Attachment B

Stormwater Treatment Systems

ADVANCED DRAFT DESIGN REPORT:

Yarralumla Brickworks stormwater treatment systems

May 2023

Document history

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Issue date	015/05/2023
Issued to	Scott Marshall (ForeGroup)
Description:	Revised advanced draft design report (incorporating responses to comments)

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SUMMARY

Alluvium was engaged by BLOC to develop a surface water management strategy for the Yarralumla Brickworks development site. The objective of the project is to develop management strategies for stormwater quality based on the ACT Practice Guidelines for WSUD (2016) and ACT Waterways: Water Sensitive Urban Design General Code (Effective 21 February 2020).

Based on early site investigations and a desire as part of the development masterplan to have the disused quarry on site converted to a water feature for amenity, ecology, stormwater treatment and irrigation supply purposes, Alluvium developed two concept level options for managing stormwater on site (based on masterplan 31st March 2020). These were:

- Option 1: Sediment basin + wetland treatment system + pond

  This option was based on receiving inflow from the combined subcatchments within the site, with the 4EY (4 Exceedances per Year) flow being diverted into a sediment basin, then flowing into a macrophyte zone (wetland), and finally into a pond, all situated in the existing depression (disused quarry).

- Option 2: Sediment basin + pond + bioretention system

  This option proposed two treatment assets – a sediment basin providing pre-treatment for a small, gravity fed pond in the existing depression (disused quarry), and a bioretention asset in landscape development area 4 (the Heritage Precinct).

Given pipe depths and cover requirements, diverting stormwater from the drainage system in the Heritage Precinct into bioretention assets resulted in deep assets with large batter footprints. Alluvium therefore recommended Option 1, which also achieved greater reductions in pollutants, a higher reliability for meeting landscape irrigation demands, and a much lower risk of deterioration of the pond due to algal blooms (i.e., more reliable inflows to the pond).

Proposed water quality treatment measures to meet water quality targets

The proposed approach is as follows:

- The existing quarry pond will be converted to accommodate a sediment basin (SB), constructed wetland and pond.
- The flows from catchment G (single dwelling T6-T20) will be directly diverted to the treatment assets via a gravity fed stormwater pipe between lots 10 and 11
- Additional runoff from the western developed surfaces will be diverted to the low point near the north-west boundary and pumped to the treatment assets. High flows will be bypassed to an on-site detention tank. The size of the detention tank needs to be refined at a later stage, to retard peak flows and ensure detained stormwater is released over a period of 6 hours after the storm event.
- Treated stormwater from the pond will be stored in an on-site retention tank for landscape irrigation purposes.
- Installation of a 200kL rainwater tank in catchment D for open space irrigation.

The overall treatment train performance results for the above configuration were modelled in MUSIC and are shown in Table 1. The proposed sediment basin, wetland and pond (including the irrigation reuse throughout the catchment) meet the overall development's stormwater treatment requirements for TSS, TP and TN at the proposed diversion rate.

Table 1. Treatment train performance results from MUSIC

Pollutant	*Source load*	*Residual load*	*% reduction*	*% reduction target*
Total Suspended Solids (kg/yr)	10,700	1920	82	80
Total Phosphorus (kg/yr)	9.94	3.87	60.1	60

Total Nitrogen (kg/yr)	131	36	72.5	45
Gross pollutants (kg/yr)	1710	171	90	90

Diverting a 0.1m^3/s flow to the SB/wetland/pond treatment system from the low point of the development will ensure sufficient turnover in the pond to avoid stagnation.

The presented strategy is the preferred approach at the site due to its significant reduction in pollutants, high reliability for meeting landscape irrigation demands, and low risk of deterioration of pond water quality due to algal blooms (i.e., reliable inflows to the pond).

Stormwater reuse opportunities and initiatives

As well as meeting required pollutant reduction treatment targets, the proposed SB/wetland/pond treatment system in combination with a 200kL rainwater harvesting tank will significantly reduce potable water use for irrigation purposes. Flows up to 5 year average recurrence intervals / AEP 20% from catchment G are diverted to the SB/wetland/pond treatment system via gravity feed. However, due to site's topography, the strategy also relies on a pump installed at the stormwater collection point (G). In case of pump failure, stormwater will be stored in the on-site detention tank, which mitigates the potential for erosion/pollution threat to the downstream stormwater network.

Diverting a 0.1m^3/s flow to the SB/wetland/pond treatment system from the low point on the development, in combination with a 500kL tank ensures an 80-85% reliability of irrigation demand from the open space surrounding the pond. Installation of a 200kL rainwater tank in catchment D ensures 70%-75% irrigation reliability for open space irrigation in and around Precinct 5.

The scope of the analysis to date does not cover detailed hydrologic modelling. This needs to be undertaken to more accurately assess peak flows, peak storage levels and critical durations for sizing detention storage.

1 Introduction

Alluvium was engaged by BLOC to develop a surface water management strategy for the Yarralumla Brickworks development site. The objective of the project is to develop management strategies for stormwater quality based on the ACT Practice Guidelines for WSUD (2016) and ACT Waterways: Water Sensitive Urban Design General Code (Effective 21 February 2020).

Through meeting this objective, the SWMS will act as a critical component of the development planning and urban design process and ensure stormwater is managed in accordance with code requirements in the ACT.

Runoff from proposed developments in the ACT is required to be treated before entering receiving waterbodies. The ACT Practice Guidelines for WSUD (2016) were used to identify stormwater quality treatment targets for the development site. The reduction targets are:

- Suspended solids reduced by at least 60% of the mean annual load
- Total phosphorous reduced by at least 45% of the mean annual load
- Total nitrogen reduced by at least 40% of the mean annual load.

However, as per Green Star Rating Credit 24A.1.2.1, the following minimum reductions in total pollutant load from the developed part of the project site must be achieved, when compared to untreated stormwater runoff.

- Suspended solids reduced by at least 80% of the mean annual load
- Total phosphorous reduced by at least 60% of the mean annual load
- Total nitrogen reduced by at least 45% of the mean annual load.
- Total gross pollutant reduced by at least 90% of the mean annual load.

1.1 Project background

The Yarralumla Brickworks site covers an area of approximately 16 hectares and is generally bounded by Bentham Street to the north, the Royal Canberra Golf Course to the west, and connects to Denman Street to the south-east (Figure 1). There are remnants of the former Yarralumla Brickworks Railway, and a depression currently exists at the site of a former quarry. This is where a pond has been proposed to be instituted.

Figure 1. *Site context*

In the absence of sufficient flow in the pond, nutrients and sediments entering the system can lead to an increased risk of algal blooms. In addition, increased pollutant load discharging from the development area can have serious implications on downstream receiving waters, also including algal blooms, and therefore needs to be managed. Thus, it is essential to understand and manage the pond residence time and turnover.

Pond residence time and turnover targets are:

- Sufficient inflow to ensure there is a Summer residence time (turn-over of water) of less than 50 days so as to avoid stagnant water and algal blooms

- Sufficient inflow to ensure a 20th percentile annual residence time of between 20 and 30 days.

1.2 Stormwater treatment concept design work undertaken to date

Alluvium developed a proof of concept for an amenity and stormwater treatment pond in support of a development tender for the Yarralumla Brickworks site in 2016.

Based on early site investigations and a desire as part of the development masterplan to have the disused quarry on site converted to a water feature for amenity, ecology, stormwater treatment and irrigation supply purposes, Alluvium developed two concept level options for managing stormwater on site (based on masterplan 31st March 2020). These were:

- Option 1: Sediment basin + wetland treatment system + pond

  This option was based on receiving inflow from the combined subcatchments within the site, with the 4EY (4 Exceedances per Year) flow being diverted into a sediment basin, then flowing into a macrophyte zone (wetland), and finally into a pond, all situated in the existing depression (disused quarry).

- Option 2: Sediment basin + pond + bioretention system

  This option proposed two treatment assets – a sediment basin providing pre-treatment for a small, gravity fed pond in the existing depression (disused quarry), and a bioretention asset in landscape development area 4 (the Heritage Precinct).

Given pipe depths and cover requirements, diverting stormwater from the drainage system in the Heritage Precinct into bioretention assets resulted in deep assets with large batter footprints. Alluvium therefore recommended Option 1, which also achieved greater reductions in pollutants, a higher reliability for meeting landscape irrigation demands, and a much lower risk of deterioration of the pond due to algal blooms (i.e., more reliable inflows to the pond).

A draft stormwater treatment strategy was presented to David Murphy (BLOC), Alex Moulis (Doma Group), and Bernie Cusack (Sellick Consultants) in June 2020. Based on discussions at the meeting and following, Alluvium refined the strategy and explored additional options for on-site stormwater management. An advanced draft strategy was provided to BLOC in June 2020.

Alluvium (David Barratt and Advait Madav) attended a meeting with BLOC, DOMA, and Sellick Consultants to finalise the water quality outcomes and the preferred strategy in February 2021. A revised strategy was delivered in July 2021 following some changes to the development concept masterplan.

This report outlines the final proposed development stormwater treatment strategy, based on the agreed approach and the latest development masterplan provided on 1 February 2022.

2 Wetland and Pond Treatment System

2.1 Catchment delineation

The development site was delineated into 9 sub catchments based on topography, the concept drainage layout and lot typology (Figure 2). These catchments were further broken into roof, road and open space for the purposes of the treatment modelling.

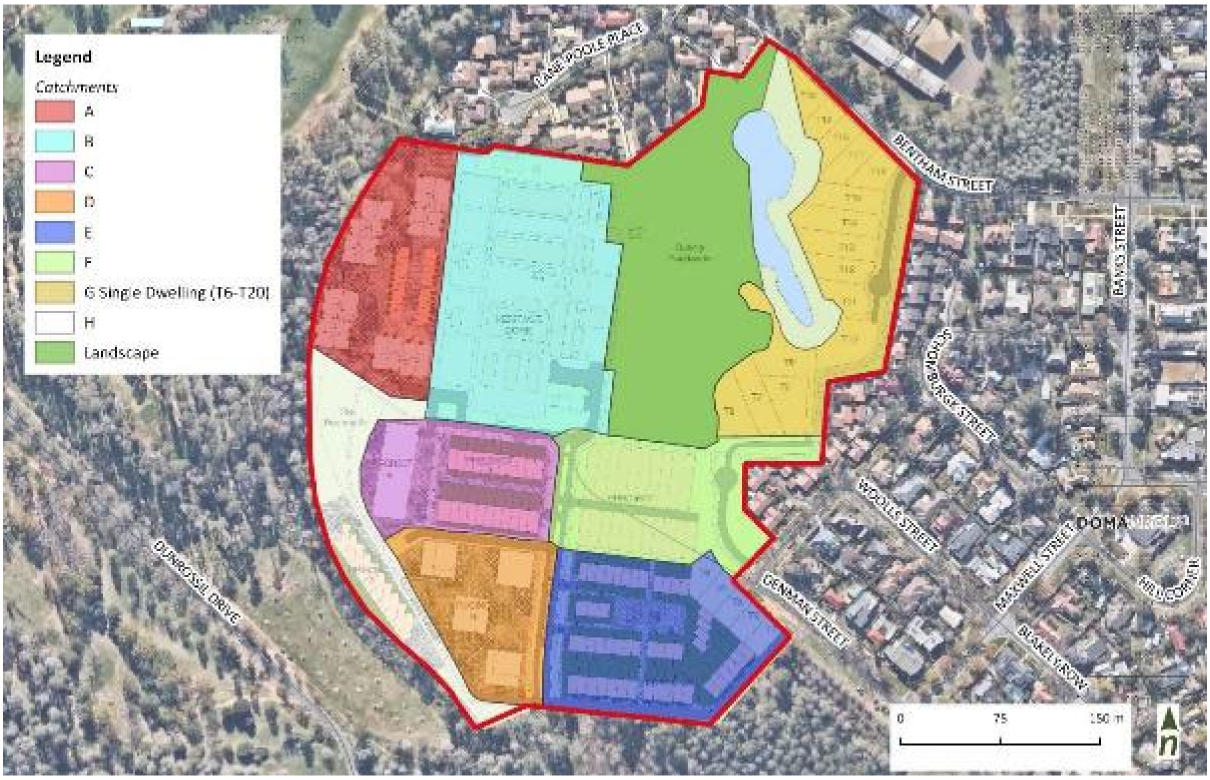

Figure 2. *Catchment delineation*

2.2 Overview of stormwater treatment strategy

This section provides an overview of stormwater treatment strategy. Please refer to Figure 2 for catchment delineation and Figure 3 for a schematic of the treatment model (Model for Urban Stormwater Improvement Conceptualisation; MUSIC). The approach is as follows:

- The existing quarry pond will be converted to accommodate a sediment basin (SB), wetland and pond.
- The flows from catchment G 'single dwelling T6-T20' will be directly diverted to treatment assets via gravity feed.
- Diverting the required flow from the development at the low point in the north-west boundary and pumping this flow to the treatment assets. High flows are bypassed to an on-site detention tank. The size of the detention tank needs to be refined at a later stage to retard the necessary peak flows and ensure detained stormwater is released over a period of 6 hours after the storm event.
- Treated stormwater from the pond will enter the on-site retention tank for landscape irrigation (passive irrigation) purposes.
- Installation of a 200kL rainwater tank in Precinct 5 for open space irrigation (passive irrigation).

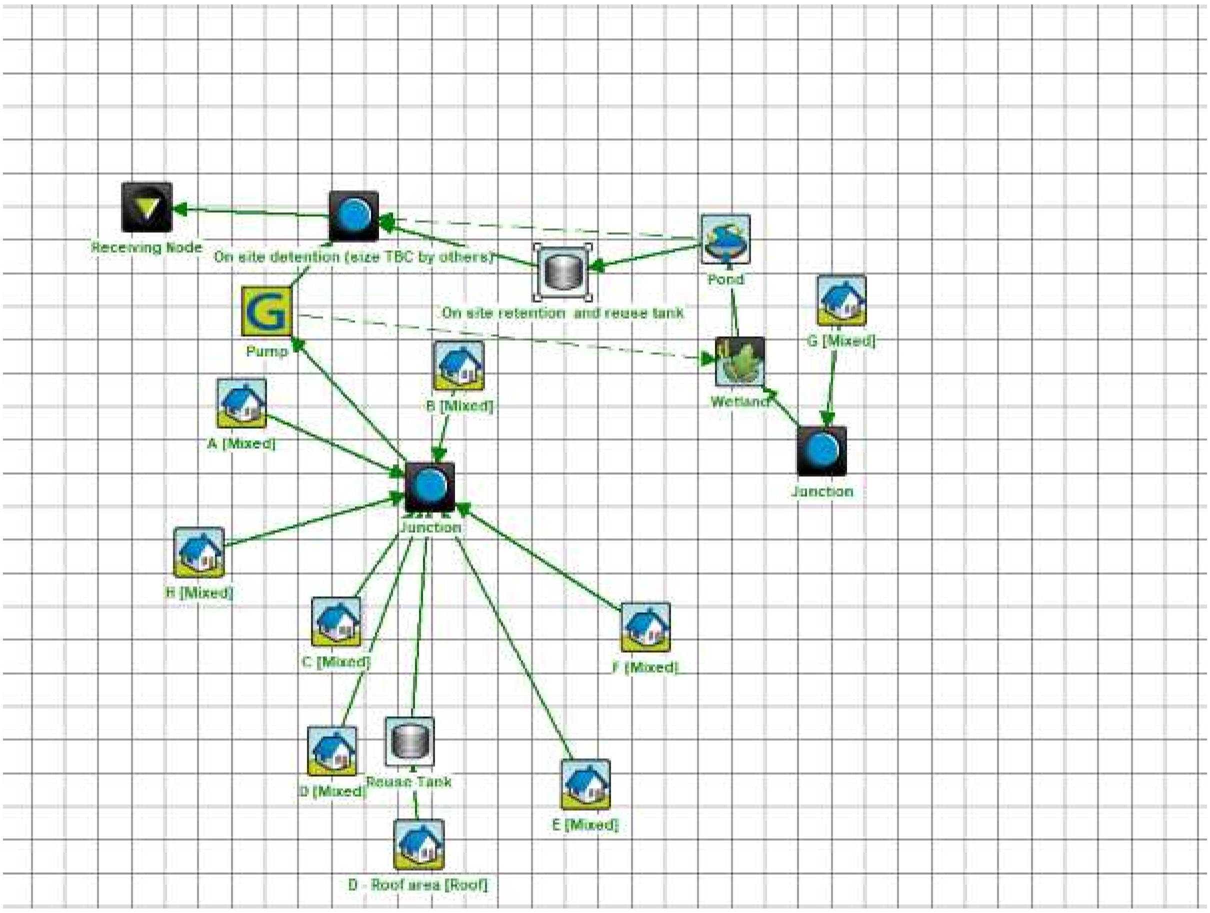

Figure 3. *MUSIC model of treatment approach*

2.3 Design considerations

Key design considerations include the following:

- Consideration of depth and inundation frequency in the wetland to ensure the health of fringing vegetation.
- Pre-treatment of the diverted stormwater to ensure minimal nutrients and sediments are entering the pond, thus reducing the risk of algal blooms. This occurs through the sediment basin and wetland.
- Sufficient inflow to the pond to ensure there is a minimum residence time (turn-over of water) of less than 50 days in Summer and a yearly 20%ile residence time between 20 and 30 days to avoid stagnant water and algal blooms.
- Sediment capture efficiency of a minimum of 95% for the sediment basin
- Sediment removal frequency for the sediment basin of at least once every 5 years
- Velocities through the wetland are less than 0.05m/s and less than 0.5 m/s in the sediment basin.
- A maximum Extended Detention Depth (EDD) of 0.35m in the wetland and sediment basin
- A minimum 72-hour detention time in the wetland to ensure adequate contact with vegetation and uptake of nutrients.
- An access ramp into the sediment basin for maintenance access
- A sediment dewatering area located next to the sediment basin
- Appropriate batters on all assets to ensure public safety (minimum of 1 in 5, safety bench of 1 in 8 for 350mm below the Normal Water Level)
- Reuse of water from onsite retention tank (500kL) and storage tanks (200kL for catchment D) for landscape irrigation (active).
- Target demand reliability of 80% for reuse from onsite retention tank.

2.4 Diversion analysis

Alluvium undertook a diversion analysis to understand the amount of stormwater that needs to be diverted to meet required pollutant reduction targets (Figure 4), as well as the residence time targets in the pond.

Alluvium recommends a diversion rate of 0.1m^3/s for on-site stormwater treatment for this proposed asset configuration.

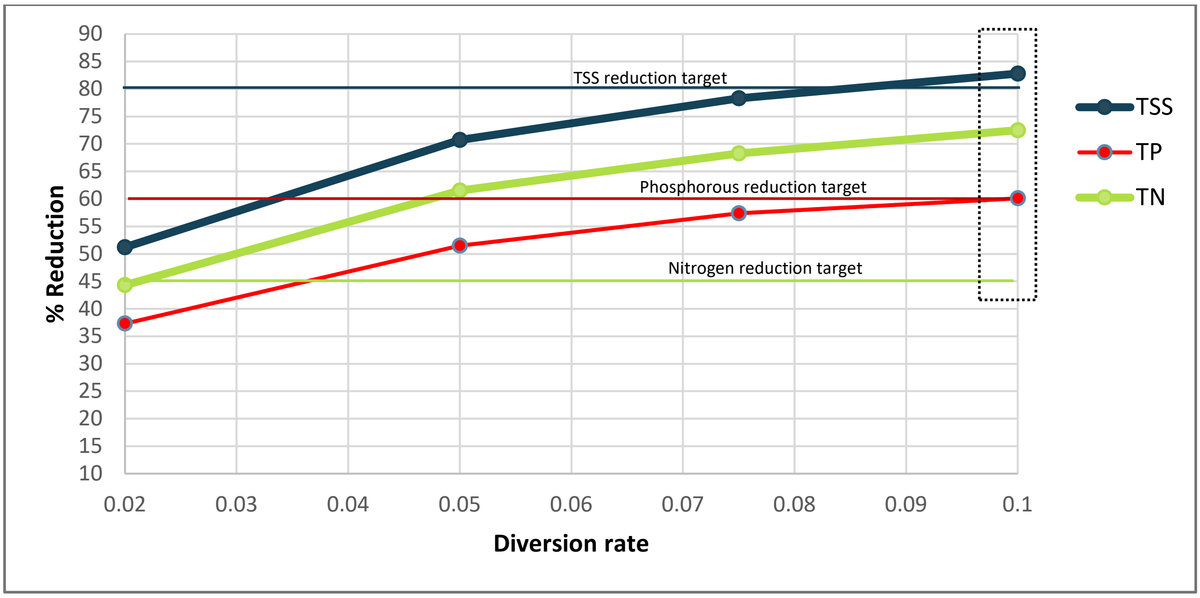

Figure 4. *Diversion analysis*

2.5 Asset parameters

Indicative design parameters of the treatment asset are provided in Table 1.

Table 2. Indicative treatment asset parameters

	Pond	***Wetland***	***Sediment Basin (SB)***
Treatment area (NWL), m^2	1500	1050	250
Average depth, m	1	0.4	1.0
Volume, m^3	1500	420	250
Extended detention, m	0.35	0.35	0.35
Freeboard, m	0.3	0.3	0.3
Extended detention time (hours)		72	

2.6 Tank analysis

Alluvium has proposed precinct scale storage tanks for open space irrigation. A demand of 2.5 ML/ha/yr for irrigation (landscape and amenities) have been adopted for storage tanks in catchment D. These tanks will harvest water from the buildings within the catchment.

A tank reliability analysis is presented in Figure 5. This analysis shows the relationship between increasing tank size and the impact on meeting the demands applied to them. Generally, having a larger tank will increase the % of demand met, but there will be a point of diminishing returns. The intent of this analysis is to determine the ideal tank size such that demand reliability is increased, but costs of tanks do not unnecessarily increase.

The storage analysis for catchments D indicate that a tank size between 200kL-300 kL storage (total) is likely to meet 70%-80% of irrigation demand. There is an opportunity to select a suitable tank size depending on available space and constraints.

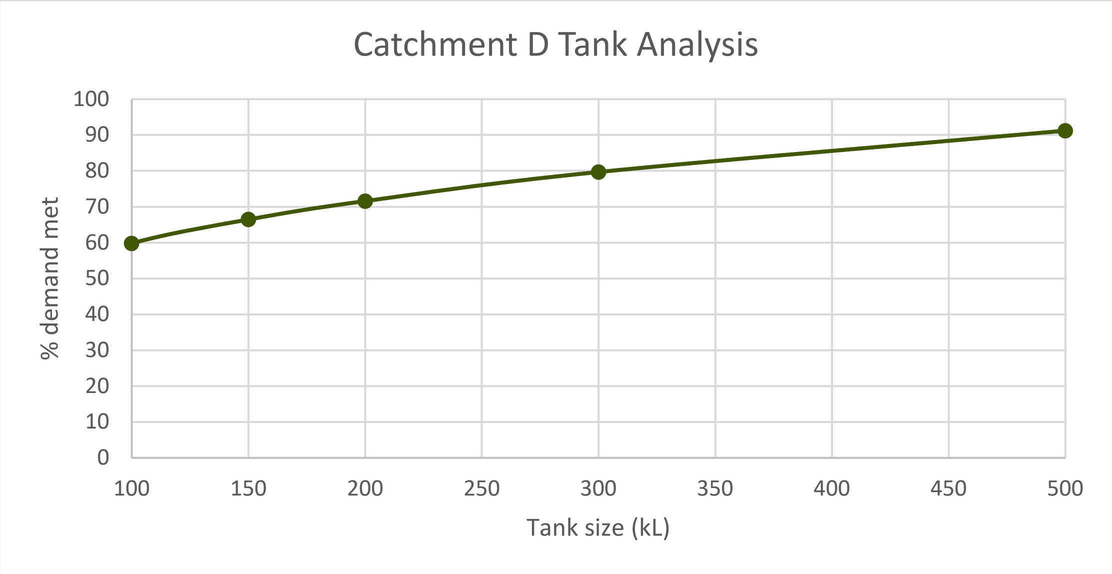

Figure 5. *Catchment D storage tank reliability*

The analysis also indicated that a 500kL retention tank receiving treated flows from the pond will be able to supply water for irrigation purposes (the green space surrounding the pond) with an 83% reliability.

2.7 Pollutant load reduction results

The overall treatment train results for the above scenario modelled in MUSIC are shown in Table 2. A litter trap/GPT could be installed at the stormwater collection point (G Node) prior to pumping to the treatment SB, wetland and pond to achieve the Gross Pollutant reduction target. The proposed sediment basin, wetland and pond (including the irrigation reuse throughout the catchment) meet the overall development's stormwater treatment requirements for TSS, TP and TN at the proposed diversion rate.

Table 3. Treatment train results

Pollutant	*Source load*	*Residual load*	*% reduction*	*% reduction target*
Total Suspended Solids (kg/yr)	10,700	1920	82	80
Total Phosphorus (kg/yr)	9.94	3.87	60.1	60
Total Nitrogen (kg/yr)	131	36	72.5	45
Gross pollutants (kg/yr)	1710	171	90	90

2.8 Residence time analysis

The results from the MUSIC modelling were used to analyse the residence time in the pond. The analysis considers:

- Inflows into the pond
- Volume of pond
- Turnover of water

The results indicate that including a diversion of 0.1m^3/s in addition to the gravity-fed stormwater, and a proposed pond volume of 1500m^3 will result in an average summer residence time of 13.2 days, which well exceeds the average summer residence time target of < 50 days.

3 Advanced draft design of treatment asset

An advanced draft design for the stormwater treatment strategy is presented below.

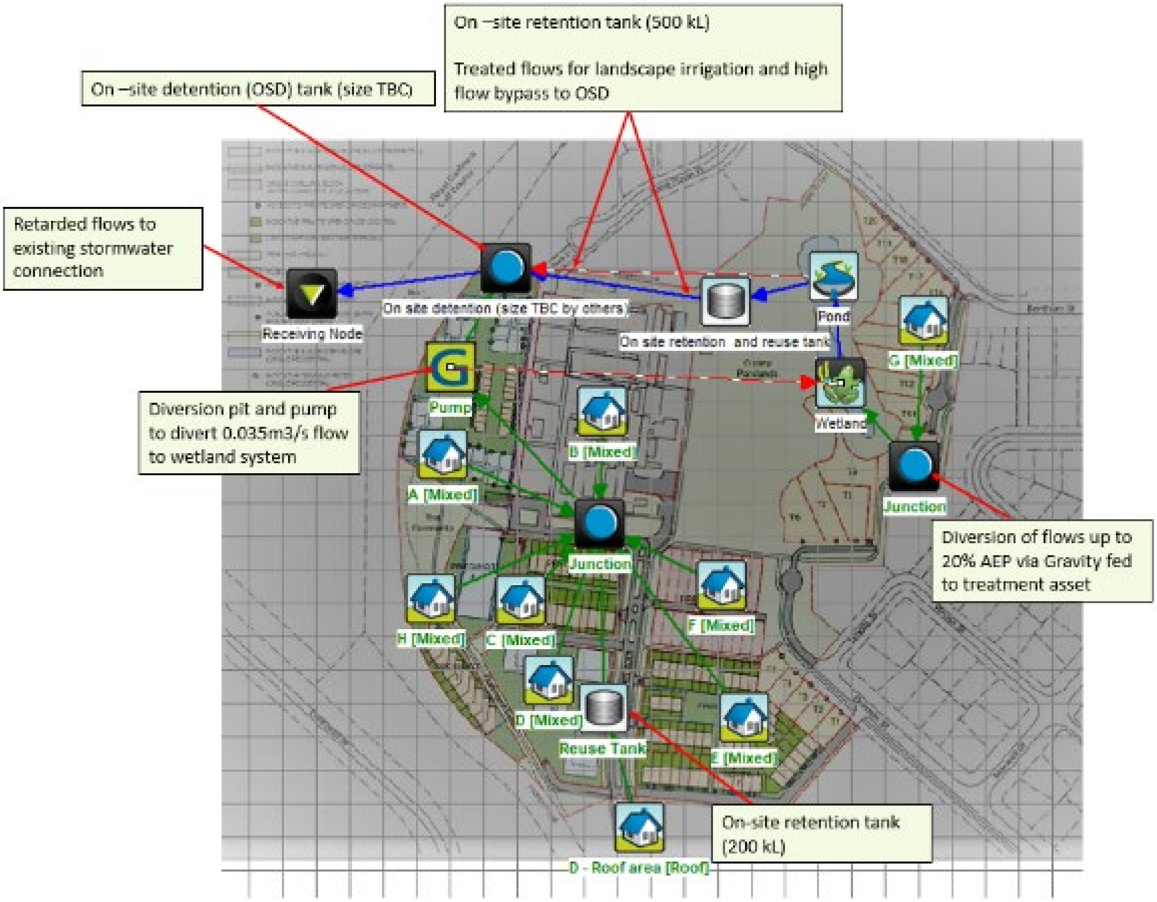

Figure 6. *Advanced draft design - overview*

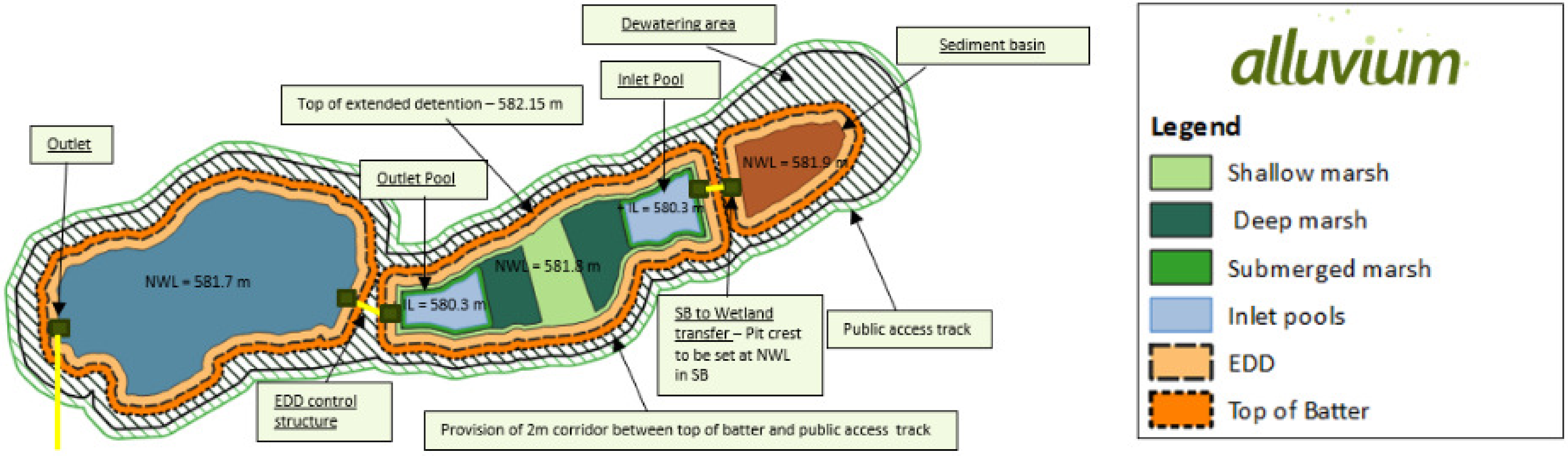

Figure 7. *Advanced draft design*

4 Discussion and recommendations

4.1 Recommended strategy

The sediment basin, wetland and pond treatment system in combination with tanks for on-site stormwater reuse provides the required pollutant reduction for the development. Installation of a 200kL tank in catchment D reduces the reliance on the SB/wetland/pond treatment system to meet water quality treatment targets. However, the SB/wetland/pond treatment system provides redundancy for ensuring of water quality treatment targets are met should rainwater tank usage be lower and/or less effective than anticipated. The capacity to pump water into that system, provides certainty of appropriate pond turnover.

Diverting a 0.1m^3/s flow to the SB/wetland/pond treatment system from the low point on the development ensures:

- Adequate pollutant reduction for the entire development
- Sufficient turnover in the pond
- 80-85% reliability of irrigation demand from the open space surrounding the pond through a 500kL tank
- The reliability of inflows to system.

As well as meeting required pollutant reduction treatment targets, the SB/wetland/pond treatment system in combination with rainwater harvesting results in reduced potable water use and increased greening and cooling benefits. Stormwater from new road and paved surfaces could be harvested into raingardens or bioretention treatment systems within the precinct. This would increase the total level of stormwater treatment and further contribute to cooling and other landscape amenity benefits.

The presented strategy is the preferred approach at the site due to its significant reduction in pollutants, high reliability for meeting landscape irrigation demands, and low risk of deterioration of pond due to algal blooms (i.e., reliable inflows to the pond).

4.2 Operation and maintenance of the system

Flows up to 5 year average recurrence intervals / 20% AEP from the single-dwelling catchment (T6-T20) are diverted to the SB/wetland/pond treatment system via gravity feed. However, due to site's topography, the treatment system also relies on a pump installed at the stormwater collection point (G). Alluvium also strongly recommends an ongoing maintenance plan is developed and implemented, including routine inspection of the pump. This can be provided to TCCS for review during the detailed design phase if necessary.

In general, the maintenance requirements of tanks and irrigation systems installed would be as per the operations manuals of those systems. Draft Operation and Maintenance manuals can also be provided to TCCS for review during the detailed design process, if required. The requirements and specifications of the Flemington Rd pond reticulation system could also be used as general guidance.

4.3 Mitigation of risks around pump failure

To mitigate the risk of pump failure, stormwater will be stored in an on-site detention tank prior to discharge from the site. Flow bypassing the pump will be attenuated by the tank, alleviating the threat of erosion in the downstream stormwater network.

Preliminary RORB modelling was performed to provide an estimate of flows for the assessment of concepts, and more detailed modelling incorporating the pipe network will be done to refine the design of the on-site detention facilities. The design basis will be that the post-development peak discharge from the project site in a major storm event will not exceed the predevelopment peak discharge in the same event, even in the case of pump failure.

The risk of treatment targets not being met as a consequence of pump failure can be mitigated by having a back-up pump installed, or provision for a portable back-up pump, in addition to an ongoing maintenance plan and routine inspection of the primary pump.

4.4 Mosquitos

The results from the MUSIC modelling were used to analyse the water residence time in the pond. They indicate that including a diversion of 0.1m^3/s in addition to the gravity-fed stormwater, and a proposed pond volume of 1500m^3 will result in an average summer residence time of 13.2 days, which well exceeds the average summer residence time target of < 50 days.

In addition, recent investigations have found that constructed wetlands are unlikely to cause mosquito problems. Most wetlands of this nature will have a natural mosquito presence. However, with healthy populations of predatory aquatic invertebrates (e.g., dragon flies, beetles) and vertebrates (fish), mosquito populations are likely to be low. After eight years of research, results suggests that with appropriate wetland design and monitoring, mosquito numbers in wetlands do not rise. Annual fluctuation in mosquito numbers do occur yet the numbers are about the same as before a wetland was constructed.

https://www.charlessturt.sa.gov.au/__data/assets/pdf_file/0036/847827/Mosquito-Monitoring-at-Constructed-Wetland-Sites-in-Adelaide.pdf

4.5 Detailed hydrologic modelling

The scope of the analysis to date does not cover detailed hydrologic modelling. This needs to be undertaken to assess peak flows, peak storage levels and critical durations for sizing detention storage.

5 References

Alluvium Consulting (2016). Surface Water management strategy Phase 1

ACT Government (2018). ACT Territory Development Master Plan

ACT Government (2019). Municipal Infrastructure Standards 08: Stormwater

ACT Government (2020). Waterways: Water Sensitive Urban Design General Code

DOMA Group (2021). The Development Masterplan

Sellick Consultants (2020). Stormwater Masterplan

ACT Planning and Land Authority (2016). The ACT Practice Guidelines for WSUD

Attachment A
Landscape Masterplan – 2022

INDICATIVE BUILDING ENVELOPE (MULTI-RESIDENTIAL)
INDICATIVE BUILDING ENVELOPE (TERRACE)
SINGLE DWELLING BLOCK WITHIN COMMUNITY TITLE SCHEME
ACCESS TO PRIVATE OPEN SPACE (APARTMENT)
INDICATIVE PRIVATE OPEN SPACE LOCATION
LANDSCAPE AREA (MULTI-RESIDENTIAL)
HERITAGE PRECINCT
PUBLIC OPEN SPACE
PRIVATE BASEMENT PARKING ENTRY
INDICATIVE BASEMENT EXTENT
PUBLIC BASEMENT CARPARK ENTRY (including visitor parking)
SINGLE RESIDENTIAL LOT
INDICATIVE BUILDING ENVELOPE (SINGLE RESIDENTIAL)
INDICATIVE DRIVEWAY ENTRY (SINGLE RESIDENTIAL)
Royal Canberra Golf Course
Lane Poole Pl
PROPERTY LINE
Quarry Parklands
HERITAGE CORE
PRECINCT 1
PRECINCT 2
PRECINCT 3
PRECINCT 4
PRECINCT 5
PRECINCT 6
PRECINCT 7
PRECINCT 8
The Remnants
BRICKWORKS WAY
T1
T2
T3
T4
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T20
Bentham St
Schomburgk St
Woolls St
Denman St
Maxwell St
Dudley St
FOR APPROVAL
SJB Architects
McGregor Coxall
Knight Frank
Godden Mackay Logan
Calibre
Douglas Partners
ARUP
InDesign
AECOM
DOMAGROUP
YARRALUMLA BRICKWORKS
SITE WIDE
DRAFT EDP - DEVELOPMENT INTENTIONS PLANS
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Attachment B
Water Sensitive Urban Design estate development checklist

DA No. .... Estate Name: Canberra Brickworks Redevelopment

Stage .... Suburb/District: Yarralumla/Canberra Central Nearest Streets: Denman street

Applicant Name .... Company BLOC

Developer Name DOMA

WSUD Concept Plan required as 1:1000 scale. Attachment C

Mains water use

Mandatory provisions for rating plumbing fittings and appliances for individual dwellings, such as in Lease and Development Conditions? N

Estimated mains water use reduction using the Design Response Report, BASIX, Green Star or other assessment tool/spreadsheet: 40%

Mains water savings proposed in the design of the public realm? Y

Description: Rainwater tanks and on-site retention tanks

Stormwater management

Development area	142750m^2
Impervious areas – Roof areas Roof connected to rainwater storage Roof area not connected to storage Total	 2737 m^2 31405.5 m^2 34142.5 m^2
Impervious areas - Paved areas Hard paved areas Permeable / porous paving Total	 12656. m^2 0 m^2 12656.m^2
Total impervious areas (with a 50% reduction applied to permeable/porous paving areas)	44061.55 m^2

*Development area doesn't include already developed heritage precinct which will be retained on site. However, the site has been included in stormwater treatment modelling.

Analysis / modelling results for sediment, nutrient and runoff volumes

	Existing conditions	Development with no WSUDmeasures	Developmentwith WSUD measures	% Reductionwith WSUD measures
Suspended solidsexport (kg/yr)	4690	10700	3920	63.3
Phosphorus export(kg/yr)	4.72	9.94	5.39	45.8
Nitrogen export (kg/yr)	59	131	59.2	54.7
Peak flow for 3 monthsARI storm (m^3/s)	0.07	0.4	0.04	90.7
Peak flow for 5 yearsARI storm (m^3/s)	0.3	1.6	0.2	88.4
Peak flow for 100 yearsARI storm (m^3/s)	0.6	3.3	0.5	84.4

Pond / Wetland proposals[1]

	RL (m AHD)	Surface area (m2)	Volume (m3)
Pond invert	580.8	0	0
NWL(1)	581.8	5000	5000
TWL(2) – 3 months ARI storm *(3 month flows from gravity-fed catchment, plus pumped flows from detention tank)*	582.01	5304	6070
TWL(2) – 100 years ARI storm *(5year flows from gravity-fed catchment, plus pumped flows from detention tanks)*	582.15	5616	6680

(1) NWL = Normal water level prior to storms

(2) TWL = Top water level

	Inflow	Outflow
1 year ARI flow	0.21	0.06
5 years ARI flow	0.25	0.07
100 years ARI flow	0.25	0.10

Catchment area to pond for small storms up to 3 months ARI = 15.57 Ha

Catchment area to pond for large storms up to 100 years ARI = 15.57 Ha

Percentage urbanised = 96%

Percentage impervious = 48%

[1] As the flow entering the pond/wetland are constrained by pipe capacity, the volumes for 3-month ARI and 100 year ARI haven't changed significantly

Extended detention = Volume at TWL (target 3 months ARI flow) – Volume at NWL

=1070m^3

Retardation storage = Volume at TWL (100 years ARI flow) – Volume at TWL (3 months ARI flow)

= 610m^3

Macrophyte zone area (less than 600 mm depth at NWL) = 80%

Plant species proposed (list and include % of total planting area):

Botanical Name	Common Name	Plants per m2	% of species per m2
SUBMERGED MARSH - 0.35m to 0.7m below NWL		1	
Myriophyllum salsugineam	Water-milfoil	600cm3 containers	20%
Potamogeton ochreatus	Blunt Pondweed		30%
Vallisneria australis	Eel-grass		50%
Subtotal planting			***100%***
DEEP MARSH - 0.15 to 0.35m below NWL		2	
Baumea articulata	Jointed Club-rush	600cm3 containers	20%
Bolboschoenus fluviatilis	Tall Club-rush		20%
Bolboschoenus medianus	Marsh Club-rush		10%
Cladium procerum	Leafy Twig-rush		10%
Eleocharis sphacelata	Tall Spike-rush		20%
Schoenoplectus tabernaemontani	River Club-rush		20%
Subtotal planting			***100%***
SHALLOW MARSH - 0.0 to 0.15m below NWL		2	
Baumea articulata	Jointed Club-rush	600cm3 containers	10%
Bolboschoenus caldwellii	Sea Club-rush		
Bolboschoenus fluviatilis	Tall Club-rush		10%
Bolboschoenus medianus	Marsh Club-rush		10%
Cladium procerum	Leafy Twig-rush		20%
Eleocharis acuta	Commone spike-rush		
Eleocharis sphacelata	Tall Spike-rush		10%
Schoenoplectus tabernaemontani	River Club-rush		20%
Triglochin procerum	Water Ribbons		20%
Subtotal planting			***100%***
EPHEMERAL PLANTING - NWL to 0.35m above NWL	Jute Mat	6	
Baumea rubiginosa	Soft Twig-rush	200cm3 containers	10%
Carex appressa	Tall Sedge		10%
Carex fasicularis	Sedge		20%
Juncus amabilis	Hollow Rush		10%
Juncus gregiflorus	Rush		10%
Juncus pallidus	Pale Rush		10%
Lythrum salicaria	Purple Loosestrife		5%
Lycopus australis	Australian gypsywort		5%
Gahnia sieberiana	Red-fruited Saw-sedge		

Botanical Name	Common Name	Plants per m2	% of species per m2
Persicaria decipiens	Slender knotweed		10%
Poa labillardierei	Common Tussock		10%
Subtotal planting			*100%*
EMBANKMENT PLANTING -0.35m to 2.0+m above NWL	Mulch	6	
Acaena novae-zelandiae	Bridgee-widgee		20%
Gahnia sieberiana	Red-fruited Saw-sedge		10%
Goodenia ovata	Hop Goodenia		10%
Lomandra longifolia	Spiny-headed Matt-rush		20%
Microlaena stipoides var. stopoides	Weeping Grass		20%
Poa labillardierei var. labillardierei	Common Tussock-grass		20%
Subtotal planting			*100%*
SHADY EMBANKMENT PLANTING	Mulch	2	
Melaleuca ericifolia	Swamp paperbark		*50%*
Acaena novae-zelandiae	Bridgee-widgee		*50%*
			100%

Wastewater reuse (optional)

Wastewater reuse proposed?	N
Type of reuse	
Untreated greywater (direct use on garden only)	N
Treated greywater	N
Community reuse facility (if available)	N
Uses for wastewater	
Garden use	N
Toilet flushing	N
Laundry use	N
other	N
Estimated annual reuse	NA

Summary of WSUD Code targets and achievements

	Target	Achieved
Mains water use reduction	40%	40%
Reduction in suspended solids	60%	63.3%
Reduction in total phosphorus	45%	45.8%
Reduction in total nitrogen	40%	54.7%
Effluent reuse	optional	NA

Element 1: Mains water use reduction

1.1 Mains Water Use Reduction Target	
Rule	**Result**
R1 Development achieves a minimum 40% reduction in mains water consumption compared to an equivalent development constructed in 2003.	Achieved

Element 2: Stormwater Quantity

2.1 On-site stormwater retention	
Rule	**Result**
R2 Development complies with at least one of the following: a) stormwater retention management measures are provided and achieve all of the following: i) Stormwater storage capacity of 1.4kL per 100m² of the total impervious area of the site is provided specifically to retain and reuse stormwater generated on site as a whole ii) Retained stormwater is used on site b) development captures, stores and uses the first 15mm of rainfall falling on the site. For this rule, on-site stormwater retention is defined as the storage and use of stormwater on site.	Achieved
2.2 On-site stormwater detention	
Rule	**Result**
R3 Stormwater detention measures are provided and achieve all of the following: a) capture and direct runoff from the entire site b) stormwater storage capacity of 1kL per 100m² of impervious area is provided to specifically detain stormwater generated on site c) the detained stormwater is designed to be released over a period of 6 hours after the storm event. For this rule on-site stormwater detention is defined as the short-term storage and release downstream of stormwater runoff.	Not applicable given Element 2.4 below, but achieved
2.3 Stormwater quantity for major roads on sites over 2000m²	
Rule	**Result**
R4 This rule applies to the development of major roads involving sites greater than 2000m2. Development complies will all of the following: a) The capacity of existing pipe (minor) stormwater connection to the site is not exceeded in the 1 in 10 year storm event b) The capacity of the existing overland (major) stormwater system to the site is not exceeded in the 1 in 100 year storm event.	Not applicable
2.4 On-site stormwater detention for estate development plans	
Criterion	**Result**
C5 Stormwater detention measures are provided and the peak rate of stormwater runoff from the estate does not exceed the peak rate of runoff from an unmitigated (rural) site of the same area for minor and major storms.	Achieved

Element 3: Stormwater Quality

3.1 Stormwater Quality Target – sites greater than 2000m^2	
Rule	**Result**
R6 The average annual stormwater pollutant export is reduced when compared with an urban catchment of the same area with no water quality management controls for all of the following: a) gross pollutants by at least 90% b) suspended solids by at least 60% c) total phosphorous by at least 45% d) total nitrogen by at least 40%.	Achieved
3.2 Stormwater Quality Target – major roads	
Rule	**Result**
R7 This rule applies to development of major roads, including the duplication of an existing major road in full or in part. The average annual stormwater pollutant export is reduced when compared with a road catchment of the same area with no water quality management controls for all of the following: a) gross pollutants by at least 90% b) suspended solids by at least 60% c) total phosphorous by at least 45% d) total nitrogen by at least 40%.	Not applicable

Element 4 Climate change adaptation

4.1 Nuisance flooding – sites greater than 2000m^2	
Criterion	**Result**
C8 Overland flow paths are provided and achieve all of the following: a) accommodate overland stormwater flows up to the 1%AEP b) reduce nuisance flooding.	Achieved
4.2 Green/living infrastructure	
Rule	**Result**
R9 Development achieves a minimum of 20% of the site area to be permeable.	Achieved

Element 5: Entity (Government agency) Endorsement

5.1 Water infrastructure	
Criterion	**Result**
C10 This criterion applies to development that will result in municipal water sensitive urban design infrastructure being handed to the ACT Government. An Operation and Maintenance Plan is to be endorsed by the ACT Government for the water sensitive urban design assets that are to be handed to the ACT Government.	Not applicable

Attachment C
Stormwater treatment plan

ARI event	Existing	Developed	WSUD intervention
3-month (m3/s)	0.07	0.43	0.04
5 year (m3/s)	0.26	1.64	0.19

Asset	Pond	Wetland	Sediment Basin
Treatment area (m2)	1500	1050	250
Volume (m3)	1500	420	250

	TSS	TP	TN
% reduction target	60	45	40
% target achieved	63.3	45.8	54.7

alluvium