Stormwater Management Strategy

Lara Farms - Rennie St, Lara

November 2024

Loetis Pty Ltd
Version: Rev06

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Document Control

Version	Date	Description of Revision	Prepared By	Reviewed By
Rev 00	Various 2022	Earlier Planit Consulting Reports	Planit Consulting	
Rev01	15 March 2024	Issued for rezoning application	LP	TR
Rev 02	20 March 2024	Issued for rezoning application	LP	TR
Rev 03	28 June 2024	Issued for rezoning application	LP	TR
Rev 04	4 November 2024	Issued for rezoning applications	LP	TR
Rev 05	6 November 2024	Issued for rezoning applications	LP	TR
Rev 06	11 November 2024	Issued for rezoning applications	**LP**	TR

Document Information

Prepared For	**Lara Farms Pty Ltd**
Report Title	**Stormwater Management Strategy**
Loetis Reference	**J10001**
Author	
Approved By	

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1 Background

1.1 Introduction

Loetis has been engaged by Lara Farms Pty Ltd to complete a stormwater assessment and prepare a Stormwater Management Strategy to accompany the rezoning applications for the subdivision of a collection of properties known as 'Lara Farms'.

These properties are individually identified as

- 76-156 Canterbury Road, Lara
- 785-805 Princes Highway, Lara
- 705-765 Princes Hwy, Lara
- 610 Rennie St, Lara

Collectively, these properties will be herein referred to as the 'subject site'.

The subject site is currently subject to two separate rezoning applications.

- Proposed planning scheme amendment **C444** proposes to rezone 76-156 Canterbury Road, 785-805 Princes Highway (Part) and 705-765 Princes Hwy, Lara (Part) for residential purposes.
- Proposed planning scheme amendment **C453** proposes to rezone 785-805 Princes Highway (Part), 705-765 Princes Hwy, Lara (Part) and 610 Rennie Street Lara (Part) for industrial / commercial purposes.

This report is intended to be read in conjunction with and support both applications, noting that both applications have shared stormwater catchments and proposed treatment assets.

It is noted that earlier reports commissioned by Lara Farms Pty Ltd were prepared by Planit Consulting and accompanied an earlier version of the planning application documents. This report supersedes these earlier applications, however, in part draws and expands on some of the works previously undertaken by Planit Consulting.

These reports are also proposed to be read in conjunction with the following reports prepared by Venant Solutions,

- Lara Farms – Preliminary Retarding Basin Requirements, M.M00441.03.00_RB_Analysis_Optimised
- Lara Farms Development, Limeburners Bay Ramsar Wetland Impact Assessment, R.M00441.01.02
- Lara Farms – Flood Impact Report, L.M00441.01.00_FIA

It is intended that this report covers off the overall site stormwater requirements and details the water quality elements, whilst summarising and referring to the Venant Solutions reports for the detailed water quantity (detention) requirements and assessment of downstream impacts, detailed calculations and discussion. These reports are enclosed as appendices to this report.

All three reports are intended to be read in conjunction with each other.

Revision 04 to the report is intended to more clearly delineate the individual planning scheme amendment applications.

1.2 Project Background

The subject site is approximately 113 hectares in overall size and is situated in the southeast corner of the Lara Township. This subject site falls within the City of Greater Geelong municipality and is currently zoned as Farm Zone (FZ).

As noted above, this report covers two separate proposed land rezonings.

Planning Scheme Amendment **C444** proposes to rezone 76-156 Canterbury Road, 785-805 Princes Highway (Part) and 705-765 Princes Hwy, Lara (Part) to general residential zone. This land area covers approximately 39Ha of land.

Proposed planning scheme amendment **C453** proposes to rezone 785-805 Princes Highway (Part), 705-765 Princes Hwy, Lara (Part) and 610 Rennie Street Lara (Part) to industrial 1 and 3 zones. This land area covers approximately 75Ha of land.

It is noted that the total combined catchments are 113Ha in size with which due to rounding is slightly different to the areas detailed above.

The overall site extent and the very approximate indicative split of the two rezonings is detailed in figure 1 below.

Figure 1 -Proposed Development Site

The proposed rezoning and developments will result in an increase in impervious surface area comparative to the existing conditions, which if not mitigated will result in an increase in stormwater runoff volumes, flowrates and contaminant loading. This report demonstrates a stormwater assessment based on proposed development expectations post rezoning and discusses the water quality and quantity measures proposed to be implemented to ensure the development delivers best practice stormwater treatment objectives and in accordance with local council and the planning scheme requirements. It is noted that the ultimate development layout will be subject to planning permit application process(s) with will require further iterations of this report and more detailed stormwater assessments at the relevant phases.

2 Study Objectives

The objective of this Stormwater Assessment is to demonstrate that a compliant solution is available for site post rezoning (subject to subsequent planning permit application(s)) in a manner that accords with local authority and best practice guidelines for stormwater quality and stormwater quantity treatment. This will enable a development to meet anticipated conditions and requirements to be set with the rezoning a future planning permit(s) for stormwater management and ensure that stormwater quality and quantity targets are achieved and maintained.

The site is located within City of Greater Geelong municipality boundary, as such stormwater objectives are based on local regulatory requirements as outlined in the Infrastructure Design Manual (IDM) along with the published Council 'design notes'.

Stormwater runoff generated within the site will be captured and conveyed via a combination of the underground drainage network and overland flow paths (road network) to the integrated stormwater treatment nodes to discharge to the site Legal Point of Discharge (LPOD).

Specific objectives are detailed below.

2.1 Site Stormwater Objectives

It is noted that the best practise requirements as outlined in the IDM are specifically,

1. Best Practice reductions for Water Quality

   - 80% reduction in Suspended solids (SS)
   - 45% reduction in total nitrogen (TN)
   - 45% reduction in total phosphorus (TP)
   - 70% reduction in gross pollutants (GP)

2. Stormwater Conveyance

   Conveyance of flows up to and including the 1% AEP flows to the Legal Point of Discharge (LPOD).

3. Stormwater Quantity

   Ensuring no increase in stormwater rates discharging from the Legal Point of Discharge (LPOD) for events up to and including the 1% AEP flows. It is noted that this element is covered by the Venant Solutions Report:
   Lara Farms – Preliminary Retarding Basin Requirements, M.M00441.03.00_RB_Analysis_Optimised

4. Stormwater Impacts on Downstream Environment

   Ensuring that any potential impacts on the downstream receiving environment are documented and assessed and options to implemented to ensure no impact. It is noted that this element of the investigation is covered by the Venant Solutions Report, Lara Farms Development, Limeburners Bay Ramsar Wetland Impact Assessment, R.M00441.01.02

The following stormwater management strategy will provide details on the stormwater treatment infrastructure and associated infrastructure requirements for the mitigation of runoff from an expected development outcome

under the proposed planning controls to ensure stormwater discharge targets are achieved before the designated LPOD.

3 Site Assessment

3.1 Site Description

The subject site is approximately 113 hectares in overall size and is situated in the southeast corner of the Lara Township. The subject site falls within the City of Greater Geelong (COGG) municipality and is currently zoned as Farm Zone (FZ). The subject site is identified for potential future residential and industrial development in the Lara Structure Plan.

The subject site is 'Wedge Shaped' shaped and is bounded by,

- On the North / Northeast side by Canterbury Road East
- On the Southeast side by Rennie Street / Princess Highway
- On the west side by the Geelong - Melbourne Railway line (Victrack Reserve).

Hovells Creek is located to the north and east of the of the subject site and is the ultimate drainage outfall for the broader area and entire site.

The site currently contains paddocks that have been grazed and cropped. For the specific site extents description and plans please refer to the proposed rezoning documents prepared by Tract Consultants, however Figure 1 gives a general indication of the proposed rezoning extents and Figure 2 for the details on the surrounding land usages.

Figure 2 – Subject Site and Surrounding Land Uses

The site ranges in elevation from a site low point of 5.6m AHD at the easternmost corner, to approximately 21.7m AHD in the south-westernmost corner. The site feature survey is shown in figure 3.

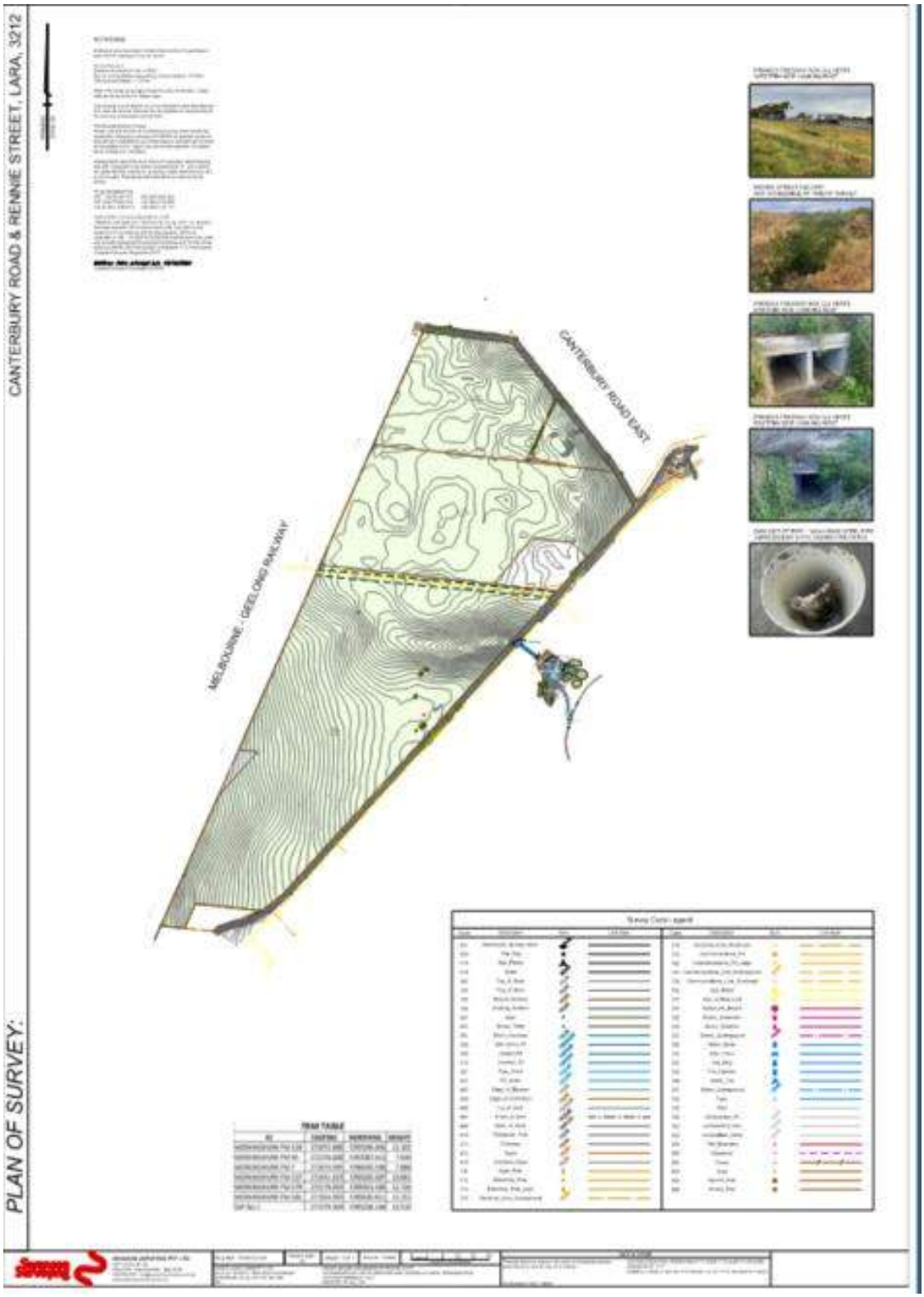


Figure 3 – Site Feature Survey (Image Courtesy of Swanson Surveying)

3.2 Engineering Design Considerations

3.2.1 Engineering Design Considerations

The internal roadways are proposed to become a COGG assets and will be designed in accordance with the Infrastructure Design Manual (IDM) as well as all codes and standards referenced in these documents. In addition, this stormwater assessment has been completed in accordance, but not limited to: COGG design notes; IDM, Melbourne Waters MUSIC modelling guidelines and wetland design manual; and ARR manuals.

3.2.2 Existing Watercourse

As per the planning map shown in Figure 3, an existing watercourse is present within the proposed development site. The existing watercourse has been further cross referenced against the Corangamite CMA Designated Waterways Map and it has been determined that the watercourse is not a catchment authority waterway, and that the CMA waterway commences downstream of the Princess Highway. See Figure 4 for details.

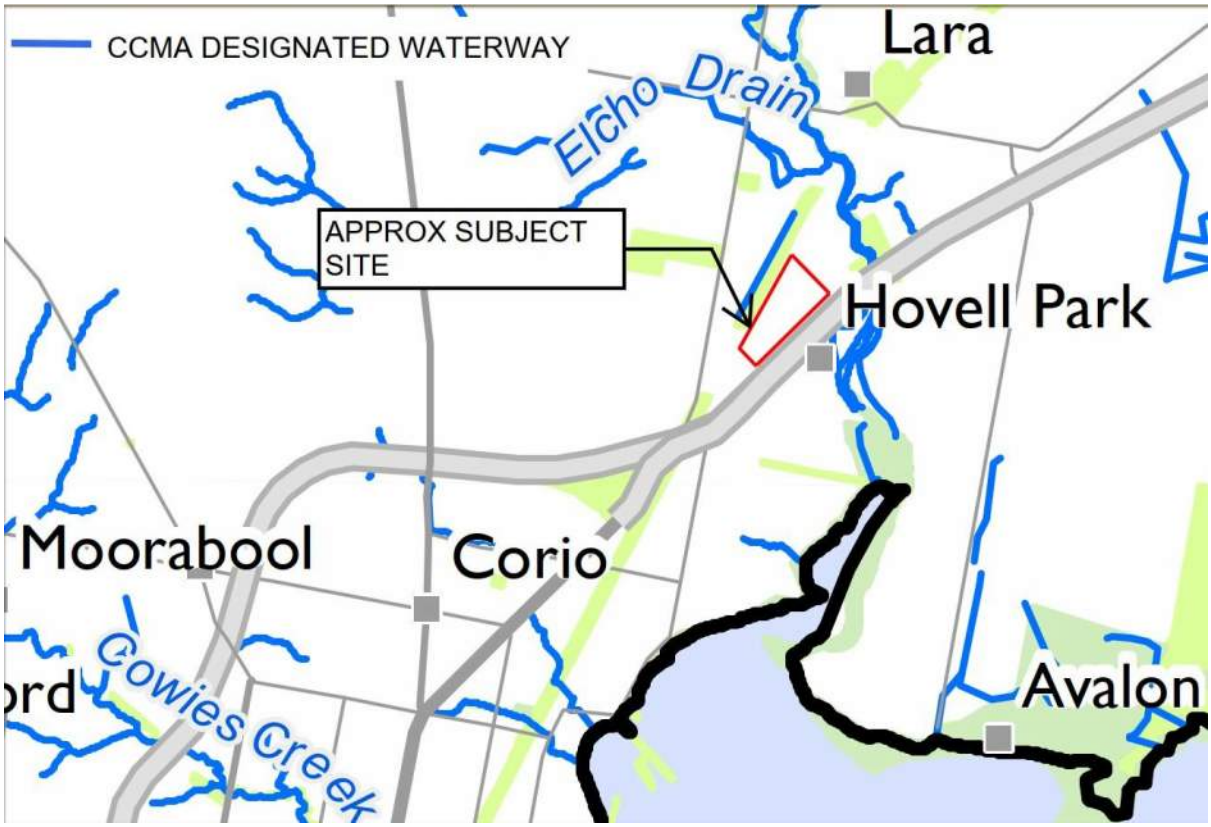


Figure 4 – Corangamite CMA Designated Waterways Map (Excerpt)

3.2.3 Flooding

The City of Greater Geelong commissioned a flood study within the Lara catchment in 2018 and this was finalised in 2020. The results of this flood study were proposed to be incorporated into the local planning scheme via a planning scheme amendment, however, following extensive community consultation, the proposed amendment has been abandoned.

It is noted that the proposed amendment would have identified part of the subject site as prone to flooding, however due to the abandonment of the process no formal designation has arisen. It is noted however that the

identified areas of flooding on the site are a result of flows generated from rainfall falling directly on the site and not from flows external to the site running onto the site. This identified areas of flooding is considered in part a result of the modelling approach undertaken (rain on grid) along with the flat nature of the site and the high-level scale of the modelling works.

Following liaison with Council officers, it is not considered as required to undertake flood modelling of the site and reference should be made to the catchment analysis in this report and in the Venant Solutions Report Lara Farms – Preliminary Retarding Basin Requirements, M.M00441.03.00_RB_Analysis_Optimised and the Venant Solutions Lara Farms – Flood Impact Report L.M00441.01.00_FIA.docx.

There are Flood Overlays adjacent to the subject site along Hovells Creek, however they do not extend to the subject site. See Figure 5 for details of the Flood Overlay associated with Hovells Creek which is external to the site.

Figure 5 – Hovells Creek Flood Overlay external to the site

4 Stormwater Assessment

4.1 Stormwater Assessment – Existing Conditions

4.1.1 Existing Site Conditions, Catchments & LPOD

The subject site has two existing distinct catchment areas, nominally the 'northern' and 'southern' catchments. They are separated by a natural ridgeline that runs east to west across the site. This ridgeline becomes less pronounced through the central and western part of the subject site with the top of the ridge forming a large plateau of very flat ground.

The southern and northern catchments are defined by a shallow ridgeline with the Rennie Street (eastern) end at approximate RL 10.8m and the western end at approximate RL 12.0m – 12.2m. As noted above, there is a significant plateau area that has very flat grades in the range of 1V:250H – 1V:500H+. The exact catchment delineation in this plateau area is undefined with irregular undulations further obscuring the surface fall.

The approximate extent of this plateau area is detailed in Figure 6 below.

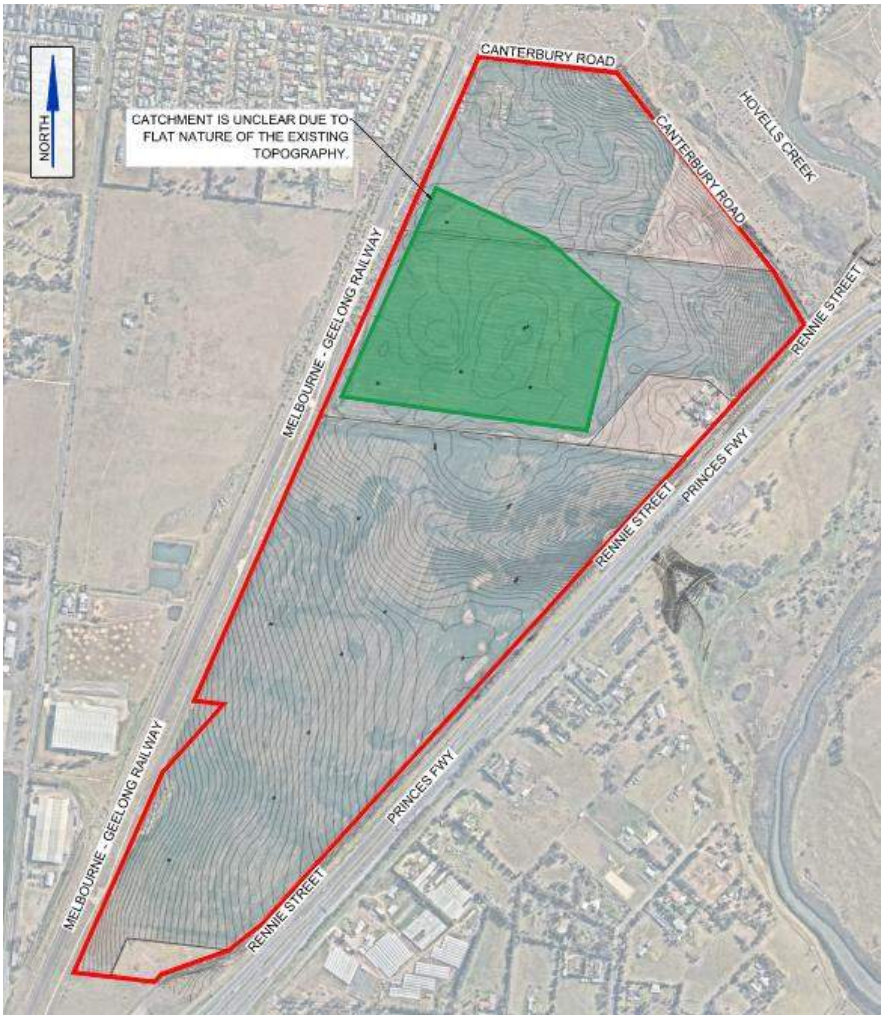


Figure 6 – Approximate Plateau Area

To complicate this catchment delineation, this flat plateau area is also bisected by the boundary between the two rezoning applications.

It is noted that the adopted catchment delineation in this area directs a larger portion of this plateau area to the north than to the south. Noting the adopted developed case catchments below, it is considered that this combined approach results in a more conservative assessment of the overall site runoff, particularly when assessed against the downstream conditions.

The northern catchment is approximately 50.7Ha in size and split into several smaller sub catchments. The site catchment has a high point of approximate RL 12.5m AHD located adjacent to the railway line in the west corner of the catchment and a low point of approximately RL 5.6m AHD located adjacent to the east corner of the site.

Canterbury Road traverses the full northern / northeastern boundary of the site and generally falls west to east across the frontage. However, there are two localised low points and three culverts located along the road. In all cases, there is no downstream infrastructure or flow path delineation downstream of the road culverts and the local catchments internal to the subject site are very small.

The intersection of Canterbury Road North and Rennie Street is considered the nominal Legal Point of Discharge for the site, however it is noted that there is minimal existing stormwater conveyance infrastructure at this location and practically, the flows from the site in the developed case will need to be safely conveyed northwards, some 300m, to Hovells Creek adjacent to the Rennie Street crossing.

The southern catchment is approximately 71.5Ha in size and has a high point of approximate RL 21.70 AHD in the southwestern most corner and falls to the northeast. Typically, the grades are in the order of 1 (vertical) in 50 (horizontal), with the steepness increasing near the low point to approximately 1V:20H. The southern catchment falls to a low point of approximate RL 6.5 AHD, with the low point located adjacent to the Rennie Street boundary and is located some 400m south of the Canterbury Road intersection. This low point discharges into culverts under Rennie Street and subsequently under the Princess Freeway. These culverts are considered the nominal Legal Point of Discharge (LPOD) for the southern catchment. This watercourse then continues east of the freeway overland through Council reserve before discharging into Hovells Creek which is considered the ultimate point of discharge for this catchment.

The site does not contain any internal stormwater infrastructure with stormwater appearing to sheet flow offsite generally in line with the above descriptions.

The adopted existing catchment areas are detailed in Figure 2 of the Venant Solutions report Lara Farms – Preliminary Retarding Basin Requirements, M.M00441.03.00_RB_Analysis_Optimised.

4.1.2 Upstream (External) Catchments

The site is bounded along the entire western boundary by the Melbourne to Geelong railway line. There is a significant open drain located on the western side of the railway lines that conveys upstream flows northwards to Hovells Creek. Additionally, the railway line(s) along the majority of the subject sites west frontage is constructed as an embankment. It is considered that this open drain in conjunction with the railway embankment effectively prevents any upstream catchments discharging into / across the subject property.

It is noted that there will be a portion of the railway reserve on the east side of the railway lines that will discharge into the site at locations, this small catchment(s) will need to be allowed for in the detail phases of the development of the subject site, and is allowed for in the Venant Solutions Report Lara Farms – Preliminary Retarding Basin Requirements, M.M00441.03.00_RB_Analysis_Optimised.

4.1.3 Existing Downstream Conveyance

The northern catchments existing LPOD is considered to be to the existing swale drains located in Rennie Street and Canterbury Road East. These swales drain overland and discharge into Hovells Creek.

The southern catchments LPOD is to the existing culverts under the Princess Highway. Downstream of this, the flow path flows eastwards through Council reserve and vegetated floodplain and into Hovells Creek. This flow path and potential downstream impacts are assessed and discussed in detail in the Venant Solutions report R.M00441.01.02 Impact Assessment.

4.2 Stormwater Assessment – Developed Conditions

4.2.1 Developed Site Catchments

As noted in the existing conditions analysis, the demarcation between the northern and southern catchments is quite flat and not clearly defined in the existing case. In preparing this strategy, along with the anticipated land use types and treatment mechanisms, particular consideration has been given to the downstream flow paths and the site topography at the proposed basin locations.

Additionally, there is a gas transmission pipeline owned and managed by APA that transects the site west to east, generally along the alignment of the 705-765 Princess Highway northern boundary. This gas transmission line has stringent requirements around clearance to services crossing the line and to maintenance of existing cover to new roads and or surfaces. This line therefor limits the ability to convey stormwater flows across the gas line in the developed conditions.

As such, a portion of the nominally northwards flowing catchment has been directed to the central basin located to the north of the gas transmission pipeline, where a more practicable treatment asset can be delivered in the more suitable topography of this site. Given the flat plateau like topography in the current conditions, analysis showed that a similar amount of earthworks and shaping would be required to ensure flow paths at minimum grades would be required to be undertaken in this area regardless of where this water is directed.

It is noted that the central catchment includes an area nominated as possible regional sports reserve. It is noted that negotiations on the requirement for and ownership transfer mechanisms are still ongoing between stakeholders. As such, whilst the stormwater detention and treatment calculations have been based on appropriate impervious figures reflect the possible regional sports reserve, the land take nominated for the central basin has been increased to reflect sufficient land should the regional sports reserve not eventuate, noting that the underlying zone would support employment uses consistent with the balance of the precinct under this scenario.

The adopted developed case catchments are detailed in figure 7 below.

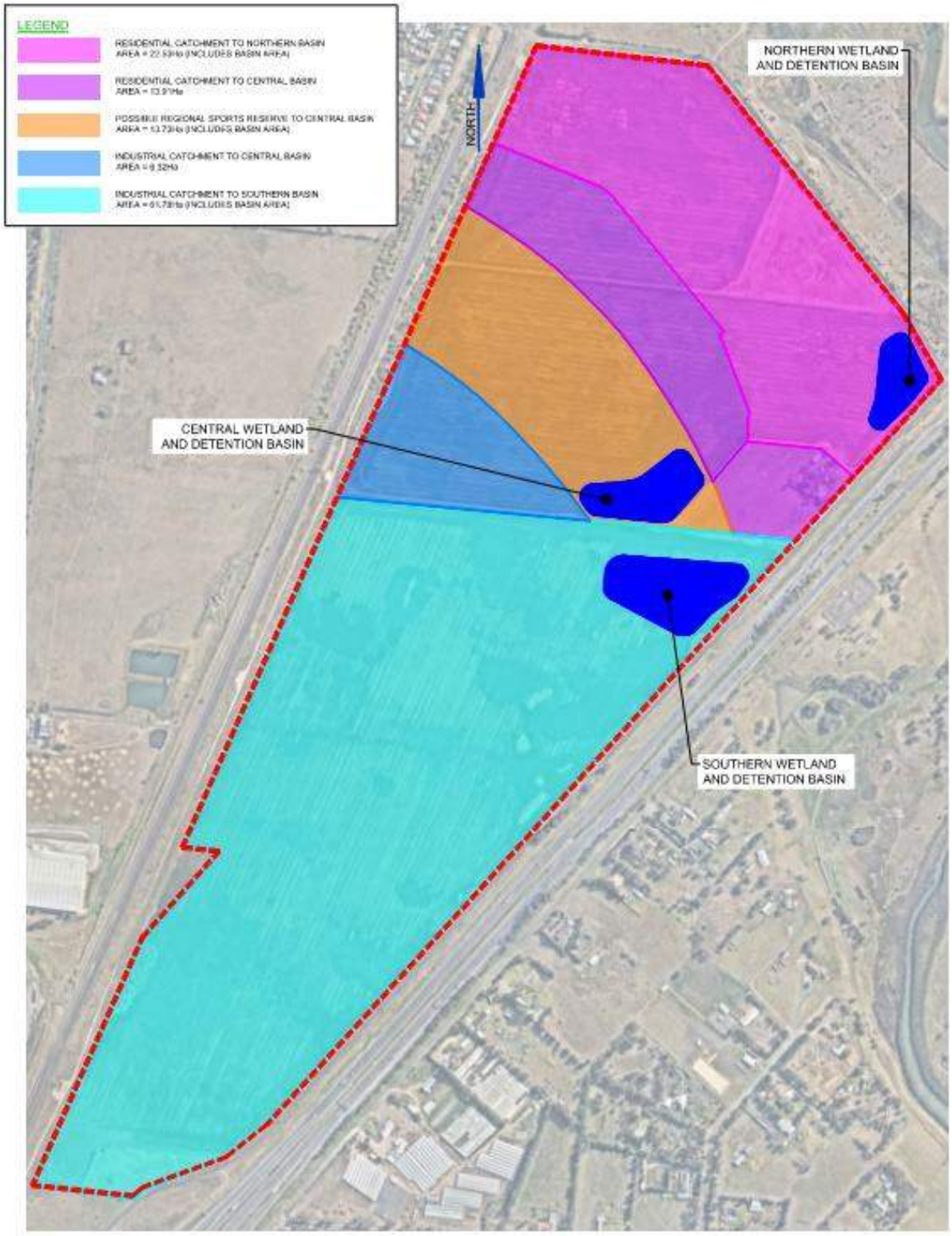


Figure 7 – Developed Site Catchment Plan

4.2.2 Developed Site Outlet – Northern Basin (C444)

As noted previously, there is minimal existing stormwater infrastructure in the vicinity of the Canterbury Road East and Rennie Street intersection and downstream to Hovells Creek. As such it is proposed to extend the discharge from the northern basin via a combined piped and swale outlet discharging to Hovells Creek.

This area has a number of constraints including a significant number of existing authority services and to the north of Rennie Street some sensitive vegetation. The area and proposed alignment is also subject to an approved Cultral Heritage Management Plan covering the proposed outfall works. The plan detailed below in Figure 8 was prepared to inform the CHMP and outlines the proposed outfall works. It is noted that this proposed outfall arrangement is designed to avoid or minimise impact on all known vegetation, cultural heritage and existing services in the vicinity. It is noted that authority reviews and approvals including works on waterways permit will ultimately be required to validate and approve this concept outfall and the ultimate design will be subject to these stakeholder discretion and inputs.

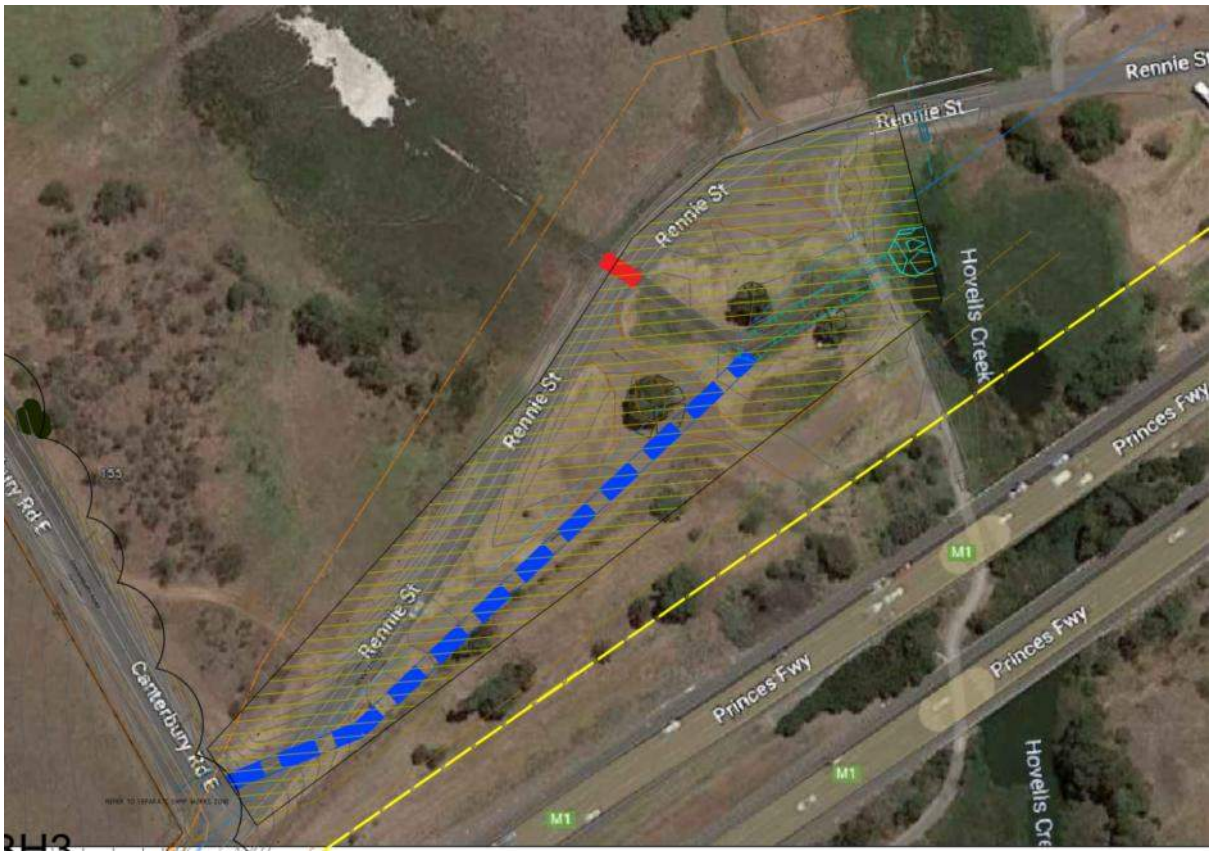


Figure 8 – Concept Northern Drainage Outfall

4.2.3 Developed Site Outlet – Central and Southern Basins (C444 & C453)

As detailed in the Venant Solutions report report R.M00441.01.02 Impact Assessment, any significant increase in mean monthly volumes downstream of the southern basin outlet has the potential to impact on the downstream floodplain. As such, it is proposed to divert the increased volume of flows northwards via a 'low flow' pipe, to join with the outlet from the northern basin and discharge directly into Hovells Creek.

Based on preliminary calculations by Venant Solutions using the assessment presented in R.M00441.01.02_Optimised, the peak diversion flow requirement is likely to be in the range of 0.1 – 0.2m^3/s.

This proposed flow diversion is covered in the Venant Solutions reports, which detail the changes in both the mean monthly volumes which are directed away from any environmentally sensitive areas and also the peak stormwater flows from the site which are not increased above predevelopment peak flows.

This splitting of low and high flows from the central and southern basin is detailed in Figure 8 below. In summary, the outfall from the southern and central basins will have a low flows directed via pipe northeastwards along Rennie Street and joining with the outlet from the northern basin. The higher event flows (limited to pre development peaks) along with environmental flows will continue south eastwards to the existing culverts under Rennie Street and the Princes Freeway.

The proposed schematic layout of this arrangement is detailed in Figure 9 below.

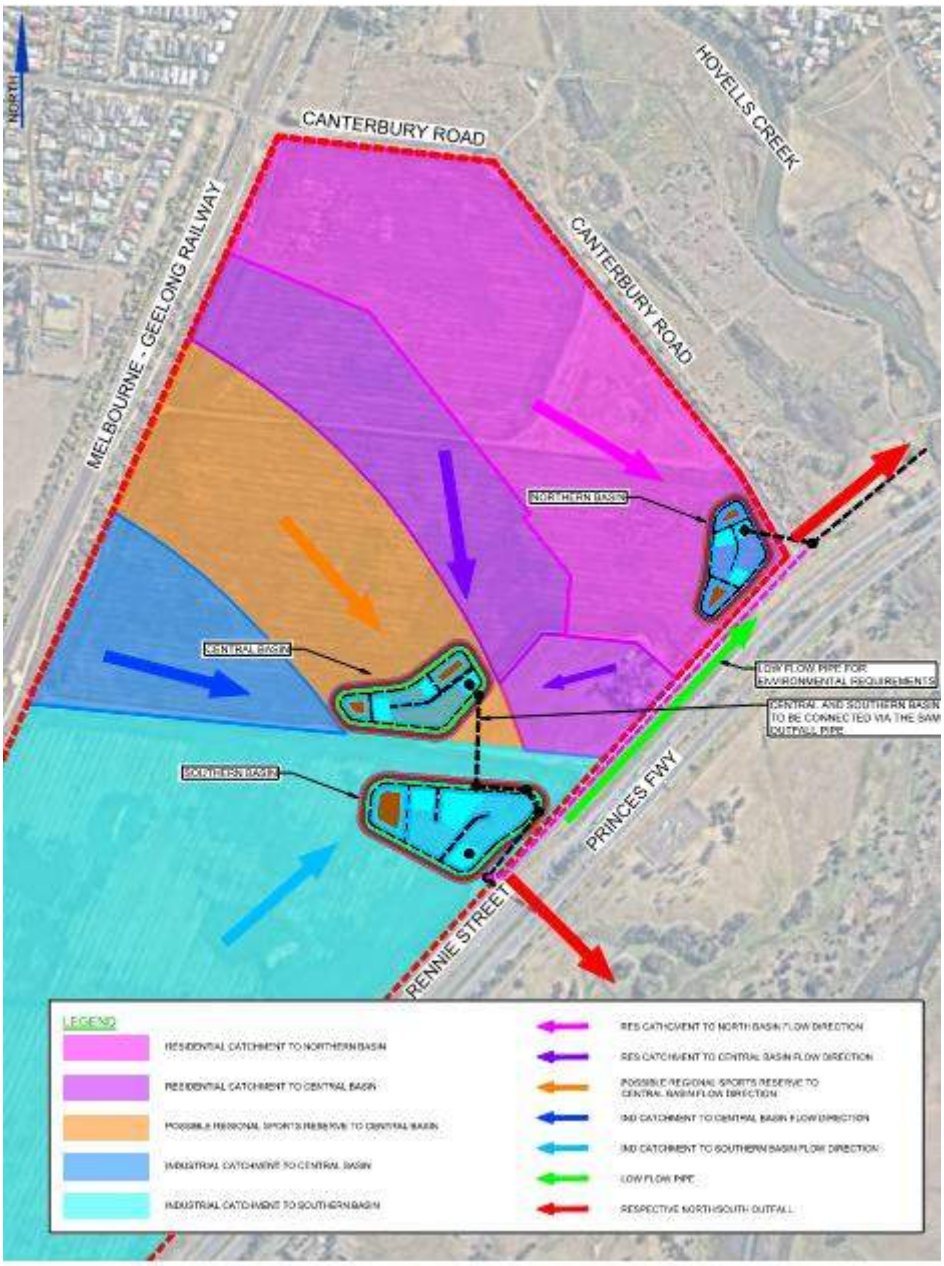


Figure 9 – Concept Southern Drainage Outfall & Low Flow Diversion

This low flow diversion pipe will traverse through the high point in Rennie Street before it effectively 'daylights' and reverts to follow the natural surfaces grades before matching with the northern basin outlet. At the maximum depth point through the high point, the pipe is approximately 3.5-4.0m deep (surface level to pipe invert) which is considered as a practicable depth to construct and maintain.

4.2.4 Proposed Detention Basin Concept Plans

Concept designs of the proposed combined wetlands and detention basins have been prepared to inform the stage storage relationships for the detention requirements and validate the proposed wetland footprints required for treatment purposes.

The basins are proposed to be constructed in a 'standard' arrangement with the wetland including the extended detention storage sitting below the detention storages in both basins. The concept designs have reflected standard Council and Melbourne Water requirements around batter slopes, wetland bathymetry, maintenance access and freeboards etc. However, it is considered that their designs will be optimised and evolved as additional levels of detail for both the basins and the surrounding development are progressed through the planning and detail design phases and as such will alter. The level of work completed however is considered sufficient to validate the proposed design concepts and site constraints.

A copy of the proposed basin concept designs are detailed in figures 10 (northern Basin) and figure 11 (Central and Southern Basins) below.

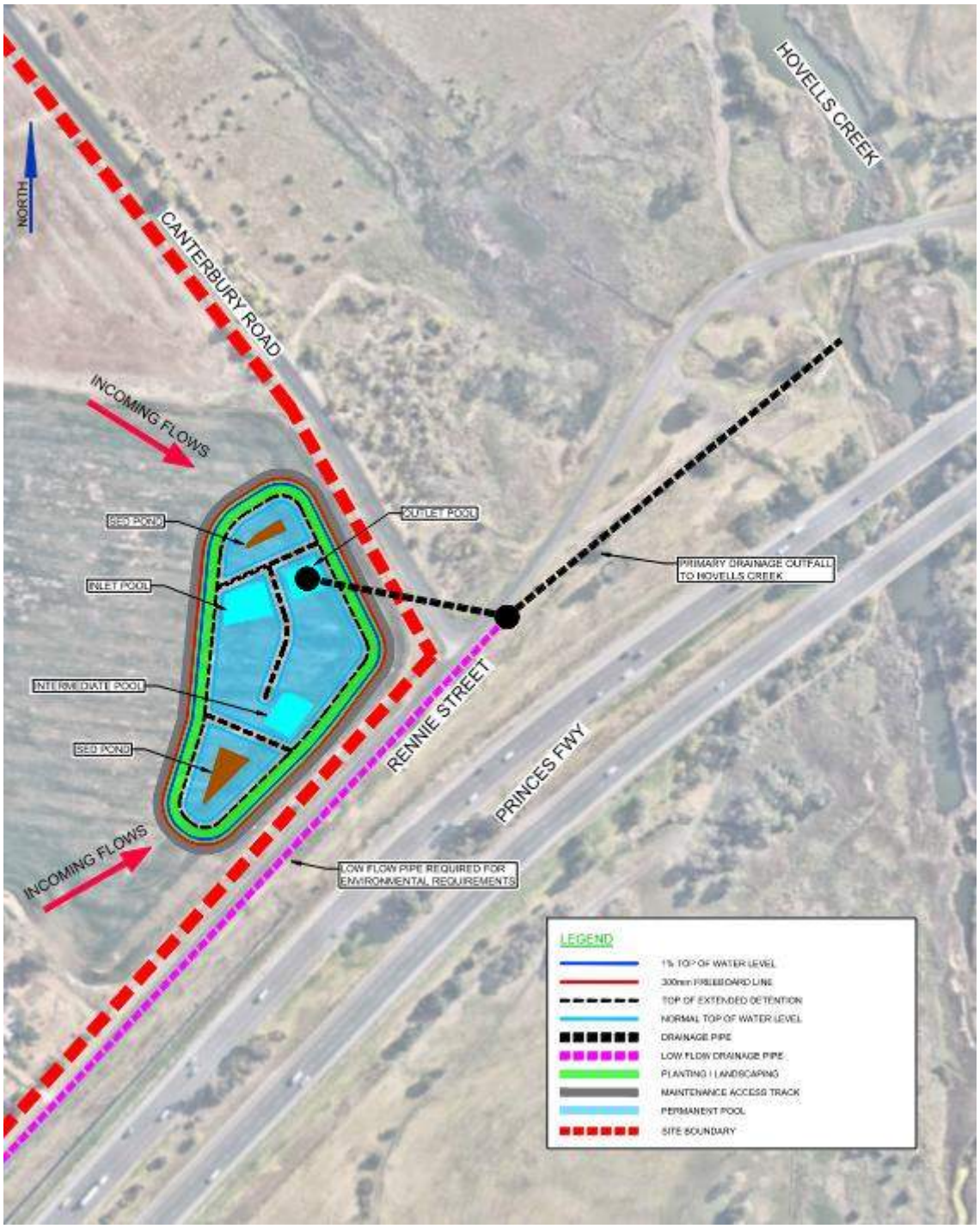


Figure 10 – Concept Northern Basin Concept Plan (C444)

The concept design for the northern basin has an indicative overall footprint of approximately 1.5Ha in total size, this incorporates the wetland and basin footprint as well as the batters access track(s) and also sediment set down / drying zones.

The conceptual design has been undertaken in line with the Melbourne Water deemed to comply guidelines, however given that no formal area set aside for the basin will be 'locked in' as part of the rezoning process, it is

considered that a more detailed design undertaking and formal assessment against the checklist is considered as an unreasonable requirement to be undertaken at this phase of the project.

This footprint will be refined and optimised as the project moves in more detailed phases and should be treated as indicative only at this time.

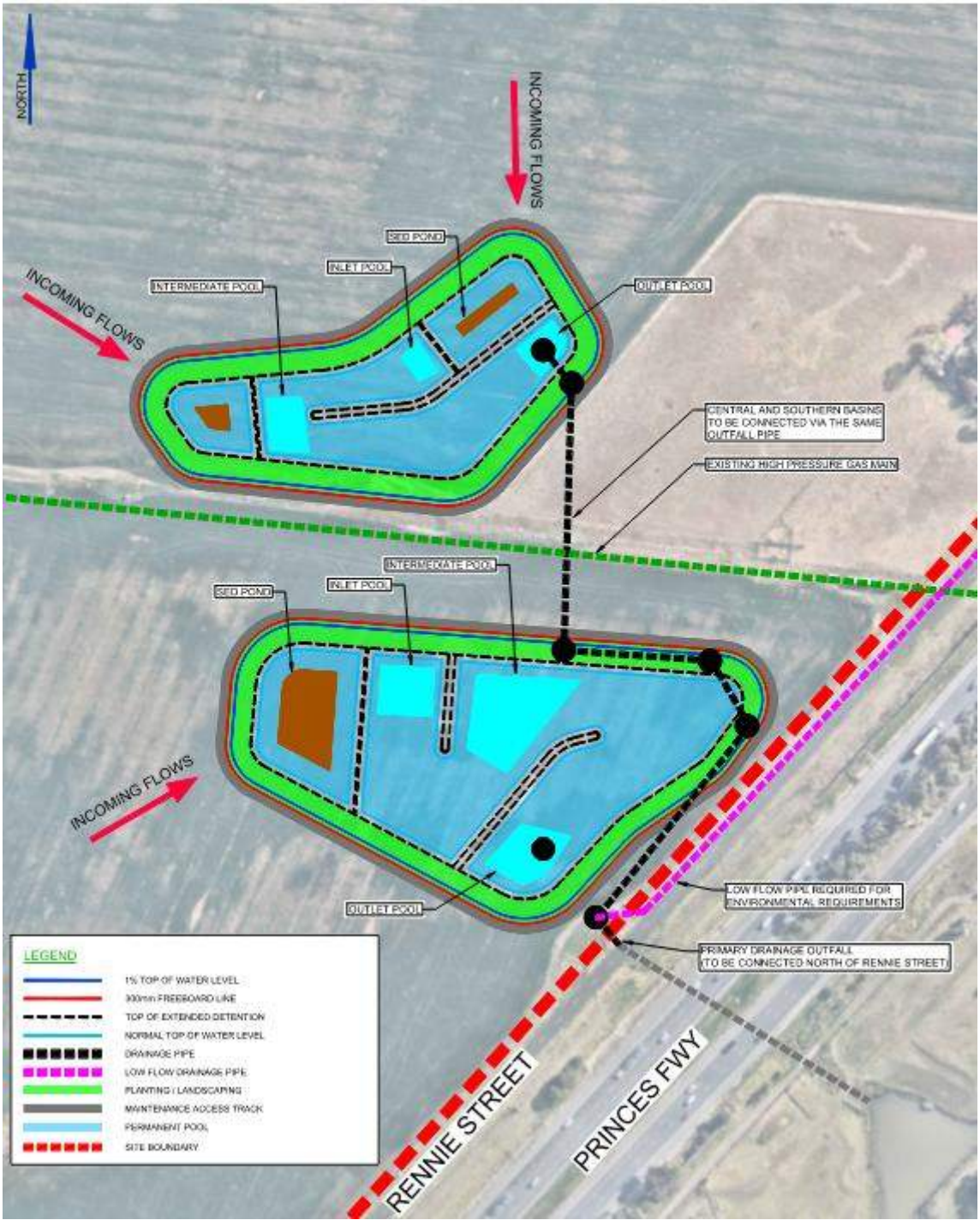


Figure 11 – Concept Central and Southern Basin Concept Plan (C444 & C453)

The concept design for the central and southern basin has an indicative overall footprint of approximately 2.1Ha and 3.5Ha in total size respectively, this incorporates the wetland and basin footprint as well as the batters access track(s) and also sediment set down / drying zones.

The conceptual design has been undertaken in line with the Melbourne Water deemed to comply guidelines, however given that no formal area set aside for the basin will be 'locked in' as part of the rezoning process, it is considered that a more detailed design undertaking and formal assessment against the checklist is considered as an unreasonable requirement to be undertaken at this phase of the project.

This footprint will be refined and optimised as the project moves in more detailed phases and should be treated as indicative only at this time.

It is noted that the central and southern basins are proposed to have the central basin outlet avoid discharging into the southern basin, with their combined flows merging at Rennie Street downstream of the southern basin. That is the basins are designed in 'parallel', not in 'series'.

5 Stormwater Mitigation Strategy

5.1 Stormwater Quality

As outlined earlier, the site is spilt into the three developed catchments, both discharging to end of line wetlands before discharging as discussed above.

As detailed in the Venant Solutions report Lara Farms Development, Limeburners Bay Ramsar Wetland Impact Assessment, R.M00441.01.02, within the residential catchments, the house roofs from every dwelling are proposed to be directed to onsite rainwater tanks utilised for garden watering and use in toilets and the laundry.

Nominally 50% of each roof is to be directed to the rainwater tank, however in most cases it is envisaged that a larger % of the roof will be directed there in reality. Please see section 4.3 generally and 4.3.2 more specifically for more detailed commentary on the rainwater tanks.

The MUSIC model utilised in this stormwater quality analysis has been iteratively developed between Venant Solutions and Loetis to ensure that the same model including the inputs and design parameters have been used in both the assessment of the water volumes and downstream impacts and also of the stormwater quality outputs of the site.

5.1.1 Northern Basin Catchment Treatment Train (C444)

The northern catchment treatment is entirely comprised of the 'northern' portion of the residential development area. This catchment is sized at 22.53Ha. As outlined above, 50% of the roofs are directed via rainwater tanks with the residual of the system directed to the end of line wetland.

A screenshot of the MUSIC model simulation for all three catchments is provided below in figure 12.

5.1.2 Central Basin Catchments Treatment Train (C444 & C453)

The central catchment treatment has a split inputs to the catchment, incorporating the residual southern portion of the proposed residential development, along with the entirety of possible regional sports reserve and part of the proposed industrial catchment. This residential catchment is sized at 13.91Ha, the possible regional sports reserve (including basin area) of 13.73Ha and the industrial catchment at 6.32Ha.

As outlined above, 50% of the roofs within the residential catchment are directed via rainwater tanks with the residual of the residential catchment and the entirety of the industrial catchment systems directed to the end of line wetland.

5.1.3 Central and Southern Basin Catchments Treatment Train (C453)

The southern catchment treatment is entirely made up of the industrial catchment at 61.78Ha.

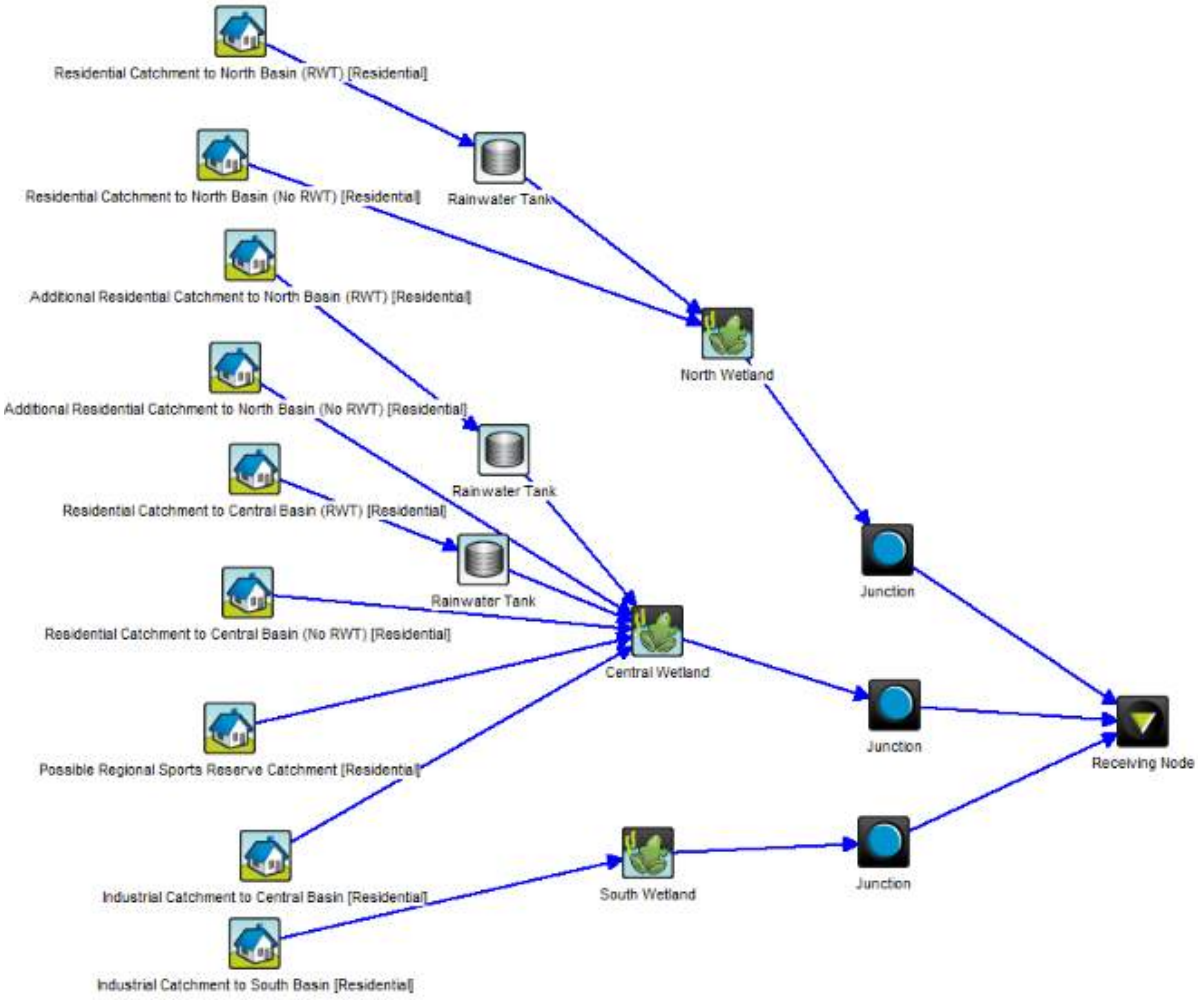


Figure 12 - MUSIC Model Simulation – Developed Case Northern Catchment

5.1.4 Modelling Results

The end-of-line efficiencies for the treatment train described above are as follows:

Table 1 – Stormwater Quality Treatment Efficiencies (Northern Catchment)

	Reduction (%)	
Criteria	**Result**	**Target**
Total Suspended Solids (kg/yr)	80.0	*80*
Total Phosphorus (kg/yr)	62.8	*45*
Total Nitrogen (kg/yr)	45.6	*45*
Gross Pollutants (kg/yr)	100	*70*

Table 2 – Stormwater Quality Treatment Efficiencies (Central Catchment)

	Reduction (%)	
Criteria	**Result**	**Target**
Total Suspended Solids (kg/yr)	85.3	*80*
Total Phosphorus (kg/yr)	69.0	*45*
Total Nitrogen (kg/yr)	53.1	*45*
Gross Pollutants (kg/yr)	100	*70*

Table 3 – Stormwater Quality Treatment Efficiencies (Southern Catchment)

	Reduction (%)	
Criteria	**Result**	**Target**
Total Suspended Solids (kg/yr)	80.0	*80*
Total Phosphorus (kg/yr)	61.8	*45*
Total Nitrogen (kg/yr)	45	*45*
Gross Pollutants (kg/yr)	100	*70*

It is noted that in both basins, the required treatment targets are being marginally exceeded. It is intended that as the concept design moves through the future planning and detailed design phases, more detailed input parameters and the proposed layouts will be undertaken to optimise the design and these results to provide an optimal design outcome and ensure compliance to all required standards.

5.2 Stormwater Quantity

As noted in section 1 of this report, Venant Solutions have assessed the requirements around the stormwater quantity requirements (detention) for the site. Please refer to their report report Lara Farms – Preliminary Retarding Basin Requirements, M.M00441.03.00_RB_Analysis_Optimised for all information on this assessment, this document is located in appendix A to this report.

In summary, their works have identified that the detention requirements for the site to ensure no increase in the peak runoff for a 1% AEP event requires basins of the following volume.

Table 4 – Stormwater Quantity Parameters (Taken from Venant Solutions Report)

Catchment	Area (Ha)	Target (Pre Development) Flow Rate (m^3/s)	Post Development Flow Rate (m^3/s)	Required Volume (m^3)
Northern Catchment	50.7	1.6	1.0	2,650
Southern & Central Catchments	122.2	*2.1*	*2.0*	47,100

5.3 Stormwater Conveyance

To accommodate the stormwater runoff generated during a 1% Annual Exceedance Probability (AEP) event, a provision for conveyance will be necessary. It is envisioned that as per general requirements, all site flows, originating from building roofs and lot areas, will be directed into an underground pit and pipe network in the road reserve designed to facilitate conveyance of the minor flows with the major flows conveyed in the road

reserves prior to discharge to the treatment area in the existing drainage reserve and the treatment and detention train systems noted above. The process may entail some manipulation of the site levels as needed to achieve the desired outcome, however generally these will be in line with the existing site contours. Specific details will be contingent upon the subsequent detailed design phase.

5.4 Integrated Water Management Plan (IWMP)

Earlier authority discussion canvassed whether a formal Integrated Water Management Plan (IWMP) is required to be prepared for the proposed rezoning. Noting this correspondence and the requirement's detailed in the Development Plan Overlay for the proposed C444 residential area it is considered that the key elements of an IWMP are assessed in detail in the Venant Solutions report Lara Farms Development, Limeburners Bay Ramsar Wetland Impact Assessment, R.M00441.01.02.

These reports assess in detail the downstream stormwater and environmental impacts from the proposed rezoning and also assesses in detail potential opportunities for onsite retention and substitution of 'traditional' sources of water supply and also the reductions in increased stormwater volumes from urbanisation of the catchment.

As a result of this report, it is proposed to mandate the installation of rainwater tanks on all residential properties as part of the future planning permit application process. Whilst noting that the primary purpose of this requirement is to deal with the increased stormwater volumes from the site, it is considered that there is a strong secondary outcome in that the volume of potable water required by the proposed development would be meaningfully reduced in comparison with a 'standard' approach to the development.

The site is currently remote from the Barwon Water recycled water network, and there are no local identified 'end users' of precinct scale captured stormwater reuse or harvesting, limiting other potential local uses of site generated water supplies.

5.5 Flood Impact Assessment (FIA)

Earlier authority discussion canvassed whether a Flood Impact Assessment (FIA) is required to be prepared for the proposed rezoning.

Please refer to the enclosed Venant Solutions report L.M00441.01.00_FIA Lara Farms Flood Impact Report.

6 Conclusion & Recommendations

The site stormwater objectives for the future development of the site in accordance with the proposed rezonings of the subject site can achieve stormwater objectives by adopting a treatment train and new stormwater infrastructure as follows:

- Installing three end of line combined wetlands and stormwater detention basins, nominally being the northern, central and southern basins.
- The northern Basin nominally treats the stormwater for the northern part of the proposed residential development and discharges directly to Hovells Creek adjacent to the existing Rennie Street road reserve.
- The central basin treats the southern portion of the proposed residential catchment, and the northern portion of the proposed industrial development. The central basin discharges environmental and high flows to the existing 'waterway' culvert crossing the Princess Freeway and discharging to Hovells Creek and diverts low flows north-eastwards to the northern basin discharge point into Hovells Creek.
- The southern basin treats the southern portion of the proposed industrial development. The southern basin discharges environmental and high flows to the existing 'waterway' culvert crossing the Princess Freeway and discharging to Hovells Creek and diverts low flows north-eastwards to the northern basin discharge point into Hovells Creek.
- Rainwater tanks are proposed to be installed on all residential dwellings, plumbed to toilets, laundry, and garden irrigation use. This outcome can be secured as part of the future planning permit application process.

These reports are proposed to be read in conjunction with the following reports prepared by Venant Solutions,

- Lara Farms – Preliminary Retarding Basin Requirements, M.M00441.03.00_RB_Analysis_Optimised
- Lara Farms Development, Limeburners Bay Ramsar Wetland Impact Assessment, R.M00441.01.02
- Lara Farms – Flood Impact Report, L.M00441.01.00_FIA

If required, refinement of modelling calculations should be completed for both stormwater quality and stormwater quantity models during the planning permit application and detailed design phases when a specific subdivision / development proposition is confirm and submitted. This will allow for optimised delivery requirements which can be tailored to meet specific development constraints that are raised as the development progresses.

Appendix A – Lara Farms Development, Limeburners Bay Ramsar Wetland Impact Assessment, R.M00441.01.02_Optimised

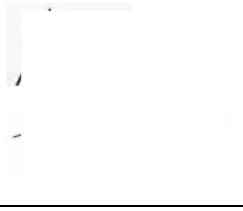
Lara Farms Development
Limeburners Bay Ramsar Wetland
Impact Assessment
Report

Report Reference: R.M00441.01.02.docx
Date: 19 February 2024
Prepared for: Lara Farms Pty Ltd

In association with

Document Control Sheet

Client	Lara Farms Pty Ltd				
Client Contact					
Project Manager	Jempson				
Report Name	Lara Farms Development Limeburners Bay Ramsar Wetland Impact Assessment				
Report Reference	R.M00441.01.02				
Author					
Issued to	Version Number				
	0	1	2	3	4
Lara Farms Pty Ltd	04/12/2023	17/01/2024	19/02/2024		

	Name	Signature	Version Number	Date
Prepared by			2	19/02/2024
				19/02/2024
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1 Introduction

1.1 Background

Lara Farms Pty Ltd is proposing the rezoning of 76-156 Canterbury Road East (SPI 3C-15B\PP5452), 785-8015 Princes Highway (SPI 1\TP156147), 705-765 Prices Highway Lara (SPI 2\LP98249) and 610 Rennie Street (SPI 1\LP98249) (the Site) for the purposes of residential and industrial/commercial subdivisions. The Site is shown in Figure 1-1. The Site is currently Farming Zone.

Rainfall runoff from the Site drains into Hovells Creek which in turn flows into Limeburners Bay. Limeburners Bay forms part of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site, which means it is a wetland of international importance. Therefore any impacts from the development need to be assessed against the Matters of National Environmental Significance test under the EPBC Act (1999) as well as against impacts on species listed under the Victorian FFG Act (1988). The development of the Site will increase the rainfall runoff from the Site because of the conversion of pervious land to impervious surface. Increases in both peak flow rate and volume will occur. The peak flow rate from the developed Site can be mitigated to match existing through the use of retarding basins but these are largely ineffective in mitigating increased volumes. Some measures such as reuse can be implemented to mitigate to a degree the increase in runoff volume but it is not practical to fully mitigate the increase in volume. Therefore an understanding of the potential impact of the increased volume on the local environment adjacent to the discharge points and to Limeburners Bay receiving environment is required.

Under existing conditions rainfall runoff discharges from the Site primarily at two locations shown as the northern and southern outlets on Figure 1-1. Discharge from northern outlet travels only a short distance through a pipe and overland flow path before entering Hovells Creek just upstream of the Princes Highway. The southern outlet flow passes through culverts under Rennie Street and the Princes Highway into an overland flowpath which flows into a small dam. Overflow from the dam flows through a parkland area into an area referred to as a floodplain wetland in this report (refer Figure 2-2 for the general area of the floodplain wetland) before entering Hovells Creek downstream of the northern outlet.

The focus of this assessment is the potential environmental impact of the mixing of the increased runoff volume into Hovells Creek as well as increased flow rates into the floodplain wetland. Preliminary investigations found the optimal solution to protect the floodplain wetland was to divert the increased runoff above existing conditions from the southern outlet to the northern outlet and then onto Hovells Creek.

The general design intent is to approximately maintain the existing flow regime into the floodplain wetland and Hovells Creek. The assessment also assumes that WSUD will be implemented within the development area to treat the water quality in accordance with the Environmental Protection Agency Urban Stormwater Management Guidelines[1] (EPA guideline), despite the water quality of discharge water, the volumes of this water are so low they will not affect water quality of receiving waters. The rationale for diversion to the northern location is also to prevent discharging volumes of fresh (low EC) water onto the saline estuarine floodplain downstream of the southern discharge zone. Therefore the assessment in this report is on the basis of this flow diversion being implemented.

This report documents the environmental values of the receiving environment, quantifies the increase in runoff volume from the Site resulting from the proposed development, investigates options to mitigate the increased volume and assesses the impact on the receiving environment. Mitigation of increased peak discharges to

[1] Urban Stormwater Management Guidelines, Environmental Protection Agency, Vicotria, Publication 1739.1, June 2021

match existing conditions and stormwater quality are addressed in the stormwater management plan (*Lara Farms, Site Stormwater Management Plan*) prepared by Loetis consulting engineers, as well as the proposed flow diversion.

1.2 Scope of Works

As described above the primary purposes of this report are to describe the changes to catchment runoff volume into Hovells Creek and Limeburners Bay resulting from urbanisation of the Site and an assessment of the impact of the additional runoff on the ecological character of Limeburners Bay Ramsar wetland. In addition, analysis has been carried out to investigate measures to mitigate the increase in runoff flow volumes.

Limeburners Bay operates under a complex hydrological regime with inflows from Hovells Creek, tidal flushing, and possibly from groundwater. As noted above urbanisation of the Site will increase the percentage of impervious surfaces which invariably leads to an increase in the total runoff volume because less rainfall infiltrates into the soil. Therefore, this study focuses on the changes to Hovells Creek inflows to the area of Limeburners Bay potentially impacted by the development.

Water balance models of the greater Hovells Creek catchment as well as the northern and southern catchments within the Site were developed using the MUSIC software so as to quantify the change in the runoff characteristics due to the proposed development. These models represented and compared the existing and proposed levels of development. The existing case represents the catchment condition prior to development of the Site and was used as the base against which the ultimate case was assessed.

Because there is significant variability in rainfall patterns from year to year, the analysis was done using continuous daily rainfall data series over a 20 year period. The model determined the runoff volume on a daily basis across the 20 years for the existing and developed conditions. A statistical analysis of the model output was undertaken to establish the monthly means as well as the 10^{th}, 25^{th}, 75^{th} and 90^{th} percentile runoff volumes.

An assessment of monthly flow volumes rather than a daily or annual volume assessment was adopted so that the effect on monthly and seasonal variation could be understood. Annual mean volumes may mask differences in the magnitude of change in different seasons/months and an analysis on a daily timescale is not appropriate, being too short for the purposes of an ecological assessment.

The results for the existing and ultimate case were compared to understand the changes in monthly runoff volume over the 20 year period of time. By doing so, the analysis provides a good indicator of the natural variability in runoff volumes under existing conditions, changes to runoff volume reaching Hovells Creek from the Site and the impact of these changes on the monthly runoff volumes from the broader Hovells Creek catchment.

The MUSIC models of the Site were also used to quantify the effects of potential mitigation measures on reducing the developed case runoff volumes.

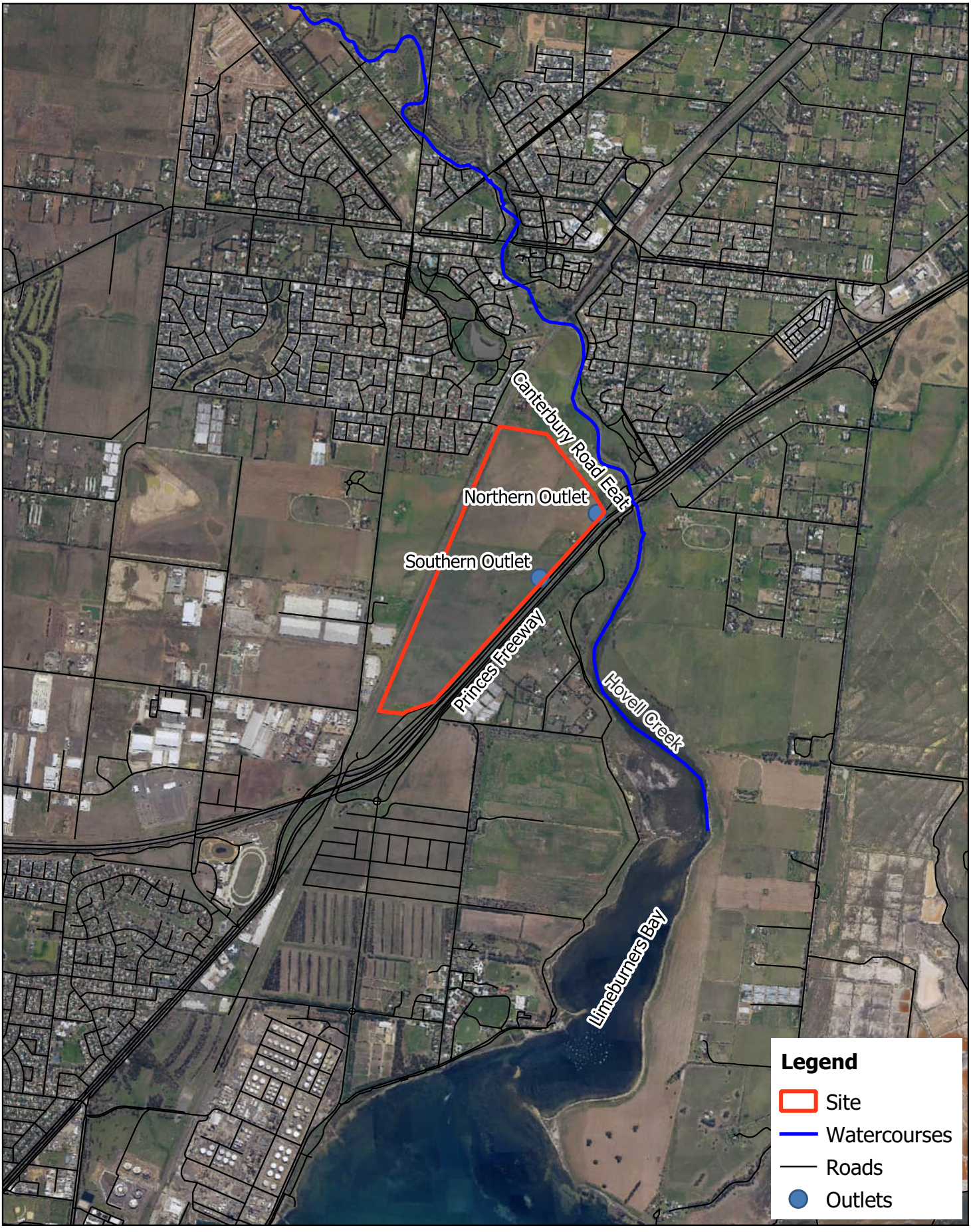
As noted above it is proposed to divert the increased runoff above existing conditions from the southern outlet to the northern outlet and then into Hovells Creek rather than adversely increase the runoff volumes into the floodplain wetland. Therefore the assessment of the overall hydrological impact on the system will be assessed at this location. Because of the significant natural variability in rainfall, and hence runoff, it would not be possible to design a diversion structure that exactly replicates the existing conditions flow into the floodplain wetland. Therefore an understanding of the sensitivity of the floodplain wetland hydrology, namely wetting extent, depth and duration, to small increases and decreases in the natural flow regime was required. To assess this a hydraulic model was developed and the existing conditions flows and variations in the range ± 20% were assessed using a typical wet month and dry month.

The scope of the study can be summarised as follows:

- Describe the Ecosystem and Ramsar Values;
- Prepare water balance models of the Hovells Creek catchment and the Site to assess stormwater runoff volumes under existing conditions and developed conditions;
- Analyse the change to monthly flow volumes in Hovells Creek;
- Assess potential Ecosystem Changes to Limeburners Bay;
- Use a hydraulic model to quantify the sensitivity of the floodplain wetland hydrology to small increases and decreases in the natural flow regime to establish practical limits to apply to the design of the proposed diversion structure
- Identify and assess mitigation options to reduce runoff volumes from the Site.

The study aims to present an understanding of the current Hovells Creek inflow regime to Limeburners Bay to allow an assessment of the potential impact on the ecological character. The water balance models developed as part of this study are suitable for this purpose, based on available data.

This report was prepared by from Lloyd Environmental and from Venant Solutions with modelling support from Venant Solutions' staff. Curricula vitae are provided in Appendix A for and .



Title:

Lara Lakes Development Limeburners Bay Impact Assessment
Site Locality

Figure:	Rev:			
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2 Catchment Characteristics

2.1 Hovells Creek Catchment

The Hovells Creek catchment is shown in Figure 2-1 and it has a catchment area to the Site of ~231.5 km^2 (23150 Ha). It has its headwaters at Mt Anakie in the Brisbane Ranges to the northwest of the Site. Farming is the predominant landuse in the catchment. Table 2-1 provides a breakdown of the landuses in the catchment (as of July 2023), the area and the adopted fraction imperviousness (FI) used in the modelling. The FI estimate was guided by the Melbourne Water MUSIC Guidelines[2]. Because the landuses are based on the planning scheme zones they represent the ultimate development within the catchment which means the area weighted FI might be slightly higher than an alternative analysis using existing levels of development. However the difference will be negligible given the landuses are predominantly zones for which there would not be ongoing development such as Farming Zone, Public Conservation and Resource, and Public Park and Recreation. A sensitivity test where the area weighted FI was recalculated assuming the commercial, industrial, rural living and residential zones were only at 75% of development gives an FI of 0.16 and which is not significantly different from the adopted scenario.

Table 2-1 Catchment Landuses and Adopted Fraction Imperviousness

Landuse	Area (Ha)	FI
Commercial Zone	9.8	0.9
Farming Zone	16303.7	0.1
General Residential Zone - Schedule 1	572.7	0.75
Industrial 1 Zone	342.2	0.9
Low Density Residential Zone - Schedule 1	104.9	0.2
Public Conservation And Resource Zone	1946.8	0
Public Park And Recreation Zone	167.3	0.1
Public Use Zone - Service And Utility	2.5	0.05
Public Use Zone - Cemetery/Crematorium	25.9	0.6
Public Use Zone - Local Government	6.4	0.7
Rural Conservation Zone - Schedule 13	118.1	0
Rural Living Zone	1055.2	0.2
Special Use Zones	974.0	0.6
Transport Zone 1 & 2	206.2	0.7
Transport Zone 3	33.1	0.6
Urban Floodway Zone	71.6	0
Urban Growth Zone	1209	0.75
Total	**23149.4**	**Area Weighted = 0.19**

[2] MUSIC Guidelines Input parameters and modelling approaches for MUSIC users in Melbourne Water's service area, 2018

2.2 Site and Development Description

The existing Site is currently zoned for farming and consists of a south and north catchment as shown in Figure 2-2 that both drain to Hovells Creek as shown on the figure. The southern catchment has an area of 71.5 Ha and the northern catchment has an area of 50.7 Ha which is only about 0.53% of the Hovells Creek catchment. These catchment areas include part of the rail corridor which drains onto the Site. The southern catchment outlets to a single location marked on Figure 2-2 as the southern outlet. The majority of the northern catchment outlets to the location marked on Figure 2-2 as the northern outlet. Small areas of the northern catchment outlet through pipes under Canterbury Road east, but for the purposes of this assessment it has been assumed that all flow outlets at the northern outlet. There is no external flow into the Site other than a small area of the rail corridor along the northern boundary.

It is proposed to rezone for a business park in the southern catchment and residential development on the northern catchment as shown on the drawing in Appendix A using the FI listed in Table 2-2 for the different landuses in accordance with the Melbourne Water MUSIC Guidelines. The areas below do not include the wetlands.

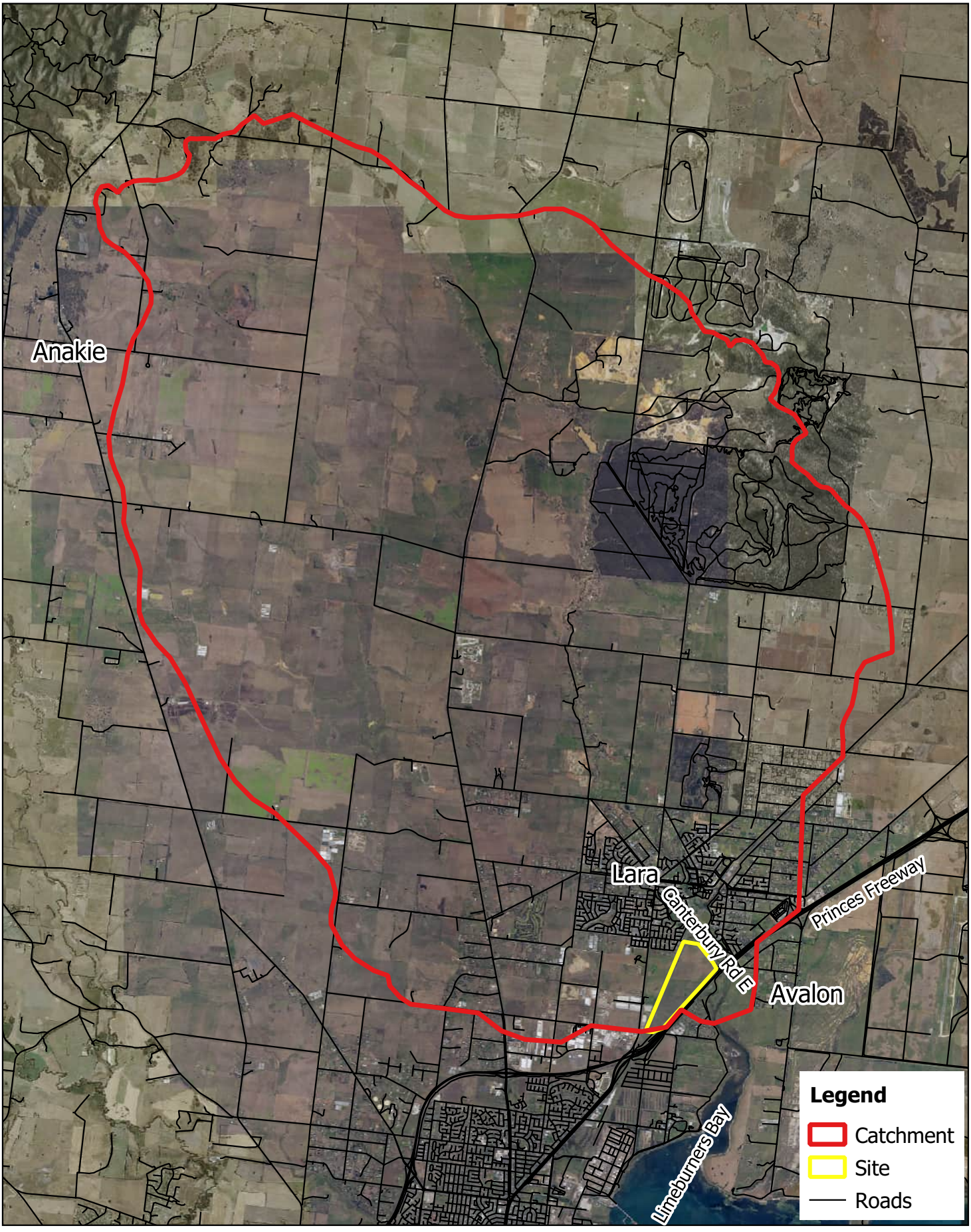
Table 2-2 Developed Site Fraction Imperviousness

Landuse	Area (Ha)	FI
Residential lots	21.46	0.75
Residential road reserve	9.75	0.6
Residential open space & drainage reserve	3.49	0.1
Total Residential	**34.7**	**0.65**
Business zone lots	54.7	0.9
Business zone road reserve	15.89	0.6
Business zone open space	7.73	0.1
Total Business Zone	**78.32**	**0.76**

As shown on the plan in Appendix B, under the developed conditions a portion of the residential development within the existing northern catchment will be designed to flow to the southern outlet rather than the northern outlet.

2.3 Local Climate

The MUSIC modelling has adopted a 20 year rainfall file (20year_GeelongNorth_1971-1990_6min_sqz) recommended in the City of Greater Geelong MUSIC modelling guidelines for the Geelong North region (mean annual rainfall > 500 mm). This City of Greater Geelong MUSIC file for the climate period has mean annual rainfall = 531 mm and mean annual evapo-transpiration = 1108 mm which is higher than the Bureau of Meteorology gauge at Avalon which has an average of 457 mm. The higher rainfall was retained for the modelling as this provides a slightly more conservative outcome when assessing increases associated with new impervious surfaces,



Title:

Lara Lakes Development Limeburners Bay Impact Assessment
Hovells Creek Catchment

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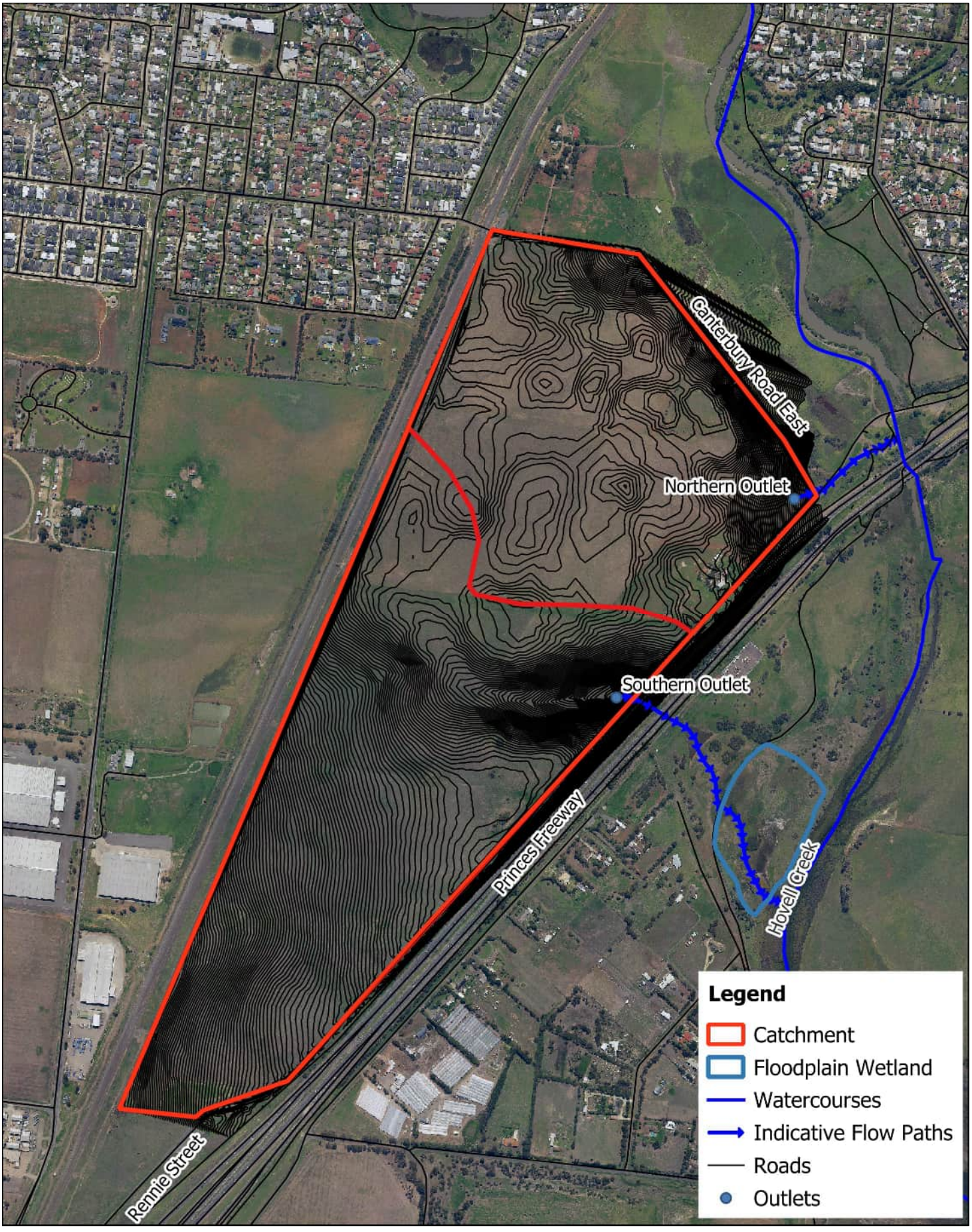

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Lara Lakes Development Limeburners Bay Impact Assessment
Existing Site Catchment and Contours

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3 Ramsar and Environmental Values

The Site is currently farming land and is located within a catchment that drains to Hovells Creek and then Limeburners Bay. Limeburners Bay is part of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. The Lake Connewarre Complex includes Limeburners Bay, Reedy Lake, Hospital Swamp, Salt Swamp Murtnaghurt Lagoon and the Barwon River estuary, each with their own unique values and assets (DELWP, 2018). Limeburners Bay is an open embayment receiving water from the catchment of Hovells Creek and is influenced by tidal fluctuations in Corio Bay, and possibly by groundwater.

Ramsar sites are wetlands of international significance and are designated as Ramsar sites if they meet one (or more) of nine criteria, established by the Ramsar Secretariat, in Switzerland (see www.ramsar.org). Ramsar wetlands are protected in Australia and considered a matter of national environmental significance under the EPBC Act (1999). Any development likely to have a significant impact on a matter protected by the Act requires approval from the Australian Government Environment Minister.

The development potentially has impacts (threats to values) at three levels:

- development site
- outlet site
- downstream of the development and outlet sites (Ramsar Site).

The impacts we are concerned about in this report are those that affect the water regime in some way which in turn adversely affects aquatic flora and fauna or their ecosystems.

To assess these impacts, we have examined the ecological values the FFG listed species (as reported by the Victorian Biodiversity Atlas; FFG Act 1988), the EPBC Act (1999) listed species; and Ramsar values of the sites using the Matters of National Environmental Significance, MNES, tool) and if the likely actions from the development would cause harm to these values (details in Section 5 of this report).

Due to proximity of the Ramsar site, the MNES tool considers the whole region to be potentially affected and the values are therefore considered together under the MNES tool for development site, outlet sites and Limeburners Bay (see Section 3.3).

A site inspection on 31 July 2023 was also conducted to understand the species, habitats and landscapes present and help understand the potential impacts from alterations to catchment, stream and wetland hydrology.

3.1 Development Site Values

The development site itself is a ~115 hectare site of cleared farming land (see Figure 3-1). The land is largely devoid of any intact native vegetation apart from a very small dam which was dry at the time of inspection (July 2023) but exhibited some water tolerant (and weedy) plants (*Rumex* sp. and *Cyperus* sp.).

Figure 3-1 Development site showing dry dam in foreground and cleared surrounding farmland

3.2 VBA Values

A VBA Search was conducted to ascertain species recorded on the development site and which are water dependent (Table 3-1) but it is unlikely all these species are present on the property but present in the buffer area of the database search as suitable habitat does not occur for these species. There are 10 native fish recorded, 3 exotic fish species and 24 birds (including the FFG listed, Hardhead) present in the database but the habitat for most of these species is absent. The database also held a couple of records of weed species as well but these were not water dependent.

Table 3-1 VBA Records of the development site and buffer zone (Table 331A).

Scientific Name	Common Name	FFG Status
Native Fish		
Anguilla australis	Southern Shortfin Eel	
Retropinna semoni	Australian Smelt	
Galaxias truttaceus	Spotted Galaxias	
Galaxias maculatus	Common Galaxias	
Atherinosoma microstoma	Smallmouthed Hardyhead	

Scientific Name	Common Name	FFG Status
Pseudaphritis urvillii	Tupong	
Afurcagobius tamarensis	Tamar Goby	
Arenigobius bifrenatus	Bridled Goby	
Philypnodon grandiceps	Flatheaded Gudgeon	
Pseudogobius eos	Eastern Bluespot Goby	
Exotic Fish		
Cyprinus carpio	European Carp	
Gambusia holbrooki	Eastern Gambusia	
Perca fluviatilis	Redfin	
Water dependent Birds		
Gallinula tenebrosa	Dusky Moorhen	
Porphyrio melanotus	Australasian Swamphen	
Poliocephalus poliocephalus	Hoary-headed Grebe	
Phalacrocorax sulcirostris	Little Black Cormorant	
Pelecanus conspicillatus	Australian Pelican	
Chroicocephalus novaehollandiae	Silver Gull	
Vanellus miles	Masked Lapwing	
Threskiornis molucca	Australian White Ibis	
Threskiornis spinicollis	Straw-necked Ibis	
Egretta novaehollandiae	White-faced Heron	
Cereopsis novaehollandiae	Cape Barren Goose	
Chenonetta jubata	Australian Wood Duck	
Cygnus atratus	Black Swan	
Anas superciliosa	Pacific Black Duck	
Anas castanea	Chestnut Teal	
Anas gracilis	Grey Teal	
Aythya australis	Hardhead	Vulnerable
Circus approximans	Swamp Harrier	
Haliastur sphenurus	Whistling Kite	
Hirundo neoxena	Welcome Swallow	
Petrochelidon ariel	Fairy Martin	
Acrocephalus australis	Reed-Warbler	
Cisticola exilis	Golden-headed Cisticola	
Ardea alba	Great Egret	

3.3 Outlet Sites Values

The two outlet sites are very close to each other with the main difference being the extent of floodplain in the lower (southern) site (refer Figure 2-2). This section includes a brief description of each outlet site and then a combined section of values.

3.3.1 Northern Outlet

The northern outlet consists of an artificial drain coming from the northern edge of the development site and a stream habitat in Hovells Creek. The drain (Figure 3-2a and Figure 3-2b) follows the natural fall of the landscape but has been deepened from the original swale or creek line. It appears little water escapes laterally from the drain as there is no evidence of riparian or floodplain vegetation. There are shallow pools present within the drain and dry sections. The presence of *Phragmites* in the stream bed indicates a water regime which is subject to drying in summer otherwise the drain would be dominated by *Typha* or other reeds. There are few aquatic values in this section. The main Hovells Creek (Figure 3-2c) shows a well-developed riparian (streamside) zone and large permanent pools and runs zones. The system also contained undercut banks and other aquatic habitat. The system is likely to provide habitat for many of the species recorded here in the past (see Section Outlet Sites Values3.3).

Figure 3-2a: Drain (in foreground) leading to Hovells Creek from development area.

Figure 3-2b: Drain leading to Hovells Creek marked by *Phragmites* in foreground. Sign in the far-ground marks the edge of Hovells Creek.

Figure 3-2c: Hovells Creek, showing habitats of open water, *Phragmites* beds and *Juncus* reeds and exotic couch grass on RHS bank.

Figure 3-2 Site Photograph of Drains and Hovells Creek Downstream of Site

3.3.2 Southern Outlet

The main receiving environment is a saline floodplain with chenopods, grasses, reeds, and scattered eucalypts on rises and a well-developed riparian zone of reeds adjacent to Hovells Creek (refer Figure 2-2). The southern outlet site initially runs through a dam built on the slope before the floodplain, which has been extensively planted with native vegetation but is a constructed wetland rather than a natural feature. There are multiple habitats within the floodplain and the main Hovells Creek which would support the values identified in Section 3.3.

Figure 3-3a: Dam through which Southern Outlet drain runs through to reach floodplain of Hovells Creek.

Figure 3-3b: Floodplain Wetland of Hovells Creek which outlet water will spill when the Southern Outlet flows.

Figure 3-3 Site Photographs of Southern Outlet dam and Floodplain Wetland

3.3.3 Outlet Values

The two sites are very close to each other and their values as represented in the Victorian Biodiversity Atlas (DEECA 2023) are similar and combined table of species is presented in Table 3-2. The main difference is the extent of floodplain each site has as described above.

There are 10 native fish recorded, 3 exotic fish species and 26 water dependent birds (including the FFG listed, Hardhead) present in the database Unlike the development site, the habitat for most of these species does exist within the two outlet sites. The database also held a few records of weed species as well but these were not water dependent.

Table 3-2 Species present in the VBA Database at the Outlet Sites (DEECA 2023)

Scientific Name	**Common Name**	**FFG Status**
Native Fish		
Anguilla australis	Southern Shortfin Eel	
Retropinna semoni	Australian Smelt	
Galaxias truttaceus	Spotted Galaxias	
Galaxias maculatus	Common Galaxias	
Atherinosoma microstoma	Smallmouthed Hardyhead	
Pseudaphritis urvillii	Tupong	
Afurcagobius tamarensis	Tamar Goby	

Scientific Name	**Common Name**	**FFG Status**
Arenigobius bifrenatus	Bridled Goby	
Philypnodon grandiceps	Flatheaded Gudgeon	
Pseudogobius eos	Eastern Bluespot Goby	
Exotic Fish		
Cyprinus carpio	European Carp	
Gambusia holbrooki	Eastern Gambusia	
Perca fluviatilis	Redfin	
Water dependent Birds		
Gallinula tenebrosa	Dusky Moorhen	
Porphyrio melanotus	Australasian Swamphen	
Poliocephalus poliocephalus	Hoary-headed Grebe	
Phalacrocorax sulcirostris	Little Black Cormorant	
Pelecanus conspicillatus	Australian Pelican	
Chroicocephalus novaehollandiae	Silver Gull	
Vanellus miles	Masked Lapwing	
Threskiornis molucca	Australian White Ibis	
Threskiornis spinicollis	Straw-necked Ibis	
Egretta novaehollandiae	White-faced Heron	
Cereopsis novaehollandiae	Cape Barren Goose	
Chenonetta jubata	Australian Wood Duck	
Cygnus atratus	Black Swan	
Anas superciliosa	Pacific Black Duck	
Anas castanea	Chestnut Teal	
Anas gracilis	Grey Teal	
Aythya australis	Hardhead	Vulnerable
Circus approximans	Swamp Harrier	
Haliastur sphenurus	Whistling Kite	
Hirundo neoxena	Welcome Swallow	
Petrochelidon ariel	Fairy Martin	
Rhipidura leucophrys	Willie Wagtail	
Acrocephalus australis	Reed-Warbler	
Cisticola exilis	Golden-headed Cisticola	
Malurus cyaneus	Superb Fairy-wren	
Ardea alba	Great Egret	

3.4 Ramsar Values and MNES

The EPBC Matters of National Environmental Significance (MNES) tool assesses the site in question and any MNES within 10 km of the site. Due to proximity of the Ramsar site, the MNES tool considers the whole region to be potentially affected and the values are therefore considered together under the MNES tool for development site, outlet sites and Limeburners Bay (see Section 3.3). Therefore, we have also assessed the complete site for identified species via the Victorian Biodiversity Atlas (DEECA 2023).

3.4.1 Limeburners Bay Description

The site exemplifies a compound estuary with a funnel-shaped morphology, showcasing numerous features characteristic of expansive estuarine systems in close spatial proximity. Noteworthy elements include active cliffs, marginal bluffs, active and relict spits, mangrove and salt marsh zones, along with terraces and materials indicative of past higher sea level events. Positioned in Port Phillip Bay, this estuary system stands as the best-preserved, and its accessibility from Melbourne and Geelong further enhances its significance. The site serves as an exceptional location for demonstrating physiographical, hydrological, and ecological attributes inherent to estuaries and coastal lagoons. It offers valuable opportunities for research on tidal circulation, salinity fluctuations, sedimentation processes, shoreline evolution, and the dynamics of spit growth. Distinguished by the most extensive mangrove stand in Port Phillip Bay and arguably the largest intact salt marsh complex, the site is a research and educational asset of considerable environmental value.

Limeburners Bay provides significant roost site for gulls, terns and cormorants. Its vegetation communities are intact and these important habitats include:

- Significant Chaffy Saw Sedge vegetation community
- One of the most intact saltmarsh complex communities in Victoria
- Large tracts of Shrubby Glasswort and Beaded Glasswort communities.

Figure 3-4 shows these habitats including open waters, sandy beaches and chenopod shrublands, Samphire and salines pools.

Figure 3-4a: Open waters and Chenopod Shrublands in distance

Figure 3-4b: Open water, sandy beaches and chenopod shrublands

Figure 3-4c: Wider angle of open water, sandy beaches and chenopod shrublands

Figure 3-4d: Samphire and salines pools and beaches and chenopod shrublands

Figure 3-4e: Samphire and salines pools and beaches and chenopod shrublands

Figure 3-4f: Samphire and salines pools and beaches and chenopod shrublands

Figure 3-4 Habitats with Limeburners Bay (July 2023)

3.4.2 VBA Values

The Victorian VBA (DEECA 2023) indicates (Table 3-3) there are 10 native fish recorded, 3 exotic fish species, and 68 water dependent birds (including the FFG listed, Common Sandpiper, Hardhead, Plumed Egret, Musk Duck, Red Know, Little Egret, Black Falcon, White-bellied Sea-Eagle, Little Eagle, Caspian Tern, Eastern Curlew, Fairy Tern, Freckled Duck and Common Greenshank) present in the database and the habitat for most of these species does exist within the two outlet sites. This site also supports 3 water-dependent mammals and 14 water-dependent plants (including the FFG Listed Grey mangrove). While not all those species would be present at any one time, the likelihood is that many listed species will be present at various times and is of very high value under the FFG Act (1988) and any habitat alteration could impact upon all of these species.

Table 3-3 Species Present in the VBA database (DEECA 2023)

Scientific Name	Common Name	FFG Status
Native Fish		
Anguilla australis	Southern Shortfin Eel	
Retropinna semoni	Australian Smelt	
Galaxias truttaceus	Spotted Galaxias	
Galaxias maculatus	Common Galaxias	
Atherinosoma microstoma	Smallmouthed Hardyhead	
Pseudaphritis urvillii	Tupong	
Afurcagobius tamarensis	Tamar Goby	
Arenigobius bifrenatus	Bridled Goby	
Philypnodon grandiceps	Flatheaded Gudgeon	
Pseudogobius eos	Eastern Bluespot Goby	
Exotic Fish		
Cyprinus carpio	European Carp	
Gambusia holbrooki	Eastern Gambusia	
Perca fluviatilis	Redfin	
Water dependent Birds		
Acrocephalus australis	Reed-Warbler	
Actitis hypoleucos	Common Sandpiper	Vulnerable
Anas castanea	Chestnut Teal	
Anas gracilis	Grey Teal	
Anas platyrhynchos	Mallard	
Anas superciliosa	Pacific Black Duck	
Ardea alba	Great Egret	
Ardea intermedia plumifera	Plumed Egret	Critically Endangered
Aythya australis	Hardhead	Vulnerable
Biziura lobata	Musk Duck	Vulnerable
Calidris canutus	Red Knot	Endangered

Scientific Name	Common Name	FFG Status
Calidris ruficollis	Red-necked Stint	
Cereopsis novaehollandiae	Cape Barren Goose	
Ceyx azureus	Azure Kingfisher	
Charadrius bicinctus	Double-banded Plover	
Charadrius ruficapillus	Red-capped Plover	
Chenonetta jubata	Australian Wood Duck	
Chlidonias hybrida	Whiskered Tern	
Chloris chloris	European Greenfinch	
Chroicocephalus novaehollandiae	Silver Gull	
Circus approximans	Swamp Harrier	
Cisticola exilis	Golden-headed Cisticola	
Cladorhynchus leucocephalus	Banded Stilt	
Cygnus atratus	Black Swan	
Egretta garzetta	Little Egret	Endangered
Egretta novaehollandiae	White-faced Heron	
Elanus axillaris	Black-shouldered Kite	
Erythrogonys cinctus	Red-kneed Dotterel	
Falco subniger	Black Falcon	Critically Endangered
Fulica atra	Eurasian Coot	
Gallinula tenebrosa	Dusky Moorhen	
Haematopus longirostris	Pied Oystercatcher	
Haliaeetus leucogaster	White-bellied Sea-Eagle	Endangered
Haliastur sphenurus	Whistling Kite	
Hieraaetus morphnoides	Little Eagle	Vulnerable
Himantopus leucocephalus	Pied Stilt	
Hirundo neoxena	Welcome Swallow	
Hydroprogne caspia	Caspian Tern	Vulnerable
Larus pacificus	Pacific Gull	
Malacorhynchus membranaceus	Pink-eared Duck	
Microcarbo melanoleucos	Little Pied Cormorant	
Morus serrator	Australasian Gannet	
Numenius madagascariensis	Eastern Curlew	Critically Endangered
Nycticorax caledonicus	Nankeen Night-Heron	
Pachycephala pectoralis	Golden Whistler	
Pelecanus conspicillatus	Australian Pelican	
Petrochelidon ariel	Fairy Martin	
Phalacrocorax carbo	Great Cormorant	

Scientific Name	Common Name	FFG Status
Phalacrocorax fuscescens	Black-faced Cormorant	
Phalacrocorax sulcirostris	Little Black Cormorant	
Phalacrocorax varius	Pied Cormorant	
Platalea flavipes	Yellow-billed Spoonbill	
Platalea regia	Royal Spoonbill	
Podiceps cristatus	Great Crested Grebe	
Poliocephalus poliocephalus	Hoary-headed Grebe	
Poodytes gramineus	Little Grassbird	
Porphyrio melanotus	Australasian Swamphen	
Porzana fluminea	Australian Spotted Crake	
Recurvirostra novaehollandiae	Red-necked Avocet	
Sericornis frontalis	White-browed Scrubwren	
Sternula nereis	Fairy Tern	Critically Endangered
Stictonetta naevosa	Freckled Duck	Endangered
Tadorna tadornoides	Australian Shelduck	
Thalasseus bergii	Crested Tern	
Threskiornis molucca	Australian White Ibis	
Threskiornis spinicollis	Straw-necked Ibis	
Tringa nebularia	Common Greenshank	Endangered
Vanellus miles	Masked Lapwing	
Mammals		
Balaenoptera edeni	Bryde's Whale	
Hydromys chrysogaster	Water Rat	
Wallabia bicolor	Swamp Wallaby	
Water Dependent Plants		
Althenia preissii	Slender Water-mat	
Atriplex cinerea	Coast Saltbush	
Avicennia marina subsp. australasica	Grey Mangrove	Endangered
Disphyma crassifolium subsp. clavellatum	Rounded Noon-flower	
Frankenia pauciflora var. gunnii	Southern Sea-heath	
Hemichroa pentandra	Trailing Hemichroa	
Puccinellia stricta s.s.	Australian Saltmarsh-grass	
Salicornia quinqueflora	Beaded Glasswort	
Samolus repens	Creeping Brookweed	
Tecticornia arbuscula	Shrubby Glasswort	
Tecticornia halocnemoides subsp. halocnemoides	Grey Glasswort	
Tecticornia pergranulata	Blackseed Glasswort	
Triglochin striata	*Streaked Arrowgrass*	

Scientific Name	Common Name	FFG Status
Suaeda australis	Austral Seablite	
Wilsonia humilis	Silky Wilsonia	

3.4.3 MNES Values

The Matters of National Environmental Significance tool provides information on what matters are considered important under the EPBC Act (1999) and full details are found in Appendix E. The relevant matters for this report include:

- Wetlands of International Importance (Ramsar Wetlands)
- Listed Threatened Ecological Communities
- Listed Threatened Species
- Listed Migratory Species
- Listed Marine Species
- Whales and Other Cetaceans

Wetlands of International Importance (Ramsar Wetlands)

Limeburners Bay is part of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. It is regarded a Ramsar site as it meets several criteria under the Ramsar Agreement. Limeburners Bay in particular supports:

- significant roost site for gulls, terns and cormorants
- significant Chaffy Saw Sedge vegetation community
- one of the most intact saltmarsh complex communities in Victoria
- large tracts of Shrubby Glasswort and Beaded Glasswort communities
- exemplifies a compound estuary with a funnel-shaped morphology, showcasing numerous features characteristic of expansive estuarine systems in close spatial proximity.
- noteworthy elements include active cliffs, marginal bluffs, active and relict spits, mangrove and salt marsh zones, along with terraces and materials indicative of past higher sea level events.
- a research and educational asset of considerable environmental value

Listed Threatened Ecological Communities

Three threatened ecological communities are listed for this site include

- No. 46 Grassy Eucalypt Woodland of the Victorian Volcanic Plain
- No. 42 Natural Temperate Grassland of the Victorian Volcanic Plain
- No. 43 White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland

Only the Grassy Eucalypt Woodland is known to occur in the region but no evidence this formed a significant part of the site, or has been cleared and only remnants remain. This community only supports 4 water dependent species:

- Corangamite Water Skink, *Eulamprus tympanum marnieae*, (Endangered)
- Southern Bell Frog, *Litoria raniformis*, (Vulnerable)
- Swamp Fireweed, *Senecio psilocarpus*, (Vulnerable)
- Swamp Everlasting, *Xerochrysum palustre*, (Vulnerable)

Listed Threatened Species

Sixty one threatened species are recorded under the MNES tool, some of which are mentioned above, however only 17 are water dependent or realistically occur in the area (Table 3-4).

Table 3-4 Water dependent species present within the development area or downstream Ramsar site under the MNES tool.

Scientific Name	Common Name	Class	Simple Presence	Threatened Category
Neophema chrysogaster	Orange-bellied Parrot	Bird	Likely	Critically Endangered
Calidris ferruginea	Curlew Sandpiper	Bird	Known	Critically Endangered
Numenius madagascariensis	Eastern Curlew, Far Eastern Curlew	Bird	Known	Critically Endangered
Lissolepis coventryi	Swamp Skink, Eastern Mourning Skink	Reptile	May	Endangered
Lachnagrostis adamsonii	Adamson's Blown-grass, Adamson's Blowngrass	Plant	May	Endangered
Calidris canutus	Red Knot, Knot	Bird	May	Endangered
Botaurus poiciloptilus	Australasian Bittern	Bird	Known	Endangered
Rostratula australis	Australian Painted Snipe	Bird	Likely	Endangered
Nannoperca obscura	Yarra Pygmy Perch	Fish	May	Vulnerable
Limosa lapponica baueri	Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit	Bird	Known	Vulnerable
Charadrius leschenaultii	Greater Sand Plover, Large Sand Plover	Bird	May	Vulnerable
Prototroctes maraena	Australian Grayling	Fish	May	Vulnerable
Pachyptila turtur subantarctica	Fairy Prion (southern)	Bird	Known	Vulnerable
Sternula nereis nereis	Australian Fairy Tern	Bird	May	Vulnerable
Galaxiella pusilla	Eastern Dwarf Galaxias, Dwarf Galaxias	Fish	May	Vulnerable
Litoria raniformis	Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog, Golden Bell Frog	Frog	Likely	Vulnerable
Amphibromus fluitans	River Swamp Wallaby-grass, Floating Swamp Wallaby-grass	Plant	Likely	Vulnerable

Listed Migratory Species

Thirty five migratory species are recorded under the MNES tool, some of which are mentioned above, however only 13 are water dependent or realistically occur in the area (Table 3-5).

Table 3-5 Migratory species which are water dependent and likely to occur near the development or Ramsar site

Scientific Name	Common Name	Class	Rank	Threatened Category
Limosa lapponica	Bar-tailed Godwit	Bird	Known	
Charadrius leschenaultii	Greater Sand Plover, Large Sand Plover	Bird	May	Vulnerable
Calidris acuminata	Sharp-tailed Sandpiper	Bird	Known	
Calidris melanotos	Pectoral Sandpiper	Bird	May	
Lagenorhynchus obscurus	Dusky Dolphin	Mammal	May	
Calidris canutus	Red Knot, Knot	Bird	May	Endangered
Tringa nebularia	Common Greenshank, Greenshank	Bird	Likely	
Apus pacificus	Fork-tailed Swift	Bird	Likely	
Actitis hypoleucos	Common Sandpiper	Bird	Likely	
Calidris ferruginea	Curlew Sandpiper	Bird	Known	Critically Endangered
Ardenna grisea	Sooty Shearwater	Bird	May	
Numenius madagascariensis	Eastern Curlew, Far Eastern Curlew	Bird	Known	Critically Endangered
Gallinago hardwickii	Latham's Snipe, Japanese Snipe	Bird	Likely	

Listed Marine Species

Forty-one listed marine species are recorded under the MNES tool, some of which are mentioned above, however only 19 are water dependent or realistically occur in the area (Table 3-6).

Table 3-6 Listed marine species which are water dependent or realistically occur in the area

Scientific Name	Common Name	Class	Rank	Threatened Category
Limosa lapponica	Bar-tailed Godwit	Bird	Known	
Charadrius leschenaultii	Greater Sand Plover, Large Sand Plover	Bird	May	Vulnerable
Calidris acuminata	Sharp-tailed Sandpiper	Bird	Known	
Calidris melanotos	Pectoral Sandpiper	Bird	May	
Sterna striata	White-fronted Tern	Bird	May	
Neophema chrysogaster	Orange-bellied Parrot	Bird	Likely	Critically Endangered
Calidris canutus	Red Knot, Knot	Bird	May	Endangered
Tringa nebularia	Common Greenshank, Greenshank	Bird	Likely	
Apus pacificus	Fork-tailed Swift	Bird	Likely	
Pachyptila turtur	Fairy Prion	Bird	Known	

Scientific Name	Common Name	Class	Rank	Threatened Category
Actitis hypoleucos	Common Sandpiper	Bird	Likely	
Calidris ferruginea	Curlew Sandpiper	Bird	Known	Critically Endangered
Haliaeetus leucogaster	White-bellied Sea-Eagle	Bird	Known	
Ardenna grisea	Sooty Shearwater	Bird	May	
Numenius madagascariensis	Eastern Curlew, Far Eastern Curlew	Bird	Known	Critically Endangered
Gallinago hardwickii	Latham's Snipe, Japanese Snipe	Bird	Likely	
Rostratula australis	Australian Painted Snipe	Bird	Likely	Endangered
Merops ornatus	Rainbow Bee-eater	Bird	May	
Bubulcus ibis	Cattle Egret	Bird	May	

Whales and Other Cetaceans

Three whale species are listed under the MNES too but none have been sighted or realistically would inhabit the development site, Hovells Creek or the Limeburners Bay Ramsar Site. These species include:

- Dusky Dolphin (Lagenorhynchus obscurus)
- Humpback Whale (Megaptera novaeangliae)
- Pygmy Right Whale (Caperea marginata)

The vast majority of the values identified under the MNES tool are those associated with the Ramsar site and a large percentage of these are not water dependent or realistically occur in the region. Nonetheless, an assessment will be made of the upstream hydrological changes on all of these water dependent species to assess if the any impacts are likely or not.

4 Flow Volume Assessment

As noted in Section 1.1, development of the Site will increase the volume of stormwater runoff from the Site compared with the existing use. Measures such as reuse can be implemented to partially mitigate to a degree the increase in runoff volume but it is not practical to fully mitigate the increase in volume. Therefore water balance modelling was undertaken to investigate volume mitigation options and to understand the potential impact of the increased volume on the Limeburners Bay receiving environment.

Preliminary investigations found that the development of the Site would result in an unacceptable increase in the volume of water flowing into the floodplain wetland downstream of the southern outlet (refer Figure 2-2). To mitigate this impact a piped flow diversion is proposed to take the increased runoff above existing conditions from the southern outlet to the northern outlet and then onto Hovells Creek. The general design intent is to approximately maintain the existing flow regime into the floodplain wetland. Therefore the assessment in this report is on the basis of this flow diversion being implemented.

Because of the significant natural variability in rainfall, and hence runoff, it would not be possible to design a diversion structure that exactly replicates the existing conditions flow into the floodplain wetland. Therefore an understanding of the sensitivity of the floodplain wetland hydrology, namely wetting extent, depth and duration, to small increases and decreases in the natural flow regime was required. To assess this a hydraulic model was developed and the existing conditions flows and variations in the range ± 20% were assessed using a typical wet and dry months.

4.1 Methodology

The assessment was carried out according to the following methodology for the Hovells Creek catchment, including the Site:

- Volume Assessment:
    - a water balance model of the Hovells Creek catchment was created to represent:
        - the existing case (previous to any development);
        - the proposed development case of the Site;
    - The model was run over a twenty year time period using a 6 minute timestep;
    - Daily time series of surface runoff volumes were taken from the model outputs for further analysis;
    - Analysis of volumes was carried out on a monthly basis and existing and developed cases compared to quantify how changes to the Site fraction impervious change the runoff volume;
    - Mitigation options assessment:
        - Mitigation options were assessed to quantify reductions in volumes;
        - Benefits of each options were assessed and considered against what could be reasonably introduced into the development and provide a meaningful reduction in volume;
    - Impact on Hovells Creek hydrological regime:
        - The impact was assessed in terms of changes in magnitude of mean monthly flow volumes in Hovells Creek;
- Floodplain Wetland Hydrology
    - The catchment to the wetland included the Site's southern catchment, the Rennie Street and Princes Freeway road reserves, the area between the Princes Freeway and the wetland, and the wetland itself;
    - The MUSIC model was refined to include these separate catchment to provide inflows for the hydraulic model;

- A 2D TUFLOW hydraulic model was setup for the assessment;
- A typical dry month and a typical wet month were assessed for existing flows and existing flows with varied by +5%, +10% +20%, -5%, -10% and -20%;
- Existing catchment flows were extracted from the MUSIC model for the selected months which was run using a 6-minute timestep. The existing flows off the Site were scaled up and down to the desired percentage change using the scaling functionality in the TUFLOW boundary database; and
- Changes in flood extent, depth and duration within the wetland were assessed.

4.2 Model Setup and Parameter

4.2.1 Water Balance Model

Water balance models of the catchments were created using the MUSIC conceptual modelling software program. The adopted modelling parameters were based on standard parameters typical for catchments of this nature. This assessment focuses on the relative changes in hydrological regime between the scenarios and as will be shown in this report the development of the Site has only a very small influence on volumes within Hovells Creek. Therefore further assessment using parameters calibrated specifically to this catchment would not be warranted as the changes in volume would need to be significantly larger to impact on Limeburners Bay.

The MUSIC modelling uses the rainfall template: 20year_GeelongNorth_1971-1990_6min.mlb, as recommended by the City of Greater Geelong guidelines[3]. The models were run at a 6-minute timestep using this 20 years of rainfall data. The MUSIC models use the recommended soil property parameter values as set out by Melbourne Waters MUSIC Modelling Guidelines: Soil Storage Capacity = 120mm, and Field Capacity = 50 mm. The remaining soil parameters were set to the default values.

The MUSIC model schematisation can be seen in Figure 4-1 for the model providing floodplain wetland flow inputs, and in Figure 4-2 (existing Hovells Creek and existing Site) and Figure 4-3 (existing Hovells Creek and Developed Site) for the models used for the Hovells Creek volume assessment. The existing greater catchment to Hovells Creek is simplified to a single node (or rather three nodes due to the 10,000 Ha node limit in MUSIC) which is considered appropriate for analysis aggregated to a daily timestep with the goal to assess medium term trends. The developed case model includes rainwater tanks in the residential portion of the Site and are included as a volume mitigation measure as described in Section 4.3. The wetlands, whilst providing some volume reduction, were sized by Loetis Consulting to satisfy water quality guidelines.

GIS analysis was used to calculate the FI for the existing catchment as previously described in Section 2.2, and for the developed case the Site areas and fraction impervious assumptions are shown in Table 4-1 and Table 4-2 for the catchments draining to the southern and northern outlets respectively. The pre-developed area total is different from the developed area total because, as noted in Section 2.2, a portion of the residential development will be designed to flow to the southern outlet even though it is located in the existing conditions northern catchment.

The analysis of the water balance model outputs for the Hovells Creek catchment uses the total flow timeseries from the catchment. The analysis at the site level uses the surface runoff timeseries. MUSIC allows the separation of baseflow and runoff components of flow from catchment nodes. MUSIC calculates baseflow as

[3] MUSIC – Modelling Approach and Parameters Design Note 3, The City of Greater Geelong, November 2019

a proportion of the volume that enters the soil profile through infiltration into pervious surfaces. The volume of water not lost to evaporation or to deep seepage is modelled as water that passes through the soil profile to the receiving body of water as baseflow, with the excess water expressed as runoff. The runoff timeseries is used for the analysis at the site scale to assess the impact of additional surface flows entering the sensitive wetland area. The total flow approach was deemed more appropriate for the greater Hovells Creek scale as the flow components are indistinguishable in the creek.

This allows the presentation of data with respect to changes in the mean monthly and daily totals for larger runoff events. These aspects of hydrological regime provide insight into wetland wetting/drying cycles, the average size of inundation events, and duration of inundation (indicated by characteristics of larger runoff events such as mean volume of events). This is considered an appropriate methodology for analysing the changes in hydrologic characteristics of the volume series for this proposed development.

Table 4-1 Areas and FI for Catchment to Northern Outlet

	Ha	FI
Residential Roof	6.06	1
Residential Other than Roof	5.74	0.49
Road reserve	5.36	0.6
Open Space	1.92	0.1
Total Area	**19.08**	**0.64**

Table 4-2 Areas and FI for Catchment to Southern Outlet

	Ha	FI
Commercial lots	54.7	0.9
Commercial road reserve	15.89	0.6
Commercial open space	7.73	0.1
Total Commercial Area	**78.32**	**0.76**
Residential Roof	4.96	1.0
Residential Other	4.7	0.49
Residential Road Reserve	4.39	.60
Residential Open Space	1.57	.10
Total Residential Area	**15.62**	**0.64**

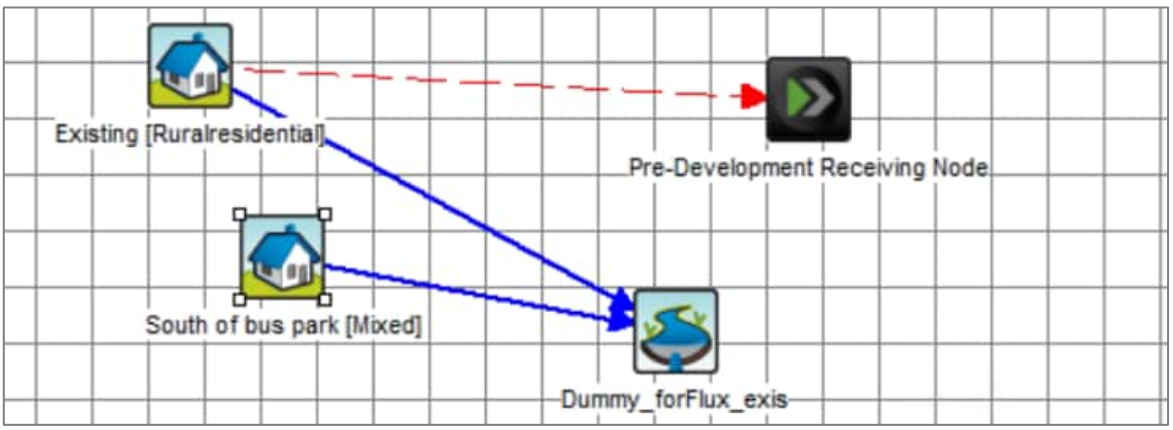


Figure 4-1 MUSIC Model Schematisation for Floodplain Wetland Inflows

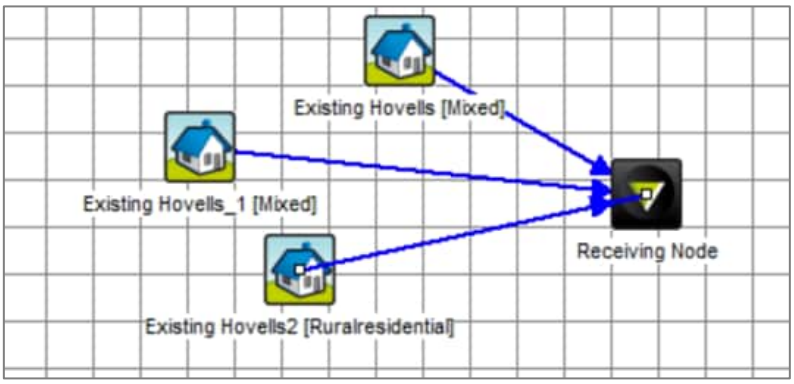


Figure 4-2 MUSIC Model Schematisation for Existing Hovells Creek Catchment

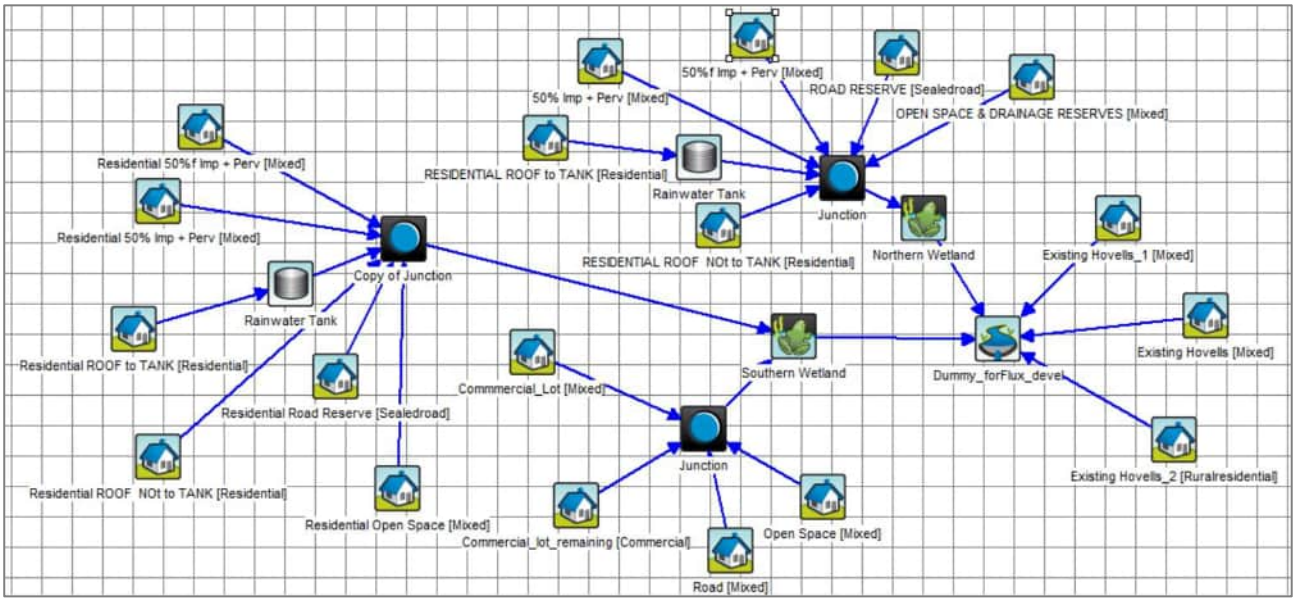


Figure 4-3 MUSIC Model Schematisation for Existing Hovells Creek Catchment & Developed Site

4.2.2 Hydraulic Model

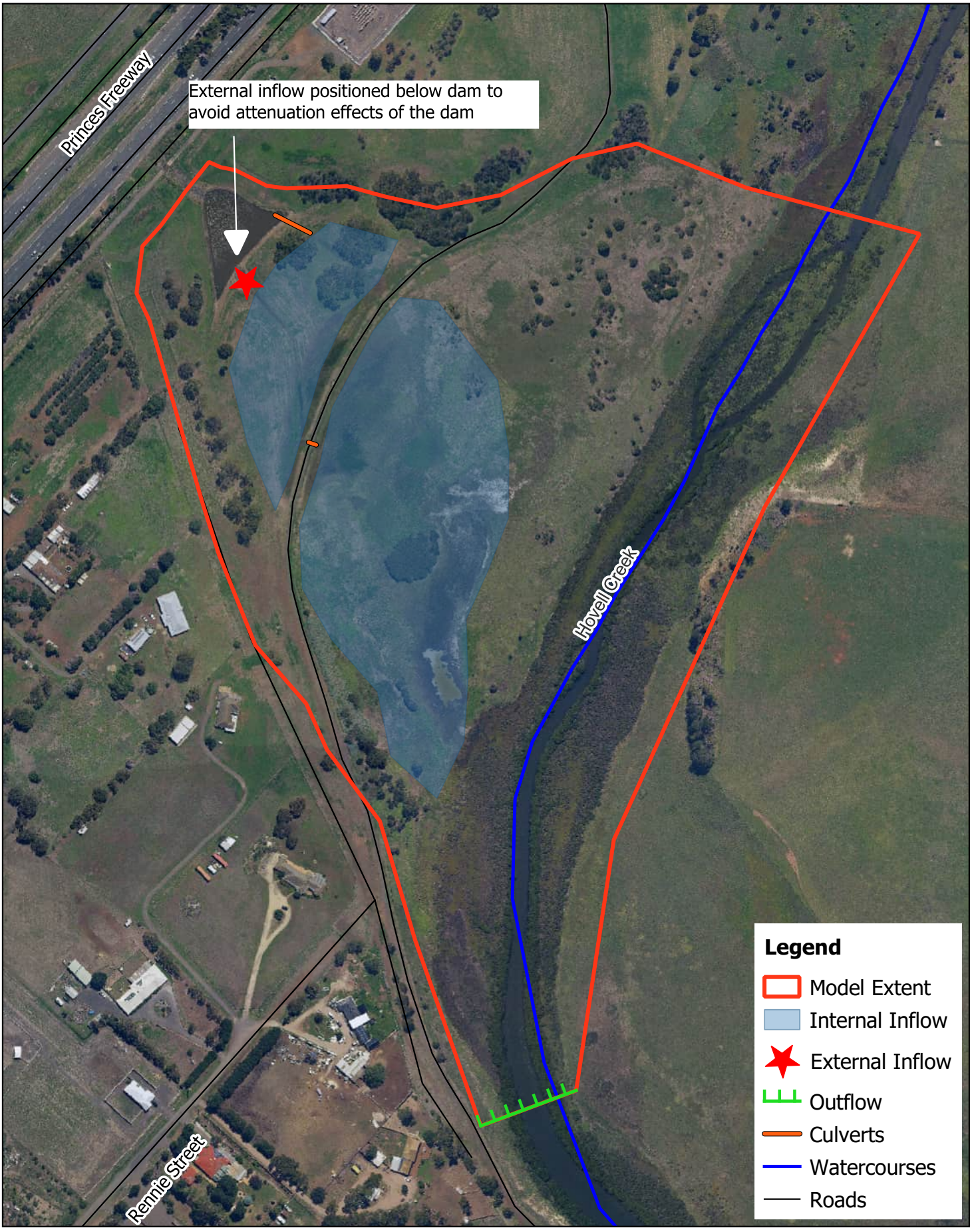
A 2D/1D TUFLOW HPC hydraulic model was used to assess the changes in flood extent, depth and duration of flooding in the floodplain wetland. The model schematisation is shown in Key as aspects of the model setup are as follows:

- Software build 2023-03-AC-iSP-w46 0 the latest version at the time the modelling was undertaken;
- Model extends from downstream of the Princes Freeway to Hovells Creek;
- 1 m computational grid size;
- Digital elevation model based on:
    - Vicmap 2012 Melbourne & Surrounds Forest Structure LiDAR (Lara) with a vertical accuracy of 0.1 m;
    - Ground survey of the following key hydraulic controls:
        - Dam crest and spillway, bathymetry and outlet riser and pipe;
        - Pedestrian/bike path immediately upstream of floodplain wetland and pipes under path;
        - Overflow point (outlet) from floodplain wetland into Hovells Creek;
- Inflow boundaries from MUSIC model:
    - Southern Site applied using a small SA downstream of dam;
    - Area from road reserve to bike path applied using a normal SA which initially applies inflow to the lowest point and then to all wetted areas proportionally with depth;
    - Floodplain wetland applied using a normal SA;
    - No Hovells Creek flow included so that the results in the floodplain wetland were not masked by submergence from Hovells Creek;
- Manning's 'n' using standard published values and the team's experience from calibrating TUFLOW models;
- Downstream boundary in Hovells Creek using a fixed H-T – sensitivity testing was undertaken to check that the boundary was not influencing the results in the area of interest;
- Evaporation applied over the model, including the floodplain wetland, but infiltration losses were not applied.

The inflow to the model was based on the mean daily volume determined from the MUSIC model. Lloyd Environmental requested that the analysis be undertaken using a typical dry month and a typical wet month. March 1973 (dry month) and October 1976 (wet month) were selected for the analysis as their monthly volumes were similar to mean monthly volume for the respective months derived from the water balance model analysis of the 20 year period.

The model was initially set up with the flow from the Site input above the dam as would be expected. This flow was routed through the dam and overflowed through the riser pipe initially and then the dam spillway if the flows were large enough. However initial testing of the increased flow scenarios (existing plus 5%, 10% and 20%) found that the increased flows were substantially attenuated by the dam (including the effects of evaporation) resulting in negligible change in the floodplain wetland, noting that the initial water level in the dam was based on a two-month warmup period, i.e., the model was run for two months prior to the months of interest. This would then mean that the decision on an acceptable tolerance on flows above or below existing when designing the diversions structure would be on the basis of the dam remaining in-place indefinitely. Therefore it was decided to place the Site inflow boundary downstream of the dam so there was not a reliance on the dam. This in effect means that in the model simulations there is no water passing through the dam which is a conservative approach to the analysis.

In total, 14-month long simulations were undertaken to represent the existing conditions for each month and the 6 sensitivity scenarios (-20%, -10%, -5%, +5%, +10%, +20%).



Title:

Lara Lakes Development Limeburners Bay Impact Assessment Tuflow Schematisation

Figure:	Rev:	0 50 100 m	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: TL Date: Dec 2023
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4.3 Volume Mitigation Scenario Assessments

In consideration of the potential impacts to the Limeburners Bay RAMSAR wetland and the performance objective on flow volume reduction in the EPA guideline mitigation measures were assessed for effectiveness and in consideration of the EPA guideline acknowledgement that "*level of flow volume performance to achieve will depend on what is reasonably practicable".* Using Table 1 in the EPA guidelines the Site would be classified as an Other Area and with a mean annual rainfall of 457 mm (Avalon Airport) the performance objective is a 32% reduction in the mean annual impervious runoff. The following measures were assessed using the water balance model to initially establish their effectiveness and then were considered against the *reasonably practicable* test:

- Residential
    - Evaporation/infiltration ponds in addition to the proposed wetland
    - Mandated rainwater tanks with re-use for toilet flushing and laundry
    - Rain gardens
- Business Park
    - Evaporation/infiltration ponds in addition to the proposed wetland
    - Rain gardens
    - Stormwater harvesting for irrigation of sporting fields
    - Street-scale tree pits

Rainwater tanks were not assessed for the business park because the benefit would be significantly dependent on the business water requirements and this is not known at this stage.

4.3.1 Evaporation/Infiltration Ponds

To inform the infiltration assumption in the MUSIC model, geotechnical and permeability testing was undertaken using materials from 5 boreholes across the Site. Sil data from a further 5 boreholes were also available for comparative purposes but permeability testing was not undertaken on these. Interpretation of the results was provided by David Ife of EHS Support. In summary there is little opportunity for infiltration as the sediments are alluvial and dominated by floodplain sediments of low permeability. Sand was encountered but is more likely to represent channel deposits laid down by meandering watercourse can be referred to as shoestring sands because of their meandering and often discontinuous nature. The drilling suggests that there is not a continuous sheet of sand. The permeability results were characteristic of clay rather than sand and in the range $1x10^{-9}$ m/s to $6x10^{-7}$ m/s or 0.004 mm/hr to 2.2 mm/hr. It is not strictly correct to correlate permeability with infiltration rate but the results indicate low infiltration rates and the CSIRO Atlas of Australian Soils suggested a wide range of typical soil types and infiltration rates in the area.so the low end of the range of 0.2 mm/hr was adopted. Infiltration areas were modelled with a 0.4 m extended detention depth and a 0.5 m filter depth, with filter perimeter calculated as = 4*√(filter area). To achieve an approximately 33% reduction in developed case runoff volume would require the following areas:

- ~10 Ha for the residential development in addition to the wetlands
- ~18 Ha for the business park in addition to the wetlands

4.3.2 Residential Rainwater Tanks

For this assessment the following assumptions were made with regards to the number of lots and sizes based on a preliminary concept for the land budget.

Table 4-3 Residential Lot Assumptions

Lot Size (m^2)	Number of Lots
300	24
350	144
450	92
500	215
600	8

The residential roof to tank modelling was done using a lumped node approach. A roof:impervious:pervious area ratio for each block size of approximately 60:30:10 (with roof proportion decreasing slightly as block size increases) was assumed, giving a total roof area was estimated as ~11 Ha. Each household was assumed to have a 3Kl harvesting tank, with a 90mm overflow diameter. Two sub-scenarios were modelled – the first with 100% roof area connected to tank, and the second with only 50% roof area connected to tank. The daily demand is in accordance with advice from the Melbourne Water MUSIC Modelling Guidelines:

- Toilet – 20 L / person / day
- Laundry – 80 L / house / day

According to the ABS census (2021) the average number of occupants per house is 2.58. This gives a re-use demand of 131.6 L/household/day, or a total daily demand of 63.5 Kl.

The impervious mean annual runoff (MAR) reductions for the two scenarios are summarised in Table 4-4. The 100% roof to tank only provides a modest benefit over the 50% roof to tank. The additional difficulty and cost to provide 100% roof to tank does not justify the benefit.

Table 4-4 Impervious MAR Reduction for Rainwater Tanks

Scenario	Impervious MAR (ML/yr)		
	Unmitigated	Volume Reduction	% Reduction
100% roof to tank	95.7	30.4	32%
50% roof to tank	95.7	20.7	22%

4.3.3 Residential Raingardens

The raingardens were modelled similarly using a lumped node approach. Each lot was assumed to have a strip raingarden 1m wide x 5m long, with an extended detention depth of 0.2 m. 50% of the lot impervious and pervious area was assumed to drain to the in-ground raingarden. The rainwater tanks overflow to the raingarden, however this has little consequence on the performance of a raingarden this size.

The residential raingardens provided a 4.7% reduction in impervious MAR.

4.3.4 Business Park Raingardens

The assumptions for lumped modelling of raingardens in the Business Park area is based on an average lot size of 1700 m^2. Given impervious fraction assumption of 90%, there is 170 m^2 of pervious area on each lot. A strip 30m x 1.5 m garden bed raingardens along both sides of the block, 30m x 1.5 m garden beds was assumed. It is assumed that all roof water drains to the rain gardens (assuming 70% of the lot is roof area).

The business park raingardens provided an 17% reduction in impervious MAR.

4.3.5 Business Park Street-Scale Tree Pits

For this scenario it was assumed there are 2 tree pits per lot frontage. Assuming approximately 272 lots based on a concept land budget, makes a total of 544 tree-pits, each with a contributing road reserve catchment (divided equally between the lots) of 253 m^2.

The street-scale tree-pits a 1% reduction in impervious MAR.

4.3.6 Wetlands

Wetlands are proposed as both the southern and northern outlets for water quality management. And whilst not specifically a volume mitigation device they provide a small contribution through evapotranspiration. The percentage reduction in impervious MAR from both of the wetlands would be 9%:

4.3.7 Summary of Volume Mitigation Options Assessment & Adopted Measures

Because of the very low infiltration rates significant areas would be required to provide a meaningful reduction in runoff volumes on both the residential and business park areas. Therefore they were not considered to be a *reasonably practicable* option and hence were not included in the Hovells Creek impact modelling.

The residential rainwater tanks provided a meaningful reduction and were adopted for the Hovells Creek impact modelling using the 50% roof to tank option.

The residential raingardens did not provide a significant reduction in volume and it was considered that they may not be retained or maintained by residents. Therefore they were not considered to be a *reasonably practicable* option and hence were not included in the Hovells Creek impact modelling.

The business park raingardens would make a reasonable contribution to volume reduction but Lara Farms Pty Ltd advised that their implementation in a business park environment would not be practical because it would involve creating encumbrances on lots where the specific requirements for each lot has not been ascertained, e.g. truck egress and ingress requirements, equipment movements in and around the sites, hard stand on the site and placement of sheds. Therefore they were not considered to be a *reasonably practicable* option and hence were not included in the Hovells Creek impact modelling.

Based on the above adopted measures the following reductions in impervious MAR volume would be achieved:

- Business: 9% (wetland)
- Residential: 31% (wetland + rainwater tanks with 50% roof to tank)

Whilst not achieving the 32% performance objective in the EPA guidelines, the adopted measures are those that are considered to be *reasonably practicable* to implement. In determining what is *reasonably practicable* the EPA provides guidance on assessing what is reasonably practicable on their website[4] where it is suggested considering the questions listed in Table 4-5. The table includes responses to the questions which led to the conclusion that the adopted measures are *reasonably practicable*, with a key element of this assessment being that there is no harm to the environment as detailed in Section 5.

[4] https://www.epa.vic.gov.au/about-epa/laws/laws-to-protect-the-environment-and-human-health/reasonably-practicable-under-the-laws

Table 4-5Reasonably Practicable Assessment

EPA Question	Response
Eliminate first – can you eliminate the risk? If it's not reasonably practicable to eliminate the risk, think about how you can reduce it.	The risk is an increase in stormwater runoff volume impacting on the ecology of the receiving environment. The increase in volume cannot be eliminated but can be mitigated as assessed in the mitigation scenarios.
Likelihood – what's the chance harm will occur? Has the harm occurred before on your site or has it commonly occurred on other sites? Seek information from suppliers, manufacturers or industry.	The water balance modelling presented in this report has identified that there will be an increase in volume. As noted in the response in the row below the increase in volume does not cause harm.
Degree – how severe could the harm be to human health or the environment.	The assessment in Section 5 of this report found that there would be no harm to the environment from the increased volume, noting the assessment was on the basis of the implementation of the volume reduction measures (rainwater tank and wetlands) and the flow diversion. The increased volume does not harm human health.
Your knowledge about the risks – what do you know, or what can you find out, about the risks your activities pose? How can you address those risks to human health and the environment?	A detailed assessment of the RAMSAR and Environmental values and the impact of the changes in flow volume on the eco-system are presented in this report with the conclusion that there is no harm.
Availability and suitability – what technology, processes or equipment are available to control the risk? What controls are suitable for use in your circumstances.	Mitigation measures and their respective benefit in reducing flow volume have been assessed and presented in this report.
Cost – how much does the control cost to put in place compared to how effective would it be in reducing risk? Importantly, the most effective solution won't always be the most expensive. Likewise, a cheaper solution may not be the most effective available to control the risk.	The selected measures in reducing the volume are cost effective. The measures that would provide further benefit, evaporation/infiltration ponds and business park rain gardens, were not cost effective because of loss of land and impractical respectively in their own right but also in consideration that it was found that the development with the adopted measures does not cause harm

4.4 Assessment of Flow Volume Changes to Limeburners Bay

This section describes the comparison of the existing and ultimate cases runoff flow volume series in Hovells Creek which flows in Limeburners Bay. The ultimate case includes the rainwater tanks (50% of roof to tank) and wetland volume mitigation measures. A sensitivity test was also undertaken assuming only 50% uptake of rainwater tanks if they are not mandated.

4.4.1 Annual Runoff Flow Volume Series

In order to gain an initial appreciation of how flow volumes into Limeburners Bay would be affected by the proposed development, daily runoff time series were generated for the existing and developed cases. Average

annual total flow volumes in ML/year are shown for each case in Table 4-6, averaged across the 20 years of data.

As described in Section 1.1 it is proposed to divert flow from the southern outlet to the northern outlet to avoid adversely impacting on the floodplain wetland. The diverted flow will be the increase in flow above existing, i.e., the approximate equivalent of existing flows will be allowed to flow to the floodplain wetland. Therefore the reporting location used in the analysis of Hovells Creek is at the location where development flow outlets into Hovells Creek just upstream of the Rennie Street crossing of Hovells Creek. This does not include all of the Hovells Creek catchment flowing to Limeburners Bay but the additional catchment downstream of this location is small and unchanged by the development. The inclusion of the additional Hovells Creek catchment would have slightly reduced the reported percentage changes caused by the development of the Site. Therefore the percentage changes reported here are marginally conservative. Under existing conditions the Site only contributes approximately 0.2% of the flow in Hovells Creek

Development of the Site shows an average annual increase in volume of approximately 268 ML/yr or about a 1% increase in the flow volume to in Hovells Creek and hence into Limeburners Bay, noting that if tidal exchange was included the percentage change would be smaller.

Table 4-6 Average Annual Total Runoff Volumes

Catchment	Existing (ML/yr)	Ultimate (ML/yr)
Hovells Creek Catchment (including Site)	~27,300	~27,600
Site	73	341

4.4.2 Monthly Flow Volume Series

As has previously been documented in this report the ecological characteristics of the receiving environment are more likely to be affected by changes in the hydrological regime on a monthly and seasonal basis, rather than annual changes. Accordingly, the detailed analysis in this chapter is presented at a monthly time scale: daily runoff volumes from the model are aggregated to give total ML/month for each month.

Figure 4-5 shows the comparison of the flow volume timeseries in ML/month for each month, for both the existing and the developed case noting:

- the box extents plotted are the 25% and 75% percentiles;
- the dark horizontal bar in the box is the median value;
- the 'cross-hair' points indicate the 10th and 90th percentile values; and
- the text describes the existing mean and the change in mean monthly flow volumes for each month.

4.4.2.1 Assessment of Flow Volume Changes to Limeburners Bay

Figure 4-5 shows the comparison of the mean monthly 'runoff volume' in ML/month. The figure shows that the mean monthly runoff volume total has a general trend of increasing over all seasons. The increase in mean monthly runoff volumes ranges from 0.8 % to 1.6 % with the greatest increase seen in the month of April. The small increases are not unexpected given the Site is only 0.53% of the Hovells Creek catchment by area.

The results for the sensitivity test with 50% uptake of rainwater tanks is presented in Figure 4-6. Compared with the 100% uptake scenario the difference in mean monthly runoff volume is 0% in 9 months of the year and 0.1% in the other three months.

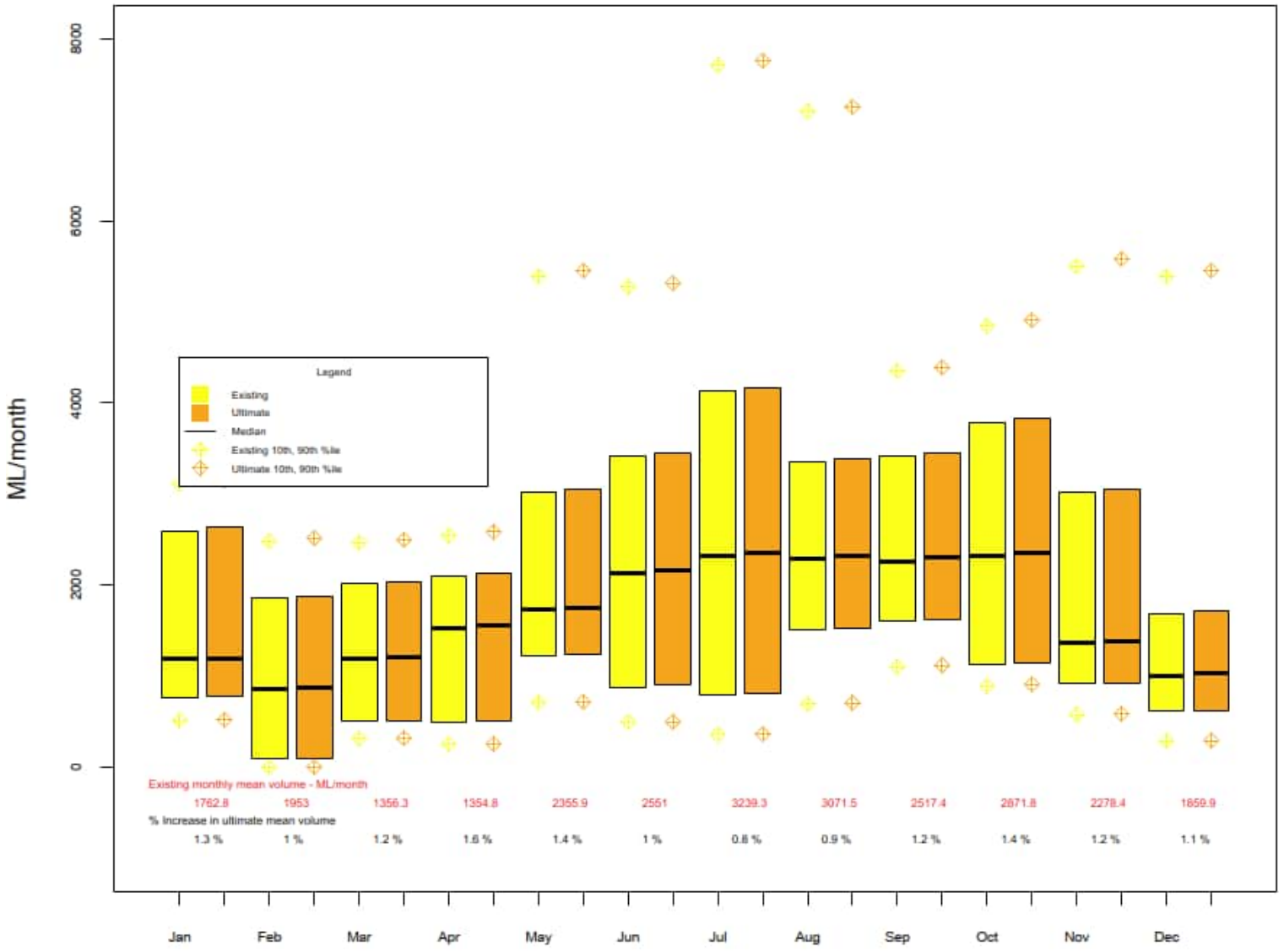


Figure 4-5 Hovells Creek Monthly Runoff flow Comparison – Existing v Developed

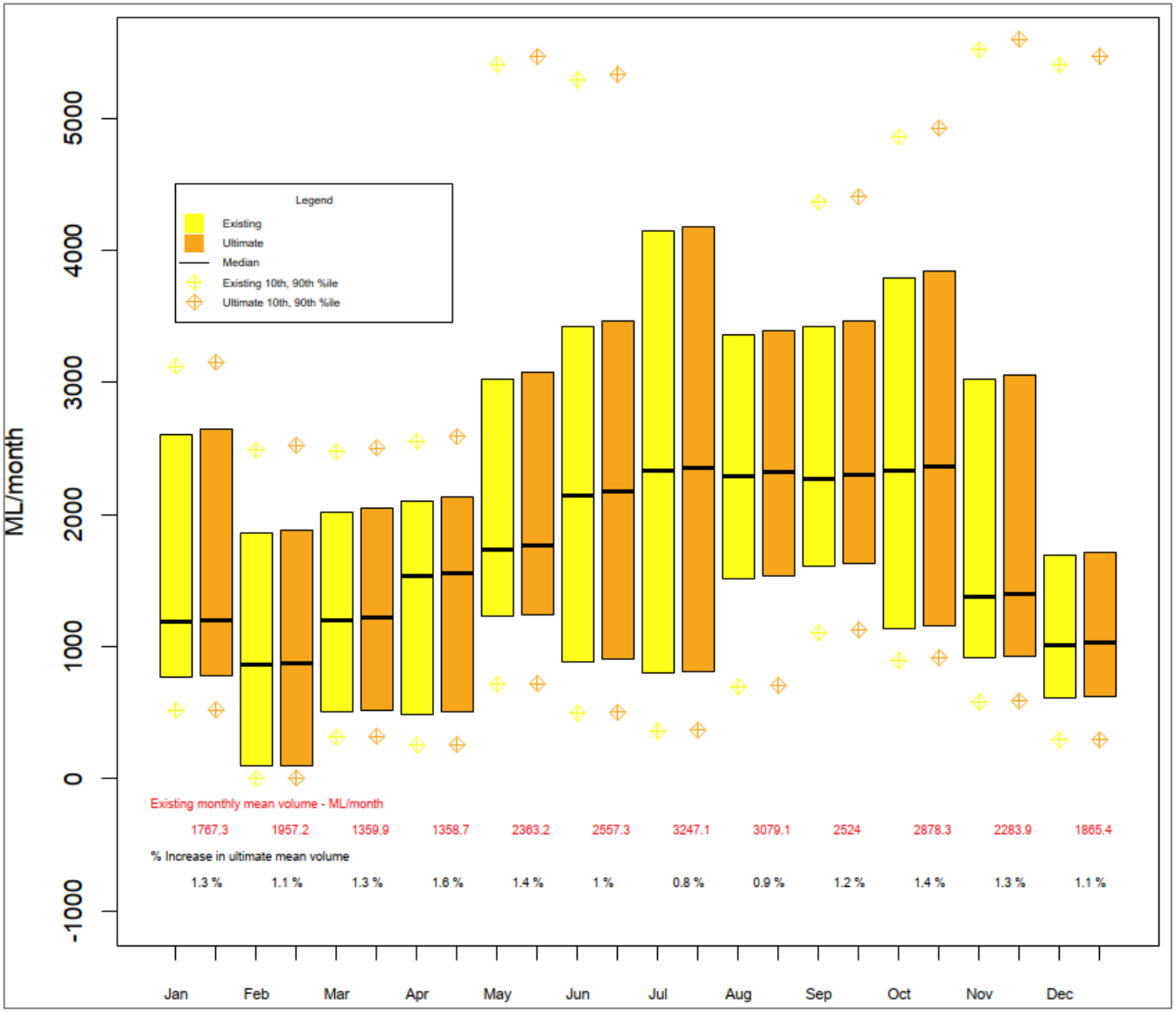


Figure 4-6 Hovells Creek Monthly Runoff flow Comparison – Existing v Developed (50% Rainwater Tank Uptake)

4.5 Floodplain Wetland Sensitivity Analysis Results

Fourteen one-month long simulations were undertaken to represent the existing flow conditions for each month and the 6 flow sensitivity scenarios for each month (-20%, -10%, -5%, +5%, +10%, +20%). The change in flood extent mapping for the +20% and -20% flow sensitivity test for March 1973 and October 1976 are included below as Figure 4-7 to Figure 4-10 with the mapping for the other sensitivity scenarios included in Appendix C. In the figures representing the +20% test the existing flow extent is mapped yellow and the additional extent is mapped in pink, and in the figures representing the -20% test the reduced extent is mapped with yellow and the blue shows the area that is no longer wet. The change in inundation areas is presented in Table 4-7 and Table 4-8.

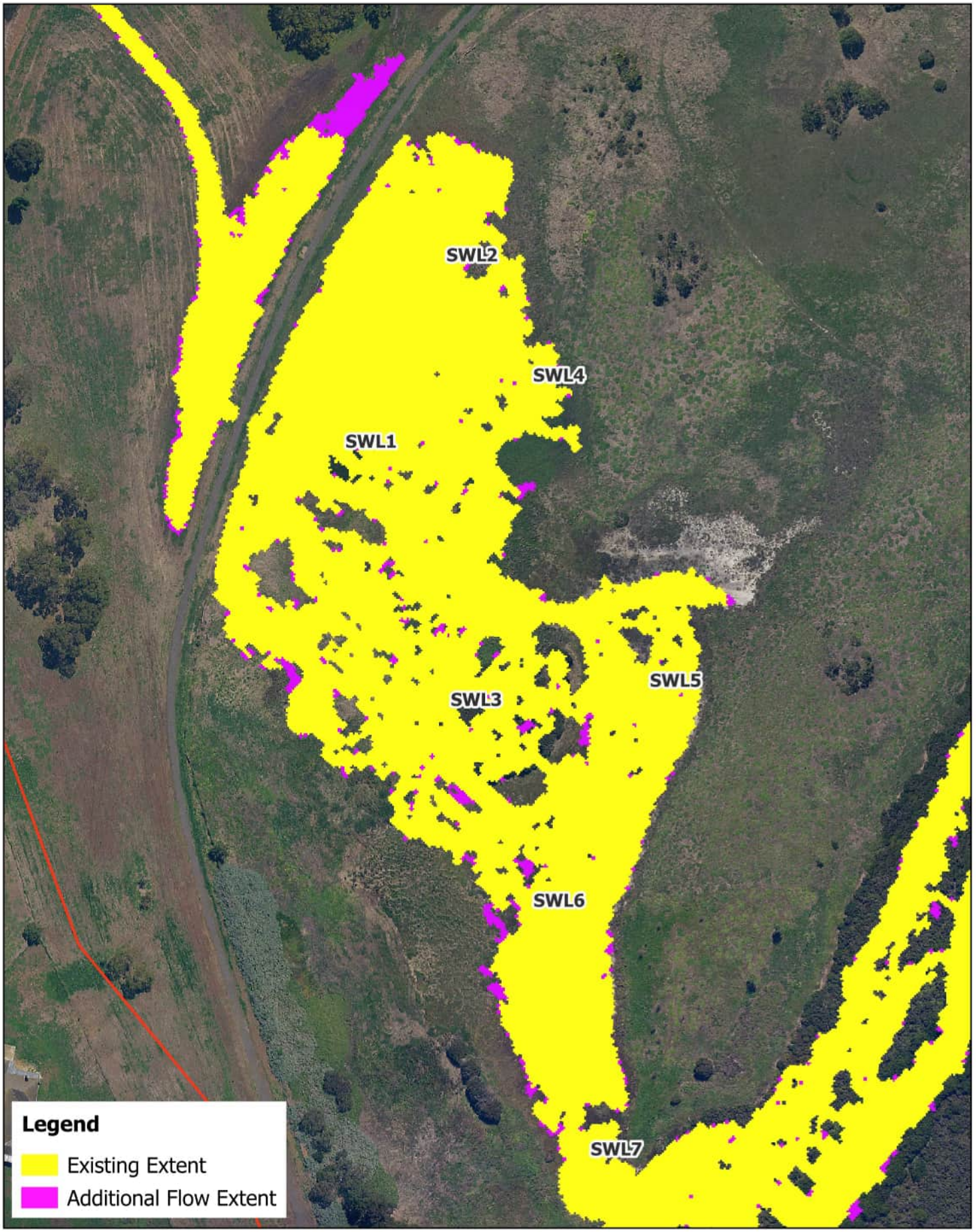
On these maps there are seven locations identified as SWL1 to SWL 7. Flood depth time series for March 1973 for existing flows and the ±20% flow scenarios are presented in Figure 4-11 to Figure 4-17 and the October 1976 time series are presented in Figure 4-18 and Figure 4-24. The other scenarios are included in Appendix D. These figures show only small changes in depths and there is no significant change in duration of flooding.

Table 4-7 Floodplain Inundation Extent Area Analysis – March 1973

Scenario	Layer	Area (m^2)
+5%	Existing Extent	15268
	Additional Flow Extent	138
	Percentage Change	0.9%
+10%	Existing Extent	15268
	Additional Flow Extent	238
	Percentage Change	1.6%
+20%	Existing Extent	15268
	Additional Flow Extent	363
	Percentage Change	2.4%
-5%	Reduced flow Extent	15196
	No longer Wet	-73
	Percentage Change	-0.5%
-10%	Reduced flow Extent	15123
	No longer Wet	-145
	Percentage Change	-1.0%
-20%	Reduced flow Extent	14950
	No longer Wet	-318
	Percentage Change	-2.1%

Table 4-8 Floodplain Inundation Extent Area Analysis – October 1976

Scenario	Layer	Area (m^2)
+5%	Existing Extent	17141
	Additional Flow Extent	21
	Percentage Change	0.1%
+10%	Existing Extent	17141
	Additional Flow Extent	45
	Percentage Change	0.3%
+20%	Existing Extent	17141
	Additional Flow Extent	126
	Percentage Change	0.7%
-5%	Reduced flow Extent	17109
	No longer Wet	-32
	Percentage Change	-0.2%
-10%	Reduced flow Extent	17072
	No longer Wet	-69
	Percentage Change	-0.4%
-20%	Reduced flow Extent	16988
	No longer Wet	-153
	Percentage Change	-0.9%



Title:

Lara Farms - Water Balance Assessment
March 1973 - Flow Extent Comparison (+20% Flow)

Figure:	Rev:	0 25 50 m	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: LD Date: Jan 2024
4-7	B			

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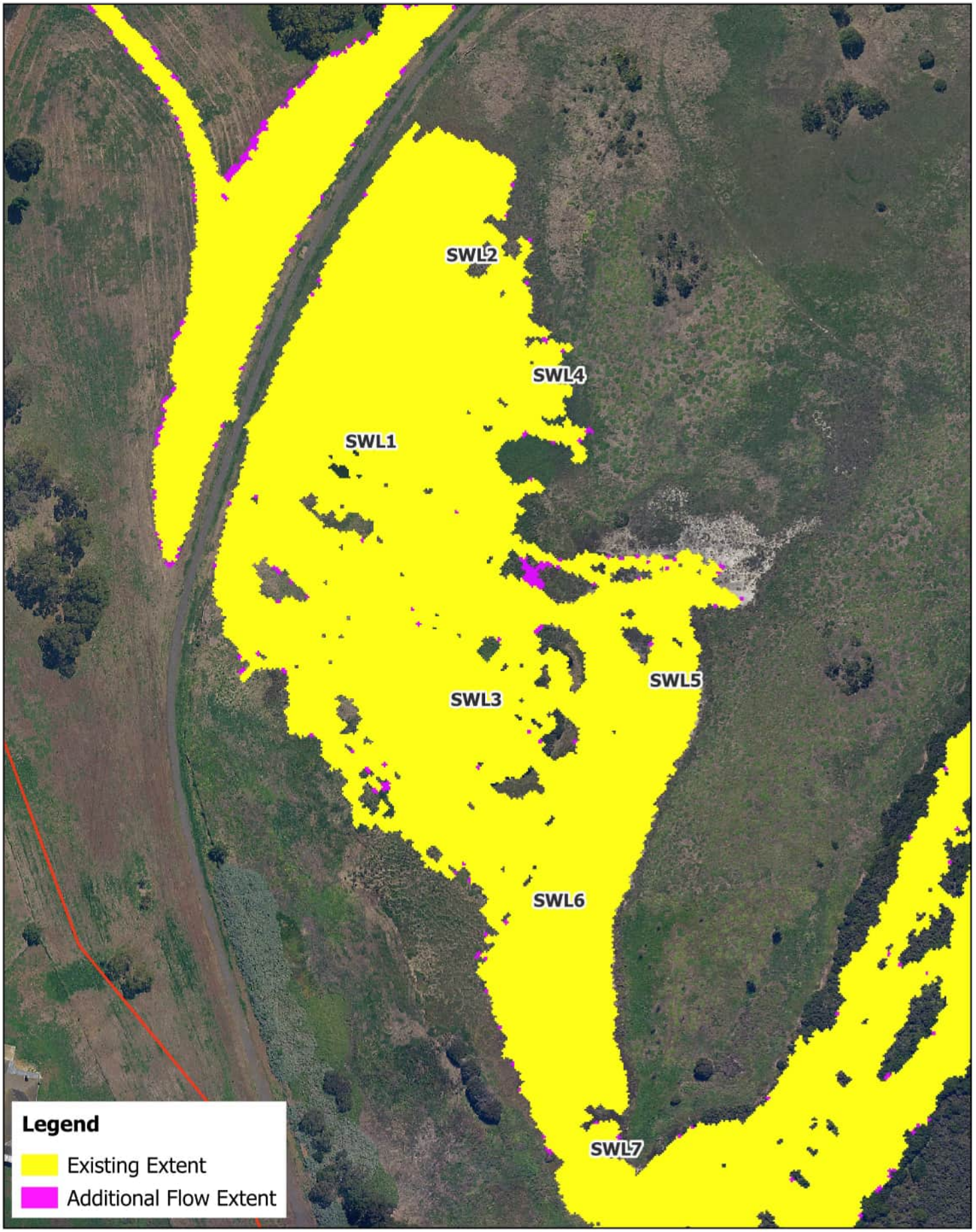

Title:

Lara Farms - Water Balance Assessment
October 1976 - Flow Extent Comparison (+20% Flow)

Figure:	Rev:			
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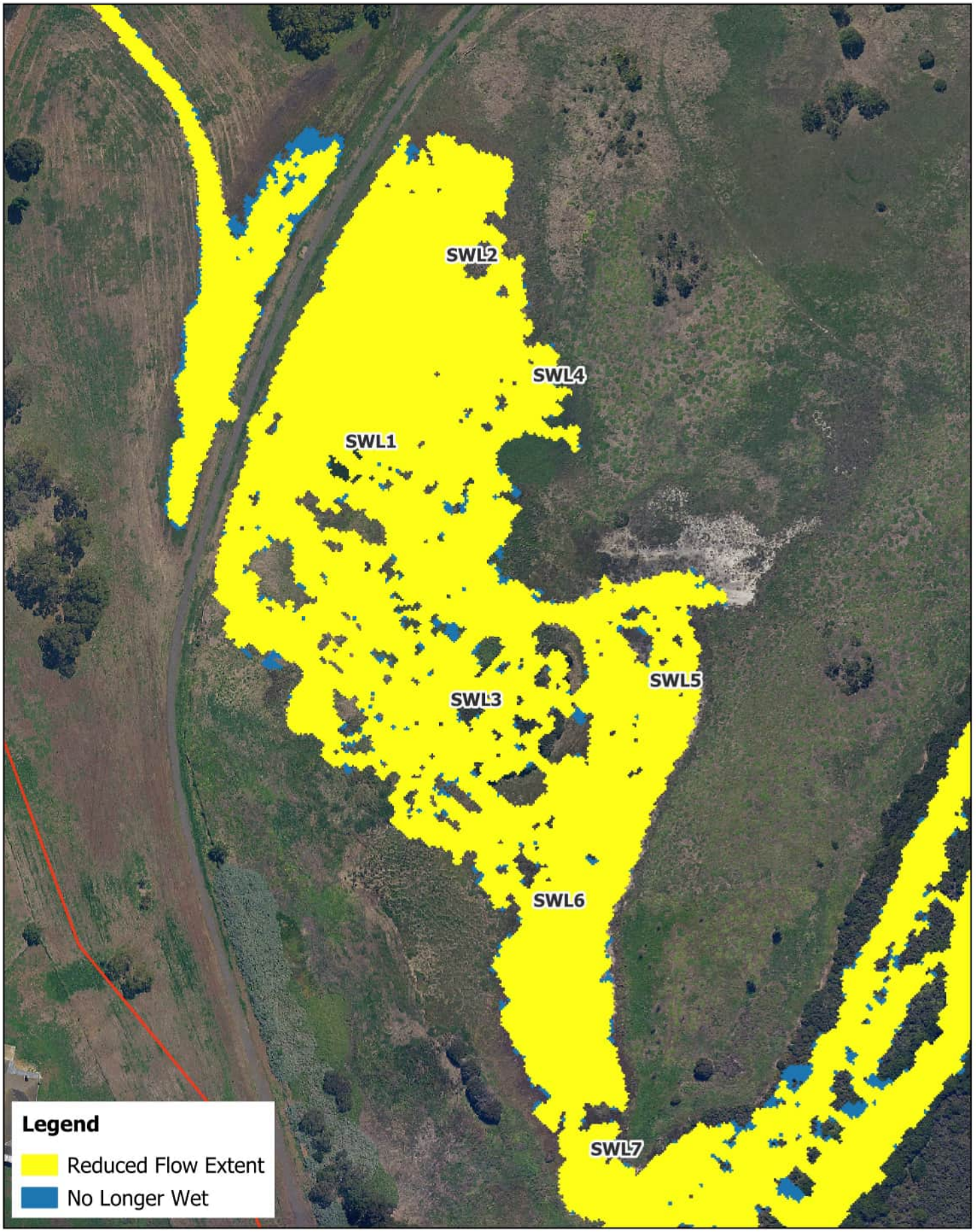

Title:

Lara Farms - Water Balance Assessment
October 1976 - Flow Extent Comparison (-20% Flow)

Figure:	Rev:			
4-9	B	0 25 50 m	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: LD Date: Jan 2024

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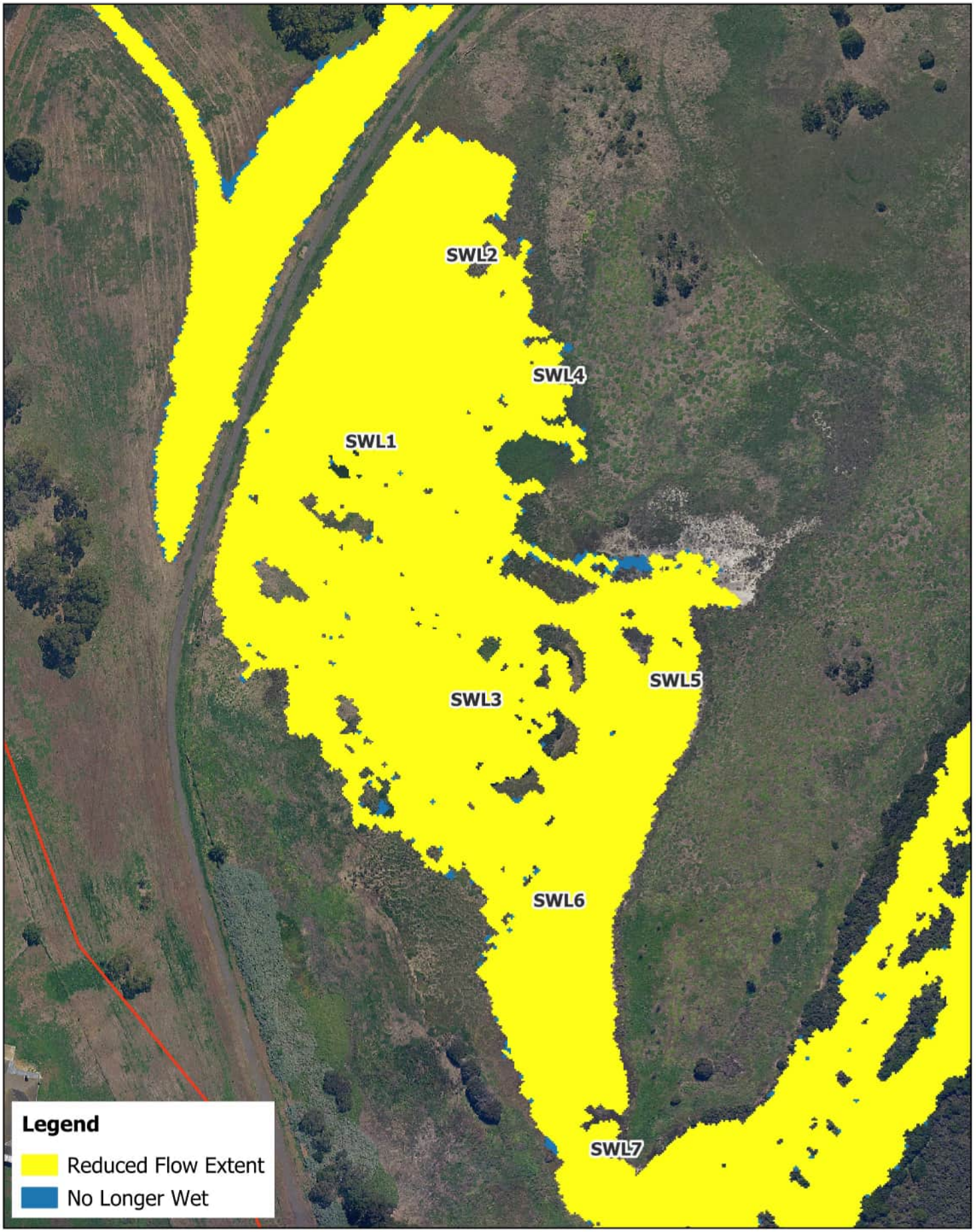

Title:

Lara Farms - Water Balance Assessment
October 1976 - Flow Extent Comparison (-20% Flow)

Figure:	Rev:			
4-10	B	0 25 50 m	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: LD Date: Jan 2024

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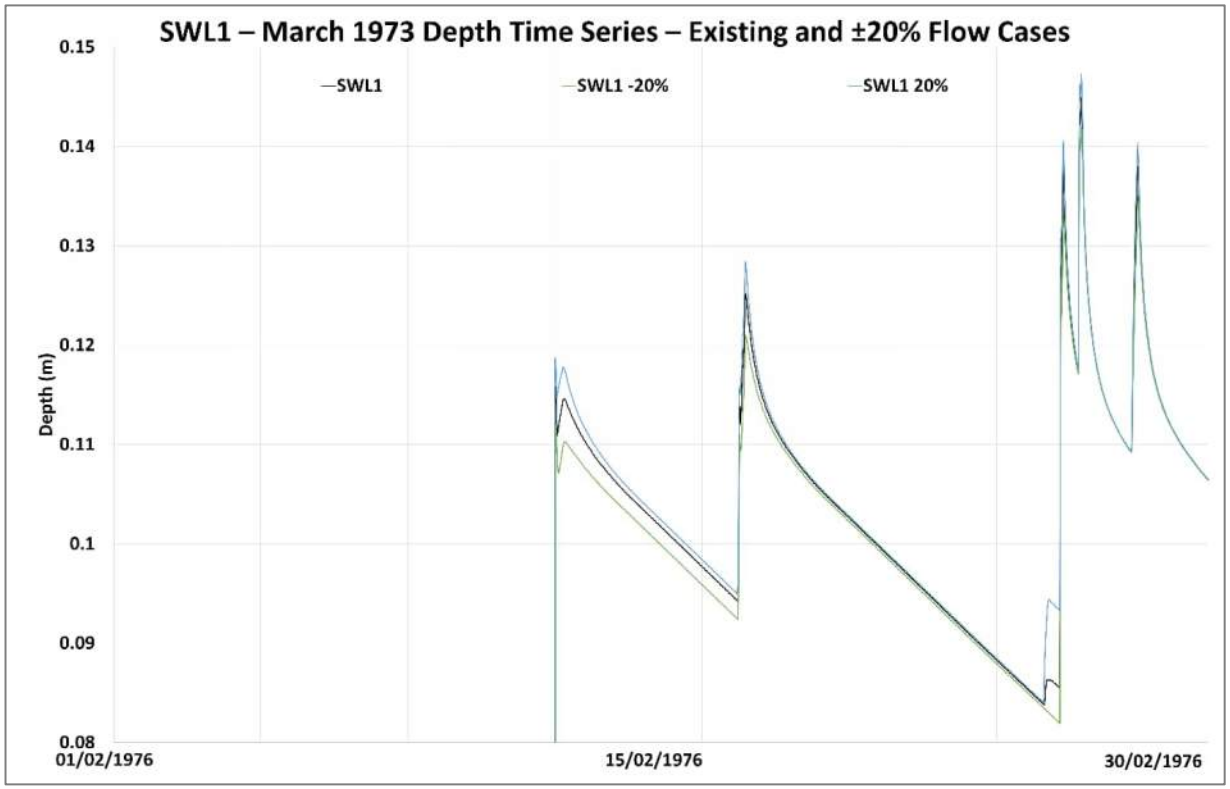

Figure 4-11 SWL1 – March 1973 Depth Time Series – Existing and ±20% Flow Cases

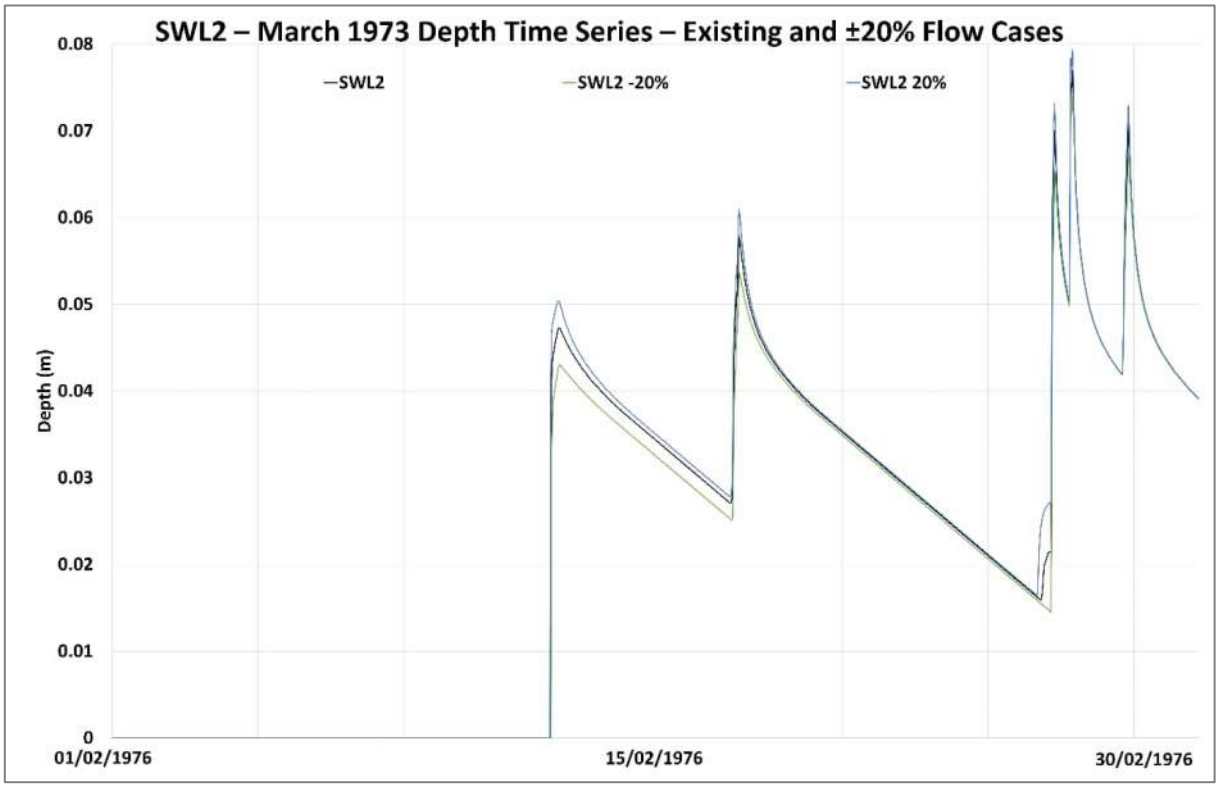

Figure 4-12 SWL2 – March 1973 Depth Time Series – Existing and ±20% Flow Cases

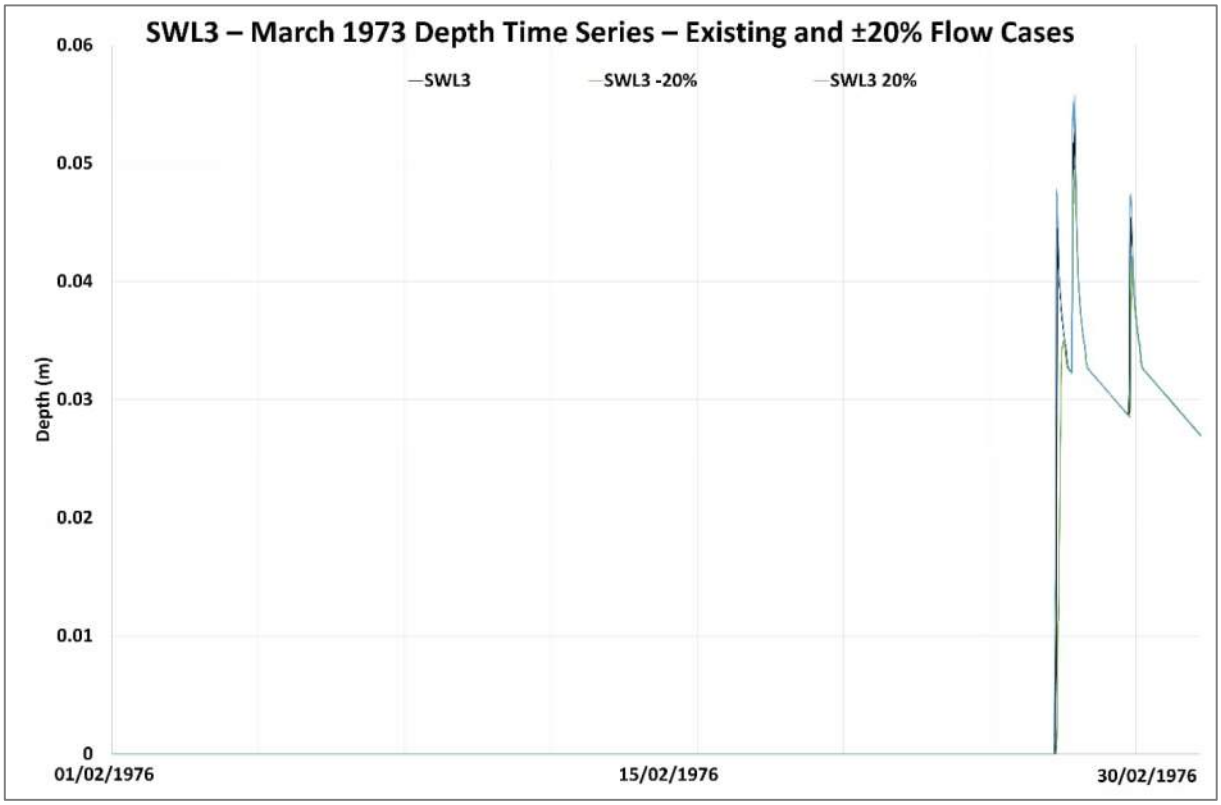

Figure 4-13 SWL3 – March 1973 Depth Time Series – Existing and ±20% Flow Cases

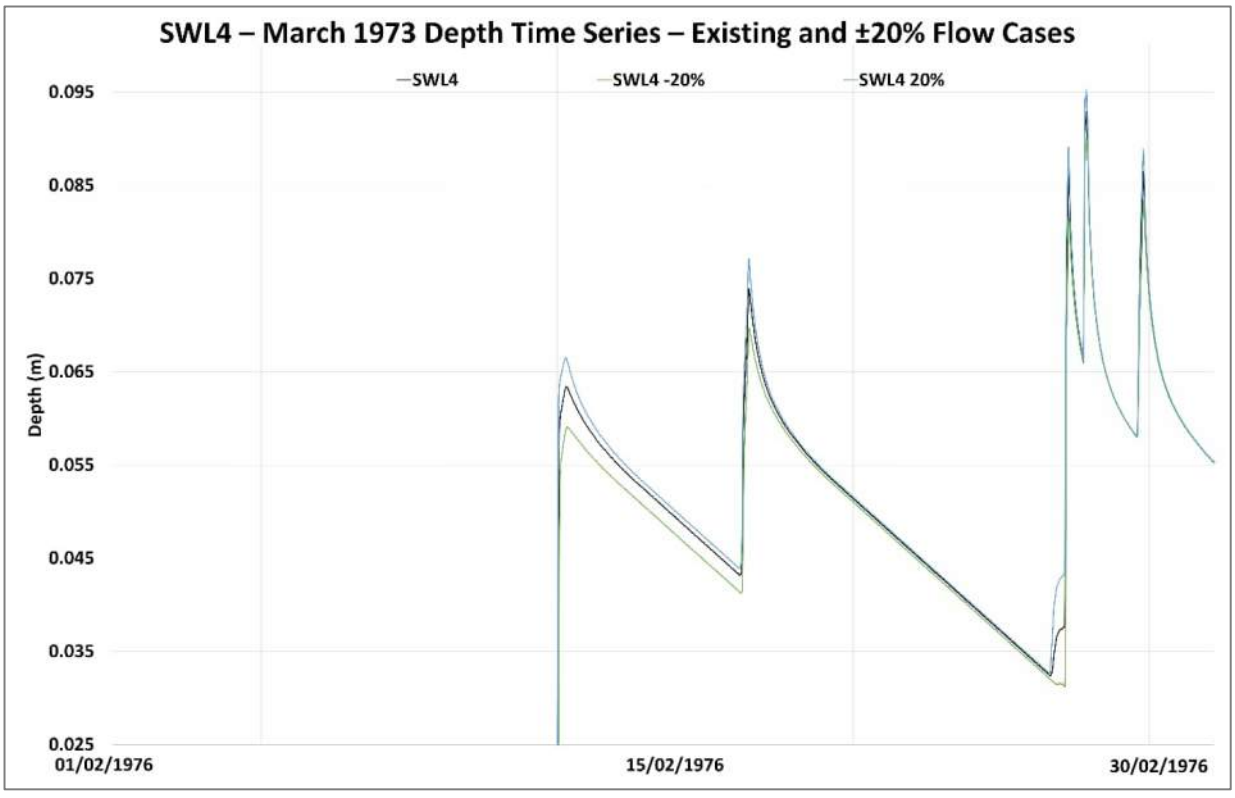

Figure 4-14 SWL4 – March 1973 Depth Time Series – Existing and ±20% Flow Cases

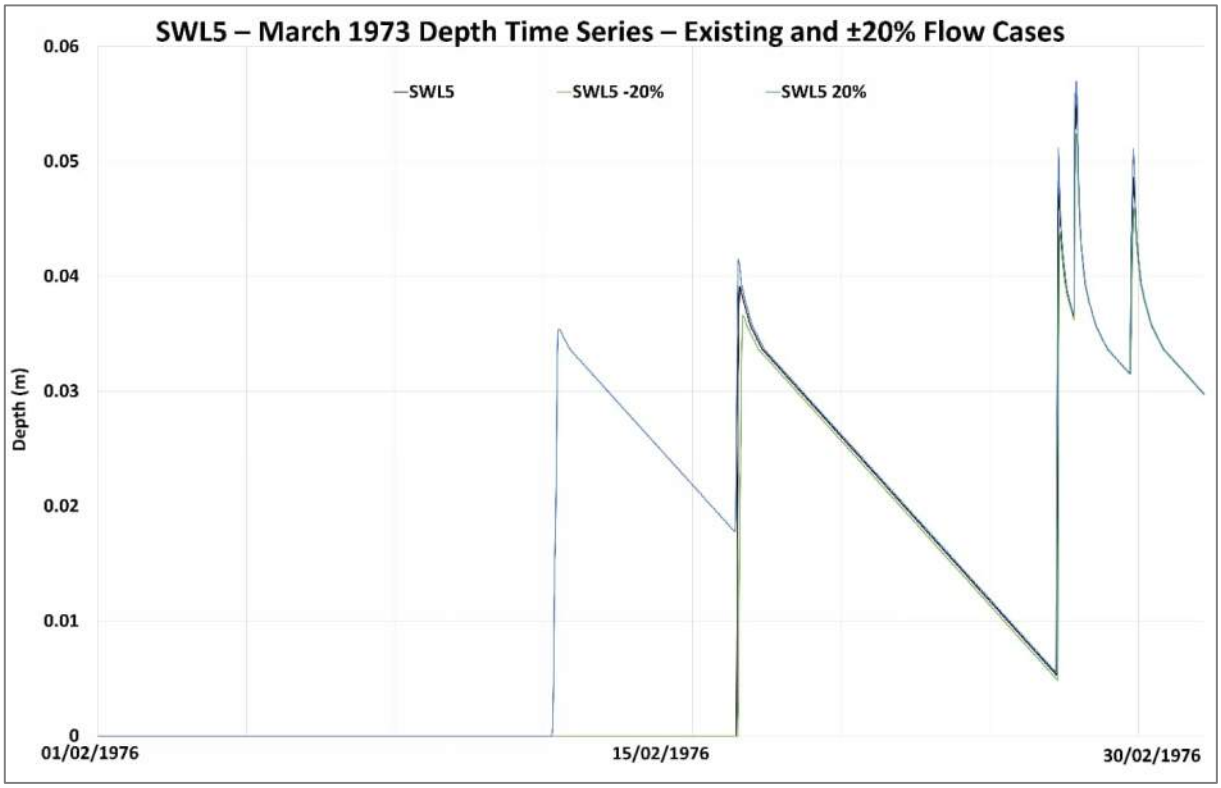

Figure 4-15 SWL5 – March 1973 Depth Time Series – Existing and ±20% Flow Cases

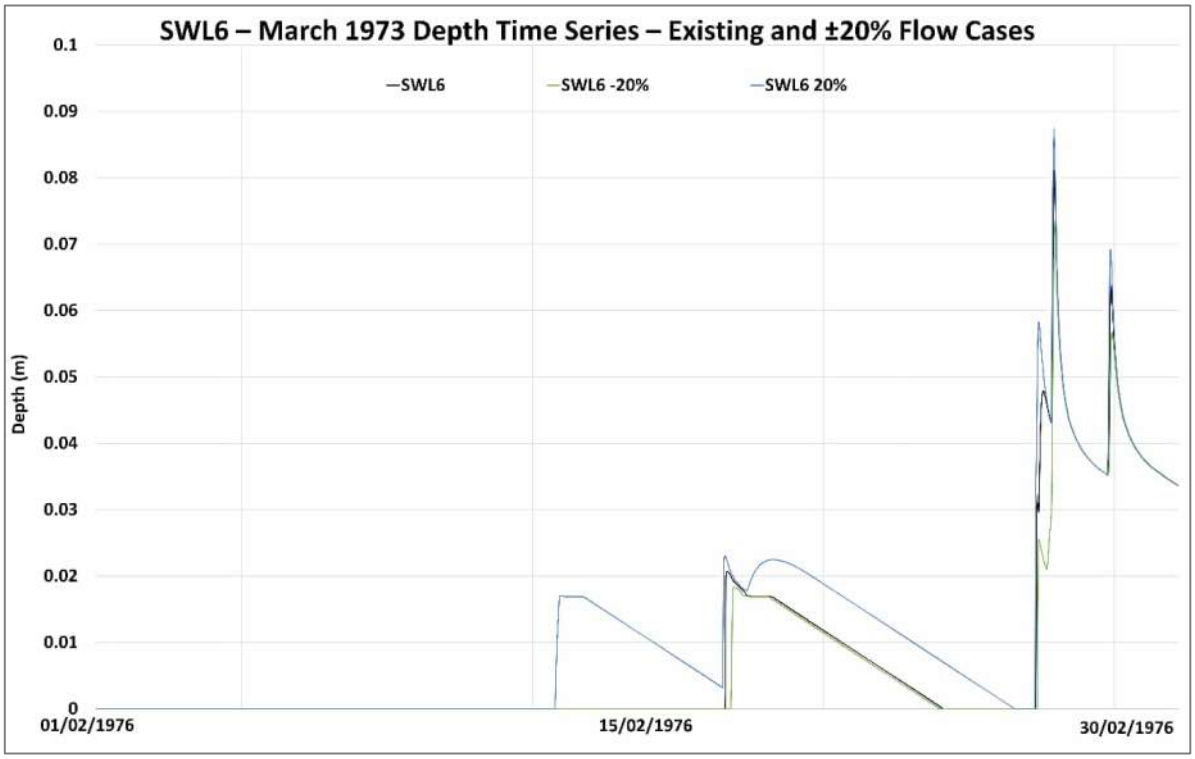

Figure 4-16 SWL6 – March 1973 Depth Time Series – Existing and ±20% Flow Cases

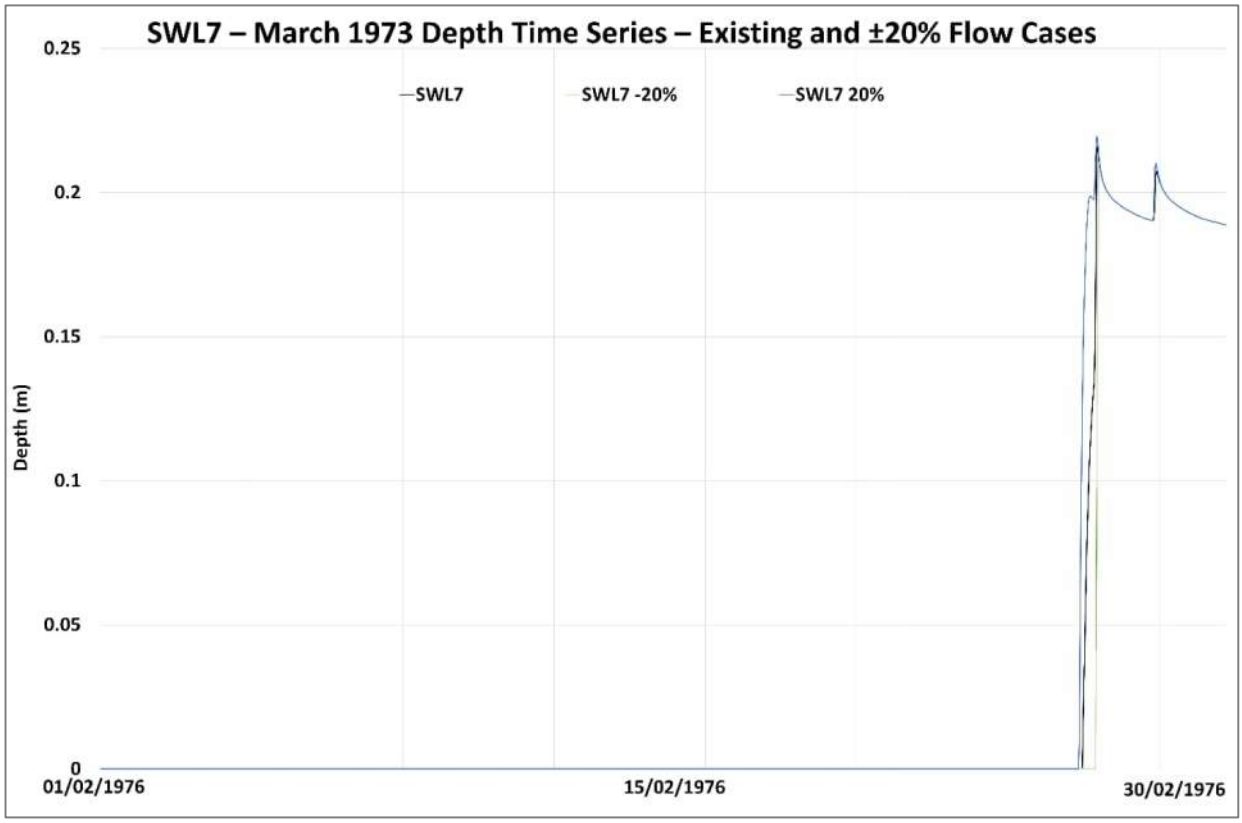

Figure 4-17 SWL7 – March 1973 Depth Time Series – Existing and ±20% Flow Cases

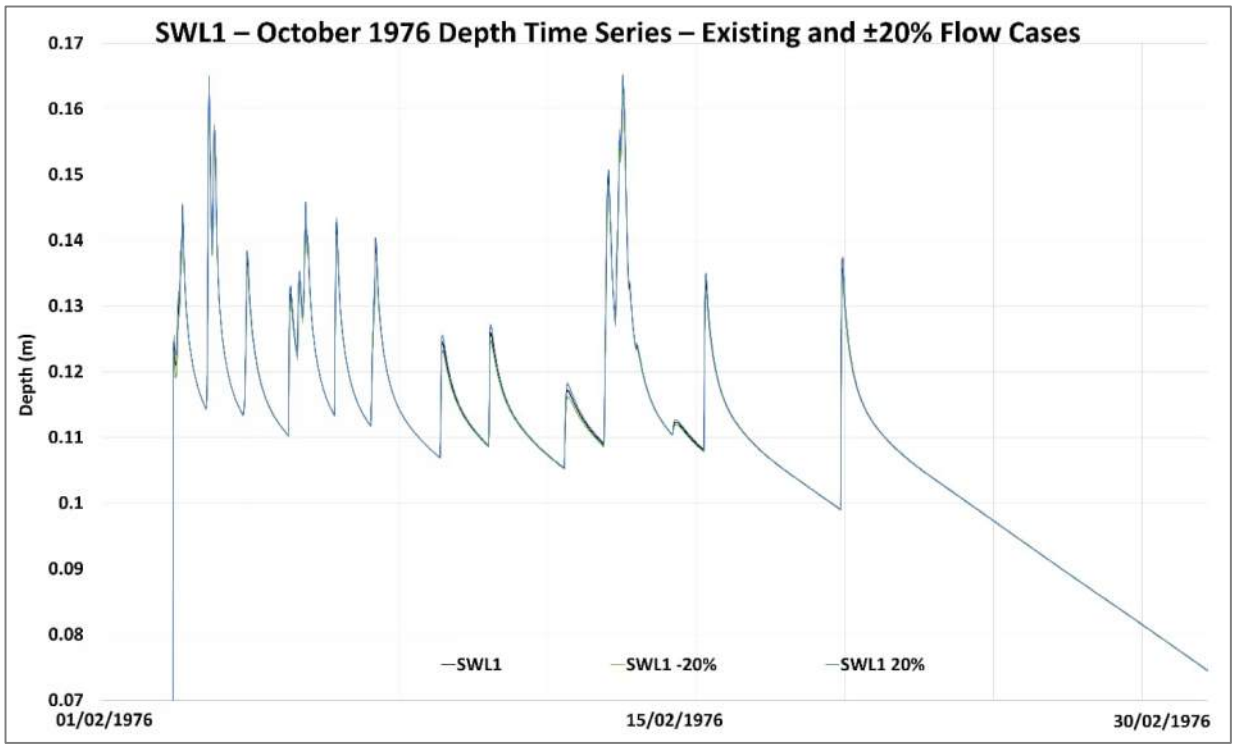

Figure 4-18 SWL1 – October 1976 Depth Time Series – Existing and ±20% Flow Cases

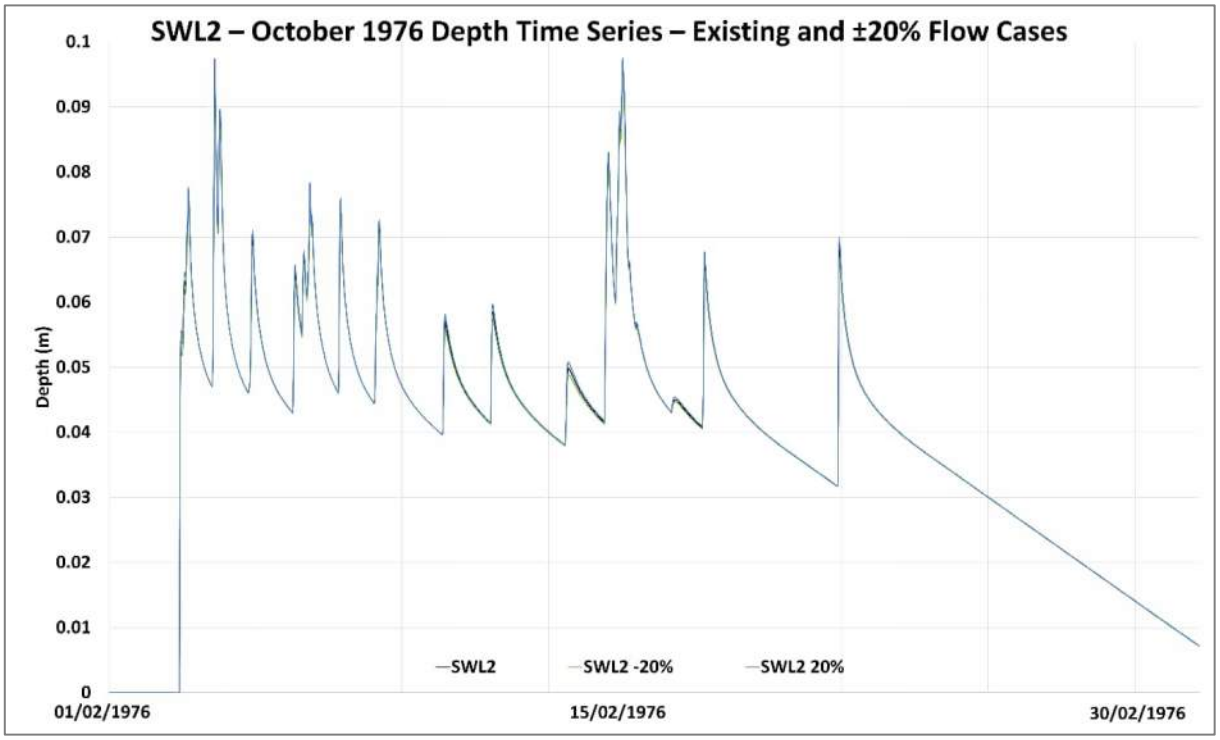

Figure 4-19 SWL2 – October 1976 Depth Time Series – Existing and ±20% Flow Cases

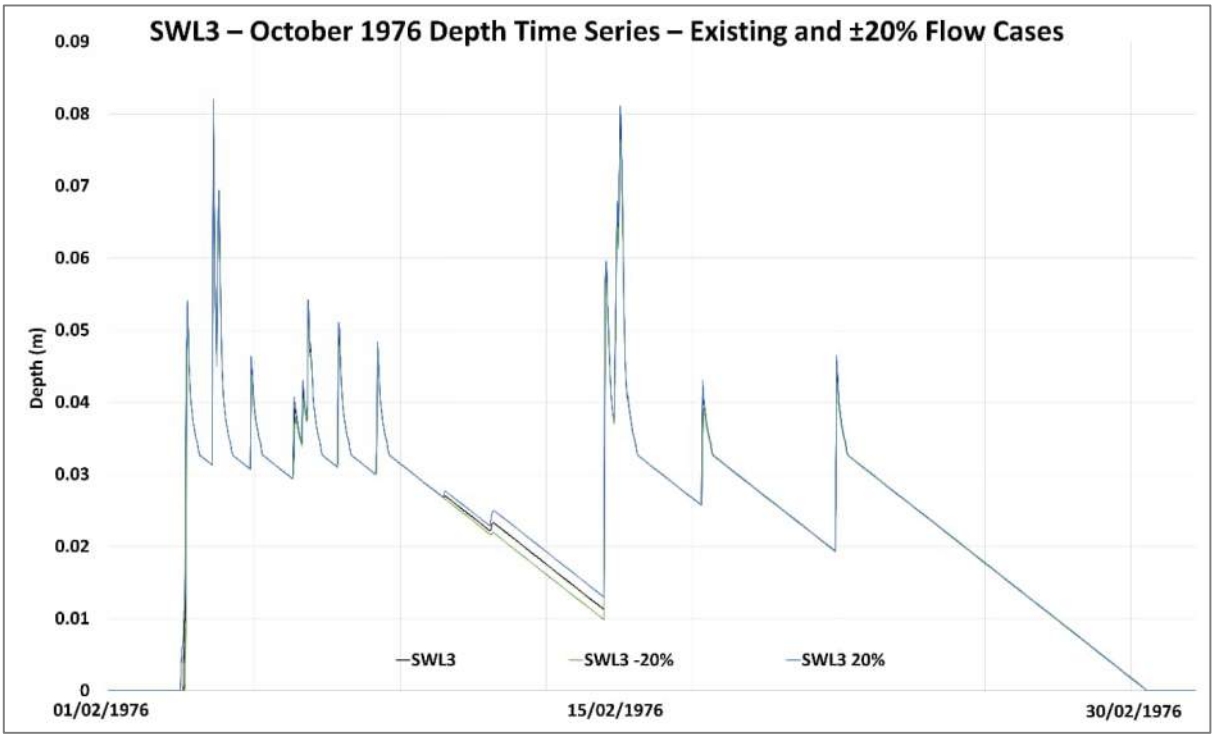

Figure 4-20 SWL3 – October 1976 Depth Time Series – Existing and ±20% Flow Cases

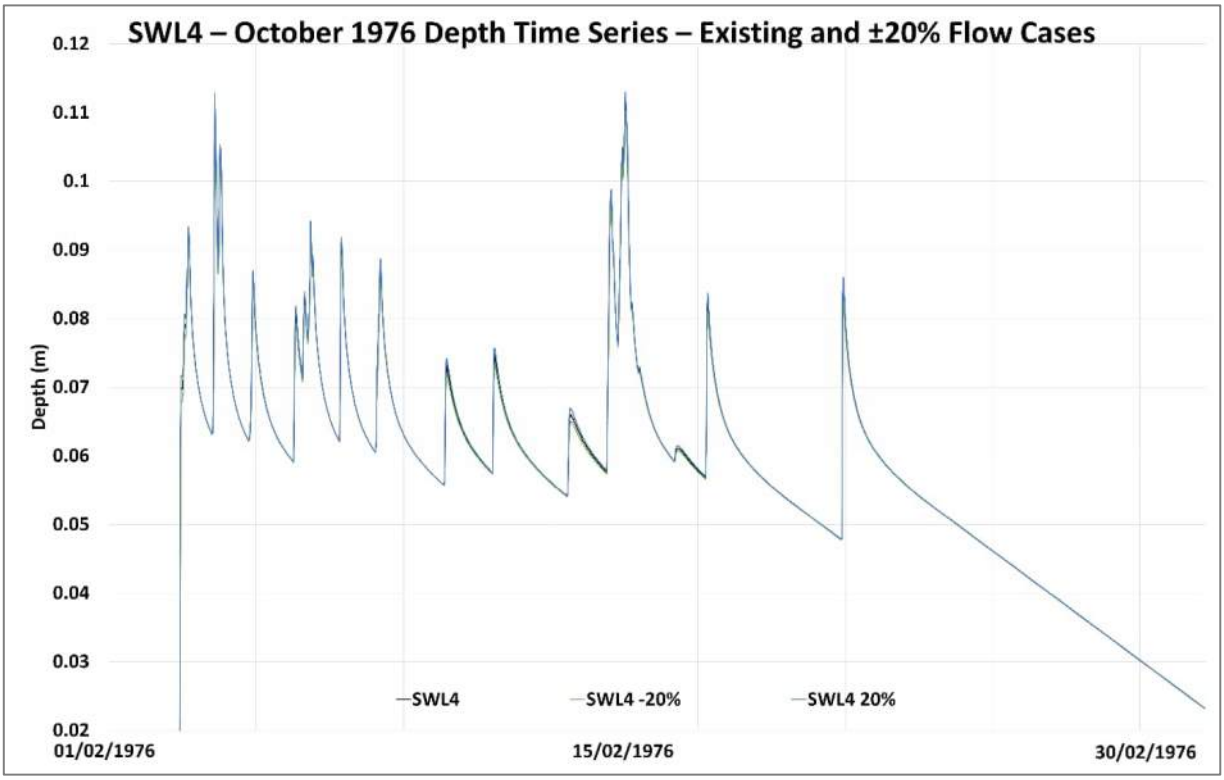

Figure 4-21 SWL4 – October 1976 Depth Time Series – Existing and ±20% Flow Cases

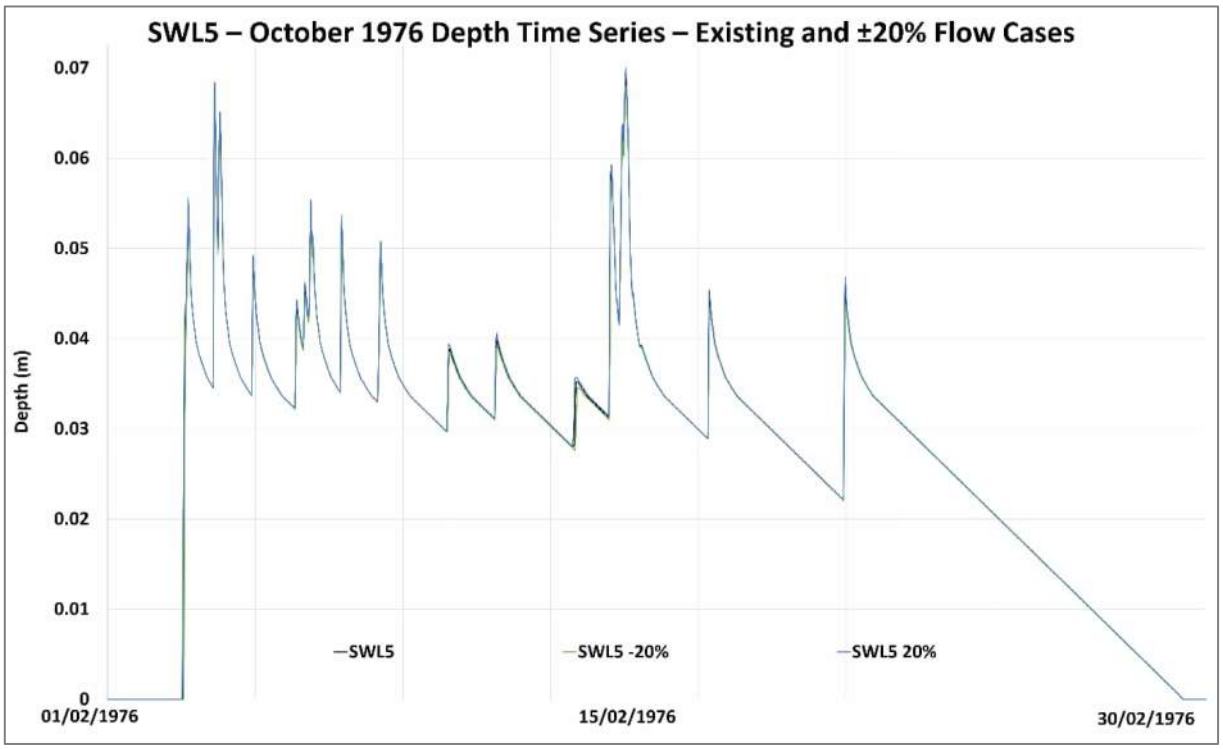

Figure 4-22 SWL5 – October 1976 Depth Time Series – Existing and ±20% Flow Cases

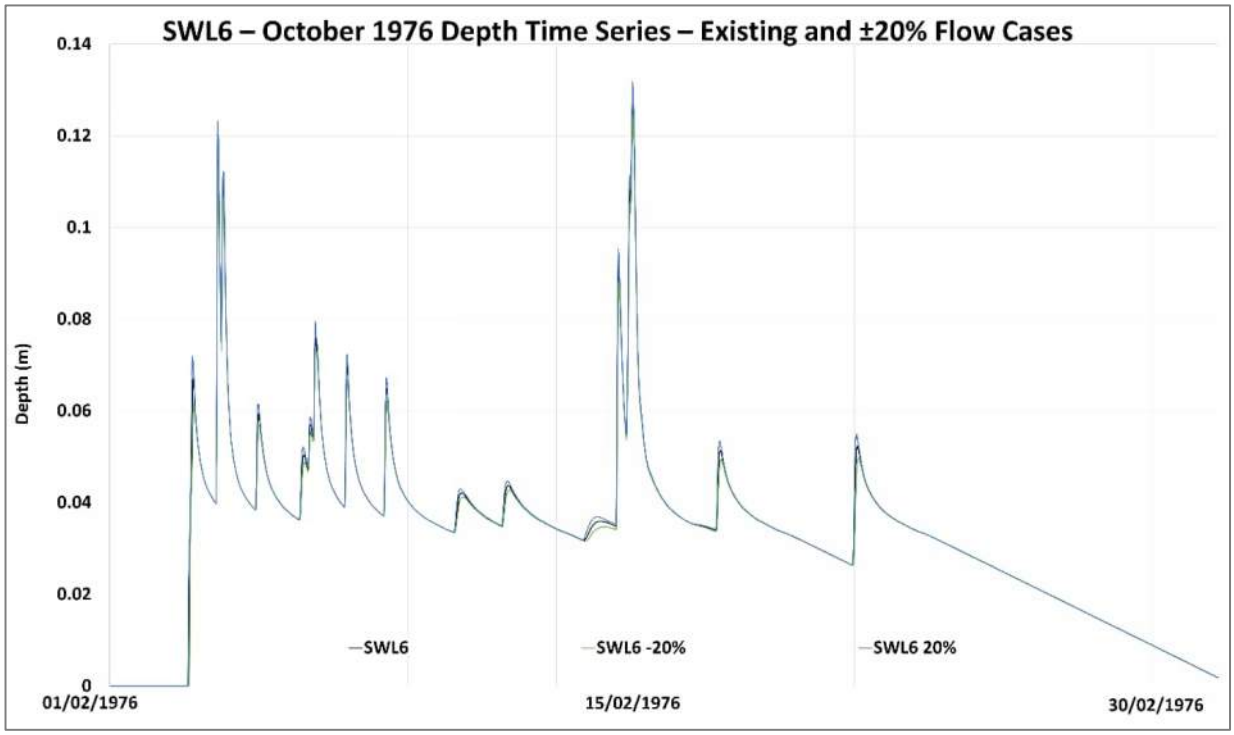

Figure 4-23 SWL6 – October 1976 Depth Time Series – Existing and ±20% Flow Cases

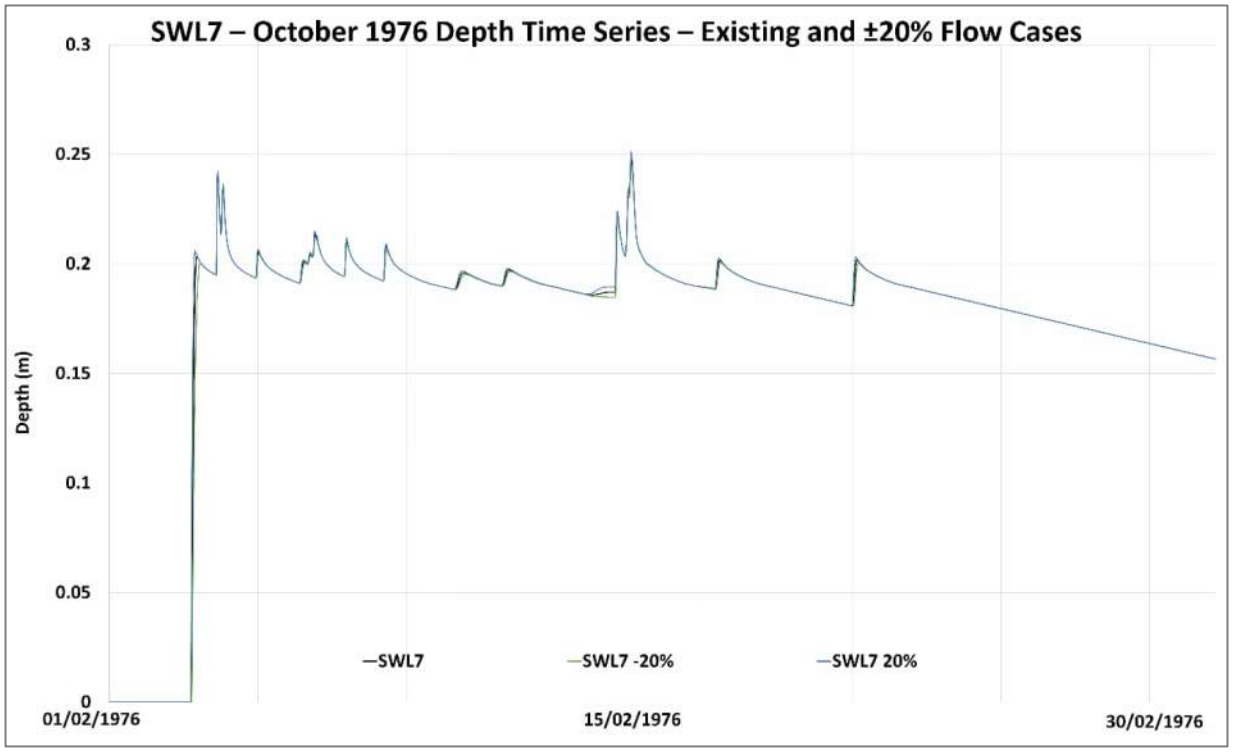

Figure 4-24 SWL7 – October 1976 Depth Time Series – Existing and ±20% Flow Cases

5 Potential Ecosystem Changes

The Site is located in close proximity to Hovells Creek and the downstream Limeburners Bay segment of the Port Phillip Bay Ramsar Site. Although the Site itself possesses few water-dependent environmental values, Hovells Creek, its floodplain, and Limeburners Bay all exhibit highly significant water-dependent environmental values, particularly with regard to fish, waterbirds, and plants. In order to evaluate the potential impacts of the development, an analysis of the hydrological changes resulting from the expanded area of impervious surfaces within the development on Hovells Creek (and the downstream Ramsar site) flow.

As detailed in Sections 1.1 and 1.2 it is proposed to divert developed conditions flows from the southern outlet to the northern outlet so as to minimise changes to the hydrology of the floodplain wetland. It is proposed to design a structure to divert excess flows above existing conditions. However it will not be possible to engineer a structure to exactly mimic existing conditions and hence an assessment on tolerable limits on changes to flows into the wetland has been undertaken to provide a design tolerance when the diversion structure is being engineered.

5.1 Impacts on Hovells Creek Flow

A hydrology assessment was conducted (refer to Section 4.4) to determine the overall monthly flow volume under existing and ultimate development conditions. Outcomes from the assessment are presented in Figure 4-5.

This analysis reveals an increase in flows by 0.8% in winter (July) to a maximum of 1.6% in Autumn, well within the seasonal variations. These flow changes are highly unlikely to exert any impact on fish, waterbirds, or plants, as they will not substantially alter the flow regimes or the water quality of the creek due to the relatively minor volumes reaching the creek. Furthermore, the Water Sensitive Urban Design (WSUD) implemented upstream will guarantee that any water quality concerns that may arise will be addressed in constructed wetlands before discharge to the creek, further reducing potential risks.

We also considered if there was a lower than full uptake of the use of rainwater tanks within the development and analysed the differences in terms of the effects on streamflow in Hovells Creek. This showed that if only a 50% take-up of rainwater tanks would occur, then the streamflow would be unchanged in 9 months of the year and 0.1% higher in the other three months compared with full uptake of tanks. There are no additional ecosystem impacts under that scenario as the flow changes are insignificant, from the base case (which is already a low impact).

5.2 Impacts on Ramsar and MNES Flows

The Ramsar Site is situated less than 3 kilometres from the northern outlet, and there are no significant inflows to the Ramsar Site that would modify flows downstream. Moreover, these minor flow changes will have even less impact, considering that the water regime of Limeburners Bay is influenced by tidal conditions from Corio Bay and potentially groundwater inflows. Therefore, although the receiving environment of the Ramsar site is of high environmental value and likely comprises very sensitive ecosystems, these flow changes are not anticipated to affect any aspect of MNES or the Ramsar Site values.

5.3 Hovells Creek Floodplain Wetland

The floodplain wetland, located downstream of the southern outlet, represents another receiving environment that may experience the influence of modified flow or inundation patterns resulting from an upstream development. The potential impact lies in the interaction of fresh (low salinity) water flows across this floodplain with the existing saline floodplain environment. However, this habitat has a history of periodic inundation by floodwaters with relatively low salinity from Hovells Creek. Therefore, an examination of the likely changes in hydrology, as well as the depth and duration of inundation, becomes crucial to assess the likelihood of any consequential impacts.

In order to evaluate the potential impacts on this floodplain wetland, hydraulic modelling was conducted to analyse variations in water depth, extent, and duration in the floodplain wetland during a typical dry month (March 1973) and a typical wet month (October 1976). This involved increasing the existing flow conditions by 5%, 10%, and 20%, as well as decreasing them by equivalent percentages. Outputs from the hydraulic modelling assessment are presented in Section 4.5 and in Appendices C and D.

The analyses reveal that, under almost every circumstance, the changes are minimal and unlikely to have significant impacts on the flora and fauna of the floodplain adjacent to Hovells Creek, which does retain some remnant aquatic ecosystem values. The most substantial decrease in the inundated area during a dry period is 318 sqm (2.1%), while in a wet period, the reduced area is 153 sqm (0.9%). The most significant increase in the inundated area during a wet period is 363 sqm (2.4%), and in a dry period, it is only 126 sqm (0.7%) under the 20% reduction scenario. In reality, it is anticipated that the flow variations of the final engineered solution will be within 10% variation (increase or decrease). Even under the 20% scenarios, the observed changes are relatively small. If a 10% threshold is established as not to be exceeded, the changes are reduced to under 1.5% under any conditions, and at these levels, no discernible impacts would be observed on the floodplain ecosystem.

The analysis also evaluated alterations in flow conditions for depth and duration of inundation during both dry and wet periods, mirroring the conditions examined in the aforementioned analysis. Results indicated that, at the furthest downstream site (SW7), the variations in depth and duration of flooding are either negligible or of very brief duration, even under the 20% variation scenario. Consequently, it can be inferred that there are minimal changes in flow at 10% or below. Under these circumstances, it can confidently be anticipated that no adverse impacts would occur to this high environmental value area.

Therefore it is recommended, in considering a permit condition, that flows from the Site’s southern outlet do not exceed ±10% of existing mean monthly flows or mean annual flow.

6 Summary of Impacts

The development site is situated near Hovells Creek and the downstream Limeburners Bay segment of the Port Phillip Bay Ramsar Site. While the site itself has very limited water-dependent environmental values, the surrounding areas, including Hovells Creek, its floodplain, and Limeburners Bay, do exhibit significant water-dependent environmental values related to fish, waterbirds, and plants.

Our assessment of the potential impacts included a hydrological assessment of the likely changes in flow resulting from increased impervious surfaces within the development to Hovells Creek. The analysis showed a slight increase in flows during winter and autumn, with minimal expected impacts on aquatic ecosystems due to the minor changes in flow regimes and water quality.

The assessment also considered the impact on the Hovells Creek floodplain wetlands, downstream of the southern outlet on the basis of diverting runoff away from the wetland to outlet into Hovells Creek with the northern outlet. Modelling undertaken to assess potential tolerance on the design of the flow diversion structure, recognising that it would not be possible to exactly mimic existing runoff patterns, revealed that variations in water depth, extent, and duration during wet and dry periods were generally very low, even under a 20% variation scenario, with changes to area inundated of less than 3% and generally around 1%. Furthermore, an analysis at the most downstream site in the floodplain wetland (SW7) indicated that changes in depth and duration of flooding are minor or short-lived, even under a 20% variation scenario. Therefore, the potential impact on the flora and fauna of the floodplain sites adjacent to Hovells Creek was found to be minimal, especially if the flow variations of the final engineered solution stay under 10%.

- Our assessment shows that while there are potentially some changes, these are very small in terms of flow volumes or areas affected and are unlikely to invoke the Matters of National Environmental Significance provisions of the EPBC Act (Australian Government 1999) nor any State EES provisions (DSE 2006). These provisions will not be triggered because the development:
- Will not result in the flows in Hovells Creek being materially altered;
- Only affects a very small area of floodplain wetland with no significant modifications to habitat or species presence (from its current condition);
- Does not have any significant change in the hydrological regime of the floodplain wetland in terms the volumes, durations or extent of flows;
- Flow regime changes at the Ramsar Wetland site will not be measurable nor will the development have any effect on ecological character of the Ramsar Site due to the small changes experienced upstream and the fact that no habitat or ecosystem effects on native species will occur due to the insignificant hydrological changes;
- Will not cause invasive species establishing or expanding in Hovells Creek, floodplain wetland downstream of the southern outfall nor within the Limeburners Bay segment of the Port Phillip Bay Ramsar Site.

In summary, the discussed analyses and assessments indicate that the anticipated impacts of the development on natural values, including aquatic ecosystems, flora, and fauna, are generally minimal when mitigated with proper engineering solutions and environmental management measures.

Appendix A Curricula Vitae

Lloyd, B.Sc., M.Sc.

Principal Ecologist,
Lloyd Environmental P/L

PO Box 3014,
Syndal, Vic, 3149

Lloyd has **over 30 years** practical experience across SE Australia, and recently in the Pacific Islands, in freshwater, estuarine, coastal and inland environments in ecology and management requirements.

Natural resource management and **habitat conservation** are his passions and he has published widely in **ecology**, water, **wetland management**, and environmental management in scientific papers and management reports. He has substantial expertise and experience in **fish biology**, general **fauna ecology**, and habitat assessment of freshwater, estuarine and coastal ecosystems across SE Australia (Qld, New South Wales, Victoria, Tasmania and South Australia). He currently chairs the Fisheries Victoria "Translocation Evaluation Panel" (which evaluates risks from fish translocations in Victoria) and the Great Australian Bight RAG (Australian Fisheries Management Authority; AFMA), and is a member of two other AFMA committees.

Skills and Expertise

He played a key role in developing **environmental water** concepts and applying these to over 30 rivers, wetlands and estuaries. He has developed widely adopted methodologies for environmental water requirement (EWR) assessments for rivers, wetlands and estuaries for the Victorian and Australian Governments. He was the co-author of FLOWS, the Victorian state-wide guidelines for environmental flow assessments of rivers and contributed to FLOWS Edition 2. He led the development and refinement of EEFAM, the estuary environmental flow assessment methodology for Victoria.

has been an innovator in the **Ramsar** process, having been appointed by the Department of the Environment (then SEWPaC) to a panel for 'The Development and Technical Review of Ramsar Wetland Documentation', working closely with the Department to update and refine the Guidelines for the preparation of Ecological Character Descriptions (ECD), preparation of ECDs and Ramsar Information Sheets (RIS), and reviewing multiple ECDs, RISs and Ramsar Management Plans. has undertaken ecological or environmental studies at each of Victoria's Ramsar sites over the last 24 years.

He led the teams which developed the Riverland Ramsar Site and Floodplain Lower Ringarooma Ramsar Site **Ecological Character Descriptions**. Further, he developed ECDs for Ramsar sites including Lavinia (King Island), Little Waterhouse Lake, Jocks Lagoon, Bool & Hacks Lagoons, Gippsland Lakes and Corner Inlet. In 2013 (and previously), he provided technical advice to DotE on "Limits of Acceptable Change and Notifying Change in Ecological Character of Australian Ramsar Sites (under Article 3.2 of the Ramsar Convention)". In 2013 and 2014, he was an active contributor to the PAGES International Ramsar Conference, contributing to innovations in Ramsar processes and was co-author of a recently accepted journal paper examining "Limits of Acceptable Change in the Riverland Ramsar Site" and he is currently co-authoring a journal paper examining trajectories of change at the Flood Plain Lower Ringarooma Ramsar Site.

In **strategic planning**, has developed skills in evaluating and identifying the management and research needs of clients. He has advised CMAs, water authorities, and the MDBA on management structures to achieve research or on-ground NRM outcomes. s experience has enabled him to provide strategic advice to senior managers on the directions of environmental programs, assessment approaches, research and development needs, risk assessments, and the potential environmental impacts of operations.

A key component of his work has been **stakeholder and community consultation**. Management strategies require commitment from stakeholders to be successful in terms of implementation and local ownership. Consultation includes several levels of involvement, such as: information exchange, stakeholder involvement and stakeholder participation. Having stakeholders participate in decision making and risk assessment is critical to the acceptance of any management plan.

Positions Held

Current:

Principal Ecologist & Director, Lloyd Environmental Pty Ltd (1998 on)

Research Fellow, Federation University Australia (2014 on)

Chair, Translocation Evaluation Panel, Fisheries Victoria, DPI (2004 on)

Chair, Great Australian Bight Resource Assessment Group, AFMA (2013 on)

Member, Great Australian Bight Management Advisory Committee, AFMA (2013 on)

Member, Southern and Eastern Scalefish and Shark Fishery RAG, AFMA (2013 on)

Previous:

Science Advisor, Water Quality Advisory Panel, MDBA (2005 – 2012)

Member, Fisheries Co-Management Council, Victoria (2002-2005)

Member, FRDC Fisheries Research Advisory Board, Victoria (2003-2005)

Rivers Program Co-ordinator, SI & E Program, Consultant to the Murray Darling Basin Commission (1998-2005)

Divisional Manager, Environmental Services Division, WATER ECOscience Pty Ltd (1994-1998)

Principal Scientist, Environmental Assessment Section, State Water Laboratory (1992-1994)

Senior Wetland Ecologist & Team Leader, Floodplain Ecology, Dept of Cons & Envt. (1990-92)

Research Officer, River Murray Laboratory, Uni of Adelaide (1986-1989)

Professional Affiliations

Australian Society of Fish Biology (Member, 1981 on)

Australian Institute of Biology (Member since 1989; President, 2005 on)

Australian Society for Limnology (Life Member, 1981 on)

River Basin Management Society (Life Member, 2015 on; Member, 1990 on; President, 1999-2002)

Education & Qualifications:

Master of Science, University of Adelaide, 1987
Bachelor of Science, University of Adelaide, 1981
MAIBiol [Member, Australian Institute of Biology, 1989]

Further Study:

Repair, Upgrade and Build Personal Computers (VisonFix 2006 & 2007)
Media Training Course, Econnect Communications Pty Ltd (2004)
Project Management Matrix System Workshop (MDBC 2003)
Short Course on Stormwater Management (Monash Uni/CRCCH 1999)
Prince2 Project Management Course (Tanner James - 1998)
Peak Performance Leadership (LBA Consulting - 1998)
Financial Management Skills (APESMA - 1995)
Strategic Marketing Skills (APESMA - 1995)
Project Management (Training Interventions Australia - 1994)
AEAM Computer Model Training Course (DCNR, Melbourne – 1992/1994)
REALM Computer Model Training Course (DWR, Melbourne -1992)

OTHER POSITIONS:

Lead Judge**, World Environment Day Awards, United Nations Association of Victoria, (2005 - 2015)**
Member**, Water Quality & River Health Working Group, MDBC ('92 – '95)**
Member**, WQ Monitoring & Reporting Working Group, DPIE, ('92 – '95)**
Member**, Water Resources Council of South Australia, South Australian Government ('88 – '89)**
Member**, Community Advisory Committee, MDB Ministerial Council ('89 & '90)**
President, **Mount Waverley North Primary School Council (1995–2001; 2004-2009)** and Council Member **(1993-2010)**

Project Experience

been involved in many strategically important projects in SE Australia for over 30 years. Some examples include:

- Corner Inlet Ramsar Site Ecological Character Description.
- Dealing with inevitable change in ecological character of Ramsar sites.
- Department of the Environment (Commonwealth) Reviewer for Ramsar Wetland Documentation (2009-2011).
- Ecological Character Description for Bool and Hacks Lagoons Ramsar Site.
- Ecological Character Description for Jocks Lagoon Ramsar Site.
- Ecological Character Description for the Flood Plain Lower Ringarooma Ramsar Site.
- Ecological Character Description for the Lavinia Ramsar Site.
- Ecological Character Description for the Little Waterhouse Lake Ramsar Site.
- Ecological Character Description for the Riverland Ramsar Site.
- Ecological Character Descriptions for the Gippsland Lakes Ramsar Site.
- EEFAM, the estuary environmental flow assessment methodology for Victoria (2008-2011)
- Environmental Flow Options for the Hattah Lakes (2005)
- Environmental Water Requirements of the Bass River including a Risk Assessment of the Estuary (2009).
- Flow/ecology relationships and scenarios for the Lower Barwon Wetlands environmental entitlement Project (2011-12).
- Barmah-Millewa Water Management Plan.
- Co-author of FLOWS methodology for EWR determination in rivers in Victoria (2002)
- FLOWS – A Method for Determining Environmental Water Requirements in Victoria.
- Gippsland Lakes Environmental Strategy (2012).
- Gippsland Lakes Environmental Strategy Business Implementation Plan.
- Gunbower Creek Environmental Flows Study.
- Gunbower Forest Flooding Enhancement Projects (multiple 2001 - 2015)
- Gunbower Forest Water Management Options.
- Hattah Lakes Ecological Operations Plan (2012)
- Implications of Environmental Trajectories for Limits of Acceptable Change at the Riverland Ramsar Site, South Australia.
- Integrated Watering Strategy for Mid-Murray Wetlands, including flood characteristics and water management options for Hattah Lakes, Barmah and Gunbower Forests (1990-92)
- Lake Condah Water Restoration Project: Hydrological Feasibility Study (for Glenelg-Hopkins CMA, 2006).
- Lake Condah Weir Fishway Design (DSE; 2008)
- Mallee Floodplain Wetlands Works and Measures Program (2012-2013)
- Mallee SDL Offset Works Risk Assessment Project (2014).
- Priorities for determining the environmental freshwater requirements of estuaries in the Port Phillip and Westernport region.
- Strategic Management Plan for the Kerang Ramsar Wetlands Site.
- Wimmera Terminal Lakes Environmental Flow Determination Project (2004)

Publications

Lloyd has established a substantial publication record with over 150 publications in local and international journals, books and management reports, some examples are below:

Arthington, A.H. & L.N. Lloyd. 1989. Introduced Poeciliids in Australia and New Zealand. In: Meffe, G.K. & K.F. Snelson (Eds). *Ecology and Evolution of Livebearing Fishes (Poeciliidae).* Prentice Hall, New Jersey, USA.

Boulton, A.J. & L.N. Lloyd. 1991. Aquatic macroinvertebrate assemblages in floodplain habitats of the lower River Murray. Regulated Rivers, 6: 183-201.

Boulton, A.J. & L.N. Lloyd. 1992. Flooding frequency and invertebrate assemblages emerging from floodplain sediments at Chowilla, lower River Murray, SA. *Regulated Rivers 7*: 137-151.

Bunn, S.E., P.I.Boon, M.A.Brock, N.J.Schofield, J.W.Bennett, J.A.Davis, C.M.Finlayson, R.H.Froend, R.Hall, L.N.Lloyd ,G.Lukacs, S.Moore ,M.McDonald, D.S.Mitchell, R.G.Pearson, J.Roberts and K.Schlusser. (1997). *National Wetlands R&D Program Scoping Review*. Land and Water Resources R&D Corporation Occasional Paper 01/97.

Cooling, M. L. Lloyd, D. Rudd & R. Hogan. (2002). Environmental Water Requirements and Management Options in Gunbower Forest, Victoria. Aust. J. Water Resources 5 (1): 75-88.

Lloyd, L. and Newall, P. (2009). Translocation risk assessment for Devilbend and Bittern Reservoirs for stocking select recreational fish species. Lloyd Environmental, for Fisheries Victoria, DPI Victoria.

Lloyd, L.N. & J.F. Tomasov. 1985. Taxonomic status of the mosquitofish. *Gambusia affinis* (Poeciliidae), in Australia. *Aust. J. Mar. Freshw. Res. 36*: 447-51.

Lloyd, L.N. & K.F. Walker. 1986. The distribution and conservation status of small fish in the River Murray in S.A. *Trans. Roy. Soc. S.A. 110*(2):49-57.

Lloyd, L.N. & Walker, K.F. 1989. Management of snags (woody debris) and river and floodplain vegetation for native fish in the Murray-Darling River System. In: Lawrence, B. (Ed.) 1989. Proc. of the Native Fish Management Workshop. Murray-Darling Basin Commission, Canberra, Australia.

Lloyd, L.N. 1986. An alternative to insect control by "mosquitofish"*, Gambusia affinis*. In: St. George, T.D., B.H. Kay & J. Blok, *Arbovirus Research In Australia*. Proceeding of the 4th Australian Arbovirus Symposium, Brisbane. 1986.

Lloyd, L.N. 1990. Ecological interactions of *Gambusia holbrooki* with Australian native fish. In: Pollard, D.A. ASFB *Workshop on introduced and translocated fishes and their ecological effects*. Bureau of Rural Resources Proceedings No. 8, AGPS, Canberra.

Lloyd, L.N. 1990. Fish Communities. In: O'Malley, C. & F. Sheldon. *Chowilla Floodplain Biological Study*. Nature Conservation Society of South Australia, Adelaide, SA.

Lloyd, L.N., A.H. Arthington & D.A. Milton. (1986). The mosquitofish - a valuable mosquito control agent or a pest? In: Kitching (Ed). The ecology of exotic plants and animals: some Australian case studies. John Wiley & Sons, Brisbane.

Lloyd, L.N., Anderson, B.G., Cooling, M., Gippel, C.J., Pope, A.J. and Sherwood, J.E. (2012). Estuary Environmental Flows Assessment Methodology for Victoria. Lloyd Environmental Pty Ltd Report to the Department of Sustainability and Environment, Melbourne Water and Corangamite CMA, Colac, Victoria, Australia.

Lloyd, L.N., B.P. Atkins, P.I. Boon, J. Roberts and T. Jacobs. 1994. Natural Processes in floodplain ecosystems. IN: Proceedings of the Murray-Darling Basin Floodplain Wetlands Management Workshop. MDBC, Canberra.

Lloyd, L.N., J.T. Puckridge & K.F. Walker. (1991). The significance of fish populations in the Murray-Darling system and their requirements for survival. In: Dendy, T. & M. Coombe (Eds). Conservation in Management of the River Murray System. Dept of Envt & Planning, Adel., S.A.

Lloyd, L.N., Newall, P.R., Loffler, T. and Knight, C.D. (2008). Tullaroop Creek Flows Ecological Risk Assessment. Lloyd Environmental report to Central Highlands Water, Mt Waverley, Victoria.

Lloyd, L.N., Vietz, G.J. Newall, P.R. and Feehan, P. (2010). Environmental Guidelines Report: Guidelines for the operation of River Murray System storages, so as to examine and take into account any possible environmental, geomorphic, water quality, and cultural heritage effects associated with exercising the MDBA's powers or functions in regard to river operations. Lloyd Environmental Pty Ltd report to the Murray-Darling Basin Authority, Syndal, Victoria.

Newall, P.R., Lloyd, L.N., Gell, P.A., and Walker, K.F. (2015). Implications of Environmental Trajectories for Limits of Acceptable Change: a case study of the Riverland Ramsar Site, South Australia. Marine and Freshwater Research Journal.

Newall, P., Tiller, D. and Lloyd, L.N. (2008). Ecological Risk Assessment of Upper Broken Creek and Lower Broken River. Lloyd Environmental Report to Goulburn Broken CMA.

Newall, P., Tiller, D. and Lloyd, L.N. (2009). Ecological Risk Assessment of Seven Creeks. Report to GBCMA. Karoo Consulting P/L, Drummond.

Newall, P.N., Mag, V. and Lloyd, L.N. (2012). La Trobe University Wildlife Sanctuary Stormwater Management Review. Lloyd Environmental Pty Ltd Report to La Trobe University. Lloyd Environmental, Syndal, Victoria.

Newall, P.R. and Lloyd, L.N. (2007). Ecological Character Description for the Floodplain Lower Ringarooma River Ramsar Site. Lloyd Environmental Pty Ltd Report (Project No: LE0722) to NRM North, Launceston, Tasmania. November 2007.

Newall, P.R. and Lloyd, L.N. (2008). Ecological Risk Assessment of Modified Releases to the Merri Creek: Final Report. Lloyd Environmental Pty Ltd Report to Yarra Valley Water. Mt Waverley, Victoria

Newall, P.R. and Lloyd, L.N. (2011). Lavinia Ramsar Site Ecological Character Description. Lloyd Environmental report to NRM North. Lloyd Environmental, Syndal, Victoria.

Newall, P.R., Lloyd, L.N. and Atchison, E.E. (2011). Ecological Character Description for the Jocks Lagoon Ramsar Site. Lloyd Environmental Pty Ltd Report (Project No: LE0930) for SEWPaC, Canberra, ACT. Final Report, February 2011.

Newall, P.R., Lloyd, L.N., Gell, P.A. and Walker K.F. (2008). Ecological Character Description for the Riverland Ramsar Site. Lloyd Environmental Pty Ltd Report (Project No: LE0739) to Department for Environment and Heritage, South Australia. June 2008.

RMCG, Lloyd Environmental and Independent Ecological Consulting (2011). Sediments, nutrients and their impacts in the Tarwin River catchment- a review of available information. RMCG Consulting Report to West Gippsland CMA, August 2011.

Shirley, M., B. Abernethy, P. Close, L. Lloyd, R. Nathan, G. Quinn & B. Zampatti. (2002). A method for determining environmental water requirements in Victoria. Report to DNRE Melb., Vic.

Jempson

Director

Qualifications and Accreditations

PhD in Civil Engineering, Hydraulics, University of Queensland.

Master of Engineering Science, University of Queensland.

Bachelor of Civil Engineering, Queensland University of Technology

Member, Engineers Australia

Chartered Professional Engineer (CPEng)

National Professional Engineers Register (NPER)

Registered Professional Engineer of Queensland, Civil (RPEQ)

Past Chair, Engineers Australia Victorian Water Engineering Branch

Summary

has thirty-five years of industry experience in hydrological, hydraulic and multidisciplinary environmental investigations, construction and bridge design. has worked in both the government and private sectors; 10 and 25 years respectively.

is recognised as one of Australia's leading experts in flood and stormwater modelling, floodplain management and road and bridge hydraulics. He has undertaken studies across Victoria, Queensland, New South Wales, Tasmania, South Australia and the UK involving hydrologic and hydrodynamic modelling and flood management of estuaries, rivers and floodplains, water quality investigations and environmental assessments.

is regularly called on as a peer reviewer and expert witness by government agencies and the private sector in QLD, NSW and Victoria. has excellent communication skills, honed from many years of community consultation, and is able to effectively communicate complex flooding issues and analysis techniques to those without a technical background.

research topic was *Flood and Debris Loads on Bridges*. was the author of the hydrodynamic and debris load chapters in the Australian Bridge Design Standard.

has hands-on experience in many of the key hydrologic and hydraulic modelling packages including XP-RAFTS, RORB, WBNM, URBS, HEC-RAS, TUFLOW, and MIKEFLOOD / MIKE21 / MIKE11.

Employment History

Current:	Venant Solutions, Director and Founder, Melbourne
2003 – 2013:	BMT WBM Water & Environment Business Unit Manager, Melbourne
1999 – 2002:	BMT WBM Senior Engineer, Brisbane
1988 – 1998:	QLD Department of Main Roads

Areas of Expertise

- Hydrodynamic modelling (1D and 2D)
- Flood hydrology
- Urban and rural flood modelling and mapping
- Floodplain Management
- Flood warning
- Expert Witness/Peer Review
- Road and Bridge Hydraulics - author of flood and debris loads in Australian Bridge Design Standard
- Stormwater Quality and Quantity Management
- GIS Mapping

Contact Details

T:

https://au.linkedin.com/in/mark-jempson

Postal: PO Box 877, Macleod, VIC 3085

Key flood management experience

Rural flood and floodplain management studies

These projects typically required the development of a survey brief, hydrologic modelling, two-dimensional hydraulic modelling, hydraulic and economic assessments of structural and non-structural floodplain management options, review of flood warning systems, community and stakeholder consultation, sedimentation assessments, and preparation of floodplain management plans. Following is a list of project in which has been involved either as project manager, project director or technical reviewer.

- Sunday & Dry Creek Flood Study (Vic)
- Goulburn-Broken Rivers Flood Study (Vic)
- Lower Thomson River Hydraulic Model (Vic)
- Coleraine Flood Study (Vic)
- Herbert River Flood and Floodplain Management Study (Qld)
- Johnstone River Flood and Floodplain Management Study (Qld)
- River Tamar and North Esk River Flood Study (Tas)
- Mt William Creek Flood Investigation (Vic)
- Upper Wimmera Flood Investigation (Vic)
- Macalister River Flood Study – Stage 1 (Vic)
- Bacchus Marsh Flood and Floodplain Management Study (Vic)
- Yarriambiack Creek Flood Investigation (Vic)
- Lower Kiewa River Flood and Floodplain Management Study (Vic)
- Casterton Flood Intelligence and Warning Improvement Study (Vic)
- Glenelg River Sand Management Hydraulic Modelling Study (Vic)

Urban flood mapping

These studies involve the development of detailed hydrologic and 1D/2D hydraulic models to establish existing flood characteristics, and to provide input into economic and flood damages assessments. Some studies required the assessment of mitigation options and benefit-cost analyses. Clients include Melbourne Water, City of Greater Geelong and City of Greater Dandenong. This list of projects undertaken includes the Western Treatment Plant, Shakespeare Grove and Byron Street Main Drains, Sweetwater Creek, Kilsyth and Bungalook Main Drains, Barwon Heads, Bridge Street and Western Gully, Port Arlington, and Dandenong CBD.

Herbert River Levee Management Study

There has been a significant change in flooding patterns on the Herbert River floodplain since the 1960's as a result of construction of levees by landholders. The construction of the levees, or the expansion of existing levees, continues as landholders respond to increased flooding on their properties. The Herbert River Improvement Trust recognises the need to control future growth of levees if a disaster is to be avoided. This study used flood modelling of future hypothetical levee construction to demonstrate the future impact on flooding. Consultation with landholders and stakeholders was then undertaken to kick start an on-going and long-term education process.

Rookwood Weir Design & Construction

Hydraulic modelling was undertaken to inform the temporary works design for the construction of the Rookwood Weir on the Fitzroy River in central Queensland. This included input into cofferdam immunity, the site access road and velocities for scour assessments.

An innovative web-based flood warning system was also developed for the construction team to provide forecast flood levels at the site for up to 7 days. This allows the construction team to plan for overtopping of the cofferdam. Flooding in the catchment is complex being around 130,000 km^2 and with five major river systems draining to the Fitzroy River. The flood warning system downloads, from the BoM, river gauge levels across the catchment as well the BoM's 8 day rainfall grids. Each hour the website automatically establishes flows at the river gauges and runs a hydrological model to establish additional potential flows based on the forecast rainfall. The flows are combined to estimate flows and flood levels at the site for the next seven days. The site staff are provided logins but are also sent SMS and email messages if overtopping of the cofferdam is forecast.

Melbourne Water Development Services Schemes

These projects involve hydrologic, hydraulic and water quality modelling and the preparation of a development services strategy. Functional design of stormwater management measures such as retarding basins and bio-retention systems were undertaken. Quantities and costs of works are determined as input into Melbourne Water's Development charges. Projects undertaken include Central Creek, New Gisborne, Romsey, Riddells Creek, Loch and Nyora.

Impacts of Pontoons and Jettys on Flooding on the Coomera and Nerang Rivers

The Gold Coast City Council was concerned that the on-going construction of pontoons and jetties on the Nerang and Coomera Rivers may impact of flood levels. The Computational Fluid Dynamics (CFD) software Fluent was used to assess the near field effects of the pontoons and jetties. Data obtained from the CFD analysis was used to inform the far-field 2D modelling undertaken using TUFLOW.

Insurance Assessments

worked on hydrology reports for insurance companies following the Victorian floods in 2012, the Queensland flood in 2013 and the floods in Victoria, NSW and Queensland

Key road and rail projects

These studies involved the development of detailed hydrologic and hydraulic models to assist in route selection and the establishment of the road grade and bridge and culvert requirements to meet flood serviceability requirements such as flood impact and time of closure. Bridge scour assessments are sometimes required. Recent major projects include:

- Inland Rail Project (Melbourne to Brisbane)
- Smithfield Bypass D&C (Qld)
- Bruce Highway Upgrade, Haughton River Floodplain, Business Case (Qld)
- Warrego Highway Upgrade, Gowrie Creek, Detailed Design (Qld)
- Bruce Highway Upgrade, Ingham to Cardwell Range Planning Study (Qld)
- Bruce Highway Upgrade, Frances and Cattle Creeks - Link Study, Business Case and Detailed Design phase
- Yaamba Rail Upgrade investigation (Qld)
- Mt Isa Rail line Jetty Branch Upgrade, Concept and Detailed Design (Qld)
- Bruce Highway Upgrade – Larsens Street to Lannercost Street (Qld)
- Gold Coast Intra-Regional Transport Corridor (Qld)
- Western Highway Duplication – Carpenter Road to Box's Track (Vic)
- Springvale Road - Railway level crossing removal (Vic)

During years at the QLD Department of Main Roads he spent 8 years working in the flood group undertaking flood assessments on bridge and road project across most parts of Queensland.

Key land development projects

Planning system requirements associated with developing on a floodplain can be complex with regards to flood and stormwater management. Mark has worked for both developers and approval authorities (review and technical advisor role) on many complex development proposals in both Victoria and Queensland from concept through to detailed design and as an expert witness in planning submissions and appeals. A selection of these projects includes:

- Gales Kingscliff (NSW)
- Queens Wharf Brisbane (Qld)
- Grand Lakes (Vic)
- Seabank Estate (Vic) – winner of the 2007 UDIA award for WSUD
- Manzeene Avenue (Vic)
- Gold Coast Convention Centre (Qld)
- Pacific View Estate (Qld)
- Gold Coast International Marine Precinct (Qld)

The Queens Wharf Development is a multi-billion dollar redevelopment of the north bank of the Brisbane River in the CBD. The project is a State initiative and as a Technical Advisor (flooding) to the State through the 18 month procurement process. This included the preparation of tender documentation, development of a TUFLOW model for use by the Proponents during tendering, assisting with Proponent questions during tendering, technical review of tenders, advising the State on planning matters.

Key environmental modelling projects

Dowd Morass Salinity Risk Assessment and Management Options

Dowd Morass is located on the southern of the lower Latrobe wetlands mosaic. The water regime of Dowd Morass is complex and water (of various salinities) can enter the wetland via several sources.

was part of a team engaged by the West Gippsland Catchment Management Authority to assess current risks of saline water intrusions into Dowd Morass but also increased risks associated with climate change including sea level rise increasing frequency of saline inundation and decreased freshwater inflow.

A hydraulic model was developed to assess saline water mixing in the Down Morass to understanding existing and future risks and to assess mitigation options.

River Tamar Estuary Modelling Study

was the Project Manager responsible for the development of a calibrated tidal hydrodynamic, water quality and cohesive sediment transport model of the Tamar River estuary for the Launceston City Council. The modelling was performed using the RMA10S and RMA11 software packages. Cohesive sediment transport and siltation modelling was an important focus of this study which seeks to develop a tool for modelling the ongoing siltation problem within the upper Tamar estuary and for predicting the flood scour which is likely to occur. The model was also used to assess the impact of changes to the Council's wastewater treatment system on the water quality of the Estuary.

Gold Coast International Marine Precinct EIS

An expansion to the marine precinct on the Coomera River is proposed. It is deemed to be a project of state significance by the State. The precinct is in an environmentally sensitive and flood prone area. was responsible for the following assessments: flood and tidal; receiving water quality; sediment accumulation; dredge plume dispersion; sediment impacts on aquatic ecology. The assessments were undertaken on a range of modelling packages including a TUFLOW FV for tide, advection dispersion model (dredge plume dispersion), and sediment accumulation. MIKE21 was used for the flood assessment.

Woollooman Creek Weir

The impact of a proposed weir in combination with an in-stream sand extraction operation on the sediment transport processes within the Creek were assessed. Long-term sediment transport processes, catchment yield and sediment capacity were assessed. Recommendations were developed for mitigating the impacts.

Maroochy River Eutrophication Modelling

The effects on sewage discharges on receiving water quality and estuarine ecological health and proposed plant augmentations were assessed using MIKE11. The eutrophication model investigated nutrient cycling, growth of phytoplankton and zooplankton as well.

Construction and bridge design experience

During his time at QLD Department of Main Roads, spent nearly two years working in road construction and bridge design.

Key peer review experience

Inquiry into Flood Mitigation Infrastructure in Victoria, Parliament of Victoria

Following the Victorian floods of 2010 and of 2011, the Victorian Government established a parliamentary enquiry into flood mitigation infrastructure in Victoria. was the technical adviser for the enquiry report.

Hawkesbury-Nepean Valley Flood Management Strategy

Infrastructure NSW is proposing a significant investment in a range of flood management strategies for the Hawkesbury-Nepean Valley. The NSW State Government requires that the strategic business case for the next phase of the scheme be independently reviewed to satisfy the requirements of its Gateway Review Process. was a member of the Gateway peer review panel established by NSW Treasury.

Brisbane River Pedestrian Riverwalk, Peer Review

The Riverwalk pedestrian bridge on the Brisbane River was washed away during the 2011 floods. To minimise the risk of a future failure, the Brisbane City Council's consultant undertook 3D hydrodynamic modelling to determine flow velocities and physical modelling to determine flood force coefficients; the coefficients were required to establish the flood loads. PhD research was in flood and debris loads on bridge structures, and so the Council engaged review the physical modelling and derivation of the force coefficients.

Flemington Racecourse Flood Wall

The Victorian Racing Club proposed the construction of a flood wall around the Flemington Racecourse to reduce the risk of the Melbourne Cup being affected by flooding. Concerns were raised as to the effects of the flood wall on existing developments along the Maribyrnong River floodplain. The City of Melbourne, Moonee Valley City Council and Maribyrnong City Council engaged to complete an independent peer review of the modelling, proposal and mitigation works.

Brisbane Airport Link and Busways, Peer Review of Hydraulic Modelling

The Airport Link and Busways project in Brisbane required the construction of a complex array of bridges/overpasses over Breakfast Creek at Herston. This resulted in a large number of piers in creek and floodplain. With a large number of flood prone houses upstream, it was important that the modelling reliably estimated the impacts of the

piers and that appropriate mitigation was implemented. Brisbane City Council engaged to peer review the modelling undertaken by the Proponents' consultants.

Salacia Waters Marina Development, Gold Coast, QLD

undertook an independent peer review of modelling and associated impacts of a proposed marina at Salacia Waters development. The review was done in order to assist in resolving a dispute between Council and the proponent with regards to the representation in the model of hydraulic losses around the marina structures.

Florina Gardens Development, Gold Coast

The Florina Gardens development on the Gold Coast is located on the Nerang River floodplain. Gold Coast City Council engaged to complete a peer review of the hydraulic modelling done by the proponent and an assessment against the planning scheme.

Key expert witness experience

regularly prepares expert witness statements for both government and private sector clients in relation to flooding and Stormwater matters. The list below is a mix of VCAT and Planning Panel work in Victoria, Planning & Environment Court in Queensland and Land and Environment Court in NSW.

- Naring Solar Farm, VIC
- Meningoort Solar Farm, VIC
- Hall Road Solar Farm, VIC
- Ibbotson St Development, St Leonards, VIC
- Mills Crescent Development, Port Fairy, VIC
- Implementation of Special Building Overlay into planning scheme, City of Greater Geelong
- Development at San Remo, VIC
- Halcyon Waters, Gold Coast, QLD
- Eastern Golf Course at Yering, VIC
- St Patricks School, Macksville, NSW
- Great Ocean Green, Apollo Bay, VIC
- Grand Lakes Development at Lara, VIC
- Caddys Road Rezoning at Lara, VIC
- Manzeene Ave Development at Lara, VIC
- Subdivision at Aireys Inlet, VIC
- Sheehan & Berry appeal, Gold Coast, QLD
- Development at Walcourm Court, Launceston, TAS
- Pizzolato Development, Innisfail, QLD
- Barwon Heads Road Development, VIC

Articles, papers and presentations

Jempson, M.A. and Apelt, C.J. (1992), Hydrodynamic forces on partially and fully submerged bridge superstructures, *Proc. 16th ARRB Conference, 9-12 November, Perth, Australia, v3, pp67-82.*

Jempson, M.A. (1994), Hydrodynamic forces on partially and fully submerged bridge superstructures, *Master of Engineering Science Thesis, The University of Queensland*

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Jempson, M.A. (2000), Flood and Debris Loads on Bridges, *Institution of Engineers Australia, Technical Seminar, March 2000, Brisbane.*

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Gillam, P, Jempson, M.A., Rogencamp, G.J., (2005), The importance of combined 2D/1D modelling of complex floodplains – Tatura Case Study, *4th Victorian Floodplain Management Conference*, Shepparton, Victoria, 2005

Jempson, M.A., Rogencamp, G.J., (2006), The Application and Benefits of 2D/1D Flood Modelling in Urban Developments, 1st *Association of Land Development Engineers Conference*, Gold Coast, Queensland, August 2006

Caddis, B.M, Jempson, M.A, Syme, W.J. and Ball, J.E. (2008) *Incorporating Hydrology into 2D Hydraulic Models – The Direct Rainfall Approach.* Proceedings of Hydraulics in Water Engineering Conference, Darwin, Australia

Leister, J.G. and Jempson, M.A. (2010), *Backwater Effects of Piers and Abutments in a 2D Hydraulic Model*, Victorian Floodplain Managers Conference, Bendigo, November 2010

Leister, J.G. & Jempson, M.A., (2011), *Backwater Effects of Bridge Piers and Abutments in 2D – Replication of Physical Model Tests in a 2D Hydrodynamic Model*, 34th International Association of Hydraulic Research (IAHR) World Congress, Brisbane, Australia, June 2011.

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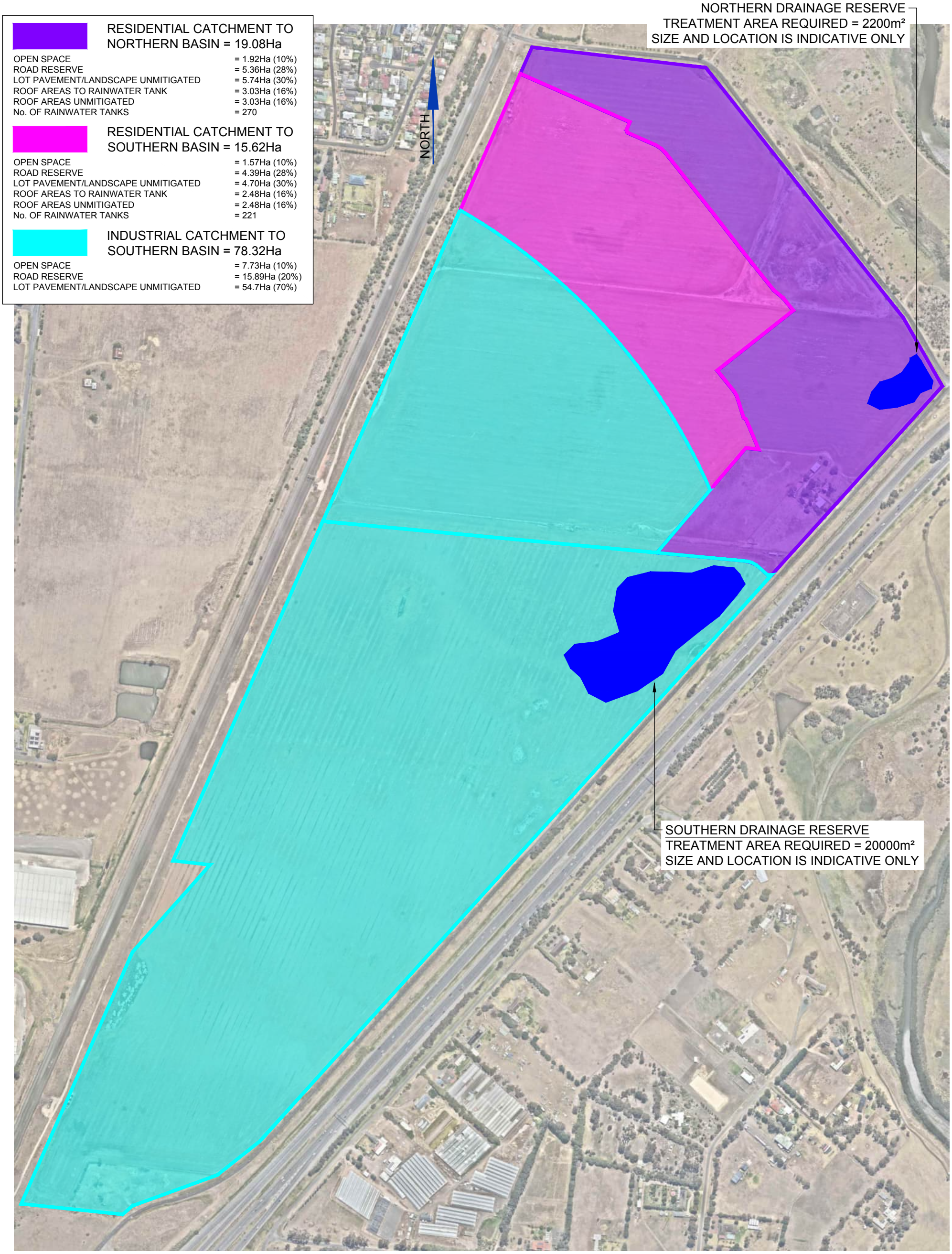
Jempson, M.J., Leach, B. and Trotter, D., (2013), *On the implementation of floodplain management plans on the Herbert and Johnstone Rivers*, IAHS Publication No. 357 (2013), ISBN 978-1-907161-35-3

Jempson, M.J., South, M.E., and Kim, Y.J., (2014), *The influence of localised upwelling at a bridge on overtopping and road closure: a case study using vertical 2D CFD and horizontal 2D flood models*, 5th International Symposium on Hydraulic Structures, Brisbane, June 2014.

Appendix B Development Catchment Plan for MUSIC Modelling



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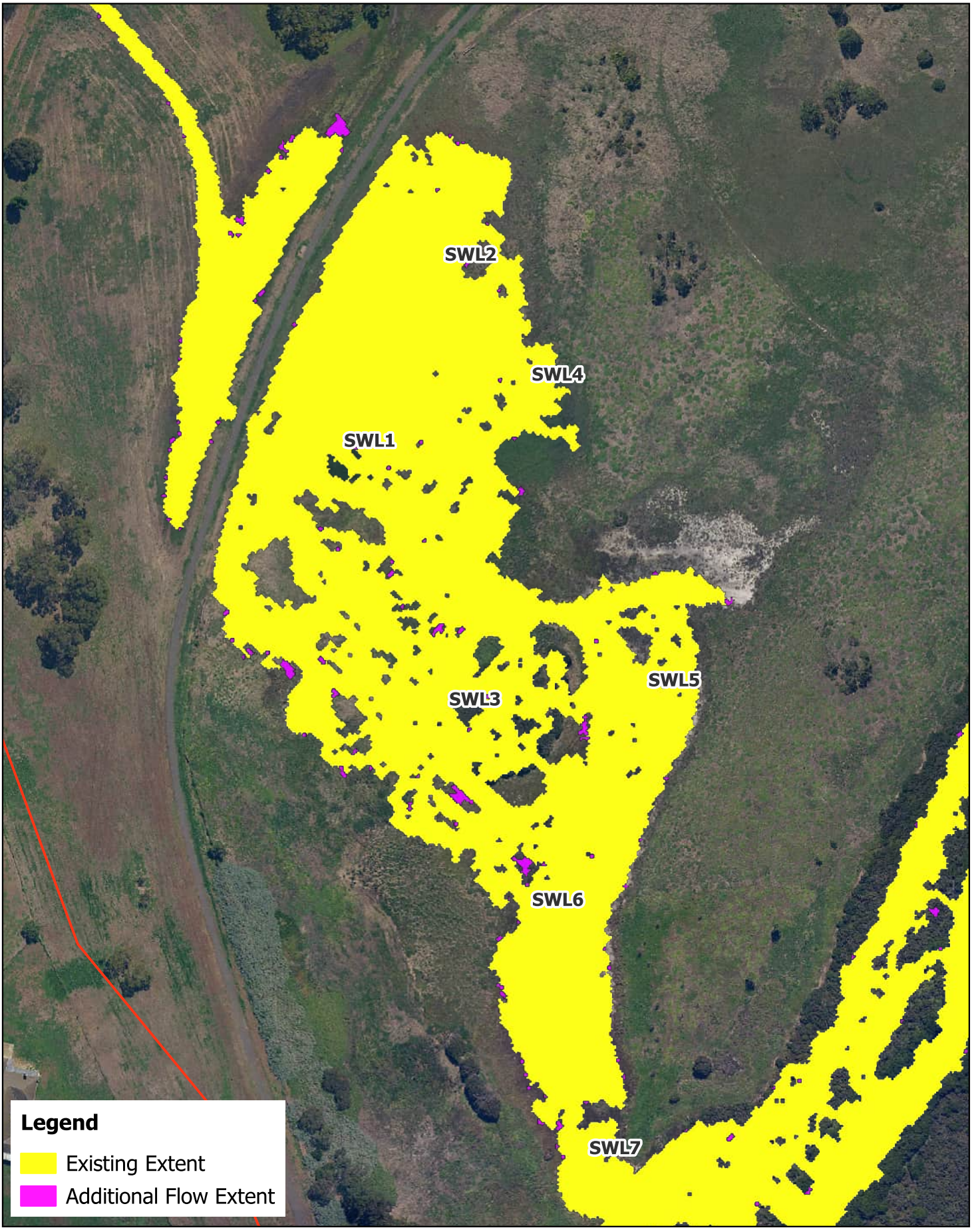
PRELIMINARY DRAWING
NOT TO BE USED FOR CONSTRUCTION

516 CANTERBURY RD LARA
MUSIC CATCHMENT PLAN

N.T.S.
November 2024
Rev. 01

C:\USERS\KEENANBOON\LOETIS PTY LTD\PROJECTS - DOCS\2. JOBS\J10001 - LARA FARMS\3. ENGINEERING\3. DRAFTING\6. ADDITIONAL DRAWINGS\MUSIC CATCHMENT PLAN R01.DWG

Appendix C Change in Flood Extent Mapping



Title:

Lara Farms - Water Balance Assessment
March 1973 - Flow Extent Comparison (+5% Flow)

Figure:	Rev:			
C-1	B	0 25 50 m	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: LD Date: Jan 2024

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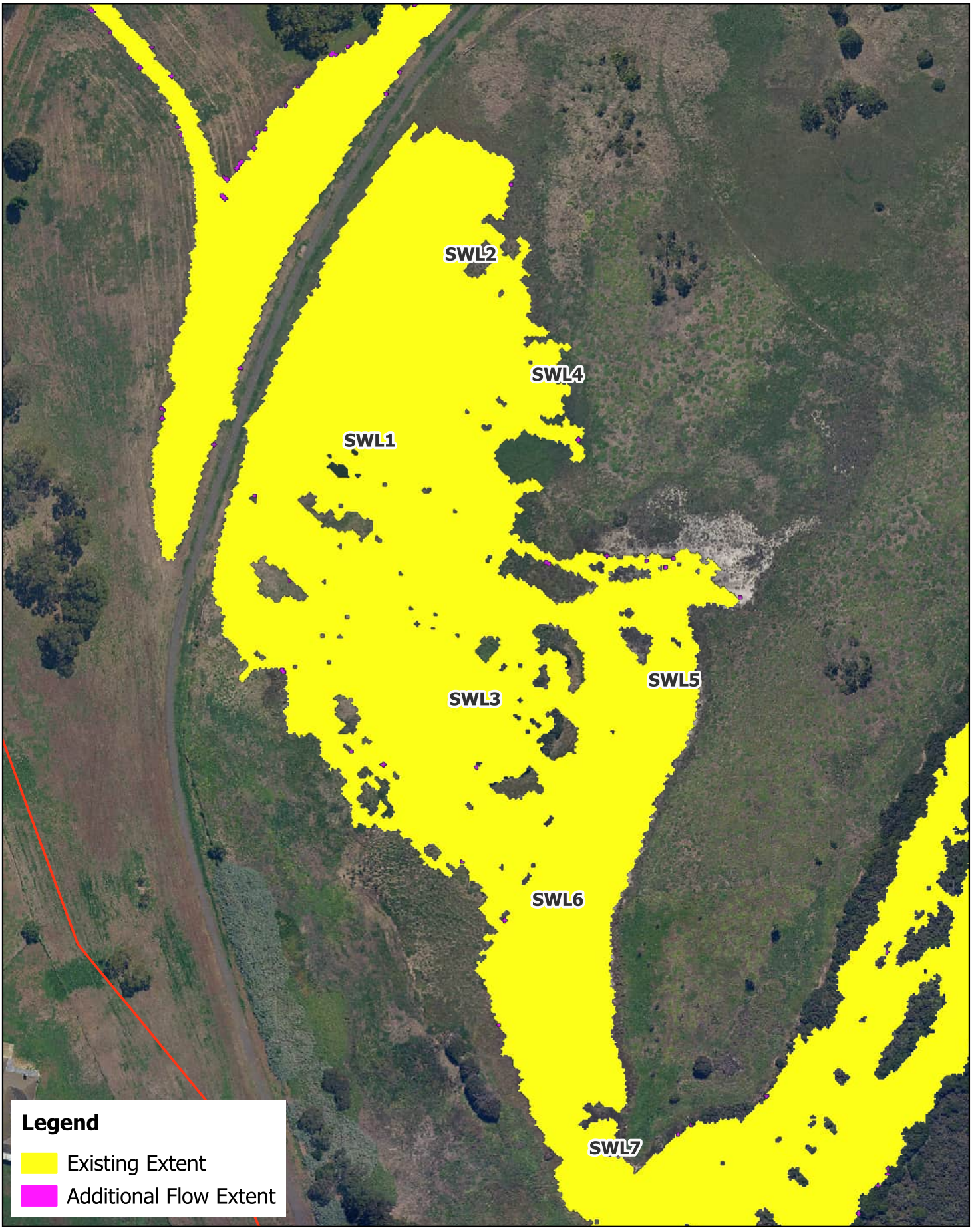

Title:

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October 1976 - Flow Extent Comparison (+5% Flow)

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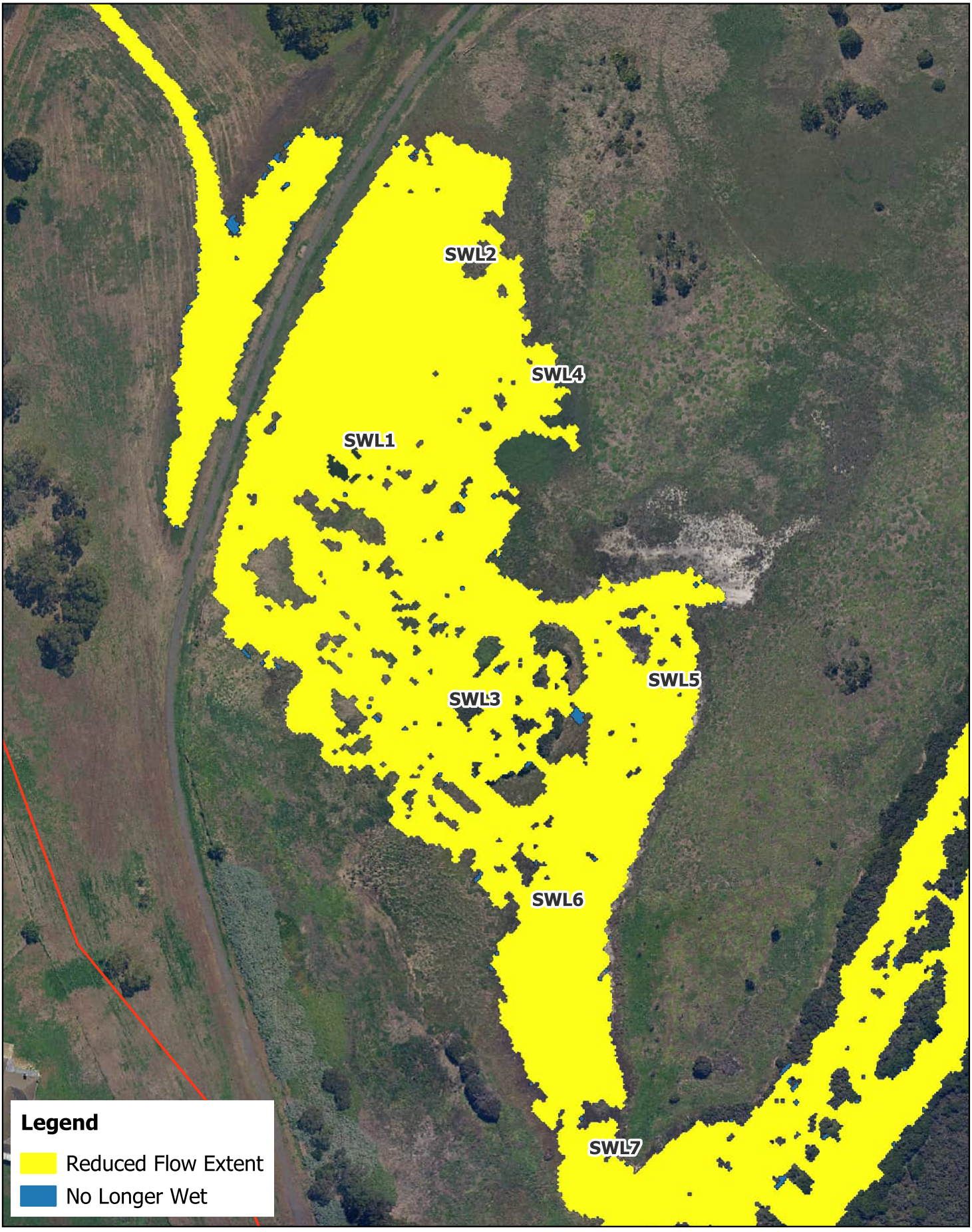

Title:

Lara Farms - Water Balance Assessment
March 1973 - Flow Extent Comparison (-5% Flow)

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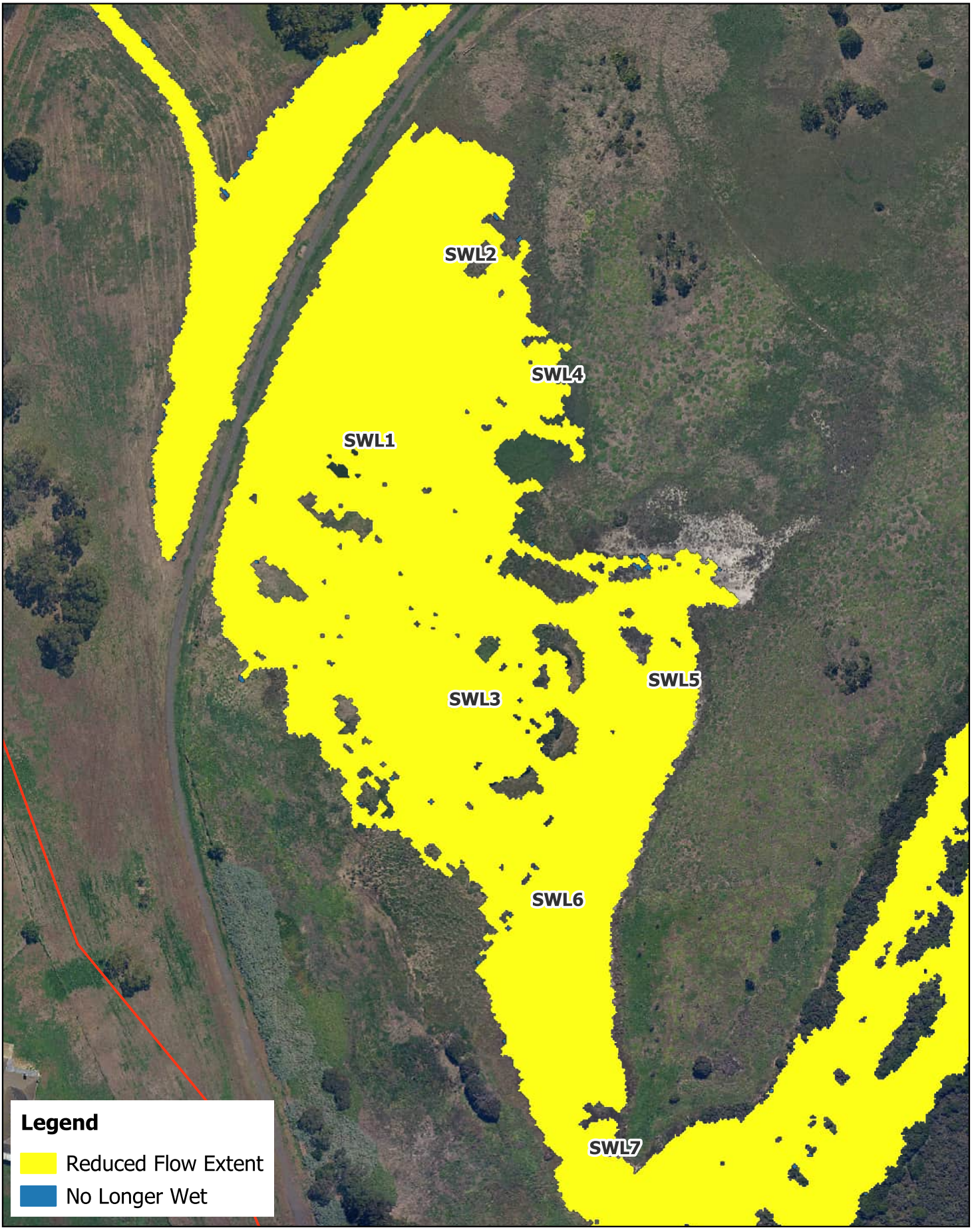

Title:

Lara Farms - Water Balance Assessment
October 1976 - Flow Extent Comparison (-5% Flow)

Figure:	Rev:			
C-4	B	0 25 50 m	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: LD Date: Jan 2024

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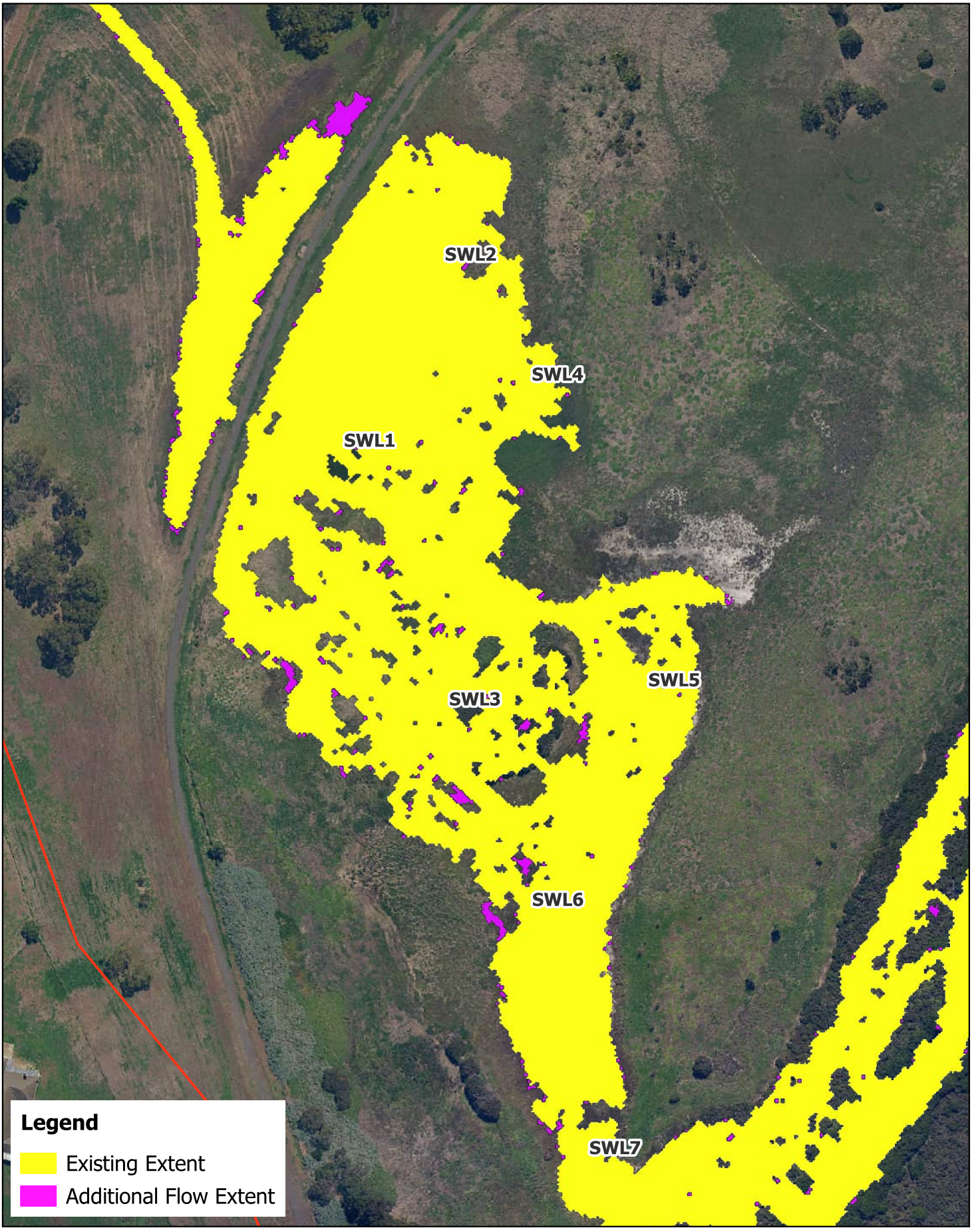

Title:

Lara Farms - Water Balance Assessment
March 1973 - Flow Extent Comparison (+10% Flow)

Figure:	Rev:			
C-5	B	0 25 50 m	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: LD Date: Jan 2024

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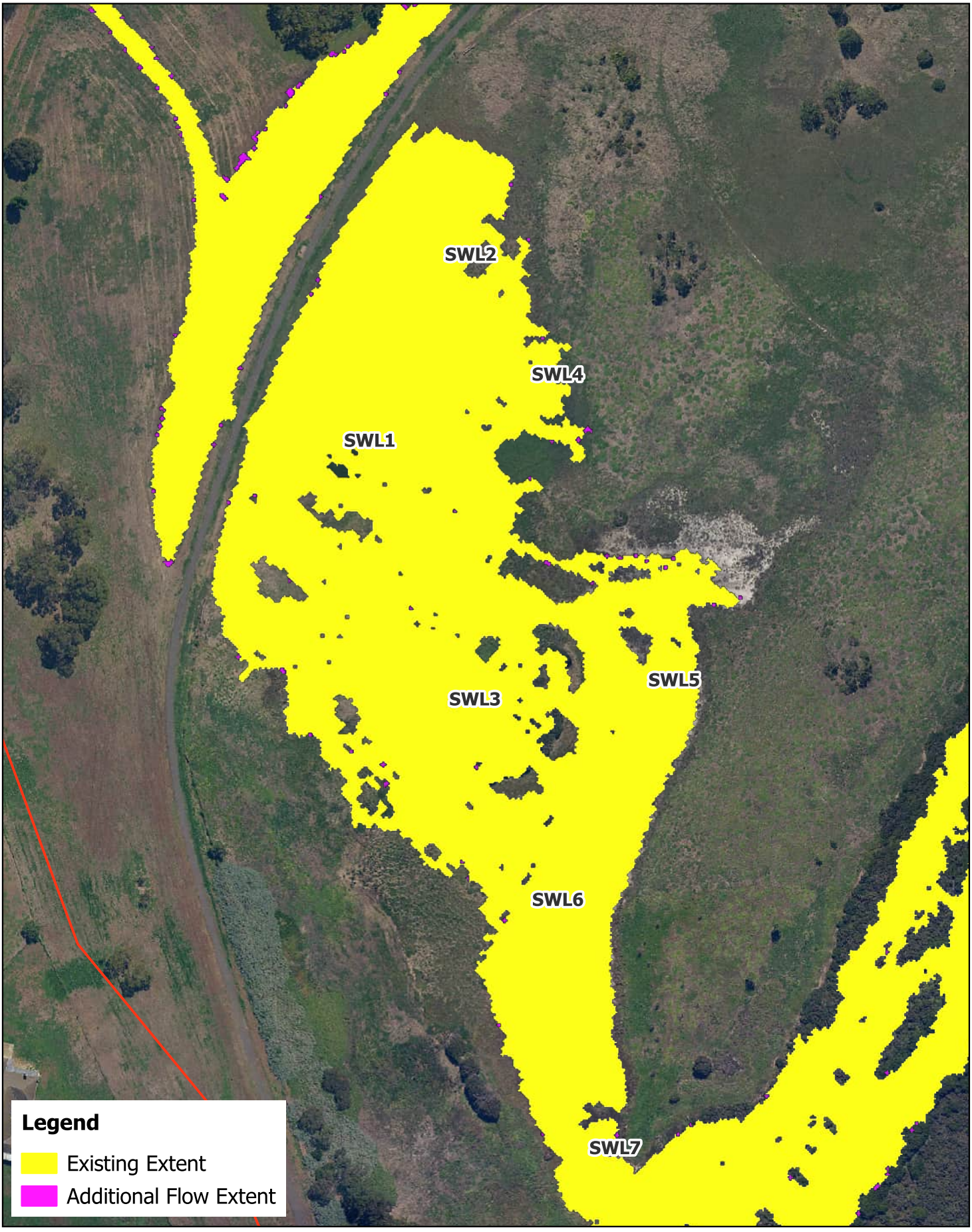

Title:

Lara Farms - Water Balance Assessment
October 1976 - Flow Extent Comparison (+10% Flow)

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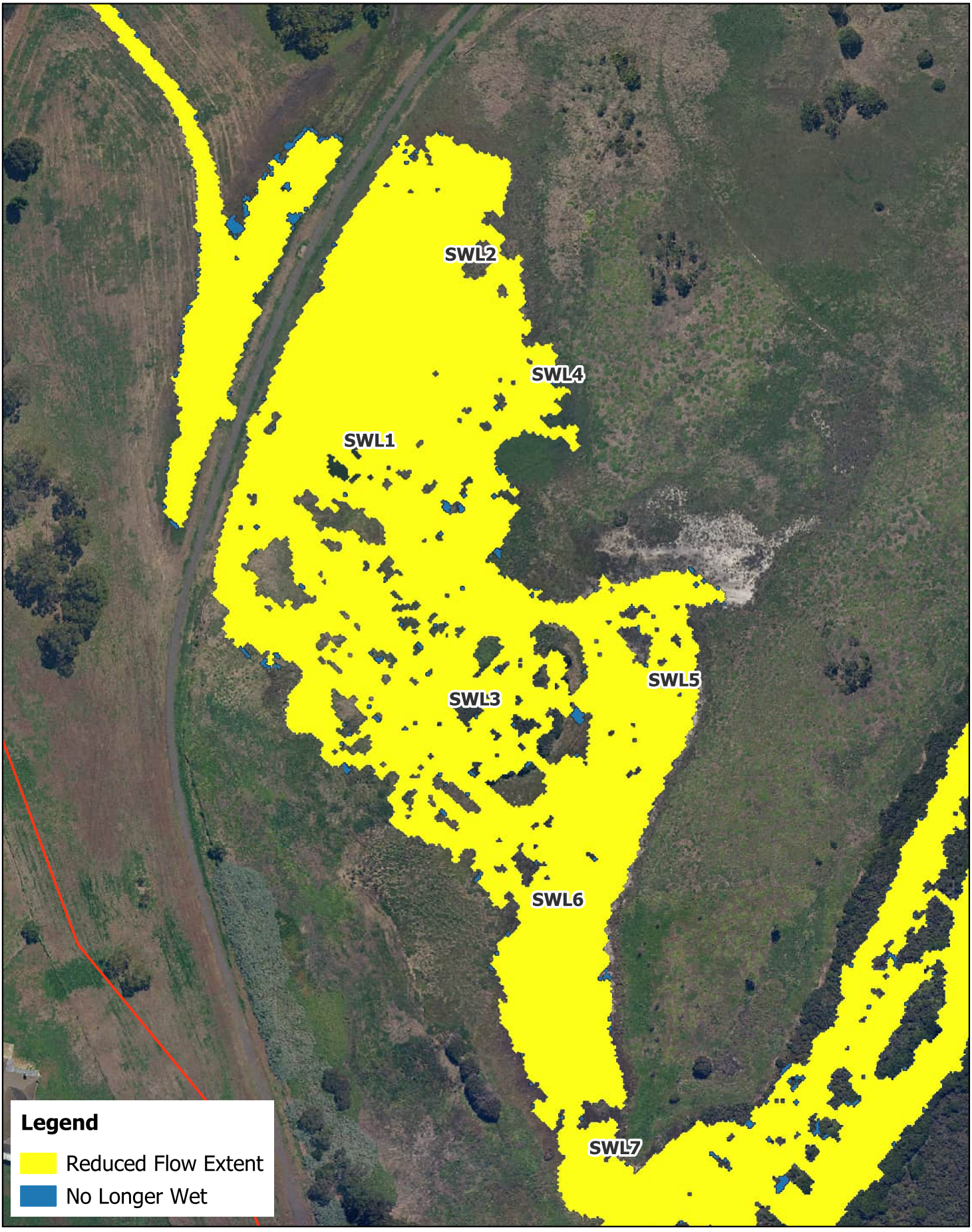

Title:

Lara Farms - Water Balance Assessment
March 1973 - Flow Extent Comparison (-10% Flow)

Figure:	Rev:			
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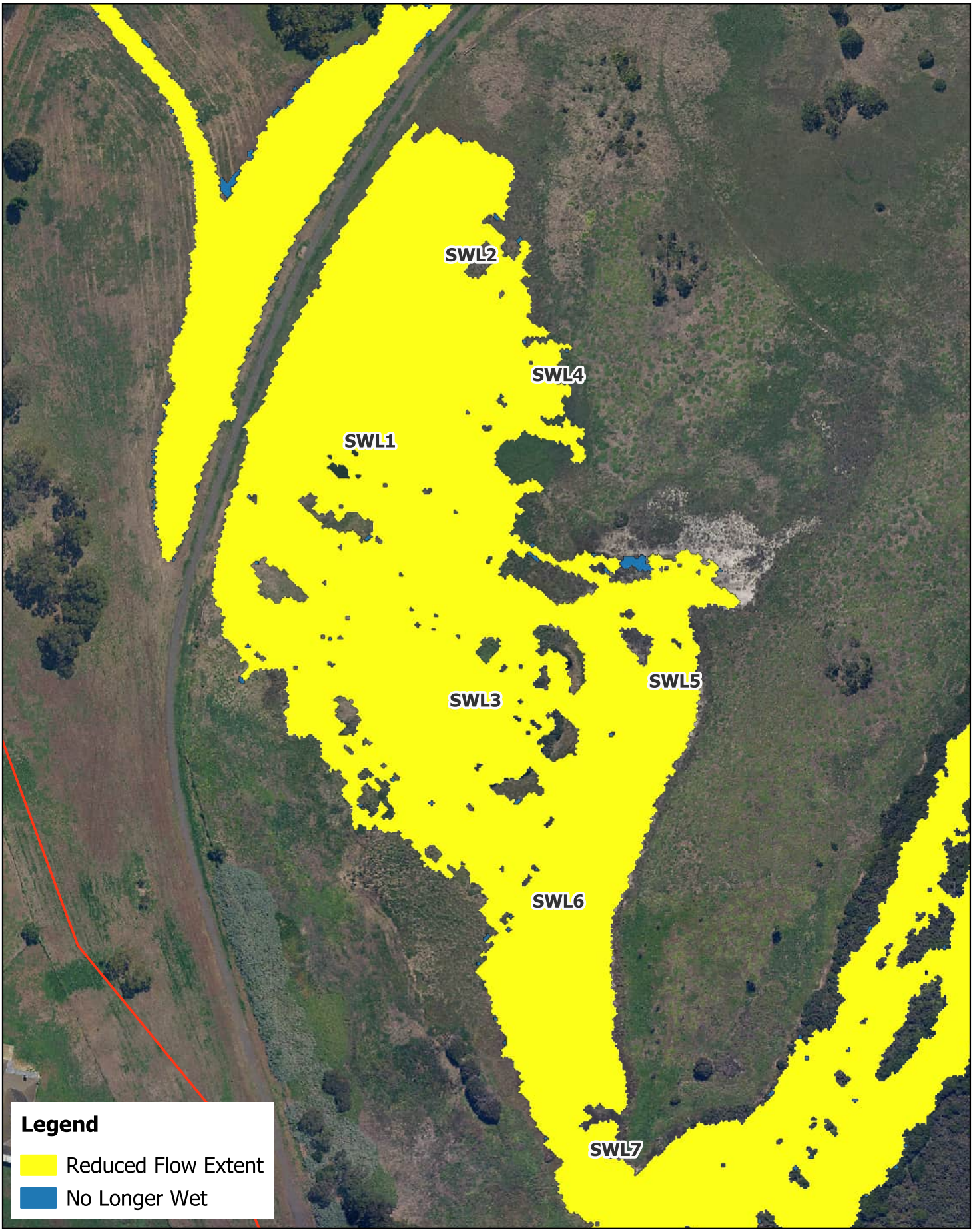

Title:

Lara Farms - Water Balance Assessment
October 1976 - Flow Extent Comparison (-10% Flow)

Figure:	Rev:			
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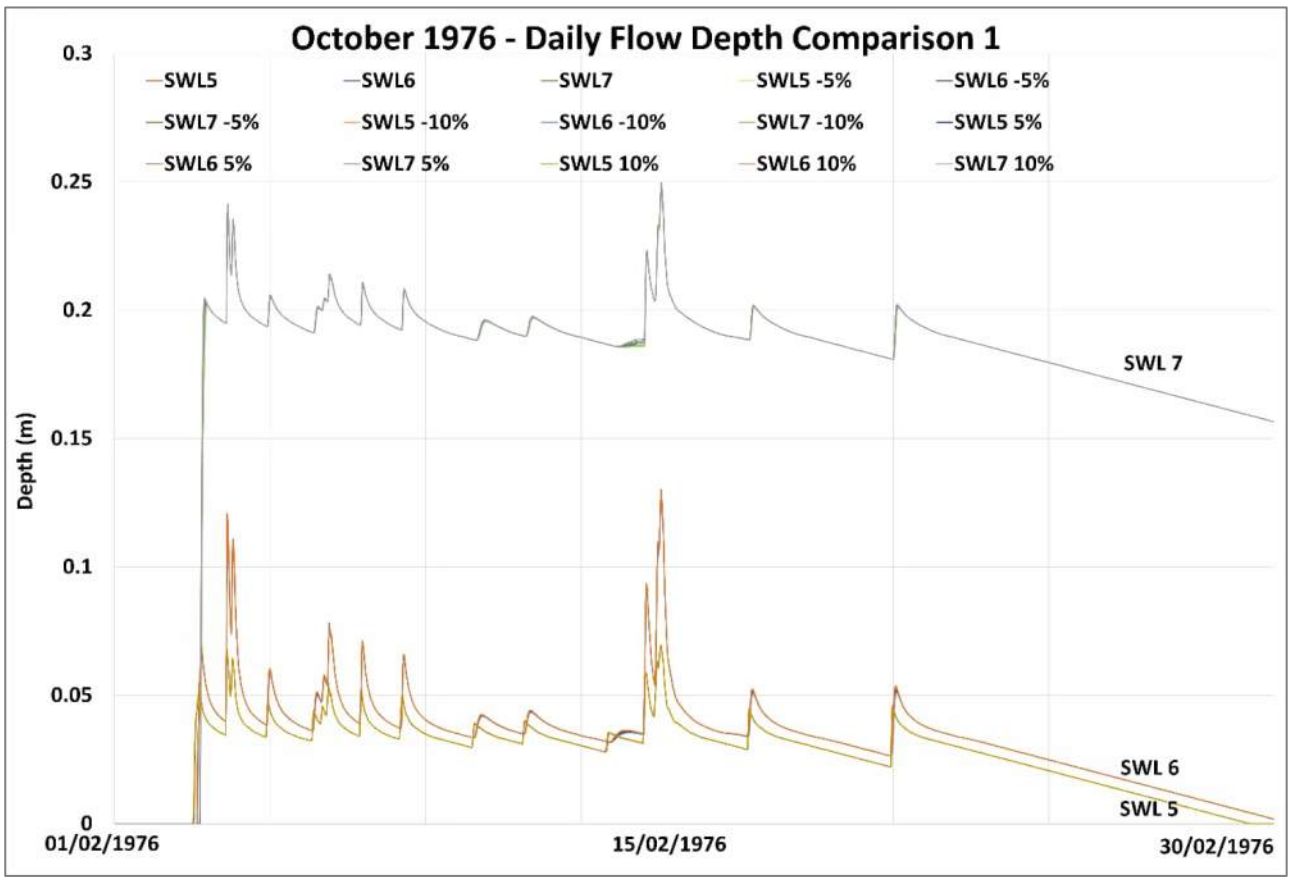
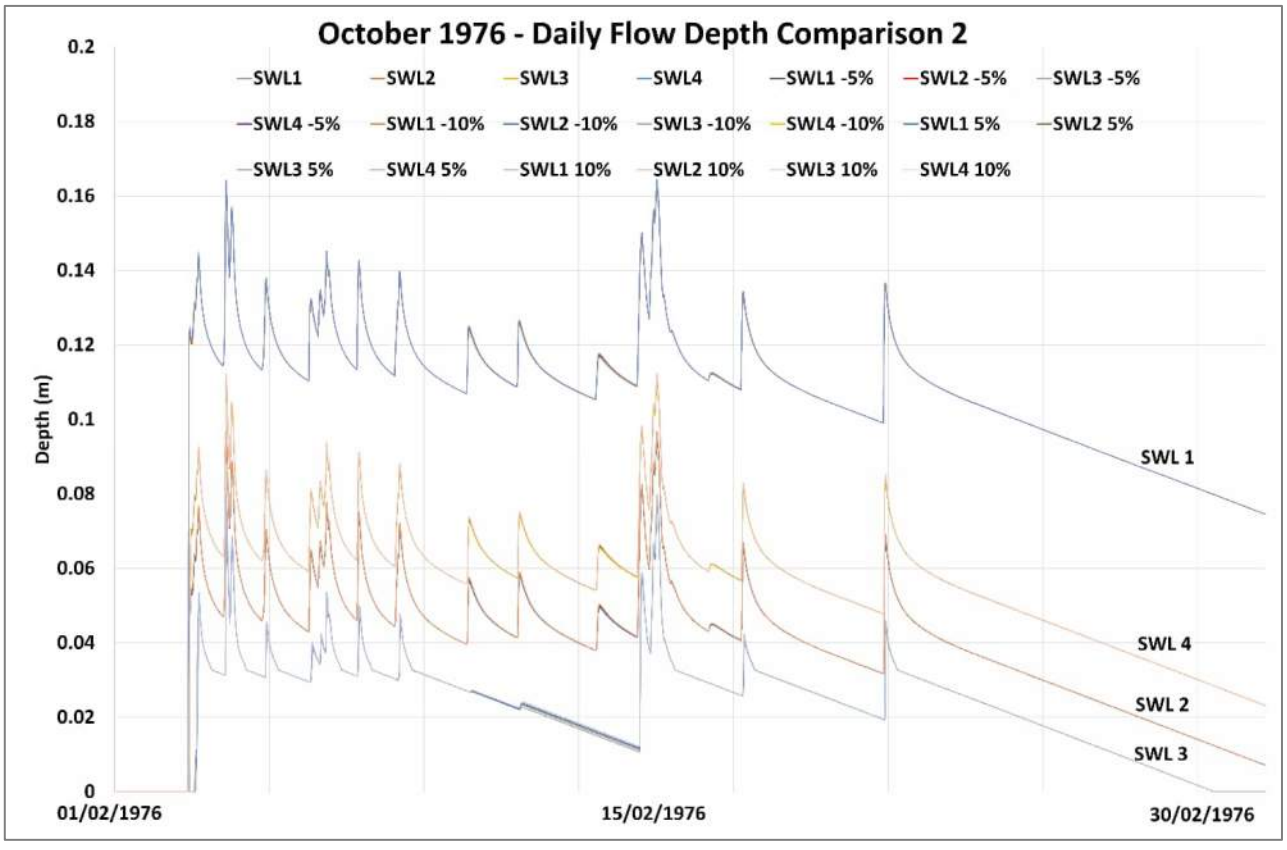
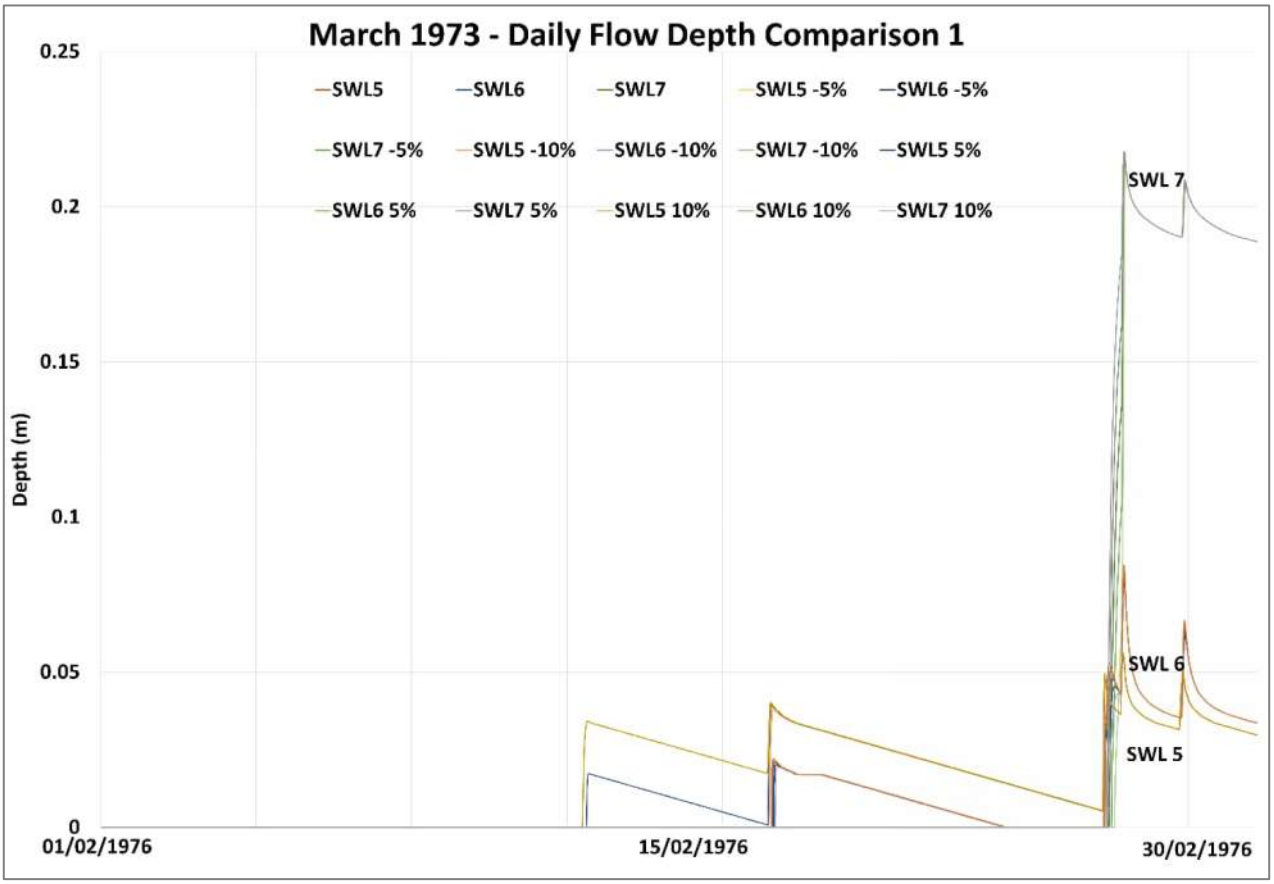
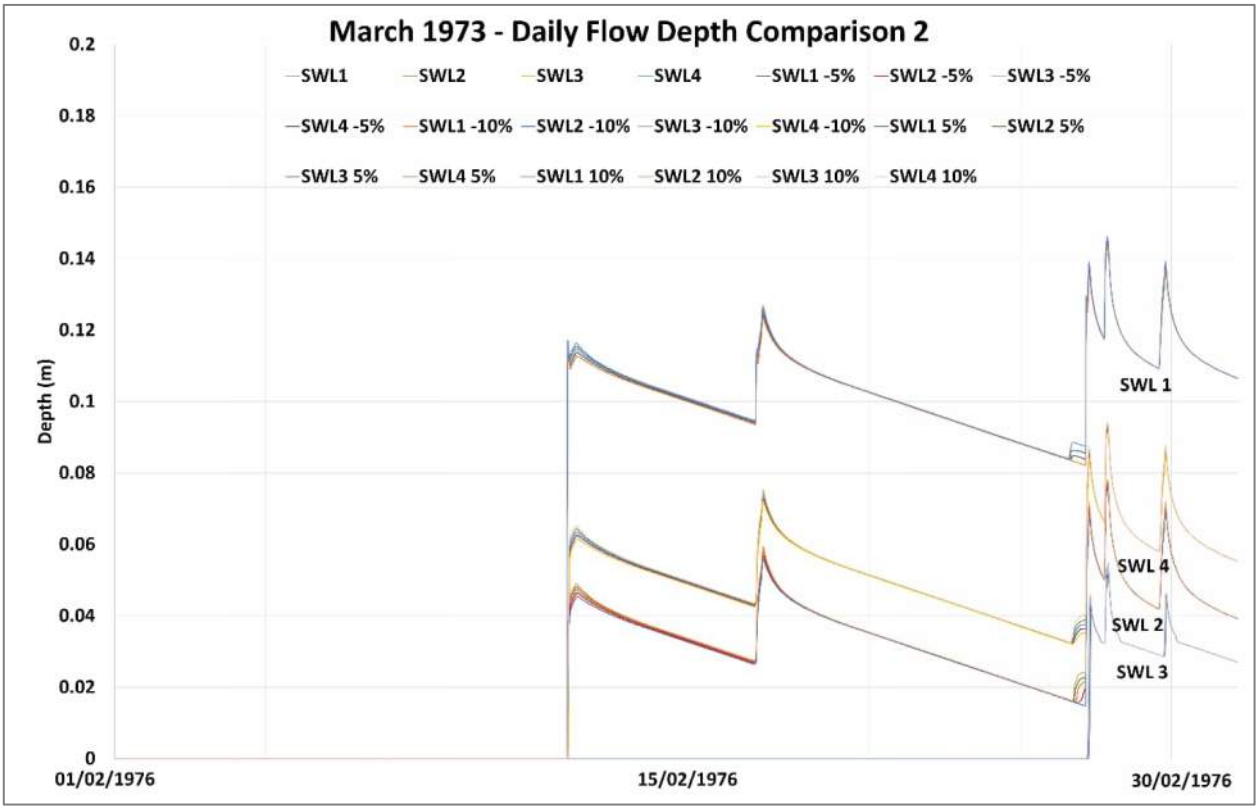
Appendix D Depth Time Series


October 1976 - Daily Flow Depth Comparison 1
SWL5
SWL6
SWL7
SWL5 -5%
SWL6 -5%
SWL7 -5%
SWL5 -10%
SWL6 -10%
SWL7 -10%
SWL5 5%
SWL6 5%
SWL7 5%
SWL5 10%
SWL6 10%
SWL7 10%
Depth (m)
0.3
0.25
0.2
0.15
0.1
0.05
0
SWL 7
SWL 6
SWL 5
01/02/1976
15/02/1976
30/02/1976


October 1976 - Daily Flow Depth Comparison 2
SWL1
SWL2
SWL3
SWL4
SWL1 -5%
SWL2 -5%
SWL3 -5%
SWL4 -5%
SWL1 -10%
SWL2 -10%
SWL3 -10%
SWL4 -10%
SWL1 5%
SWL2 5%
SWL3 5%
SWL4 5%
SWL1 10%
SWL2 10%
SWL3 10%
SWL4 10%
Depth (m)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
SWL 1
SWL 4
SWL 2
SWL 3
01/02/1976
15/02/1976
30/02/1976


March 1973 - Daily Flow Depth Comparison 1
SWL5
SWL6
SWL7
SWL5 -5%
SWL6 -5%
SWL7 -5%
SWL5 -10%
SWL6 -10%
SWL7 -10%
SWL5 5%
SWL6 5%
SWL7 5%
SWL5 10%
SWL6 10%
SWL7 10%
Depth (m)
0.25
0.2
0.15
0.1
0.05
0
01/02/1976
15/02/1976
30/02/1976
SWL 7
SWL 6
SWL 5


March 1973 - Daily Flow Depth Comparison 2
SWL1
SWL2
SWL3
SWL4
SWL1 -5%
SWL2 -5%
SWL3 -5%
SWL4 -5%
SWL1 -10%
SWL2 -10%
SWL3 -10%
SWL4 -10%
SWL1 5%
SWL2 5%
SWL3 5%
SWL4 5%
SWL1 10%
SWL2 10%
SWL3 10%
SWL4 10%
Depth (m)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
01/02/1976
15/02/1976
30/02/1976
SWL 1
SWL 4
SWL 2
SWL 3

Appendix E Protected Matters – MNES Layers

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 03-Aug-2023

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	61
Listed Migratory Species:	35

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	41
Whales and Other Cetaceans:	3
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	1
Nationally Important Wetlands:	None
EPBC Act Referrals:	10
Key Ecological Features (Marine):	None
Biologically Important Areas:	5
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar Wetlands) [Resource Information]

Ramsar Site Name	Proximity
Port phillip bay (western shoreline) and bellarine peninsula	Within 10km of Ramsar site

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.
Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.

Community Name	Threatened Category	Presence Text
Grassy Eucalypt Woodland of the Victorian Volcanic Plain	Critically Endangered	Community known to occur within area
Natural Temperate Grassland of the Victorian Volcanic Plain	Critically Endangered	Community likely to occur within area
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour may occur within area
Aphelocephala leucopsis Southern Whiteface [529]	Vulnerable	Species or species habitat likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Callocephalon fimbriatum Gang-gang Cockatoo [768]	Endangered	Species or species habitat may occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat may occur within area
Climacteris picumnus victoriae Brown Treecreeper (south-eastern) [67062]	Vulnerable	Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat likely to occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limosa lapponica baueri Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Melanodryas cucullata cucullata South-eastern Hooded Robin, Hooded Robin (south-eastern) [67093]	Endangered	Species or species habitat likely to occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Species or species habitat likely to occur within area
Neophema chrysostoma Blue-winged Parrot [726]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Pedionomus torquatus Plains-wanderer [906]	Critically Endangered	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Stagonopleura guttata Diamond Firetail [59398]	Vulnerable	Species or species habitat likely to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri platei Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Species or species habitat may occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Species or species habitat likely to occur within area
FISH		
Galaxiella pusilla Eastern Dwarf Galaxias, Dwarf Galaxias [56790]	Vulnerable	Species or species habitat may occur within area
Nannoperca obscura Yarra Pygmy Perch [26177]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
[Prototroctes maraena](#)		
Australian Grayling [26179]	Vulnerable	Species or species habitat may occur within area
[Seriolella brama](#)		
Blue Warehou [69374]	Conservation Dependent	Species or species habitat known to occur within area
[Thunnus maccoyii](#)		
Southern Bluefin Tuna [69402]	Conservation Dependent	Species or species habitat likely to occur within area
FROG		
[Litoria raniformis](#)		
Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog, Golden Bell Frog [1828]	Vulnerable	Species or species habitat likely to occur within area
INSECT		
[Synemon plana](#)		
Golden Sun Moth [25234]	Vulnerable	Species or species habitat likely to occur within area
MAMMAL		
[Pteropus poliocephalus](#)		
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
PLANT		
[Amphibromus fluitans](#)		
River Swamp Wallaby-grass, Floating Swamp Wallaby-grass [19215]	Vulnerable	Species or species habitat likely to occur within area
[Dianella amoena](#)		
Matted Flax-lily [64886]	Endangered	Species or species habitat likely to occur within area
[Dodonaea procumbens](#)		
Trailing Hop-bush [12149]	Vulnerable	Species or species habitat may occur within area
[Glycine latrobeana](#)		
Clover Glycine, Purple Clover [13910]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Lachnagrostis adamsonii		
Adamson's Blown-grass, Adamson's Blowngrass [76211]	Endangered	Species or species habitat may occur within area
Lepidium aschersonii		
Spiny Peppercress [10976]	Vulnerable	Species or species habitat may occur within area
Lepidium hyssopifolium		
Basalt Pepper-cress, Peppercress, Rubble Pepper-cress, Pepperweed [16542]	Endangered	Species or species habitat may occur within area
Leucochrysum albicans subsp. tricolor		
Hoary Sunray, Grassland Paper-daisy [89104]	Endangered	Species or species habitat may occur within area
Pimelea spinescens subsp. spinescens		
Plains Rice-flower, Spiny Rice-flower, Prickly Pimelea [21980]	Critically Endangered	Species or species habitat likely to occur within area
Pterostylis cucullata		
Leafy Greenhood [15459]	Vulnerable	Species or species habitat may occur within area
Rutidosis leptorhynchoides		
Button Wrinklewort [67251]	Endangered	Species or species habitat likely to occur within area
Senecio macrocarpus		
Large-fruit Fireweed, Large-fruit Groundsel [16333]	Vulnerable	Species or species habitat likely to occur within area
REPTILE		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area
Delma impar		
Striped Legless Lizard, Striped Snake-lizard [1649]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Lissolepis coventryi		
Swamp Skink, Eastern Mourning Skink [84053]	Endangered	Species or species habitat may occur within area
Tympanocryptis pinguicolla		
Victorian Grassland Earless Dragon [66727]	Critically Endangered	Species or species habitat likely to occur within area
SHARK		
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species		[Resource Information]
Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna grisea		
Sooty Shearwater [82651]		Species or species habitat may occur within area
Diomedea antipodensis		
Antipodean Albatross [64458]	Vulnerable	Species or species habitat likely to occur within area
Diomedea epomophora		
Southern Royal Albatross [89221]	Vulnerable	Species or species habitat likely to occur within area
Diomedea exulans		
Wandering Albatross [89223]	Vulnerable	Species or species habitat likely to occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Macronectes halli		
Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri		
Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche chrysostoma		
Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini		
Salvin's Albatross [64463]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche steadi		
White-capped Albatross [64462]	Vulnerable	Species or species habitat likely to occur within area
Migratory Marine Species		
Caperea marginata		
Pygmy Right Whale [39]		Species or species habitat may occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat likely to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
[Dermochelys coriacea](#) Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
[Lagenorhynchus obscurus](#) Dusky Dolphin [43]		Species or species habitat may occur within area
[Lamna nasus](#) Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
[Megaptera novaeangliae](#) Humpback Whale [38]		Species or species habitat may occur within area
Migratory Terrestrial Species		
[Hirundapus caudacutus](#) White-throated Needletail [682]	Vulnerable	Species or species habitat likely to occur within area
[Motacilla flava](#) Yellow Wagtail [644]		Species or species habitat likely to occur within area
[Myiagra cyanoleuca](#) Satin Flycatcher [612]		Species or species habitat known to occur within area
[Rhipidura rufifrons](#) Rufous Fantail [592]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
[Actitis hypoleucos](#) Common Sandpiper [59309]		Species or species habitat likely to occur within area
[Calidris acuminata](#) Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
[Calidris canutus](#) Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat likely to occur within area
Limosa lapponica		
Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat likely to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Ardenna grisea as Puffinus griseus Sooty Shearwater [82651]		Species or species habitat may occur within area
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area overfly marine area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area
Chalcites osculans as Chrysococcyx osculans Black-eared Cuckoo [83425]		Species or species habitat likely to occur within area overfly marine area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat likely to occur within area overfly marine area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat likely to occur within area overfly marine area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area overfly marine area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area overfly marine area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Species or species habitat likely to occur within area overfly marine area
Neophema chrysostoma Blue-winged Parrot [726]	Vulnerable	Species or species habitat known to occur within area overfly marine area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area overfly marine area
Rostratula australis as Rostratula benghalensis (sensu lato) Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area overfly marine area
Sterna striata White-fronted Tern [799]		Migration route may occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri platei as Thalassarche sp. nov. Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche chrysostoma		
Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini		
Salvin's Albatross [64463]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche steadi		
White-capped Albatross [64462]	Vulnerable	Species or species habitat likely to occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area overfly marine area
Reptile		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area

Whales and Other Cetaceans		[Resource Information]
Current Scientific Name	Status	Type of Presence
Mammal		
Caperea marginata		
Pygmy Right Whale [39]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat may occur within area

Extra Information

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included. Please see the associated resource information for specific caveats and use limitations associated with RFA boundary information.

RFA Name	State
West Victoria RFA	Victoria

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Basalt Quarry Extension (Mountainview Quarry)	2004/1329	Controlled Action	Completed
Viva Energy Gas Terminal Project	2020/8838	Controlled Action	Assessment Approach
Not controlled action			
Extension of Mountain View basalt quarry by 113 hectares (stage one)	2004/1591	Not Controlled Action	Completed
Geelong Bypass Sections 1 & 2	2005/2097	Not Controlled Action	Completed
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed
INDIGO Central Submarine Telecommunications Cable	2017/8127	Not Controlled Action	Completed
Wastewater Treatment System Upgrade	2004/1420	Not Controlled Action	Completed
Not controlled action (particular manner)			
Gas Pipeline	2006/3093	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
INDIGO Marine Cable Route Survey (INDIGO)	2017/7996	Not Controlled Action (Particular Manner)	Post-Approval
Rail Upgrades at Geelong Port Project	2010/5363	Not Controlled Action (Particular Manner)	Post-Approval

Biologically Important Areas

Scientific Name	Behaviour	Presence
Seabirds		
Ardenna tenuirostris		
Short-tailed Shearwater [82652]	Foraging	Known to occur
Pelagodroma marina		
White-faced Storm-petrel [1016]	Foraging	Known to occur
Pelecanoides urinatrix		
Common Diving-petrel [1018]	Foraging	Known to occur
Thalassarche cauta cauta		
Shy Albatross [82345]	Foraging likely	Likely to occur
Whales		
Eubalaena australis		
Southern Right Whale [40]	Known core range	Known to occur

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

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Appendix B – Lara Farms – Preliminary Retarding Basin Requirements, M.M00441.03.00_RB_Analysis_Optimised

Memorandum

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To: (Loetis)

CC: (Costa Property Group)

From:

Date: 8 March 2024

Re: **LARA FARMS – PRELIMINARY RETARDING BASIN REQUIREMENTS**

Background

Lara Farms Pty Ltd is proposing the rezoning of 76-156 Canterbury Road East (SPI 3C-15B\PP5452), 785-805 Princes Highway (SPI 1\TP156147), 705-765 Princes Highway, Lara (SPI 2\LP98249) and 610 Rennie Street (SPI 1\LP98249) (the Site) for the purposes of residential and industrial/commercial subdivisions. The Site is shown in Figure 1 .The Site is currently Farming Zone.

Under existing conditions rainfall runoff discharges from the Site at two locations shown as the northern and southern outlets on Figure 1. Development of the Site will increase the rainfall runoff from the Site because of the conversion of pervious land to impervious surface resulting in an increase in the peak flow rate. Mitigation of the peak flows back to match existing conditions will be required to ensure no downstream impacts. This can be achieved through the inclusion of retarding basins. Lara Farms Pty Ltd engaged Venant Solutions to determine the volume of the retarding basins and to work with Loetis to establish a concept design for the retarding basins.

This memorandum documents the hydrological modelling undertaken to establish the retarding basin volume requirements.

Site Description

The existing Site is currently zoned for farming and consists of a south and north catchment as shown in Figure 2 that both drain to Hovells Creek as shown on the figure. The southern catchment has an area of 71.5 Ha and the northern catchment has an area of 50.7 Ha giving at total area of 122.2 Ha. The Site itself covers an area of 113 Ha with the additional 9.2 Ha being catchment external to the Site, primarily the rail corridor. As noted above, the catchments outlet from the Site at the locations marked on Figure 2.

It is proposed to rezone for a business park in the southern catchment and residential development on the northern catchment as shown on the drawing in Appendix A. In developed conditions a portion of the residential development within the existing northern catchment will be designed to flow to the southern outlet rather than the northern outlet as detailed in Section 5.1.1 of the Loetis stormwater management plan.

Assessment Methodology

The assessment was undertaken using the industry standard RORB hydrological modelling software (Version 6.45). The assessment was done in accordance the methodologies described in the 2019 *Australia Rainfall & Runoff: A Guide to Flood Estimation in Australia* (ARR2019), 2022 (Version 5.4) *Infrastructure Design Manual*

and Melbourne Water's *Flood Mapping Projects Specification* (July 2020) (MW2020). Models were setup as follows:

- Separate models of the northern and southern existing conditions catchments
- Separate models of the northern and southern developed conditions catchments with retarding basins
    - Because the northern and southern catchment areas are different in the developed case, the structure of the developed case RORB models are different to the existing case models
- To establish an appropriate Kc routing parameter for the RORB model, validation was undertaken using the Rational Method and the ARR2019 Regional Flood Frequency Estimation Model (RFFE)
- The developed case models were updated to include conceptual retarding basins with the basin volume and outlet pipe iterated until the 1% AEP peak flow was no greater than the existing flow at each of the outlets
- The peak volume requirements were provided to Loetis who designed conceptual basins and provided the stage-storage relations back to Venant Solutions
- The RORB models were updated with the provided stage-storage relationships and run to check that outlet developed conditions flows were still no greater than existing condition flows.

For the purposes of developing the retarding basin concept, only the 1% AEP event has been assessed as this will control volume and footprint requirements.

RORB Model Development

Model Sub-catchments and reaches

Figure 3 and Figure 4 show the RORB schematisation for the existing and developed case models respectively. Reaches were digitised to follow the overland flow paths with the slopes derived from the LiDAR data. The following reach types were adopted:

- **Reach Type 1** (natural) – Used for flow paths through undeveloped areas
- **Reach Type 2** (excavated but unlined) – Used for flow paths through the developed areas on the assumption that flows in excess of the pipe capacity would be conveyed along streets or designated overland flow paths.

Design Storm Events

The 1% AEP design storm event was modelled based on the following rainfall parameters using inbuilt Functionality in RORBwin to generate rainfall inputs into the RORB model:

- **Intensity-Frequency-Duration (IFDs)** - Sourced from the Bureau of Meteorology's Design Rainfall Data System (2016) (www.bom.gov.au/water/designRainfalls/revised-ifd/) for the co-ordinates; Latitude -38.044, Longitude 144.406.
- **Temporal Patterns** - As per ARR 2019 for catchments less than 75 km^2 point temporal patterns for the Southern Slopes (mainland) region were used. The temporal patterns were filtered using the in-built functionality in RORBwin.
- **Pre-burst rainfall depths** – The median pre-burst rainfall depths from the ARR 2019 DataHub were used.
- **Storm losses** – The regional initial and continuing loss values of 11 mm and 2 mm/hr from the ARR 2019 DataHub were adopted. The initial loss (IL) was reduced to account for median pre-burst depths with the resulting initial loss values presented in Table 1. The initial losses for intermediate events such as the 4.5 hr and 9 hr events were linearly interpolated.

Table 1 Adopted initial losses

	30 min	45min	1 hr	1.5 hr	2 hr	3 hr	6 hr	12 hr
1% AEP IL (mm)	8.0	8.0	8.6	8.9	8.2	9.2	8.9	10.0

Impervious area

ARR2019 recommends adopting the effective impervious area (EIA) in an urban catchment rather than the total impervious area (TIA) because adopting TIA can result in an overestimate of the runoff. ARR2019 states '*the EIA is generally considered to be representative of the area of the catchment that generates a rapid runoff response in rainfall events. It incorporates the impervious area with a hydraulic connection to the drainage network (DCIA), plus a contribution comprising discharges from an impervious area onto a pervious area (ICIA), which rapidly saturates and acts in a similar manner to an impervious area. The EIA therefore provides a more realistic measure of the impervious area that generates runoff at the catchment outlet*'.

Surfaces are categorised as follows per ARR 2019:

- **Directly Connected Impervious Area (DCIA)** - impervious areas (e.g. roofs and paved areas) which are directly connected to the drainage system
- **Indirectly Connected Area (ICA)**
  - Impervious areas which are not directly connected, runoff from which flows over pervious surfaces before reaching the drainage system such as footpaths, paved patios etc
  - the pervious areas that interact with these impervious areas, such as nature strips, garden areas next to paved patios, etc.
- **Pervious Area (PA)** – Pervious areas such as forests or bushlands from which runoff does not interact with impervious areas.

In the absence of historical local streamflow and rainfall data ARR2019 recommends using an EIA/TIA ratio to back-calculate the EIA where the TIA is known. ARR2019 recommends and EIA/TIA ratio in the range 50% to 70% for residential properties with MW2020 recommending 60% as being suitable for most cases. ARR2019 suggest that it '…*may be appropriate to adopt higher values for EIA/TIA for highly impervious industrial, commercial as well as metropolitan areas (ie total imperviousness greater than 80%)*.' Therefore where the TIA is greater than 80% the EIA/TIA ratio was increased based on an interpolation between 60% and 100%.

For existing conditions the EIA was assumed to be 5%.

For the developed case scenario the TIA was adopted from Appendix 14 of MW2020 and adjusted as described above to get the EIA.

ARR2019 and MW2020 recommend that the full pervious initial loss not be applied to the pervious component of the ICA. It recommends that the initial loss rate be 60% to 80% of the pervious rural loss. For this study 70% was adopted. As RORB only allows a single fraction impervious value per sub-catchment in its excess rainfall calculations the EIA was increased by 30% of the ICA where the ICA = (1 – DCIA). The land use, the assumed TIA, the EIA adopted for RORB are provided in Table 2.

Table 2 Landuse, TIA, DCIA, ICA, PA and Adopted EIA Fractions

Landuse	TIA	DCIA	ICA	PA	Adopted EIA in RORB
Higher Density Residential Zone	0.85	0.595	0.405	0	0.72
Medium Density Residential Zone	0.75	0.45	0.55	0	0.62

Business Park	0.90	0.72	0.28	0	0.80
Roads	1.00	1.0	0.00	0	1.00
Special Uses	0.70	0.42	0.58	0	0.60
Park	0.05	0.00	0.05	0.95	0.015

RORB model parameter validation

The adopted k_c routing parameters were calculated using the default RORB equation following a validation exercise to the RFFE model and the Rational Method for the existing conditions, and the Rational Method only for the developed conditions. The validation exercise was undertaken using the southern catchment. The results from the validation exercise are summarised in Table 3 and further details of the RFFE, Rational Method and RORB model are provided in subsequent sections. The default 'm' routing parameter value of 0.8 was adopted as there was no justification for an alternative value.

K_c values calculated using the RORB default equation and the Victoria data Pearse et al (2002) equation were used to derive 1% AEP flows and compared with the RFFE (existing conditions only) and Rational Method flows. For the developed case the RORB flows are those entering the retarding basin.

The flows using RORB default k_c equation gave similar results to the RFFE and Rational Method peak flows in both the existing and developed case whereas the flows using the Victoria data Pearse et al (2002) k_c equation were substantially higher suggesting it is overestimating flows. Therefore the RORB default k_c was adopted. Based on the outcomes of this validation exercise the RORB default k_c was also applied to the northern catchment.

Table 3 K_c Validation results

Regional equation	K_c	1% AEP flow (m^3/s)
Existing conditions (Southern)		
RFFE	-	1.7
RFFE Update	-	0.8
Rational Method	-	1.3
RORB Default	1.86	2.1
Victoria data Pearse et al (2002)	0.83	4.3
Developed conditions (Southern - without the basin)		
Rational Method	-	12.1
RORB Default	2.66	8.2
Victoria data Pearse (2002)	0.81	20.6

Regional Flood Frequency Estimate Model

The RFFE model gave a 1% peak flow estimate of 1.7 m^3/s for the southern undeveloped catchment using the currently published version of the model on the ARR2019 website. An updated version of the model has been

developed and is available on the WMA website[1] but is yet to be published on the ARR2019 website. The peak 1% AEP flow from the updated model is 0.8 m^3/s.

The following input parameters were used:

- Latitude at catchment outlet = -38.0446
- Longitude at catchment outlet = 144.4048
- Latitude at catchment centroid = -38.0428
- Longitude at catchment centroid = 144.4015
- Catchment area = 0.71 km^2

It is noted that the catchment area is near the recommended lower bound of 0.5 km^2 for use of the RFFE and its applicability is limited because the catchment is significantly affected by agricultural activities.

Rational Method

The Rational Method gave a peak 1% AEP flow estimate for the southern undeveloped catchment of 1.3 m^3/s using the following input parameters:

- C = 0.14 (adopted from Table 3 in CoGG document *Stormwater Detention Storage Design Notes - 2023*
- Time of concentration of 45 minutes
- I (mm/hr) = 4
- A (hectares) = 71.1

The nature of the catchment made it difficult to apply overland flow and gully calculations available in various publications for calculating travel time and hence the time of concentration. Therefore a TUFLOW model of the existing catchment was established with an upstream flow boundary applied to estimate the travel time from the upper catchment to the outlet.

The Rational Method gave a peak 1% AEP flow estimate for the southern developed catchment of 7.7 m^3/s using the following input parameters:

- C = 0.84 (adopted from Table 3 in CoGG document *Stormwater Detention Storage Design Notes - 2023*
- Time of concentration of 41 minutes
- I (mm/hr) = 35.2
- A (hectares) = 71.1

The TUFLOW model was also used in the to assess the travel for the developed case but with the Manning's 'n' reduced from 0.045 to 0.025 lower resistance flow paths. This was cross-checked with a more traditional approach of using street flow nomographs from the upper catchment which gave a travel time of 48 minutes. Therefore the 41 minutes was adopted giving the higher flow.

Retarding Basin

The stage-storage relationship for the proposed northern and southern basins and the pipe outlet are provided in Appendix B. The stage-storage relationship was provided by Loetis and the pipe size iterated in RORB to mitigate developed case peak flows back to be no more than the existing conditions outflow at each outlet.

[1] https://rffe-2021.wmawater.com.au/

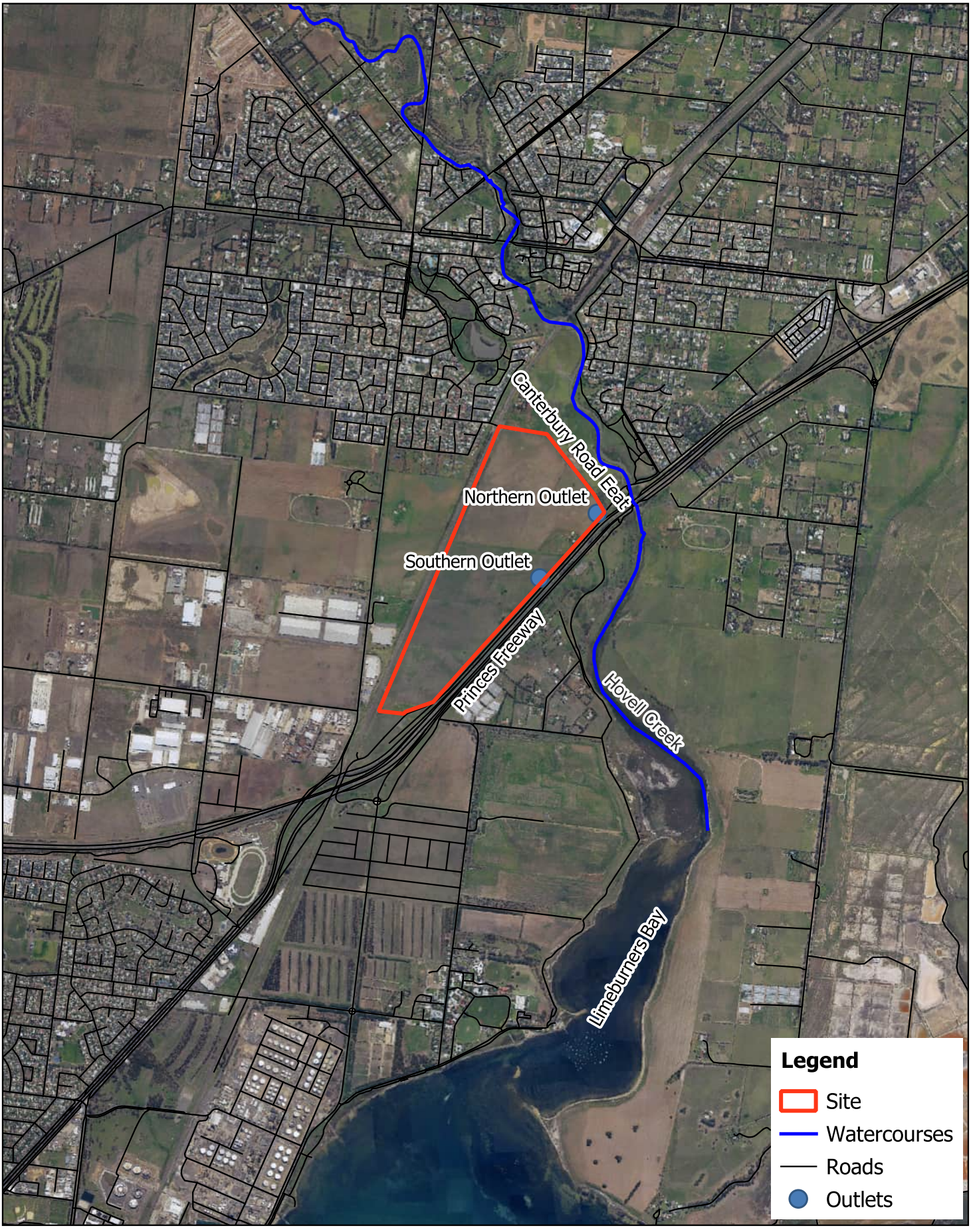
Design Event Flows

The ensemble event method was used to model the 1% AEP events. The resulting peak flows at the catchment outlet based on the average of the 10 temporal patterns is presented in Table 4 for existing conditions and inflows and outflows from the retarding basins; the inflow to the basin in the developed case is effect the unmitigated flow. Also included in the table are peak levels and volumes in the basins and the critical storm durations.

At both outlet locations the developed case flows are lower than the existing; 1.0 m^3/s compared with 1.6 m^3/s at the northern basin and 2.0 m^3/s compared with 2.1 m^3/s at the southern basin. In the northern basin there is only a small difference in peak flow between the existing and developed case inflow to the basin because of the diversion of flow to the southern basin in the developed case, i.e. the catchment area draining to the basin is much smaller in the developed case. Conversely there is a significant increase at the southern basin inflow for the same reason.

Table 4 1% AEP event peak flows

	Existing Conditions (Northern Outlet)	Developed Conditions (Northern-Basin Inflow)	Developed Conditions (Northern-Basin Outflow)	Existing Conditions (Southern Outlet)	Developed Conditions (Southern – Basin Inflow)	Developed Conditions (Southern – Basin Outflow)
1% AEP Peak Flow (m^3/s)	**1.6**	1.9	**1.0**	**2.1**	8.2	**2.0**
Peak Water Level in Basin (m)			0.62			1.61
Peak Volume in Basin (m^3)			2650			47100
Critical Event Duration (h)	2.0	0.5	1.5	2.0	1.5	12



Title:

Lara Lakes Development Limeburners Bay Impact Assessment
Site Locality

Figure:	Rev:			
1	A	0 0.5 1 km	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: TL Date: Feb 2024

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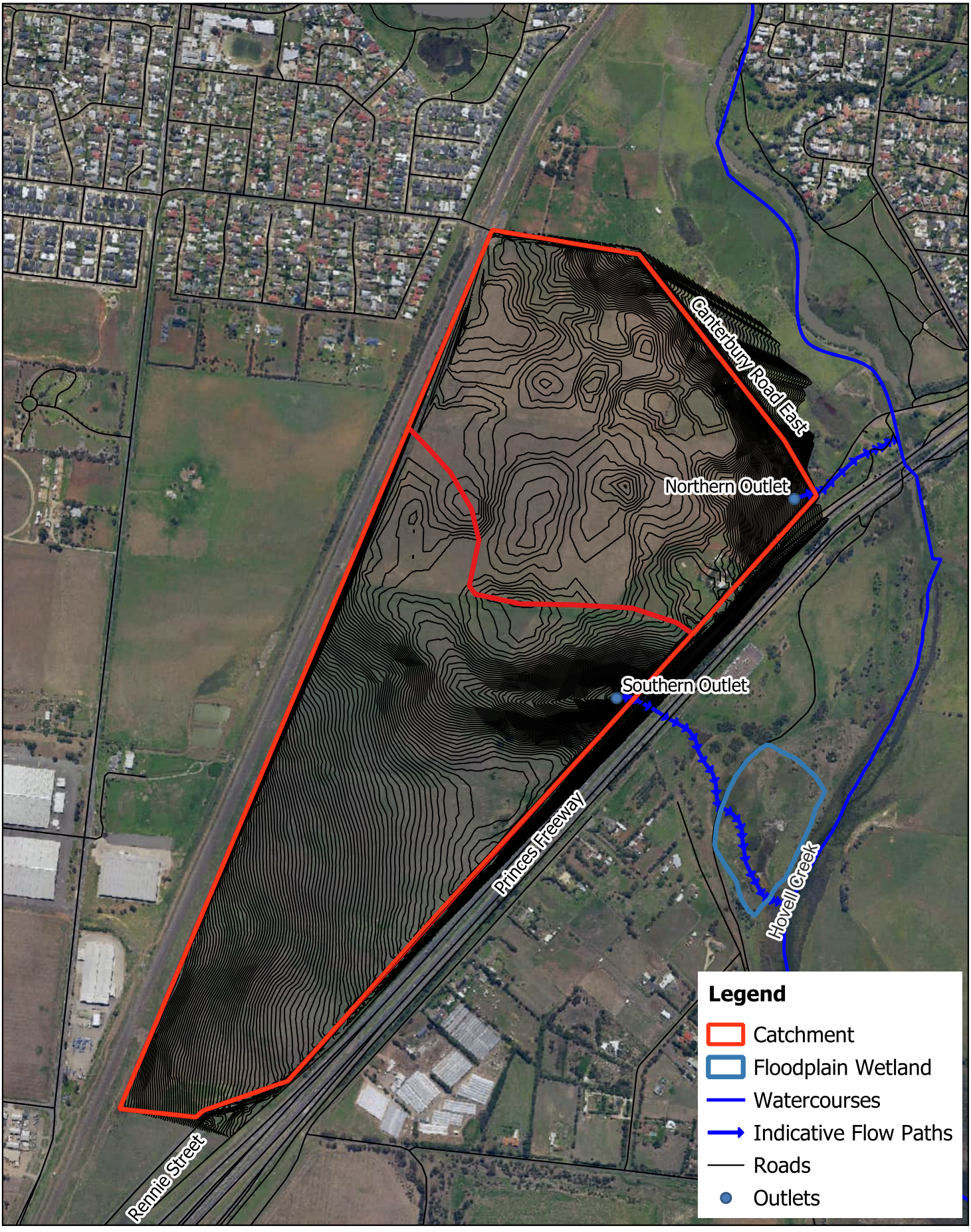
Filename: S:\Projects\M00441.MJ.LaraFarms\GIS\Drawings\M.M00441.003.00\Fig1_Site_Locality.qgz



Title:

Lara Lakes Development Limeburners Bay Impact Assessment
Existing Site Catchment and Contours

Figure:	Rev:	0 200 400 m	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: TL
2	A			Date: Feb 2024

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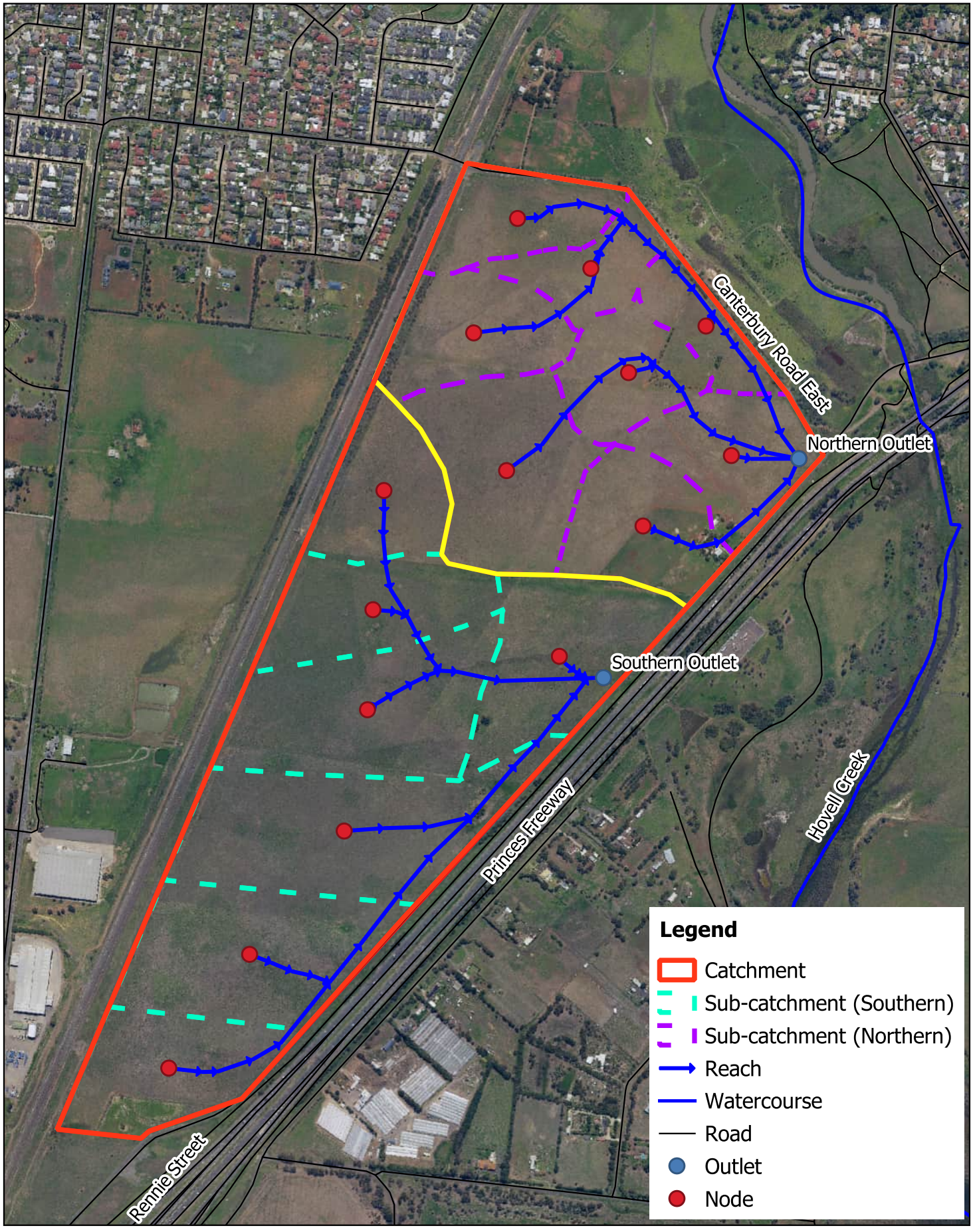

Title:

Lara Lakes Development Limeburners Bay Impact Assessment
Existing Conditions RORB Schematisation

Figure:	Rev:			
3	A	0 200 400 m	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: TL Date: Feb 2024

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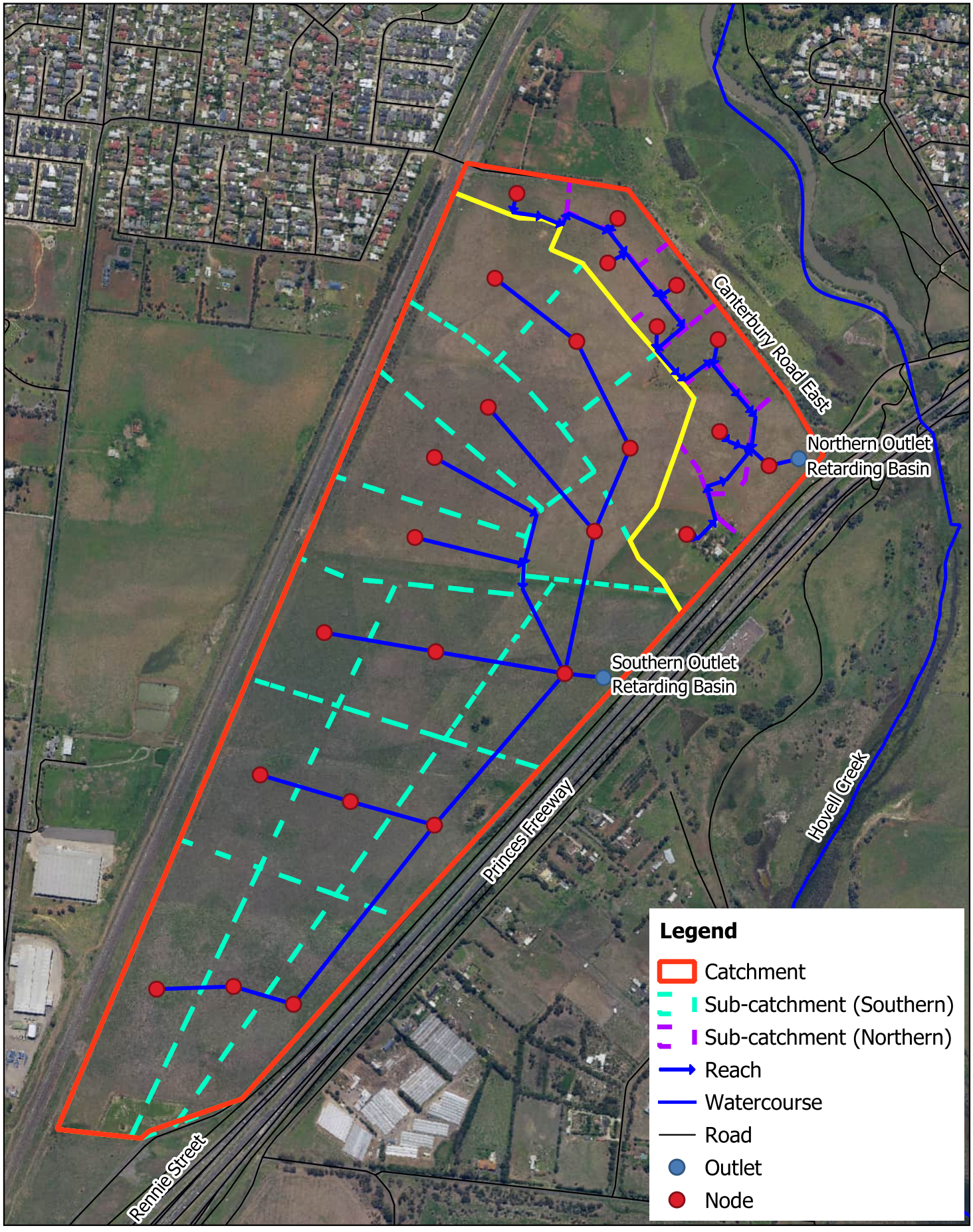

Title:

Lara Lakes Development Limeburners Bay Impact Assessment
Developed Conditions RORB Schematisation

Figure:	Rev:	0 200 400 m	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	By: TL
4	A			Date: Feb 2024

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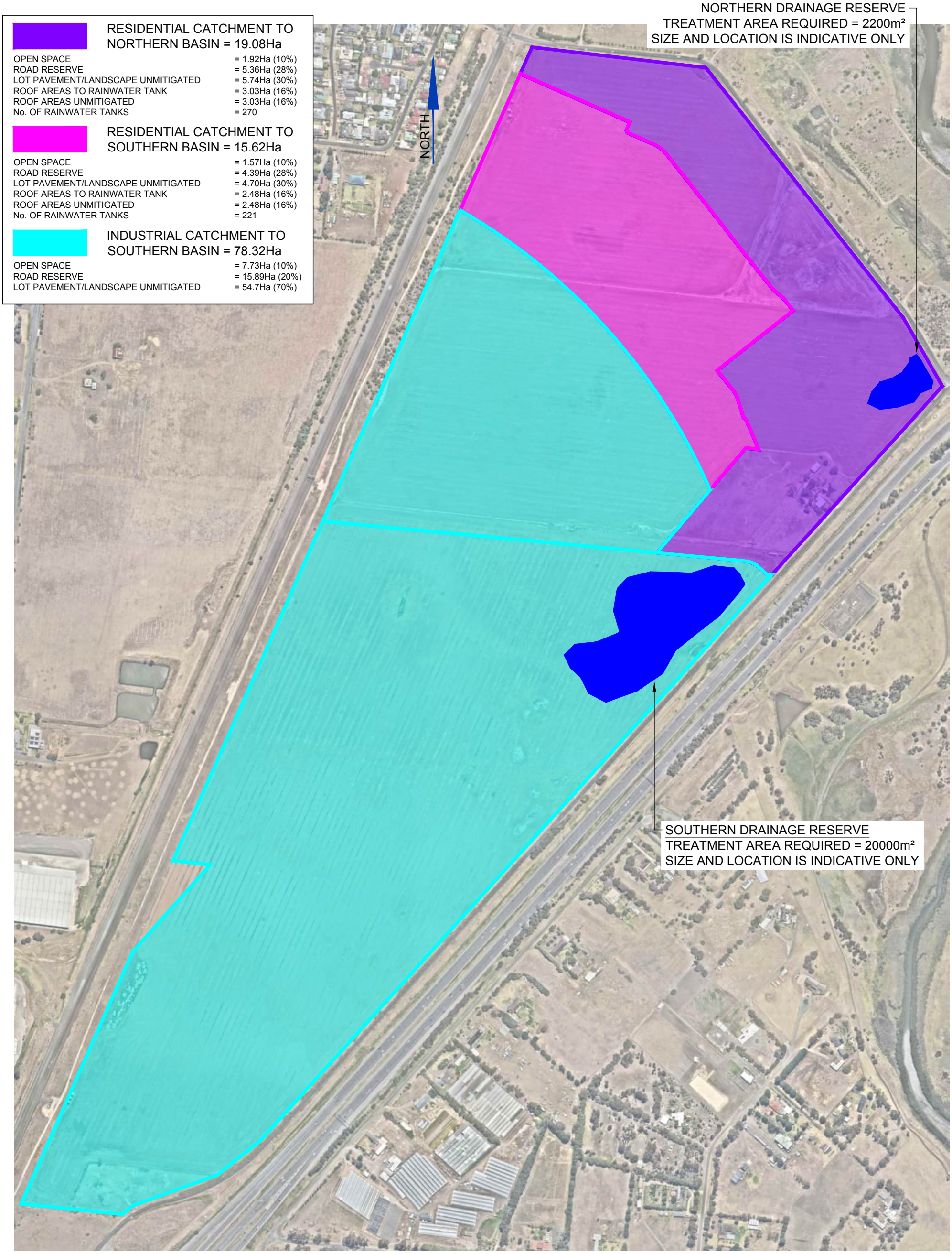
Filename: S:\Projects\M00441.MJ.LaraFarms\GIS\Drawings\M.M00441.003.00\Fig4_Developed_Conditions_RORB_Schematisation.qgz

APPENDIX A



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JAS-ANZ ACCREDITED: QUALITY ISO 9001 - OH&S AS/NZS 4801 - ENVIRONMENT ISO14001

PRELIMINARY DRAWING
NOT TO BE USED FOR CONSTRUCTION

516 CANTERBURY RD LARA
MUSIC CATCHMENT PLAN

N.T.S.
November 2024
Rev. 01

C:\USERS\KEENANBOON\LOETIS PTY LTD\PROJECTS - DOCS\2. JOBS\J10001 - LARA FARMS\3. ENGINEERING\3. DRAFTING\6. ADDITIONAL DRAWINGS\MUSIC CATCHMENT PLAN R01.DWG

Appendix B

Table B-1 Details of retarding basin

Height (m AHD)	Delta Height (m)	Vol to Height (m^3)	Delta Vol (m^3)
Retarding Basin (Northern)			
7.1		4179.808	
	0.1		563.904
7.0		3615.903	
	0.1		538.097
6.9		3077.807	
	0.1		512.690
6.8		2565.116	
	0.1		487.686
6.7		2077.430	
	0.1		463.084
6.6		1614.346	
	0.1		438.883
6.5		1175.463	
	0.1		415.084
6.4		760.379	
	0.1		391.687
6.3		368.692	
	0.1		368.692
6.2		0.000	
	0.1		0.000
6.2		0.000	
Retarding Basin (Southern)			
9.5		57007.288	
	0.1		3531.536
9.4		53475.752	
	0.1		3470.241
9.3		50005.511	
	0.1		3409.348
9.2		46596.164	
	0.1		3348.857
9.1		43247.307	
	0.1		3288.768
9.0		39958.539	
	0.1		3229.081

Height (m AHD)	Delta Height (m)	Vol to Height (m^3)	Delta Vol (m^3)
8.9		36729.459	
	0.1		3169.796
8.8		33559.663	
	0.1		3110.913
8.7		30448.750	
	0.1		3052.432
8.6		27396.318	
	0.1		2994.353
8.5		24401.965	
	0.1		2936.676
8.4		21465.289	
	0.1		2879.401
8.3		18585.888	
	0.1		2822.529
8.2		15763.359	
	0.1		2766.058
8.1		12997.301	
	0.1		2709.989
8.0		10287.312	
	0.1		2654.323
7.9		7632.989	
	0.1		2599.058
7.8		5033.931	
	0.1		2544.196
7.7		2489.735	
	0.1		2489.735
7.6		0.000	
	0.0		0.000
7.6		0.000	

Table B-2 Details of pipes

	Pipes (Northern Basin)	Pipes (Southern Basin)
Type	Circular - 450 mm diameter	Circular - 600 mm diameter
Number	4	2

Appendix C – Lara Farms – Flood Impact Report L.M00441.01.00_FIA

Venant Solutions Pty Ltd

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Our Ref: L.M00441.01.00_FIA.docx

14 June 2024

Lara Farms Pty Ltd
Level 1, 2-6 Myers Street
Geelong VIC 3220

Attention:

Dear

RE: LARA FARMS – FLOOD IMPACT REPORT

Lara Farms Pty Ltd is proposing the rezoning of 76-156 Canterbury Road East (SPI 3C-15B\PP5452), 785-805 Princes Highway (SPI 1\TP156147), 705-765 Princes Highway, Lara (SPI 2\LP98249) and 610 Rennie Street (SPI 1\LP98249) (the Site) for the purposes of residential and industrial/commercial subdivisions. The Site is shown in Figure 1.

The City of Greater Geelong (CoGG) Design Notes require a flood impact report for all rezoning applications within or adjacent to any known or likely flood-prone areas. The flood impact assessment report considers riverine flooding and is separate from a drainage feasibility report (stormwater management strategy), also required by the Design Notes, which considers local catchment runoff. This letter documents the flood impact assessment for the Site.

The Site is adjacent to Hovells Creek. The following flood mapping was sourced:

1. Figure 2 shows the planning scheme flood overlays[1]:
    a. There is a Flood Overlay (FO) covering Hovells Creek and the floodplain adjacent to the Site, but it does not extend into the Site.
2. Figure 3 shows the Corangamite Catchment Management Authority's 1% AEP (annual exceedance probability) flood extent[2] which is based on the CoGG 2020 Lara Flood Study:
    a. The flood extent does not encroach onto the Site.
    b. The flood extent is closest to the Site in the southeast corner at the intersection of Rennie Street and Canterbury Road East.
    c. At this location the 1% AEP flood level is 4.8 m AHD. The minimum ground level in the southeast corner from site feature survey is 5.8 m AHD, which is 1 m above the flood level.
3. Figure 4 shows an excerpt from the CoGG 1% AEP flood mapping from the 2020 Lara Flood Study[3] available on the CoGG website:
    a. The green shading shows the known flood extent prior to the 2020 study update and the blue shading shows additional land liable to flooding identified by the 2020 study.
    b. The inundation shown on the Site is from the local catchment runoff, i.e., it is not riverine flooding from Hovells Creek but is from rainfall falling on the Site. This is evident because the

[1] https://mapshare.vic.gov.au/vicplan/
[2] https://digitaltwin.vic.gov.au/public/
[3] https://www.geelongaustralia.com.au/stormwater/article/item/8d93690ab320663.aspx

CCMA flood extent (Figure 3) is from the same dataset used by the CoGG in Figure 4 but the CCMA has removed all local catchment flooding to show only riverine flooding.

c. Other than a portion of the rail corridor there are no external catchment draining through the Site. The management of the local catchment runoff is addressed separately in the Stormwater Management Study prepared by Loetis.

Therefore, it is concluded that the Site is unaffected by riverine flooding and hence changes to ground elevations (cut/fill) will not cause flood impacts. The development of the Site will increase runoff in a local catchment event and management of this is documented in the Stormwater Management Study prepared by Loetis.

Director

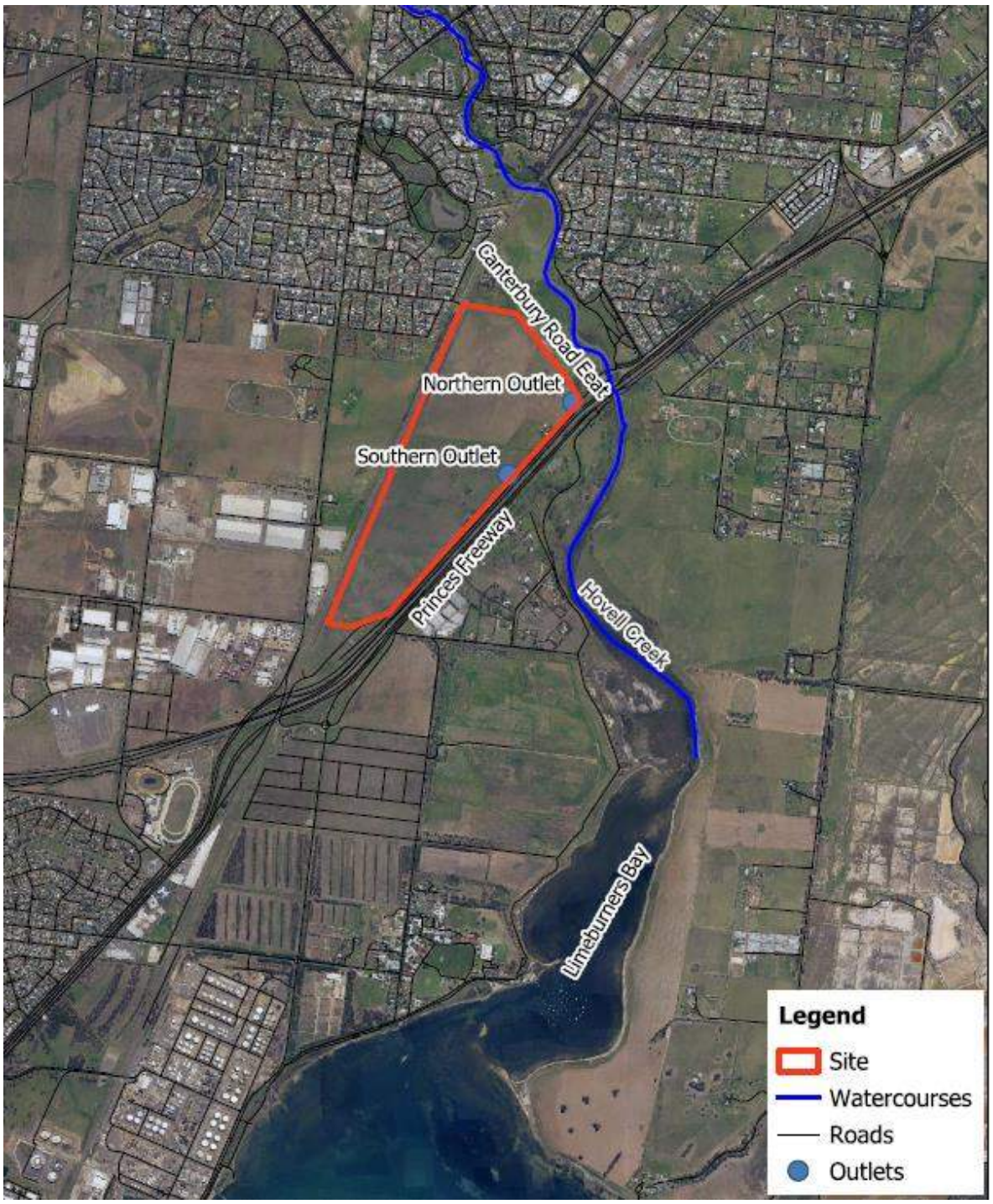

Figure 1 Site Locality

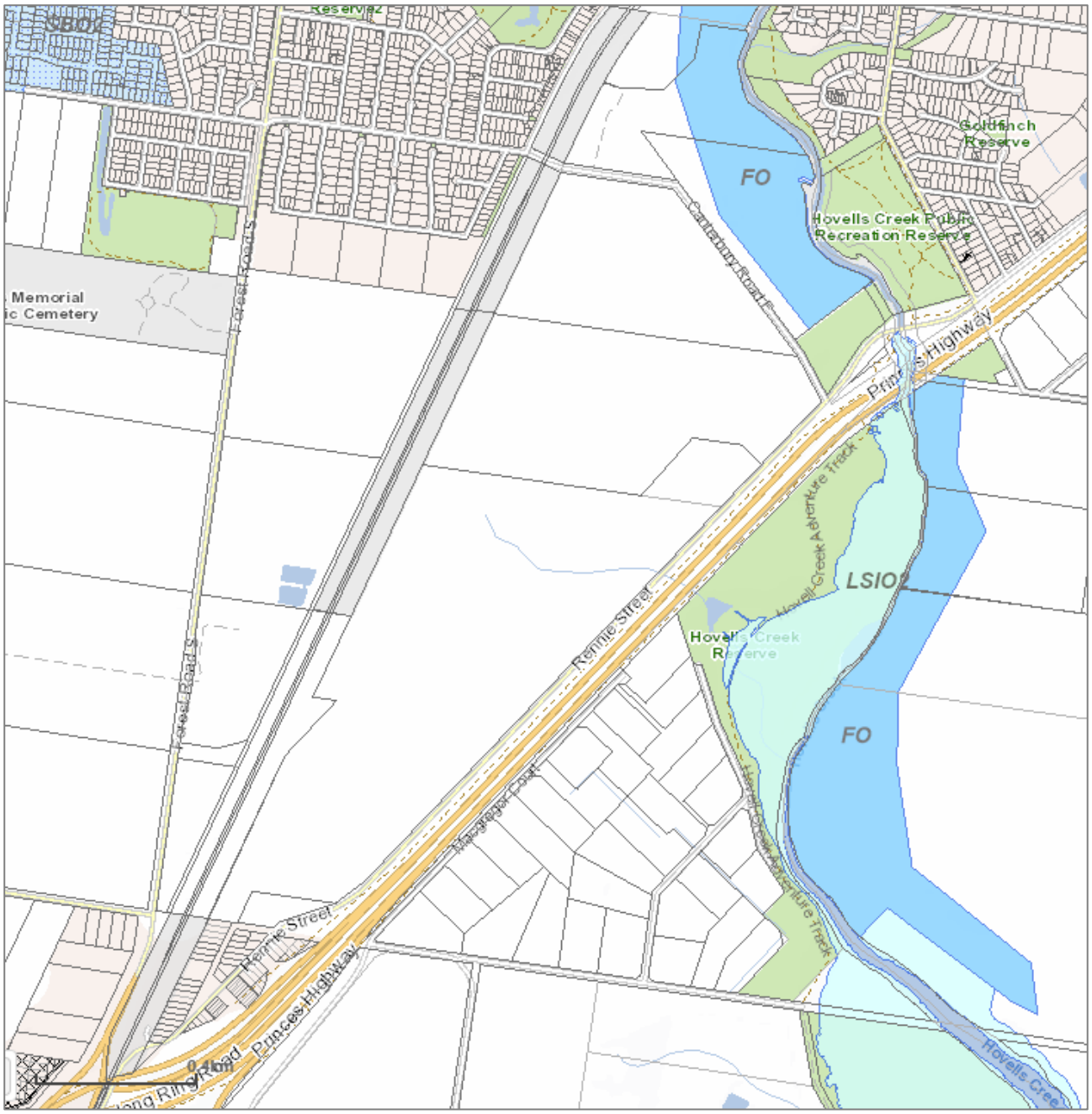

Figure 2 Flood related planning scheme overlays

Figure 3 CCMA 1% AEP Regional (Riverine) Flood Extent

Figure 4 1% AEP Flood mapping from CoGG Lara Flood Study (2020)