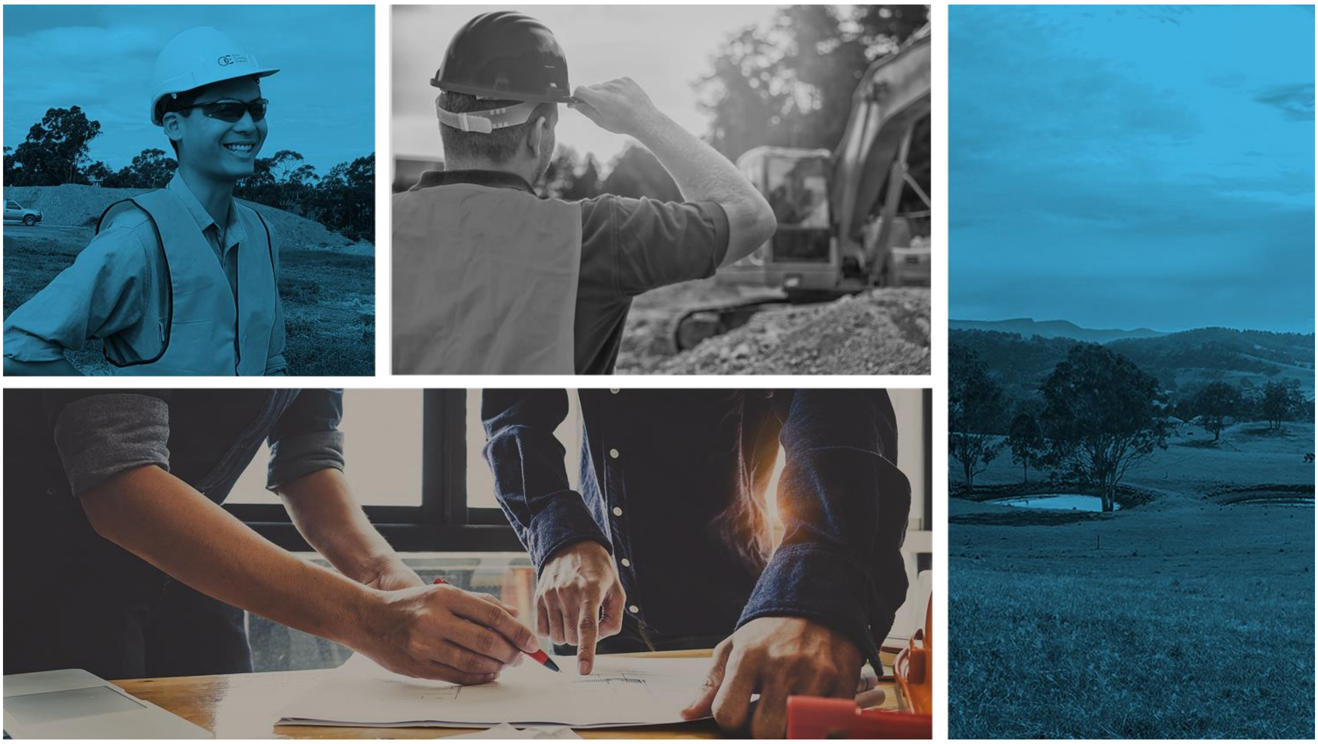
Orion Consulting
orionconsulting.com.au
info@orionconsulting.com.au
(02) 8660 0035

mirvac

Integrated Water Cycle Management Report

Mirvac Residential – Cobbitty Masterplan
Lot 2005 in DP 1162239
No. 531 Cobbitty Road, COBBITTY



12/04/2023 | Mirvac | Revision B | Ref: 21-0258-04

Commercial in Confidence

Contact

Orion Consulting Engineers Pty Ltd

ABN 25 604 069 981
Suite 4.04, No. 12 Century Circuit
Baulkham Hills NSW 2153

P: 02 8660 0035
E: info@orionconsulting.com.au

Prepared by:

Christopher Scholes
Senior Civil Design Engineer

Effective Date: 09/06/2022

Approved by:

Nathan Gundlach
Senior Civil Design Engineer

Document Control

Revision	Prepared	Reviewed	Approved	Date	Description	Project Reference
A	Christopher Scholes	Nathan Gundlach	Nathan Gundlach	09/06/2022	Issued with DCP/ILP Amendment	21-0258-04
B	Christopher Scholes	Mariano Polisciuk	Mariano Polisciuk	12/04/2023	Added Velocity Difference Flood Maps	21-0258-04

Table of Contents

List of Tables

List of Figures

Summary of Document Revision Changes

Revision B:

1. Added new velocity difference maps extracted at the flood peak for the critical duration 5, 20 and 100 Year ARI events. Pre versus post flood velocity difference maps have been added to Appendix E (new sheets FM-07-300-308).

   Provided in response to peer review recommendation to assess compliance with the flood velocity impact criterion.

2. Added Peer Review Report by Cardno (now Stantec) to new Appendix G.

3. Added new line for subcatchment and control node PD08 to table 19 – fixing omission in previous revision.

Executive Summary

Orion Consulting has been engaged by Mirvac Homes (NSW) to prepare this Masterplan Integrated Water Cycle Management Study (IWCMS) and Plan in support of the proposed amendment of the Oran Park Development Control Plan (DCP) to support the development of the site known as No. 531 Cobbitty Road, Cobbitty.

The need to amend the existing supporting water cycle management documentation which supports the DCP was crystallised by the determination that post development flows could not be managed to existing levels without consideration of online storage. This is due to the existing large farm dam and the attenuation it provides in the existing case. In addition to contemplating online storage, this new plan needs to address continuity with the latest flood planning information available for the greater Nepean River catchment.

This study presents a water management strategy that focuses on the re-creation of the existing farm dam into a new man-made lake, on-line to the same creek the existing farm dam sits on. This facilitates the dual use of land and achieves both water management and open space objectives for the site.

Prior to the development of this study, consultation was held between Camden Councils Floodplain Management Team and Camden Council's external expert consultant for the Nepean River Tributaries Study. Modelling methodologies and calibration requirements were classified during this consultation process to ensure this IWCM study and supporting electronic data is suitable for assessment, review and endorsement. The latest Nepean River Tributaries Study electronic modelling information was provided under licence agreement. This report presents information and extracts from both the Hydrologic and Hydraulic modelling undertaken in this study and demonstrates that calibration objectives to the Nepean River Tributaries Study were achieved with consideration to the latest data available for the site.

For water quantity and floodplain management the proposed Masterplan features active storage above the proposed lake and sports fields that attenuates all combined post developed flows back to pre-developed flows achieved by the existing farm dam. Two smaller on-site stormwater detention basins are proposed to treat other independent urban catchment flows, offline to the main creek lines. Combined, these water quantity facilities adequately ensure that the proposed masterplan does not adversely impact adjoining properties.

All urban catchments will feature primary and secondary water quality controls in the form of gross pollutant traps and biofiltration systems that adequately address Camden Councils water quality management objectives.

1 Introduction

Orion Consulting Engineers Pty. Ltd (Orion) has been engaged by Mirvac Homes (NSW) Pty Limited (Mirvac) to prepare a Masterplan Integrated Water Cycle Management (IWCM) Strategy in support of the proposed modification of DCP and ILP to facilitate future development of the site known as No. 531 Cobbitty Road Cobbitty (Lot 2005 in DP 1162239).

The Masterplan IWCM Strategy has been prepared in support of the Development Control Plan (DCP) and Indicative Layout Plan (ILP) modification that will facilitate the future development of the site.

1.1 Site Description

The subject site is located within the Camden Council LGA, approximately 3km South West of the new Oran Park town centre. The site extents are shown in the figure below.

Figure 1 – Site Extents (Imagery courtesy of Nearmap ©)

The site is bordered by Cobbitty Road to the South, Macarthur Anglican School and Arcadian Hills development to the East, rural properties and farmland to West and the Denbigh heritage listed homestead to the North (531A and 531B Cobbitty Road). No. 581 Cobbitty Road (Lot 1 in DP 1014583) has been included in this Masterplan Study to allow for future orderly development of this site.

The site is features moderate (≈ 5% - northern boundary) to flat (≈1% and flatter – around watercourses) natural grades with several defined ephemeral watercourses. Cobbitty Creek enters the site along the southern boundary at an existing culvert crossing under Cobbitty Road. An unnamed 3rd order water course enters the site along the Eastern boundary and discharges into a large rural farm dam located centrally within the site. Both the high-level overflow from the farm dam and Cobbitty Creek combines at a washout zone with undefined creek banks that straddles the common boundary with No. 455 Cobbitty Road. The confluence of these streams results in a 4th order stream classification of Cobbitty Creek exiting the site to the West. The figure blow shows the existing site topography.

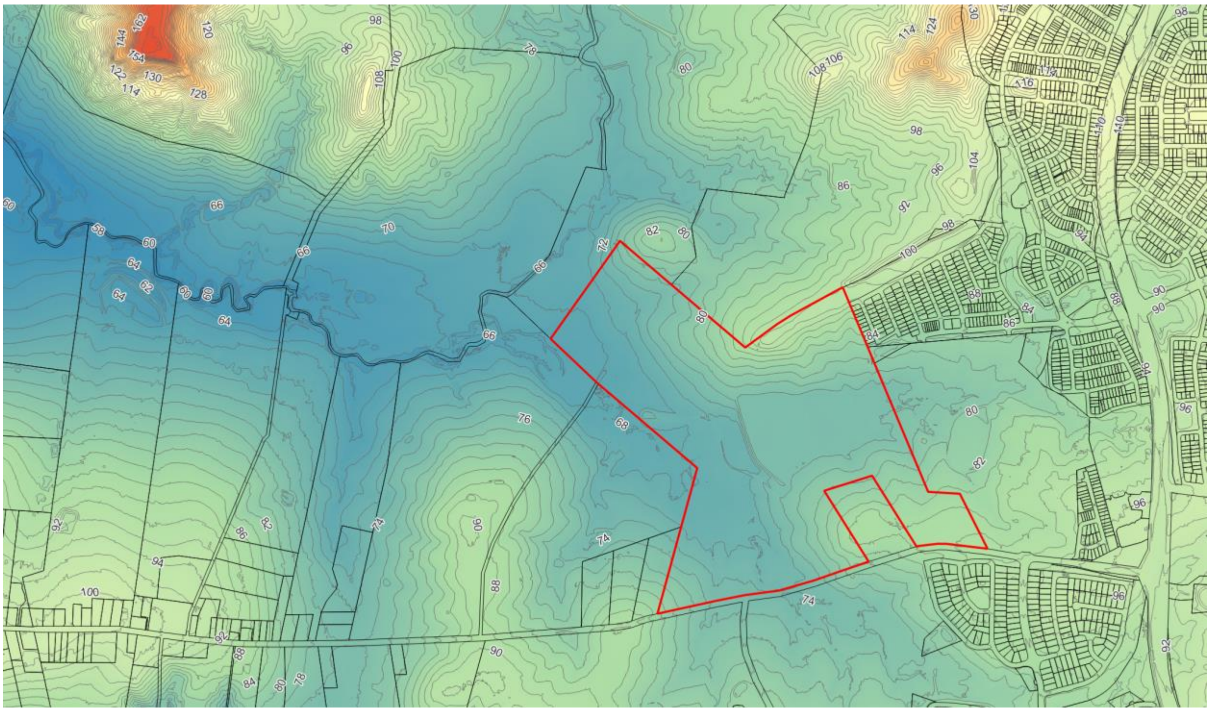


Figure 2 - Existing Topography

1.2 The Proposed Development

As a part of this proposed Masterplan Mirvac are aiming to:

- Provide an updated site-wide masterplan layout and supporting documentation for the site that will facilitate future development approvals.
- Facilitate the development of approximately 900 residential dwellings, playing fields and associated infrastructure, local neighbourhood centre, a school and open parkland.
- Demonstrate that with the new proposal, development objectives around open space, ecology and riparian management, road infrastructure and water management can be adequately achieved.

Figure 3 - Masterplan Layout Extract (Paterson Design Studio)

1.3 Objectives

The purpose of this report and assessment is to design, establish and present the integrated water cycle management strategy proposed for this Masterplan including:

- Stormwater management controls that meet the intent of the existing Oran Park Development Control Plan (hereinafter referred to as 'the DCP').
- Stormwater management controls that do not adversely impact conditions to adjacent surrounding properties. Adoption of 'no-net-negative' design principles to generally ensure that post developed flooding impacts are not greater than pre-existing flooding.
- To provide Council with a calibrated overland flow assessment over the site and surrounding catchments that ties into the current Nepean River tributary modelling which is in a pre-public exhibition phase.

- Re-creation of on-line flood storage that the existing rural farm dam currently provides to the catchment in the form of a new man-made open water body. Given the need to replicate the existing flood storage conditions on the site, this approach is suitable and still allows for the new riparian zone to be created upstream.

- Water Sensitive Urban Design (WSUD) to meet the requirements of the DCP for the post-development percentage reduction targets for total suspended solids, phosphorus, nitrogen and gross pollutants.

1.4 Study Methodology

The study methodology is in two distinct components:

- Water quantity and overland flow assessment that includes the design of detention (OSD) and flood mitigation controls and;

- Water quality or WSUD controls.

1.4.1 Water Quantity Methodology

Consultation with Council's flooding team leader and the author of the pre-exhibition Nepean River Tributary Model was held prior to model development to ratify parameters and methods this IWCM Strategy must comply to. In this workshop, modelling methodologies, software formats was discussed and agreed too. This included the pre-eminence of matching water surface levels between the two hydraulic models rather than matching stream flows from the two lumped hydrological models.

The water quantity methodology was adopted as follows:

- Development of overall catchment plans encompassing the whole study area with clear structure for a suitable rainfall-runoff-routing hydrologic model.

- Development of a RAFTS rainfall-runoff hydrological model for both pre-developed and post-developed scenarios for assessment. ARR87 methodologies have been adopted in consultation with Camden Council to maintain continuity between historical and current studies currently in progress for the Nepean River and adjacent Tributaries.

- Development of a masterplan scale civil design surface model of the site to inform road grades and levels, particularly around critical sag points and the interface with the existing and new riparian corridors, the proposed lake and public open space.

- Development of a 2D TUFLOW hydraulic model for both pre developed and post developed scenarios for detailed hydraulic assessment to validate the RAFTS pre and post developed model scenarios. The 2D TUFLOW model is set-up within 12D model software to combine both GIS and civil design information in a coordinated environment.

- Calibration and validation of the Pre developed (existing scenario) hydrologic and hydraulic model against the latest Nepean River Tributaries modelling information provided by Camden Council under licence agreement.

Regarding nomenclature – ARI terminology (over AEP) has been maintained in this report due to the adoption of ARR87 rainfall and procedures.

1.4.2 Water Quality Methodology

The water quality methodology was adopted as follows:

- Development of a detailed catchment plan encompassing a breakdown of total lots and proposed land use by sub-catchment.
- Development of a MUSIC Model (Model for Urban Stormwater Improvement Conceptualisation) for pre and post developed cases; assessment of percentage reduction target requirements for isolation of critical design requirements. Utilises the Camden Council MUSIC Link
- Development of a MUSIC Model for SEI and Lake water balance calculations with an extended rainfall range available.

2 Adopted Information

2.1 Pre-Existing Flood Studies and Water Cycle Management Plans

2.1.1 Integrated Water Cycle Management Study - Ecological Engineering, 2007

This report by Ecological Engineering forms the original water cycle management report submitted to the Growth Centres Commission to support the land release and sets a number of general design principles for stormwater quality and quantity management.

Some key points noted from this study are as follows:

- Major online flood / OSD storage for events greater than the 5 Year ARI.
- Indicative locations for stormwater quality treatment systems and major OSD basins.
- Specifications for the implementation of engineered wetlands and biofiltration systems for water quality control.
- Sets the environmental stormwater quality control objectives for Oran Park.

2.1.2 Stormwater Quantity Management & Flooding - Brown Consulting, 2007

The Oran Park Precinct Masterplan Stormwater Quantity Management & Flooding by Brown Consulting forms the original water quantity and flood management strategy submitted to the Growth Centres Commission to support the land release and sets a number of general design principles for stormwater quality and quantity management.

Some key points noted from this study are as follows:

- Implementation of a RAFTS hydrological model for pre and post developed assessment of the catchment under ARR1987 guidelines.
- Establishment of fraction impervious areas and soil loss model parameters.
- Implementation of a 1D/2D SOBEK Hydraulic Model to validate the hydrological modelling.

2.1.3 Nepean River Tributaries Study – Cardno on behalf of Camden Council, 2022

Orion and Mirvac have entered into a licence agreement with Camden Council to obtain the latest modelling information available for the Nepean River Tributaries study within the Camden Council LGA. During the development of this Masterplan strategy and documentation, workshops were held with Camden Council's Floodplain Management team and external Floodplain Assessment Team to confirm modelling methodology and requirements for this project. As this study has yet to go on exhibition for comment within the public domain, only modelling information received under licence agreement is referenced in this report.

Some key points from this consultation and this data received informed the methodology for quantity modelling as follows:

- Set the need to adopt the Flood Frequency Analysis calibrated rainfall (adjusted ARR87 coefficients) from the Nepean River Tributaries study.

- Set the need to complete hydrological calculations using Laurenson-RAFTS procedures. Given that XP-RAFTS is no longer commercially available for implementation, a calibrated DRAINS-RAFTS model would be a suitable substitute for submission and assessment.

- That the hydraulic model under this study would need to be calibrated with respect to calculated Existing Scenario flood planning levels set by the Nepean River Tributaries study.

- That the Nepean River Tributaries study does not in its current form allow for a suitable pre versus post assessment of the strategy outlined in this report and new sub catchment delineation is required for the study area.

- Given that the site is located over 3.5km upstream of the confluence of Cobbitty Creek and the Nepean River, a local modelling domain could be considered that generally excludes the immediate Nepean River floodplain and associated breakouts that occur closer to the Nepean River provided appropriate water surface level was carried out prior to the downstream domain boundary.

2.2 Survey Data

2.2.1 Detailed Survey Data

Original detailed survey data was provided by Geolyse (now Premise Pty Ltd) and dated 20th December 2018. This data has since been translated to GDA2020 and validated by Orion.
The scope of this survey incorporated all lands within the subject site and survey works over portions of Cobbitty Road and levels upstream of the existing farm dam.

All electronic modelling data and files presented in this report are coordinated to GDA2020 to tie into the future design and documentation packages.

2.2.2 ALS / LiDAR Survey Data

For areas of the study outside the scope of the detailed survey data, Aerial Laser or LiDAR Scanning data was obtained from the ELVIS - Elevation and Depth Foundation Spatial Data website. The following ALS data has been adopted:

- 1m DEM (digital elevation model) data as published by NSW Land Registry Services (ex LPI) and dated July 2019.

2.2.3 Aerial Imagery

Historical and recent aerial imagery of the site was obtained through NearMap for documentation purposes.

2.2.4 Cadastral Data

Cadastral data of the surrounding lot boundaries was obtained through NSW LRS Spatial Information Exchange 'Clip & Ship' data service.

3 Hydrology

3.1 Catchment Delineation

The available survey data was combined to form a 'master' existing survey model used to delineate sub-catchments within the study area. To maintain continuity with existing studies and minimise extensive re-assessment, the pre-developed 'existing' catchment plan as prepared by Brown Consulting (2007) was adopted as a base and adjusted to suit base off the latest surface data and future hydraulic modelling considerations.

The figure below shows an extract of the pre-developed scenario catchment plan and can be found in full in Appendix A.

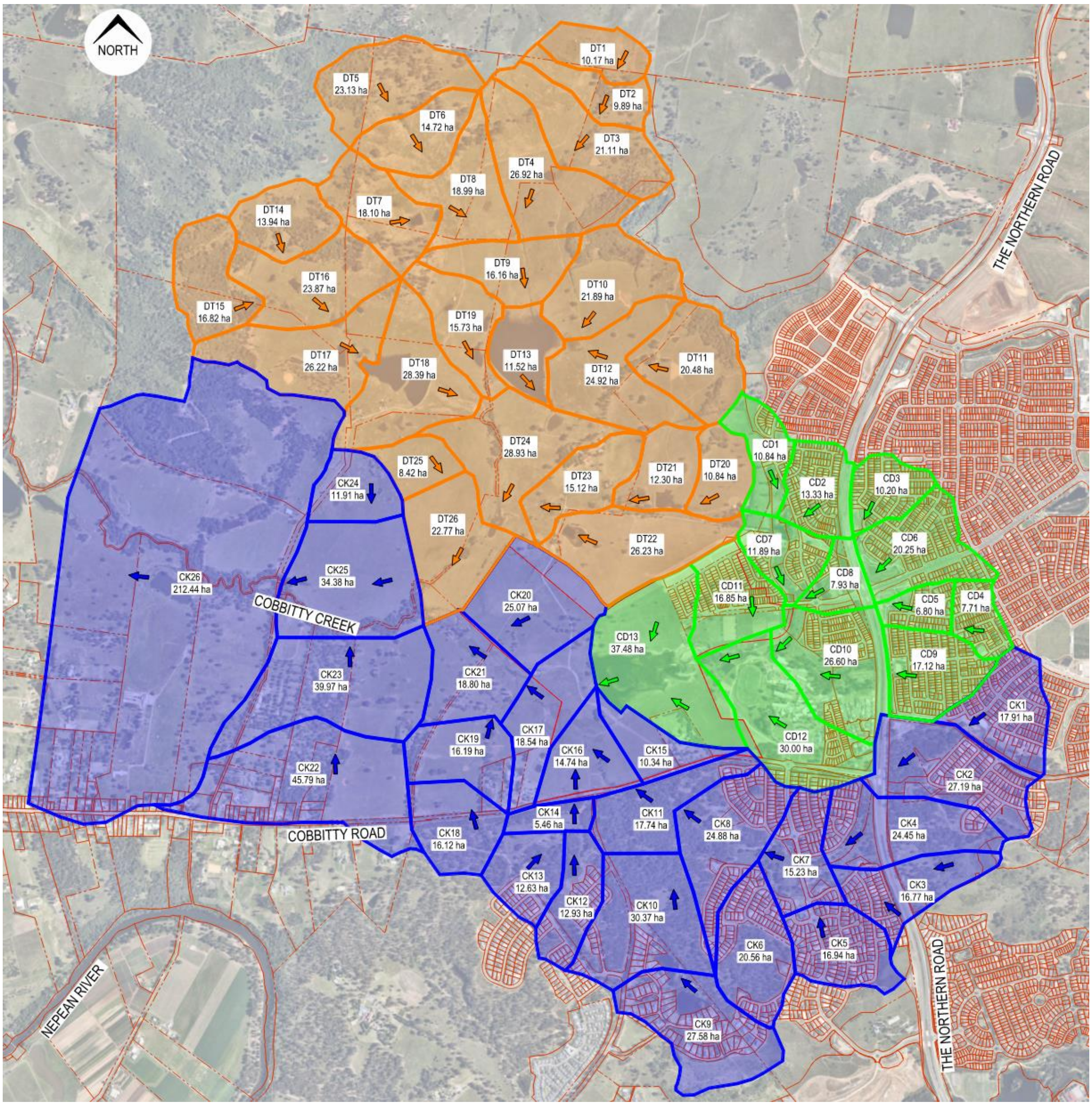


Figure 4 - Pre-Developed Scenario Catchment Plan

The boundary between Catchment CK25 and CK26 near the Western downstream extent of the plan correlates with the catchment boundary between catchments 'COBBITTY B' and 'COBBITTY C' from the Nepean River Tributaries Study. Total catchments to CK25 is the end of the sub-catchment discretisation of catchments COBBITTY A and COBBITTY B from the Nepean River Tributaries Study.

For the post developed scenario the pre-developed scenario catchment delineation is adjusted to suite the proposed masterplan strategy. The figure below shows an extract of the post developed scenario catchment plan and can be found in full in Appendix A. Like the pre-developed scenario catchment plan, post-developed catchment delineation has been prepared with consideration of the hydrologic and hydraulic modelling steps to follow.

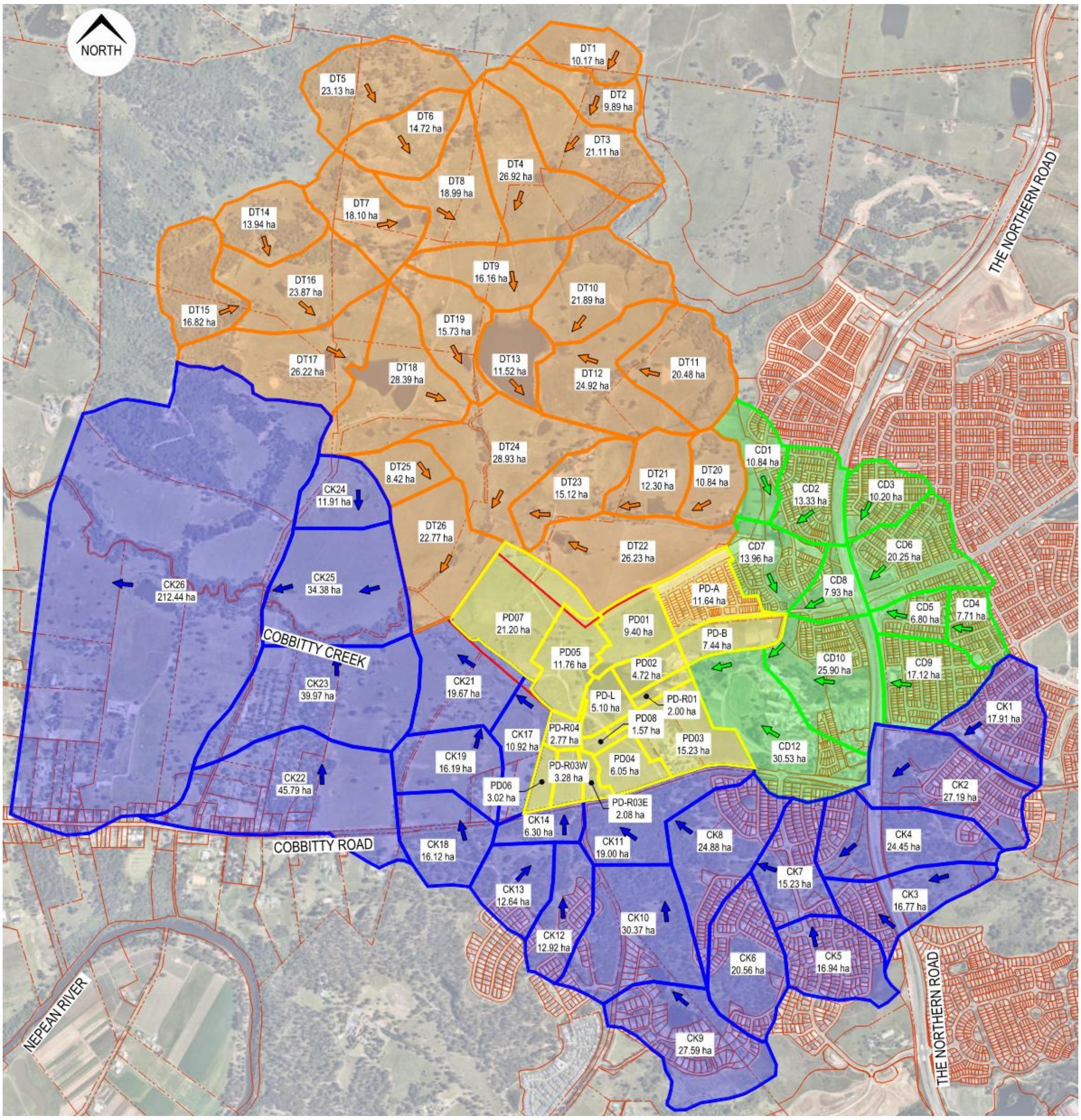


Figure 5 - Post-Developed Scenario Catchment Plan

The **total catchment study area** is 1439.5 ha.

3.2 Modelling Parameters

3.2.1 Rainfall Data

Adjusted ARR1987 Rainfall data for the proposed development was extracted from XP-RAFTS data files from the Nepean River Tributaries study received under licence agreement and as such is consistent with that governing study and appropriate for ongoing future applications. The coefficients adopted for rainfall and storm event generation are shown in the table below:

Table 1 - ARR1987 Rainfall Data Coefficients

Coefficient	Value
2 Year ARI, 1 Hour Intensity	29.7 mm/hr
2 Year ARI, 12 Hour Intensity	6.36 mm/hr
2 Year ARI, 72 Hour Intensity	1.86 mm/hr
50 Year ARI, 1 Hour Intensity	59.9 mm/hr
50 Year ARI, 12 Hour Intensity	13.0 mm/hr
50 Year ARI, 72 Hour Intensity	4.06 mm/hr
F2 Factor	4.29
F50 Factor	15.79
Skew	0.02

Minor rounding on some coefficients was required for input into DRAINS due to significant figure limitations for rainfall intensities and is tested and discussed in section 3.4.1 of this report.

3.2.2 Soil Loss Model

An Initial Loss - Continuing Loss (ILCL) model was adopted in accordance with the data files from the Nepean River Tributaries study with the parameters shown in the table below:

Table 2 - Soil Loss Model Parameters

Parameter	Loss
Initial Loss (pervious)	15 mm
Continuing Loss (pervious)	2.5 mm/hr
Initial Loss (impervious)	1.0 mm
Continuing Loss (impervious)	0 mm/hr

The RAFTS **Bx** Parameter was set at 1.0

3.2.3 Slope

The equal area slope (EAS) methodology was applied to stream flow lines for each sub catchment for input into the hydrological model. EAS was automatically calculated within 12D using the combined lidar and existing survey surfaces. For the total 1439.5 ha study area, the **area weighted average slope** was calculated to be 3.2% for the existing scenario. A sensitivity test was undertaken on the impact of the different catchment slopes adopted between the discretised DRAINS-RAFTS model and the Nepean River Tributaries Study and is discussed in section 3.4.2 of this report

3.2.4 Roughness

For standard rural catchments (grass, farmland) a default Manning's 'n' of 0.05 was applied as per the Nepean River Tributaries hydrological modelling. Sub catchment topography and land coverage was assessed via current and historical aerial imagery with surface roughness's adjusted to a Manning's 'n' of 0.1 for catchments with woodland or dense vegetation.

3.2.5 Streams/Node-to-Node Links

An idealised 1D overland flow cross section with defined channel and overbank profiles was constructed in DRAINS to simulate the ephemeral creek lines that links the sub catchments. This method also captures geographically accurate upstream and downstream invert levels and reach lengths to approximate stream grades and associated link travel times. Application of this method is required to ensure Volume is accurately modelled within both the pre and post developed models and facilitates the use of dynamic hydraulic structures in the post developed model.

Full unsteady state analysis within DRAINS was conducted on the RAFTS model for both the pre and post developed scenarios.

3.2.6 Version Control

DRAINS version **2021.031** (27 October 2021) was used for the hydrologic assessment.

3.3 Existing Farm Dam

The existing rural farm dam on the site is a prominent site feature approximately 9ha in size and has a moderate to significant impact on peak flow attenuation for the unnamed 3rd order stream it currently sits on-line to.

The existing detail survey data available contains detailed bathymetry data of the existing farm dam. A staged-storage-discharge curve was established for dam for the pre developed scenario hydrologic model. The discharge curve was calculated by approximating 1D irregular channel flow from a cross section at the narrowest point of the spillway and is shown in the table below:

Table 3 - Existing Farm Dam Staged Storage Discharge

WSL (m AHD)	Volume (m^3)		WSL (m AHD)	Discharge (m^3/s)
75	90964.2		75.15	0
75.2	105423		75.35	0.91
75.4	123736		75.55	3.68
75.6	143381		75.75	8.22
75.8	164060		75.95	14.5
76	185671		76.15	22.59
76.2	208170			

In consultation with Camden Council the *dead storage* of the farm dam (the volume available below the spillway) is to be considered full at the start of every storm. The effects of the *active* flood storage component (the volume available between the spillway level and an overtopping of the entire dam wall) is required to be assessed and considered for the pre developed modelling scenario due to flow rate attenuation at the outlet of the sub catchment.

The dead storage water level is RL 75.15 m AHD (by survey).

3.4 Hydrological Pre-Developed Model Calibration

3.4.1 DRAINS-RAFTS Implementation

To validate the use of RAFTS hydrological procedures within the DRAINS modelling software a comparison was made for identical sub-catchments as extracted from the Nepean River Tributaries Study for the identified critical duration 20 Year ARI and 100 Year ARI events. Catchment area, slope, impervious fraction and roughness were matched from the XP-RAFTS Nepean River Tributaries Study for equivalent lumped catchments nodes to simulate sub-catchments 'COBBITTY A, COBBITTY B and COBBITTY C' within the DRAINS modelling software.

Table 4 – Local Catchment Flows - XP-RAFTS vs DRAINS-RAFTS Equivalent Comparison

Catchment Name	XP-RAFTS Nepean River (20yr9hr - cu.m/s)	DRAINS-RAFTS Cobbitty (20yr9hr - cu.m/s)	XP-RAFTS Nepean River (100yr9hr - cu.m/s)	DRAINS-RAFTS Cobbitty (100yr9hr - cu.m/s)
COBBITTY A	4.89	4.99	6.43	6.54
COBBITTY B	50.45	51.9	73.1	74.5
COBBITTY C	26.88	27.9	40.56	41.3

The above table shows that the modelled DRAINS - RAFTS catchments result in slightly higher calculated peak flows than that calculated by XP-RAFTS. As this is a very minor (<2% for the major event) difference in calculated flows the DRAINS-RAFTS hydrological model was adopted in full. These minor differences in flows can be attributed to the local rounding in Rainfall Intensity coefficients due to the 3 significant figure limitation on the input fields within DRAINS.

3.4.2 Results Comparison

To compare the differences in modelling results between the Nepean River Tributaries Hydrological Model and the DRAINS-RAFTS hydrological model developed for this study, catchment discretisation was selected to provide a common point of measurement across all models.

Total cumulative catchment upstream of 'CK25' (1227.1 ha) from the Cobbitty-Mirvac Study directly correlates with the total cumulative catchment upstream of 'COBBITTY B' (1230.1 ha) from the Nepean Study. Minor differences in catchment area (0.24% smaller) can be associated with different surface lidar datasets and resolutions being adopted for catchment delineation between the two models. The total cumulative catchment to CK25 has been modelled as per the sub-catchment plan presented in Appendix A. Sub-catchment data is presented in Appendix B.

The following table overleaf identifies the as-modelled total cumulative flows immediately downstream of catchment CK25 from the disaggregated catchment model vs the cumulative flows immediately downstream of catchment COBBITTY B from the XP-RAFTS Lumped Nepean River Tributaries Model.

Table 5 - DRAINS-RAFTS vs Nepean Tributary Peak Flows at Outlet

Event	'LINK COBBITTY B' – Nepean River Tributaries (cu.m/s)	'DS CK25' (cu.m/s) – Orion-Mirvac DRAINS-RAFTS
5 Year 9 Hour	35	52.7
20 Year 9 Hour	55	77
100 Year 9 Hour	79	104

The table above shows that the modelled peak flows from the DRAINS-RAFTS Hydrological model are significantly different than that calculated in the Nepean Tributaries Study. This can be attributed to the following:

- Minor rounding in rainfall coefficients
- Different calculated equal-slope area (Calculated Slope of 3.2% vs the 1.44% as presented in lumped catchment 'COBBITTY B' from the Nepean River Tributaries Study).
- Different (more current) surface topography
- Timing differences in 2 distinct creek lines instead of modelling as a single lumped catchment (Cobbitty B). The catchment (DT1 – DT26) upstream from Denbigh is of roughly equivalent area to the contributing catchment for Cobbitty Creek (CK1-CK21 and CD1 – CD13).

To validate the hydrological model a sensitivity test was applied for catchment slope on the lumped catchment node that simulates the COBBITTY A and COBBITTY B sub catchments from the Nepean River Study.

Table 6 - Hydrological Model Slope Sensitivity Test Peak Flows

Event	LINK COBBITTY B - Nepean River Tributaries (cu.m/s)	DS CK25 (cu.m/s) - Orion-Mirvac DRAINS-RAFTS	Cobbitty A + B EAS 3.21% (cu.m/s)
5 Year 9 Hour	35	52.7	47.7
20 Year 9 Hour	55	77	71.5
100 Year 9 Hour	79	104	98.5

The table above identifies that peak flow is sensitive to the topographically calculated sub-catchment slope. All other catchment modelling parameters between the DRAINS-RAFTS and the Nepean River Tributaries study are equivalent.

These differences and sensitivity to catchment slope was discussed with Council prior to finalisation of this study. It was discussed that the final performance and suitability of the DRAINS-RAFTS pre-developed model against the Nepean River Tributaries study is validated in the 2D Tuflow hydraulic model results and comparisons with a direct comparison of calculated water surface levels, and specifically, the flood planning level. This check and discussion is presented discussed in section 4.4 of this report.

3.5 Post Developed Scenario Management Strategy

To achieve no-net-negative water quantity management outcomes a series of on-site stormwater detention systems and flood mitigation strategies are proposed to be provided throughout the development.

The on-site stormwater detention (OSD) strategy has been designed to manage post developed flows at the following locations:

Table 7 – Proposed On-Site Stormwater Detention Facilities

Outlet / Catchment	Comments
PD04	Dry OSD Basin offline to Cobbitty Creek servicing the local urban sub-catchment upstream.
PD-L	Active flood storage above new lake. Flood storage and outlet configuration set to replicate flood attenuation characteristics the existing farm dam currently provides coming from Oran Park. Storage is kept on-line to the Riparian Corridor, equal to the existing farm dam. The dead storage component of the lake is to be considered full at the start of any storm simulation.
PDR04	Dual use of the sports field as dry OSD basin for additional major storm (50 Year ARI or greater) flood storage overflowing from the lake active flood storage component. Required to achieve flow attenuation in the (critical) long duration major event to replicate flood attenuation characteristics of the existing farm dam. Designed to not be used for frequent and intermediate events (Less than the 50 Year ARI). Storage is offline to Cobbitty Creek.
PD07	Dry OSD Basin offline to Cobbitty Creek servicing the local urban sub-catchment upstream.

Outlet control and storage volumes is discussed section 4.

3.5.1 Bypass Catchments

Due to the performance of the proposed On-Site Stormwater Detention facilities, several design urban sub catchments can be bypassed from intermediate and major storm quantity control due to the local outlet timing differences that occur for the critical storm.

Catchments PDR-03 (East and West), PD05 and PD06 have been designed to bypass local water quantity management controls.

3.5.2 Post Developed Catchment Parameters

All urban design catchments under the scope of this Masterplan were modelled as 85% Impervious with a Manning's 'n' value of 0.025 to account for accelerated catchment runoff times. Riparian Areas were modelled with a variable impervious fraction of between 25% and 50% as a conservative estimate subject to anticipated land use for passive and active open space activation for public amenity.

3.5.1 Hydrological Model On-Site Stormwater Detention Performance

OSD performance has been measured for the 5, 20, and 100 Year ARI critical duration events at a number of locations within the subject site. The 540 minute duration storm was found to be critical at all key locations for pre-vs-post assessment.

The following locations on Cobbitty Creek were selected for pre vs post comparisons:

- At the common boundary of No 455 Cobbitty Road
  (Upstream of CK17 - Pre, Downstream of PDR04 – Post)

- Adjacent to the North Western site boundary within No. 415 Cobbitty Road
  (Downstream of CK21 – Pre and Post)

- Downstream of all major confluences at the common point shared between the DRAINS-RAFTS Model and the Nepean River Tributaries Study Model at the downstream end of sub catchment CK25.

Catchment plans showing these abovementioned locations are shown in Appendix A.

Table 8 - Pre Developed Scenario Flow Summary

Event	Q_{PRE} US CK17	Q_{PRE} DS CK21	Q_{PRE} DS CK25
ARI (duration)	cu.m/s	cu.m/s	cu.m/s
5 Year 9 Hour	19.70	23.00	52.70
20 Year 9 Hour	29.00	33.80	76.80
100 Year 9 Hour	41.70	48.30	104.0

Table 9 - Post Developed Scenario Flow Summary

Event	Q_{POST} DS PDR04	Q_{POST} DS CK21	Q_{POST} DS CK25
ARI (duration)	cu.m/s	cu.m/s	cu.m/s
5 Year 9 Hour	18.5	21.40	51.3
20 Year 9 Hour	28.40	32.0	72.90
100 Year 9 Hour	40.80	46.40	101.0

Table 10 - Pre vs Post Developed Scenario Flow Summary

Event	ΔQ US CK17	ΔQ DS CK21	ΔQ DS CK25
ARI (duration)	cu.m/s	cu.m/s	cu.m/s
5 (9hr)	-1.20	-1.60	-1.40
20 (9hr)	-0.60	-1.80	-3.90
100 (9hr)	-0.90	-1.9	-3.00

From the above table the proposed conceptual OSD design reduces the post developed flows to match the pre-developed flow rates downstream of the subject site. The proposed design is validated in the 2D Tuflow Hydraulic model of which will be used to set the Masterplan water quantity management controls for the site as discussed in section 4.6 of this report. This model takes into account the existing active storage that the existing farm dam provides for the pre development scenario.

4 Hydraulics - TUFLOW Model

To determine the extent of flood affected land downstream of the development in the pre-development scenario as well as to validate the DRAINS-RAFTS modelling, proposed flood mitigation and on-site stormwater detention strategy, a fully integrated 1D-2D linked TUFLOW Hydraulic model was developed over the study area. Key features of the model include:

- Primarily focusing on local and total inflow hydrographs from the DRAINS-RAFTS model via exported .ts1 files - to simplify model domain extents and reduce calculation run times due to the catchment area.
- 2D Domain extending from Cobbitty Road in the South, the upper limits of the existing farm dam to the east and a downstream tailwater set approximately 1km downstream from the calibration point at CK25/Cobbitty B to the west.
- Modelling of major 1D culverts, idealised outlet controls and pipe systems linked with the 2D model domain.
- Consideration of the existing farm dam with the dead storage as completely full at the start of the simulation (maintaining consistency with the DRAINS-RAFTS model).
- Adoption of the Nepean River Tributaries study materials GIS layers and roughness coefficients

The 2D domain is shown on the flood maps contained within Appendix C.

4.1 Materials and Impervious Area Mapping

The following table below presents the materials Mannings 'n' roughness coefficients adopted within the hydraulic model.

Table 11 - Materials Properties

Material	Manning's n Roughness Coefficient
Urban Areas	0.15
Watercourses	0.04
Roads	0.02
Pasture (Default)	0.06
Forested Woodland	0.1
Heavily Vegetated Creeks	0.06

4.2 Primary 1D Model Elements

The following 1D hydraulic structures were modelled within the 2D domain:

Table 12 - 1D hydraulic structures

Location	Size	Source/Comment
Cobbitty Road	5 x 1200 Ø RCP	Visual Site Inspection, Detailed Survey (Geolyse, 2018)
Cobbitty Road	3 x 600 Ø RCP	Detailed Survey (Geolyse, 2018)
Existing Low Flow Crossing Under Service Road	375 Ø RCP	Detailed Survey (Geolyse, 2018) Removed in the Post Developed Scenario
Crossing Under Service Road	2.4w x 0.45h RCBC	Visual Site Inspection Removed in the Post Developed Scenario
Crossing Under Service Road	2.4w x 0.45h RCBC	Visual Site Inspection Removed in the Post Developed Scenario
Post Developed:		
Cobbitty Creek Crossing under Charles McIntosh Parkway	3 x 3.3w x 1.8h RCBC	Proposed new culvert crossing under Charles McIntosh Parkway for Cobbitty Creek.
Lake Outlet	2 x 900 Ø RCP Weir 1 – 7.0m @RL 73.35 Weir 2 – 25m @RL 74.05	900mm Ø Culverts – Sized for the maximum allowable 5 Year ARI critical duration event. Weir 1 directed directly to Cobbitty Creek and sized for storms greater than the 5 Year Event. Weir 2 directed into Sports field and sized to trigger for Major events. Weirs 1 and 2 will be connected to independent drop structures located inside the Lake Park footprint to pipe flows under Charles McIntosh Parkway.
Sports fields	525 Ø RCP Weir 1 – 5.0m @RL 71.60	Inlet to sports fields triggers in major storm events only (50 Year ARI or greater).
PD04	450 Ø RCP Weir 1 – 3.6m @RL 73.5	
PD07 – North West Basin	525 Ø RCP Weir 1 – 3.6m @RL 68	

Blockage scenarios in either pre or post developed cases have not been considered for this initial design assessment as this report is to set the underlying pre-vs-post controls of the Masterplan (storge volumes and peak allowable flows).

4.3 Downstream Boundary

Downstream tailwater levels for each respective event have been extracted from the Nepean River Tributaries Study as inserted into the model as a static tailwater level. The tailwater control is set sufficiently downstream (≈1km downstream) from calibration and pre-vs-post measurement points as to not influence modelling results. For the 100 Year ARI, 9 Hour event tailwater levels were tested both with and without baseflow.

4.4 Hydraulic Pre-Developed Model Calibration

To validate the suitability of the DRAINS-RAFTS hydrologic model and local and total hydrograph inputs into the 2D model the following table below compares modelled peak water levels and flows at the common point immediately downstream of catchment CK25/COBBITTY B. Refer to the key plan within Appendix C for 2D Domain 'PO' flow line locations.

Table 13 - Hydraulic Model Comparison and Validation

Event	Tuflow Results Orion-Mirvac Masterplan		Tuflow Results Nepean River Tributaries	
	PO Line 'DS CK25'	at Flow Line DS CK25	PO Line '63'	at Flow Line 63
	cu.m/s	WSL m AHD	cu.m/s	WSL m AHD
20 Year 9 Hour	77.36	63.93	42.47	63.9
100 Year 9 Hour	108.15	64.172	81.1	64.12
100 Year 9 Hour (with BF)	108.47	64.174	81.04	64.15

The above table displays a consistent result between the modelled water surface levels for each of the two independent overland flow Hydraulic Models. From workshops held with Camden Council prior to submission, model validity and performance are based off the ability to demonstrate continuity in calculated flood planning levels.

From the above results it can be observed that the predeveloped or existing scenario Hydrologic and Hydraulic Models accurately calculate floodplain characteristics at the common calibration point. While water surface level continuity has been achieved – peak flows are notably different between the two models which is associated with the application of more detailed and current topographic data and steeper catchment slopes.

Given the achieved continuity between modelled water levels, the proposed hydrological and hydraulic modelling submitted with this report is deemed fit for purpose as an accurate representation of the overland flow characteristics of the site per the agreed calibration methodology discussed with Council.

From the above results it is observed that the impact of Baseflow in the Nepean River is negligible at this validation point (and for all points upstream) and as such has been excluded from further pre or post developed results assessment.

Other key points observed for the pre-developed scenario include:

- Only minor natural channelisation of Cobbitty Creek. Beyond the confluence of the farm dam overflow and Cobbitty Creek, a washout zone and sheet flow regime occurs across the western boundary.
- Localised overbank flooding occurs for both the minor 5 Year ARI and major 100 Year ARI event through the second order Cobbitty Creek (between the washout zone and Cobbitty Road Culvert Crossing).
- The washout zone transitions back into a reasonably well-defined channel with relatively minor (200-300mm) of overbank flooding witnessed in the minor 5 Year ARI event downstream of the subject site.
- The extent of overbank and sheet flow regimes is generally attributed to the extremely flat (1% and in some areas less than 0.5%) throughout the various defined riparian zones.
- Active flood storage of approximately 90,000 m^3 provided by the existing farm dam for the critical duration 100 Year event.

4.5 Flood Risk

To quantify and classify the flood risk hazard to people and property the flood risk hazard curves and associated Hazard Vulnerability Classifications were adopted from the Flood Hazard technical report prepared by Smith *et al.* 2014 and as generally suggested by Australian Rainfall and Runoff 2019, Book 6, Chapter 7 Section 7.2.7. It is noted that these flood hazard curves incorporate new stability curves for different vehicle classes and pedestrian age groups with defined limiting conditions for both velocity and depth profiles.

The following figure below shows the general flood hazard curves adopted:

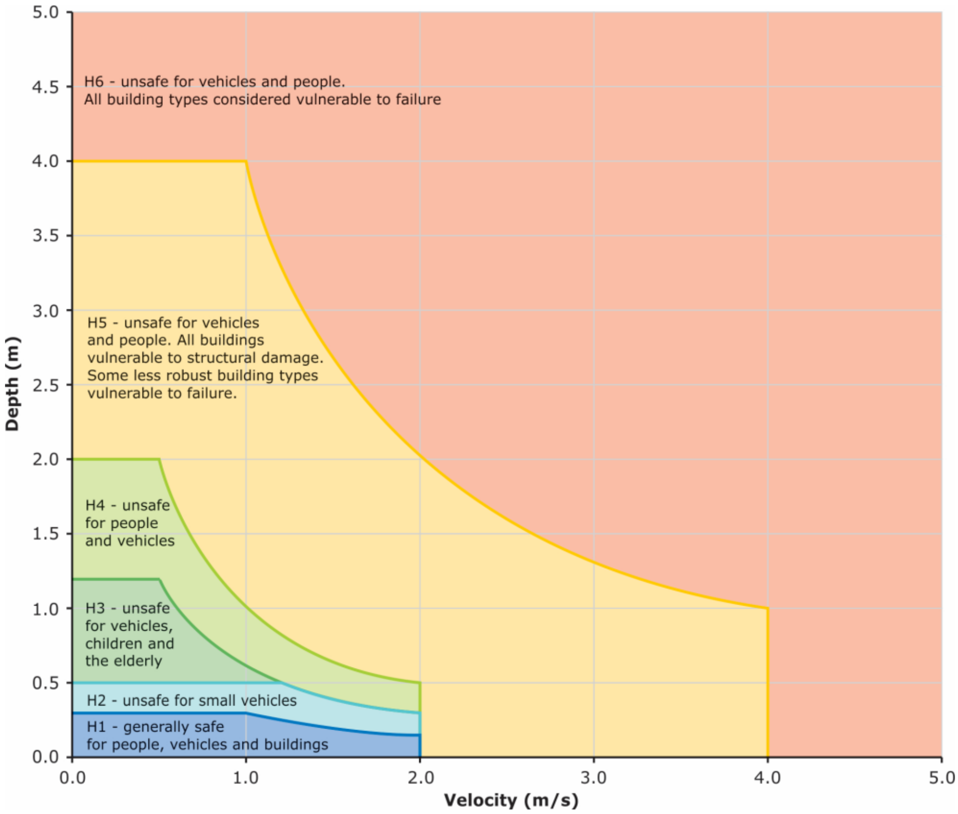


Figure 6 - General Flood Hazard Curves (Smith et al. 2014)

The following tables below identifies the Hazard Vulnerability Classifications and the limiting conditions:

Table 14 - Hazard Vulnerability Classifications

Hazard Vulnerability Classification	Description
H1	Generally safe for vehicles, people and buildings.
H2	Unsafe for small vehicles.
H3	Unsafe for vehicles. children and the elderly.
H4	Unsafe for vehicles and people.
H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

Table 15 - Hazard Vulnerability Classification Limiting Conditions

Hazard Vulnerability Classification	Classification Limit (D and V in combination)	Limiting Still Water Depth (D)	Limiting Velocity (V)
H1	D*V ≤ 0.3	0.3	2.0
H2	D*V ≤ 0.6	0.5	2.0
H3	D*V ≤ 0.6	1.2	2.0
H4	D*V ≤ 1.0	2.0	2.0
H5	D*V ≤ 4.0	4.0	4.0
H6	D*V > 4.0	-	-

The flood hazard maps contained within Appendix C and D adopt the abovementioned flood hazard vulnerability classifications.

4.6 Post-Developed Scenario

4.6.1 Design Concept

The prevalence of existing ephemeral streams and the active flood storage component of the existing farm dam presents unique set of constraints that are considered in the proposed concept Masterplan.

- Re-creation of the active flood storage component of the existing farm dam by utilising the area above the proposed lake.
- Maximisation of public amenity for the public open spaces by concentrating areas of inundation locally within the immediate lake foreshore area.
- Dual use of the Sports Fields for both active open space and additional flood storage that triggers for major events only. Additional storage is required over the sports field for the Major events to keep road and earthworks import levels for Charles McIntosh Parkway as low as possible.
- Achieve practical, low maintenance hydraulic structures for outlet control from the Lake.
- Provides a balance between no-net negative design that is achieved for the critical duration 5 Year ARI, 20 Year ARI and 100 Year ARI and free outfall for low flows in accordance with NRAR obectives.

4.6.2 Design Performance

Similar to validating the performance of the hydrological model, pre-vs-post peak flows were extracted from the 2D domain (via ‘PO’ Flow Measure Lines) at the following locations:

- At the common boundary of No 455 Cobbitty Road.
- Adjacent to the North Western site boundary within No. 415 Cobbitty Road (Downstream of CK21 – Pre and Post).
- Downstream of all major confluences at the common point shared between the DRAINS-RAFTS Model and the Nepean River Tributaries Study Model at the downstream end of sub catchment CK25.

Refer to the key plan within Appendix C for 2D Domain ‘PO’ flow line locations.

Table 16 - Pre-Developed Scenario TUFLOW Flow Summary

Event	Q_{PRE} No455 BDY	Q_{PRE} DS CK21	Q_{PRE} DS CK25
ARI (duration)	(cu.m/s)	(cu.m/s)	(cu.m/s)
5 (9hr)	18.51	22.17	52.03
20 (9hr)	28.7	34.27	77.36
100)9hr)	41.32	49.39	108.15

Table 17 - Post Developed Scenario TUFLOW Flow Summary

Event	Q_{POST} No455 BDY	Q_{POST} DS CK21	Q_{POST} DS CK25
ARI (duration)	(cu.m/s)	(cu.m/s)	(cu.m/s)
5 (9hr)	17.9	21.18	51.77
20 (9hr)	28.59	33.61	76.97
100)9hr)	41.87	48.94	107.74

Table 18 - Pre vs Post Tuflow Flow Difference Summary

Event	ΔQ No455 BDY	ΔQ DS CK21	ΔQ DS CK25
ARI (duration)	(cu.m/s)	(cu.m/s)	(cu.m/s)
5 (9hr)	-0.61	-0.99	-0.26
20 (9hr)	-0.11	-0.66	-0.39
100)9hr)	+0.55	-0.45	-0.41

The above results demonstrate that the proposed concept design adequately meets the required performance objectives for water quantity management. Continuity between the hydrological and hydraulic models is also achieved for the pre and post developed scenarios when compared against the flow summary tables in section 3.5.1 of this report.

A minor local increase in peak flow is observed occurring across the boundary of No. 455 Cobbitty Road in the 100 Year Major Event. This locally results in a minor water depth increase of approximately 60mm and a minor velocity increase of approximately 0.2m/s. This local increase does not increase existing floodway affectation (extents or hazard within the existing floodplain) and is attributed to the reduction in available cross sectional area due to Charles McIntosh Parkway and associated Culvert Crossings replacing the existing sheet flow regime. This local increase is minor in nature and does not preclude current, proposed, or future development downstream of the site boundary.

4.6.3 Design Controls

For each of the respective water quantity management nodes the following table below provides the concept design requirements for peak water level and volume for each 9 hour event:

ARI (Duration)	5 (9hr)	5 (9hr)	20 (9hr)	20 (9hr)	100 (9hr)	100 (9hr)
	WSL m AHD	Max Vol m^3	WSL m AHD	Max Vol m^3	WSL m AHD	Max Vol m^3
PD04	73.1	1,075	73.5	1,720	73.62	1,920
PD-L	73.4	67,000	73.9	87,000	74.25	101,600
Sports Field	N/A	N/A	N/A	N/A	71.6	9,000
PD07	68.3	6,400	68.45	7,300	68.53	7,800

A full set of pre, post and difference maps are provided in the appendices.

5 Water Quality

The water quality or Water Sensitive Urban Design (WSUD) strategy for the proposed development has been determined through the adoption and implementation of a MUSIC model. MUSIC is an industry standard modelling program used to design and size water quality controls subject to a number of water quality assessment criteria.

5.1 Assessment Metrics

The Oran Park Development Control Plan Section 6.2 identifies the following assessment criteria for water sensitive urban design:

Percentage reduction targets:

- Total Suspended Solids (TSS) 85%
- Total Phosphorus (TP) 65%
- Total Nitrogen (TN) 45%
- Gross Pollutants (GP) 90%

Environmental Flows – Stream Erosion Control Ratio (SEI)
Required Management Objective 3.5-5.0 : 1

5.2 Proposed Treatment Train

The following water quality control assets are proposed for implementation:

i. Gross pollutant trap (GPT) - for removal of coarse sediment and large debris reducing maintenance obligations and pollutant load on the tertiary treatment controls. Sized generally for the 3-6-month flow (approximated as 50% of the 1EY flow rate).

ii. Bioretention systems - capture of finer sediments and nutrients (proprietary solution nominated to maximise public amenity and long term water quality control effectiveness).

iii. Rainwater tanks - generally required in order to meet BASIX requirements and provides a starting point for pollutant capture and removal as well as reduction in runoff from the site due to the provided storage. A nominal 3,000 litre tank has been allowed for each lot with 90mm dia. uPVC outlet and a re-use drawdown of 360 Litres, per lot, per day (in accordance with table 5.4 of the Using Music in the Sydney Drinking Water Catchment Guideline for a 3 bedroom house with connected toilets and laundry).

In order to maximise recreational land use and promote more efficient use of materials for long duration maintenance cycles, the proposed WSUD design features the use of proprietary high-flow bioretention systems. This allows for:

- Significantly increased treatment rates thus significantly reducing required plan footprint

- Engineered media and sacrificial mulch layer forms primary form of nutrient removal not the plants, this allows for more native vegetation to be planted increasing resilience to drought conditions and protects the media layer from siltation and clogging.

- Smaller footprint and number of plants reduces garden maintenance requirements.

The table below summaries the proposed treatment train strategy for the different stormwater outlets for the proposed development:

Table 19 - Water Quality Control Treatment Train Strategy

Outlet / Catchment	Control Measures
PD-A & PD01	1 x GPT, 850 m^2 Filterra Biofiltration System
PD-B & PD02	1 x GPT, 500 m^2 Filterra Biofiltration System
PD03	1 x GPT, 650 m^2 Filterra Biofiltration System
PD04	1 x GPT, 250 m^2 Filterra Biofiltration System
PD05	1 x GPT, 500 m^2 Filterra Biofiltration System
PD06	1 x GPT, 150 m^2 Filterra Biofiltration System
PD07	1 x GPT, 900 m^2 Filterra Biofiltration System
PD08	1 x GPT, 100 m^2 Filterra Biofiltration System

5.3 Modelling Input Data

Camden Council MUSIC Link version 6.3 was implemented for water quality modelling and assessment.

5.3.1 Catchment Delineation

The post-developed scenario catchment delineation that was adopted for the hydrological modelling has been further refined and is shown in greater detail in Appendix A.

5.3.2 Sub-Catchment Breakdown

To apply both a conservative and accurate modelling approach sub-catchments and adopted impervious areas are defined by the following:

i. Calculation of total number of lots and corresponding total lot areas for each sub-catchment.

ii. Breakdown of the total lot areas into both roof area and supplementary (garden, driveway) areas. Supplementary areas were modelled as 65% impervious.

iii. An estimate of 225 m^2 average roof area was allowed for each individual lot with 50% of the roof area to drain to a rainwater tank. All roof areas were modelled as 100% impervious.

iv. Total area of road corridors was calculated for each sub-catchment and assumed to be 95% impervious.

5.3.3 Catchment Areas Summary

The tables below summarise the primary sub-catchment areas and breakdown of land use:

Table 20 - MUSIC Sub-Catchment Summary (1 of 3)

Catchment	PD-A (External)	PD-B (External)	PD01	PD02	PD03
Total Lots	158	149	111	74	166
Lot Area (ha)	8.37	5.27	4.39	1.97	6.84
Roof Area (ha)	3.56	3.35	2.50	1.67	3.74
Lot Sup. Area (ha)	4.816	1.919	1.888	0.305	3.106
Roads (ha)	3.264	2.171	2.741	0.890	3.907
Other (ha)			2.28	1.854	4.455
Total Area (ha)	**11.635**	**7.437**	**9.406**	**4.714**	**15.202**

Table 21 - MUSIC Sub-Catchment Summary (2 of 3)

Catchment	PD04	PD05	PD06	PD07	PD08
Total Lots	89	143	23	276	30
Lot Area (ha)	4.22	5.68	2.60	10.50	1.02
Roof Area (ha)	2.00	3.22	0.52	6.21	0.68
Lot Sup. Area (ha)	2.216	2.458	2.086	4.292	0.340
Roads (ha)	1.594	2.542	0.485	4.830	0.428
Other (ha)	0.231	3.485	0.155	5.912	0.134
Total Area (ha)	**6.044**	**11.702**	**3.243**	**21.244**	**1.572**

Table 22 - MUSIC Sub-Catchment Summary (3 of 3)

Additional Catchments	Area (ha)
Total Vegetated Area	**14.70**
School	**2.01**
B1 Zone	**1.85**
581 Cobbitty Road	**4.45**
Sports Field	**3.05**
Total Road Bypass	**1.34**
Water Management	**1.29**
General Lake Area	**4.81**

The total Music model catchment area is the sum of all Developed Catchments and the additional catchment areas summing to **107.2 ha**

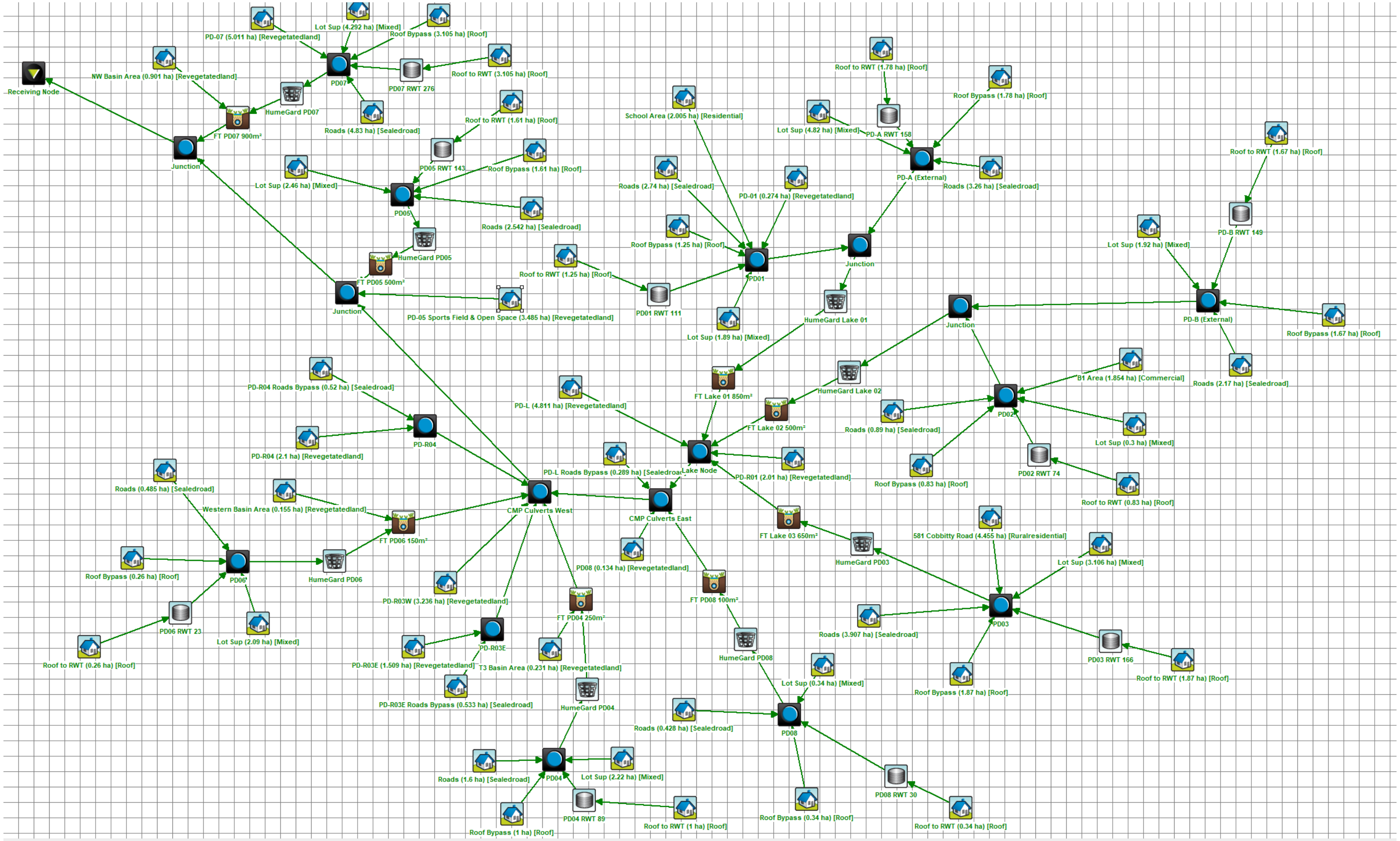


Figure 7 - MUSIC Model Layout

5.4 Modelling Results

The table below summarises post-developed scenario source and residual pollutant loads as well as the percentage reduction results.

Table 23 - Treatment Train Effectiveness

	Sources	Residual Load	% Reduction	% Target
TSS (kg/yr)	94300	9450	90	85
TP (kg/yr)	190	25.4	86.7	65
TN (kg/yr)	1310	382	70.8	45
Gross Pollutants (kg/yr)	14500	515	96.4	90

The above table demonstrates percentage reduction targets are achieved with the proposed treatment train and water quality management strategy.

5.5 Stream Erosion Index

In order to accurately calculate the stream erosion index the total cumulative stream forming flow at each outlet location was calculated using the DRAINS-RAFTS Hydrological model.

50% AEP flows were extracted from the Hydrologic model at each respective global outlet location. This allows for the true capture of all flows in Cobbitty Creek with respect to global external catchments influencing the respective streams which are being discharged into. This method allows for a direct assessment of mean average volume above the stream forming flow for each major outlet of the site.

The Critical stream forming flow has been estimated as 25% of the 50% AEP flow in relation to the presence of predominantly silty clays. The critical stream forming flow for each respective sub catchment has been inserted into a separate MUSIC model for the SEI calculations in order to calculate Mean Annual flows above the Critical Stream Forming flows for both the Pre and Post Developed Modelling Scenarios. The calculations and results for the SEI is presented in the table below for each respective catchment outlet.

As the Camden MUSIC Link only provides a limited range of rainfall data, the separate MUSIC model developed for SEI calculations has been based off Richmond RAAF Base rainfall data for the years between 1954 and 1994, similar to that presented in the original Integrated Water Cycle Management Study – Water Sensitive Urban Design Component (Ecological Engineering, 2007).

Table 24 - Stream Erosion Index Calculations and Results

Outlet / Catchment	50% AEP Flow (cu.m/s)	Critical Stream Forming Flow (cu.m/s)	Pre Developed Annual Volume (ML/y)	Post Developed Annual Volume (ML/y)	SEI (x:1)
A	15	3.75	862	733	0.85
B	13	3.25	759	642	0.85
C	9.52	2.38	893	752	0.84
D	8	2	265	286	1.08
E	3.68	0.92	401	330	0.82

Table 24 previous demonstrates that for most outlet locations, the stream erosion index 'ideal' stormwater outcome of a 1:1 ratio is achieved for most of the site. All catchments and outlet locations achieve the required management objective with a SEI of less than 5:1 in all cases.

Ideal SEI targets are being met due to the comparatively low volumetric contribution the proposed development gives Cobbitty Creek and the implementation of rainwater tanks and raingardens for each of the modelled urban design catchments. Global Catchment measurement nodes are shown within Appendix A.

5.6 Lake Water Balance

In support of the concept masterplan a preliminary water balance assessment was undertaken for the proposed lake. For the preliminary water balance assessment the following parameters were implemented:

• Lake Surface Area	1.5 ha
• Lake Volume	37.5 ML (assuming an average nominal depth of 2.5m)
• Lake Volume at start of Simulation	37.5 ML
• Exfiltration Rate	0 mm/hr

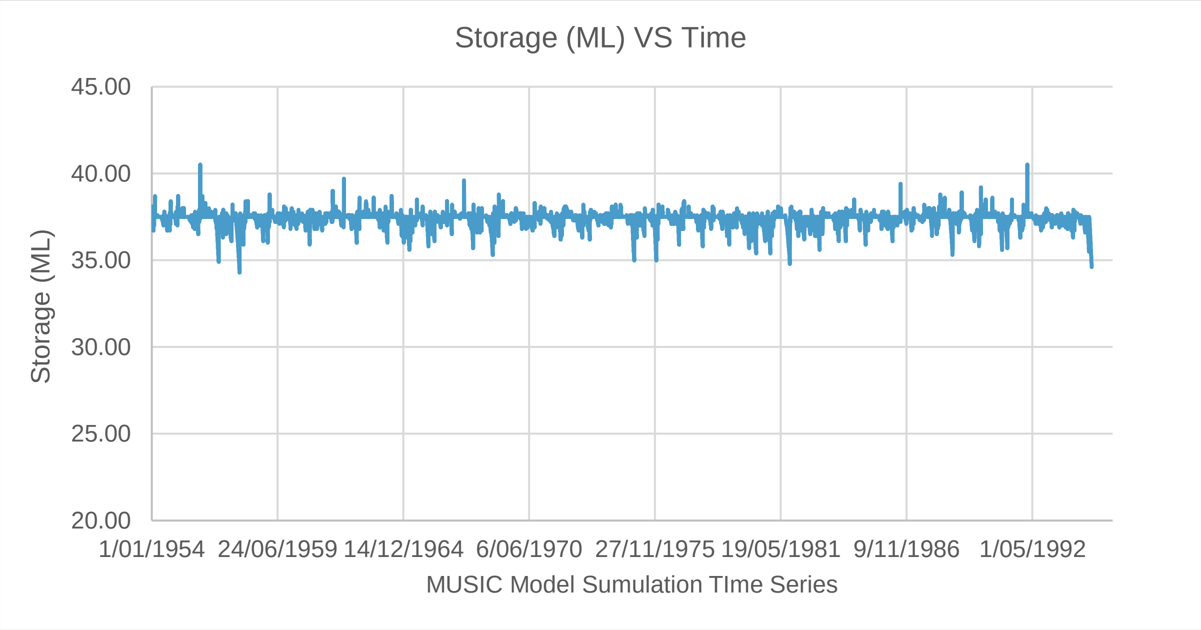


Figure 8 - Lake Storage Vs Time

Based on the preliminary water balance assessment, over the simulated circa 40 year period the lake does not lose on average any more than 8.5% (3.2ML) of its total volume which will equate to a fluctuating water level of no more than 200 to 300mm on average due to evaporation during normal operation. The final water level fluctuation will be a function of detailed design final plan area and staged storage relationship of the lake.

It is recommended that a detailed lake and water health assessment will be undertaken in support of approval for the 'lake park' to calculate and validate the statistical breakdown and link between of pollutant loads, water temperature and residence time.

6 Conclusions and Recommendations

This Integrated Water Cycle Management Strategy responds to site specific constraints posed by the existing farm dam and the attenuation it currently provides. For water quantity, floodplain management and water quality this report demonstrates that the proposed management strategies reduce downstream peak flows and flooded depths and meet the relevant regulatory requirements for water quality targets. As such we conclude that this integrated water cycle management strategy is suitable to support the development proposal.

A summary of key findings is provided below:

i. The adopted hydrological model and underlying input data has been predominantly based on the Nepean River Tributaries study electronic data received under licence agreement from Camden Council. The combined hydrologic and hydraulic model developed for the existing scenario has been calibrated to this model and achieves congruence with calculated water surface levels when compared against the Nepean River Tributaries study results dataset.

ii. The proposed hydrologic and hydraulic model demonstrates compliance with no-net-negative design principles for the site and fully accommodates the storage provided by the existing farm dam. The minor local concentration of water immediately downstream of the site is a function of the significant reduction in the existing sheet flow regimes across the boundary but does not increase existing floodplain affectation or hazard.

iii. The proposed design controls provide a balance between earthworks import requirements, open space activation and amenity and safe water quantity management. This is primarily achieved by retaining the lake and flood storage above it online to the upstream flows from Oran Park – similar to what the existing farm dam currently provides.

iv. The proposed water quality treatment train comprising of rainwater tanks, proprietary bioretention systems meets the post developed percentage reduction targets as outlined in the Oran Park DCP.

v. An independent MUSIC model was set up to capture 40 years of rainfall data demonstrates that the proposed treatment train adequately meets Stream Erosion Index Targets. This model also shows that the maximum drawdown of the proposed lake is limited to 3.2ML or approximately 200-300mm of water depth.

The proposed water management strategy outlined in this report will set the underlying development controls and objectives that must be complied with for all future approval stages. These future approval and future detailed design stages will be required to demonstrate compliance with the controls and objectives of this study.

7 References

Australian Rainfall and Runoff: A Guide to Flood Estimation, Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), Commonwealth of Australia (Geoscience Australia) 2019

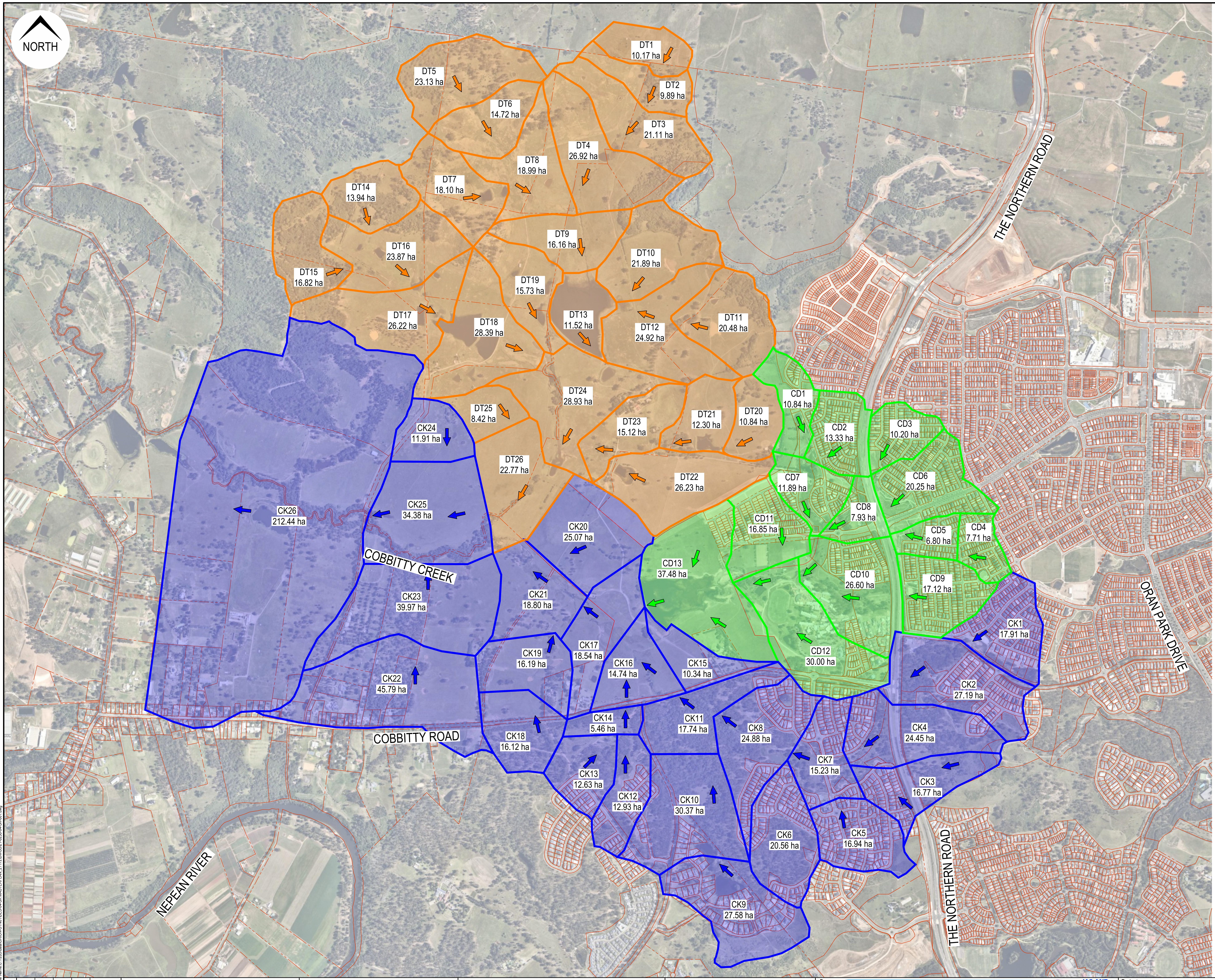
Flood Hazard, Smith G, Davey E, Cox R S, University of New South Wales Water Research Laboratory Technical Report 2014/07, September 2014

Floodplain Development Manual, NSW Government Department of Infrastructure, Planning and Natural Resources April 2005

Queensland Urban Drainage Design Manual, Third Edition, Queensland Government Department of Energy and Water Supply 2013

Using MUSIC in Sydney Drinking Water Catchment, WaterNSW 2019

APPENDIX A - Catchment Plans



LEGEND

COBBITTY DAM CATCHMENTS	(green arrow)
COBBITTY CREEK CATCHMENTS	(blue arrow)
DENBIGH TRIBUTARY CATCHMENTS	(orange arrow)
STUDY AREA	(red outline)

Rev	Drawn	Design	Check	Appd.	Date	Revision Description
A	AP	CS	-	-	09/06/2022	ISSUED WITH IWCM REPORT

Scale:
0 100 200 300 400 500 600 700 800 900 1000
SCALE 1:10000 (A1) SCALE 1:20000 (A3)

For: mirvac

By: Orion Consulting
ABN:25 604 069 981 PO Box:7936, BAULKHAM HILLS NSW 2153 T:(02) 8660 0035 E:info@orionconsulting.com.au

Project:
LOT 2005 DP 1162239
No. 531 COBBITTY ROAD, COBBITTY
MASTERPLAN

Title:
PRE DEVELOPMENT CATCHMENT PLAN

Project No.	Set No.	Milestone	Plan	Revision
21-0258	04	SK	001	A

Plotted:Monday, 30 March 2020 2:57:46 PM File Name:C:\12d\data\ORION-SYN...

Rev	Drawn	Design	Check	Appd.	Date	Revision Description
A	AP	CS	-	-	09/06/2022	ISSUED WITH IWCM REPORT

Scale:
0 100 200 300 400 500 600 700 800 900 1000
SCALE 1:10000 (A1) SCALE 1:20000 (A3)

For: mirvac

By: Orion Consulting

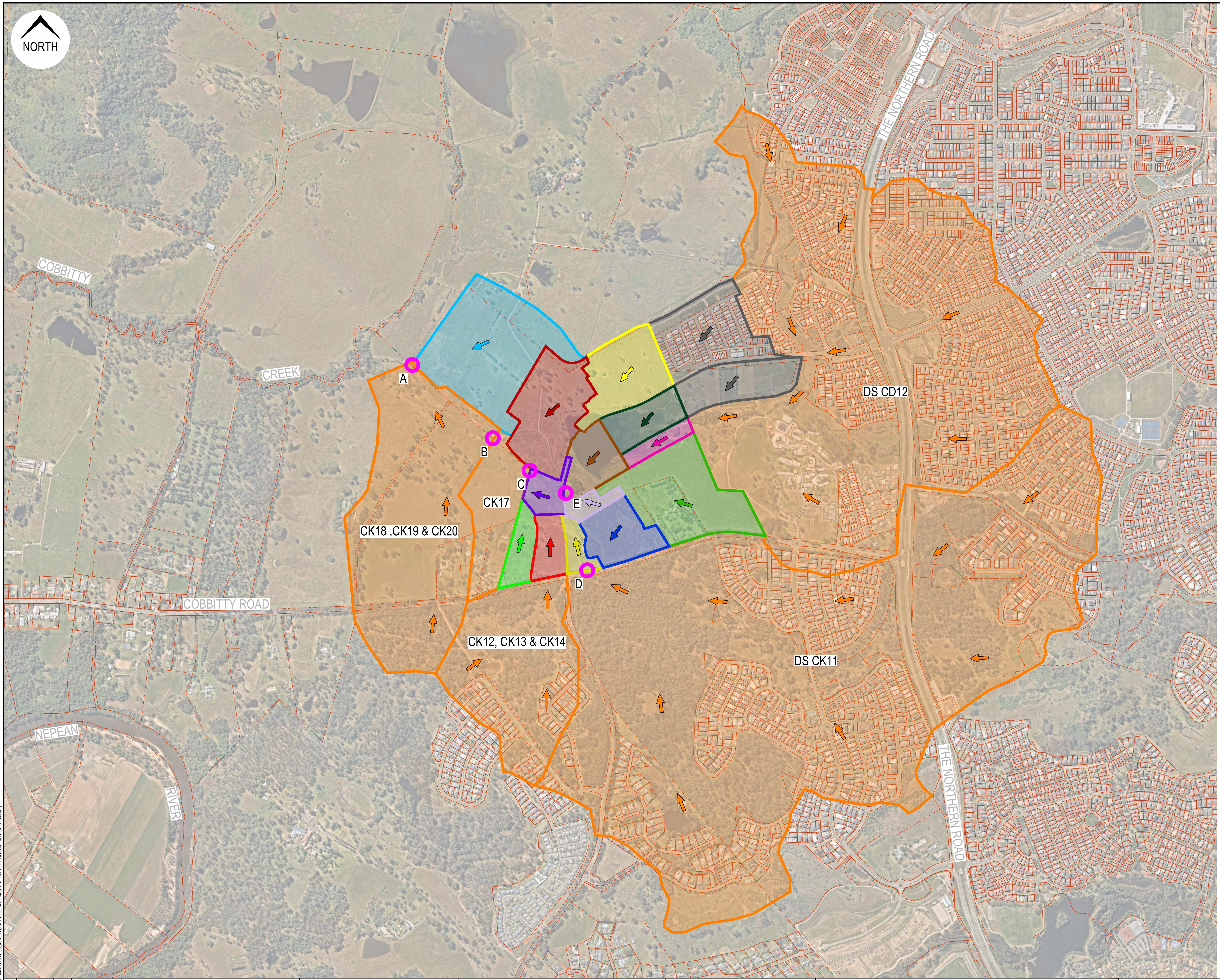
SUSTAINABLE CERTIFICATION ISO 9001 ISO 45001 ISO 14001
JAS-ANZ WWW.JAS-ANZ.ORG/REGISTER

ABN:25 604 069 981 PO Box:7936, BAULKHAM HILLS NSW 2153 T:(02) 8660 0035 E:info@orionconsulting.com.au

Project:
LOT 2005 DP 1162239
No. 531 COBBITTY ROAD, COBBITTY
MASTERPLAN

Title:
POST DEVELOPMENT CATCHMENT PLAN

Project No.	Set No.	Milestone	Plan	Revision
21-0258	04	SK	002	A



LEGEND

EXISTING CADASTRAL BOUNDARY	
DENOTES **PD01** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD02** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD03** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD04** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD05** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD06** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD07** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD08** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD-R01** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD-R03E** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD-R03W** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD-R04** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD-L** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **PD-A & PD-B** CATCHMENT BOUNDARY AND FLOW ARROW	
DENOTES **EXTERNAL UPSTREAM** CATCHMENT BOUNDARY AND FLOW ARROW - IMPLEMENTED TO CUMULATIVE STREAM EROSION INDEX CALCULATIONS	
DENOTES MEASURING POINTS ALONG COBBITTY CREEK FOR STREAM EROSION INDEX CALCULATIONS	

Plotted:Monday, 30 March 2020 2:57:46 PM File Name:C:\12dS\data\ORION-SYN\...

Rev	Drawn	Design	Check	Appd.	Date	Revision Description
A	AP	CS	-	-	09/06/2022	ISSUED WITH IWCM REPORT

Scale:
0 75 150 225 300 375 450 525 600 675 750
SCALE 1:7500(A1) SCALE 1:15000(A3)

For: mirvac

By: Orion Consulting
SUSTAINABLE CERTIFICATION ISO 9001 ISO 45001 ISO 14001
JAS-ANZ WWW.JAS-ANZ.ORG/REGISTER
ABN:25 604 069 981 **PO Box:**7936, BAULKHAM HILLS NSW 2153 **T:**(02) 8660 0035 **E:**info@orionconsulting.com.au

Project:
LOT 2005 DP 1162239
No. 531 COBBITTY ROAD,
COBBITTY
MASTERPLAN

Title:
WATER QUALITY
& STREAM EROSION INDEX
CATCHMENT PLAN

Project No.	Set No.	Milestone	Plan	Revision
21-0258	04	SK	003	A

APPENDIX B – DRAINS-RAFTS Catchment Data

Catchment Name	Area (ha)	Average Slope	Equal Area Slope	Mannings n
CAT CD1	10.84	6.84%	4.23%	0.05
CAT CD2	13.33	4.13%	3.49%	0.05
CAT CD3	10.2	4.00%	3.87%	0.05
CAT CD4	7.71	4.62%	5.90%	0.05
CAT CD5	6.8	3.47%	2.60%	0.05
CAT CD6	20.25	4.07%	3.28%	0.05
CAT CD7	11.89	3.44%	1.53%	0.05
CAT CD8	7.93	2.56%	0.90%	0.05
CAT CD9	17.12	4.98%	4.50%	0.05
CAT CD10	26.6	2.34%	2.10%	0.05
CAT CD11	16.85	3.59%	2.83%	0.05
CAT CD12	30	2.01%	1.80%	0.05
CAT CD13	37.48	2.43%	0.50%	0.025
CAT CK1	17.91	2.71%	3.00%	0.05
CAT CK2	27.19	4.11%	2.80%	0.1
CAT CK3	16.77	7.04%	4.10%	0.05
CAT CK4	24.45	5.42%	3.18%	0.1
CAT CK5	16.94	3.52%	2.62%	0.05
CAT CK6	20.56	4.07%	2.50%	0.1
CAT CK7	15.23	1.88%	1.16%	0.05
CAT CK8	24.88	2.02%	1.63%	0.1
CAT CK9	27.58	4.09%	3.37%	0.05
CAT CK10	30.37	3.18%	2.72%	0.1
CAT CK11	17.74	2.24%	1.78%	0.1
CAT CK12	12.93	3.15%	2.50%	0.05
CAT CK13	12.63	2.57%	2.12%	0.1
CAT CK14	5.46	2.74%	2.10%	0.05
CAT CK15	10.34	4.17%	4.50%	0.05
CAT CK16	14.74	2.12%	1.40%	0.05
CAT CK17	18.54	3.26%	2.15%	0.05
CAT CK18	16.12	3.02%	2.94%	0.1
CAT CK19	16.19	3.22%	2.36%	0.05
CAT CK20	25.07	2.96%	2.21%	0.05
CAT CK21	18.8	3.06%	2.29%	0.05
CAT CK22	45.79	2.98%	2.65%	0.1
CAT CK23	39.97	3.82%	2.73%	0.05
CAT CK24	11.91	11.35%	9.10%	0.05
CAT CK25	34.38	1.89%	1.40%	0.05

Catchment Name	Area (ha)	Average Slope	Equal Area Slope	Mannings n
CAT CK26	212.44	2.34%	1.79%	0.05
CAT DT1	10.17	9.56%	8.55%	0.05
CAT DT2	9.89	8.31%	6.12%	0.1
CAT DT3	21.11	9.27%	6.76%	0.05
CAT DT4	26.92	8.26%	4.88%	0.05
CAT DT5	23.13	17.98%	11.70%	0.1
CAT DT6	14.72	10.61%	7.64%	0.05
CAT DT7	18.1	7.71%	5.00%	0.05
CAT DT8	18.99	9.15%	5.90%	0.05
CAT DT9	16.16	8.27%	4.29%	0.05
CAT DT10	21.89	8.38%	4.68%	0.05
CAT DT11	20.48	8.74%	4.84%	0.05
CAT DT12	24.92	3.55%	2.63%	0.05
CAT DT13	11.52	0.28%	0.28%	0.01
CAT DT14	13.94	11.83%	8.90%	0.1
CAT DT15	16.82	14.21%	8.70%	0.1
CAT DT16	23.87	8.53%	4.44%	0.05
CAT DT17	26.22	10.38%	5.69%	0.05
CAT DT18	28.39	5.92%	2.92%	0.05
CAT DT19	15.73	8.42%	4.20%	0.05
CAT DT20	10.84	10.29%	5.36%	0.05
CAT DT21	12.3	4.97%	3.81%	0.05
CAT DT22	26.23	3.08%	2.44%	0.05
CAT DT23	15.12	3.25%	2.42%	0.05
CAT DT24	28.93	1.86%	1.06%	0.05
CAT DT25	8.42	4.60%	4.10%	0.05
CAT DT26	22.77	1.19%	1.08%	0.05

APPENDIX C - Pre Developed Flood Maps

Plotted:Monday, 30 March 2020 2:57:46 PM File Name:C:\12d\data\ORION-SY...

Rev	Drawn	Design	Check	Appd.	Date	Revision Description
A	HS	CS			09/06/2022	ISSUED WITH IWCM MASTERPLAN REPORT

Disclaimer and Copyright:

Scale:

0 50 100 150 200 250 300 350 400 450 500

SCALE 1:5000 (A1) SCALE 1:10000 (A3)

For: mirvac

By: Orion Consulting

SUSTAINABLE CERTIFICATION ISO 9001 ISO 45001 ISO 14001 JAS-ANZ WWW.JAS-ANZ.ORG/REGISTER

ABN:25 604 069 981 PO Box:7936, BAULKHAM HILLS NSW 2153 T:(02) 8660 0035 E:info@orionconsulting.com.au

Project:

No. 531 COBBITTY ROAD, COBBITY - INTEGRATED WATER CYCLE MANAGEMENT

Title:

KEY & 2D DOMAIN PLAN

Project No.	Set No.	Milestone	Plan	Revision
21-0258	07	FM	001	A