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E2DESIGNLAB

Mildura East Growth Area

Stormwater Management Strategy

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1 Introduction

E2Designlab has been engaged by Hansen Partnership to prepare a stormwater management strategy to support the Mildura East Growth Area Strategic Framework. This report provides a summary of the work to date. The subject site is located east of Mildura, and north-east of Irymple. The stormwater management strategy will assess the hydrologic and hydraulic characteristics of the site to ensure that the site can cater for the major and minor storm events in both an ultimate scenario, as well as the stages leading up to it. Water quality will also be assessed to investigate what water quality treatment is required to protect downstream receiving waters such as Lake Hawthorn, Etiwanda Wetland and the Murray River.

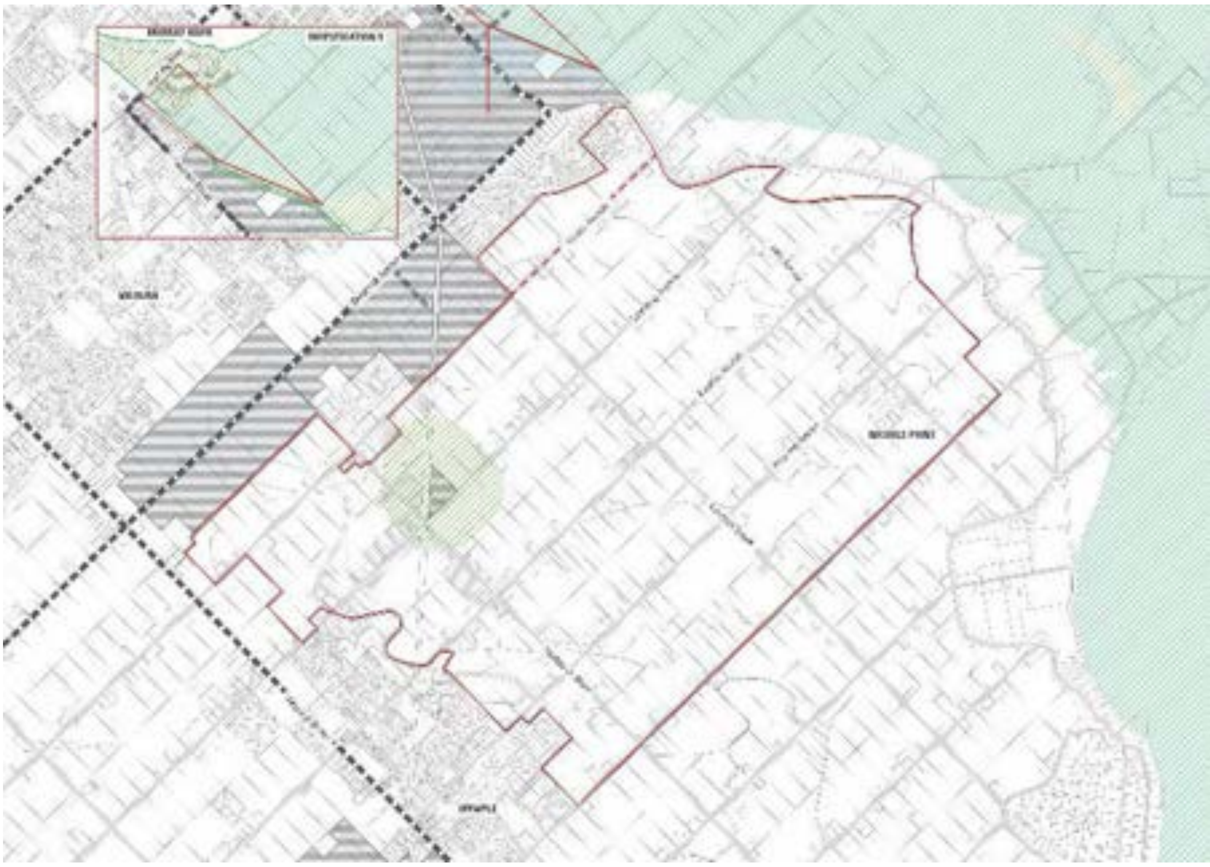


Figure 1 Subject Site (delineated red) Layout Plan

1.1 Site Overview

The subject site analysed in this stormwater strategy is approximately 10.4 km^2 and is pre-dominantly farms lots with pockets of low density residential development. The subject site is bound by the town of

Mildura on the western edge, Irymple to the south-western edge, and Nichols Point in the north-east corner.

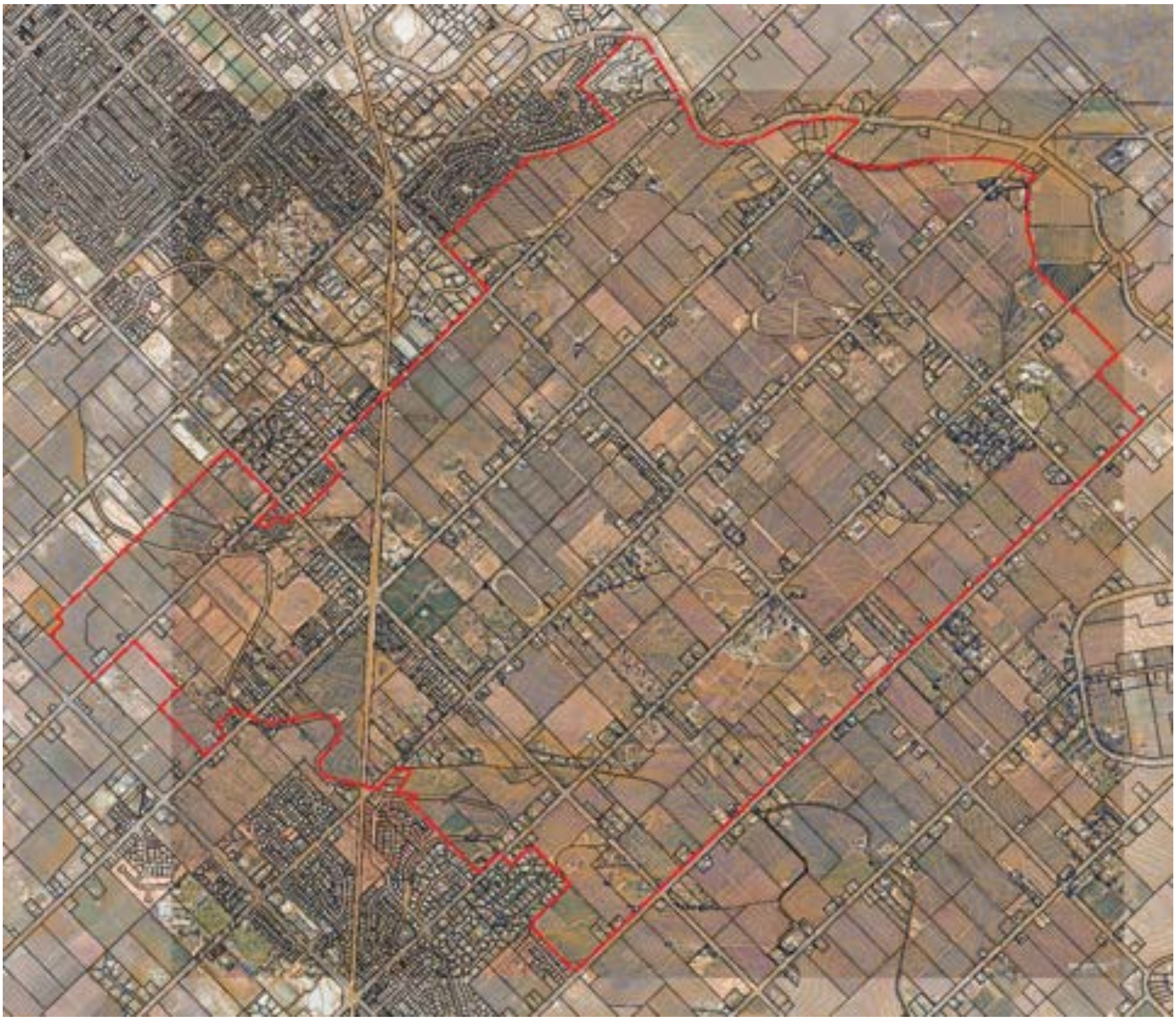


Figure 2: Subject Site Overview

The existing site topography varies between steep fall to long reaches of flat grade and trapped low points. The undulating contours result in rainfall runoff draining in multiple directions and becoming trapped, providing a particular challenge for designing future stormwater infrastructure.

The Murray River is located north of the development and will be one of the discharge locations for stormwater runoff of this site. The town of Irymple, and Mildura are also located nearby and have drainage infrastructure that can be utilised by the subject site to assist in catering for major and minor storm events.

1.2 Proposed Development

A revised concept development plan was made available to E2Designlab on the 9th October 2022 and is shown in Figure 3. Note that this includes drainage basins that E2Designlab had previously identified in preliminary investigations as the development and drainage design is iterative given the inter-dependencies. The concept development plan details where residential and mixed used development will occur and provides preliminary staging. The general strategy for the development plan is that development will occur on the edges of the subject site so that it is adjacent to existing communities and infrastructure. This will allow farming to continue to occur within the centre of the subject site in the short to medium term. Note that this is concept only and subject to change as part of the Framework Plan preparation.

Figure 3: Concept development plan

1.3 Background

The following documents and meetings have formed the basis of this report:

- Stormwater Drainage Technical Report for Irymple Structure Plan and Urban Design Framework (Spiire, June 2021
- Irymple Drainage Modelling (Aurecon, 2011)
- Lake Hawthorn Management Plan, December 2015 (Kate Lumb Consulting Pty Ltd, 2015)
- Meeting with Mildura Regional City Council, Hansen and E2Designlab on 2nd August 2021
- Meeting with Mildura Regional City Council, Hansen and E2Designlab on 9th September 2021
- Mildura and Irymple Stormwater Drainage Basins Project Report (Aurecon, December 2017)
- Mildura South Drainage Modelling (Aurecon, 2012)
- Report for Nichols Point Drainage Concept Design (GHD, June 2006)
- Mildura Stormwater Quality Improvement Plan 2009-2014 (BMT WBM, 2008)
- Sunraysia Drainage Strategy (Sinclair Knight Merz, 2002)
- Drainage Report – Nichols Point Residence Development – Concept Stormwater Drainage Design (Tonkin, 2022)
- Email correspondence from MRCC dated 6 April 2024

A number of meetings were also held with Council and written comments and feedback were provided to early drafts of the report, providing the project team with information relating to the drainage infrastructure, existing and proposed developments and local context.

Please refer to appendix A for a summary of key documents and information shared with the project team.

1.4 Integrated water management and stormwater Objectives

The Integrated Water Management Framework sets out the approach for planning, managing and delivering water and water infrastructure throughout Victoria's towns and cities. The framework identifies a range of outcomes to deliver resilient and liveable cities and town.

Figure 4 Water related outcomes (Water for Victoria)

This project set out to understand the infrastructure needs for IWM to support the Mildura East Growth Area. The design of the stormwater system will be primarily guided by the needs to meet stormwater conveyance, flood mitigation and waterway protection. The plan also considers opportunities to enable and support healthy and valued urban landscapes and community values. This study does not directly address considerations for potable water supply and wastewater.

1.4.1 Stormwater conveyance and flood protection

Stormwater infrastructure will be selected and designed to best cater for minor and major storm events while considering local context. Generally, piped drainage will be adopted for minor flows and overland flow paths for major flows, but other interventions will be adopted if they are more appropriate for the setting. This may include options such as pumping.

For the minor (piped) drainage system, a 20% annual exceedance probability (AEP) standard will generally be applied for typical urban development such as residential and a higher standard of 10% AEP for commercial and industrial areas, as per authority requirements.

1.4.2 Healthy waterways and water sensitive urban design

The strategy will provide the basis to manage urban stormwater runoff in an environmentally and socially sustainable manner and in compliance with relevant objectives and requirements considering the specific needs of the local context and receiving waters. This includes protection of the beneficial uses of receiving waters by:

- Minimising discharge of urban stormwater pollutants (such as litter, sediment, nutrients and heavy metals) and salt to the River Murray and inland water bodies
- Minimising the impact of declining flows (from irrigation drainage) on the environmental and amenity values of inland waterbodies

This strategy will provide the basis to ensure uptake of water sensitive urban design principles including stormwater treatment and reuse. This includes initiatives such as:

- Water sensitive urban design principles are to be considered for any new development
- It is recognised that at present there is little reuse of stormwater due to the climate conditions and challenging economics in the area.
- Any change in runoff characteristics should be minimised according to the following hierarchy:
  - Avoid (e.g., reduce the use of impermeable surfaces)
  - Reuse
  - Treat
  - Containment
  - Disposal

1.5 Greening and cooling

Opportunities for greening and cooling through the use of stormwater will be identified where these are practical and can support the delivery of a range of objectives. These include stormwater treatment wetlands within basins as well as potentially streetscape interventions such as bioretention or tree pits.

It is recognised that Mildura has an arid climate. It already experiences relatively high temperatures and long dry periods and these can be expected to become hotter and longer with climate change. This means that there is a clear need for efforts to improve urban cooling and provide shade to provide comfortable and accessible travel corridors and spaces for residents. On the other hand, the limited water availability during dry periods presents challenges for sustaining vegetation that must be considered.

2 Environmental Considerations

The following material has been largely drawn from the Mildura Stormwater Quality Improvement Plan 2009-2014 (BMT WBM, 2008) which provides a detailed summary of each of the main receiving waters.

2.1 Murray River

The Murray River is the only natural waterway in the region and forms the northern boundary of the study area. The Murray River rises in the Australian Alps and flows west across the riverine plains for 800 km before reaching the Sunraysia Region. Downstream of Mildura, the Murray River is joined by the Darling River before turning south through South Australia. The Murray River is regulated along most of its length and supplies water for irrigation throughout northern Victorian and southern New South Wales. Lock 11 is used to maintain the Mildura weir pool, the backwater effects of which extend past Red Cliffs. Stormwater from Mildura's commercial, industrial and residential areas is discharged to the Murray River above and below Lock 11, as well as to inland water bodies.

The water above Lock 11 provides significant in-stream and riparian habitat and supports a range of threatened species. Part of this system is listed on the Register of the National Estate and the Directory of Important Wetlands in Australia. The Murray River is also significant for its cultural and heritage values and there are numerous archaeological sites highlighting the links with indigenous cultures. The river environment is highly valued for its recreational tourism and amenity values. The Murray River is the main source of water for domestic, industrial and irrigation supply.

The northern catchments of the subject area including Etiwanda Wetland, Mildura East Catchments and potentially Nichols Point Catchment are most likely to drain to the Murray River Lock 11. Stormwater treatment to remove pollutants of concern and protect environmental values as well as extractions for other uses will be essential.

2.2 Lake Hawthorn

Lake Hawthorn is a natural floodplain deflation basin lake, which historically would have only filled only during very high flows such as those of the 1956 flood (Lloyd 2007). Levees adjacent to the River Murray now restrict flooding of the banks and filling of the lake. While it was once an ephemeral freshwater floodplain wetland, the lake is now saline due to its use as an irrigation drainage basin and altered management practices.

Stormwater from residential areas of Mildura South drain to Lake Hawthorn via the Mildura South Drainage Scheme. As more irrigated land is urbanised, Lake Hawthorn will receive less irrigation drainage and additional urban runoff with a shift in seasonal flow patterns, volumes and pollutant loads.

Lake Hawthorn was historically used for a range of recreational activities that include boating, camping, swimming and fishing. The millennium drought saw a dramatic decline of water levels and the reduction of the lake amenity. There has also been a reduction in inflows from irrigated agriculture. The lower current management levels have reduced its use for recreation purposes and activities such as sailing or skiing are no longer viable.

Lake Hawthorn is home to a variety of native fish including the endangered Murray hardyhead (Craterocephalus fluviatilis). Other native species include carp gudgeons (Hypseleotris spp.), bony herring (Nematalosa erebi), flathead gudgeon (Philypnodon grandiceps), golden perch (Macquaria ambigua), Australian smelt (Retropinna semoni) and flyspecked hardyhead (Craterocephalus stercusmuscarum).

Significantly, it is one of only four known Victorian habitats for a small native fish, the Murray hardyhead, Craterocephalus fluviatilis. The Murray hardyhead is declared endangered under the Victorian Flora and Fauna Guarantee (FFG) Act 1988 and the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act 1998.

Lake Hawthorn supports three turtle species and over 60 species of waterbirds have been recorded in the lake (Lloyd 2007). A management plan was developed for the lake in 2007 (Lloyd 2007) which identifies stormwater as an important management issue because of its potential to create localised episodes of anoxia.

The Irymple catchment which will include the southern areas of the subject site currently drains to Lake Hawthorn. It is important for stormwater treatment to remove urban pollutants that may adversely impact on the ecological and amenity values of the lakes. These include sediment, nutrients and heavy metals. Given historical algal blooms and concern about risks of anoxia, the minimisation of nutrient inputs (phosphorus, nitrogen as well as organic matter contributing to BOD/COD loads) that would add to the accumulated loads already embedded in the lake sediments are of particular importance.

2.3 Lake Ranfurly

Lake Ranfurly is a large, shallow wetland on the ancestral floodplain west of Mildura (Figure 7-3). It is separated into two waterbodies by a causeway and isolated from the Murray River by levees. Lake Ranfurly East receives urban stormwater run-off from residential, commercial and industrial areas of Irymple and residential areas of Mildura. Lake Ranfurly provides significant habitat for many bird species, including species listed under State Government threatened species legislation. It is listed on the Directory of Important Wetlands in Australia for its significant bird habitat. While the area around Lake Ranfurly is degraded, there are opportunities for improved amenity for local residential communities. By directing urban stormwater to Lake Ranfurly, inputs to the Murray River can be reduced.

Parts of Mildura drain into Lake Ranfurly including 15th Street drain from Deakin Avenue and areas draining through Bob Cobolt wetlands (Rifle Butt Swamp).

The lakes have seen a significant decline in inflows due to the effects of the millennium drought as well as changes in irrigation practices from flood irrigation to more efficient methods. In future it can be expected that inflow volumes will remain lower than historical levels and this presents some challenges for sustaining the ecology and amenity values of the lakes. It is recognised that stormwater runoff is delivered in short high intensity bursts and is a poor substitute for the historical irrigation drainage inflows.

Given the context it is considered that efforts to significantly reduce stormwater inflows to the lakes may not necessarily be warranted nor desirable from the perspective of managing lake water levels. However, consideration should be given to ensuring that inflows are managed and controlled so that lake levels can be effectively maintained within desired ranges. This may involve storage and regulated release or combination with other reuse responses to address other challenges upstream. There is a need for pollutant and particularly nutrient loads from urban stormwater into the lakes to be managed through upstream treatment.

3 Hydrology and Hydraulics

3.1 Catchment Analysis

The subject site is split across three catchments which drain in different directions, as shown in Figure 5. The existing topography of the site varies from locations of reasonably steep fall to flat low points where gravity drainage is not feasible. To accommodate these trapped low points, flows are pumped from these to a gravity drainage network or another basin. Hydrologic models of each catchment were set up using RORB and are discussed in the following sections.

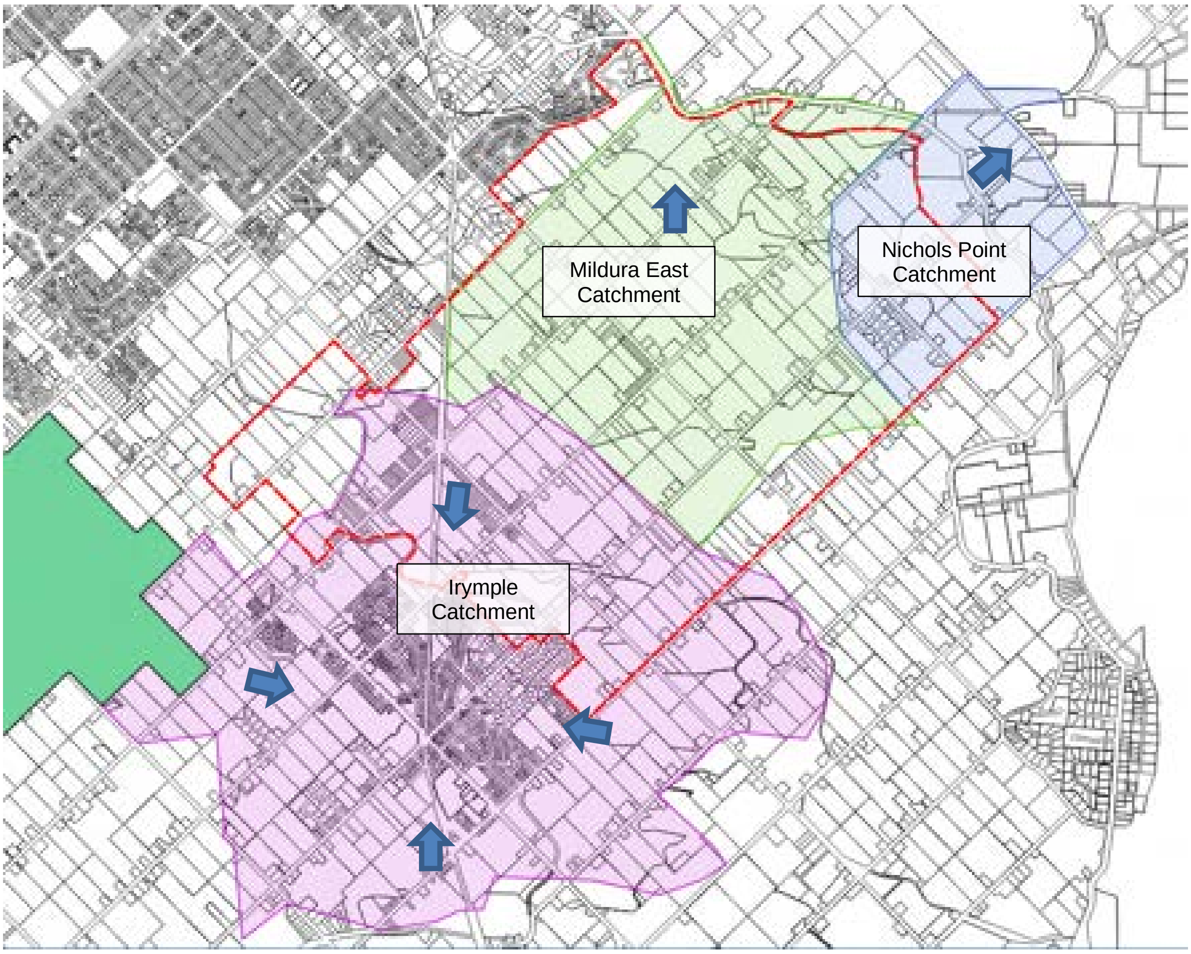


Figure 5: Mildura East Growth Area catchment split (flow direction shown with blue arrows)

3.1.1 Irymple Catchment

The southern portion of the subject site (highlighted red) generally drains towards a drainage basin at Henshilwood Reserve located within the town of Irymple at the centre of the catchment. There are localised low points and basins throughout the catchment that require pumping to the nearest gravity drainage then to the central drainage basin. The retarding basin has an existing pump system at RL 41.5 m AHD with a pump rate of 160 L/s. This outfalls to gravity drainage in Fifteenth St then drains to Calder Basin. From there it is pumped again to gravity drainage and flows to Lake Hawthorn. Water levels in Lake Hawthorn are managed with flows pumped out to Wargan Wetlands (Wargan Basins) by Goulburn Murray Water (GMW). The system is part of a salt interception scheme to divert salt from the Murray.

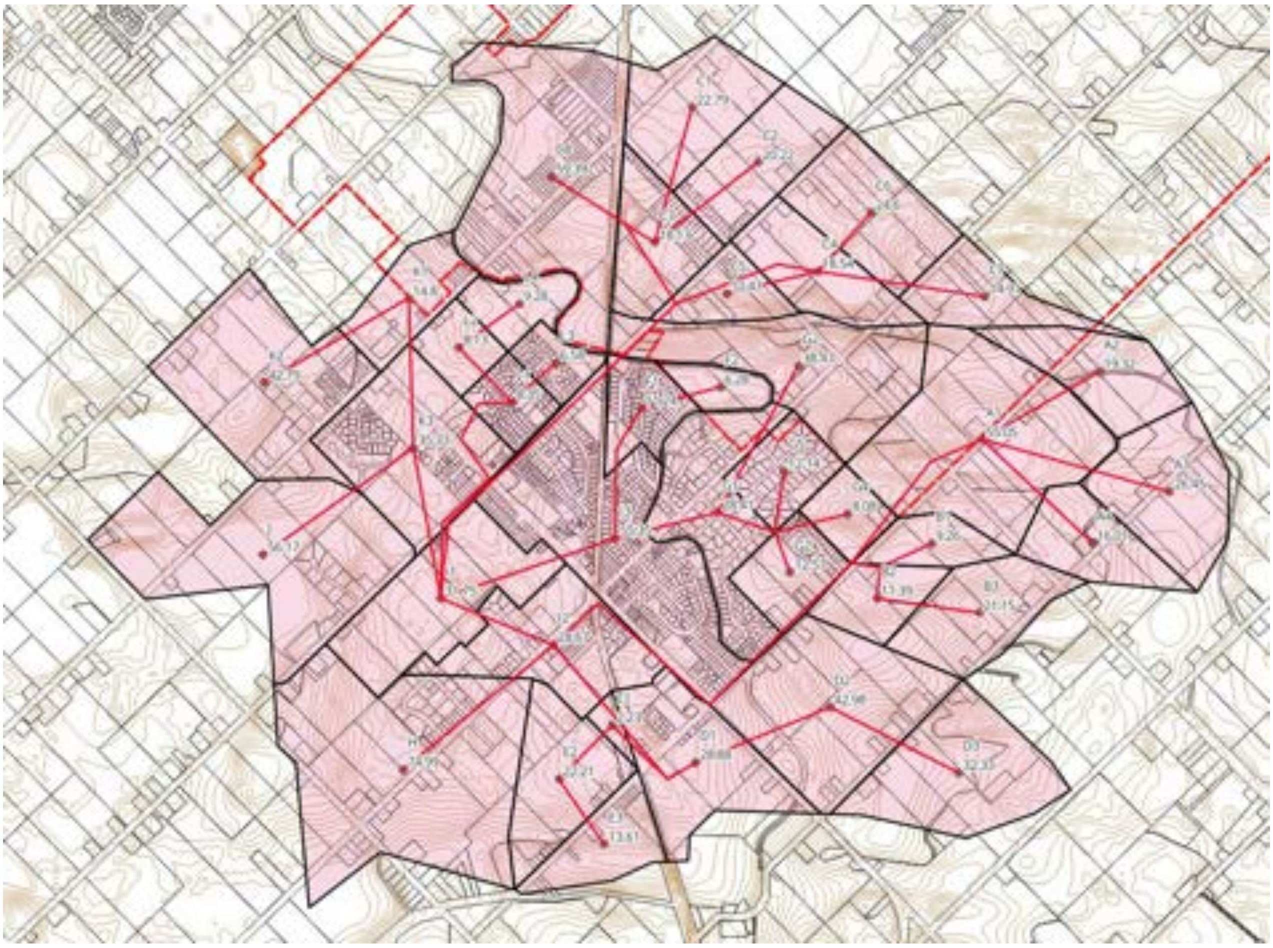


Figure 6: Irymple catchment plan

3.1.2 Mildura East Catchment

The north portion of the subject site falls to the north-west, towards the Etiwanda Wetland. Flows from here drain to the wetland, where they are treated prior to discharge into the Murray River. The central and eastern portion of the catchment features trapped low points that require pumping. Generally, these eventually flow to the west towards Cowra Avenue.

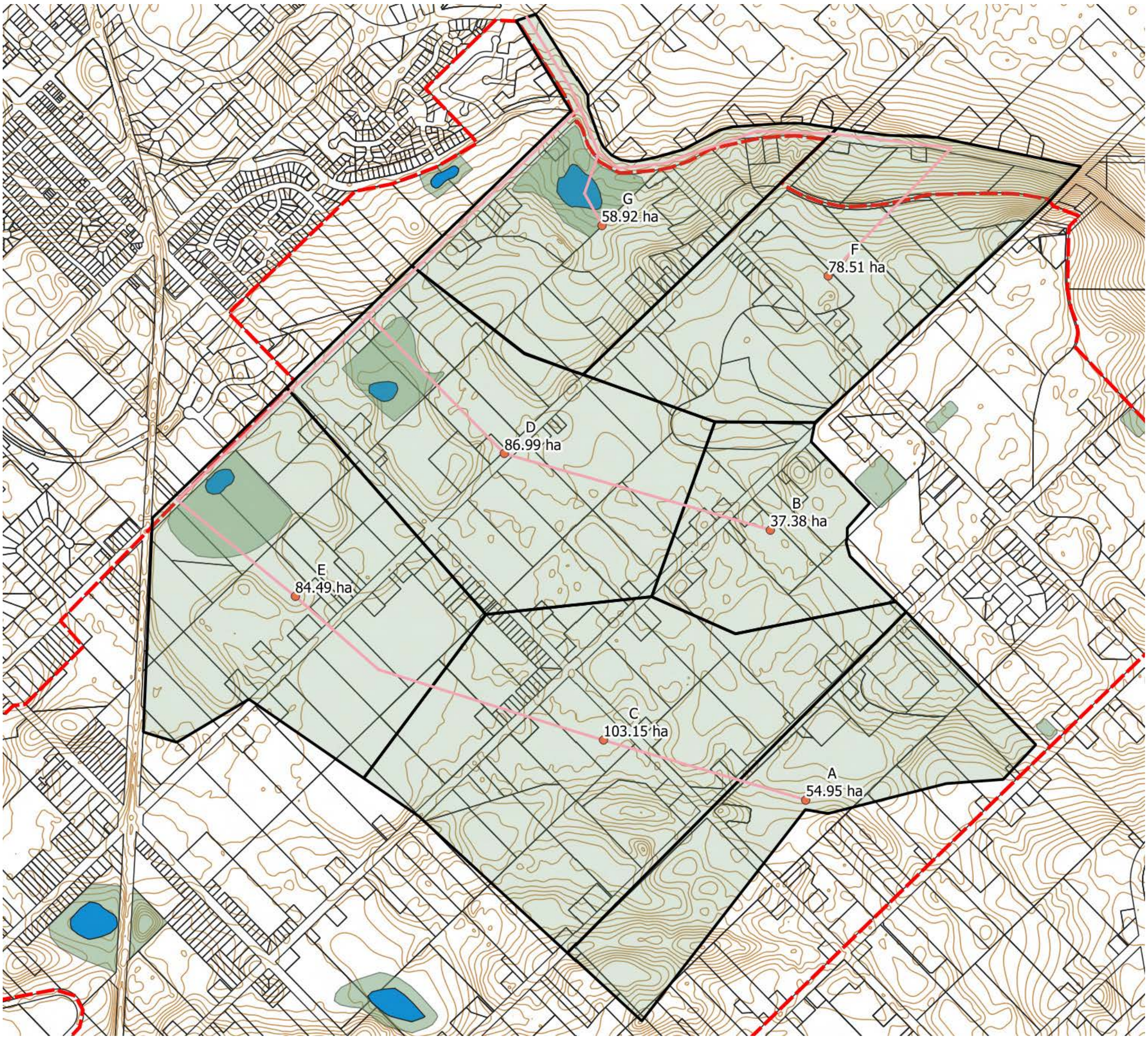


Figure 7: Mildura East catchment plan

3.1.3 Nichols Point

Nichols Point is located within the north-eastern portion of the subject site. The portion the subject site highlighted purple drains towards Nichols Point, which eventually discharges into the Murray River.

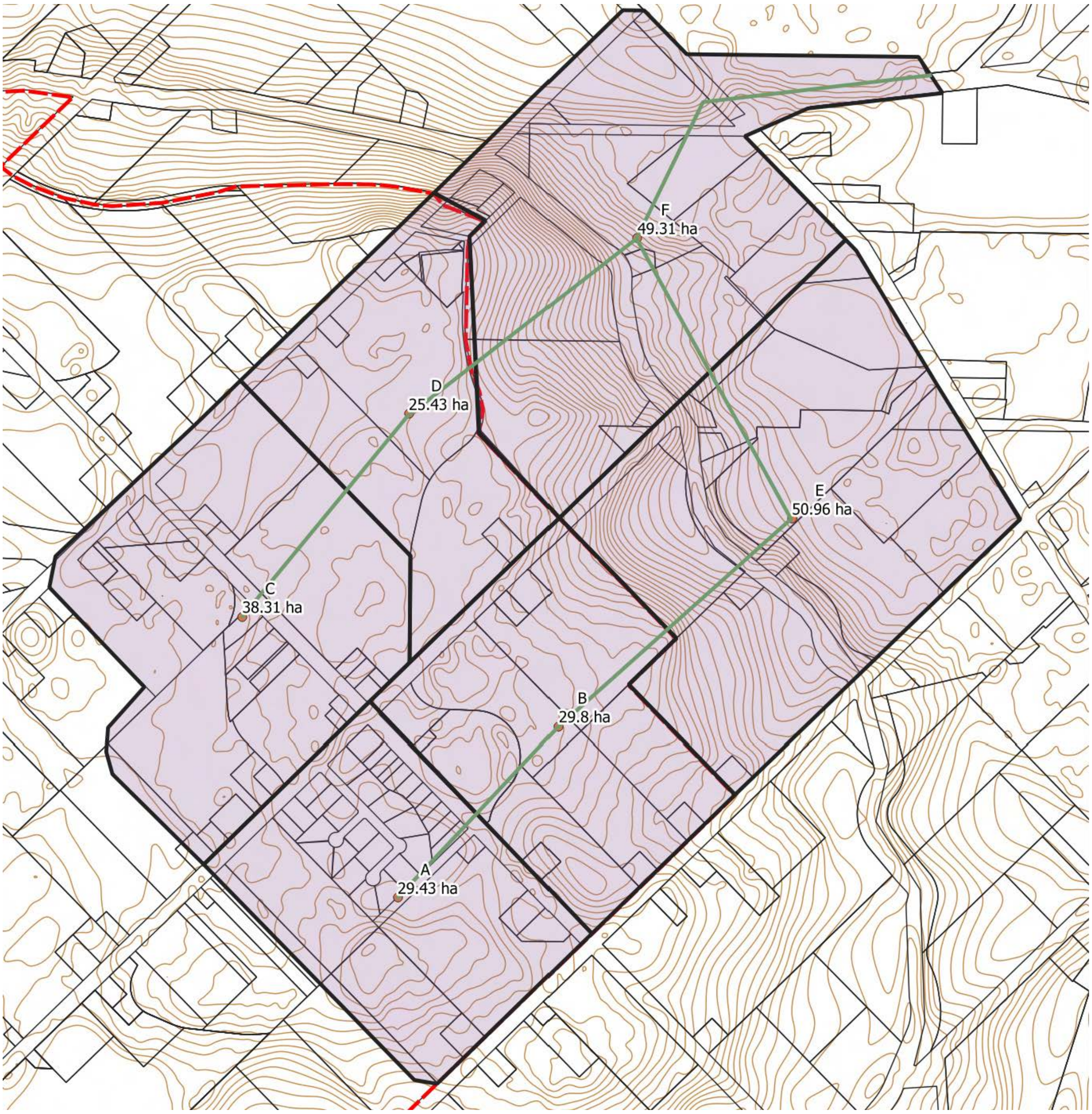


Figure 8: Nichols Point catchment plan

3.1.4 Other Catchments

There are several pockets within the subject site that do not drain to the three main catchments discussed above. These are discussed below.

3.1.4.1 Pocket 1 – Ellswood Crescent Catchment

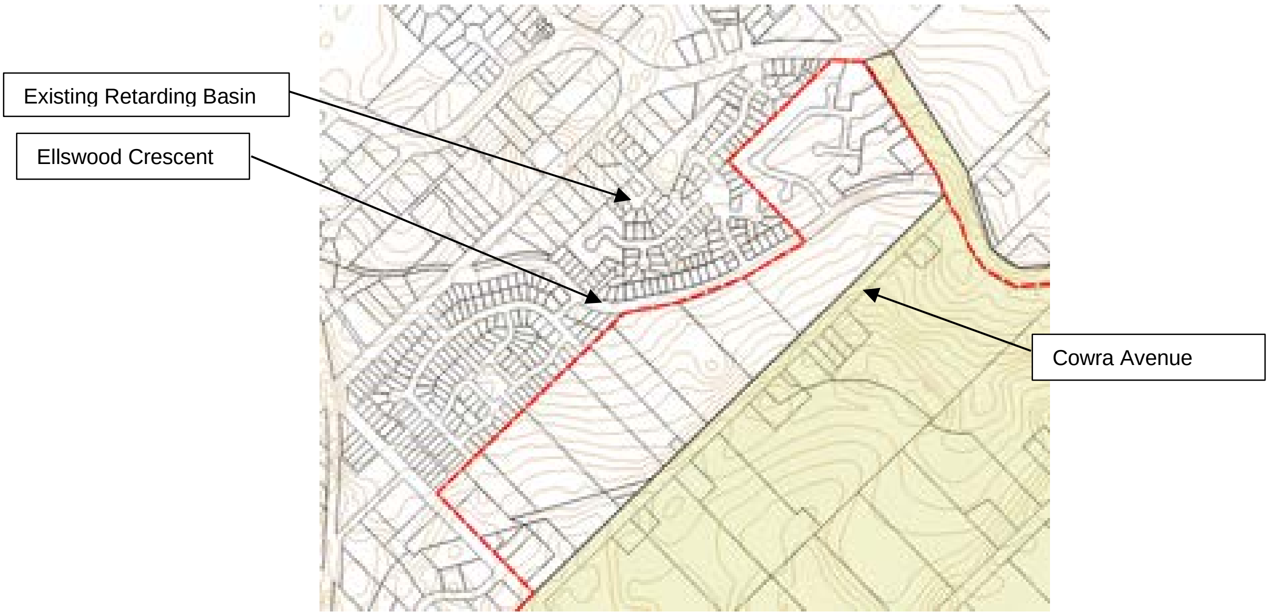


Figure 9 Pocket 1: Ellswood Crescent

The catchment to the north-west of Cowra Avenue is not captured by likely drainage basin locations within the Mildura East Catchment. Directly west of the subject site and Ellswood Crescent is a residential development. Conversations with Council indicate that there is a retarding basin within this development that caters for this catchment and pumps its flows to Etiwanda Wetland. It is expected that at least one retarding basin will be required to provide flood mitigation for the remaining undeveloped portion of the catchment so that flows are reduced to acceptable levels prior to discharge through the existing residential area.

3.1.4.2 Pocket 2 – Cowra Avenue

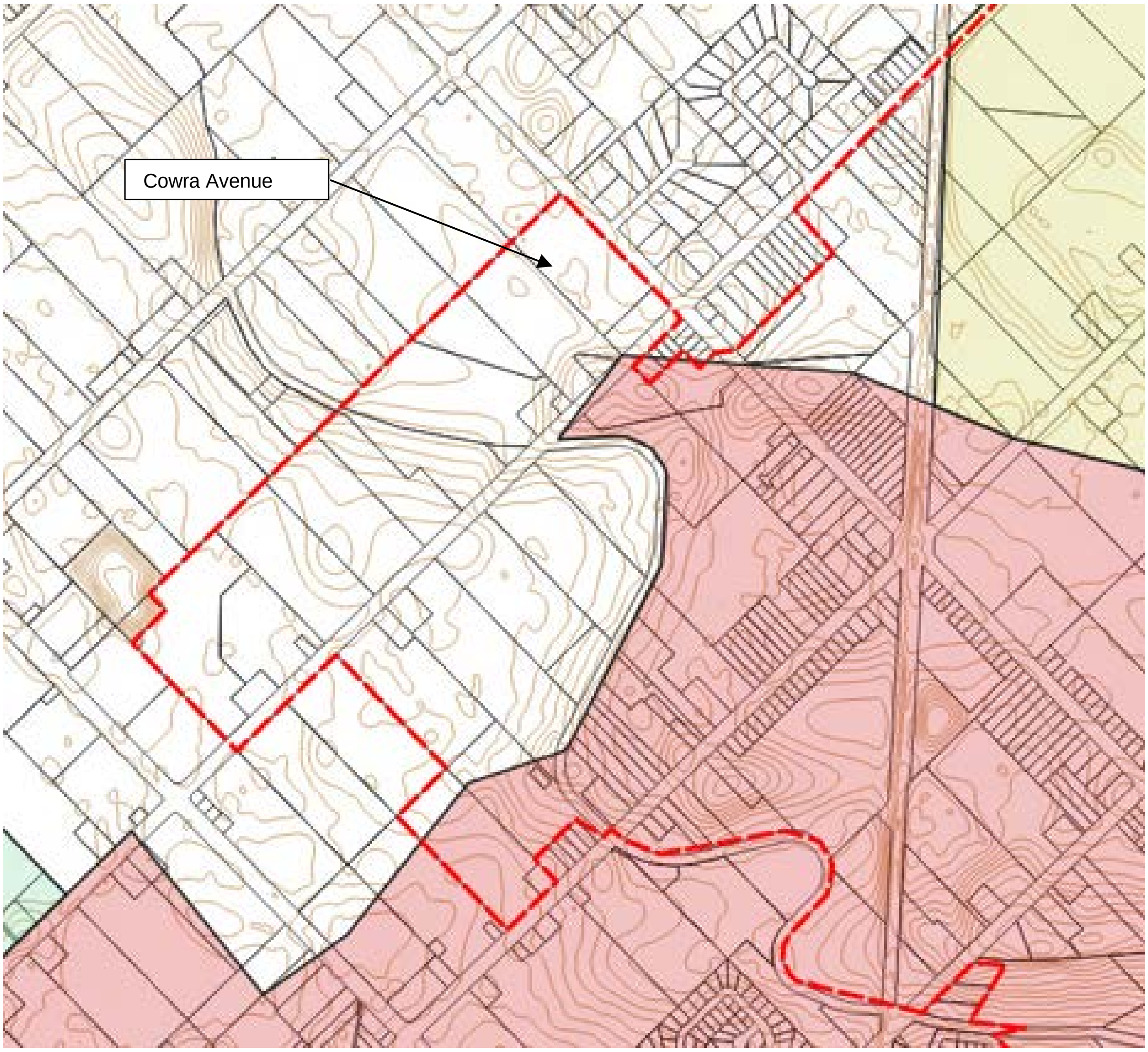


Figure 10 Pocket 2 - Cowra Avenue

This pocket of catchment is split from the Irymple catchment. It drains south-west to the Calder Basin and is understood to be already catered for within the existing drainage in Mildura South.

3.1.4.3 Pocket 3: Irymple Avenue

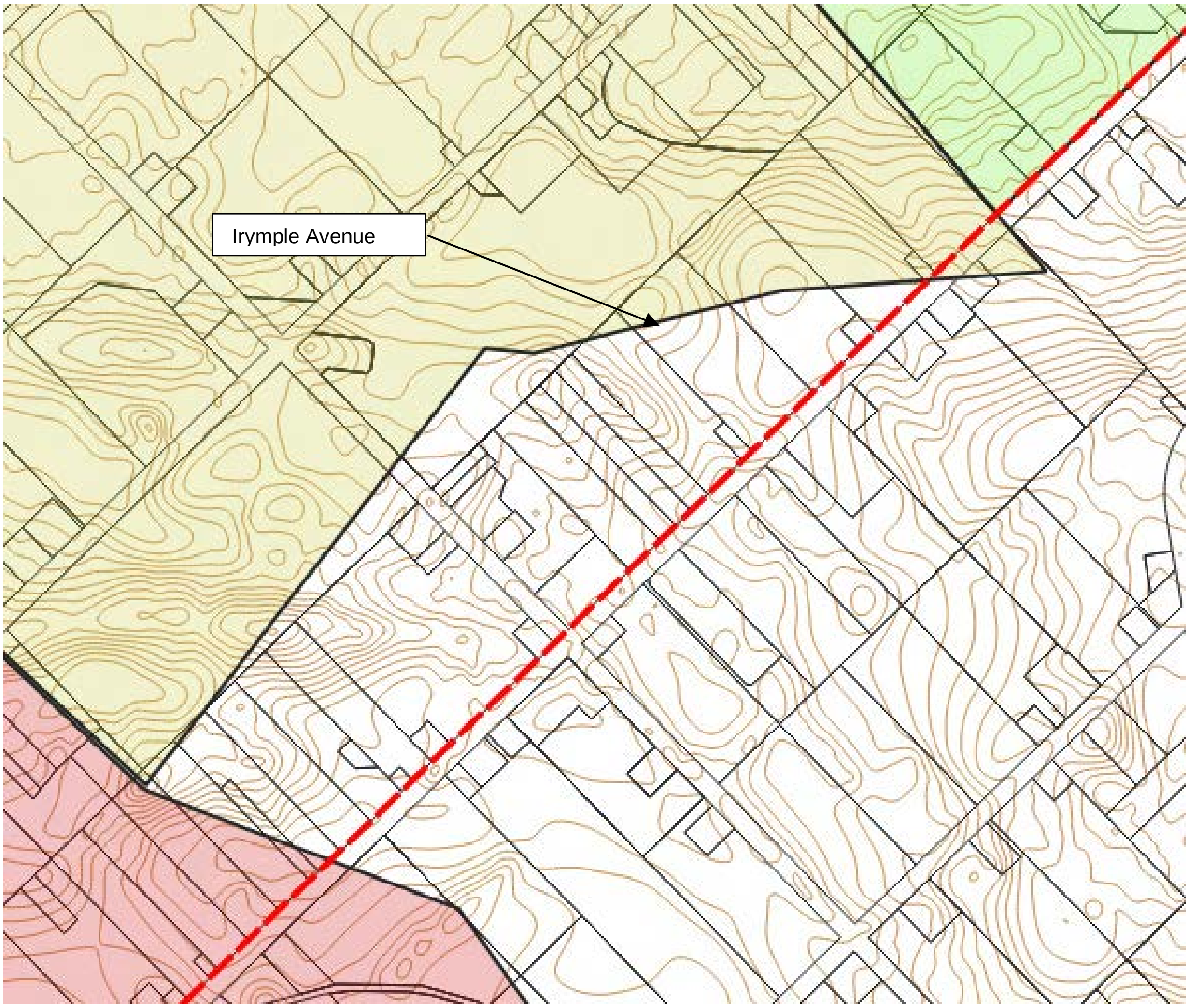


Figure 11 Pocket 3 - Irymple Avenue

This catchment is east of the Mildura East catchment, where the topography is undulating and pooling in various locations. A high-level analysis suggests that surface flows from this catchment will most likely drain east towards the Murray River although achieving an outfall would require construction of drainage through rural land. It is understood that the existing farm drainage in the area drains west into the LMW network. A similar approach could be adopted for piped urban drainage. However, provision would still need to be made for 1% AEP stormwater surface flows.

3.2 Hydrologic analysis

A hydrologic analysis has been undertaken on the subject site to gain an understanding of the flows and volumes throughout the site with focus on the three main catchments. Three scenarios have been analysed for the subject site: pre-development scenario, existing scenario, and a post-development scenario, which will be discussed further in Section 3.2.1. AR&R 2019 rainfall data has been adopted for this analysis. Flow calculations have been used to inform drainage infrastructure sizing and water quality treatment analysis for the subject site.

3.2.1 Scenarios

Three development scenarios have been modelled and are described in Table 1.

Table 1: Hydrologic Modelling Scenarios

Scenario	Description
Pre-Development	Consists of modelling a catchment scenario prior to any development, a 'rural' case. Used to estimate a pre-development flow rate for retarding basins and to calibrate RORB models.
Existing	Modelling existing development of the catchment. Used to understand the current catchment flows and what the existing infrastructure is catering for.
Post-Development	Modelling the future development of the catchment to understand what proposed designs must cater for. Used to design retarding basins and water quality treatment assets as well.

3.2.2 RORB modelling

Industry standard software, RORB was used to model the scenarios above, adopting ARR19 guidelines. Typically, the Regional Flood Frequency Estimator (RFFE) is used to estimate pre-development flow rates and calibrate RORB accordingly. However, RFFE flow rates were not available in Mildura, and as such equations for rural flows were adopted. Each formula recommended by Melbourne Water to calculate the calibration coefficient K_c, was tested for the modelling and the appropriate one was adopted based on how closely the calculated flow rate matched the estimated pre-development flow rate. Refer to Appendix B for details on the RORB modelling. A summary of the existing and post development flow rates is summarised below in Table 2. These flows highlight the magnitude of flows that need to be catered for by the Mildura drainage infrastructure.

Table 2: RORB results summary

Catchment	Catchment Area (ha)	$Q_{existing}$ (m^3/s)	$Q_{post-dev}$ (m^3/s)
Irymple	980	38.1	48.5
Mildura East	504	29.3	35.8
Nichols Point	223	13.5	18.9

3.3 Existing Infrastructure

3.3.1 Irymple Catchment

The Irymple catchment is fairly established in comparison to the others within the subject site area. This is due to the catchment including the town of Irymple at the centre, where there have been multiple drainage studies completed for the catchment and surrounds, discussing the implementation of drainage assets to mitigate major and minor storm events. The study completed by Spiire “Stormwater Drainage Technical Report – Irymple Structure Plan and Urban Design Framework’, documents three retarding basins within Irymple. These are labelled Casuarina Crescent Drainage Basin, Industrial Court Drainage Basin and Henshilwood Reserve Soccer Drainage Basin. These three basins work together to capture major flows. These flows are then pumped to gravity drainage along Fifteenth Street and drain to the Calder Retarding basin. From there they are pumped again and drain through Mildura South to Lake Hawthorn. The pump at Henshilwood Reserve is reported to have a capacity of 160 L/s (with slight variations reported in different sources) and is set at 41.5 m AHD. Flows find their way to the basins via rural drainage systems such as overland swales, roads and pipe networks.

The Sunraysia Drainage Study (Sinclair Knight Merz, 2002) for the area has identified that the pump of 160 L/s is inadequate at catering for flows and recommended an upgrade to 400 L/s. These existing and proposed pump capacities were adopted as the basis for design in this study.

3.3.2 Mildura East Catchment

The Mildura East catchment consists of large rural lots and rural roads to the east of the existing urban areas of Mildura. Areas north of Cureton Avenue are within a floodplain and are not being developed. Due to undulating contours, there are several trapped low points throughout the catchment. The catchment currently has no formal urban stormwater outfall, with local rural drainage such as road swales and drainage pipes to convey stormwater runoff. This can allow a portion of the catchment to drain either north-west or south towards Irymple as the fall can be directed either way with appropriate earthworks and pumping. However, draining north-west both requires less pumping infrastructure and avoids putting additional pressure on the constrained Irymple system and is therefore preferred. The catchment roughly drains to the north-western edge, where it is bound by the railway corridor and Cowra Avenue. Due to the proximity to existing, developed drainage systems, there is opportunity to locate retarding basins near the corner of Cowra Avenue and Cureton Avenue for more efficient use of space. Retarding basins have been proposed by Aurecon (2017). Some of these have already been constructed while others remain proposed. Refer to Figure 12 for their locations.

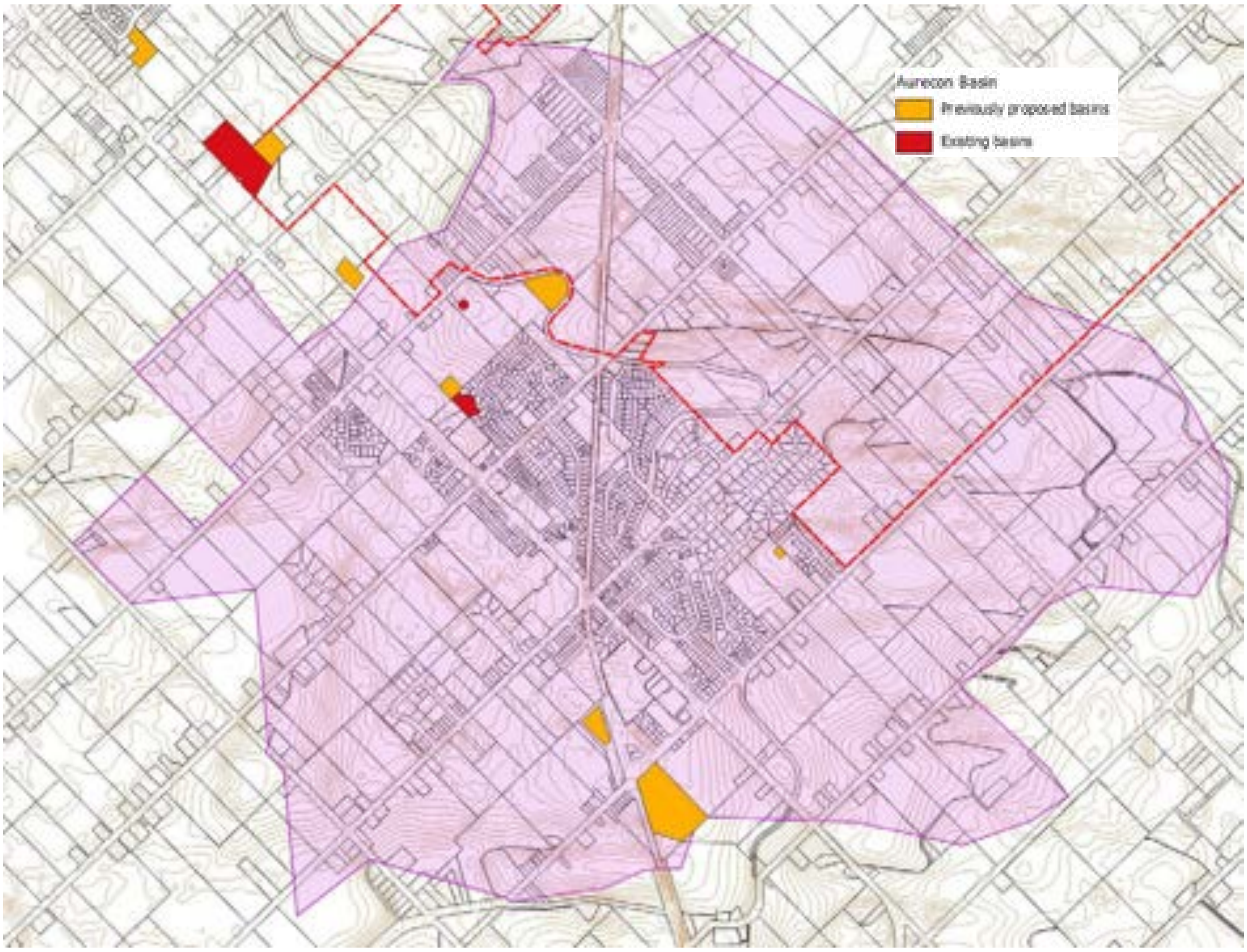


Figure 12: Existing and previously proposed basins within Irymple (Aurecon, 2017)

3.3.3 Nichols Point Catchment

The Nichols Point catchment consists mostly of large rural lots and rural roads. There was originally a stormwater strategy with the intention to utilise small retarding basins and pumps to deal with stormwater runoff. However, this is yet to be implemented and instead rural drainage such as open drains and pipes have been adopted in the interim. The catchment drains to the north where there is an outfall into the Murray River floodplain. A wetland referred to as the Sandilong Basin is proposed for this outfall but has not yet been constructed. Refer to Figure 13 for an extract of the original stormwater management strategy by GHD (2006).

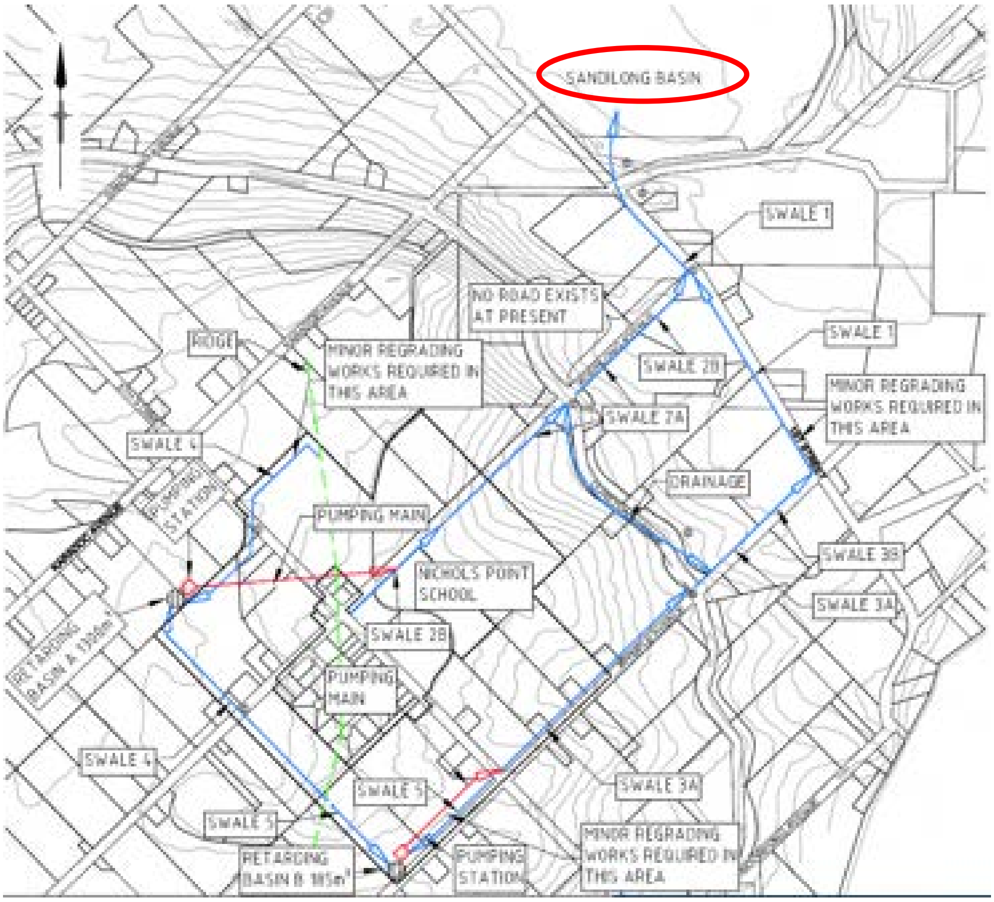


Figure 13: Nichols Point drainage strategy by GHD (2006)

3.3.4 Etiwanda Wetland Outfall

It is understood from discussions with Council, that the retarding basin is not intended to retard flows back to pre-development flow rates, but to ensure that the outfall pipe can cater for incoming storm events. As such, the wetland outfall configuration will need to be reviewed and upgraded in a timely manner to accommodate stormwater runoff increases, as flows may overtop and spill into the surrounds. It is understood the existing outfall is a pipe and channel flowing into a 1,650 mm drain which acts as the constraint on the system. A parallel 1,500 mm outfall is also proposed.

3.4 Minor Drainage System

The minor drainage system will primarily consist of a subsurface pipe network designed to capture and convey all stormwater runoff generated from the catchment for rainfall events up to and including the 20% Annual Exceedance Probability (AEP) design storm for residential developments. Where there is commercial zoning, the minor drainage network will need to be upsized to cater for the 10% AEP design storm. There may also be opportunity to utilise open drainage infrastructure or pumps if necessary.

Discussions with Council indicate that there is preference for ensuring that large pipe sizes are not adopted for long stretches of network as these will be both costly and near impossible to construct, due to issues with fall across the land and subsurface conditions. Considerations must be taken to reduce pipe sizes through additional grade, multiple barrels, or retardation. E2Designlab have taken this into consideration when developing the drainage response.

Where a pipe network cannot drain due to the fall of the land, pumping may be required. Discussions with Council suggest that they acknowledge this will be necessary in some areas of the development.

3.5 Major Drainage System

Conveyance of flows up to and including the 1% AEP storm event are managed throughout the site via a combination of overland flow paths. Overland flow paths will consist of road reserves, grassed swales, open drains or waterways.

Road reserves are to be designed to safely convey the gap flow in accordance with DEECA's overland flow flood safety criteria. Finished lot levels are to be set a minimum of 300mm above the 1% AEP water level in overland flow paths to ensure compliance with DEECA's requirements for freeboard.

DELWP's "Guidelines for Development in Flood Affected Areas' document gives guidance on appropriate flood safety criteria to adopt for residential streets acting as an overland flow path. The applicable criteria are:

1. $V_{av}.d_{av}$ must be less than 0.3 m;
2. d_{av} must be less than 0.3 m.

Where V_{av} and d_{av} is the average velocity and average depth of flow through the critical road cross section respectively.

3.6 Drainage Summary

To summarise the drainage:

- Minor drainage network should consist primarily of a subsurface pipe network, where the storm AEP capacity will be dependent on the land use zoning. Open drainage infrastructure such as swales and drains may be implemented depending on the context. Pumps will be utilised where the fall of the land is undulating, and a pipe cannot be graded to the outlet.
- Concept pipe sizing has been completed assuming a pipe grade of 1 in 300
- Overland flow paths such as road reserves and waterways will cater for up to the 1% AEP storm event. DELWP's flood safety requirements should be adhered to as documented above in Section 3.5. Similar to minor drainage, pumps were used where an outlet cannot be graded out.

3.7 Hydraulic Analysis

Section 3.1 discussed some of the catchment outlet characteristics, such as Irymple having a pumped outlet of 160 L/s (0.160 m^3/s). Comparing this to the calculated developed flow rate of 48.5 m^3/s, it can immediately be seen that there will be significant hydraulic and storage assets required to cater for this difference.

High level hydraulic analysis was undertaken on the subject site to understand the existing drainage infrastructure and what it caters for, as well what additional infrastructure will be required for future development. Further functional and detailed hydraulic analysis would be undertaken as part of the preparation of any future development plan / subdivision application.

3.8 Retarding Basin Design

Retarding basins will be required throughout the subject site to mitigate post-development flow rates down to the allowable outlet flow rates. Concept plans for the future development within the subject site have been made available to E2D, enabling preliminary retarding basin design to be undertaken.

Retarding basin design has considered the below:

- ***Retarding basins have been sized to provide full mitigation of the 1% annual exceedance probability storm event for the critical duration to pre-development levels for Henshilwood Reserve.*** Without this requirement, existing flooding within Irymple would be exacerbated and the frequency and impact of flooding on existing urban areas would increase.
- Whereas retarding basins typically mitigate flow rates to pre-development flow rates, some retarding basins reduce flow rates to levels where downstream drainage infrastructure or pumps can cater for it.
- Retarding basins have been sized conceptually in RORB.
- Stage storage relationships have assumed a simple rectangular shaped basin for modelling purposes only, detailed planning for these basins in conjunction with open space is anticipated to result in more organic basins.
- Stage-storage-outflow relationships have been iterated to obtain the allowable flow rate as per outfall constraints.
- Where outfall constraints are unknown, a gravity outfall has been adopted.
- Retarding basins with embankments in fill greater than 500 mm may be subject to a dam break assessment as per ANCOLD guidelines.
- The actual land take of basins may vary at future functional and / or detailed design stages to achieve an optimal earthworks to balance between the drainage system requirements and integrated with surrounding urban open space.
- Appropriate flood immunity requirements for surrounding developments will need to be adhered to either within the basin or the developments finished surface levels.
- Average depths of retarding basins should generally be in the range of 1-1.5 m to support effective integration with surrounding open space areas and ensure these areas can deliver a range of IWM benefits including treatment, biodiversity and amenity.

As noted in Section 3.3, there is existing infrastructure such as retarding basins present throughout the catchments. Previous drainage strategies completed within the catchment and surrounds have also recommended new basins and upgraded infrastructure to cater for increased stormwater runoff from future development. These drainage strategies are:

- Sunraysia Drainage Strategy (Sunraysia Task Force, 2002)
- Irymple Drainage Modelling (Aurecon, 2011)
- Mildura South Drainage Modelling (Aurecon, 2012)
- Mildura and Irymple Stormwater Drainage Basins (Aurecon, 2017)
- Stormwater Drainage Technical Report – Irymple Structure Plan and Urban Design Framework (Spiire, 2021)

The retarding basins within the RORB model have been located based on existing and proposed infrastructure information to best represent what is in the ground and what can be realistically achieved. However, due to differences in modelling approaches, assumptions and adopted AR&R data, there are increases in the prescribed retarding volume required.

This study provides an indication of desired retarding basin areas and volumes that may be needed and where this could be located, assuming consolidated basins at the outlet of relatively large catchments. These may be used as a basis for development plans. The retarding basins should preferably be incorporated within and integrated with larger open space areas that also need to be identified within future development plans.

3.8.1 Irymple Catchment

The reports documented in Section 3.8 detail the following retarding basins within the Irymple catchment. Additional basins are also required to reduce the demands for storage at Henshilwood reserve and other downstream basins. These are documented below in Figure 14.

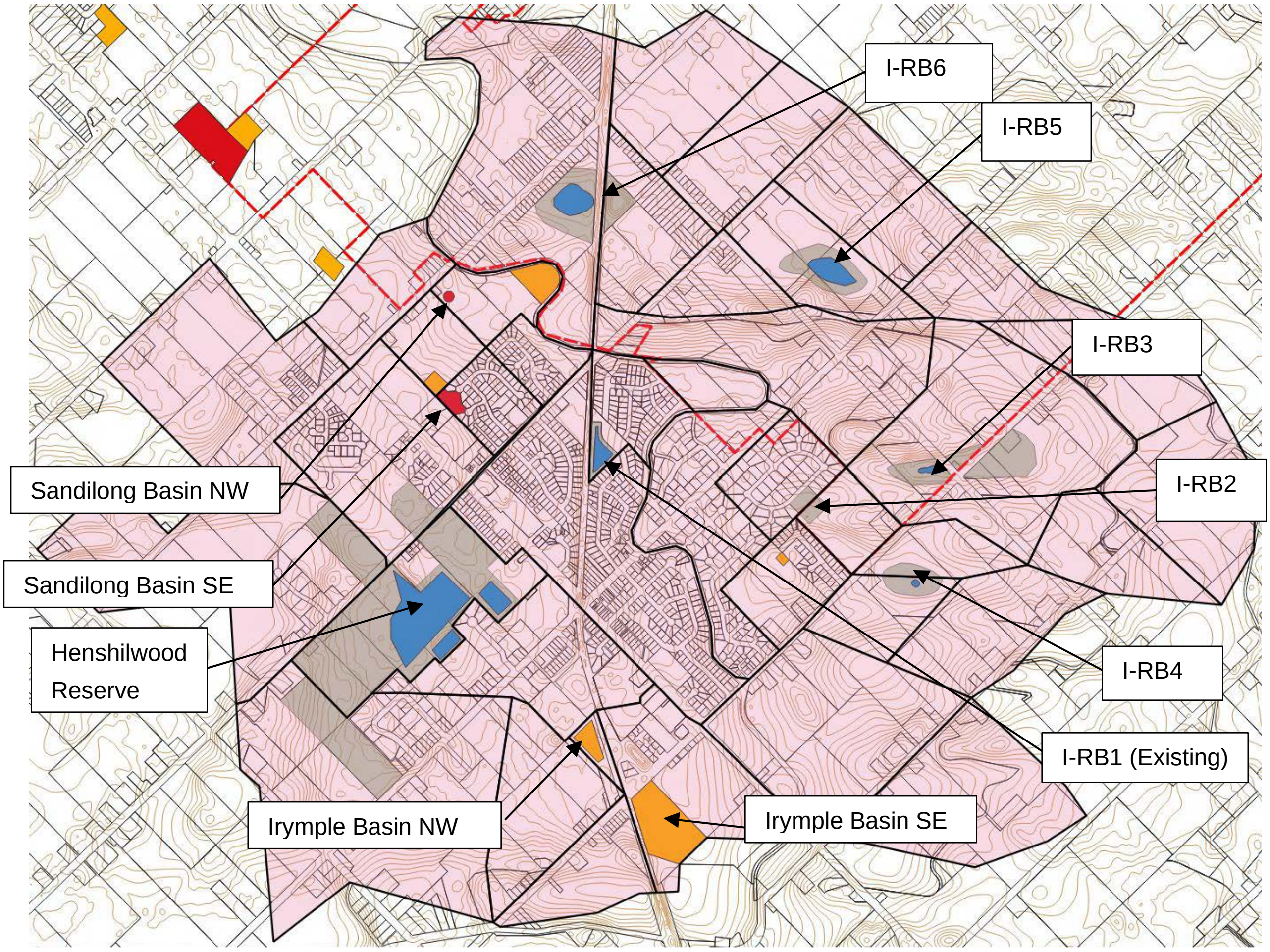


Figure 14: Irymple catchment concept drainage layout (Green represents the retarding basin land take, blue represents the WSUD asset land take)

These basins have been represented within the RORB model, and any outlet details or height-storage details documented in previous drainage strategies were adopted as the first iteration of the models. The final storage and outlet flow rate for each basin are summarised below in Table 3.

Table 3: Irymple ultimate retarding basin requirements summary

Basin Name	Storage (ML)	Land take (ha)	Peak Outflow (m^3/s)	Outlet type	Pipe size (mm)
Henshilwood Reserve	619	41.7	0.4	Pump	N/A
Irymple Basin SE	47	3.4	2.5	Gravity	900
Irymple Basin NW	14	0.9	1.8	Gravity	900
Sandilong Basin NW	6	0.4	0.15	Gravity	600
Sandilong Basin SE	16	1.0	0.7	Gravity	750
I-RB1 (Existing)	7	3.0	0.4	Gravity	450
I-RB2	16	2.1	0.7	Gravity	600
I-RB3	66	4.9	0.5	Pump	N/A
I-RB4	21	1.6	0.4	Pump	N/A

Basin Name	Storage (ML)	Land take (ha)	Peak Outflow (m^3/s)	Outlet type	Pipe size (mm)
I-RB5	47	4.1	0.26	Pump	N/A
I-RB6	90	4.1	0.26	Pump	N/A

The total retarding volume required for Irymple catchment is 950 ML. The original Sunraysia drainage strategy reported a total of approximately 290 ML. The increase can be attributed to the following reasons:

- The Sunraysia drainage strategy (Sinclair Knight Merz, 2002) accounted for extensive future development albeit at a lower impervious fraction than is typically used for contemporary development. It also potentially did not fully account for the potential effects of rural areas draining to retarding basins within Henshilwood Reserve.
- The 2011 study (Aurecon, 2011) included consideration of rural areas draining to Henshilwood Reserve and identified that the implications of these were significant for the duration and volume of flood impacts. However, this study considered only existing urban development at the time, not future development.
- The Sunraysia drainage study was completed in 2002 and the Aurecon study in 2011. Since then, ARR19 guidelines have been released which has contributed to the increase of stormwater runoff volumes. This was also apparent in a recent drainage strategy on Nichols Point completed by Tonkin.
- Previous drainage strategies have used varying proportions of the total Irymple catchment to best reflect the low points and true catchment draining to the Irymple outfall.
- Different modelling approaches have been adopted for each drainage strategy completed within this catchment. Previous models have adopted hydraulic / flood models whereas the approach here is a hydrologic model.
- The peak inflow to the basins documented in Table 2 is 38.1 m^3/s for existing, rising to 48.8 m^3/s for future and the peak allowable outflow from the catchment based on pump capacity is 160 L/s (0.16 m^3/s), which has been increased to 400 L/s (0.40 m^3/s) as per proposed upgrades within the Sunraysia Drainage Strategy. The large difference in inflow and outflow rates is a significant challenge that will need to be addressed by Council through storage, increased downstream capacity or other responses regardless of catchments and modelling approaches.

It is noted that additional capacity required in the Henderson basin catchment, could potentially be achieved further towards 14th street in the low-lying areas, where public open space will also be required. This may allow for a greater amenity to be provided to the community as an integrated space. It will also assist with the reduction in pipe capacity throughout the catchment to some extent. These opportunities should be considered within future investigations and functional to detailed design.

3.8.2 Mildura East catchment

The Mildura East catchment featured less overlap with previous drainage strategies completed. After discussions with Council, three retarding basins have been proposed in the locations marked in Figure 15.

These locations are based on areas that are currently low points collecting volumes of water and use Cowra Avenue as the main conveyance path. while the catchments upstream of RB3 will not be developed within the scope of this project. RB3 is still required to capture undeveloped surface runoff and relieve stress from the downstream retarding basins which are catering for an increased magnitude of surface flows due to urban development. The location and timing of RB3 is flexible, and ultimately more than one basin may be constructed to allow for the undulating contours and trapped low points. Preference may be given to relocating part or all of RB3 into the College Lease land highlighted orange in the below Figure 15.

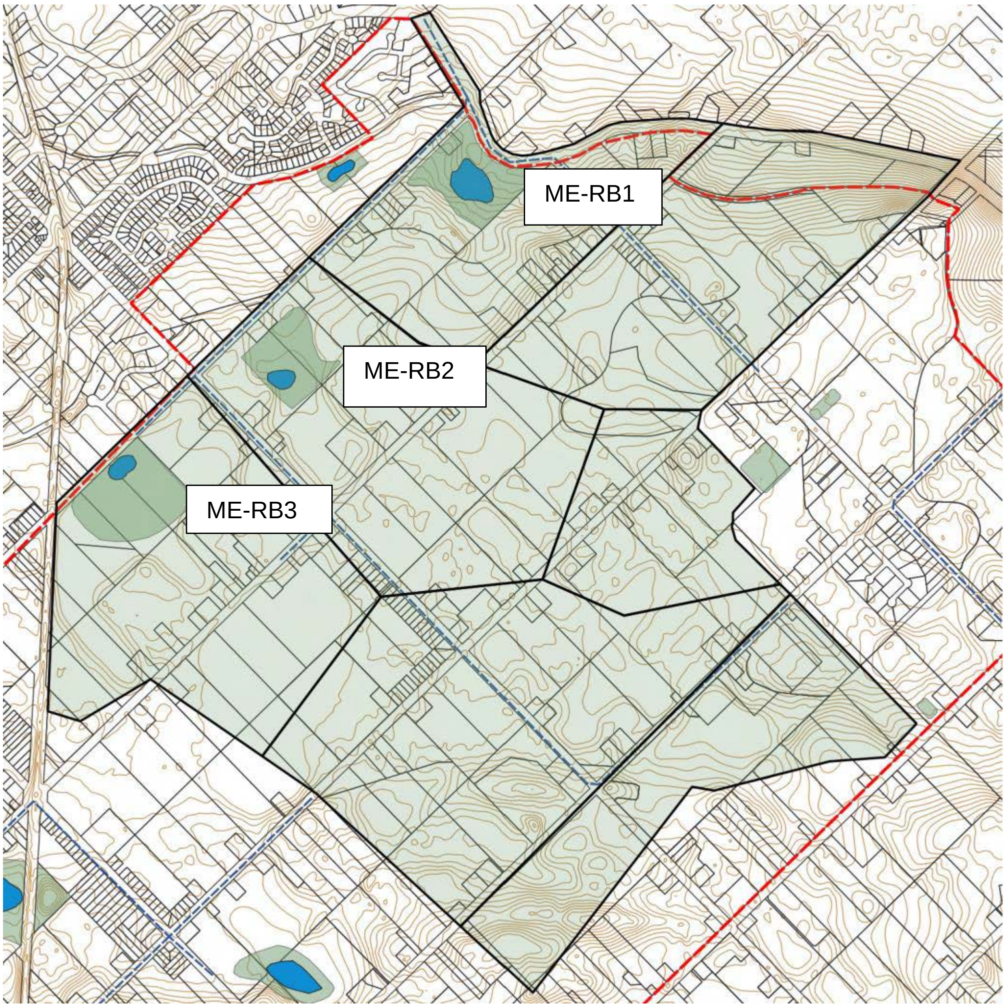


Figure 15: Mildura East catchment concept drainage layout

The details of the retarding basin concept designs are provided below in Table 4.

Table 4: Mildura East ultimate retarding basin requirements summary

Basin Name	Storage (ML)	Land take (ha)	Peak Outflow (m^3/s)	Outlet type	Pipe size (mm)
ME-RB1	99	6.6	3.72	Gravity	1,500
ME-RB2	83	5.5	3.63	Gravity	1,500
ME-RB3	134	8.9	3.73	Gravity	1,500

The total retarding volume required for Irymple catchment is 316 ML. The original Sunraysia drainage strategy reported a total of approximately 161 ML. This almost doubling of required retarding volume can be attributed to the same reasons as the Irymple catchment, discussed above in Section 3.3.1 above. The Mildura East catchment flows into Etiwanda Wetland. We recommend further investigation into Etiwanda Wetland to understand whether additional capacity should be allowed for in the outfall upgrade, and whether changes to the wetland are required to cater for the increased stormwater volume.

3.8.3 Nichols Point catchment

A drainage study was completed on Nichols Point by Tonkin in September 2022. This drainage strategy reviewed the previous basin and infrastructure sizing recommendations and revised them using ARR19 rainfall data. The basins are shown on Figure 16 and their sizes in Table 5 below. Basin A is pumped to the wetland and that the wetland on the floodplain is the discharge point for the whole Nichols Point catchment. Based on the location of the basins and drainage infrastructure, we understand that the infrastructure does not fully cater for a wedge of future development between Karadoc Avenue and Basin 4. As such, there is a need to revise the Tonkin drainage models and strategy to cater for this development. We expect that the proposed Based A and Basin 4 will increase in volume and may need to be shifted closer to Karadoc Avenue, or that an additional basin will be required to accommodate the new development area. This revision could occur when development is intended to commence and footprints need to be confirmed.

Drainage is indicated to terminate within the Murray River floodplain at the location of what was previously referred to as the Sandilong Basin.

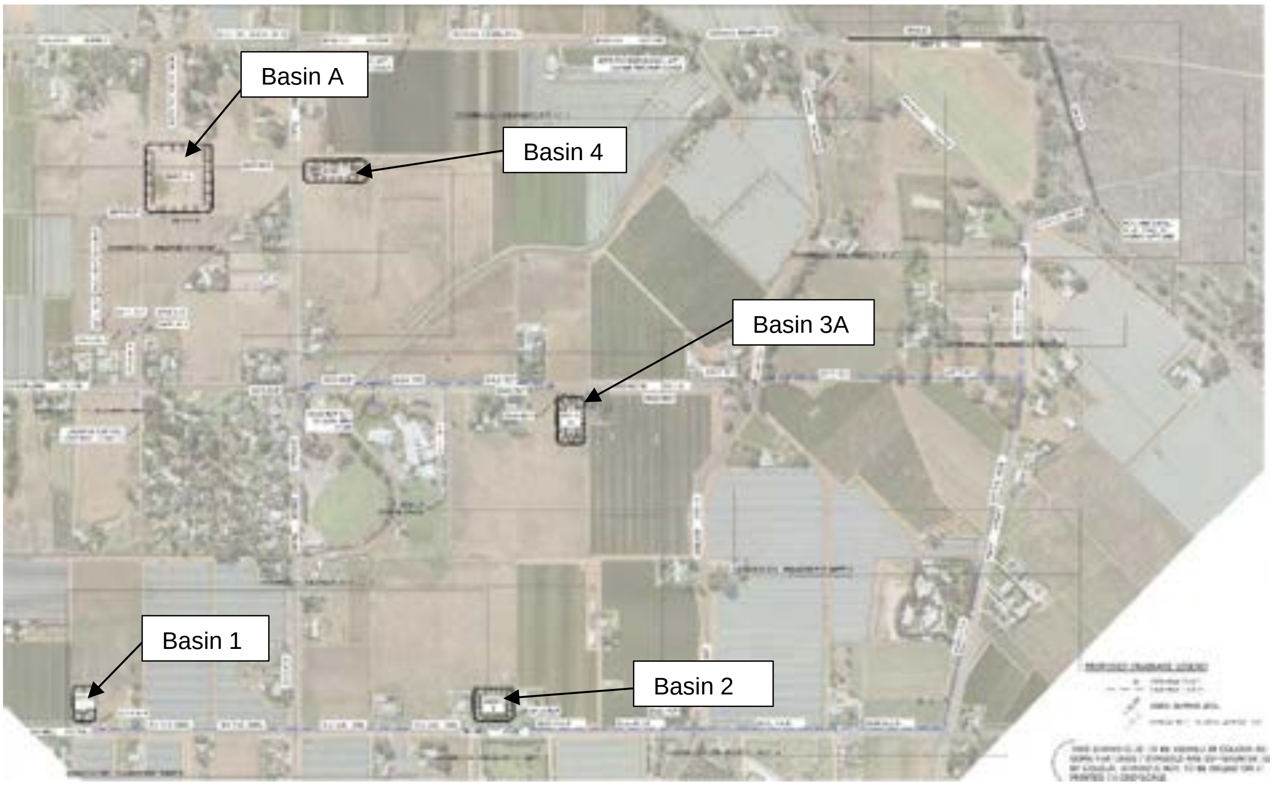


Figure 16: Nichols Point catchment concept drainage layout (Tonkin, 2022)

Table 5: Nichols Point basin sizing summary (Provided By Mildura City Council, 6 April 2023)

Basin Name	Storage (ML)	Outlet type	Pipe size (mm)
Basin 1	1.58	Gravity	375
Basin 2	5.0	Gravity	450
Basin 3A	5.78	Gravity	525
Basin 4	5.26	Gravity	450
Basin A	18.8	Pump	375

A total of 36.4 ML of retarding volume is proposed for the Nichols Point catchment.

3.8.4 Hydraulic summary

Hydrologic modelling completed in RORB has seen an increase in flow rates and retarding volumes required when compared to earlier drainage strategies. This can be attributed to several factors such as: the update to ARR19 rainfall data, differences in assumptions, catchment areas and levels of urbanisation analysed, and modelling methodology and software.

RORB modelling has been completed for the Irymple and Etiwanda Wetland catchments to calculate the retarding volume required. A recent drainage study on Nichols Point by Tonkin has also sized the required retarding volume. A summary of the total retarding volume required for each catchment is:

- Irymple catchment will require approximately 1084 ML of retarding basin volume
- Mildura East catchment will require approximately 316 ML of retarding basin volume
- Nichols Point catchment will require approximately 36.4 ML of retarding basin volume (as per correspondence from MRC)

4 Integrated water management and stormwater quality

4.1 Objectives and requirements

The *Environment Protection Act 2017* (as amended) came into effect on 1 July 2021. Under the Act, all Victorian's have a *General Environmental Duty* (GED) to "*minimise, so far as reasonably practicable, risks of harm to human health and the environment*" or from pollution or waste through good environmental practice. To do this, Victorian's have an obligation to practice under the *current body of knowledge*.

This supersedes the State Environmental Protection Policy (Waters of Victoria) which previously set out obligations for development to protect waterways and water bodies.

4.1.1 Best practice environmental management guidelines

To support achievement of these outcomes, the Best Practice Environmental Management Guidelines: Stormwater (BPEMG) (Victoria Stormwater Committee, 1999) remains the primary reference and sets out objectives for stormwater management including reducing typical urban stormwater pollutant loads as follows:

- 80% for Total Suspended Solids (TSS)
- 45% for Total Phosphorus (TP)
- 45% for Total Nitrogen (TN)
- 70% for Gross Pollutants

These best practice objectives are referenced in the Victoria Planning Provisions for a range of development types and are well recognised as standard requirements for new development.

4.1.2 EPA urban stormwater management guidance and stormwater flow volume objectives

Building upon BPEMG, the Victorian Environment Protection Authority's Urban Stormwater Management Guidance (EPA, 2021) sets out urban stormwater performance objectives flow volume performance objectives. These objectives set within EPA Urban Stormwater Management Guidance, referred to in this guideline as "EPA Guidance", are dependent on what is reasonably practicable[1]. The flow objectives are comprised of two components:

[1] https://www.epa.vic.gov.au/about-epa/laws/new-laws/what-is-reasonably-practicable

- Harvesting/ evapotranspiration (expressed as a percentage of mean annual impervious runoff) and
- Infiltration/ filtering. (expressed as a percentage of mean annual impervious runoff)

These objectives are not yet adopted in any form into the Victorian Planning Provisions. However, under the new General Environmental Duty (GED), Council, landowners and developers will have an obligation to take them into account through their planning and actions. The approach taken, the reasons why it is practical and reasonable and the anticipated outcomes should be documented, as well as justification if any of the objectives are not achieved.

The flow objectives are scaled based on rainfall. For Mildura, the mean annual rainfall (based on long term daily data for Mildura Airport for 1946-2018) is 290 mm/year.

Objectives are provided for priority and non-priority areas. At this time, priority areas have only been defined for Melbourne while DEECA are working on a framework to identify priority areas and waterways throughout regional Victoria. Mildura and surrounding areas all ultimately discharge to either inland wetlands or in rare high flow events, to the Murray River. Part of the area of interest will discharge via the Etiwanda Wetlands to the Murray River while other areas will drain via Irymple to Lake Hawthorn. These receiving waters have high environmental values. However, the main risk to these is expected to be urban stormwater pollutants rather than flow volumes due to the scale of the Murray River and historical hydrology of Lake Hawthorn.

Irymple and Mildura South catchment areas to Lake Hawthorn

Flow volumes into Lake Ranfurly and Lake Hawthorn have decreased significantly due to reduced rainfall through the millennium drought (BMT WBM, 2008) as well as through reduced discharges from irrigation drainage (Kate Lumb Consulting Pty Ltd, 2015). This has affected the amenity of the lake and *additional flows are now considered desirable to improve amenity outcomes* although these must be balanced with salinity and flood mitigation objectives (Kate Lumb Consulting Pty Ltd, 2015). The Lakes also provide substantial evaporation of flows before they are pumped inland to Wargan Wetlands (Wargan Basin) for evaporation disposal or, in rare very high flow events discharged to the Murray River.

Our preliminary assessment is that consideration should be given to allowing increased stormwater volumes to be directed to the basin to supplement water levels. This must be undertaken with consideration of flow patterns and balancing of management objectives for amenity, ecology, salinity and flood mitigation. Consideration may also be given to possibly reducing the areal extent of the basin and corresponding evapotranspiration in future, although it is recognised this may be contentious.

Mildura East Growth Area catchment areas to Etiwanda Wetlands

Given the scale of the urban area relative to the Murray River it is most likely that urban discharge volumes would have a negligible effect on flow rates and volumes. Furthermore, significant irrigation extractions from the river occur.

Further consideration may need to be given to potential impacts of flow volumes discharged directly to the Murray River (via Etiwanda wetlands) and whether these need to be mitigated. At the least, attenuation through treatment assets such as wetlands is desirable to reduce any effect of high intensity urban stormwater pollutant loadings.

Infiltration

In terms of infiltration, it is recognised that groundwater tables and salinity levels in the area are elevated and that there are active drainage measures in place to divert irrigation leachate away from groundwater to mitigate salinity risks. These are likely to remain in place within the development area and surrounds. In this context, *intentional infiltration is unlikely to be either desirable or actively pursued* although incidental occurrences may occur. This should not be seen as precluding the use of assets such as passively irrigated street trees where the majority of stormwater directed to the asset is returned to the atmosphere through evapotranspiration (although infiltration volumes should be checked for any large-scale projects).

Preliminary recommendation for flow objectives

Given the above context, it will most likely be appropriate to have either no flow volume objectives within the Mildura Area or for these to be categorised as a low priority area with zero infiltration.

Overall, it is considered that the Mildura area would be considered a 'Low priority' catchment from this perspective. On this basis, the indicative corresponding EPA flow volume objectives for Mildura would be as follows:

- Harvest and/or evapo-transpire 35% of mean annual flow volume
- Infiltrate 0% of mean annual flow volume

We consider it important to advocate for new standards and objectives that will provide greater protection of our receiving water bodies and waterway. In setting objectives however, the specific needs of the relevant local waters and context must be considered.

Given the hydrology of Lake Hawthorn and Lake Ranfurly and the likelihood that additional flow volumes will be mostly beneficial rather than having adverse impacts, *it is recommended that no flow volume reduction objective should be applied for these catchments*. However, it is important that flows discharged to the lake are appropriately treated to mitigate the further deposition of nutrients and pollutants into the bed of the lake as these are already likely to be presenting an issue and risk of re-suspension given the maturity of the water body. It is additionally noted that the lake levels are managed with occasional pumping to Wargan Wetlands (Wargan Basins) west of Mildura for disposal. Consideration could be given to enabling more control over timing of these discharges through the design of upstream storage and drainage assets. There is also a pumping cost that may be offset by upstream stormwater reuse (accounting for losses within Lake Hawthorn).

The 0% infiltration objective (or lack of an objective) fits well with the groundwater conditions in the area. Under such conditions with high and saline groundwater, we would likely recommend against requiring or actively pursuing enhanced efforts for infiltration. It is noted that these would be over and above such infiltration as may naturally occur through responses such as raingardens or tree pits that may be unlined given the heavy underlying soils and we would not preclude the use of these.

The question of the Murray River is more complex and while a preliminary view is that there would be limited value in seeking volume reductions this may need further consideration in future. In assessing outcomes for the subject area catchments draining via Irymple and implications for the Murray River, consideration may also be given to the substantial volumes of evaporation that are already being achieved at Lake Hawthorn and Lake Ranfurly. Losses within these lakes are substantial and may well exceed potential objectives. *Our preliminary recommendation would be that no flow volume objective is applied for catchments discharging directly to the Murray River.*

It is noted planning requirements have not been established at this time for flow objectives although they form part of the state of knowledge that should be taken into account.

For the purposes of this study, the design sought to meet the legislated BPEMG stormwater reduction objectives.

On the basis of the above considerations flow volume reductions were reported but *the design has not sought to meet any volume reduction objectives given the above context and considerations*. This preliminary approach should be reviewed and either revised or confirmed once a framework and process for assessing priority and non-priority catchments and establishing flow objectives is established for regional Victoria.

4.2 Climate data for modelling

A rainfall template of the local area was created based on rainfall data from the Bureau of Meteorology. The long term mean annual rainfall for the daily gauge at Mildura Airport for the period of record from 1946-2018 was estimated at 290 mm/year. A comparison of the recent period from 1975-2015 resulted in a similar mean annual rainfall of 282 mm/year. A 10-year period of pluviograph (6 minute) data suitable for use in MUSIC with a similar mean annual rainfall to the long term and good quality was chosen. A summary of the rainfall is provided in Table 6. The variability in annual rainfall totals can be seen in Figure 17, confirming the need for at least 10 years of data. An earlier period was chosen as this closely matches the target long term mean annual average and also has good quality with minimal missing or accumulated data which feature more prominently in the more recent data periods.

Rainfall in the area is very low and highly variable with mean annual rainfall typically in the order of 200-300 mm/year. The climate present specific challenges for design of stormwater treatment infrastructure to cope with long dry periods contrasted with short periods of more intense rainfall.

Table 6: Rainfall Template Summary

Name	Rainfall Period	Mean Annual Rainfall (mm/year)
Mildura Airport (6 min data)	1957 – 1966	289

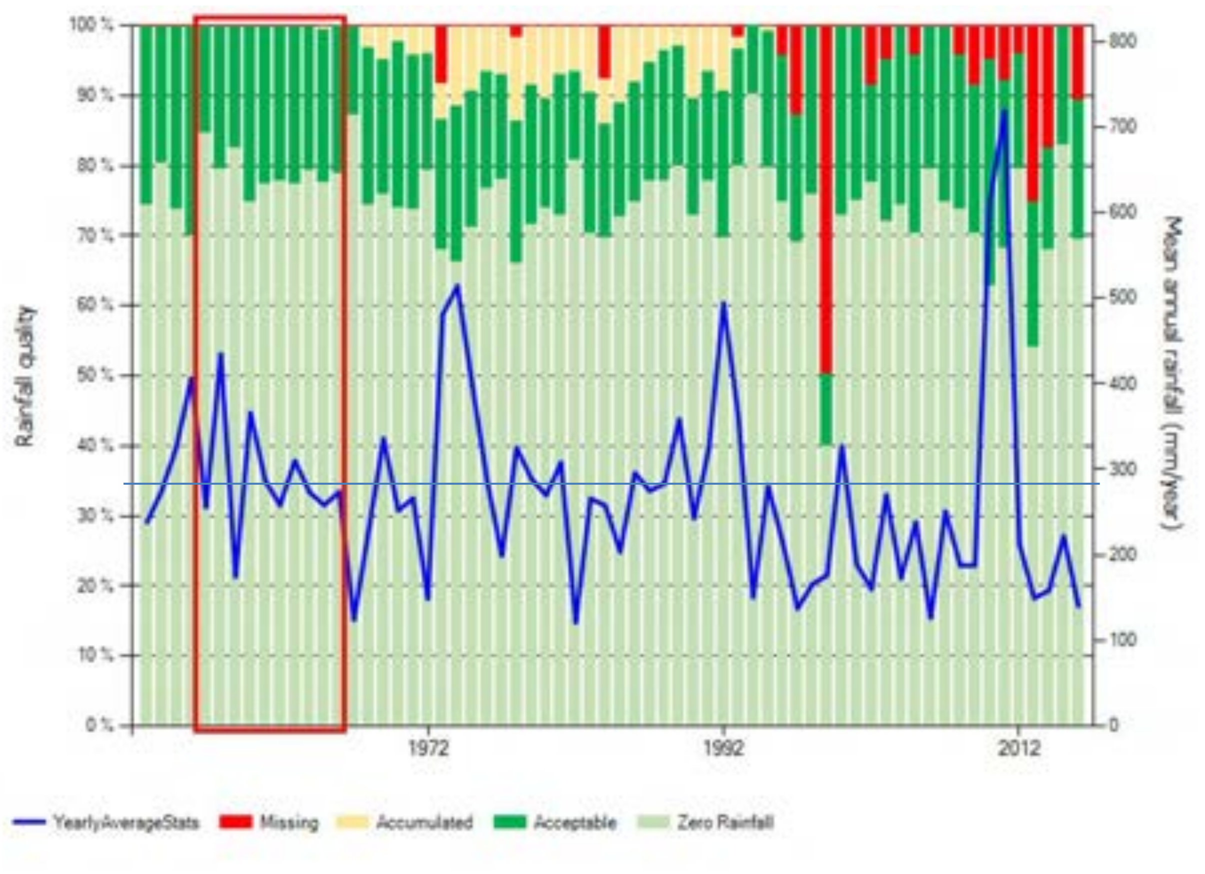


Figure 17 076031 Mildura Airport Pluviograph mean annual rainfall and quality

4.3 Etiwanda Wetland / Mildura East

The Etiwanda Wetland is the primary water quality treatment asset in Mildura. It currently treats the town of Mildura and surrounding towns stormwater runoff to BPEM water quality targets prior to discharging into the Murray River. Future development will need to consider the impact increased stormwater runoff will have on the wetland, and if additional water quality treatment interventions are required to support it. The potential to expand the wetlands capacity may also be considered to complement upstream assets. For the purposes of our work, we have assumed that all new development areas must meet best practice without additional dependence upon Etiwanda Wetlands.

4.3.1 Existing Design

Drawings were provided by Council for the existing design of the Etiwanda Wetland. These consist of layout plans and a concept section of the assets. The water quality treatment system is as follows:

- Silt trap and litter screen at the inlet drain;
- Primary sediment pond, shallow reed beds and a collection channel co-located within a retarding basin;
- Pump into the flow distribution channel upstream of the treatment wetland;
- Treatment wetland consisting of treatment reed beds
- A collection channel and outlet weir to outlet into the river.

The wetland drainage reserve is approximately 16.4 ha and has been designed to remove fine sediments and nutrients, as well a gross pollutant, with a GPT being installed.

4.3.1.1 Model Set Up

Design parameters and water quality modelling for the Etiwanda Wetland were estimated based on the limited information available including discussions with Council, information in prior reports and data extracted from the drawings provided. MUSIC was used to model performance.

The current catchment to Etiwanda wetland is uncertain with one report (BMT WBM, 2008) putting it at 876 ha including the Etiwanda and San Mateo drains while Council officers believed it to be in the order of 550 ha. Review of the catchments identified approximately 700 ha of existing urban areas draining to the wetland. The original catchment plans were not available so it is difficult to determine whether the quoted 876 ha may have included parts of the subject area even though they are not formally draining to the wetland at present. We understand from Council comments (Pers. Comm. David Arnold) that an allowance for development within Mildura East/Nichols Point with basins and pumping was factored in so it is likely they were included, however assumptions regarding development densities are unknown. Given the uncertainties, changes in development densities and design guidance for wetlands we have adopted a conservative approach and assumed treatment will be needed upstream. This could be refined at a later date during functional design.

A model has been created for the Etiwanda Wetland, which consists of the existing catchment and Mildura East catchment draining to it. Wetlands have been proposed within the new development and was created using catchment nodes and treatment nodes. The treatment train layout is shown below in Figure 18.

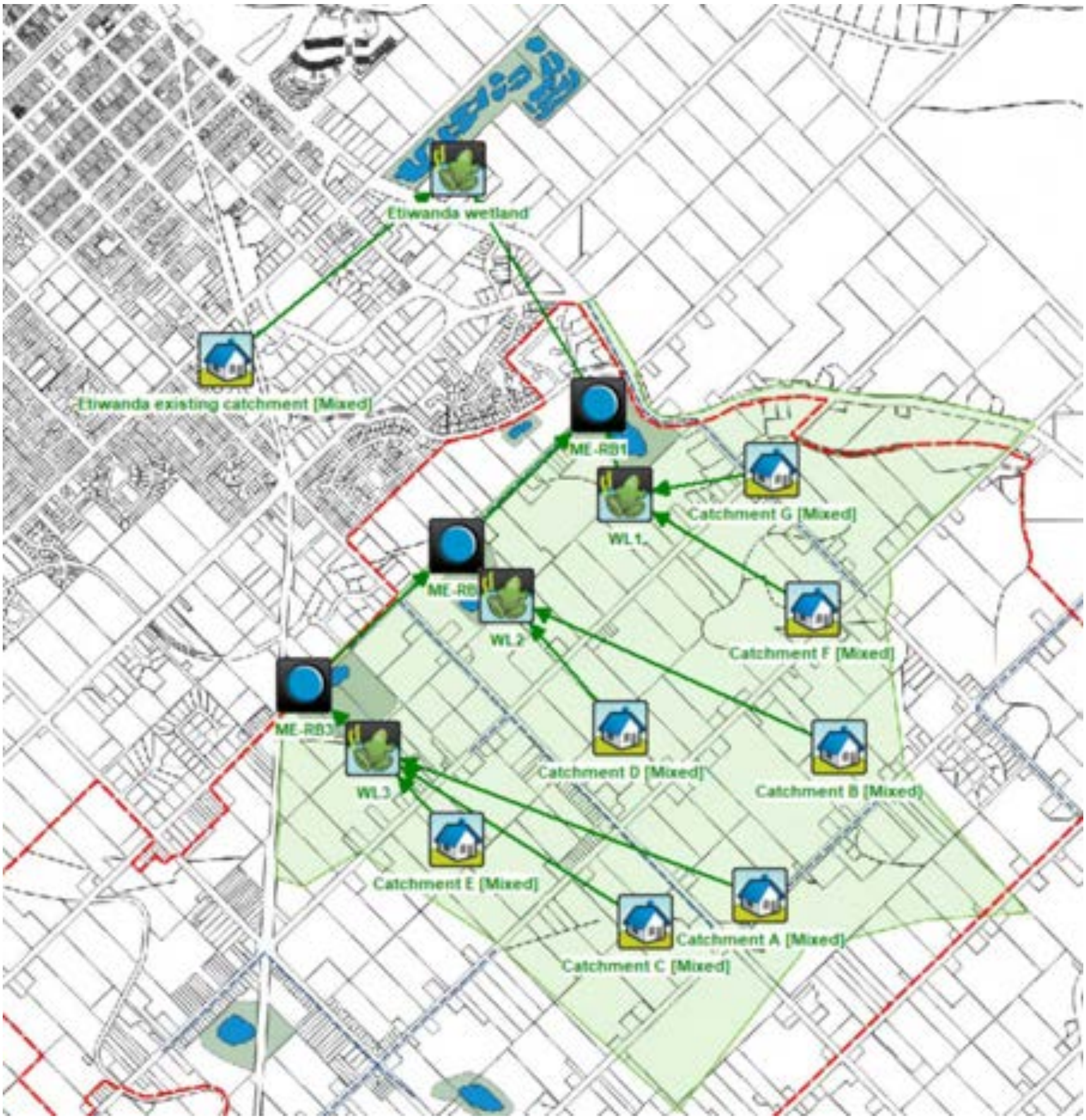


Figure 18: Mildura East treatment train set up

A summary of the treatment parameters is provided in Table 7.

Table 7 Etiwanda Wetland / Mildura East MUSIC Parameters

Reference Basin	Catchment Area (ha)	Fraction Impervious (%)	Wetland Area (m^2)	Sediment Pond Area (m^2)	Wetland: Impervious Catchment Ratio (%)
ME-RB3	243	8	5,000	2,500	3.6
ME-RB2	124	16	4,500	1,800	3.2
ME-RB1	154	35	14,000	2,000	3.0

4.3.1.2 Treatment Train Results

Whatever assumptions are made regarding the existing catchment, additional catchments of some 505 ha will place considerable pressure on the wetlands, and it must reasonably be anticipated that they will need to be expanded and/or additional treatment introduced upstream to ensure flows can be adequately treated. Refer to Table 8 and Table 9 for wetland MUSIC model results for the Etiwanda Wetland with the existing catchment, and for the existing and proposed catchment. Table 10 shows the MUSIC results with additional wetlands included. The upstream catchments are treated to best practice targets (Note that this does not necessarily equate to outflows from Etiwanda wetlands meeting best practice since it is an existing asset). Overall the percentage reductions at Etiwanda are similar or better (although noting loads will be higher since new development generates additional loads and best practice treatment does not equate to full mitigation to pre-development conditions).

Table 8 Treatment train results at outlet of Etiwanda wetland under existing conditions

Catchment	Sources	Residual Load	% Reduction
Flow (ML/yr)	1,220	1,130	7
Total Suspended Solids (kg/yr)	251,000	70,400	72
Total Phosphorus (kg/yr)	512	216	58
Total Nitrogen (kg/yr)	3,540	2,300	35
Gross Pollutants (kg/yr)	52,600	124	100

Table 9 Treatment train results Etiwanda wetland outlet under future conditions (prior to introducing additional assets)

Catchment	Sources	Residual Load	% Reduction
Flow (ML/yr)	1,550	1,470	5.2
Total Suspended Solids (kg/yr)	315,000	108,000	65.7
Total Phosphorus (kg/yr)	634	299	52.8
Total Nitrogen (kg/yr)	4,510	3190	29.2
Gross Pollutants (kg/yr)	64,700	254	99.6

Table 10: Treatment train results at Etiwanda wetland outlet under future conditions (after introducing additional assets)

Catchment	Sources	Residual Load	% Reduction
Flow (ML/yr)	1,550	1,440	7.3
Total Suspended Solids (kg/yr)	316,000	92,500	71
Total Phosphorus (kg/yr)	630	263	58
Total Nitrogen (kg/yr)	4,420	2,890	35
Gross Pollutants (kg/yr)	65,700	161	99.8

4.4 Nichols Point

The Nichols Point catchment currently has no stormwater treatment. It is anticipated to outfall to the Murray River Floodplain south of the racecourse at the site previously referred to as Sandilong Basin and now referred to as WL1 (Wetland 1) for clarity. These flows should preferably be treated with a wetland to mitigate potential risk of contamination of groundwater from untreated stormwater flows and therefore, as for other areas, contributions toward the cost of a wetland should be collected as development progresses.

With increasing urbanisation, it may eventually no longer be practical to simply discharge the stormwater to the floodplain and allow it to either evaporate or infiltrate to groundwater. Therefore, outflows from the wetland may potentially be pumped to Etiwanda Wetland in future. The need for this may be further investigated during future work and is unlikely to be warranted in the short to medium term.

Figure 19: Nichols Point catchment treatment train

A wetland to treat the Nichols Point catchment has previously been proposed for the Sandilong Basin (renamed WL1 for clarity) and will likely be the most practical treatment response for this catchment. We have assumed this will be the case with a wetland at this location and one additional wetland (WL2) within one of the retarding basins. Refer to Table 11 and Table 12 for wetland MUSIC model parameters and results respectively.

Table 11: Nichols Point Wetland MUSIC Parameters

Name	Reference Catchment	Catchment Area (ha)	Fraction Impervious (%)	Wetland Area (m^2)	Sediment Pond Area (m^2)	Wetland to Impervious Catchment Ratio (%)
WL1	ABE	107	65	12,000	5,000	1.1
WL2	CDF	100	65	12,000	5,000	1.2

Table 12: Treatment train results at outlet of Nichols Point wetland under future conditions

Catchment	Sources	Residual Load	% Reduction
Flow (ML/yr)	314	281	10.4
Total Suspended Solids (kg/yr)	63500	13200	80
Total Phosphorus (kg/yr)	132	44.4	67
Total Nitrogen (kg/yr)	911	503	45
Gross Pollutants (kg/yr)	13200	0	100

4.5 Irymple catchment

The southern parts of the subject area drain inland to the centre of the catchment and Irymple town centre. Flows are pumped from the basin at Henshilwood Reserve into 15th Street drain, flow on via gravity drainage to the Calder Basin and are pumped again before ultimately discharging to Lake Hawthorn.

Opportunities for stormwater quality treatment within the existing Irymple basins at Henshilwood Reserve will most likely be limited to effectively addressing the existing areas of Irymple itself, while any new upstream storage basins will also need to have wetlands included. The potential for wetlands at downstream basins such as Calder Basin and the proposed Etiwanda Basin could also be considered but space is limited at Calder Basin and these will also need to prioritise addressing their own catchment areas downstream of Irymple.

We therefore have not assumed any reliance upon wetlands within either Calder or Etiwanda basin for treatment of the Irymple catchments within the proposed response.

Sediment ponds and wetlands have been proposed within all viable retarding basins within the Irymple catchment including at Henshilwood Reserve as well as other existing and new basins to address water quality objectives. Figure 20 shows the Irymple catchment treatment train.

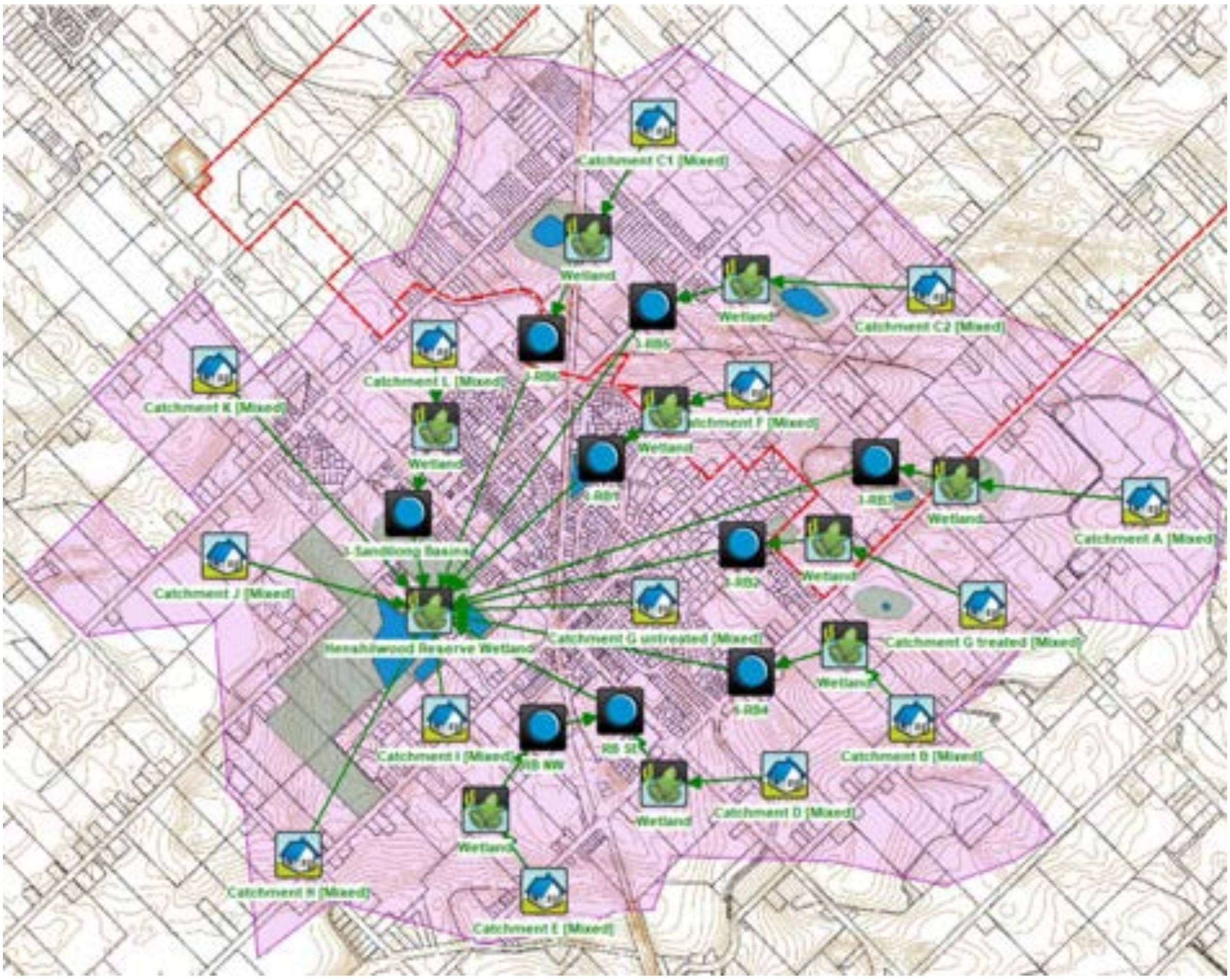


Figure 20: Irymple catchment treatment train

Setting aside the above complexities, an indicative unit sizing suggests that for the area involved, refer to Table 13 and Table 14 WSUD sizing and MUSIC model results respectively.

The wetland to impervious catchment ratio may be used to obtain an expected sizing for wetlands within each catchment area, relative to their upstream impervious catchment area (that is the proportion of upstream catchment that is impervious). This is generally at least 3% although some catchments are higher. All new development areas should meet relevant best practice objectives through WSUD assets for the relevant catchments including consideration of potential upstream catchment areas. We recommend that a drainage scheme approach is used to enable appropriate planning of these and to ensure costs are distributed equitably.

Table 13: Irymple Wetlands MUSIC summary

Reference Basin	Catchment Area (ha)	Fraction Impervious (%)	Wetland Area (m^2)	Sediment Pond Area (m^2)	Wetland : Impervious Catchment Ratio (%)
I-RB1	17.5	0.56	2,000	1,000	3.1
I-RB2	32.8	0.65	5,000	1,500	3.0
I-RB3	116.8	0.03	1,500	300	5.1
I-RB4	41.8	0.03	600	240	6.7
I-RB5	100.8	0.64	14,000	5,000	2.9
I-RB6	120.5	0.64	16,000	6,000	2.9
Sandilong Basins	32.3	0.65	5,000	1,500	3.1
Irymple Basin SE	104.2	0.08	2,500	600	3.7
Irymple Basin NW	38.1	0.16	1,800	420	3.6
Henshilwood Reserve Wetland (Existing)			10,000	1,000	

Table 14: Treatment train results at outlet of Irymple wetland under future conditions

Catchment	Sources	Residual Load	% Reduction
Flow (ML/yr)	792	716	9.7
Total Suspended Solids (kg/yr)	154000	65000	57.9
Total Phosphorus (kg/yr)	319	160	49.7
Total Nitrogen (kg/yr)	2260	1480	34.4
Gross Pollutants (kg/yr)	32800	9250	71.8

4.6 WSUD approaches, greening and cooling opportunities

Wetlands within retarding basins are the preferred stormwater treatment approach in Mildura. The climate conditions require robust treatment responses that can tolerate extended drying periods. We therefore recommend using wetlands where this is practical and expect these will be the most common response for any new development areas. Below is a typical of section of a sediment pond and wetland, with a pumped outfall configuration, that can be co-located within a retarding basin.

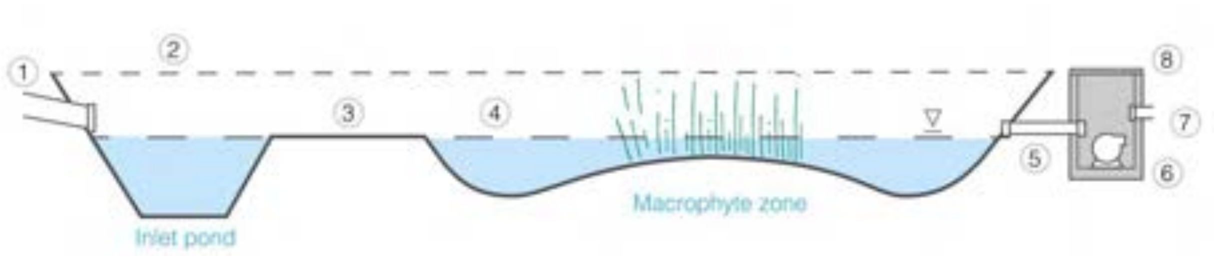


Figure 21: Cross section of a sediment pond and wetland with pump outlet

Biofilters, including bioretention, raingardens and tree pits may be feasible and should not be ruled out but will be more challenging and require special consideration and design to cope with potentially long dry periods. As such, they are not the preferred approach for end of line treatment. They are suitable for and will most likely be used within streetscapes and open spaces to enable passive irrigation of landscapes with stormwater and support greening and cooling.

It has been identified that there is a strong desire to create green links and increased canopy cover to support active transport such as walking and cycling. Trees and green areas passively irrigated with stormwater offer an effective means to achieve these. The use of the available stormwater from adjacent roads can significantly increase runoff flows and soil moisture storage to support vegetation. It is important to recognise that such assets (like most vegetated areas in Mildura) may still ideally require some potable irrigation during extended dry periods, therefore placement and extent will need to be considered in this context.

We recommend that road and street design should support passive irrigation of canopy trees. In low density residential areas, this may be progressed through relatively low technology and cost interventions such as flush kerbs draining into swales with trees planted along them.

In more urbanised areas, tree pits with kerbs and inlets may be used. Trees may be placed within the nature strip or on-road as bump-outs for traffic calming and between parking spaces. A drop-down kerb, porous kerb, infiltration trench or structural soils can aid in directing water into the soil around the tree.

Some examples of different approaches for raingardens and tree pits to achieve passive irrigation, greening and cooling are shown below. A number of relevant resources with further information have also been listed.

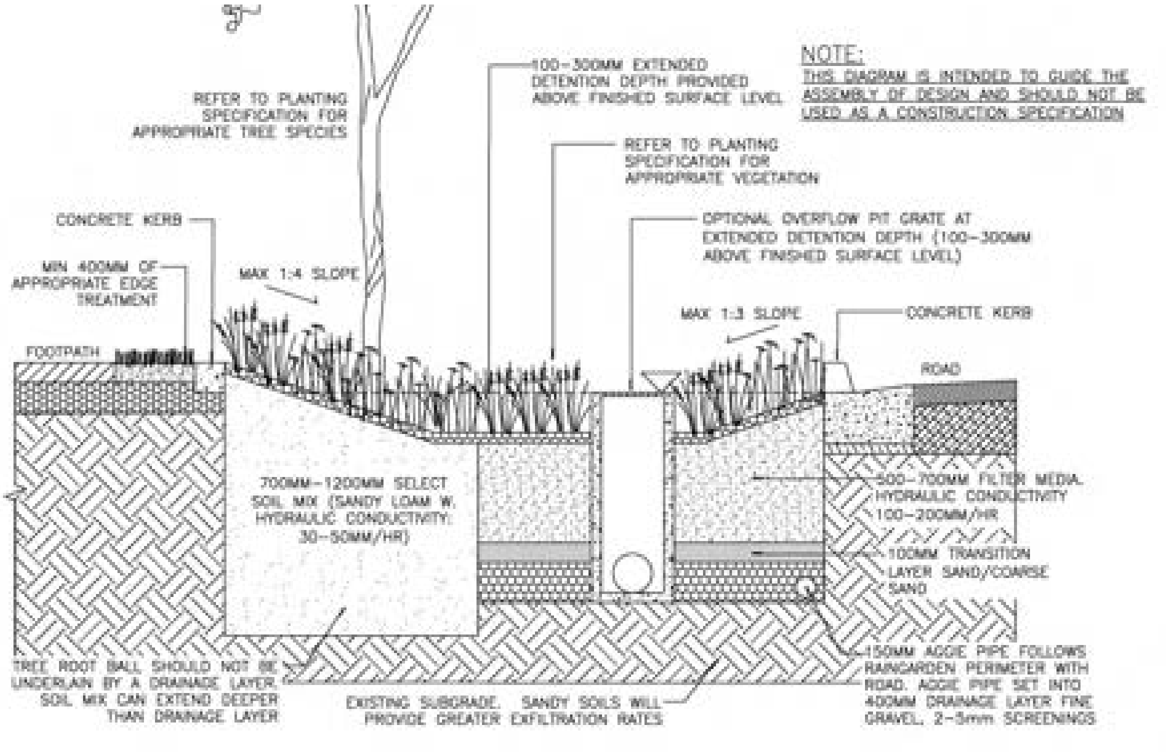


Figure 22 Raingarden section (E2Designlab, 2018)

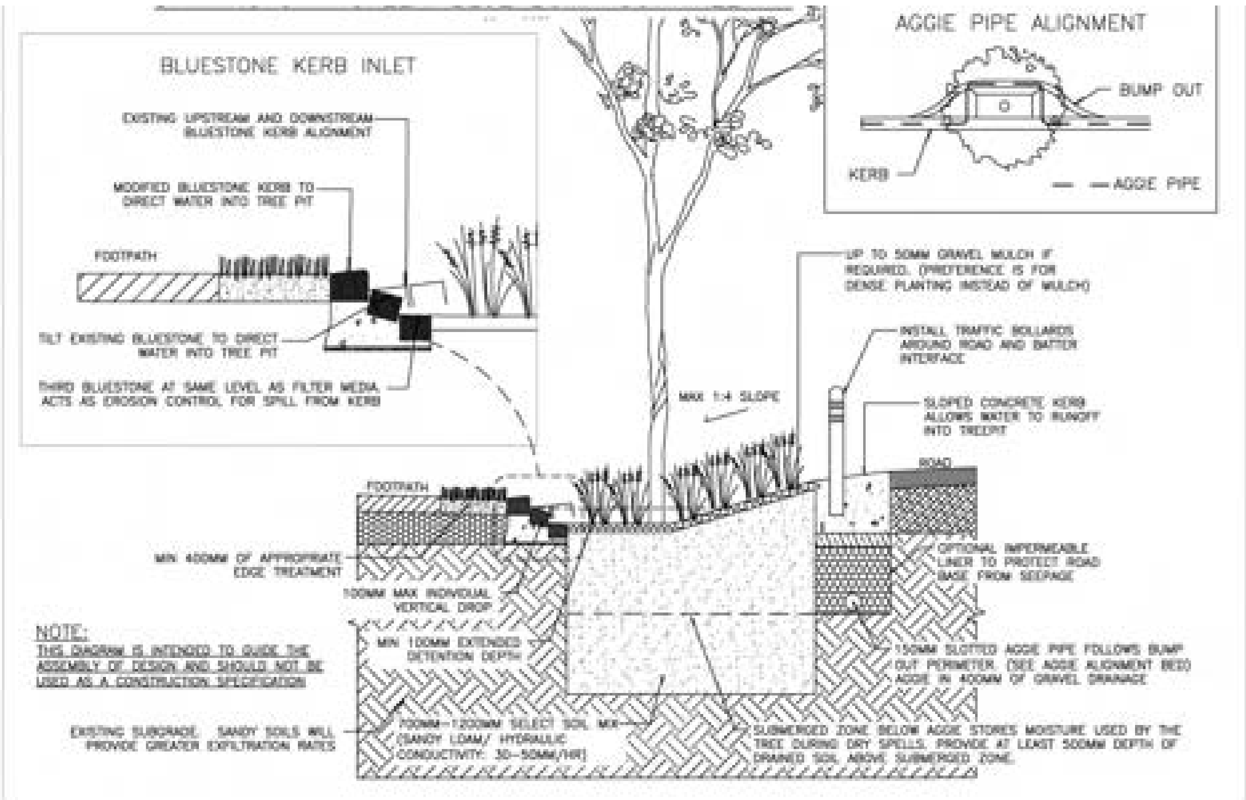


Figure 23 Tree pit section (E2Designlab, 2018)

Resources

The following resources may contain useful guidance, illustrations and cross-sections that Council can refer to and draw on where needed:

- Designing for a cool city – Guidelines for passively irrigated landscapes, CRCWSC, 2020, https://watersensitivecities.org.au/wp-content/uploads/2020/04/200427_V13_CRC-DesigningForACoolCity.pdf
- City of Yarra Embedding Green Infrastructure Guidelines, E2Designlab, 2018, https://www.yarracity.vic.gov.au/about-us/council-taking-climate-action/embedding-green-infrastructure-toolkit#accordion-design-guidelines
- DPIE NSW Water efficiency study for urban tree management, E2Designlab 2020, https://www.dpie.nsw.gov.au/__data/assets/pdf_file/0006/346659/Water-Efficiency-Study-Urban-Tree-Management-Report.pdf

Stormwater reuse

Taking into account the preceding discussions on water volumes for Lake Hawthorn, opportunities for stormwater reuse may be investigated at basins. In addition to providing alternative water supplies, the objectives for this would be to reduce the duration for which storage basins retain water, allow temporary storage areas (with multiple functions such as sports fields) to dry out and ensure that capacity is available for subsequent events.

Henshilwood Reserve is an obvious potential opportunity for stormwater reuse, given the extensive retarding basin and wetland areas as well as large sports field area that could potentially be irrigated. In future it is also likely to have a growing number of upstream storages, and these could be configured to slowly release water to Henshilwood, allowing that water to then be reused with an efficient stormwater harvesting system.

5 Conclusion

Development within the Mildura East strategic growth area is required to be able to safely capture and convey major and minor storm events as well as provide appropriate water quality treatment to protect the natural environment and waterways such as the Murray River. This report assesses the existing and potential future conditions of the subject site against these requirements and identifies potential interventions to achieve them in the ultimate scenario where possible, given the information available.

To summarise:

- The subject site is broadly divided into three main catchments:
    - Irymple area which drains into Henshilwood Reserve in the centre of Irymple and then to Lake Hawthorn via Mildura South
    - Mildura East which drains to Etiwanda Wetlands then the Murray River
    - Nichols Point which terminates within the Murray River floodplain. This location has previously been referred to as ‘Sandilong Basin’.
- The topography of the land is undulating with multiple low points. In some cases, these can be gravity drained but where this is not possible, further earthworks intervention or more likely pumping from trapped low points are necessary. This presents challenges for drainage design, particularly the need to accommodate significant storage volumes to allow time for downstream pumping, usually at much lower flow rates than would typically be possible in a gravity system.
- The Irymple catchment in particular has no natural gravity outlet and the township is located in proximity to the catchment low point. This situation requires special consideration of flood risks to the existing urban areas. Specifically, the potential impacts of flooding at Henshilwood Reserve and provision of commensurate storage for new development areas need to be considered. This study has endeavoured to identify the total storage volumes required for the catchment.
- *Significant new and upgraded drainage and storage infrastructure is required*. This is particularly the case in Irymple where flood mitigation is needed to both address long-standing flood risks and existing urban development as well as future proposed development.
- The potential consequences of outlet pump failure, above design events (to the probable maximum flood or PMF), changes in rainfall intensity and effects of residual stored water from events or agricultural drainage on subsequent events) are amplified relative to a conventional gravity drained catchment. These must be given due consideration in future drainage studies.
- *All new development within the Irymple catchment may increase existing flood risks and potential downstream flood impacts around Henshilwood Reserve which has a minimal and mechanical outlet need. These catchment level effects must be considered for all new development. This includes mitigation of flood volumes from new development to pre-development levels to at least the 1% AEP (but consider also the preceding point).*

- Retarding basins, underground pipe drainage and overland flow paths make up much of the minor and major drainage infrastructure needed. Retarding basins will be required throughout the catchment to reduce peak flow rates and cater for outfall infrastructure constraints. Other infrastructure such as pumps and swales may also be required where appropriate for the local context.
- Downstream infrastructure and its capacity in the areas of Irymple and Mildura South will need to be carefully considered when sizing infrastructure in the subject site. Similar considerations are also required for Etiwanda Wetland.
- Hydrologic modelling completed in RORB has seen an increase in flow rates and retarding volumes required when compared to earlier drainage strategies. This can be attributed to several factors such as: the update to AR&R19 rainfall data, differences in assumptions, catchment areas and levels of urbanisation analysed including revised assumptions for contemporary development conditions as well modelling methodology and software.
    - There have been several drainage strategies completed within the subject site and surrounding areas of Mildura over the last 20 years. These studies adopted ARR87 rainfall data and guidelines which has since been superseded by ARR19 rainfall data. The most recently completed drainage strategy of Nichols Point by Tonkin saw a 30% increase in infrastructure, which was regarded as being likely due to the change in rainfall data.
- RORB modelling for the Irymple and Etiwanda Wetland catchments was used to calculate the retarding volume required. A recent drainage study by Tonkin has sized the required retarding volume for Nichols Point.
    - Irymple catchment will require approximately 950 ML of storage within retarding basins
    - Etiwanda Wetland catchment will require approximately 316 ML of retarding basins
    - Nichols Point catchment will require approximately 36.4 ML of retarding basins (as correspondence with MRCC on 6 April 2023)
- The Nichols Point drainage study (Tonkin, 2022) completed modelling and sizing of drainage infrastructure for Nichols Point but did not consider the new development areas proposed by Council. The basins proposed will need to increase in volume and be shifted, or an additional basin required to accommodate the new development area.
- The extent of existing urban catchment currently draining to Etiwanda Wetland is unclear and best available information has been adopted. Further analysis and modelling will be required to understand its current loads and how best to configure treatment assets for other catchments to help support it.
- Discussions of EPA flow volume performance objectives must consider local context such as saline subsurface water table and downstream receiving waterbodies including Lake Hawthorn and Lake Ranfurly. Irrigation drainage flows to Lake Hawthorn have decreased substantially horizontally and there is a desire to maintain water levels for amenity and recreational purposes. While it is desirable to avoid excess stormwater inflows to waterways, it is likely that such efforts would not be warranted for this catchment. The management objective for discharges may be to reduce intense stormwater peak flows to more natural flow patterns (balancing ecological and

amenity objectives for the lake). The focus may be more on meeting stormwater harvesting and upstream objectives to better manage basin storage volumes and conditions.

- A wetland treatment asset referred to as NP-WL1 is proposed for Nichols Point within the Murray River wetland at the location previously referred to as Sandilong basin. A decision needs to be made regarding ultimate outfall for drainage from Nichols Point to consider whether this remains floodplain disposal (likely) or whether this may need to be pumped to Etiwanda wetland in future to limit wetting duration for the floodplain. A trigger for further assessment would be initiation of significant development within the Nichols Point catchment.
- Wetlands will be the primary form of stormwater treatment and preferred over bioretention due to the climate conditions. Other assets such as passively irrigated street trees may be pursued to realise objectives for increased vegetation and canopy cover for cooling and shade for active transport.
- Flows draining through Irymple are pumped and additional treatment will be required. Treatment assets are proposed to be co-located within new retarding basins to treat upstream catchments prior to discharge to Henshilwood Reserve. Alternatively, Council may want to consider a combined downstream treatment asset at either the Calder or Etiwanda basin.

It is recommended that Council:

- Adopt the indicative storage sizing and footprints within this report as an initial basis to inform development and drainage planning within the Mildura East growth area until such time as a more detailed and comprehensive drainage study is completed as per below.
    - The basin footprints provided are indicative of the area required for drainage infrastructure and may be used as a starting basis for future development plans. This should be referenced in conjunction with relevant drainage studies such as the Irymple Drainage Study (Aurecon, 2011) which identifies land for drainage basins. The development plans will also need to allocate public open space in addition any drainage requirements. Consideration should be given to incorporating drainage basins within broader unencumbered public open spaces where possible with an integrated design. This will allow benefits to be maximised and also provide a buffer for future uncertainties such as changing development expectations, climate change impacts on rainfall intensity, changes in guidelines and storm events above design intent.
- Undertake a comprehensive drainage review for Mildura to bring together, review and update prior work and provide a single consolidated understanding of the overall drainage system based on contemporary practices including AR&R 2019 assumptions, consideration of climate change and incorporating IWM principles.
- To support future precinct structure plans within the Irymple catchment or any development beyond the existing structure plan, it is necessary to undertake a comprehensive drainage study for the combined Mildura South and Irymple catchments. This should occur within the broader review of Mildura's drainage to confirm existing capacities, future needs and further develop drainage planning to provide for future development. This should include consideration of risk at the

catchment scale at all levels and probabilities (including PMF), AR&R 2019, climate change as well as implications of effective storage. The study may include:

  - Revision and update of drainage infrastructure plans throughout Mildura to account for changes in flow rates due to AR&R 2019 and inclusion of climate change
  - Review of basin size and footprint requirements throughout Mildura South as well as additional wetland requirements for stormwater quality treatment
  - Further refine and develop required storage basin and wetland volumes and required footprints taking into account batters and integration with surrounds. It is particularly important to consider the integration of drainage assets within open space and opportunities to deliver on a range of IWM and other objectives.
  - Confirm capacity of Etiwanda retarding basin and wetland to accept flows from the Mildura East north-west catchment and any changes in outlet design or configuration of the wetland that may be warranted to improve its operation.
  - Review assumptions and intentions regarding pumped discharge flow rates from Henshilwood Reserve and Calder Basin and whether these should be retained at 400 L/s or revised taking into consideration conditions and implications for the downstream drainage.
  - Consideration of flood risks for more frequent storm events such as the 5% and 20% annual exceedance probability (AEP) events to better inform residents of flood risks as well as above design event risk up to the PMF to better inform requirements for new development to manage downstream flood risks.
  - Establish minimum storage and other requirements for all new development areas within the Irymple catchment
  - Ultimate fate of flows from Nichols Point and whether floodplain discharge will remain acceptable for the foreseeable future and ultimate expected development for the area.
- Engage Tonkin to revise their Nichols Point drainage study to include the newly proposed development areas.
- Pursue efforts to upgrade infrastructure, increase storage capacity and acquire land within the Irymple catchment to address existing flood issues and prepare for future development.
- Invest in upgrade of the Henshilwood Reserve and Mildura South drainage infrastructure.
- A requirement is recommended to be applied for all future development, particularly within the Irymple catchment area to ensure that existing flood risks are not exacerbated as follows: *Developers and their consultants must take into consideration downstream flood risks (to at least the retarding basins within Henshilwood Reserve) and appropriate mitigation for all events up to the PMF in accordance with relevant AR&R requirements. Retarding basins are required for all new development areas to provide full mitigation of the 1% annual exceedance probability storm event for the critical duration to pre-development levels (or outlet pump flow rate if lower) as well as local flood mitigation requirements and constraints.*

Appendix A – Background Report Summary

Irymple Drainage Modelling (Aurecon, 2011)

Summary of drainage and hydraulic modelling for Irymple.

All flows drain to Irymple retarding basin. Flows are pumped from here into the 15th St gravity main discharging to Lake Ranfurly East with the pump station having a reported capacity of 186 L/s. Six (or seven) smaller pump stations service low lying areas. Drainage in rural areas is assumed to be limited to LMW's irrigation drainage with no formal drainage in most areas.

The report contains details for 14 retarding basins in the Irymple area.

Details of the accuracy or otherwise of data is recorded.

Further information on the LMW network is provided. The study found that overflows from the LMW rural network exacerbate and significantly impact on predicted flooding within Irymple. They also found that they need to be considered within the modelling to provide a good match between modelled and observed flows for a calibration event. In effect, rural areas should be considered as being effectively connected to the urban drainage system even if they lack urban drainage.

MRCC network has insufficient capacity in 1 in 5-year ARI. Significant flooding is predicted for the 1 in 100-year ARI event. It is identified that preventing or minimising overflows from LMW network may be more practical and cost effective.

A basin with at least 12,000 m^3 storage capacity and 45 L/s pumped outlet is needed to address flooding at Irymple Avenue, not considering future growth.

Mildura South Drainage Modelling (Aurecon, 2012)

This report details modelling of the Mildura South drainage network. Scenarios were developed for existing conditions and two future conditions accounting for 190 L/s and 380 L/s to be pumped from the Calder Basin into the Mildura South drainage system in Deakin Avenue respectively. The scenarios assumed a future development area catchment to the northern side of Fifteenth Street with an impervious fraction of 60% and 80% for the 2013 and 2030 scenarios respectively.

The report provides data on the Mildura South drainage network including existing and proposed retarding basins including the proposed Etiwanda Retarding Basin.

Mildura Stormwater Quality Improvement Plan 2009-2014 (BMT WBM, 2008)

This report contains useful information about the social and environmental values and other details of the Murray River, wetlands and waterbodies including Etiwanda Wetlands, Lake Ranfurly and Lake Hawthorn.

Sunraysia Drainage Strategy (Sinclair Knight Merz, 2002)

- Overview of context. Sets out principles and guidelines.
- Sets out a general drainage strategy for Mildura that forms the basis for all future design and construction work that has been progressed.
- Sets out a 20 year works plan.

The Sunraysia drainage strategy accounted for extensive future development albeit at a lower impervious fraction than is typically used for contemporary development. It also potentially did not fully account for the potential effects of rural areas draining to retarding basins within Henshilwood Reserve which were identified as significant in more recent drainage studies (Aurecon, 2011).

Lake Hawthorn Management Plan (Kate Lumb Consulting Pty Ltd, 2015)

Provides a comprehensive overview of management issues, lake operation and objectives for Lake Hawthorn.

Appendix B – RORB Modelling Summary

The following fraction impervious (FI) values were adopted throughout the site analysis:

- Pre-development zone FI = 0.01;
- Existing rural zone FI = 0.03; and
- Post-developed zone FI = 0.65

The following reach types were adopted for each scenario:

- Reach type 1 adopted for pre-development scenario
- Reach type 2 adopted for existing and post-development scenario

Due to there being insufficient data to accurately map all reaches throughout each catchment, reach type length was kept consistent through each scenario.

Refer to Table 15, Table 16, Table 17 and Table 2 for summaries of the RORB model for each scenario.

Table 15: Pre-Development Flow Estimation Summary

Catchment	Area (ha)	Nikolaou / von't Steen $Q_{pre\text{-}dev}$ (m^3/s)
Irymple	980	27.3
Mildura East	504	12.1
Nichols Point	223	16.7

Table 16: RORB model parameter summary

Parameter	Value		
	Irymple	Mildura East	Nichols Point
Catchment Area (km^2)	9.8	5.0	2.2
Initial Loss (mm)	15	15	15
Continuing Loss (mm/hr)	2	2	2
m	0.8	0.8	0.8
Average Flow Distance D_{av} (km)	1.80	3.26	1.56
K_c	6.89	4.94	3.29

Table 17: Pre-Development RORB Results

Catchment	Storm Duration	Temporal Pattern	$Q_{pre\text{-}dev}$ (m^3/s)
Irymple	6 hr	TP6	18.1
Mildura East	3 hr	TP1	15.6
Nichols Point	3 hr	TP6	8.5

Table 18: Existing RORB Results

Catchment	Storm Duration	Temporal Pattern	$Q_{existing}$ (m^3/s)
Irymple	3 hr	TP9	38.1
Mildura East	1.5 hr	TP8	29.3
Nichols Point	2 hr	TP4	13.5

Table 19: Post-Development RORB Results

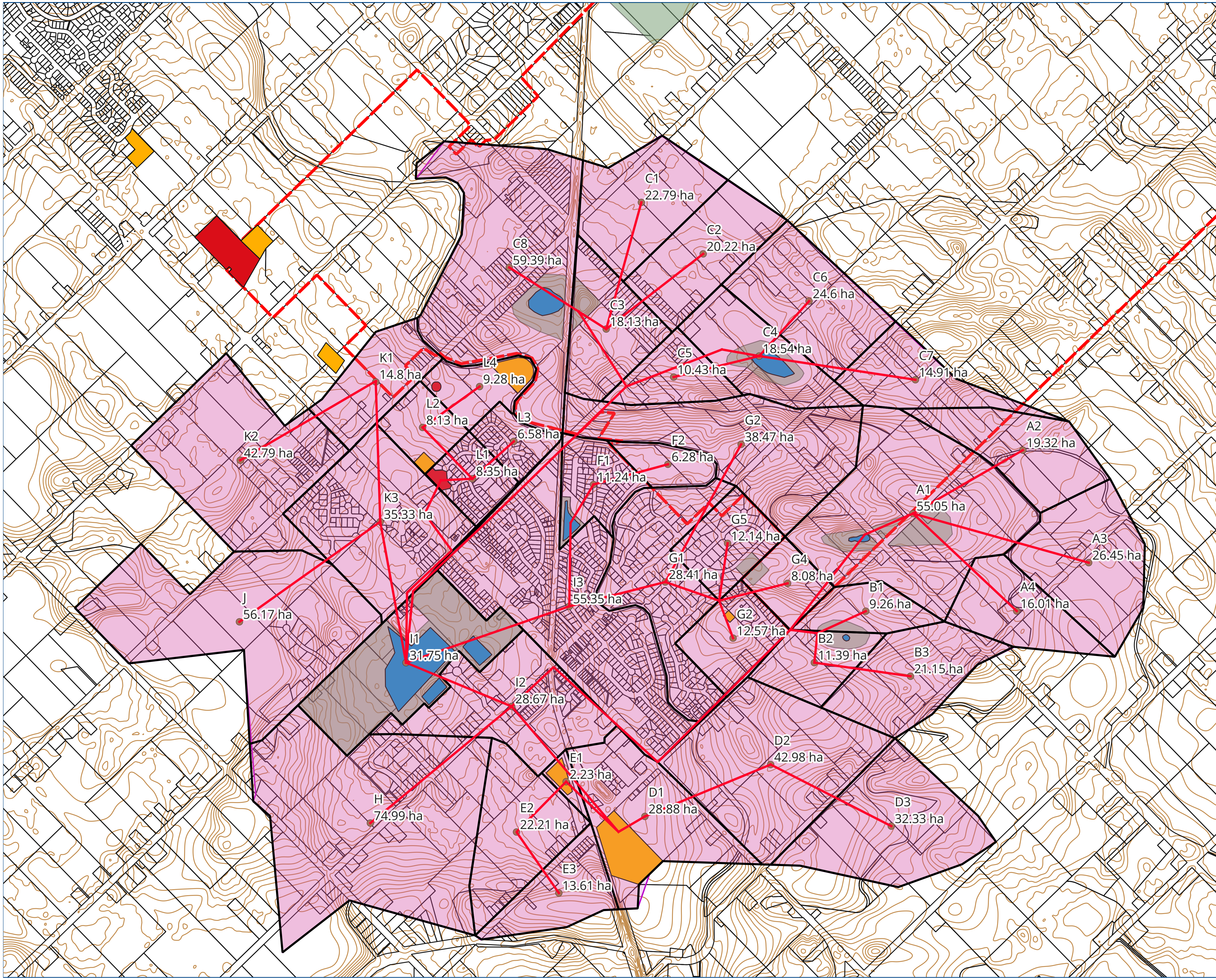
Catchment	Storm Duration	Temporal Pattern	$Q_{post\text{-}dev}$ (m^3/s)
Irymple	2 hr	TP10	48.5
Mildura East	1.5 hr	TP8	35.8
Nichols Point	1.5 hr	TP3	18.9

The land take required for the retarding basins was based on an average height of 1.5 m.

A pipe grade of 1 in 300 was assumed when sizing outfall pipes for the basins. Manning's equation was used to conservatively estimate pipe sizes. Further modelling of outfalls will be required at detailed design to refine the outfall pipe size.

The sediment pond area was assumed to have 1:1 ratio to the sediment pond storage volume required, which results in an assumed average depth of 1 metre.

Appendix C – Catchment Plans



Notes:

- Subject Site Extent
- Existing contours 500mm
- Cadastre
- RORB Centroids
- RORB Reaches
- RORB Catchments Irymple v2
- Proposed basin land take
- Proposed WSUD land take

Aurecon Basin

- Existing basins
- Preivously proposed basins

Revision	Description	by	Date
D	Revised catchments	DB	04/09/23
C	Revised catchment	DB	23/5/23
B	Final issue	DB	30/1/23
A	Preliminary Issue	DB	7/9/21

Status

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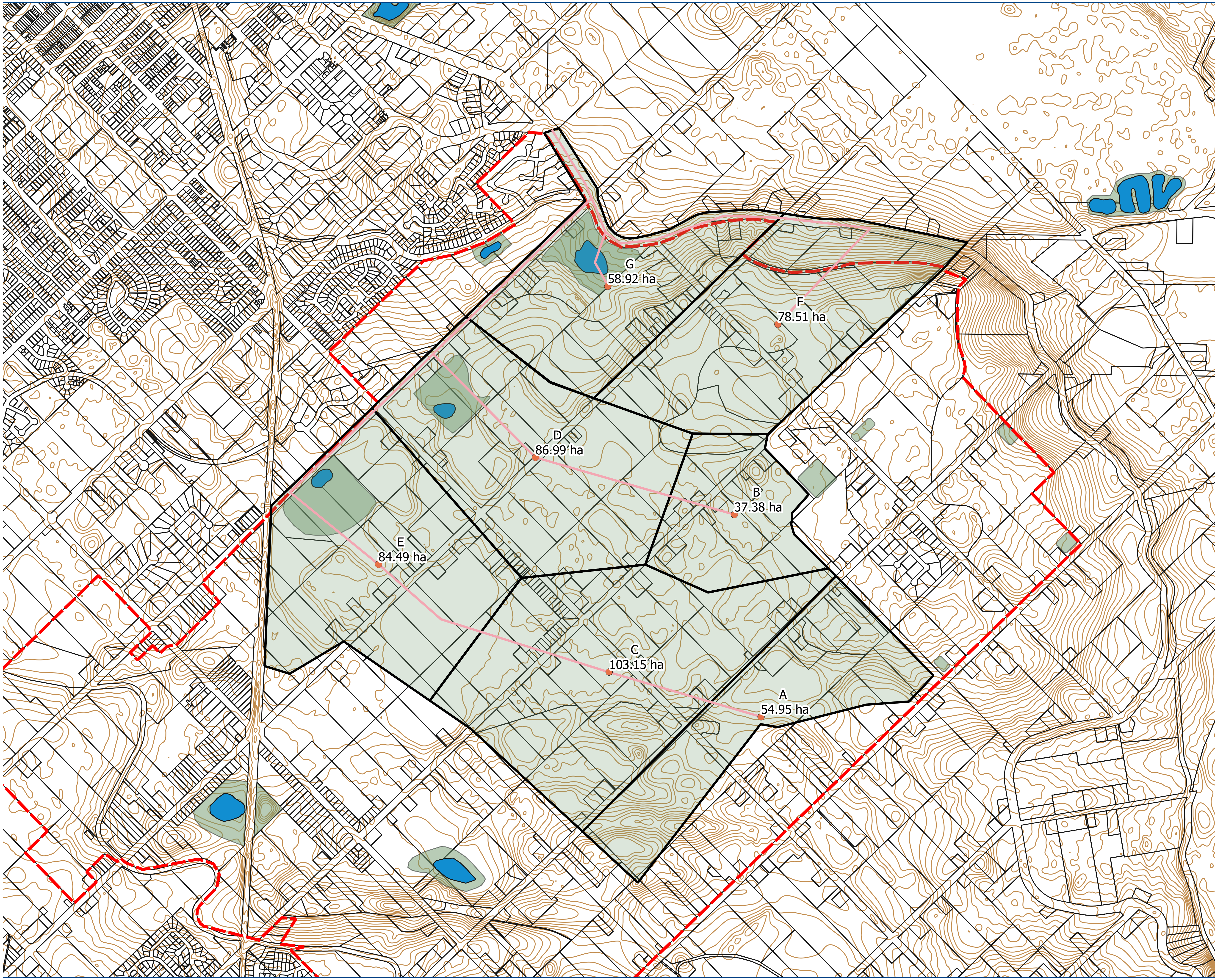
Client:
Hansen Partnership

Site:
Mildura East

Project Title:
Growth Area Strategic Framework

Scale @ A3	Date	Drawn	Checked
1:15000	04/09/23	ZI	DB

Project No.	Drawing No.	Revision
M1122_001	GIS 001	C



Notes:

Subject Site Extent

Existing contours 500mm

Cadastre

Revision	Description	by	Date
C	Revised catchment	DB	23/5/23
B	Final issue	DB	30/1/23
A	Preliminary Issue	DB	7/9/21

Status

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Project Title:
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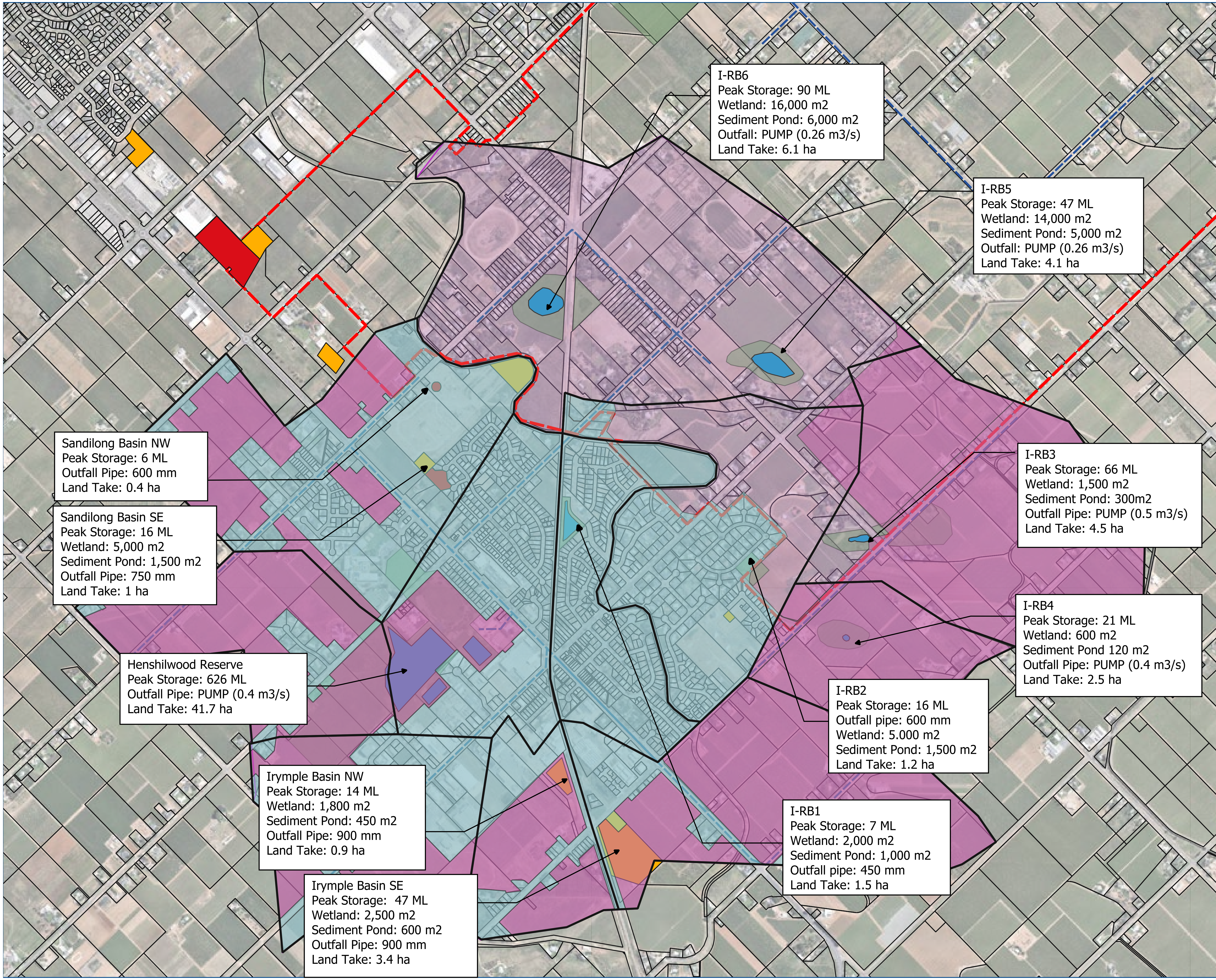
Scale @ A3	Date	Drawn	Checked
1:15000	23/5/23	ZI	DB

Project No.	Drawing No.	Revision
M1122_001	GIS 002	C

Appendix D – Drainage Plans



Legend:

- Subject Site Extent
- WSUD
  - WSUD Drainage Alignment
  - Cadastre
  - Proposed WSUD land take
  - Proposed basin land take
- Aurecon Basin
  - Existing basins
  - Previously proposed basins
- Land use
  - Developed
  - Undeveloped

Revision	Description	by	Date
F	Revised footprint	DB	05/02/24
E	Final issue	DB	04/09/23
D	Revised catchments	DB	23/5/23
C	Final issue	DB	24/03/23
B	Issued to client	DB	06/12/22
A	Preliminary Issue	DB	08/11/22

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Project Title:
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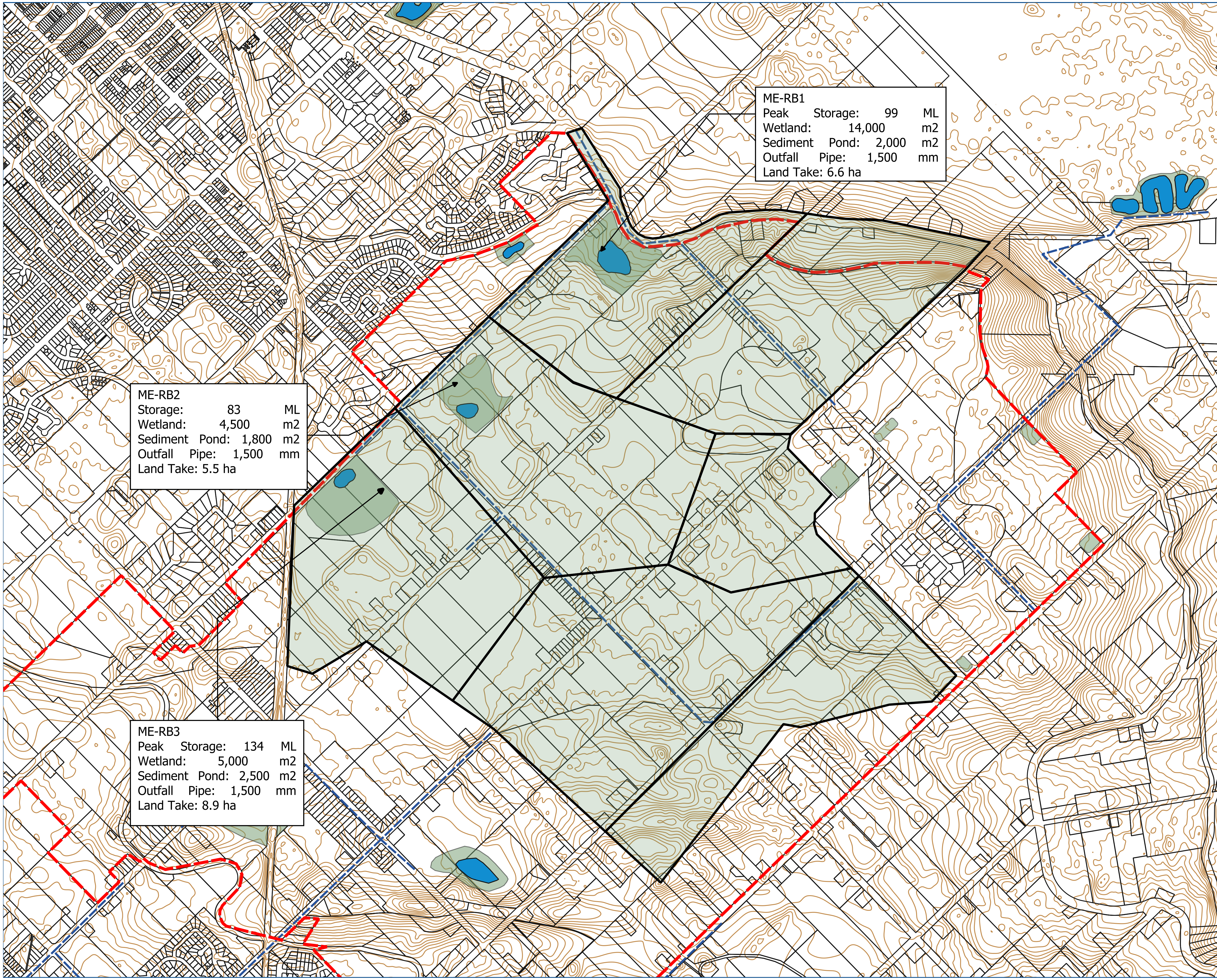
Scale @ A3	Date	Drawn	Checked
1:25000	2024/02/05	ZI	DB

Project No.	Drawing No.	Revision
M1122_001	GIS 004	F



Notes:

- Subject Site Extent
- WSUD
- WSUD Drainage Alignment
- Proposed WSUD land take
- Proposed basin land take
- Cadastre

Revision	Description	by	Date
D	Revised catchments	DB	23/5/23
C	Final issue	DB	24/03/23
B	Issued to client	DB	06/12/22
A	Preliminary Issue	DB	08/11/22

Status

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Scale @ A3	Date	Drawn	Checked
1:15000	2024/02/08	ZI	DB

Project No.	Drawing No.	Revision
M1122_001	GIS 007	D