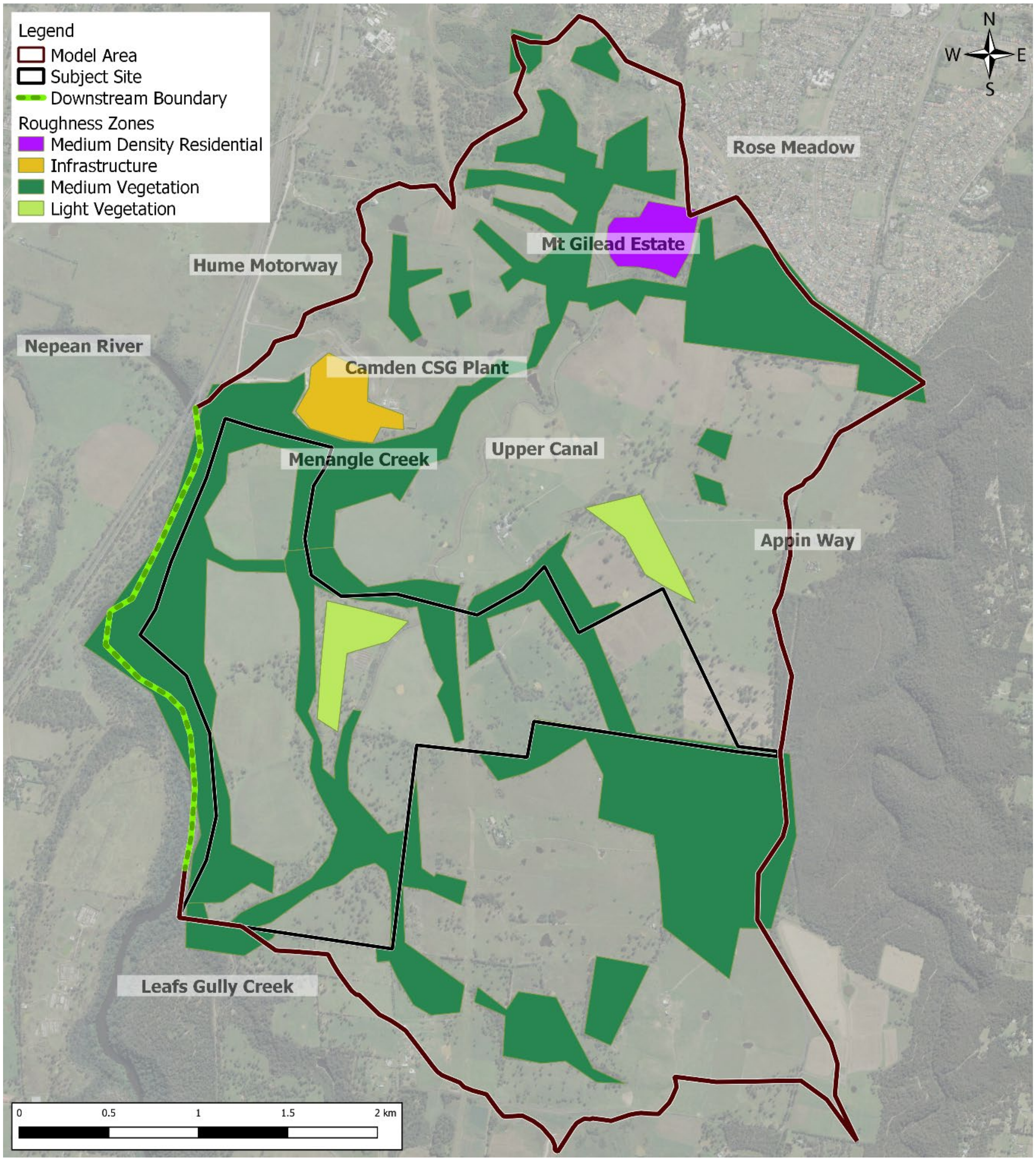


Figure 3 – TUFLOW Model Setup

Note: Areas without a roughness zone in the figure above have been classed as open space.

Modelled Flood Events

All modelling has been undertaken in accordance with ARR2019.

For the annual exceedance probability (AEP) event modelling, the full set of ensemble temporal patterns was run in the hydrological model for durations from 15 minutes to 12 hours. Critical durations for the study area were determined from the RAFTS model, with these selected durations then run in the hydraulic model (for all 10 temporal patterns).

PMF modelling was undertaken using the Generalised Short Duration Method (GSDM) as per the ARR2019 guidance for a catchment of this size.

The critical durations for each event were:

- 50% AEP 360-minute
- 1% AEP 60- and 120-minute
- PMF 30- and 60-minute

The results were then processed to:

- Extract the median plus one event from the peak water levels from the 10 temporal patterns for each duration, and
- Determine the maximum results from the set of median results.

Existing Flood Behaviour

Peak flood depths, with the proposed development extents overlaid, are attached to this letter report, and are shown in:

- RG-00-01 50% AEP
- RG-00-02 1% AEP
- RG-00-03 PMF

The results show that under existing conditions, due to the highly incised nature of the local creeks and channels, that flows are typically well contained throughout the study for events up to and including the PMF.

The exception to this is some minor overland flowpaths in the south-west of the site that drain directly to the Nepean River. The depths of these flowpaths are typically 0.1m – 0.2m in the 50% AEP and 1% AEP, but increase to 0.6m in the PMF. These flowpaths are proposed to be managed through a pit and pipe system in the post-development scenario.

Nepean River Flood Behaviour

The site lies adjacent to the Nepean River, and will be subject to some degree of riverine flooding.

As part of the *Greater Macarthur Water Management Report*, prepared for the Department of Planning and Environment by GHD in 2015, flood modelling of the Nepean River upstream of Menangle Weir was undertaken for the 50%, 5% and 1% AEP events, and the PMF event.

Whilst electronic data of this modelling was not available, the figures from the report (reproduced below in **Figure 4**) indicated that the peak Nepean River levels are in the order of:

- 78 – 85mAHD in the 1% AEP; and,
- 80 – 90mAHD in the PMF.

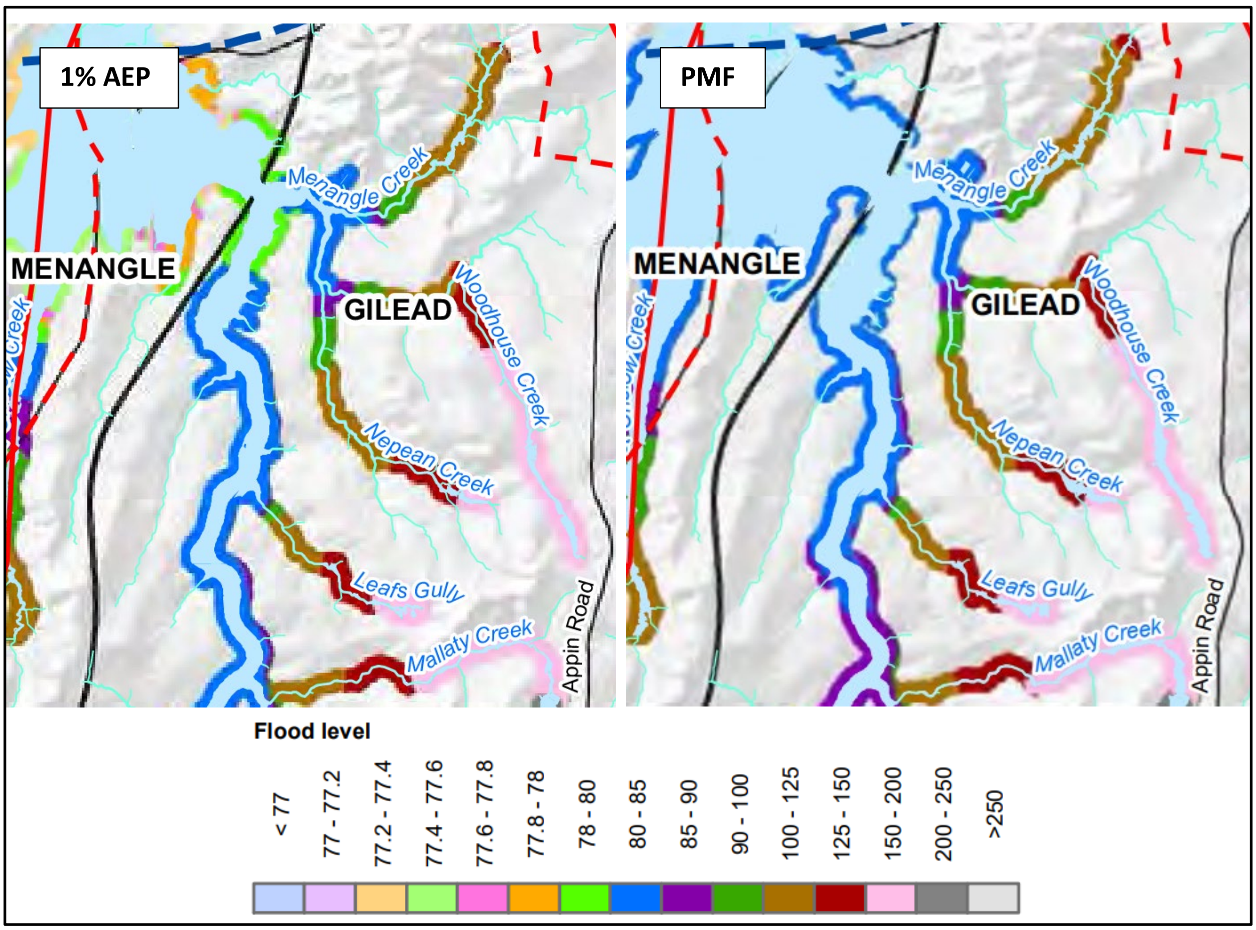


Figure 4 –Nepean River Flooding (GHD, 2015)

Limitations and Assumptions

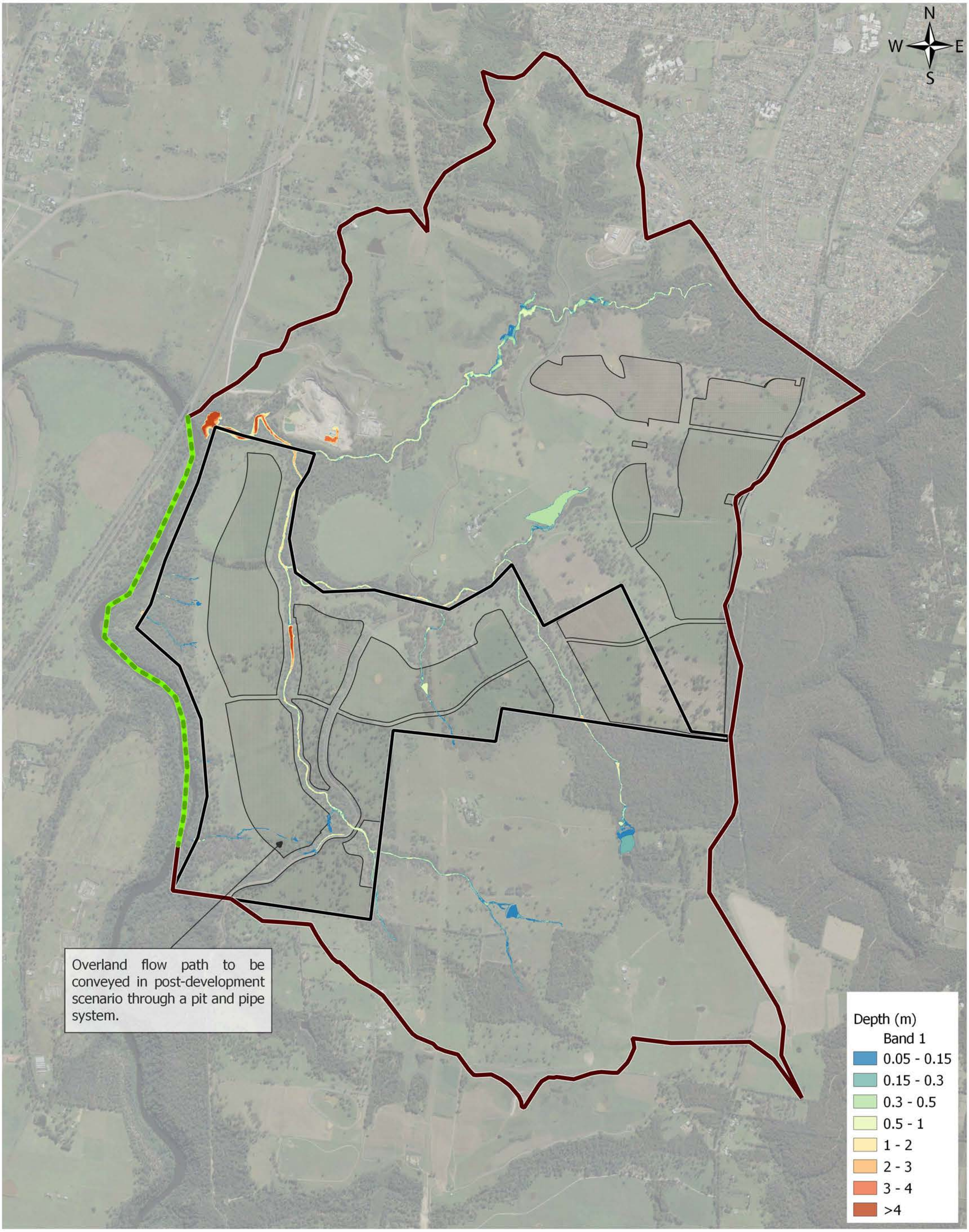
This assessment has been undertaken in accordance with the latest industry guidelines, namely ARR2019. However, the assessment is preliminary, and the following should be noted:

- No calibration, validation, sensitivity testing or ground truthing have been undertaken.
- All model parameters are as per typical values noted in ARR2019 and have not been adjusted for this catchment area.
- A detailed survey of creeks and channels within the study area is currently being undertaken, and once available, can be used to confirm the DEM used in the TUFLOW model and the resulting flood behaviour.
- No flooding of the Nepean River has incorporated in this assessment. The results presented are for local catchment flooding only.
- The LiDAR data underlying the model typically has a vertical accuracy of 0.1 – 0.3m. In the absence of ground survey to confirm LiDAR levels, or calibration / validation to confirm flood levels, a similar level of accuracy should be assumed for the reported preliminary results.
- Modelling of flood flows near the Upper Canal, while roughly represented in the LiDAR ground level data, does not incorporate any of the existing cross drainage structures. It is not expected that these cross-drainage structures would significantly impact the creek flows shown in these results. Future flood modelling will take this into account.

If you have any questions concerning this report or the attached maps, please do not hesitate to contact me.

Sincerely,

Luke Evans
Senior Engineer.



Rhelm

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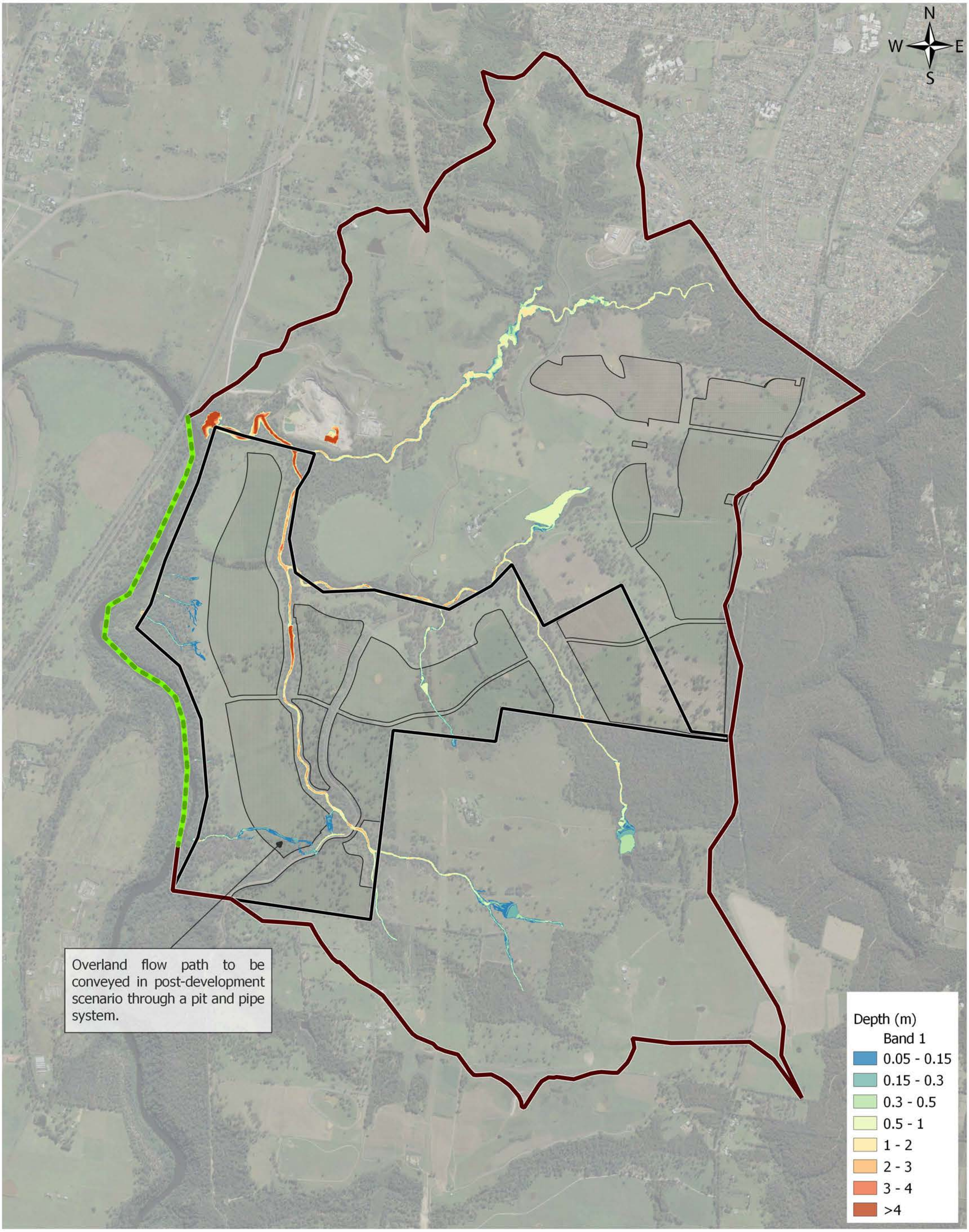
Date : 7 June 2022
Revision : A
Created by : LRE
Coordinate System : MGA 2020/56

0 250 500 750 1,000 m

Legend
Model Area
Subject Site
Proposed Masterplan Development Regions

RG-00-01
Mount Gilead
Prelminary 50% AEP Depths and Extents



Rhelm

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Date : 7 June 2022
Revision : A
Created by : LRE
Coordinate System : MGA 2020/56

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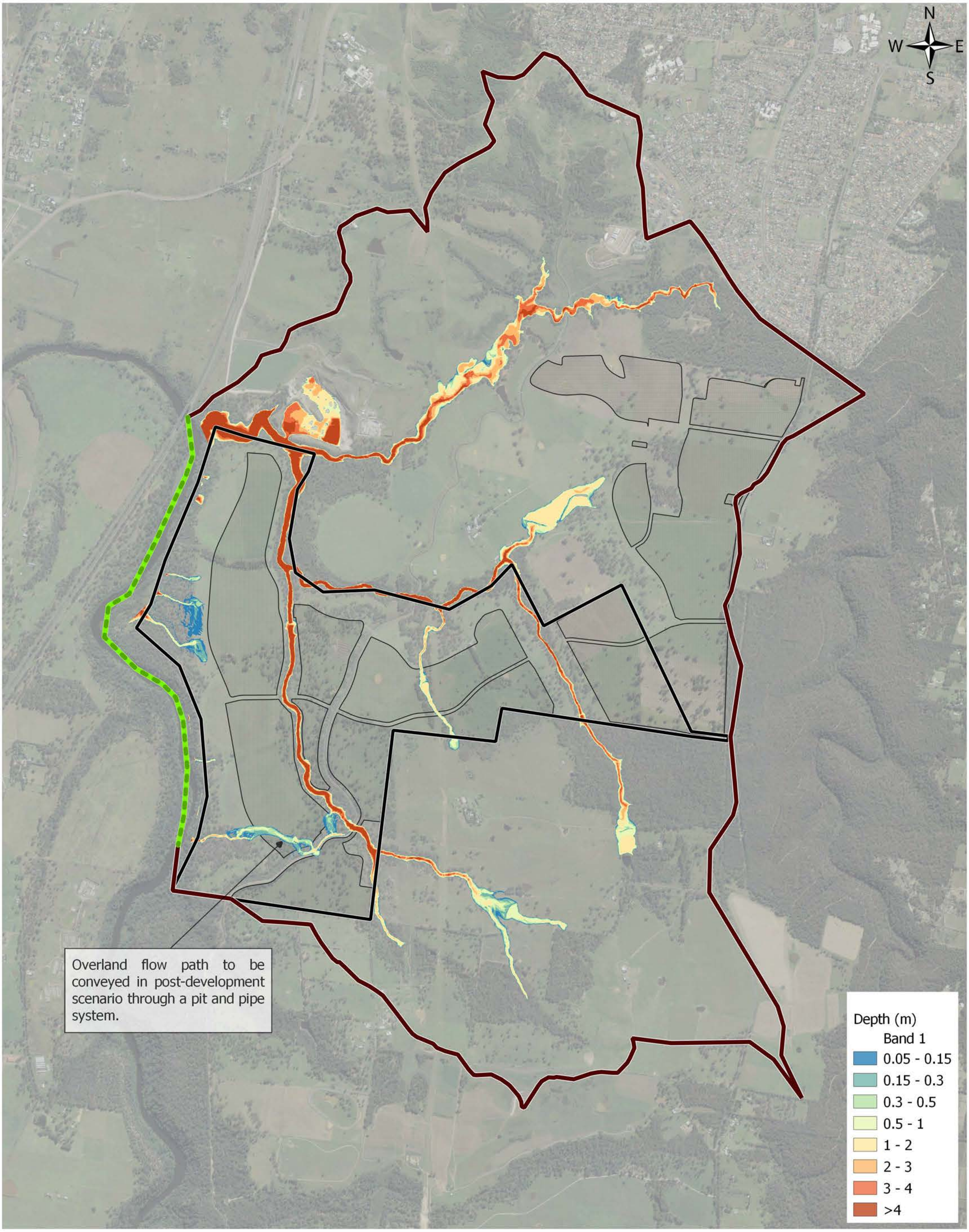
Legend
Model Area
Subject Site
Proposed Masterplan Development Regions

RG-00-02
Mount Gilead
Prelminary 1% AEP Depths and Extents



Rhelm

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Date : 7 June 2022
Revision : A
Created by : LRE
Coordinate System : MGA 2020/56

0 250 500 750 1,000 m

Legend
Model Area
Subject Site
Proposed Masterplan Development Regions

RG-00-03
Mount Gilead
Prelminary PMF Depths and Extents

Appendix B Upper Canal Flume Data

WaterNSW

Mt Gilead Drainage information

The new return period should be above 100 year flood. The cross drains at the location should be the addition of whatever was there before the drainage project along with the new drains in the rightmost column, otherwise the upstream berm was increased where the 100year flood criteria was not met.

ID	Chainage (m)	Easting	Northing	Type	Material	Shape	Size before drainage project	Significance	Return Period before drainage project	Action	No. and size of additional/replaced drain
32	17481	150.757	-34.151	Flume	Steel	Half pipe	1000 dia	Moderate	above 100 year	Repair ^	
33	17892	150.758	-34.147	Flume	Steel (cement lined)	Pipe	1000 dia	Moderate	32.78520645	Repair, Supplement	Increase upstream berm 150mm
34	18144	150.760	-34.146	Flume	Steel	Box	600x600	Moderate	above 100 year	Repair only	
35	18273	150.761	-34.146	Flume	Steel	Pipe	500 dia	Exceptional	57.84700973	Repair, Supplement	1 x 700 half pipe
36	18407	150.762	-34.145	Flume	Steel	Half pipe	800 dia + 100 high walls	Moderate/Intrusive	above 100 year	Repair only	
37	18598	150.764	-34.144	Flume	Steel (cement lined)	Pipe	1200 dia	Moderate	above 100 year	Repair only	
38	18745	150.765	-34.143	Flume	Steel	Box	600x450	High	59.32066745	Repair, Supplement	1 x 700 half pipe

39	19038	150.766	-34.142	Flume	Steel	Box	575x1000	High	72.73472197	Repair, Supplement	1 x 700 half pipe
40	19164	150.766	-34.141	Flume	Steel	Half pipe	600 dia	High	above 100 year	No action	
41	19401	150.765	-34.139	Siphon	Concrete	Pipe	1200 dia	Exceptional	above 100 year	Clear drainage path	
42	19606	150.765	-34.137	Flume	Steel	Box	900x800	Moderate/Intrusive	56.96149922	Repair, Supplement	Increase upstream berm 100mm
43	19750	150.766	-34.136	Flume	Steel	Box	1050x500	Moderate	above 100 year	No action	
44	20092	150.767	-34.133	Flume	Steel	Half pipe	800 dia + 200 high walls	High	above 100 year	Repair only	
45	20343	150.769	-34.132	Flume	Steel	Box	600x600	Moderate/Intrusive	24.21156501	Repair, Supplement	1 x 700 half pipe

APPIN ROAD
HUME MOTORWAY
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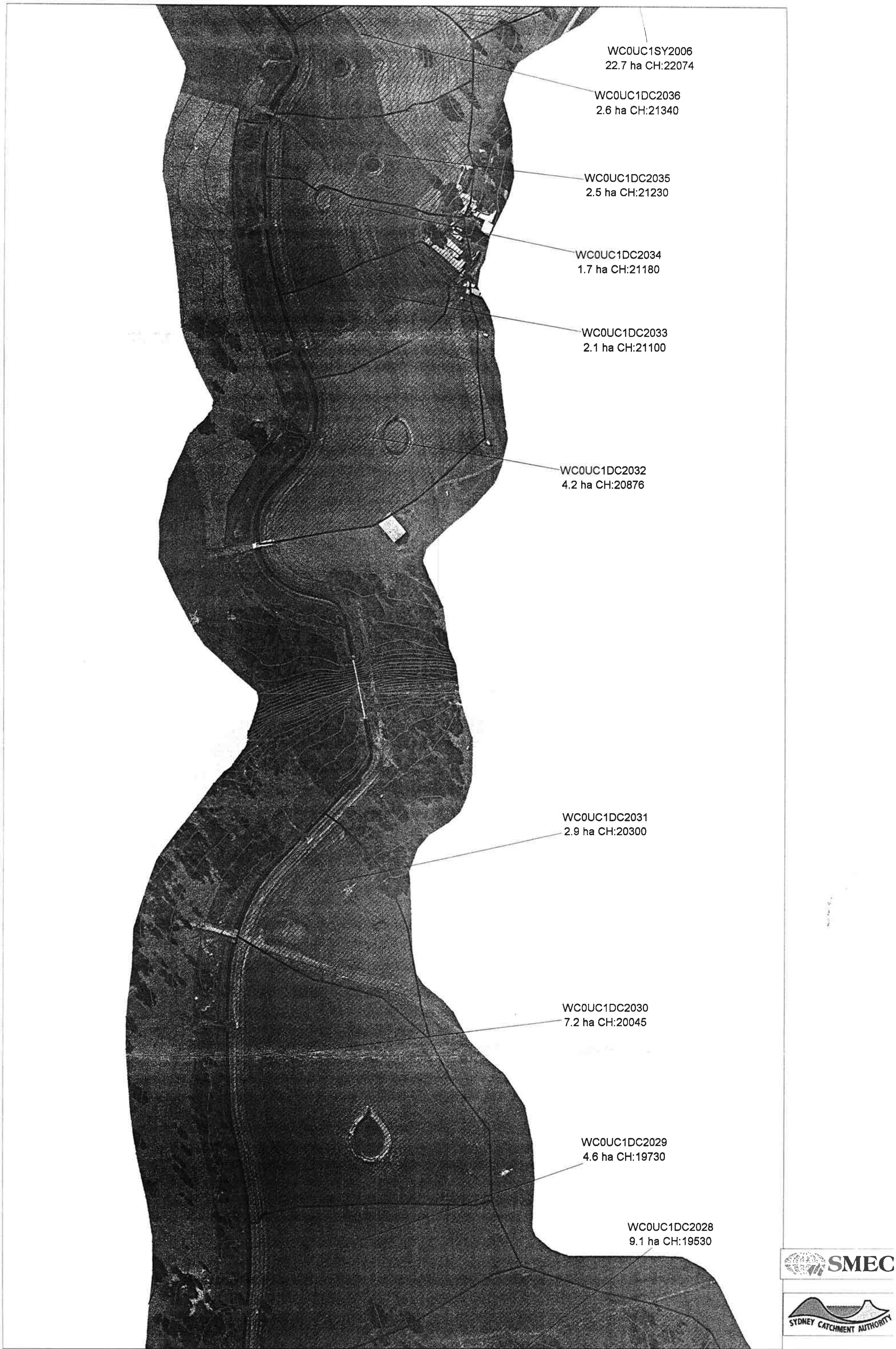

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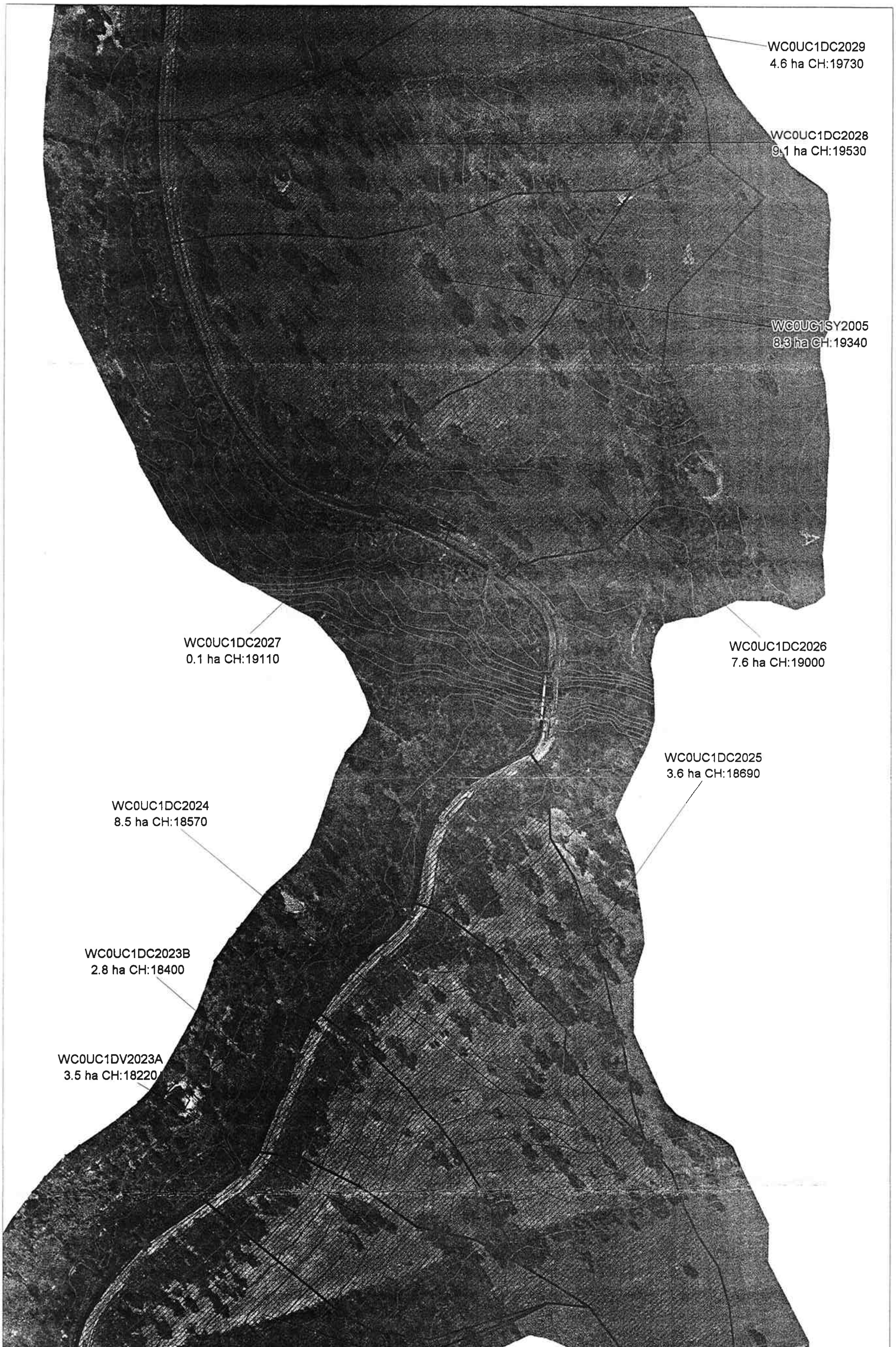
Plotted 6/8/2001

Upper Canal Cross Drainage Analysis
Catchment Layout - Map 24 / 29



SMEC

SYDNEY CATCHMENT AUTHORITY

SCALE 1:4 000
Plotted 6/8/2001

Upper Canal Cross Drainage Analysis
Catchment Layout - Map 25 / 29

Chainage:	16477	Description: Trapezoidal Channel, Base - 3, Depth - , Slopes 1:2					2
USIL	DSIL	Pit Level US DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10.6				Out	10000	1247	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	1.076	1.076	10.6	**10.824**	0	Critical Depth
2	1.476	1.476	10.6	**10.873**	0	Critical Depth
5	1.978	1.978	10.6	**10.928**	0	Critical Depth
10	2.282	2.282	10.6	**10.958**	0	Critical Depth
20	2.738	2.738	10.6	**11**	0	Critical Depth
50	3.309	3.309	10.6	**11.049**	0	Critical Depth
100	3.765	3.765	10.6	**11.085**	0	Critical Depth
10000	9.893	9.893	10.6	**11.451**	0	Critical Depth

Chainage:	17461	Description: 1 x 1/2 pipe open flume 1m dia 0.5m high					1
USIL	DSIL	Pit Level US DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10	9.9		10.6	Canal	150	150	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.184	0.184	10.084	**10.28**	0	Subcritical Flow - Outlet Control
2	0.248	0.248	10.116	**10.327**	0	Subcritical Flow - Outlet Control
5	0.337	0.337	10.156	**10.384**	0	Subcritical Flow - Outlet Control
10	0.384	0.384	10.175	**10.411**	0	Subcritical Flow - Outlet Control
20	0.454	0.454	10.201	**10.45**	0	Subcritical Flow - Outlet Control
50	0.553	0.553	10.236	**10.5**	0	Subcritical Flow - Outlet Control
100	0.628	0.628	10.261	**10.535**	0	Subcritical Flow - Outlet Control
10000	2.389	0.784	10.31	**10.604**	1.605	Subcritical Flow - Outlet Control

Chainage:	17857	Description: 1 x closed pipe flume, 1.02m dia					1
USIL	DSIL	Pit Level US DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10	9.762		10.416	Canal	4	4	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.187	0.187	9.92	**10.299**	0	Inlet Control - Inlet not submerged
2	0.259	0.259	9.951	**10.365**	0	Inlet Control - Inlet not submerged
5	0.347	0.325	9.977	**10.419**	0.022	Inlet Control - Inlet not submerged
10	0.4	0.325	9.977	**10.419**	0.075	Inlet Control - Inlet not submerged
20	0.48	0.325	9.977	**10.419**	0.155	Inlet Control - Inlet not submerged
50	0.58	0.325	9.977	**10.419**	0.255	Inlet Control - Inlet not submerged
100	0.66	0.325	9.977	**10.419**	0.335	Inlet Control - Inlet not submerged
10000	2.62	0.325	9.977	**10.419**	2.295	Inlet Control - Inlet not submerged

Chainage:	17857	Description: Trapezoidal Channel, Base - 2.5, Depth - 0.6, Slopes 1:3, Top - 20					2
USIL	DSIL	Pit Level US DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
9.762			10.442	Canal	10000	4	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.187	0.187	9.762	**9.829**	0	Normal Depth
2	0.259	0.259	9.762	**9.843**	0	Normal Depth
5	0.325	0.325	9.762	**9.854**	0	Normal Depth
10	0.325	0.325	9.762	**9.854**	0	Normal Depth
20	0.325	0.325	9.762	**9.854**	0	Normal Depth
50	0.325	0.325	9.762	**9.854**	0	Normal Depth
100	0.325	0.325	9.762	**9.854**	0	Normal Depth
10000	0.325	0.325	9.762	**9.854**	0	Normal Depth

Chainage:	18120	Description: 1 x rectangular open flume 0.615m high x 0.6m wide						1
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10	9.535			10.9	Canal	381	25	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.19	0.19	9.635	**10.271**	0	Subcritical Flow - Outlet Control
2	0.261	0.261	9.664	**10.335**	0	Subcritical Flow - Outlet Control
5	0.355	0.355	9.701	**10.412**	0	Subcritical Flow - Outlet Control
10	0.407	0.407	9.721	**10.451**	0	Subcritical Flow - Outlet Control
20	0.493	0.493	9.752	**10.512**	0	Subcritical Flow - Outlet Control
50	0.591	0.591	9.787	**10.578**	0	Subcritical Flow - Outlet Control
100	0.663	0.663	9.812	**10.624**	0	Subcritical Flow - Outlet Control
10000	2.64	1.237	9.986	**10.902**	1.403	Subcritical Flow - Outlet Control

Chainage:	18120	Description: Trapezoidal Channel, Base - 2.5, Depth - 0.5, Slopes 1:1, Top - 5						2
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
9.535				9.642	Canal	25	25	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.19	0.19	9.535	**9.596**	0	Normal Depth
2	0.261	0.261	9.535	**9.608**	0	Normal Depth
5	0.355	0.355	9.535	**9.623**	0	Normal Depth
10	0.407	0.407	9.535	**9.631**	0	Normal Depth
20	0.493	0.493	9.535	**9.642**	0	Normal Depth
50	0.591	0.517	9.535	**9.646**	0.074	Normal Depth
100	0.663	0.517	9.535	**9.646**	0.146	Normal Depth
10000	1.237	0.517	9.535	**9.646**	0.72	Normal Depth

Chainage:	18220	Description: 1 x closed pipe culvert, 0.46m dia						1
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10.913	10.796			11.721	Next Structure	4	13	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.194	0.194	11.024	**11.38**	0	Inlet Control - Inlet not submerged
2	0.268	0.268	11.073	**11.468**	0	Inlet Control - Inlet submerged
5	0.355	0.34	11.115	**11.721**	0.015	Inlet Control - Inlet submerged
10	0.413	0.34	11.115	**11.721**	0.073	Inlet Control - Inlet submerged
20	0.494	0.34	11.115	**11.721**	0.154	Inlet Control - Inlet submerged
50	0.582	0.34	11.115	**11.721**	0.242	Inlet Control - Inlet submerged
100	0.675	0.34	11.115	**11.721**	0.335	Inlet Control - Inlet submerged
10000	2.652	0.34	11.115	**11.721**	2.312	Inlet Control - Inlet submerged

Chainage:	18220	Description: 1 x closed pipe flume, 0.51m dia						2
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10	9.7			10.925	Canal	13	13	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.194	0.194	9.885	**10.442**	0	Inlet Control - Inlet not submerged
2	0.268	0.268	9.925	**10.539**	0	Inlet Control - Inlet not submerged
5	0.355	0.355	9.967	**10.638**	0	Inlet Control - Inlet submerged
10	0.413	0.413	9.994	**10.811**	0	Inlet Control - Inlet submerged
20	0.494	0.448	10.008	**10.922**	0.046	Inlet Control - Inlet submerged
50	0.582	0.448	10.008	**10.922**	0.134	Inlet Control - Inlet submerged
100	0.675	0.448	10.008	**10.922**	0.227	Inlet Control - Inlet submerged
10000	2.652	0.448	10.008	**10.922**	2.204	Inlet Control - Inlet submerged

Chainage:	18400	Description: 1 x 1/2 pipe open flume 0.8m dia 0.51m high					1
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10	9.586			11.295	Canal	10000	10000

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.142	0.142	9.706	**10.262**	0	Subcritical Flow - Outlet Control
2	0.195	0.195	9.731	**10.309**	0	Subcritical Flow - Outlet Control
5	0.264	0.264	9.759	**10.363**	0	Subcritical Flow - Outlet Control
10	0.306	0.306	9.776	**10.393**	0	Subcritical Flow - Outlet Control
20	0.361	0.361	9.795	**10.429**	0	Subcritical Flow - Outlet Control
50	0.44	0.44	9.822	**10.478**	0	Subcritical Flow - Outlet Control
100	0.491	0.491	9.838	**10.507**	0	Subcritical Flow - Outlet Control
10000	1.974	1.974	10.208	**11.152**	0	Subcritical Flow - Outlet Control

Chainage:	18400	Description: Trapezoidal Channel, Base - 3, Depth - , Slopes 1:1					2
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
9.586				9.856	Canal	10000	10000

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.142	0.142	9.586	**9.639**	0	Normal Depth - Water on overbank
2	0.195	0.195	9.586	**9.65**	0	Normal Depth - Water on overbank
5	0.264	0.264	9.586	**9.663**	0	Normal Depth - Water on overbank
10	0.306	0.306	9.586	**9.67**	0	Normal Depth - Water on overbank
20	0.361	0.361	9.586	**9.678**	0	Normal Depth - Water on overbank
50	0.44	0.44	9.586	**9.69**	0	Normal Depth - Water on overbank
100	0.491	0.491	9.586	**9.697**	0	Normal Depth - Water on overbank
10000	1.974	1.974	9.586	**9.843**	0	Normal Depth - Water on overbank

Chainage:	18570	Description: 1 x closed pipe culvert, 0.45m dia					1
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10.661	10.591			11.241	Next Structure	1	60

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.378	0.266	10.896	**11.245**	0.112	Inlet Control - Inlet submerged
2	0.522	0.266	10.896	**11.245**	0.256	Inlet Control - Inlet submerged
5	0.703	0.266	10.896	**11.245**	0.437	Inlet Control - Inlet submerged
10	0.819	0.266	10.896	**11.245**	0.553	Inlet Control - Inlet submerged
20	0.974	0.266	10.896	**11.245**	0.708	Inlet Control - Inlet submerged
50	1.186	0.266	10.896	**11.245**	0.92	Inlet Control - Inlet submerged
100	1.327	0.266	10.896	**11.245**	1.061	Inlet Control - Inlet submerged
10000	5.378	0.266	10.896	**11.245**	5.112	Inlet Control - Inlet submerged

Chainage:	18570	Description: 1 x closed pipe flume, 1.2m dia					2
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10	9.634			10.864	Canal	60	60

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.378	0.378	9.834	**10.422**	0	Inlet Control - Inlet not submerged
2	0.522	0.522	9.875	**10.514**	0	Inlet Control - Inlet not submerged
5	0.703	0.703	9.92	**10.617**	0	Inlet Control - Inlet not submerged
10	0.819	0.819	9.947	**10.677**	0	Inlet Control - Inlet not submerged
20	0.974	0.974	9.981	**10.753**	0	Inlet Control - Inlet not submerged
50	1.186	1.186	10.025	**10.85**	0	Inlet Control - Inlet not submerged
100	1.327	1.223	10.032	**10.866**	0.104	Inlet Control - Inlet not submerged
10000	5.378	1.223	10.032	**10.866**	4.155	Inlet Control - Inlet not submerged

Chainage:	18570	Description: Trapezoidal Channel, Base - 1, Depth - 1.6, Slopes 1:1	3

USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
9.634				10.261	Canal	10000	60

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.378	0.378	9.634	**9.828**	0	Normal Depth
2	0.522	0.522	9.634	**9.869**	0	Normal Depth
5	0.703	0.703	9.634	**9.913**	0	Normal Depth
10	0.819	0.819	9.634	**9.938**	0	Normal Depth
20	0.974	0.974	9.634	**9.97**	0	Normal Depth
50	1.186	1.186	9.634	**10.01**	0	Normal Depth
100	1.223	1.223	9.634	**10.016**	0	Normal Depth
10000	1.223	1.223	9.634	**10.016**	0	Normal Depth

Chainage:	18690	Description: 1 x rectangular open flume 0.45m high x 0.6m wide	1

USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10	9.808			10.45	Canal	10	10

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.188	0.188	9.939	**10.269**	0	Subcritical Flow - Outlet Control
2	0.259	0.259	9.976	**10.334**	0	Subcritical Flow - Outlet Control
5	0.347	0.347	10.019	**10.405**	0	Subcritical Flow - Outlet Control
10	0.401	0.401	10.044	**10.447**	0	Subcritical Flow - Outlet Control
20	0.479	0.404	10.045	**10.449**	0.075	Subcritical Flow - Outlet Control
50	0.574	0.404	10.045	**10.449**	0.17	Subcritical Flow - Outlet Control
100	0.652	0.404	10.045	**10.449**	0.248	Subcritical Flow - Outlet Control
10000	2.549	0.404	10.045	**10.449**	2.145	Subcritical Flow - Outlet Control

Chainage:	19000	Description: 2 x closed pipe culvert, 0.3m dia	1

USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10.768	10.703			11.396	Next Structure	1	12

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.476	0.26	10.975	**11.395**	0.216	Inlet Control - Inlet submerged
2	0.654	0.26	10.975	**11.395**	0.394	Inlet Control - Inlet submerged
5	0.881	0.26	10.975	**11.395**	0.621	Inlet Control - Inlet submerged
10	1.019	0.26	10.975	**11.395**	0.759	Inlet Control - Inlet submerged
20	1.221	0.26	10.975	**11.395**	0.961	Inlet Control - Inlet submerged
50	1.447	0.26	10.975	**11.395**	1.187	Inlet Control - Inlet submerged
100	1.648	0.26	10.975	**11.395**	1.388	Inlet Control - Inlet submerged
10000	6.191	0.26	10.975	**11.395**	5.931	Inlet Control - Inlet submerged

Chainage:	19000	Description: 1 x rectangular open flume 0.99m high x 0.58m wide	2

USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10	9.647			10.877	Canal	12	12

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.476	0.476	9.883	**10.512**	0	Subcritical Flow - Outlet Control
2	0.654	0.654	9.952	**10.633**	0	Subcritical Flow - Outlet Control
5	0.881	0.881	10.035	**10.772**	0	Subcritical Flow - Outlet Control
10	1.019	1.019	10.084	**10.85**	0	Subcritical Flow - Outlet Control
20	1.221	1.068	10.1	**10.877**	0.153	Subcritical Flow - Outlet Control
50	1.447	1.068	10.1	**10.877**	0.379	Subcritical Flow - Outlet Control
100	1.648	1.068	10.1	**10.877**	0.58	Subcritical Flow - Outlet Control
10000	6.191	1.068	10.1	**10.877**	5.123	Subcritical Flow - Outlet Control

Chainage:	19110	Description: 1 x closed pipe culvert, 0.3m dia				1

USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
11.355	11.001			11.593	Next Structure	989	10000

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.005	0.005	11.029	**11.419**	0	Subcritical Flow - Outlet Control
2	0.007	0.007	11.034	**11.431**	0	Inlet Control - Inlet not submerged
5	0.01	0.01	11.041	**11.45**	0	Inlet Control - Inlet not submerged
10	0.012	0.012	11.044	**11.461**	0	Inlet Control - Inlet not submerged
20	0.013	0.013	11.046	**11.467**	0	Inlet Control - Inlet not submerged
50	0.016	0.016	11.051	**11.482**	0	Inlet Control - Inlet not submerged
100	0.018	0.018	11.055	**11.491**	0	Inlet Control - Inlet not submerged
10000	0.071	0.044	11.09	**11.592**	0.027	Inlet Control - Inlet not submerged

Chainage:	19110	Description: 1 x 1/2 pipe open flume 0.69m dia 0.345m high				2

USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10	9.969			10.254	Canal	10000	10000

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.005	0.005	10.038	**10.049**	0	Supercritical Flow - Jump w ithin Structure
2	0.007	0.007	10.045	**10.059**	0	Supercritical Flow - Jump w ithin Structure
5	0.01	0.01	10.059	**10.07**	0	Supercritical Flow - Jump w ithin Structure
10	0.012	0.012	10.062	**10.077**	0	Supercritical Flow - Jump w ithin Structure
20	0.013	0.013	10.066	**10.08**	0	Supercritical Flow - Jump w ithin Structure
50	0.016	0.016	10.072	**10.089**	0	Supercritical Flow - Jump w ithin Structure
100	0.018	0.018	10.076	**10.094**	0	Supercritical Flow - Jump w ithin Structure
10000	0.071	0.071	10.158	**10.191**	0	Supercritical Flow - Jump w ithin Structure

Chainage:	19110	Description: Trapezoidal Channel, Base - 0.6, Depth - 0.5, Slopes 1:2.6, Top - 10				3

USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10.004				10.221	Canal	10000	10000

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.005	0.005	10.004	**10.038**	0	Normal Depth
2	0.007	0.007	10.004	**10.045**	0	Normal Depth
5	0.01	0.01	10.004	**10.059**	0	Normal Depth
10	0.012	0.012	10.004	**10.062**	0	Normal Depth
20	0.013	0.013	10.004	**10.066**	0	Normal Depth
50	0.016	0.016	10.004	**10.072**	0	Normal Depth
100	0.018	0.018	10.004	**10.076**	0	Normal Depth
10000	0.071	0.071	10.004	**10.158**	0	Normal Depth

Chainage:	19340	Description: 1 x closed pipe culvert, 0.3m dia				1

USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
14.2	14.1			14.8	Canal	10000	71

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0	0	14.1	**14.2**	0	No Flow
2	0	0	14.1	**14.2**	0	No Flow
5	0	0	14.1	**14.2**	0	No Flow
10	0	0	14.1	**14.2**	0	No Flow
20	0	0	14.247	**14.247**	0	No Flow
50	0	0	14.623	**14.623**	0	No Flow
100	0	0	14.797	**14.797**	0	No Flow
10000	0	0	14.797	**14.797**	0	No Flow

Chainage:	19340	Description: 1 x closed pipe siphon, 0.75m dia					2
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10	9.9085	13.2	12.9	14.8	Canal	71	71

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.463	0.463	13.272	**13.373**	0	Subcritical Flow - Outlet Control
2	0.64	0.64	13.362	**13.553**	0	Subcritical Flow - Outlet Control
5	0.849	0.849	13.457	**13.793**	0	Subcritical Flow - Outlet Control
10	0.988	0.988	13.517	**13.972**	0	Subcritical Flow - Outlet Control
20	1.183	1.183	13.595	**14.247**	0	Subcritical Flow - Outlet Control
50	1.419	1.419	13.685	**14.623**	0	Subcritical Flow - Outlet Control
100	1.614	1.519	13.722	**14.797**	0.095	Subcritical Flow - Outlet Control
10000	6.346	1.519	13.722	**14.797**	4.827	Subcritical Flow - Outlet Control

Chainage:	19340	Description: Rectangular Channel, Base - 2, Depth -					3
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
12.9					Out	10000	71

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.463	0.463	12.9	**13.076**	0	Critical Depth
2	0.64	0.64	12.9	**13.118**	0	Critical Depth
5	0.849	0.849	12.9	**13.164**	0	Critical Depth
10	0.988	0.988	12.9	**13.192**	0	Critical Depth
20	1.183	1.183	12.9	**13.229**	0	Critical Depth
50	1.419	1.419	12.9	**13.272**	0	Critical Depth
100	1.519	1.519	12.9	**13.289**	0	Critical Depth
10000	1.519	1.519	12.9	**13.289**	0	Critical Depth

Chainage:	19530	Description: 2 x closed pipe culvert, 0.3m dia					1
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10.42	10.339			10.979	Next Structure	1	8

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.451	0.243	10.565	**10.982**	0.208	Inlet Control - Inlet submerged
2	0.616	0.243	10.565	**10.982**	0.373	Inlet Control - Inlet submerged
5	0.839	0.243	10.565	**10.982**	0.596	Inlet Control - Inlet submerged
10	0.961	0.243	10.565	**10.982**	0.718	Inlet Control - Inlet submerged
20	1.159	0.243	10.565	**10.982**	0.916	Inlet Control - Inlet submerged
50	1.388	0.243	10.565	**10.982**	1.145	Inlet Control - Inlet submerged
100	1.571	0.243	10.565	**10.982**	1.328	Inlet Control - Inlet submerged
10000	6.13	0.243	10.565	**10.982**	5.887	Inlet Control - Inlet submerged

Chainage:	19530	Description: 1 x rectangular open flume 0.8m high x 0.91m w ide					2
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10	9.911			10.593	Canal	8	8

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.451	0.451	10.128	**10.366**	0	Subcritical Flow - Outlet Control
2	0.616	0.616	10.185	**10.45**	0	Subcritical Flow - Outlet Control
5	0.839	0.839	10.256	**10.553**	0	Subcritical Flow - Outlet Control
10	0.961	0.931	10.284	**10.593**	0.03	Subcritical Flow - Outlet Control
20	1.159	0.931	10.284	**10.593**	0.228	Subcritical Flow - Outlet Control
50	1.388	0.931	10.284	**10.593**	0.457	Subcritical Flow - Outlet Control
100	1.571	0.931	10.284	**10.593**	0.64	Subcritical Flow - Outlet Control
10000	6.13	0.931	10.284	**10.593**	5.199	Subcritical Flow - Outlet Control

Chainage:	19530	Description: Trapezoidal Channel, Base - 2, Depth - , Slopes 1:0.7					3
USIL	DSIL	Pit Level US DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
9.911			10.296	Canal	10000	8	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.451	0.451	9.911	**10.071**	0	Normal Depth - Water on overbank
2	0.616	0.616	9.911	**10.104**	0	Normal Depth - Water on overbank
5	0.839	0.839	9.911	**10.144**	0	Normal Depth - Water on overbank
10	0.931	0.931	9.911	**10.159**	0	Normal Depth - Water on overbank
20	0.931	0.931	9.911	**10.159**	0	Normal Depth - Water on overbank
50	0.931	0.931	9.911	**10.159**	0	Normal Depth - Water on overbank
100	0.931	0.931	9.911	**10.159**	0	Normal Depth - Water on overbank
10000	0.931	0.931	9.911	**10.159**	0	Normal Depth - Water on overbank

Chainage:	19730	Description: 1 x closed pipe culvert, 0.6m dia					1
USIL	DSIL	Pit Level US DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10.474	10.369		11.275	Next Structure	6	38	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.295	0.295	10.643	**10.998**	0	Inlet Control - Inlet not submerged
2	0.399	0.399	10.697	**11.105**	0	Inlet Control - Inlet not submerged
5	0.537	0.537	10.76	**11.234**	0	Inlet Control - Inlet submerged
10	0.621	0.556	10.768	**11.275**	0.065	Inlet Control - Inlet submerged
20	0.744	0.556	10.768	**11.275**	0.188	Inlet Control - Inlet submerged
50	0.882	0.556	10.768	**11.275**	0.326	Inlet Control - Inlet submerged
100	1.004	0.556	10.768	**11.275**	0.448	Inlet Control - Inlet submerged
10000	3.91	0.556	10.768	**11.275**	3.354	Inlet Control - Inlet submerged

Chainage:	19730	Description: 1 x rectangular open flume 0.52m high x 1.06m wide					2
USIL	DSIL	Pit Level US DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10	9.759		10.5	Canal	38	38	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.295	0.295	9.867	**10.249**	0	Subcritical Flow - Outlet Control
2	0.399	0.399	9.896	**10.305**	0	Subcritical Flow - Outlet Control
5	0.537	0.537	9.932	**10.371**	0	Subcritical Flow - Outlet Control
10	0.621	0.621	9.953	**10.409**	0	Subcritical Flow - Outlet Control
20	0.744	0.744	9.983	**10.461**	0	Subcritical Flow - Outlet Control
50	0.882	0.841	10.006	**10.5**	0.041	Subcritical Flow - Outlet Control
100	1.004	0.841	10.006	**10.5**	0.163	Subcritical Flow - Outlet Control
10000	3.91	0.841	10.006	**10.5**	3.069	Subcritical Flow - Outlet Control

Chainage:	20045	Description: 1 x closed pipe culvert, 0.375m dia					1
USIL	DSIL	Pit Level US DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10.517	10.257		11.046	Next Structure	1	611	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.376	0.178	10.46	**11.047**	0.198	Inlet Control - Inlet submerged
2	0.517	0.178	10.46	**11.047**	0.339	Inlet Control - Inlet submerged
5	0.693	0.178	10.46	**11.047**	0.515	Inlet Control - Inlet submerged
10	0.801	0.178	10.46	**11.047**	0.623	Inlet Control - Inlet submerged
20	0.956	0.178	10.739	**11.047**	0.778	Inlet Control - Inlet submerged
50	1.147	0.178	10.46	**11.047**	0.969	Inlet Control - Inlet submerged
100	1.303	0.178	10.46	**11.047**	1.125	Inlet Control - Inlet submerged
10000	5.091	0.178	11.192	**11.192**	4.913	Subcritical Flow - Outlet Control

Chainage:	20045	Description: 1 x 1/2 pipe open flume 0.81m dia 0.625m high						2
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10	9.849			13	Canal	611	611	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.376	0.376	10.113	**10.437**	0	Subcritical Flow - Outlet Control
2	0.517	0.517	10.167	**10.52**	0	Subcritical Flow - Outlet Control
5	0.693	0.693	10.227	**10.613**	0	Subcritical Flow - Outlet Control
10	0.801	0.801	10.262	**10.666**	0	Subcritical Flow - Outlet Control
20	0.956	0.956	10.31	**10.739**	0	Subcritical Flow - Outlet Control
50	0.178	0.178	10.021	**10.293**	0	Subcritical Flow - Outlet Control
100	0.178	0.178	10.021	**10.293**	0	Subcritical Flow - Outlet Control
10000	5.091	2.108	10.623	**11.192**	2.983	Spills over flume

Chainage:	20300	Description: 1 x rectangular open flume 0.61m high x 0.58m wide						1
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10	9.974			10.472	Canal	2	2	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.171	0.171	10.181	**10.367**	0	Subcritical Flow - Outlet Control
2	0.234	0.234	10.229	**10.455**	0	Subcritical Flow - Outlet Control
5	0.32	0.245	10.237	**10.47**	0.075	Subcritical Flow - Outlet Control
10	0.364	0.245	10.237	**10.47**	0.119	Subcritical Flow - Outlet Control
20	0.433	0.245	10.237	**10.47**	0.188	Subcritical Flow - Outlet Control
50	0.516	0.245	10.237	**10.47**	0.271	Subcritical Flow - Outlet Control
100	0.595	0.245	10.237	**10.47**	0.35	Subcritical Flow - Outlet Control
10000	2.331	0.245	10.237	**10.47**	2.086	Subcritical Flow - Outlet Control

Chainage:	20876	Description: 1 x closed arch culvert, 0.42m high x 0.75m wide						1
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10.425	10.34			11.006	Next Structure	3	4	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.313	0.313	10.528	**10.746**	0	Subcritical Flow - Outlet Control
2	0.423	0.423	10.57	**10.86**	0	Inlet Control - Inlet submerged
5	0.557	0.505	10.602	**11.006**	0.052	Inlet Control - Inlet submerged
10	0.642	0.505	10.602	**11.006**	0.137	Inlet Control - Inlet submerged
20	0.761	0.505	10.602	**11.006**	0.256	Inlet Control - Inlet submerged
50	0.909	0.505	10.602	**11.006**	0.404	Inlet Control - Inlet submerged
100	1.036	0.505	10.602	**11.006**	0.531	Inlet Control - Inlet submerged
10000	3.955	0.505	10.602	**11.006**	3.45	Inlet Control - Inlet submerged

Chainage:	20876	Description: 1 x 1/2 pipe open flume 0.83m dia 0.535m high						2
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10	9.64			10.53	Canal	4	4	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.313	0.313	9.837	**10.393**	0	Subcritical Flow - Outlet Control
2	0.423	0.423	9.876	**10.461**	0	Subcritical Flow - Outlet Control
5	0.557	0.54	9.913	**10.527**	0.017	Subcritical Flow - Outlet Control
10	0.642	0.54	9.913	**10.527**	0.102	Subcritical Flow - Outlet Control
20	0.761	0.54	9.913	**10.527**	0.221	Subcritical Flow - Outlet Control
50	0.909	0.54	9.913	**10.527**	0.369	Subcritical Flow - Outlet Control
100	1.036	0.54	9.913	**10.527**	0.496	Subcritical Flow - Outlet Control
10000	3.955	0.54	9.913	**10.527**	3.415	Subcritical Flow - Outlet Control

Chainage:	21100	Description: 1 x closed arch culvert, 0.42m high x 0.75m w ide					1

USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10.371	10.242			10.943	Next Structure	54	143

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.163	0.163	10.344	**10.625**	0	Inlet Control - Inlet not submerged
2	0.226	0.226	10.373	**10.633**	0	Subcritical Flow - Outlet Control
5	0.301	0.301	10.406	**10.687**	0	Subcritical Flow - Outlet Control
10	0.348	0.348	10.425	**10.714**	0	Subcritical Flow - Outlet Control
20	0.408	0.408	10.446	**10.781**	0	Inlet Control - Inlet submerged
50	0.494	0.494	10.476	**10.932**	0	Inlet Control - Inlet submerged
100	0.545	0.502	10.478	**10.943**	0.043	Inlet Control - Inlet submerged
10000	2.01	0.502	10.478	**10.943**	1.508	Inlet Control - Inlet submerged

Chainage:	21100	Description: 1 x rectangular open flume 0.62m high x 0.59m w ide					2

USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10	9.711			10.628	Canal	143	143

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.163	0.163	9.815	**10.248**	0	Subcritical Flow - Outlet Control
2	0.226	0.226	9.846	**10.308**	0	Subcritical Flow - Outlet Control
5	0.301	0.301	9.881	**10.373**	0	Subcritical Flow - Outlet Control
10	0.348	0.348	9.902	**10.411**	0	Subcritical Flow - Outlet Control
20	0.408	0.408	9.928	**10.457**	0	Subcritical Flow - Outlet Control
50	0.494	0.494	9.964	**10.519**	0	Subcritical Flow - Outlet Control
100	0.545	0.545	9.984	**10.554**	0	Subcritical Flow - Outlet Control
10000	2.01	0.66	10.029	**10.629**	1.35	Subcritical Flow - Outlet Control

Chainage:	21180	Description: 1 x 1/2 pipe open flume 0.97m dia 0.485m high					1

USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10	9.933			10.398	Canal	26	26

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.135	0.135	10.092	**10.241**	0	Subcritical Flow - Outlet Control
2	0.183	0.183	10.12	**10.282**	0	Subcritical Flow - Outlet Control
5	0.244	0.244	10.153	**10.327**	0	Subcritical Flow - Outlet Control
10	0.281	0.281	10.17	**10.352**	0	Subcritical Flow - Outlet Control
20	0.331	0.331	10.193	**10.384**	0	Subcritical Flow - Outlet Control
50	0.4	0.35	10.201	**10.396**	0.05	Subcritical Flow - Outlet Control
100	0.458	0.35	10.201	**10.396**	0.108	Subcritical Flow - Outlet Control
10000	1.714	0.35	10.201	**10.396**	1.364	Subcritical Flow - Outlet Control

Chainage:	21230	Description: 1 x closed arch culvert, 0.4m high x 1m w ide					1

USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI
10.776	10.578			11.709	Next Structure	165	71

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.2	0.2	10.665	**11.016**	0	Inlet Control - Inlet not submerged
2	0.269	0.269	10.688	**11.068**	0	Inlet Control - Inlet not submerged
5	0.365	0.365	10.717	**11.074**	0	Subcritical Flow - Outlet Control
10	0.42	0.42	10.733	**11.098**	0	Subcritical Flow - Outlet Control
20	0.496	0.496	10.753	**11.151**	0	Inlet Control - Inlet submerged
50	0.58	0.58	10.775	**11.26**	0	Inlet Control - Inlet submerged
100	0.664	0.664	10.795	**11.38**	0	Inlet Control - Inlet submerged
10000	2.482	0.863	10.845	**11.705**	1.619	Inlet Control - Inlet submerged

Chainage:	21230	Description: 1 x rectangular open flume 0.62m high x 0.6m wide						2
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10	9.546			10.6	Canal	71	71	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.2	0.2	9.651	**10.281**	0	Subcritical Flow - Outlet Control
2	0.269	0.269	9.679	**10.342**	0	Subcritical Flow - Outlet Control
5	0.365	0.365	9.717	**10.419**	0	Subcritical Flow - Outlet Control
10	0.42	0.42	9.738	**10.46**	0	Subcritical Flow - Outlet Control
20	0.496	0.496	9.766	**10.514**	0	Subcritical Flow - Outlet Control
50	0.58	0.58	9.796	**10.571**	0	Subcritical Flow - Outlet Control
100	0.664	0.623	9.811	**10.599**	0.041	Subcritical Flow - Outlet Control
10000	2.482	0.623	9.811	**10.599**	1.86	Subcritical Flow - Outlet Control

Chainage:	21340	Description: 1 x closed pipe culvert, 0.8m dia						1
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10.828	10.25			11.885	Next Structure	253	15	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.225	0.225	10.398	**11.209**	0	Inlet Control - Inlet not submerged
2	0.308	0.308	10.428	**11.29**	0	Inlet Control - Inlet not submerged
5	0.416	0.416	10.464	**11.383**	0	Inlet Control - Inlet not submerged
10	0.464	0.464	10.478	**11.422**	0	Inlet Control - Inlet not submerged
20	0.55	0.55	10.503	**11.487**	0	Inlet Control - Inlet not submerged
50	0.667	0.667	10.535	**11.57**	0	Inlet Control - Inlet not submerged
100	0.737	0.737	10.553	**11.616**	0	Inlet Control - Inlet not submerged
10000	2.717	1.136	10.647	**11.89**	1.581	Inlet Control - Inlet submerged

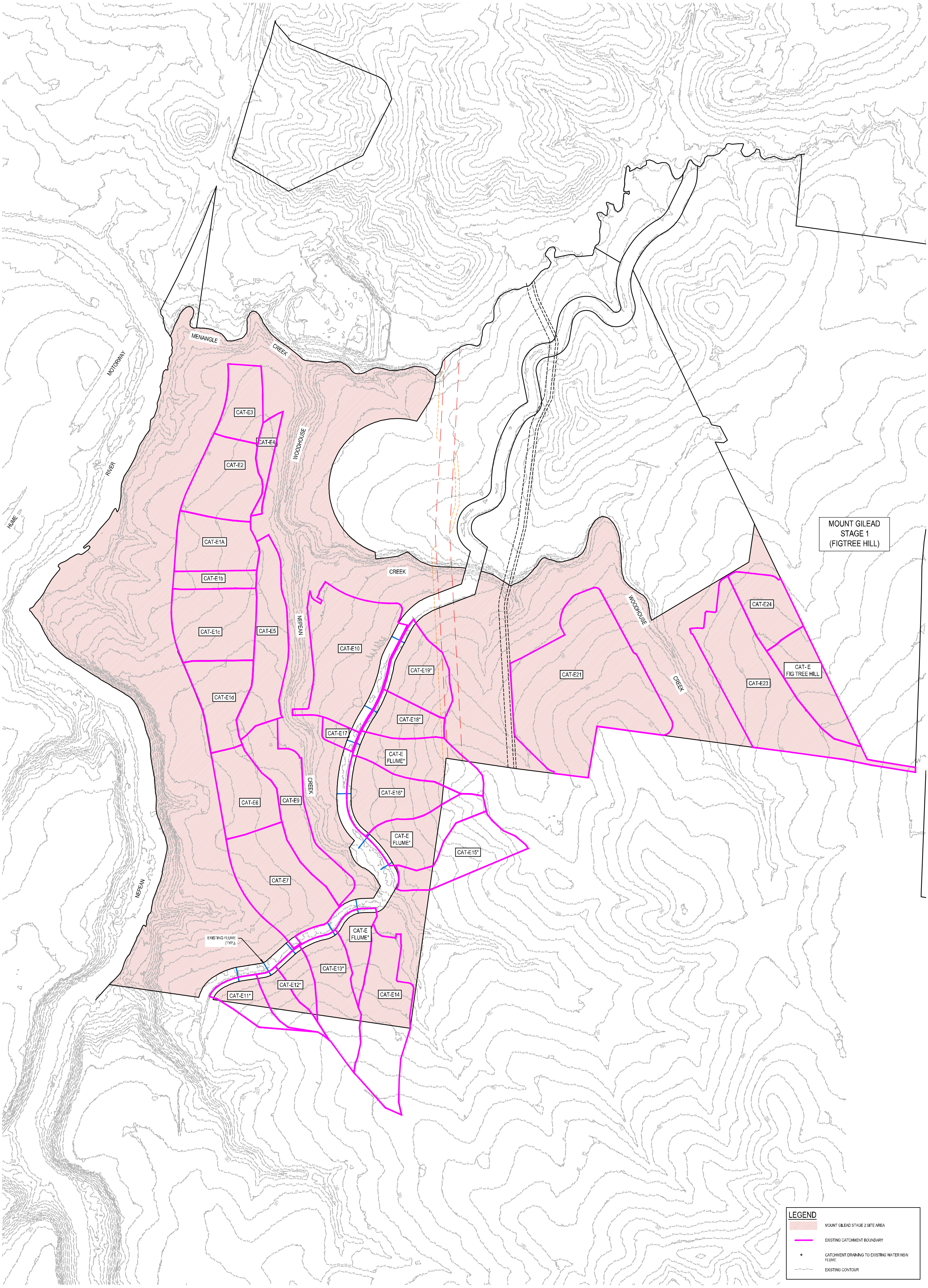
Chainage:	21340	Description: 1 x rectangular open flume 0.99m high x 0.59m wide						2
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
10	9.575			10.53	Canal	15	15	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.225	0.225	9.694	**10.307**	0	Subcritical Flow - Outlet Control
2	0.308	0.308	9.728	**10.378**	0	Subcritical Flow - Outlet Control
5	0.416	0.416	9.771	**10.463**	0	Subcritical Flow - Outlet Control
10	0.464	0.464	9.789	**10.498**	0	Subcritical Flow - Outlet Control
20	0.55	0.516	9.809	**10.534**	0.034	Subcritical Flow - Outlet Control
50	0.667	0.516	9.809	**10.534**	0.151	Subcritical Flow - Outlet Control
100	0.737	0.516	9.809	**10.534**	0.221	Subcritical Flow - Outlet Control
10000	2.717	0.516	9.809	**10.534**	2.201	Subcritical Flow - Outlet Control

Chainage:	21470	Description: 1 x closed pipe culvert, 0.3m dia						1
USIL	DSIL	Pit Level US	Pit Level DS	Overflow Level	Overflows To	Struct Cap ARI	Locatn Cap ARI	
11.529	11.073			12	Next Structure	1	147	

ARI	Flow Arriving	Flow Through	Effective Tailwater	Water Level	Excess Flow	Descriptn
1	0.143	0.109	11.218	**12.001**	0.034	Inlet Control - Inlet submerged
2	0.19	0.109	11.218	**12.001**	0.081	Inlet Control - Inlet submerged
5	0.257	0.109	11.218	**12.001**	0.148	Inlet Control - Inlet submerged
10	0.289	0.109	11.218	**12.001**	0.18	Inlet Control - Inlet submerged
20	0.346	0.109	11.218	**12.001**	0.237	Inlet Control - Inlet submerged
50	0.419	0.109	11.218	**12.001**	0.31	Inlet Control - Inlet submerged
100	0.463	0.109	11.218	**12.001**	0.354	Inlet Control - Inlet submerged
10000	1.63	0.109	11.218	**12.001**	1.521	Inlet Control - Inlet submerged

Appendix C Stormwater Model Plans



REV.	DATE	DESCRIPTION	DRN.	DES.	VERIF.	APPD.
1	31/05/2022	ISSUED FOR INFORMATION	ALI	ALI	SHH	LMC

Client: lendlease

Scale: 0 100 200 300 400 500m SCALE 1:5000 @A0

North: N

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Project	Scale	Status
MOUNT GILEAD STAGE 2 STORMWATER MANAGEMENT STRATEGY REPORT	1:5000	PRELIMINARY NOT TO BE USED FOR CONSTRUCTION
	Date: 31/05/2022	
Title: PRE DEVELOPMENT CATCHMENT PLAN	Size: A0	Project Number/Drawing Number: 190086-02-SK001 — Revision: 1
	Datum: MGA94	

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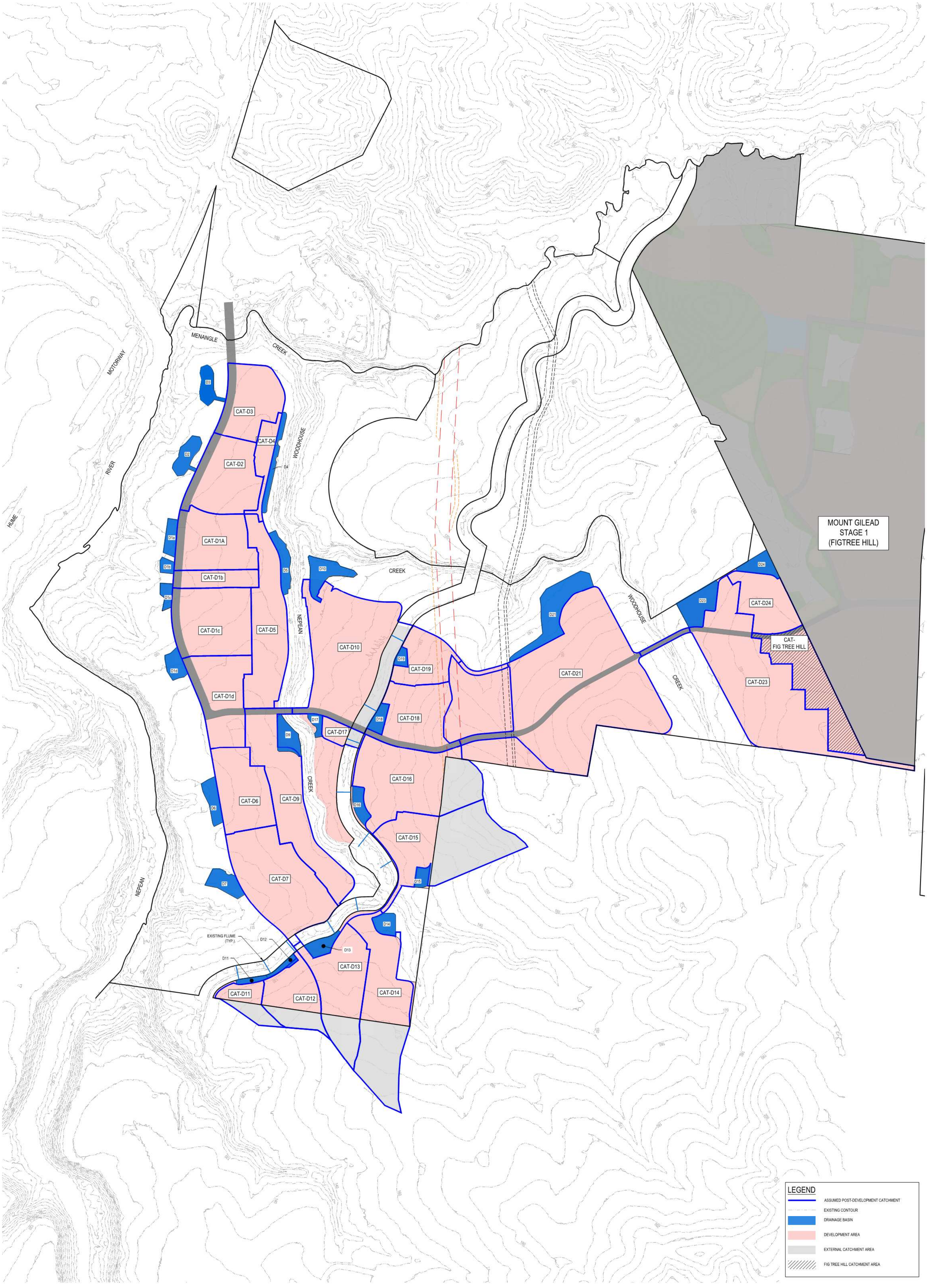
DATE PLOTTED: 31 May 2022 2:38 PM BY : SHAWN HOTONG



REV.	DATE	DESCRIPTION	DRN.	DES.	VERIF	APPD.
1	31/05/2022	ISSUED FOR INFORMATION	ALI	ALI	SHH	LMC

Client: lendlease

Scale: 0 100 200 300 400 500m — SCALE 1:5000 @A0

North: N

enspire
Enspire Solutions Pty Ltd
1302/83 Mount Street, North Sydney NSW 2060
ABN: 71 624 801 690
Phone: 02 9922 6135

Project: MOUNT GILEAD STAGE 2 STORMWATER MANAGEMENT STRATEGY REPORT

Title: POST DEVELOPMENT CATCHMENT PLAN

Scale: 1:5000
Date: 31/05/2022
Size: A0
Datum: MGA94

Status: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

Project Number/Drawing Number: 190086-02-SK002

Revision: 1

DATE PLOTTED: 31 May 2022 2:38 PM BY : SHAWN HOTONG

CAD File: P:\190086 GileadStg2\D-Civil\02-Stormwater Management Strategy Report\Drawings\1-REPORT DRAWINGS\220526-02-SK002- PRE DEVELOPMENT CATCHMENT PLAN.dwg

Appendix D Figtree Hill Strategy Coordination

Arcadis

Will Laurantus
Development Manager, Communities
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Exchange Place, 300 Barangaroo Avenue, Barangaroo NSW 2000

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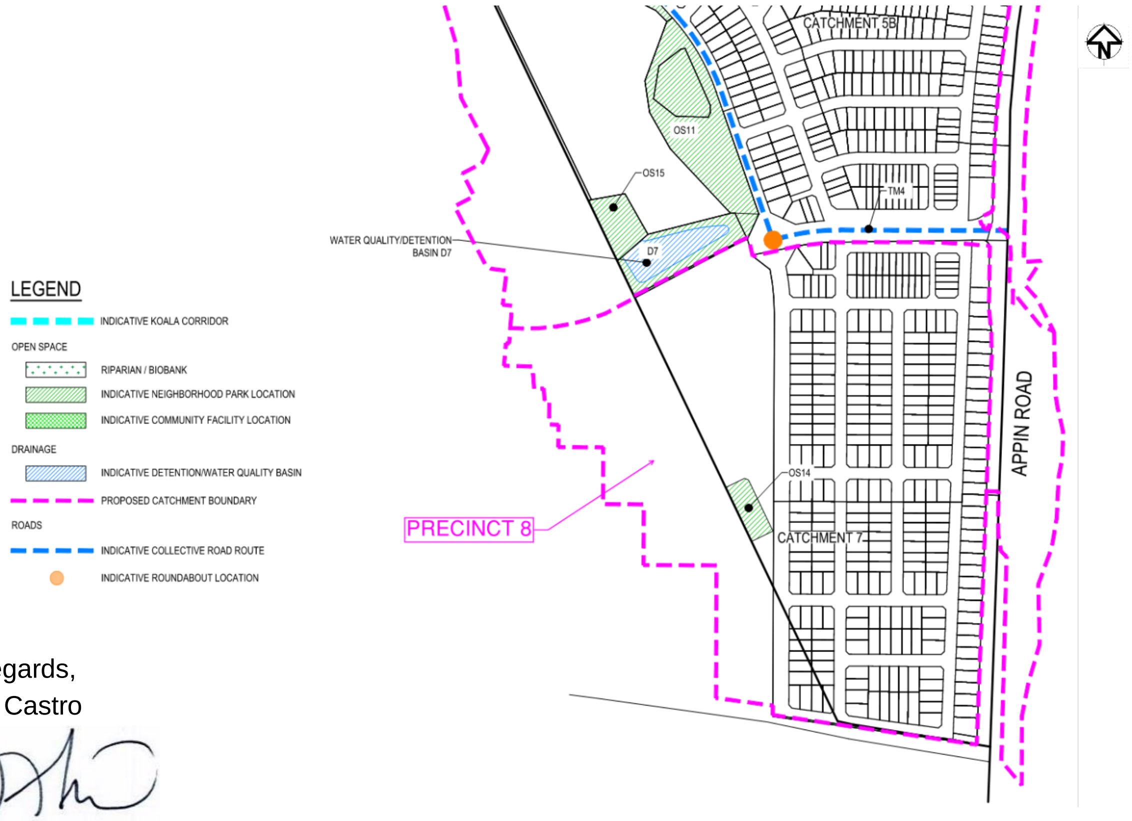
Subject: **Figtree Hill Stormwater Strategy – Precinct 8**
Our Ref: FTH-00-CC-AAP-CV-LET-0005-StormStrategyPrecinct8
Date: 21/06/2022

Dear Will,

Arcadis has been engaged by Lendlease on the Figtree Hill project to provide civil engineering and stormwater drainage design services. We are currently assessing the masterplan strategy for site grading and stormwater drainage across the project to ensure that the staged delivery considers future stages, adjacent and external catchments and receiving water conditions (such as tailwater or canal crossings).

Precinct 8 is located at and adjacent to the southwestern end of the Figtree Hill site and is part of a potential future development area. This area is currently being master planned by another engineering consultant who has provided their stormwater catchment areas, design calculations and anticipated flows which will drain towards Figtree Hill. This information has been used as part of our overall stormwater strategy assessment and incorporated into water quantity (detention) sizing and quality (water sensitive urban design) control measures proposed within the Figtree Hill Precinct.



Kind regards,
Darlan Castro

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