

Peak flood velocity in the 1% AEP event is generally less than 0.3 m/s across the township. Locations which experience higher velocities are consistent with those in the 20% AEP event. At the intersection of McCallum Street, and on the nearby McCrae Street, velocities exceed 1.5 m/s. This is presented in **Figure 5-35**.



Figure 5-35 Peak Velocity on McCallum and McCrae Street in the 1% AEP Event

Flow velocity in the town centre is relatively high compared to the remaining areas of Swan Hill. Several flow paths at the intersections of McCallum and Beveridge Street, and McCrae and Beveridge Street, reach velocities exceeding 1 m/s. Flow paths on Campbell and Rutherford Street also exceed 1 m/s at several locations. Peak velocities along these flow paths are presented in **Figure 5-36**.

As with the 20% AEP, peak velocities in the 1% AEP are high on at the intersection of Gray Street and Coronation Avenue, which is attributed to the overland flow path that forms at this location. Peak velocity at this location in the 1% AEP is presented in **Figure 5-37**.



Figure 5-36 Peak Velocity in the Vicinity of the Swan Hill Town Centre in the 1% AEP Event



Figure 5-37 Peak Velocity on the Overland Flow Path on Gray Street and Coronation Avenue in the 1% AEP Event

Peak modelled flood depths and velocities on prominent roads within Swan Hill are summarised in **Table 5-2**. Note that peak depth and peak velocity on each road may not occur at the same location. Refer to mapping of results in **Appendix B**.

Table 5-2 Summary of Peak Depths and Velocities on Prominent Swan Hill Roads for the 20% and 1% AEP Events

Road Name	20% AEP Event		1% AEP Event	
	Peak Depth (m)	Peak Velocity (m/s):	Peak Depth (m)	Peak Velocity (m/s):
Williams Road	Dry	Dry	0.72	0.47
Chapman Street	0.40	0.31	0.65	0.59
Murlong Street	0.05	0.13	0.66	0.54
Thurla Street	0.15	0.36	0.52	0.64
Curlewis Street	0.31	0.62	0.44	0.89
Pye Street	0.26	0.44	0.52	0.86
McCallum Street	0.32	1.12	0.53	1.62
Beveridge Street	0.32	0.67	0.55	1.05
Campbell Street	0.30	1.00	0.41	1.31
McCrae Street	0.32	0.81	0.40	1.29
Rutherford Street	0.16	0.63	0.45	1.24
Gray Street	0.28	0.90	0.53	1.58
Yana Street	0.14	0.25	0.43	0.69
Coronation Avenue	0.17	1.02	0.34	1.73
Wattie Street	0.25	0.57	0.46	0.88

6 SENSITIVITY TESTING

The primary focus of this study is to define flood behaviour in Swan Hill and Robinvale due to local rainfall, not riverine flooding from the Murray River. As such, the design events have been investigated assuming the Murray River is sufficiently low to allow all pipe outlets to drain freely, and was modelled with a static level of 48 mAHD at Robinvale and 64.5 mAHD at Swan Hill. These levels correspond to a 6.16 m Robinvale gauge depth and 4.82 m Swan Hill gauge depth respectively, and are equivalent to a “SES Minor Flood” at each township as per the *Robinvale Local Flood Guide* (SES, 2019) and *Municipal Flood Emergency Plan - Swan Hill Rural City* (SES, 2018).

However, the performance of stormwater pipes that discharge to the Murray River can be affected by elevated river levels, which can result in prolonged ponding of water inside the towns. To better understand the potential effect of elevated tailwater on local drainage, sensitivity testing was undertaken for both the Robinvale and Swan Hill hydraulic models. The primary purpose of this sensitivity testing was to quantify impacts of coincident major flooding of the Murray River with minor local catchment flooding of the two townships. For both towns, the 20% AEP local catchment rainfall has been modelled with a static tailwater level consistent with the Major Flood level per the *Robinvale Local Flood Guide* (SES, 2019) and *Municipal Flood Emergency Plan - Swan Hill Rural City* (SES, 2018).

Note: The results of the sensitivity analysis relate to the increased depths and extent of ponding in Swan Hill and Robinvale. Duration of inundation has not been investigated as it is highly dependent on the duration of elevated river levels, which can take several weeks to fall depending on the flood event, and is not practical to model within the scope of this study.

6.1 EFFECTS OF COINCIDENT FLOODING IN ROBINVALE

The Robinvale hydraulic model was used to simulate coincident flooding of the Murray River and local catchment flooding within the township. Model inflows for this scenario included 20% AEP design rainfall hyetographs for Robinvale, with high river level “SES major flood levels” applied for the river outfall tailwater conditions as detailed in **Section 3.1.3**. Peak water surface levels were compared to the low river level scenario results to quantify impacts to flood levels.

In the northern area of Robinvale, peak water levels rose by 40 – 90 mm on Latje Road and Robin Street. Flood extent increased marginally near the sag in the road on Robin Street. Water level afflux (change in water level) at these locations are presented in **Figure 6-1**.

To the east, peak flood levels on Latje Road increased by approximately 100 mm, with minor increases in flood level to the west of the levee on Lawrence Road and adjacent land holdings. Flood levels in other areas of the township remain largely unchanged, with no fundamental change in flood behaviour during a coincident flooding event in Robinvale. Water level afflux in the vicinity of Lawrence Road is presented in **Figure 6-2**.

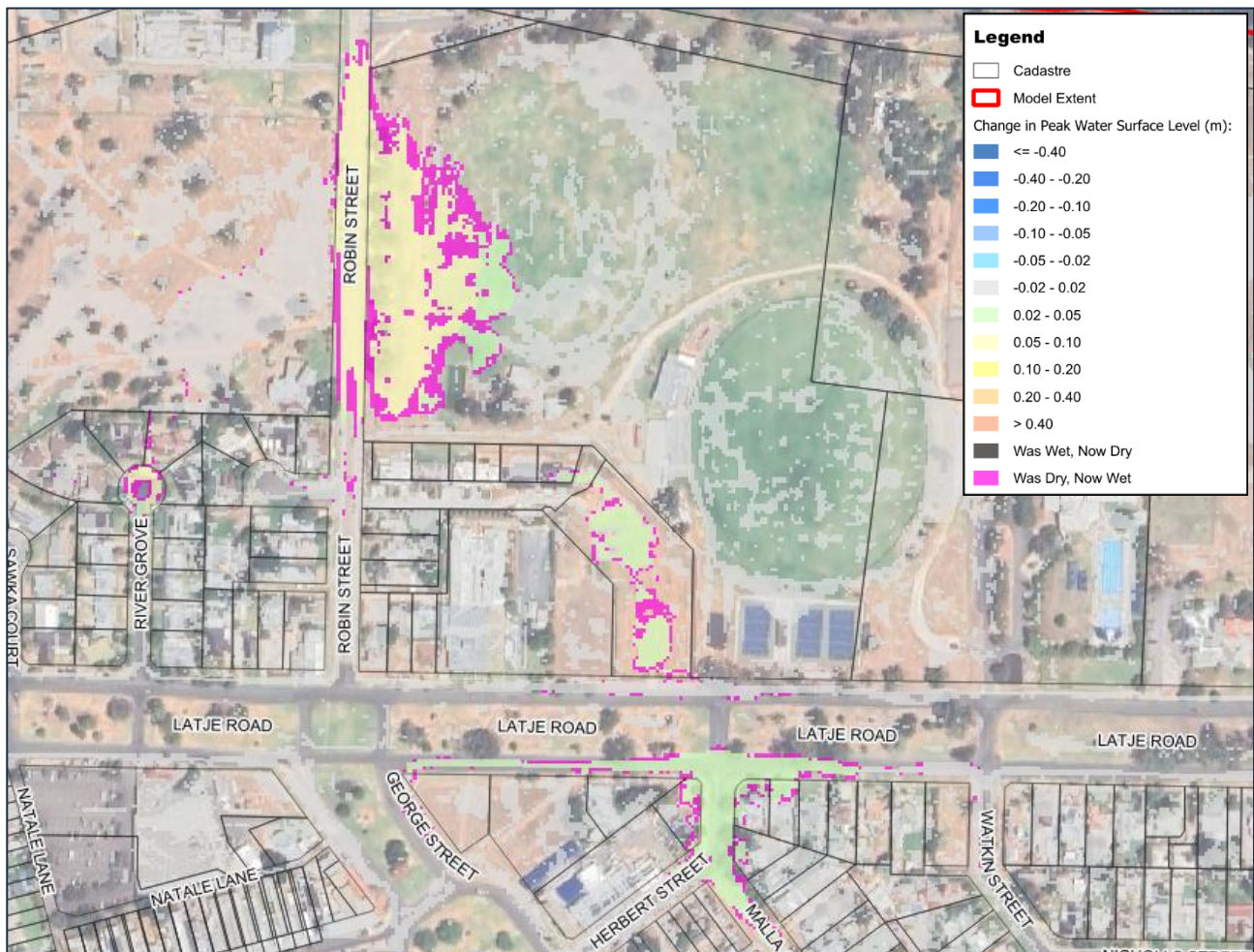


Figure 6-1 Water Level Afflux (Effect of Coincident Flooding on Robinvale Drainage) on Robin Street and Latje Road

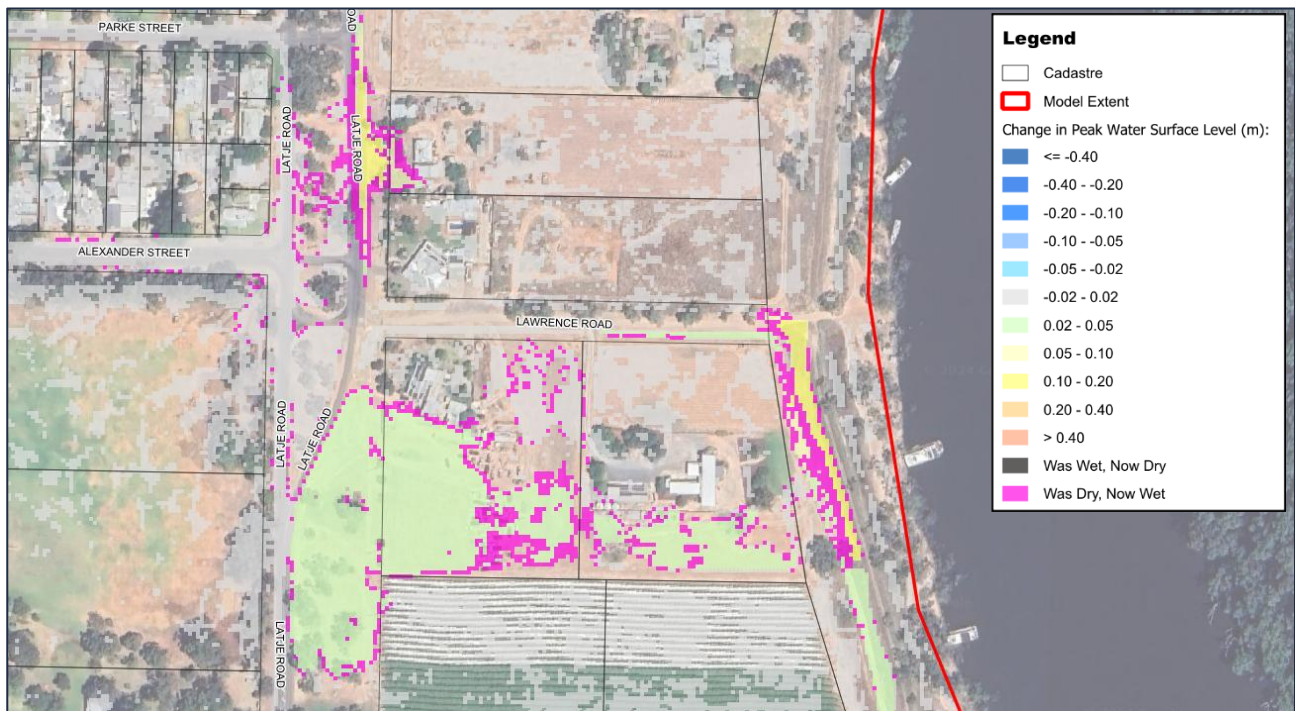


Figure 6-2 Water Level Afflux (Effect of Coincident Flooding on Robinvale Drainage) in the Vicinity of Lawrence Road

6.2 EFFECTS OF COINCIDENT FLOODING ON SWAN HILL

The Swan Hill hydraulic model was tested with a 1% AEP Murray River flood level as a tailwater condition. This equated to a river height of 67.74 mAHD and gauge depth of 4.82 m (SES,2018). The tailwater condition was coupled with a 20% AEP design rainfall hyetograph inflow to simulate effects of a minor local catchment flood event coinciding with a major Murray River flood event. Tailwater levels set for this simulation are detailed in **Section 3.2.4**. Peak water surface levels for the coincident flooding scenario were compared against the low river level scenario to understand model sensitivity to the Murray River tailwater conditions.

The most significant changes to flood levels were observed adjacent to the town levee in the vicinity of Milloo and Naretha Street. Backwater flooding through stormwater pipe outlets to the river resulted in up to 600 mm of increased flood levels, and a large increase in flood extent. This reduced stormwater network performance on Chapman Street, resulting in 100 – 200 mm in afflux with the road reserve. Pye and Beveridge Street also saw minor flood level increases compared to the low river height scenario. Water level afflux (change in flood level from the low river height scenario) at these locations is presented in **Figure 6-4**.

Flood levels in El Alamein Avenue and Tobruk Street indicate sensitivity to Murray River flood levels, with up to 650 mm of afflux at these locations. Further south in the vicinity of Wattie Street and Nalder Drive, isolated low points of the roadways in the area experience afflux due to reduced stormwater network performance. Water level afflux at these locations is presented in **Figure 6-5** and **Figure 6-6** respectively.

Generally, 20% AEP flood levels across Swan Hill underwent minimal change with application of a high Murray River tailwater condition. Refer to **Figure 6-3** for an overview of water level surface difference across the township. The locations in which significant afflux was observed have stormwater pipes discharging directly to the Murray River, making them susceptible to backwater flooding and reduced network capacity. This highlights the need for stormwater mitigation options which are not dependent on tailwater levels to achieve adequate performance.

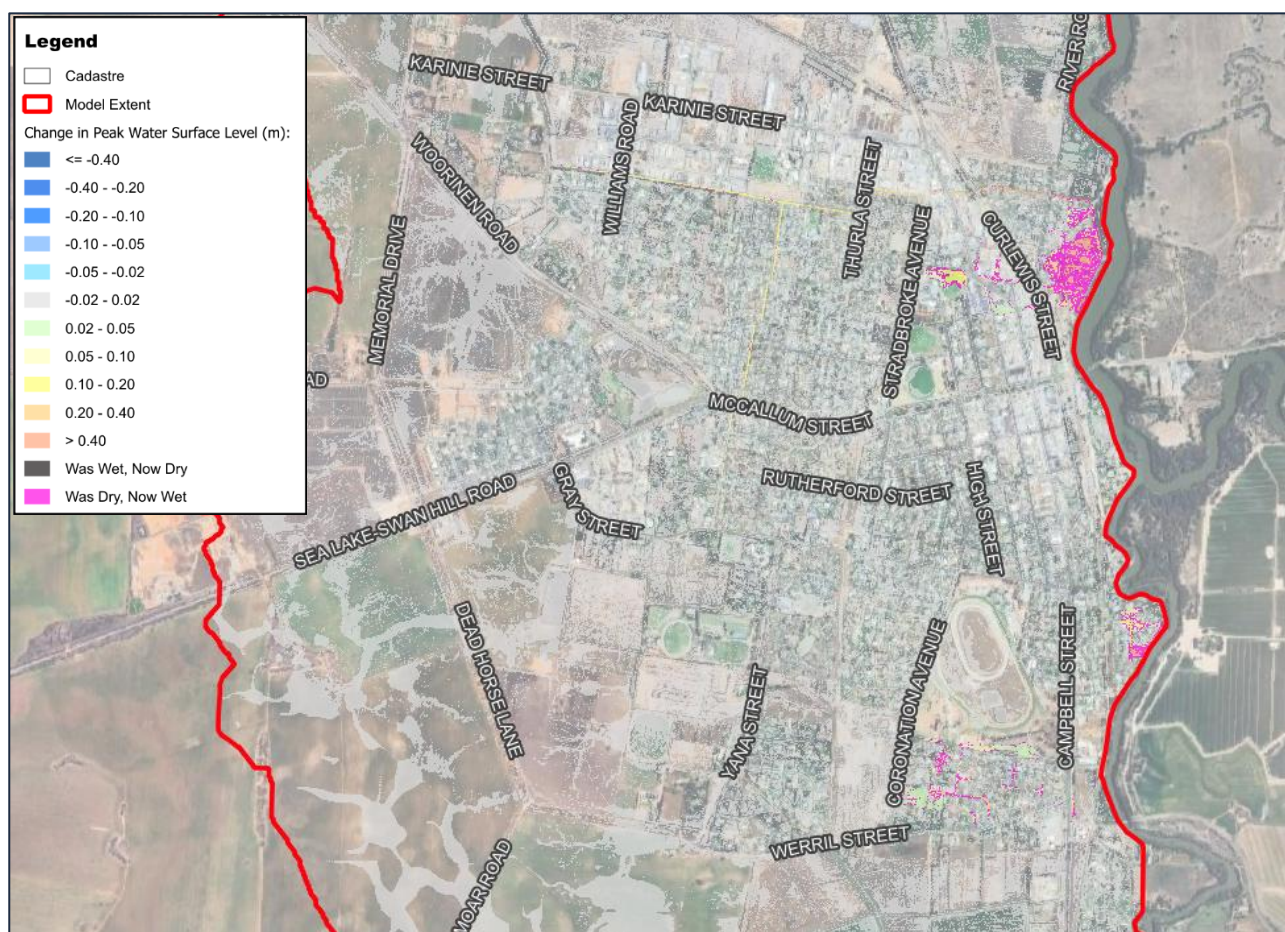


Figure 6-3 Water Level Afflux (Effect of Coincident Flooding on Swan Hill Drainage) Across Swan Hill Township

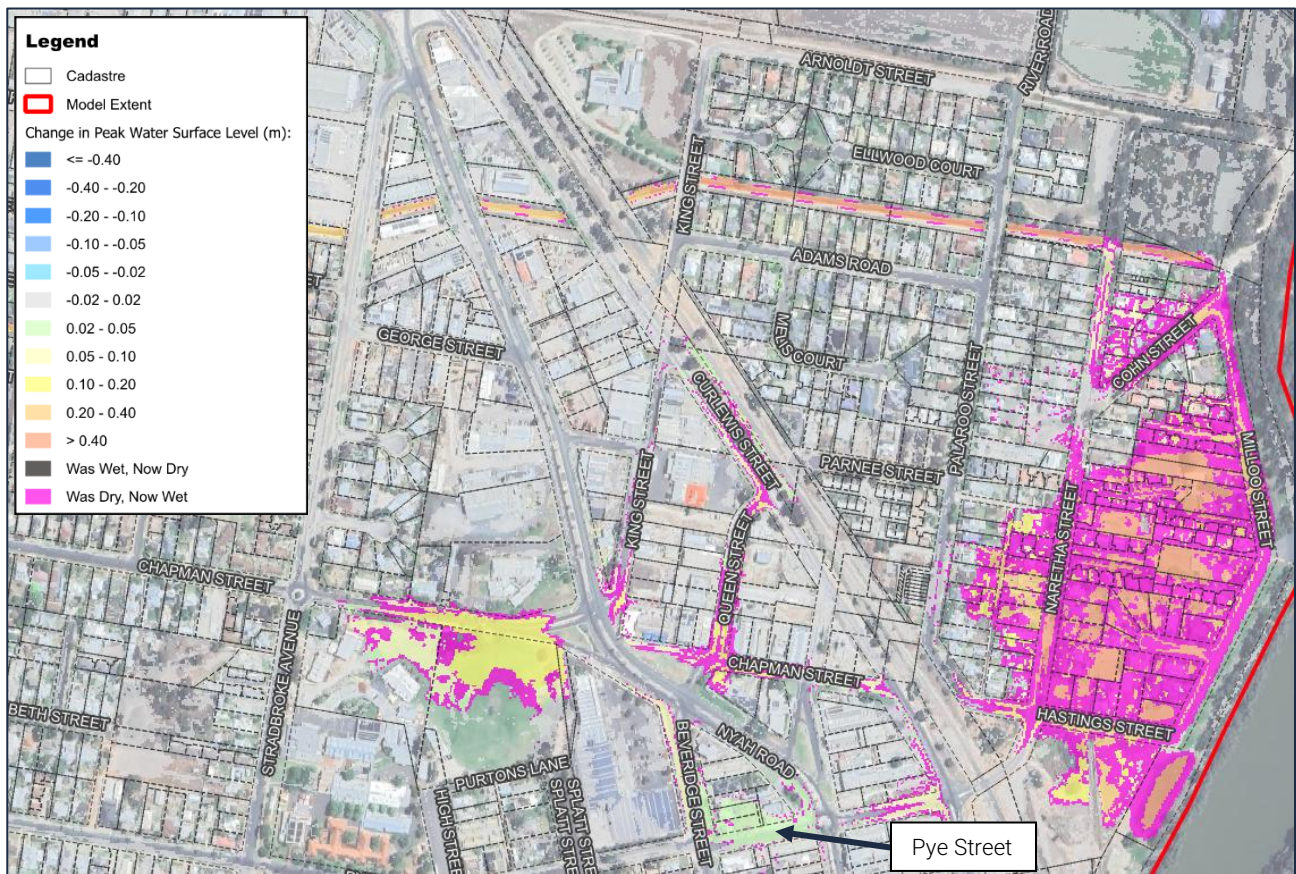


Figure 6-4 Water Level Afflux (Effect of Coincident Flooding on Swan Hill Drainage) in the Vicinity of Millloo Street

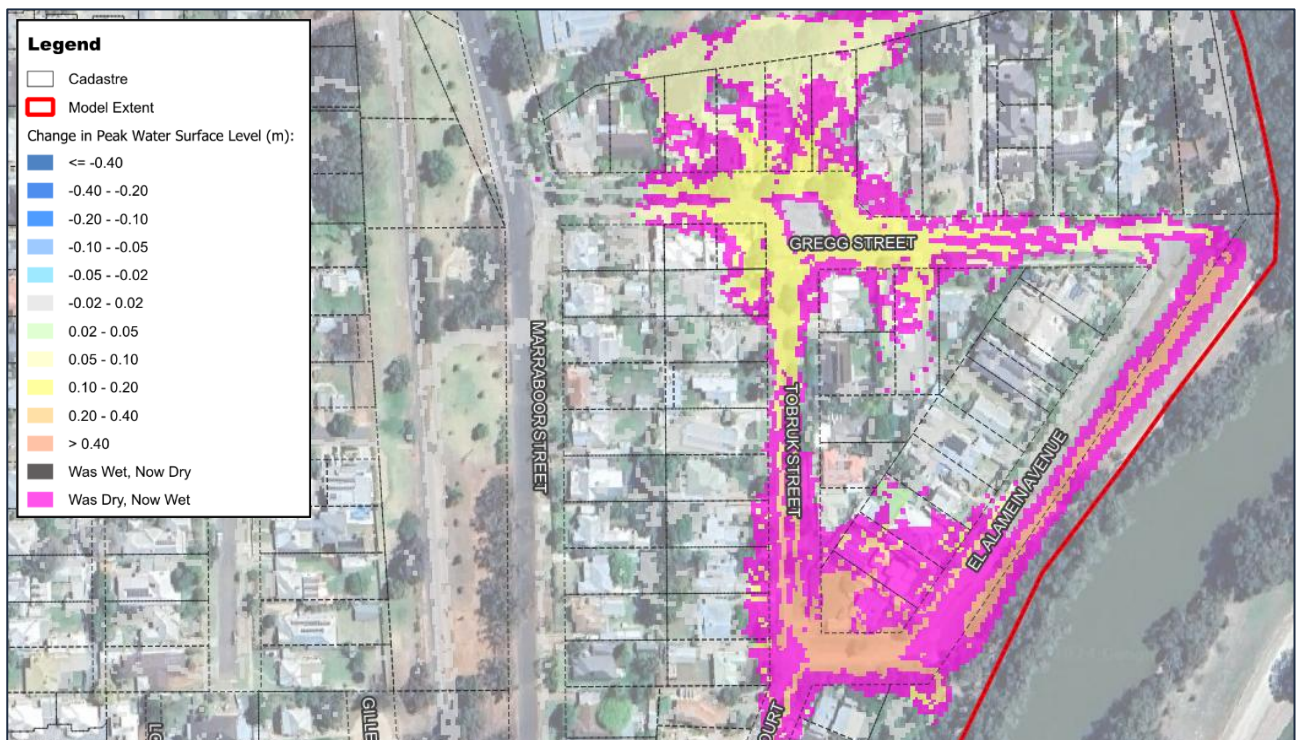


Figure 6-5 Water Level Afflux (Effect of Coincident Flooding on Swan Hill Drainage) on El Alamein Avenue

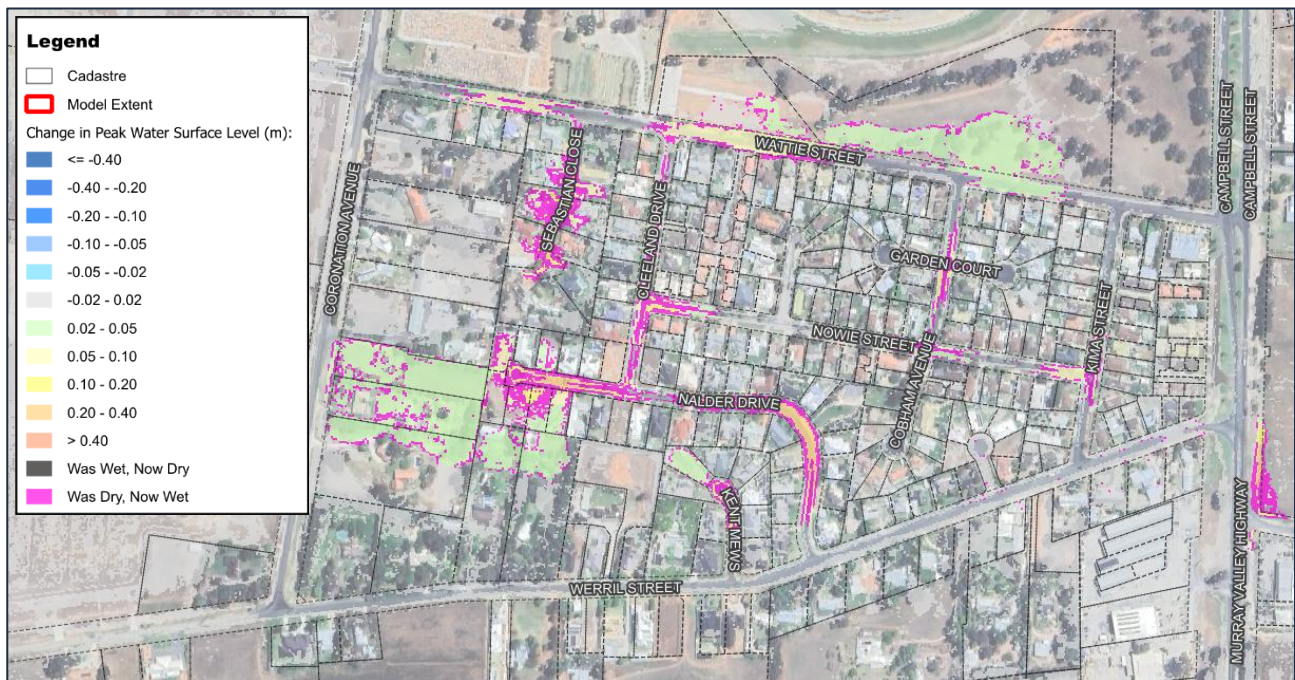


Figure 6-6 Water Level Afflux (Effect of Coincident Flooding on Swan Hill Drainage) in the Vicinity of Wattie Street and Nalder Drive

7 COMMUNITY CONSULTATION

7.1 OBJECTIVES

Community Consultation was an important component of the Drainage Strategy and Software Model – Swan Hill and Robinvale. The key purpose of the consultation was to gather information from residents and stakeholders about specific drainage issues, and gather suggestions for mitigation options to be investigated in the study.

The objectives of the community engagement included:

- Inform the community about the study;
- Identify community concerns about specific drainage issues;
- Gather information from the community by participation;
- Record input from the community on potential future management options.

7.2 STAKEHOLDER ENGAGEMENT

On the 7th August 2024, WMS facilitated three discussion sessions for key stakeholders with an interest in the project. These included:

- Council officers (including Planning, Engineering and Development);
- Stakeholder Agencies (Lower Murray Water and Mallee CMA); and
- Local consultants, engineers and developers

Key discussion points are noted below.

7.2.1 Session 1: Council Officers

7.2.1.1 *Swan Hill*

- Current Issues:
 - Drainage system has an estimated capacity of 1 in 1 to 1 in 2 year ARI;
 - Swan Hill has very flat gradients;
 - Mosquitoes are an issue in standing water inside drains more so than wetlands due to protection from elements and predators;
 - General preference amongst the group for water to get away rather than ponding for extended periods;
 - At present, developers do not make financial contributions, making pipe upgrade costs challenging for Council;
 - Some appetite for wetlands for environmental/recreational value, however with low gradient topography in Swan Hill it is difficult to gain sufficient airspace to have a benefit in local flood events;
- Pipe Network
 - Despite feasibility challenges, include pipe upgrade in modelling to understand potential benefits;
- No. 9 Channel
 - Consider using the disused No. 9 Channel reserve for new drainage infrastructure;
 - Seek co-benefits (e.g. walking track, cycleway)
 - Challenges relating to ownership of the channel (many and varied owners including Council, Goulburn Murray Water, Private, Deceased Estates), and titles that span the channel (likely existing prior to the construction of the channel).
 - Challenges relating to social impacts to the neighbours abutting the reserve;
- Aerodrome

- Not appropriate to store water at the aerodrome;
- Council staff noted the risks of storing water within the aerodrome site particularly relating to attracting birds, risk of bird strikes and damage caused by birds eating/damaging equipment and vegetation.
- Planning
 - Council planners are interested in having mapped flood risk areas and Land Subject to Inundation Overlay for Swan Hill, particularly to guide future development;
- Southwest Development Precinct
 - Suggestion to construct a new trunk drain to convey stormwater in an easterly direction to the Little Murray River to reduce the catchment contributing to the Main Drain

7.2.1.2 Robinvale

Current Issues:

- Socio-economic impacts of flooding in Robinvale (and during recovery after floods) more pronounced than in Swan Hill;
- Drainage capacity limited by existing levee pipes with no permanent pump stations (temporary pumps used when needed);
- Council has funding to install two new levee pipe gates on existing pipes, backflow during riverine flood events is an issue – currently addressed with blow-up bungs installed during floods;
- Existing Drain that runs perpendicular to Leonora Street, Ronald Street, Kennedy Street, Morris Street and Rowe Street appears to be undersized based on existing conditions flood mapping.
- Issues with Glenda Court Basin to be noted;

7.2.2 Session 2: Stakeholder Agencies

Lower Murray Water:

- Main issue occurs when the Main Drain fills up and backs up into the external areas of private properties, inundating the sewerage system through residential connections and sewer gully traps.
- LMW has identified a future sewerage pump station to be located at Feldtmann Lane – may provide an opportunity for stormwater infrastructure also;
- One existing Sewerage Treatment Plant in Robinvale, some irrigation infrastructure also. Noted that the population of Robinvale is underestimated in census data due to the population living in Robinvale but working out of town on agricultural properties. This means demand on water supply and sewerage is underestimated.
- Robinvale – currently relies on temporary pumps to drain local stormwater when the Murray River is elevated. This study could look into feasibility of permanent pumps (noting that connection to support generators would be of benefit).

Mallee Catchment Management Authority

- Mallee CMA noted their main focus is on riverine flooding, but had an interest in this project for context and information.
- Mallee CMA and North Central CMA would be offered the opportunity to review the Draft Final Report down the track, particularly in relation to the planning layers produced by this study.

7.2.3 Session 3: Private Consultants, Developers and Surveyors

Local service providers including planning consultants, developers, civil engineers and surveyors were invited to raise their concerns around existing drainage issues, and make suggestions for potential mitigation options. The discussion focused on Swan Hill, no comments were made in regards to Robinvale. The key discussion points are listed below:

- Retarding Basin Considerations

- Current requirement for new subdivisions/developments to have their own on-site detention basin is becoming problematic for a few reasons, including detracting from the overall development, not able to be used as public spaces, and builds in more and more assets to be maintained and managed;
- Strong preference to develop a basin strategy to establish one or two major basins that many developments can use;
- Basin located at Tower Hill to be included in Strategy;
- Opportunity to use the Racecourse for a secondary storage site (not primary). Racecourse would like a permanent water feature on-site – will need to consider airspace/usability for detention during storm events;
- Existing low point between Yana Street and Coronation Drive – potential location for basin
- Suggested Mitigation Options
 - Bigger pumps for main drain;
 - Excavating the main drain deeper to increase storage capacity;
 - Support for idea of a “Southern Main Drain” with an outlet to the Little Murray River;
 - New Major Trunk Drains;
 - New Pump Stations (including allowance for connection to generators);
 - Increase pump station capacity at the end of Gray Street
 - Use No. 9 Channel reserve for new drainage infrastructure

7.3 COMMUNITY ENGAGEMENT ACTIVITIES

7.3.1 Media and Promotions

WMS provided materials to Swan Hill Rural City Council to support a range of media and social media promotions of the Drop-In Session and Questionnaire. The promotions included:

- Hardcopy posters displayed at in Robinvale and Swan Hill;
- Social media posts (including Facebook and Instagram).

7.3.2 Drop-In Sessions

The Drop-In sessions provided an informal opportunity for residents to discuss the study and voice their concerns about overland flow and drainage in the Study Area. The following drop-in sessions were hosted by WMS staff accompanied by Swan Hill Rural City Council staff:

- 11th September 2024, Robinvale Resource Centre, 9:00 – 11:00 am (2 attendees);
- 11th September 2024, Swan Hill Town Hall, 3:30 – 5:30 pm (17 attendees).

7.3.3 Questionnaire

A brief online questionnaire was prepared to gather information from residents of Swan Hill and Robinvale who could not attend the drop-in sessions. This was made available to the public online via a QR code on the posters advertising the community drop-in sessions.

7.4 COMMUNITY ENGAGEMENT FINDINGS

The community engagement activities saw a total of 19 attendees to Drop-In sessions and 37 responses to the online questionnaire. Online responses included written descriptions and flood photography, and the questionnaire allowed the community members to geotag the location of their photos and anecdotes. Many attendees to the Drop-In sessions came prepared with printed photos and/or digital photos and videos. WMS took notes of attendees’ descriptions and supplemented these notes by marking key

locations on printed A3 maps of each township. Key issues and concerns reported by the community members in these sessions are summarised in the sections below.

7.4.1 Robinvale

The Robinvale Community Drop-In session saw 2 community members attend. These attendees provided valuable information of typical stormwater flooding issues within the town, having gathered data themselves from other residents. An overview of locations highlighted by the attendees is presented in **Figure 7-1**. General commentary from the community regarding stormwater in Robinvale aligns with known issues and limitations experienced by the town's drainage infrastructure. Issues cited included undersized stormwater pipes, very flat nature of areas in the township (lack of gradient to drive gravity-fed drainage systems) and the town's flood levee blocking overland flow on its way to the Murray River. There is also concern amongst residents and emergency response organisations that overland flow flooding in Robinvale disproportionately affects low socio-economic areas of the town.

Flooding and stormwater issues highlighted by the session attendees are summarised in **Table 7-1**.

Table 7-1 Summary of Community-Supplied Flooding and Stormwater Information for Robinvale

Location ID	Location	Reported Issues/Observations	Community Suggestions
1	Stormwater pipe outlet to the Murray River at intersection of Robin Street and McLennan Drive	No backflow prevention at outlet. Divers are required to insert bungs to block pipes during riverine flood events (if possible).	
2	Robin Street	Existing 12-inch pump does not work. Frequent flooding of Robin Street and the nearby football fields. Local residents suspect that the stormwater pipe underneath the road has structural damage and is dysfunctional.	Pipe condition assessment (i.e. via CCTV) to understand damage and ability to convey stormwater. New pump station.
3	Caix Square	The area frequently floods during intense rain events. The existing drainage system is unable to cope with typical storm events and takes hours to drain water away.	
4	Malla Avenue	Experiences flooding every time there is 10 mm or greater rainfall.	
5	Intersection of Latje Road and Watkin Street	Experiences flooding every time there is 10 mm or greater of rainfall. Water typically remains on the roadway for several hours after storm events.	
6	Leonora Street	Experiences flooding every time there is 10 mm or greater rainfall. Residents are frequently required to sand-bag their houses to prevent flooding. Many vulnerable residents in this area.	
7	Rowe Street	Frequently flooded when heavy rainfall occurs. Low socio-economic area with vulnerable residents.	
8	Intersection of Latje Road and Parke Street	Experiences flooding every time there is 10 mm or greater rainfall.	
9	Intersection of Latje Road and Alexander Street	Experiences flooding every time there is 10 mm or greater rainfall. Cars driving through floodwaters create waves which impact the adjacent low-lying houses.	
10	Stormwater pipe underneath Lawrence Road	Pipe segments have reportedly split in some areas, preventing flow.	Pipe condition assessment (i.e. via CCTV) to understand damage and ability to convey stormwater.

Location ID	Location	Reported Issues/Observations	Community Suggestions
11	Levee at end of Lawrence Road.	Temporary pumps used during recent rainfall events does not keep up with stormwater flow, causing flooding.	New, permanent pump station.
12	Levee at end of Williams Road.	Temporary pumps used during recent rainfall events does not keep up with stormwater flow, causing flooding.	New, permanent pump station.

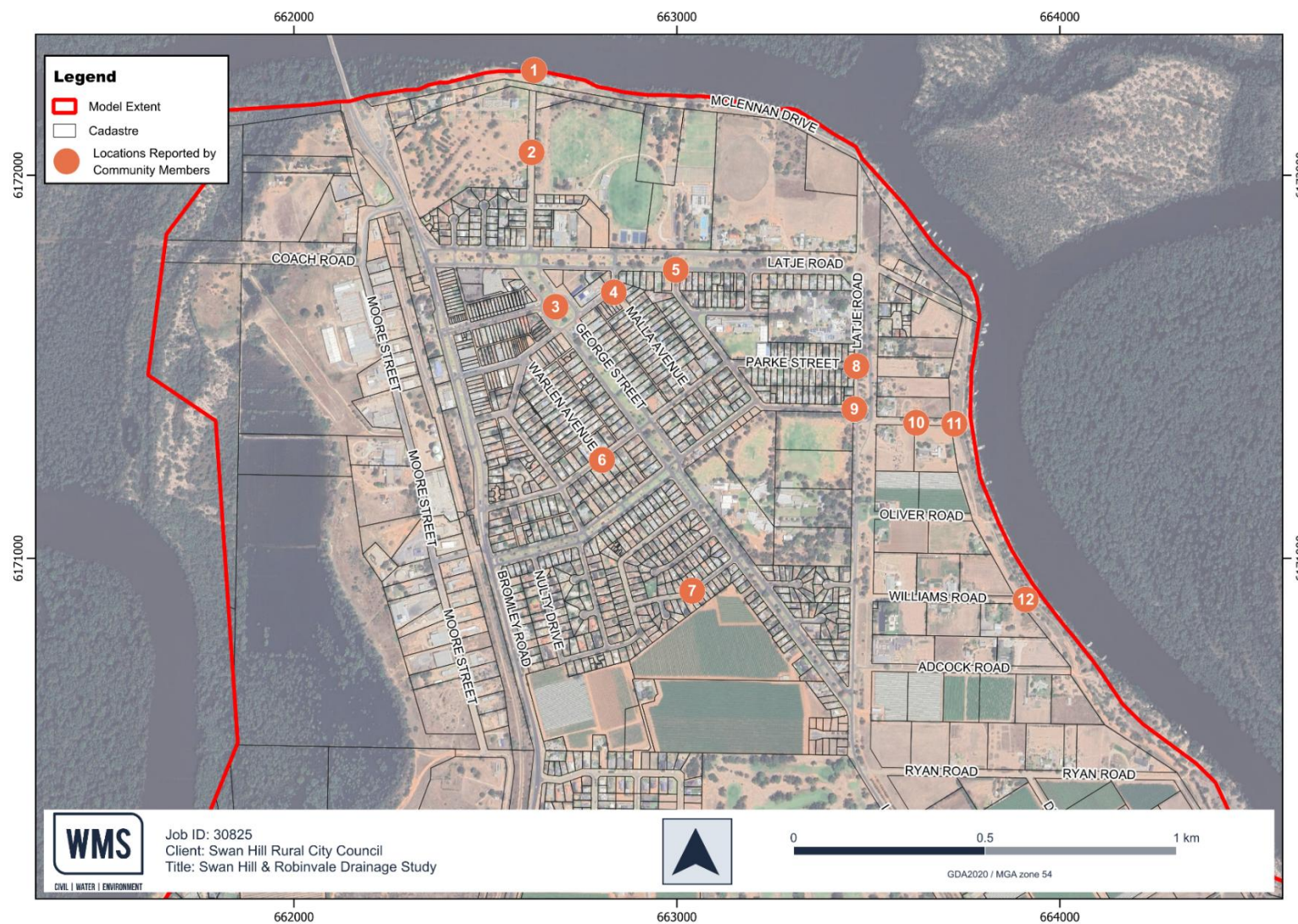


Figure 7-1 Key Locations Reported by Robinvale Community Members

7.4.2 Swan Hill

The community engagement activities in Swan Hill received a strong response with 17 attendees to the Drop-In session and 37 responses to the online questionnaire. Of the 17 attendees to the Drop-In session, five also submitted responses to the online questionnaire. Community feedback detailed a broad range of locations across the township. **Figure 7-2** presents an overview of the locations highlighted by community responses.

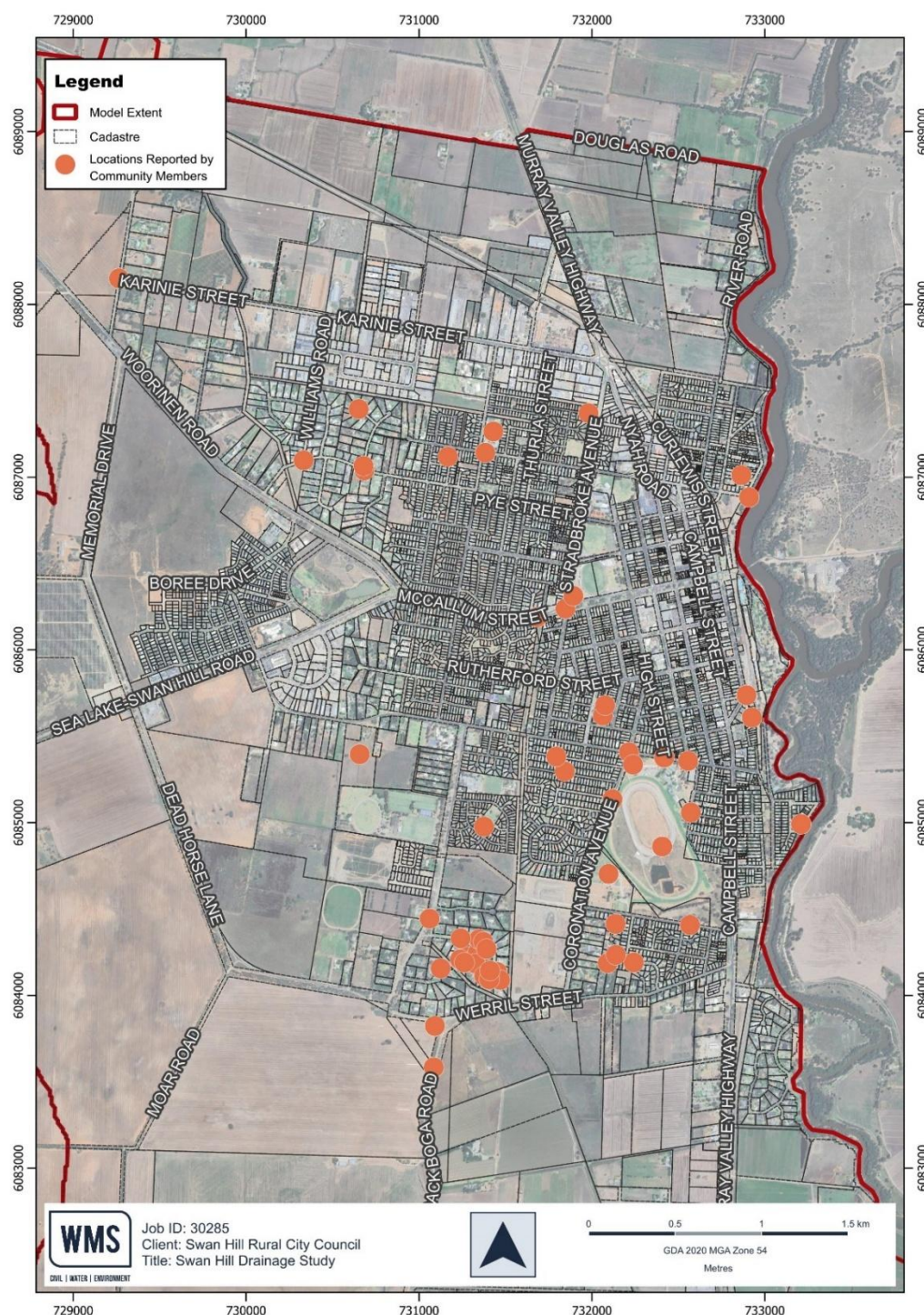


Figure 7-2 Key Locations Reported by Swan Hill Community Members

Community-sourced information for each location marked in **Figure 7-2** will be summarised in the following sections. Key clusters of data and major points of concern for the community will be highlighted.

7.4.2.1 Bish Road and Karinie Street

Community members have recorded that this area is very flat and has no formal drainage system. Reportedly, water frequently accumulates here in storm events and does not readily drain away. Refer to **Figure 7-3** for the location indicated with the community response.



Figure 7-3 Intersection of Bish Road and Karinie Street Described by Community Members

7.4.2.2 Butterworth Street, Berrybank Drive and Yvonne Close

Several community members raised concerns about inadequate drainage in the vicinity of Butterworth Street and Berrybank Drive. The inlet pit on the corner of Butterworth and Berrybank (which drains eastward) is reportedly blocked and does not adequately perform in storm events. There is no formal drainage network on Berrybank Drive or west of the intersection between Butterworth and Berrybank. Residents believe that the drainage pipes and pits that are on Butterworth Street are blocked and/or damaged and need to undergo a conditions assessment.

Residents note that there are small table drains on these roads but are concerned that these do not interface with the greater township's drainage system, leaving stormwater to accumulate and remain as stagnant water. One resident expressed concern that Yvonne Close does not have a formalised drainage system. Refer to **Figure 7-4** for locations attached to these community responses.

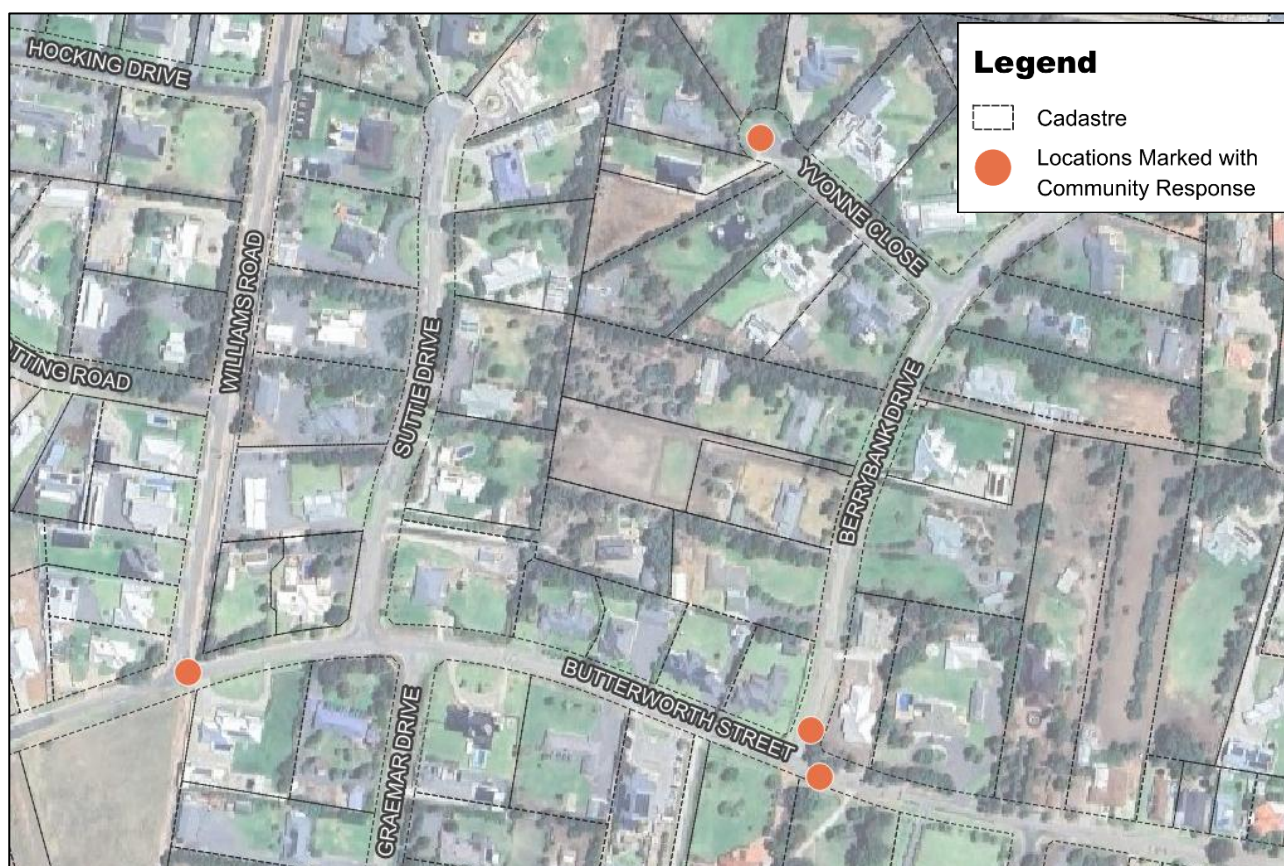


Figure 7-4 Locations on Berrybank Drive, Butterworth Street and Yvonne Close Marked by Community Members

7.4.2.3 Swan Hill North Primary School and Surrounds

Multiple community members cited flooding issues at Swan Hill North Primary School which is a well-documented issue that SHRCC is aware of. Responses specifically voiced concern over the impact to children's education due to school closures and accessibility issues caused by flooding. Reported causes of the school's flooding focus on a lack of capacity in Chapman Street's stormwater network. On Gerrand Street, community members report that the street's stormwater network typically has stagnant water inside and drains poorly. It is reported that 1 mm of rainfall in a 24-hour period results in water over the road. The locations marked with these community responses are presented in **Figure 7-5**.



Figure 7-5 Locations Marked in Community Responses in the Vicinity of Swan Hill North Primary School

7.4.2.4 Mulbar Street

One community response described a caved-in stormwater drain underneath Number 6, Mulbar Street. The associated location for this response is presented in **Figure 7-6**.



Figure 7-6 Location of Damaged Stormwater Drain Reported on Mulbar Street

7.4.2.5 Milloo Crescent and the Milloo Street Pump Station

Based on resident responses, community members are concerned that the drainage system of Milloo Crescent and Milloo Street is overly reliant on the Milloo Street pump station. This pump reportedly either fails or has insufficient capacity to discharge stormwater to the river, resulting in backwater flowing through the pipes and flooding Milloo Crescent. Locations marked with these community responses are presented in **Figure 7-7**.



Figure 7-7 Locations Marked in Community Responses Regarding Milloo Crescent and the Milloo Street Pump Station

7.4.2.6 McCallum Street Roundabout

Residents have reported that stormwater accumulates at the McCallum Street roundabout (at the intersection of McCallum Street and Stradbroke Avenue) and remains stagnant at this location for extended periods. One response describes this issue as being the result of the bridge over the former Number 9 Channel, which forms a high point along the roadway and prevents water from moving west towards the Main Drain.

One resident nominated the vacant parkland on the corner of McCallum Street and Stradbroke Avenue as being a suitable location for a Water Sensitive Urban Design (WSUD) solution.

The locations specified in these responses are presented in **Figure 7-8**.



Figure 7-8 Locations of Community Response Items Regarding the McCallum Street Roundabout

7.4.2.7 Vicinity of Boys and Gummow Street

Community responses for this location highlighted reports that overland flow travels from east on Gummow Street west through the residential properties towards Brown Street. These flows stop at the location of the access lane behind the properties, and pool at this location with no formal drainage system to remove the water. Refer to **Figure 7-9**.



Figure 7-9 Locations Marked in Community Responses Regarding Boys/Gummow Street

7.4.2.8 Railway Avenue

Community responses report significant overland flow flooding at this location, particularly in the December 2022 event where over 200 mm of water was over the road and the adjacent properties. Residents are concerned that the stormwater pipes running north to Curlewis Street are both too flat and undersized. Reportedly, all stormwater collecting on Railway Avenue relies on one side entry inlet pit on the corner, which is small and partially blocked. Refer to **Figure 7-10** for the associated location markers.



Figure 7-10 Locations Marked in Community Responses Regarding Railway Avenue

7.4.2.9 Burton and Donnington Street

Residents report that overland flow runs south down Coronation Avenue before flowing into both Burton and Donnington Street. Flows accumulate at the sags in these roads and the drainage system is unable to dissipate the water and prevent flooding. The community responses indicated concern that the inlet pits at these locations are blocked. Numerous photos were included in these submissions. Refer to **Figure 7-11** for photography of Burton Street and flooded floor level of 30 Burton Street during the January 2022 event. Refer to **Figure 7-12** for the locations marked with these community responses.



Figure 7-11 Photos Submitted as part of the Community Response for Burton Street (January 2022)



Figure 7-12 Locations Marked with the Community Responses for Burton and Donnington Street

7.4.2.10 Vicinity of Charlie Gray Close, Settlers Court and Landy Crescent

This location saw the highest concentration of community response markers submitted, with a notable presence also at the Swan Hill Community Drop-In sessions. The general sentiment of responses at this location highlights the lack of formalised stormwater infrastructure in the development. The area is very flat, and residents report that stormwater accumulates with no adequate method of discharging anywhere downstream. Reportedly, residents have been forced to organise their own pump solutions on numerous occasions, which involved a series of hired pumps transporting water from Charlie Gray Close to the (now decommissioned) No. 9 Drain. Now that the No. 9 Channel is no longer operational there is no suitable location to pump to.

Numerous photos were submitted as part of the responses for this location. Refer to **Figure 7-13** and **Figure 7-14** for community-submitted photography of flooding on Charlie Gray Close. Refer to **Figure 7-15** for locations marked with community responses for this area.



Figure 7-13 Flooded Residence and Temporary Flood Barrier on Charlie Gray Close



Figure 7-14 Photos Submitted by Community Members of Flooding on Charlie Gray Close



Figure 7-15 Locations Marked by Community Responses in the Vicinity of Charlie Gray Close

7.4.2.11 Nalder Drive

Residents reported a lack of capacity in the stormwater network on Nalder Drive, resulting in relatively frequent inundation of the roadway. Community members are concerned that this prevents safe egress from properties on the street and the nuisance it causes. Photos were submitted as part of these responses, which are presented in **Figure 7-16**. Locations marked with these community responses are presented in **Figure 7-17**.



Figure 7-16 Inundation of the Roadway on Nalder Drive

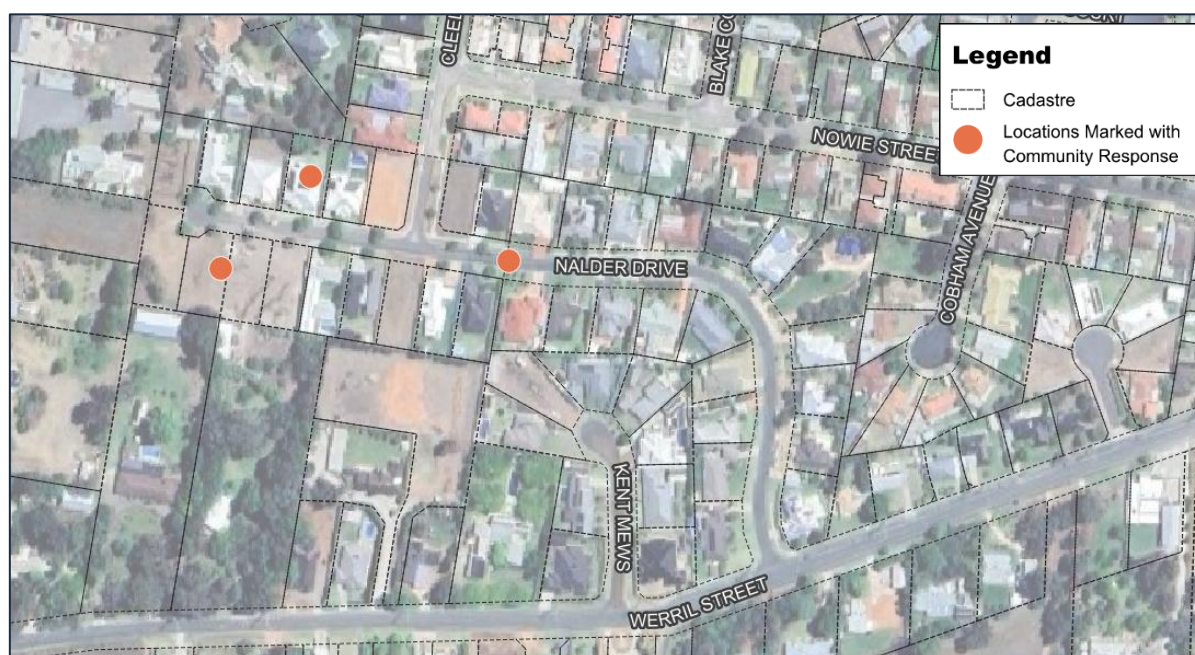


Figure 7-17 Locations Marked with Community Responses for Nalder Drive

A full list of numbered Swan Hill community responses with the associated locations are available in **Appendix C**.

8 MITIGATION OPTIONS SCREENING ASSESSMENT

8.1 LONG LIST DEVELOPMENT

Suggestions and ideas for potential flood mitigation options were gathered throughout the study, particularly during the stakeholder and community engagement activities. As part of the initial screening assessment, a 'long-list' of options was collated and assessed to develop a refined list of mitigation options for each township.

Details of the long list of mitigation options developed for Robinvale are recorded in **Table 8-1**, and Swan Hill in **Table 8-2**. Each option was allocated a traffic light colour of green, amber or red to indicate the likely feasibility and success of each option after consideration of the benefits and constraints. The green, amber and red colours represent high, medium and low success potential respectively.

Subsequent discussions with SHRCC regarding the long list of options found that there was general agreement in the findings and additional information was provided with regard to some of the options investigated. Some key points from these discussions are summarised as follows;

- Options including culverts under/through major Murray River levees were replaced with pump stations option, as SHRCC had preference for options with higher resilience to riverine flooding;
- Concrete levee walls around the Main Drain were not preferred due to construction expense and residual flood risk due to structural failure.

Options sourced from previous investigations undertaken by/for SHRCC as part of the Major Projects Plan (MPP) feature the MPP acronym in the mitigation option description.

Table 8-1 Robinvale Mitigation Options Long List

ID	Mitigation	Description	Expected Flood Improvement	Risks and Disadvantages	Benefits and Opportunities	Score	Traffic Light
Central Zone							
R1	Underground stormwater network upgrades from Leonora Street to Rowe Street	Increase the pit and pipe sizes Lower the pipe outfall at the river to 49 mAHD (originally 50.3 mAHD)	Improve network conveyance to reduce flood levels across Robinvale town centre	Underground networks currently passing through private property, existing easement width needs to be checked. Traffic disruptions. Given that the existing stormwater network is not designed for extreme events, this option cannot provide enough immunity.	Potential low cost option. Improve the flood immunity in the frequent events	1	
R2	New stormwater pits and pipes running from Leonora St down George St	New pipes to divert water southeast along George St to tie into existing network downstream	Reduced depth and extent at low points along Leonora St, Ronald St, Kennedy St and Morris St.	Pipes would have to fall against the natural terrain to reach George St from the sag at Leonora, and then again southeast along George St until the crest of the street between Kennedy and Morris. May require pump system to perform well.	No required works to the pipes underneath private residential lots. No resumptions required.	2	
Eastern Levee Zone							
R3	Additional culverts underneath the western flood levee	Add six box culverts (assuming 2.1m wide 0.9m high) underneath the levee to allow conveyance of overland flow to the river	Drawdown flood levels at the upstream levee	The backflow during riverine flood events is an issue.	Widespread decrease in peak water surface level in the 1% AEP event by 150 - 300 mm. At the end of the storm event, there is also much less remaining flood water.	3	
R4	Add Pump stations along the western flood levee	Add six pumps with a constant 20 L/s flow rate	Drawdown flood levels at the upstream levee	Pump failure risk. Regular maintenance required. It would only be efficiently compared to box culverts when the river level is higher	Little to no earthworks required compared to a culvert option.	1	
R5	Larger capacity swale on the western side of the levee and upgraded table drains along Smith Rd, Ryan Rd, Adcock Rd and Williams Rd	Formalise the existing table drains along these roads to divert overland flow towards the western flood levee quickly. Construct a large swale adjacent to levee to provide overland flow storage whilst flows discharge through levee culverts and/or pumps.	Less large-scale ponding (or 'bathtub' effect) on low-lying land west of the levee in Eastern Zone. Reduced flood levels and extent.	Major earthworks. Relatively expensive.	Potential to accommodate for future residential development in the vicinity. Open channels would be more easily maintained/upgraded than underground pipe systems.	2	

ID	Mitigation	Description	Expected Flood Improvement	Risks and Disadvantages	Benefits and Opportunities	Score	Traffic Light
R6	New 1200 mm pipes from Latje Rd down Williams Road to the River	Upgrade existing 900 mm pipes along Williams Rd to match the existing 1200 mm pipes upstream, removing the constriction.	Improved pipe network performance upstream of Latje Rd.	Existing pipes on Williams Rd are reportedly prone to differential settlement and associated long-term damage.	Simple solution to improve existing network. Would not require resumptions.	3	
Northern Zone - Robin Street Area							
R7	Detention basins near Robinvale football club and tennis courts	Diverting flow from Caix Square, Latje Rd and Herbert St to the Football Club. Use the football club to detain the water.	Potential to reduce flood levels upstream by detaining flow	Space requirements. Major earthworks.	Significant reduction in flood levels in the vicinity of Caix Square and Herbert Street. Improves flood conditions on new development off of Robin Street west of the tennis courts. Potential WSUD option for improved environmental outcomes.	2	
R8	Robin Street underground stormwater network upgrades	Increase the pit and pipe sizes under Robin Street Lower the pipe outfall at the river to 49 mAHD	Improved channel conveyance to reduce flood levels upstream of Robin Street.	Traffic disruptions due to existing pipes being underneath Robin Street road crest.	Potential low cost option. Improve the flood immunity in the frequent events	3	
R9	Pump Station on Robin Street	Pump station to pump water from sag along Robin St to the river	Reduce the extensive inundation on Robin Street and the surrounding areas. Allows overland flow to overcome the increase in elevation on Robin St just north of the Community Arts Centre	Pump failure risk. Regular maintenance required.	Little to no earthworks required. Relatively cheap.	2	
R10	Detention basins on the median strips of Ronald Street	Excavate two detention basins on the median strip of Ronald St which would link to the existing drainage network perpendicular to the street.	Reduce flood level on Ronald St and surrounding areas. Retain stormwater in specific location until the existing drainage network can dissipate flows.	Effectiveness may be limited by existing pipe network, which was observed to partially blocked, and is reportedly damaged in numerous areas.	No required works to the pipes underneath private residential lots. No resumptions required. WSUD opportunity.	1	

Table 8-2 Swan Hill Mitigation Options Long List

ID	Mitigation	Description	Expected Flood Improvement	Estimated Cost	Risks and Disadvantages	Benefits and Opportunities	Score	Traffic Light
S1	Excavating the Main Drain deeper to increase storage capacity	Maintain the current Main Drain footprint and width but with lower inverts.	Reduced flood level in the vicinity of the Main Drain in rare events (i.e. 1% AEP), especially in areas where the Main Drain is overtopping such as at Williams Rd and Murlong St.	Over \$2M ex.	May collect standing water in dry periods and exacerbate mosquito issues. Construction works would likely elevate flood risk in the short term due to the town's reliance on the Main Drain. Relatively expensive.	Does not require any new easements or resumptions.	2	
S2	No. 9 Channel reserve for new drainage infrastructure	Use the disused No.9 Channel to collect overland runoff. Excavate within former No. 9 Channel footprint to add flood storage.	Provide additional flood storage, provide a discharge point for potential drainage networks around Yana Street, and reduce reliance on Main Drain.	Over \$1M ex.	May collect standing water in dry periods and exacerbate mosquito issues. Would require a new major drain line to discharge into (offers little benefit as a standalone solution). Issues relating to ownership/easements of lots at former No. 9 Drain. Relatively expensive.	Potential for a WSUD solution, positive environmental outcomes. Possibility of implementing as a new/enhanced community space. Vegetated land offers aesthetic benefits.	2	
S3	A new trunk drain in southern Swan Hill	Add a new trunk drain to convey stormwater in an easterly direction to the Little Murray River to reduce the catchment contributing to the Main Drain.	Prevent significant ponding in the various flood prone streets in the vicinity. Reduce flood levels and inundation times generally.	Over \$2M ex.	Limited available space/easements to place a large open channel along or north of Werril St (where the channel is most needed). Relatively expensive.	Provide base stormwater infrastructure for the surrounding residential areas to discharge into. Accommodate for future residential development in southern areas of Swan Hill.	1	
S4	Upgrade existing Pump Stations	Increase pump capacity of current pumps.	Reduce flood levels and inundation times of areas adjacent to the river and levees (e.g. Milloo Cr, El Alamein Ave, River Oaks Drive). Enhance performance of Main Drain to improve town drainage response.	Over \$1M ex.	Most significant benefits likely to be restricted to the immediate vicinity of the pump stations as the drainage network is generally undersized. Will increase Swan Hill's reliance on pump stations.	There is already designated space for the pump stations. Existing town drainage network links up reasonably well with the pump station locations. No need for new easements or resumptions.	3	
S5	Southern Detention Basins	Establish one or two major basins in the southern end of town, with the Racecourse as a secondary storage site. Potential basin sites include the corner of Back Boga Rd and Werril St, and the council lot south of the Racecourse on Wattie Street.	Provide flood storage retention to reduce pressure on drainage network and reduce flooding upstream.	Over \$2M ex.	To be most effective, the existing drainage network south of Gray Street would need to be reconfigured to drain south to the basins before draining to the Little Murray River. Would need to manage risk of mosquito issues in the basin.	Potential for a WSUD solution, positive environmental outcomes. Relatively easy to upgrade in the future compared with underground storages or drains.	2	

ID	Mitigation	Description	Expected Flood Improvement	Estimated Cost	Risks and Disadvantages	Benefits and Opportunities	Score	Traffic Light
S6	New drainage pipeline down Werril Street to River	Large underground pipes (e.g. 2 x 1200mm) to drain southern areas of the town.	Prevent significant ponding in the various flood prone streets in the vicinity. Reduce flood levels and inundation times generally.	Over \$2M ex.	Relatively expensive.	Provide base stormwater infrastructure for the surrounding residential areas to discharge into. Accommodate for future residential development in southern areas of Swan Hill.	2	
S7	Eastern Chapman St pipe network upgrade (MPP)	Resolves a pipe diameter restriction and removes an existing pipe underneath a building on the corner of Chapman and Campbell Street.	Aims to improve drainage that backs up west of Campbell St on Pye and Pritchard St. Reduce flood levels and ponding on Pye Street in frequent events.	\$282k ex.	Likely only localised benefits in the adjacent streets.	Easier access and maintenance for new Chapman Street pipe in the road reserve (rather than underneath the building). Simple solution.	2	
S8	New pump station and rising main at Charlie Gray Close (MPP)	To link Charlie Gray Cl, Landy Cres, Settlers Ct and Peppercorn Mews to town drainage network.	Allow capture and drainage of runoff where there is currently no stormwater drainage network and significant ponding/flooding issues.	\$220k ex.	There is currently limited options for these streets to discharge stormwater to. Would be most effective in conjunction with a new major drainage line to the Little Murray.	Numerous concerned residents in this area who would benefit. Opportunity to rectify significant problems with the original development.	2	
S9	New drainage network in the vicinity of Butterworth, Suttie, Berrybank and Graemer (MPP)	Add an underground pit and pipe network.	Overcome onsite detention and swale drain capacity issues in the area.	\$825k ex.	Relatively expensive. Somewhat limited by the downstream capacity of the network (i.e. the pits and pipes on the corner of Berrybank Dr and Butterworth St, which are only 300 mm RCPs). Will increase runoff into the Main Drain and cause minor worsening of flooding downstream unless there are additional upgrades.	Potentially a simple solution for several streets with stormwater issues.	2	
S10	Drainage network extension on southern end of Yana St (MPP)	Add pits and pipes to either link up to Main Drain or new southern drainage line.	Improve flooding issues on Charlie Gray, Settlers and Landy. Allow discharge of the new housing development west of Yana St to a major drainage line.	\$715k ex.	Would need to be implemented in conjunction with a new southern drainage line to perform adequately. Limited fall available for gravity fed system, may require more pump stations.	Potential to alleviate current flooding issues in the vicinity and prevent future issues due to increased residential development.	2	

ID	Mitigation	Description	Expected Flood Improvement	Estimated Cost	Risks and Disadvantages	Benefits and Opportunities	Score	Traffic Light
S11	Upgrade drainage network from Railway Ave down to McCallum St (MPP)	Increase pit and pipe sizes.	Reduce ponding issues on the bend of Railway Avenue and flooding of Curlewis St.	\$1.66M ex.	Relatively expensive. Capacity of all downstream pipes and pits would need to be upgraded to prevent worsening flooding in the CBD.	Potential to mitigate ongoing issues on Railway Avenue and Curlewis Street.	2	
S12	Extend drainage network on River Oaks Drive (MPP)	Extend existing infrastructure to drain stormwater from properties and swales.	Reduce flood levels on River Oaks Drive in both frequent and rare storm events.	\$464k ex.	Increased reliance on the pump station in Squire Grove. Potential to worsen flooding on Squire Grove if pump capacity or pipes at that location are not upgraded.	Only one access road in and out of the residences on River Oaks Drive, Kennon Court and Squire Grove - there is an opportunity to improve the flood resilience of numerous properties if the flooding on River Oaks Drive is addressed.	2	
S13	Upgrade drainage network on Naretha St (MPP)	Increase pit and pipe sizes.	Improve/overcome localised stormwater drainage issues	\$440k ex.	Nearby Milloo Crescent has known flooding issues, suspected to be due to lack of pump station capacity. Potential to worsen flooding at that location if there are larger inflows from Naretha Street.	No existing drainage network for the majority of Naretha Street so no need to remove or grout-fill old pipes.	2	
S14	Northern Detention Basins	Establish one or two major detention basins in the northern end of town. Potential locations include Mundara Park, George Lay Park, the empty Council land on Butterworth Street adjacent to the old No. 9 Drain.	Provide flood storage retention to reduce pressure on drainage network and reduce flooding upstream.	Over \$2M ex.	Would need to manage risk of mosquito issues in the basin. Would require substantial pipe network upgrades in the vicinity to be effective.	Potential for a WSUD solution, positive environmental outcomes. Relatively easy to upgrade in the future compared with underground storages or drains.	2	
S15	Concrete levee walls around Main Drain to increase capacity	Concrete levee walls to increase capacity of Main Drain and prevent spilling into adjacent streets without need for excavation works within drain.	Additional flood storage and conveyance of Main Drain, reduced flooding of low-lying streets adjacent to drain.	Over \$2M ex.	High engineering cost. Easily vandalised and generally not aesthetically pleasing. Makes maintenance access and egress from Main Drain difficult.	Potential to mitigate major flooding at both St Mary's Primary School and Swan Hill North Primary School. Walls can prevent pedestrian access to Main Drain.	1	

ID	Mitigation	Description	Expected Flood Improvement	Estimated Cost	Risks and Disadvantages	Benefits and Opportunities	Score	Traffic Light
S16	Increased pit and pipe capacity on Webster Drive and Westbrook Road.	Increase pipe and inlet pit sizes. Add flood storage pits.	Increase network storage and conveyance capacity to reduce significant ponding in rare events.	\$500k - \$1M ex.	Limited fall available as area is already low-lying. Limited effectiveness if overtopping of the Main Drain at this location is not prevented. Two existing pipes discharging to the Main Drain from Webster Drive run underneath private property.	Simple solution. Improved flood resilience of industrial estate has potential to enhance Swan Hill local economy.	2	
S17	Council resumes and converts empty private lot at 32 Murlong Street into detention basin.	Construct detention basin to be auxiliary storage for adjacent Main Drain.	Provide additional storage for Main Drain to reduce/prevent overtopping into adjacent streets.	Over \$2M ex.	Currently privately owned - requires resumption of land. Relatively expensive.	Potential to reduce flooding of both St Mary's Primary School and Swan Hill North Primary School. Potential for a WSUD solution, positive environmental outcomes.	1	
S18	Upgrade the box culverts along the Main Drain	Increase sizes of culverts where the Main Drain passes under roads in the town.	Increased flow through Main Drain, increasing capacity of the town drainage network generally.	Over \$1M ex.	Road closures during construction. Flooding risks during construction. Expensive.	Simple solution. No resumptions required.	3	

8.2 SHORT LIST OPTION DEVELOPMENT

Following development of the long list for each township, five potential options were short-listed and presented to SHRCC on 18 October 2024. This meeting included further deliberation between WMS and SHRCC, which resulted in a revised short list of 5 mitigation options for each township.

The investigations included three broad strategies that are to be assessed against existing conditions. The final mitigation options do not necessarily have to include all three strategies and are to focus on the most effective options for the location in question. The strategies included

- New/upgraded stormwater pipes, pits and channels;
- New/upgraded pump stations;
- New flood storage/detention basins.

It is understood that floodplain management techniques can also include awareness (i.e. warnings and evacuation planning) and property-based methods. These strategies have not formed a part of the investigation as they are developed and assessed internally by SHRCC.

These mitigation options to be progressed as part of the study for Robinvale and Swan Hill are presented in **Table 8-3** and **Table 8-4** respectively.

Table 8-3 Robinvale Mitigation Options Short List

ID	Description	Expected Flood Improvement
R01	Increase pit and pipe sizes under Robin Street and install a pump station at the end Robin Street.	Improved conveyance to reduce flood levels upstream of Robin Street and Community Arts Centre
R02	Further refinement of option R01 using alternate pipe, pump sizes.	
R03	Increase pipe sizes under Williams Road and install a pump station.	Reduced depth and extent of inundation in both 1% and 20% AEP west of the levee and allow for future development
R04	Further refinement of option R03 using alternate pipe, pump sizes.	
R05	New drainage pipes starting from the sag in Ronald Street, connecting to the existing drainage network under Alexander Street. New formalised swales along Lawrence Rd and Williams Rd. New pump stations at these two road ends.	Reduced depth and extent of inundation at low points along Leonora St, Ronald St, Kennedy St and Morris St.

Table 8-4 Swan Hill Mitigation Options Short List

ID	Description	Expected Flood Improvement
S01	New major stormwater pipes under Werril Street from the intersection with Yana Street east to the Little Murray River. Re-establish and excavate the No. 9 Channel to redirect flows from Burton, Donnington etc. south towards the new Werril Street drainage line. New pipes on the southern half of Yana Street flowing to the new drainage line. New pump station and drainage network on Charlie Gray Close discharging into the Yana Street pipes.	Reduced depth and extent of inundation in both 1% and 20% AEP and release the pressure from Main Drain.

ID	Description	Expected Flood Improvement
S02	Upgrade the pit and pipe sizes between Nalder Drive and Nowie Street, and the pipes downstream of these (This option is independent of S01)	Reduced depth and extent of inundation in both 1% and 20% AEP
S03	Upgrade existing pump stations at the end of the Main Drain.	Reduced depth and extent of inundation adjacent to the river and levees (e.g. Milloo Cr, El Alamein Ave, River Oaks Drive) in both 1% and 20% AEP. Enhance performance of Main Drain to improve town drainage response.
S04	Upgrade existing pump stations on Milloo Street and existing drainage network on Chapman Street.	Reduced depth and extent of inundation in both 1% and 20% AEP
S05	New pipe and pit network on Butterworth St, Berrybank, Suttie Dr vicinity draining northwards on Williams Road to Main Drain.	Allow capture and drainage of runoff where there is currently no stormwater drainage network

9 MITIGATION OPTIONS ANALYSIS

The shortlisted mitigation options determined in **Section 8.2** were each implemented into the TUFLOW hydraulic model to assess the resulting flood impacts and benefits. The following sections outline relevant details of each mitigation option and hydraulic model results of the options.

9.1 ROBINVALE MITIGATION OPTIONS

9.1.1 Robin Street Stormwater Network Upgrade with Pump Stations – R01

Mitigation Option R01 involved upgrades to the stormwater pipe network along Robin Street and the northern end of George Street. The existing stormwater pipe running from the corner of Perrin and George Street northwards to Latje Road was increased from a 600 mm RCP to a 900 mm RCP. Similarly, the 900 mm RCP running northwards underneath Robin Street was increased to a 1200 mm RCP. An additional 900 mm side entry inlet pit was added on Robin Street to draw more flow to the upgraded pipe under the road. A pump station was placed at the intersection of Robin Street and McLennan Drive to pump stormwater flows into the Murray. This pump station was modelled with a peak capacity of 2 m³/s. The layout of mitigation Option R01 is presented in **Figure 9-1**.

9.1.2 Refined Robin Street Stormwater Network Upgrade – R02

Mitigation Option R02 built upon R01, with additional pipe size and inlet pit upgrades. The existing 600 mm RCP running from Herbert Street west to the pipe junction at the start of Robin Street were increased to a 900 mm RCP. Two inlet pits at the corner of Herbert Street and Latje Road were upgraded from 900 mm side entry pits to 1200 x 1200 mm square inlet pits. An additional two 900 mm side entry pits were upgraded to 1200 x 1200 mm inlet pits on Robin Street. The layout of mitigation Option R02 is presented in **Figure 9-2**.

9.1.3 Williams Road Stormwater Upgrade with Pump Station – R03

Mitigation Option R03 involved upgrading the size of the existing 900 mm stormwater pipe underneath Williams Road to a 1200 mm RCP. A pump station was added where this stormwater pipe meets the existing levee at the eastern end of Williams Road. This pump station was modelled to have a peak capacity of 2 m³/s. The layout of mitigation Option R03 is presented in **Figure 9-3**.

9.1.4 Refined Williams Road Stormwater Upgrade – R04

Mitigation Option R04 was similar to mitigation Option R03 but featured two 1200 mm RCPs under Williams Road instead of one. Additionally, the new pump station was given additional peak capacity of 3.5 m³/s. The layout of mitigation Option R04 is presented in **Figure 9-4**.

9.1.5 Ronald Street Stormwater Upgrade with Swales and Pump Station – R05

Mitigation Option R05 implemented several upgrades to stormwater infrastructure. New stormwater pipes were added along Ronald Street, connecting the flood-prone low point of the road to the existing Ronald Street stormwater network on the other side of George Street to the northwest. Two 600 x 600 mm inlet pits were added on Ronald Street to divert overland flow into these new pipes. New swales were added parallel to Lawrence and Williams Road respectively, draining to new pump stations adjacent to the levee at the end of each road. Each new pump station was modelled to have a peak capacity of 1.2 m³/s. The layout of mitigation Option R05 is presented in **Figure 9-5**.

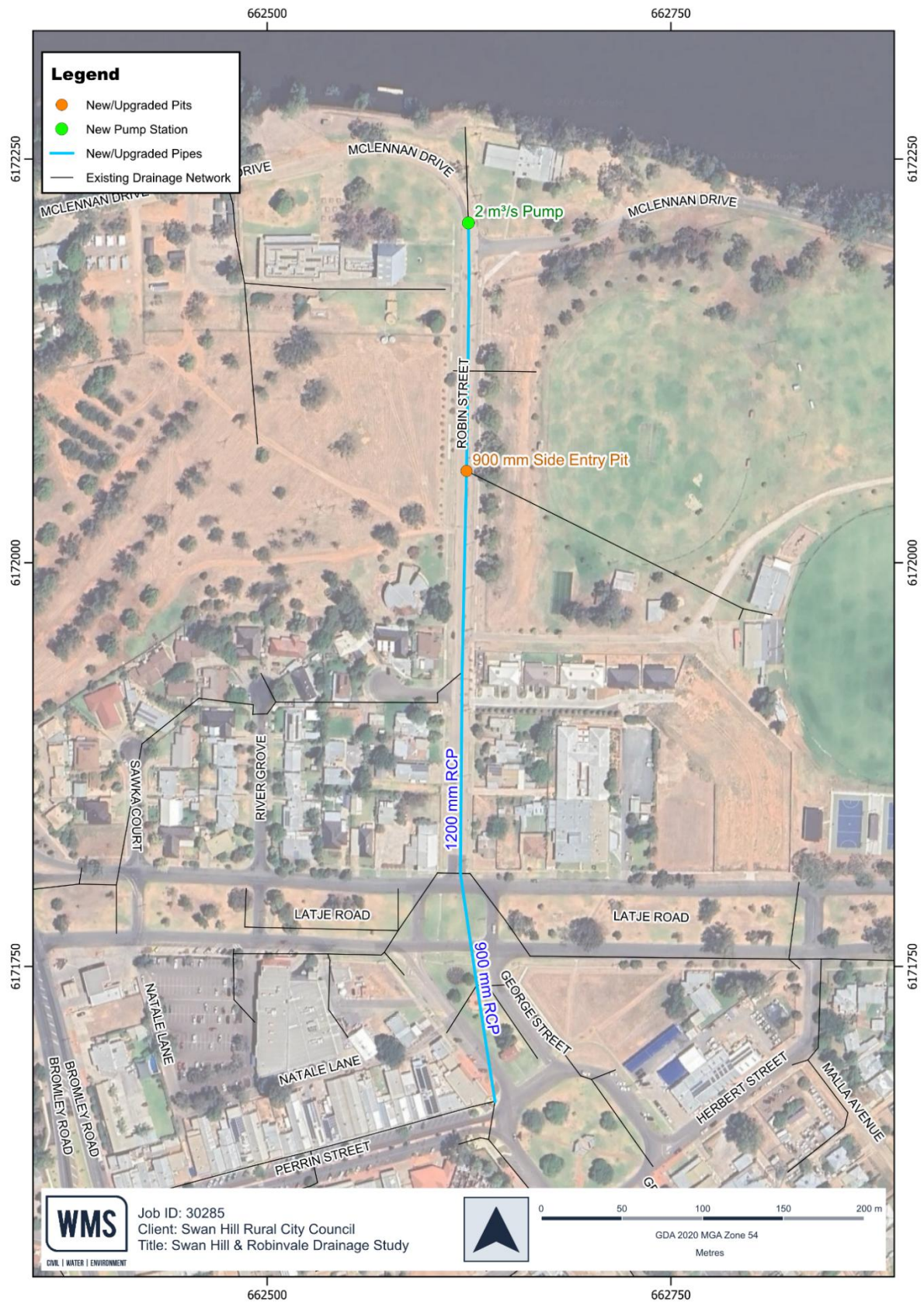


Figure 9-1 Robinvale Mitigation Option R01 Layout



Figure 9-2 Robinvale Mitigation Option R02 Layout



Figure 9-3 Robinvale Mitigation Option R03 Layout



Figure 9-4 Robinvale Mitigation Option R04 Layout

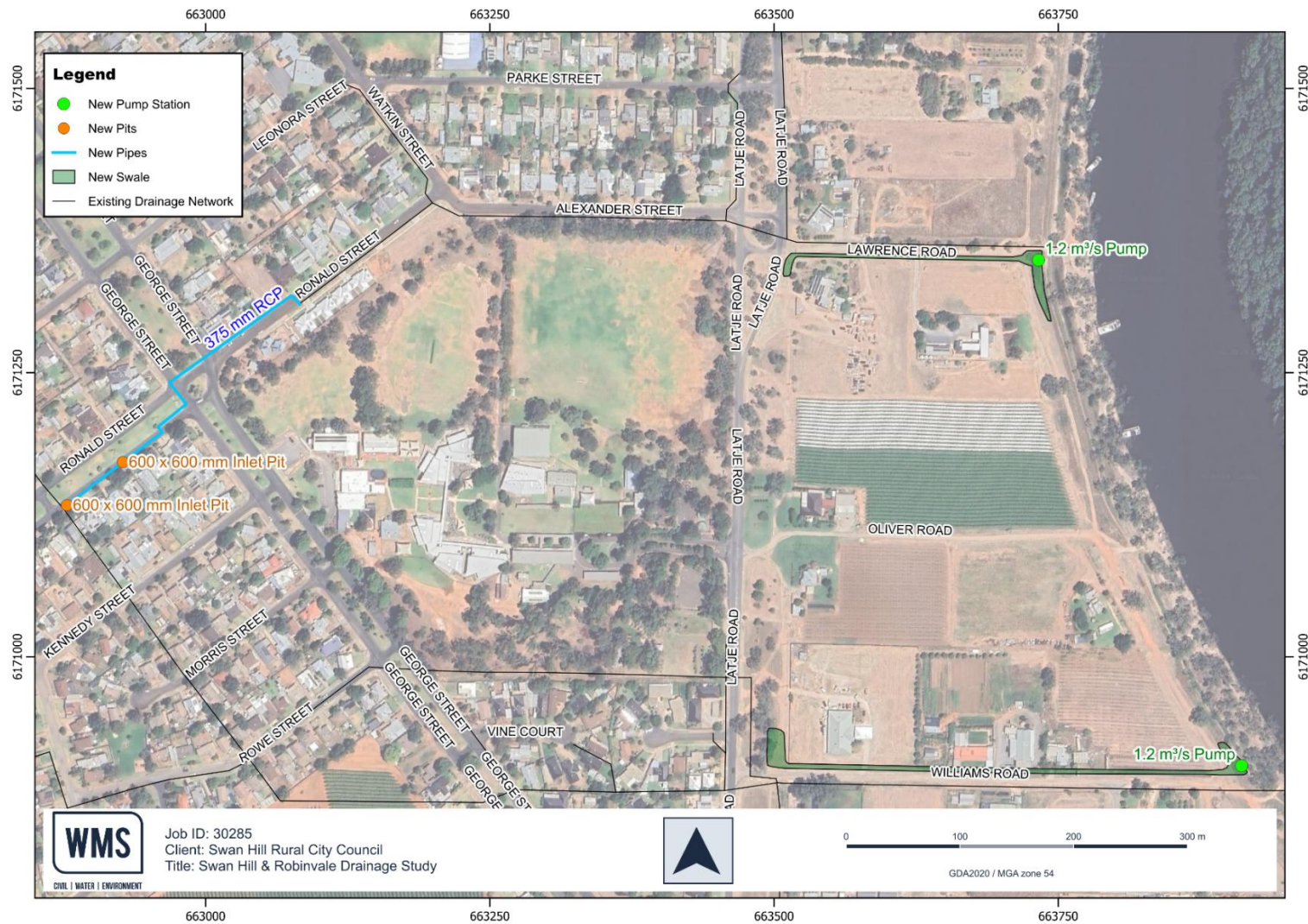


Figure 9-5 Robinvale Mitigation Option R05 Layout

9.2 ROBINVALE MITIGATION OPTION RESULTS

For each mitigation option, afflux (difference in peak water level) between the simulated mitigation option and existing case model results were produced. These afflux results highlight the expected locations and magnitude of flood improvements following implementation of each mitigation option. The following sections detail water level afflux results for each Robinvale mitigation option. Mappings of flood depth, velocity, hazard and afflux for each mitigation option are presented in **Appendix D**.

9.2.1 Robin Street Stormwater Network Upgrade with Pump Stations – R01

Mitigation Option R01 resulted in slightly reduced peak water levels along the sag of Robin Street and the overland flow path on Herbert Street in the 1% AEP event. Peak water levels reductions reached 90 mm on Robin Street, with up to 40 mm on Herbert Street. In the 20% AEP event, peak water levels were largely unchanged except for a 40 mm reduction on the Robin Street low point. Afflux in the 1% AEP event for Option R01 is presented in **Figure 9-6**.

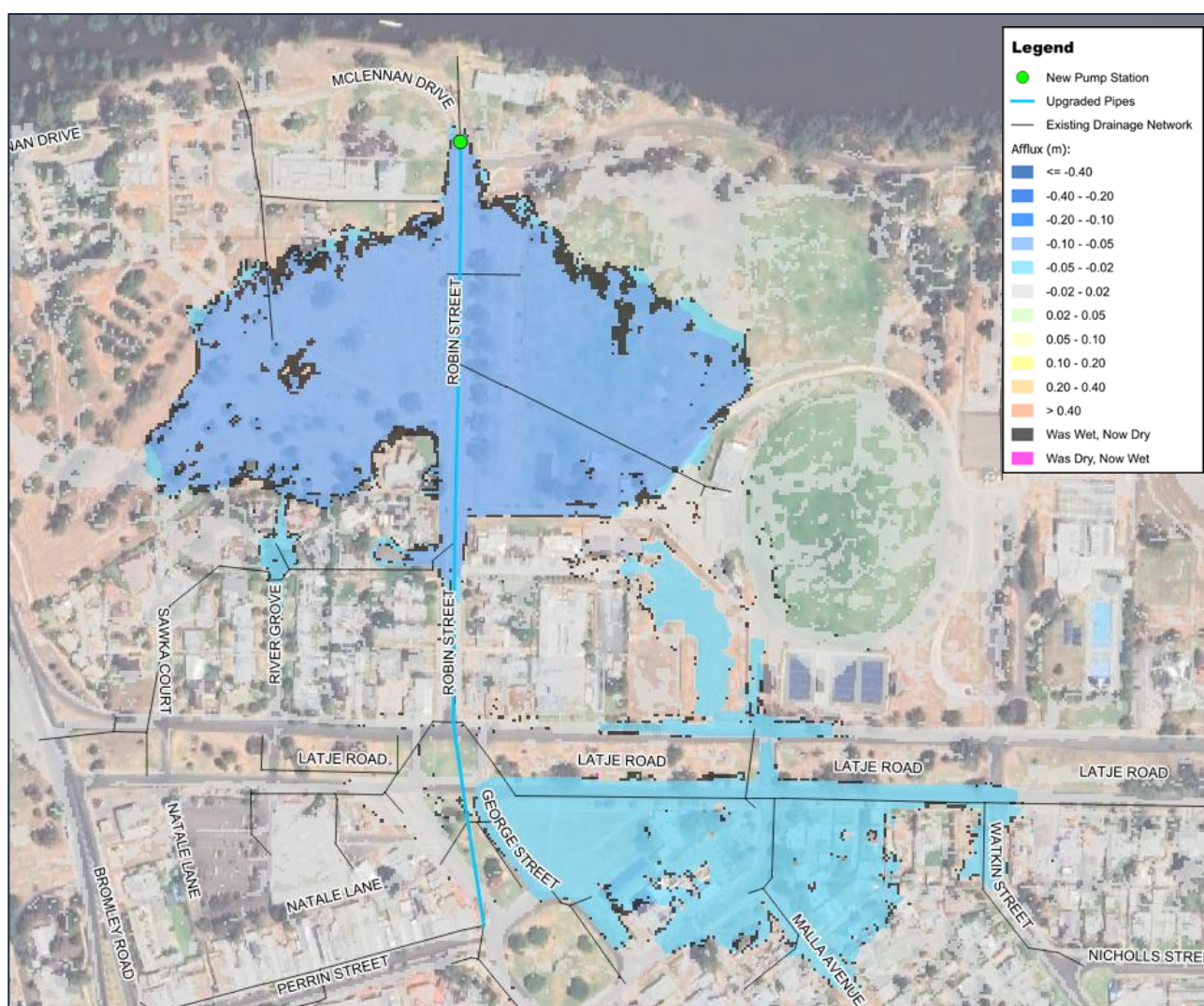


Figure 9-6 Mitigation Option R01 - 1% AEP Afflux

9.2.2 Refined Robin Street Stormwater Network Upgrade – R02

Option R02 resulted in further reductions in peak water level to the similar Option R01. On Robin Street, peak water levels were reduced by 130 mm in the 1% AEP and 150 mm in the 20% AEP event. On Herbert Street, peak water level reduced by 80 mm in the 1% AEP event and 30 mm in the 20% AEP event. Option R02 afflux is presented in **Figure 9-7** and **Figure 9-8**.

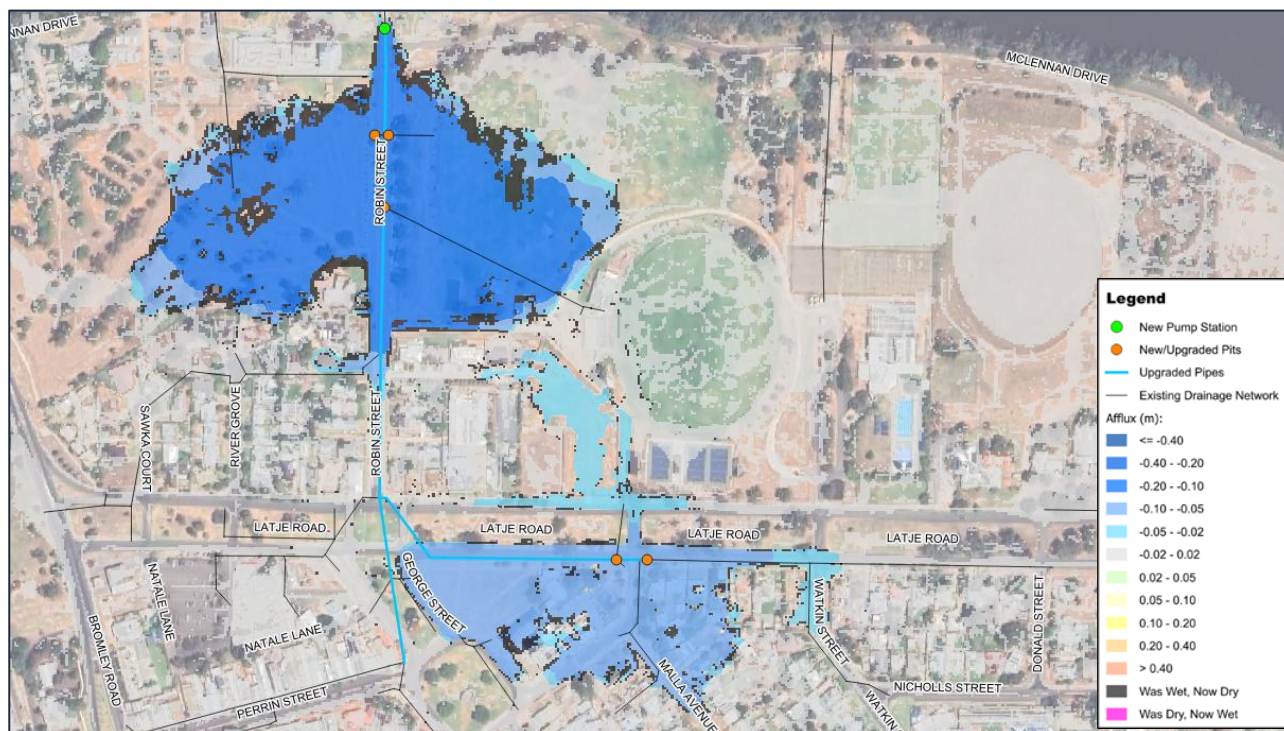


Figure 9-7 Mitigation Option R02 - 1% AEP Afflux



Figure 9-8 Mitigation Option R02 - 20% AEP Afflux

9.2.3 Williams Road Stormwater Upgrade with Pump Station – R03

Option R03 resulted in widespread, minor reductions in peak water level in the 1% AEP event across the central and eastern areas of Robinvale, with large reductions on Morris and Rowe Street. On Leonora Street and Ronald Street, 1% AEP peak water level reduced by 30 mm. On Morris and Rowe Street, 1% AEP peak water level reduced by 280 mm and 110 mm respectively. Afflux in the central area of Robinvale in the 1% AEP event is presented in **Figure 9-9**.

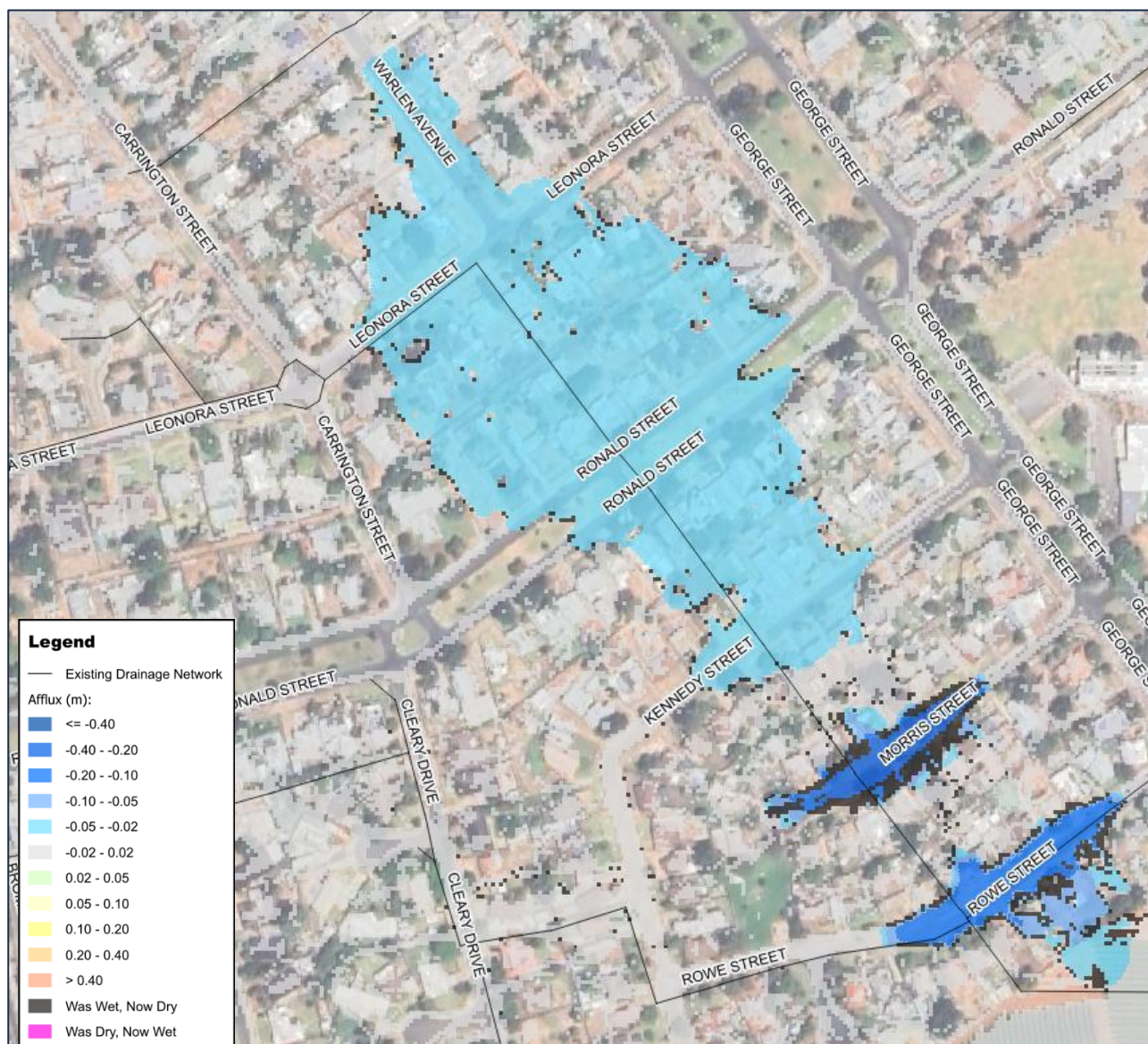


Figure 9-9 Mitigation Option R03 - 1% AEP Afflux in Central Robinvale

In the eastern areas of Robinvale, 1% AEP peak water levels adjacent to the town levee reduced by 20 – 30 mm as presented in Figure 9-10.

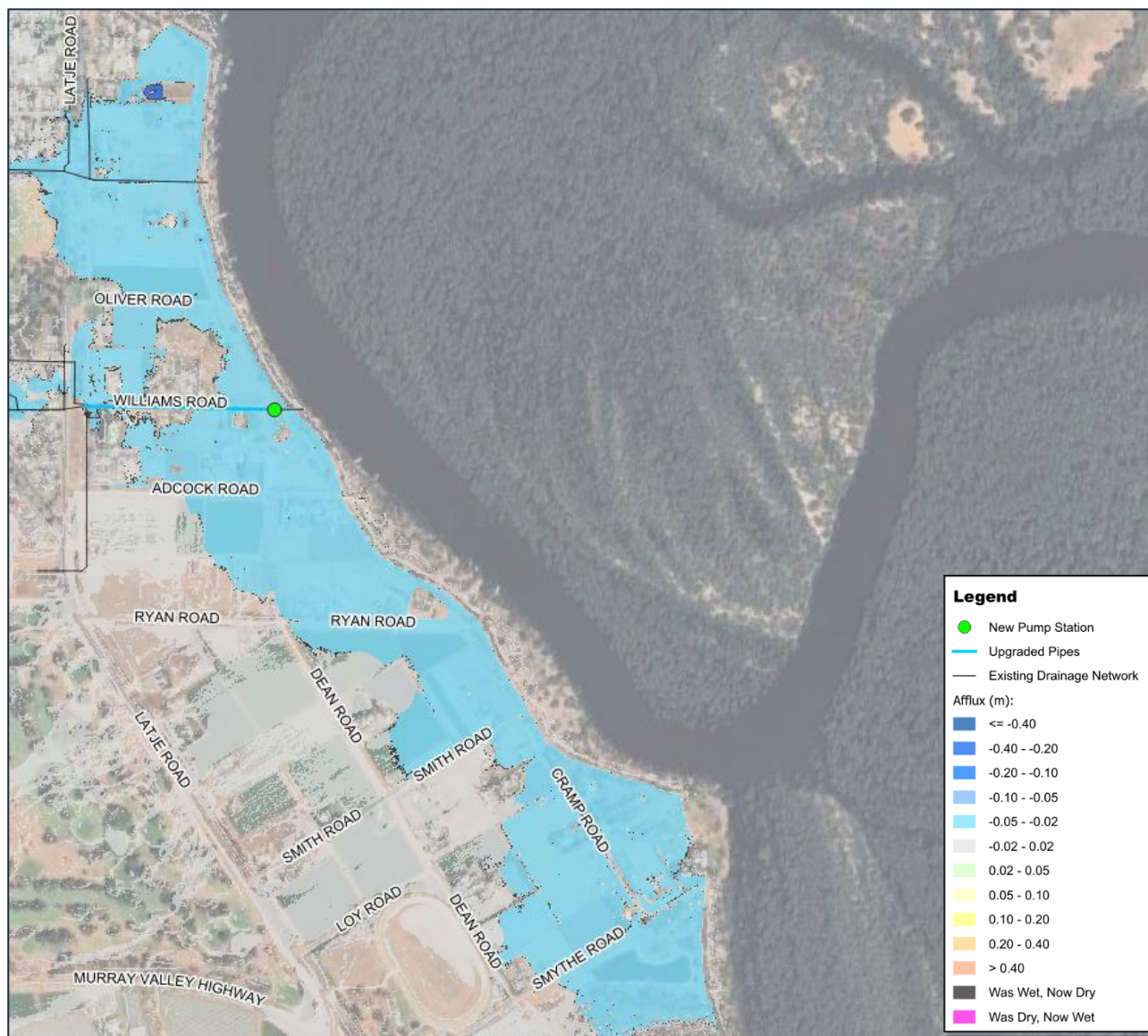


Figure 9-10 Mitigation Option R03 - 1% AEP Afflux in Eastern Robinvale

In the 5% AEP event, Option R03 provided minimal improvement to peak water levels. On Latje Road adjacent to the upgraded Williams Road stormwater pipes, 20% AEP peak water levels reduced by 55 mm. Option R03 20% afflux is presented in **Figure 9-11**.



Figure 9-11 Mitigation Option R03 - 20% AEP Afflux

9.2.4 Refined Williams Road Stormwater Upgrade – R04

Option R04 reduced 1% AEP peak water levels on Leonora Street and Ronald Street by up to 50 mm. On Morris and Rowe Street, 1% AEP peak water levels were reduced by 430 mm and 125 mm respectively. Option R04 1% AEP afflux in central Robinvale is presented in **Figure 9-12**.

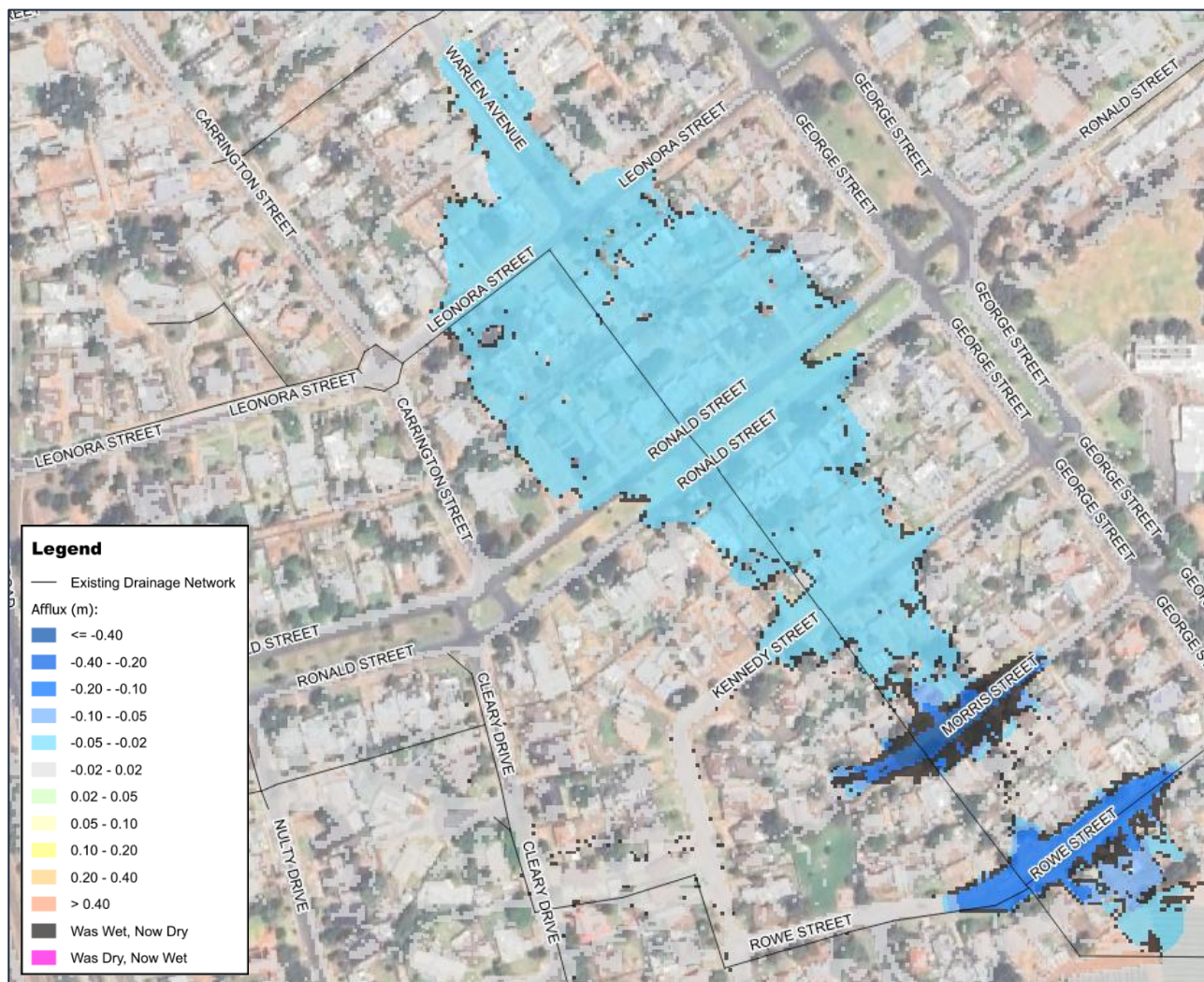


Figure 9-12 Mitigation Option R04 - 1% AEP Afflux in Central Robinvale

In eastern Robinvale, Option R04 resulted in a 30 – 60 mm reduction in 1% AEP peak water level, presented in Figure 9-13.

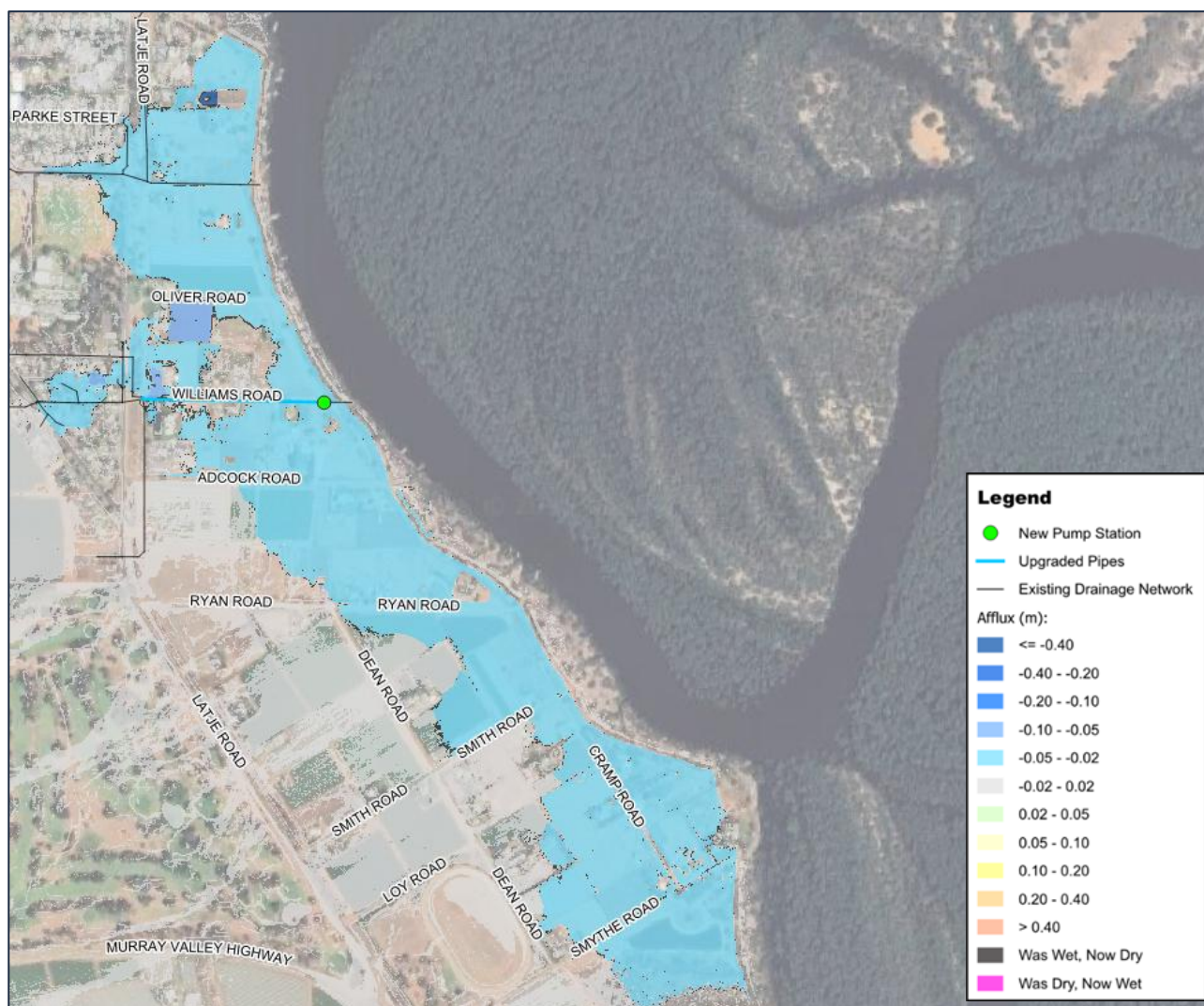


Figure 9-13 Mitigation Option R04 - 1% AEP Afflux in Eastern Robinvale

For Option R04, the 20% AEP event resulted in very similar afflux to that of Option R03, with 55 mm reductions in peak water level on Latje Road adjacent to the upgraded Williams Road pipes.

9.2.5 Ronald Street Stormwater Upgrade with Swales and Pump Station – R05

Option R05 produced substantial reductions in 1% AEP peak water level for both central and eastern Robinvale. In central Robinvale, 1% AEP peak water levels were reduced by 130 mm on Morris Street and up to 40 mm on the adjacent streets of Leonora, Ronald and Rowe Street. Option R05 Central Robinvale afflux in the 1% AEP event is presented in **Figure 9-14**.

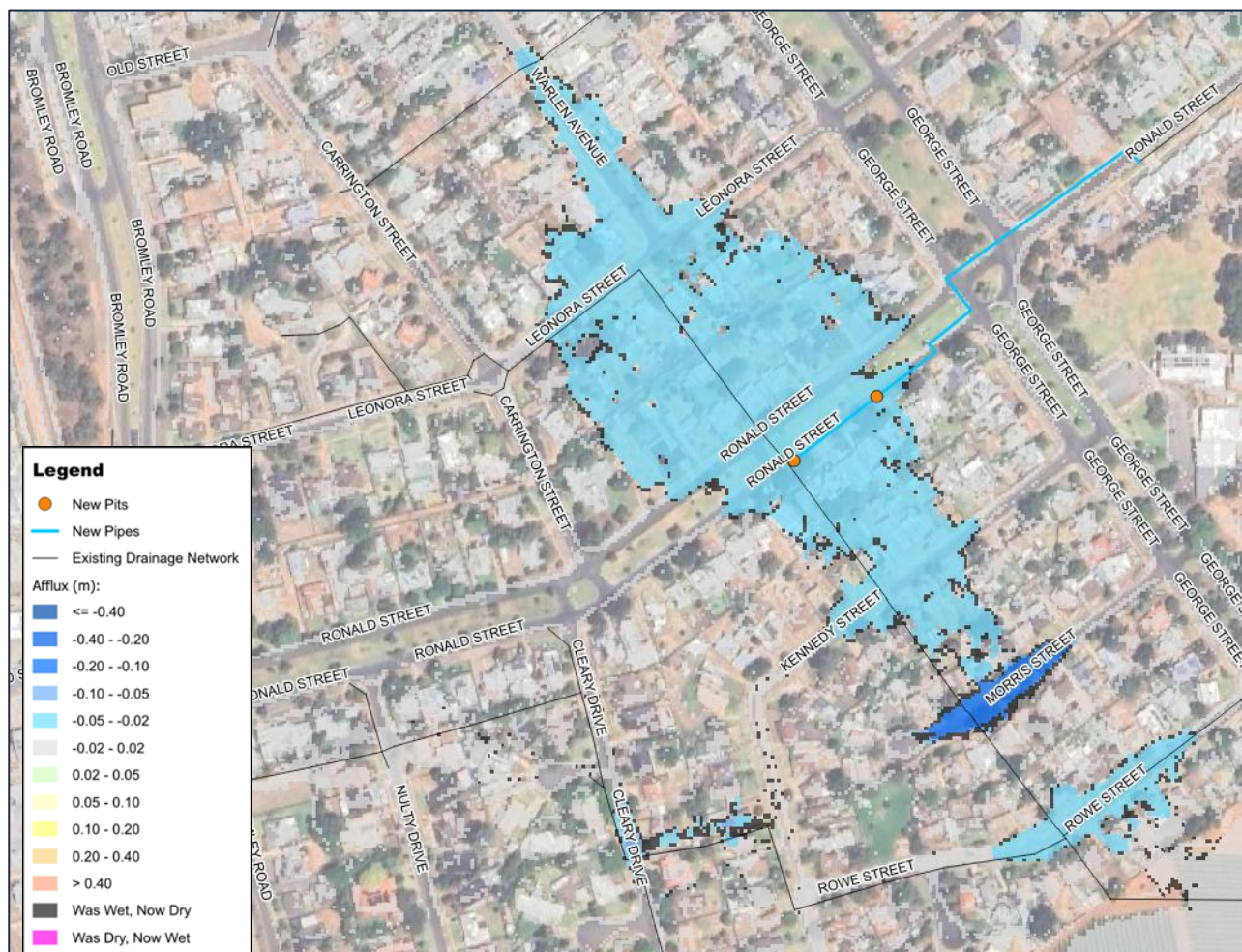


Figure 9-14 Mitigation Option R05 - 1% AEP Afflux in Central Robinvale

In the vicinity of Lawrence Road and Alexander Street, 1% AEP peak water levels reduced by 160 – 190 mm, with a substantial reduction in flood extent (denoted by the "Was Wet, Now Dry" region). Option R05 1% afflux in this area is presented in **Figure 9-15**.

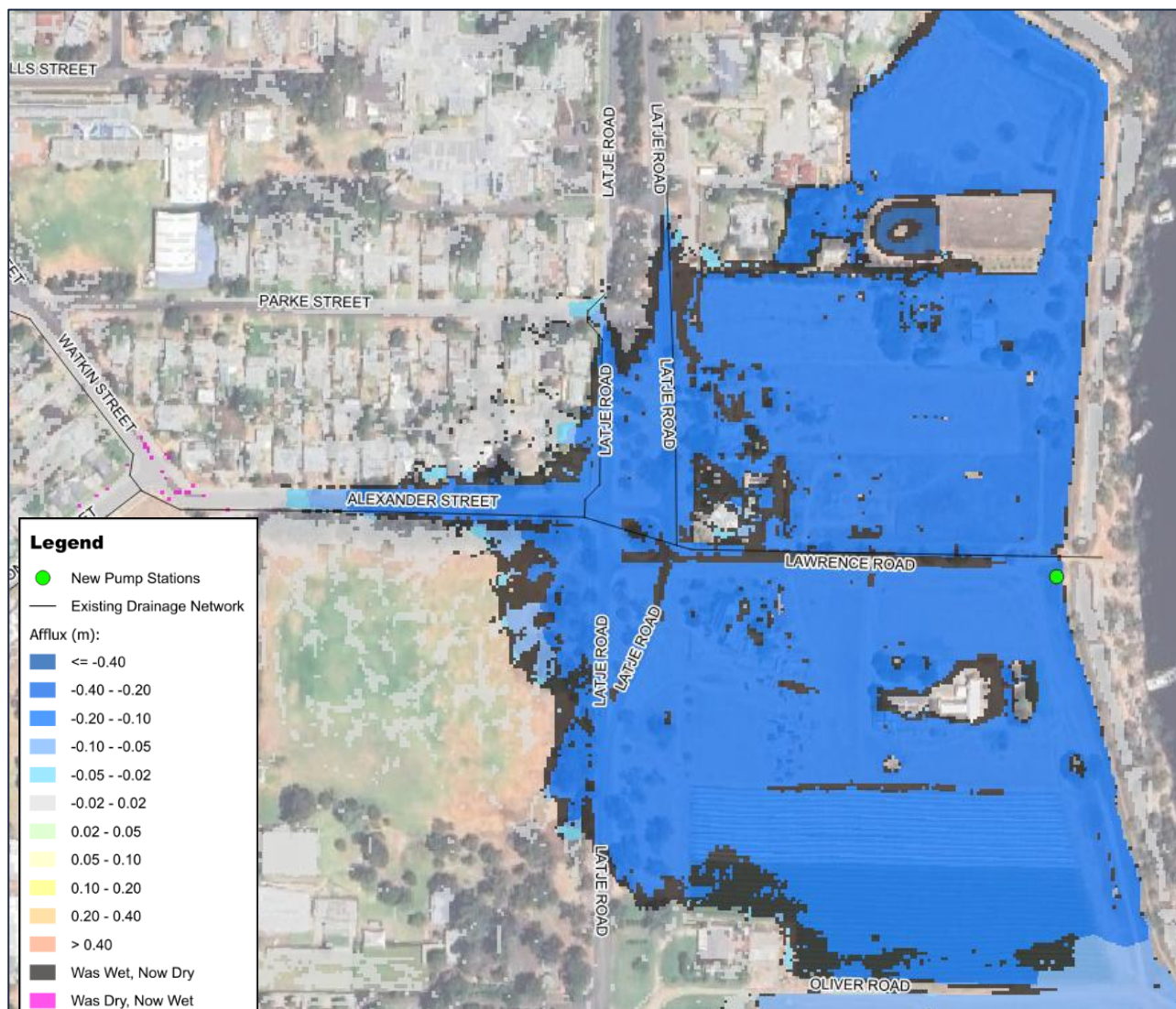


Figure 9-15 Mitigation Option R05 - 1% AEP Afflux in the Vicinity of Lawrence Road and Alexander Street

South of Oliver Road, peak water level reductions diminished from 80 mm at Oliver Road to 20 mm at Smythe Road to the southeast, presented in **Figure 9-16**.

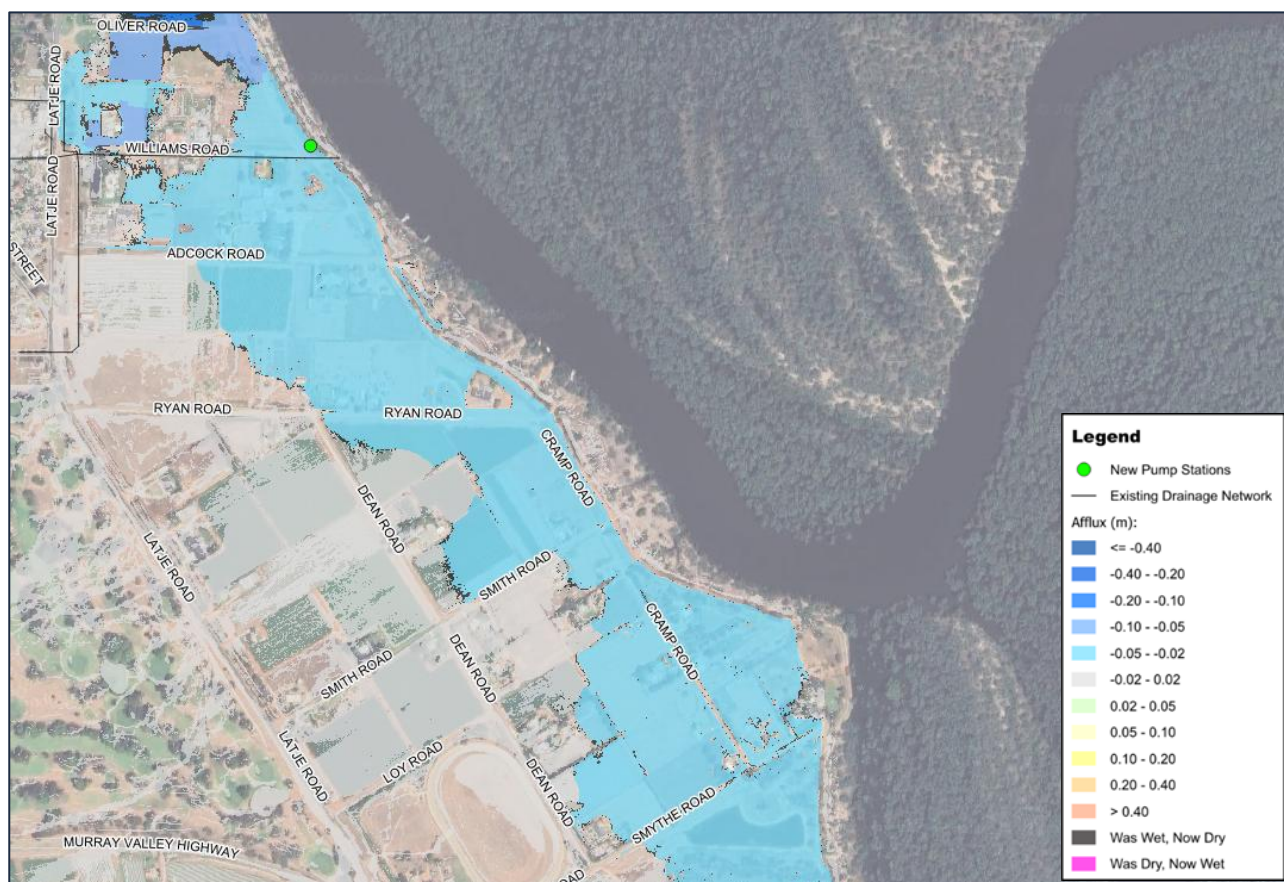


Figure 9-16 Mitigation Option R05 - 1% AEP Afflux in the from Oliver Road to Smythe Road

In the 20% AEP event, peak water level on Ronald Street reduced by 70 – 110 mm near the new inlet pits, as presented in **Figure 9-17**.



Figure 9-17 Mitigation Option R05 - 20% AEP Afflux on Ronald Street

Option R05 presented moderate improvements to 20% AEP peak water level in eastern Robinvale. In the vicinity of Williams and Adcock Road, peak water level was reduced by 40 – 70 mm, with greater reductions immediately surrounding the new pump station. These reductions in peak water level are presented in **Figure 9-18**.

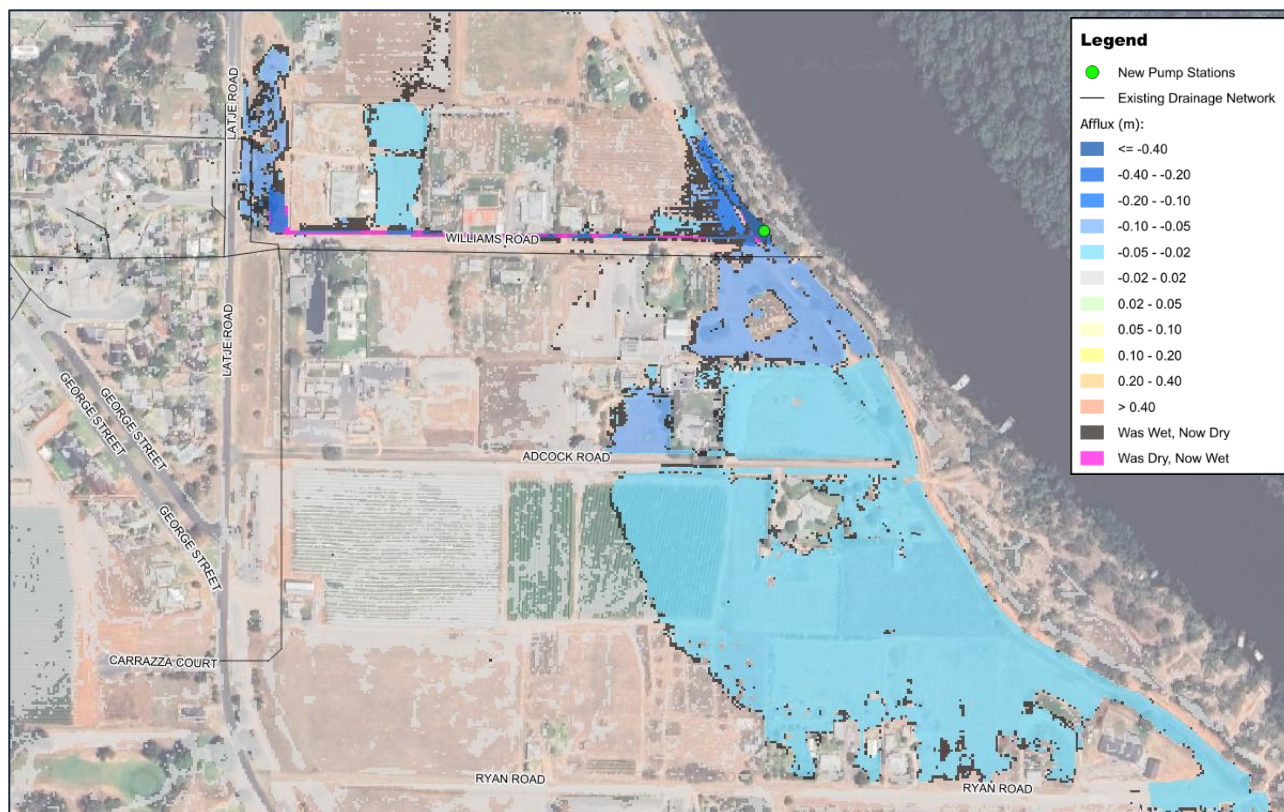


Figure 9-18 Mitigation Option R05 - 20% AEP Afflux in the Vicinity of Williams and Adcock Road

9.2.6 Results Summary

The decrease in the duration of inundation for each mitigation option compared to the existing scenario is summarised below in **Table 9-1** and **Table 9-2** for the 1% and 20% AEP event, respectively. Mitigation options R02 and R04 are further refinements of mitigation options R01 and R04, resulting in larger decreases in the duration of inundation. Compared to focusing on upgrading the existing stormwater network under Williams Road (i.e., R03 and R04), constructing a new drainage network from the low-lying areas in Ronald Street, along with new formalised swales, significantly reduces the inundation time—particularly at Ronald Street, Ryan Road, Williams Road, and Adcock Road.

It is recommended that Council consider Robin Street Stormwater Network Upgrade (R02) and Ronald Street Stormwater Upgrade with Swales and Pump Station (R05) and progress them to the next stage of discussion.

Table 9-1 Robinvale Inundation Duration Change 1% AEP

Road Name	Decrease in in Duration of Inundation [hours] (Duration of Inundation for Mitigation Option [hours])				
	R01	R02	R03	R04	R05
	360 min, TP02	360 min, TP02	360 min, TP09	360 min, TP09	540 min, TP07
Robin Street	5.2 (9.2)	7.7 (5.3)	NA (11.8)	NA (11.8)	NA (16.5)
River Grove	2.5 (0.8)	1.2 (2.2)	NA (2.9)	NA (2.9)	NA (3.8)
Margaret Street	4.9 (0)	4.7 (0)	NA (0)	NA (0)	NA (0)
Latje Road	1.6 (12.1)	2.9 (12.1)	1.5 (12.2)	4.0 (12.2)	6.5 (14.8)
George Street	1.4 (12.9)	4.0 (12.9)	NA (12.9)	NA (12.9)	NA (18.3)
Herbert Street	1.3 (7.3)	3.2 (5.8)	NA (9.0)	NA (9.0)	NA (9.6)
Malla Avenue	1.2 (7.0)	3.1 (5.4)	NA (8.3)	NA (8.4)	NA (9.2)
Watkin Street	1.4 (1.8)	2.3 (1.0)	NA (2.2)	NA (2.2)	NA (2.3)
Warlen Avenue	NA (9.9)	NA (9.9)	1.3 (9.5)	1.6 (9.2)	1.3 (10.9)
Leanora Street	NA (12.9)	NA (12.9)	1.1 (12.9)	1.6 (12.9)	1.1 (18.3)
Ronald Street	NA (10.7)	NA (10.7)	1.1 (10.2)	1.4 (9.9)	1.9 (8.4)
Morris Street	NA (5.6)	NA (5.6)	2.6 (4.0)	4.4 (1.8)	1.3 (5.6)
Row Street	NA (6.0)	NA (6.0)	1.1 (5.5)	1.3 (5.4)	NA (7.2)
Ryan Road	NA (10.5)	NA (10.5)	5.2 (10.4)	5.3 (10.4)	9.2 (14.4)
Williams Road	NA (9.2)	NA (9.2)	4.3 (8.0)	4.8 (8.0)	8.2 (6.9)
Adcock Road	NA (10.6)	NA (10.6)	3.9 (10.5)	4.4 (10.5)	10.4 (14.6)

Table 9-2 **Inundation Duration Change 20% AEP**

Road Name	Decrease in in Duration of Inundation [hours] (Duration of Inundation for Mitigation Option [hours])				
	R01	R02	R03	R04	R05
	270 min, TP04	270 min, TP04	360 min, TP06	540 min, TP02	540 min, TP02
Robin Street	1.3 (2.7)	3.2 (0.8)	NA (4.8)	NA (8.6)	NA (8.6)
River Grove	NA (0)	NA (0)	NA (0)	NA (0)	NA (0)
Margaret Street	NA (0)	NA (0)	NA (0)	NA (0)	NA (0)
Latje Road	NA (0)	NA (0)	-1.7 (0)	-1.7 (0)	NA (0)
George Street	NA (6.2)	NA (6.2)	-2.3 (12.1)	-2.3 (18.8)	-0.7 (18.8)
Herbert Street	NA (1.8)	NA (1.8)	NA (2.7)	NA (2.9)	NA (2.9)
Malla Avenue	NA (1.4)	NA (1.2)	NA (0)	NA (1.5)	NA (1.5)
Watkin Street	NA (0)	NA (0)	NA (0)	NA (0)	NA (0)
Warlen Avenue	NA (3.9)	NA (3.9)	NA (5.1)	NA (7.5)	NA (7.5)
Leanora Street	NA (6.6)	NA (6.6)	NA (12.2)	NA (18.9)	NA (18.9)
Ronald Street	NA (2.4)	NA (2.4)	NA (5.0)	NA (6.5)	NA (0)
Morris Street	NA (0)	NA (0)	NA (0)	NA (0)	NA (0)
Row Street	NA (2.2)	NA (2.2)	NA (3.3)	NA (3.6)	NA (3.6)
Ryan Road	NA (1.7)	NA (1.7)	NA (7.1)	NA (12.3)	NA (12.2)
Williams Road	NA (0)	NA (0)	NA (0)	NA (0)	NA (0)
Adcock Road	NA (0)	NA (0)	NA (6.9)	NA (12.8)	NA (12.8)

9.3 SWAN HILL MITIGATION OPTIONS

9.3.1 Werril Street Drainage Upgrade with Channel Re-establishment and Pump Station - S01

Mitigation Option S01 focused on development of a new major drainage network in the southern end of the township. A new major drainage pipeline was implemented along Werril Street, featuring twin 1200 mm RCPs underneath the road corridor. Feeding into this drainage pipeline was a new stormwater network on the southern half of Yana Street, and the re-established No. 9 Channel. The existing stormwater network on Parkview Drive, Wilkins Grove and Poole Boulevard was redirected into the No. 9 Channel to utilise the new southern drainage pipeline. New pump stations were implemented on Landy Crescent and Charlie Gray Close, pumping stormwater to both the No. 9 Channel and the new stormwater pipes on Yana Street.

The existing pump station on Pental Island Road was upgraded to have a peak capacity of 4 m³/s (increased from 0.28 m³/s) to accommodate the new pipeline flows which drain to the basin adjacent to the pump station. The layout of Option S01 is presented in **Figure 9-19**.

9.3.2 Nalder Drive to Nowie Street Stormwater Upgrade - S02

Mitigation Option S02 involved upgrading pipe sizes in the existing stormwater network in the vicinity of Nowie Street to remove several pipe size bottlenecks. The stormwater pipes on Nowie Street between Cleeland Drive and Cobham Avenue were increased to 750 mm diameter RCPs. The stormwater pipes running from the bend in Nalder Drive to the intersection of Cobham Avenue and Nowie Street were increased to 600 mm RCPs. Certain inlet pit sizes were also upgraded in the vicinity. Additionally, the stormwater pipes from Campbell Street to the outlet at the Little Murray River were increased to 900 mm RCPs. The layout of Option S02 is presented in **Figure 9-20**.

9.3.3 Main Drain Pump Station Upgrade - S03

Mitigation Option S03 focused on a major upgrade to Swan Hill's largest pump station, the pump station at the downstream end of the Main Drain. Option S03 was simulated to have a total peak pump station capacity of 10 m³/s, increased from the existing case peak capacity of 3.3 m³/s. The layout of Option S03 is presented in **Figure 9-21**.

9.3.4 Milloo Street and Chapman Street Pump Station and Drainage Upgrade - S04

Mitigation Option S04 included various pipe size and inlet pit upgrades near the Swan Hill CBD. Along Chapman Street, the stormwater pipes between Gurnett Oval and Campbell Street were increased to 600 mm diameter RCPs. From Campbell to Curlewis Street, the Chapman Street stormwater pipes were increased to 750 mm diameter RCPs. The stormwater pipes along Hastings Street were increased to 900 mm RCPs. Four inlet pits were upgraded to 1200 x 1200 mm square inlet pits. Additionally, the existing pump station on Milloo Street was upgraded to have a peak capacity of 1.1 m³/s. The layout of Option S04 is presented in **Figure 9-22**.

9.3.5 Butterworth Street to Main Drain Stormwater Network - S05

Mitigation Option S05 featured a new stormwater pipe network on Notting Road, Hocking Drive, Williams Road, Suttie Drive, Butterworth Street, Graemer Drive, Derham Drive and Yvonne Close. With the exception of Butterworth Street and Williams Road, all of these streets were simulated with 300 mm stormwater pipes and 600 x 900 mm inlet pits. These streets drained to Butterworth Street and Williams Road, through 450 mm and then 600 mm RCPs respectively. The stormwater pipes along Williams Road discharged to the Main Drain. The layout of Option S04 is presented in **Figure 9-23**.

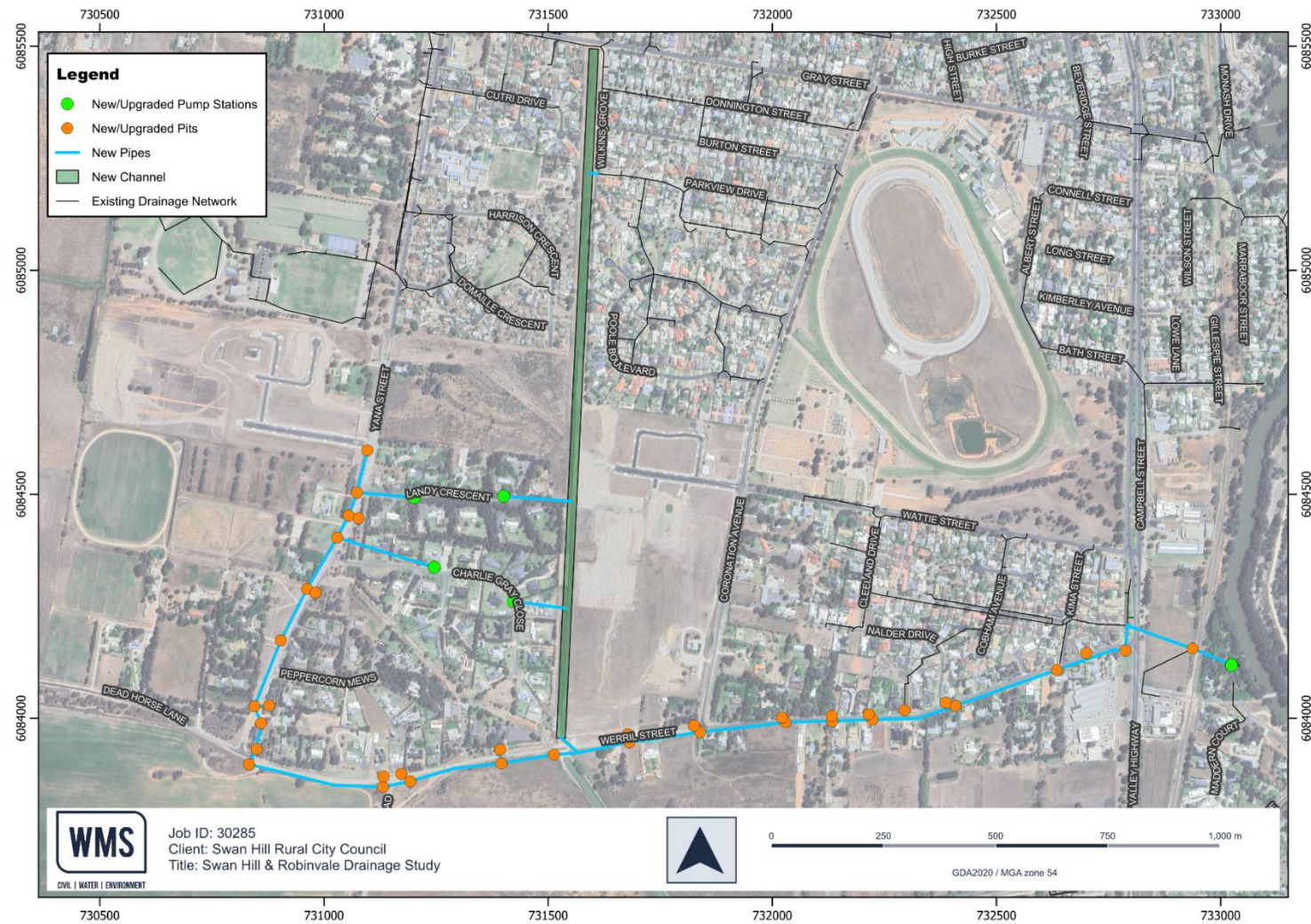


Figure 9-19 Swan Hill Mitigation Option S01 Layout

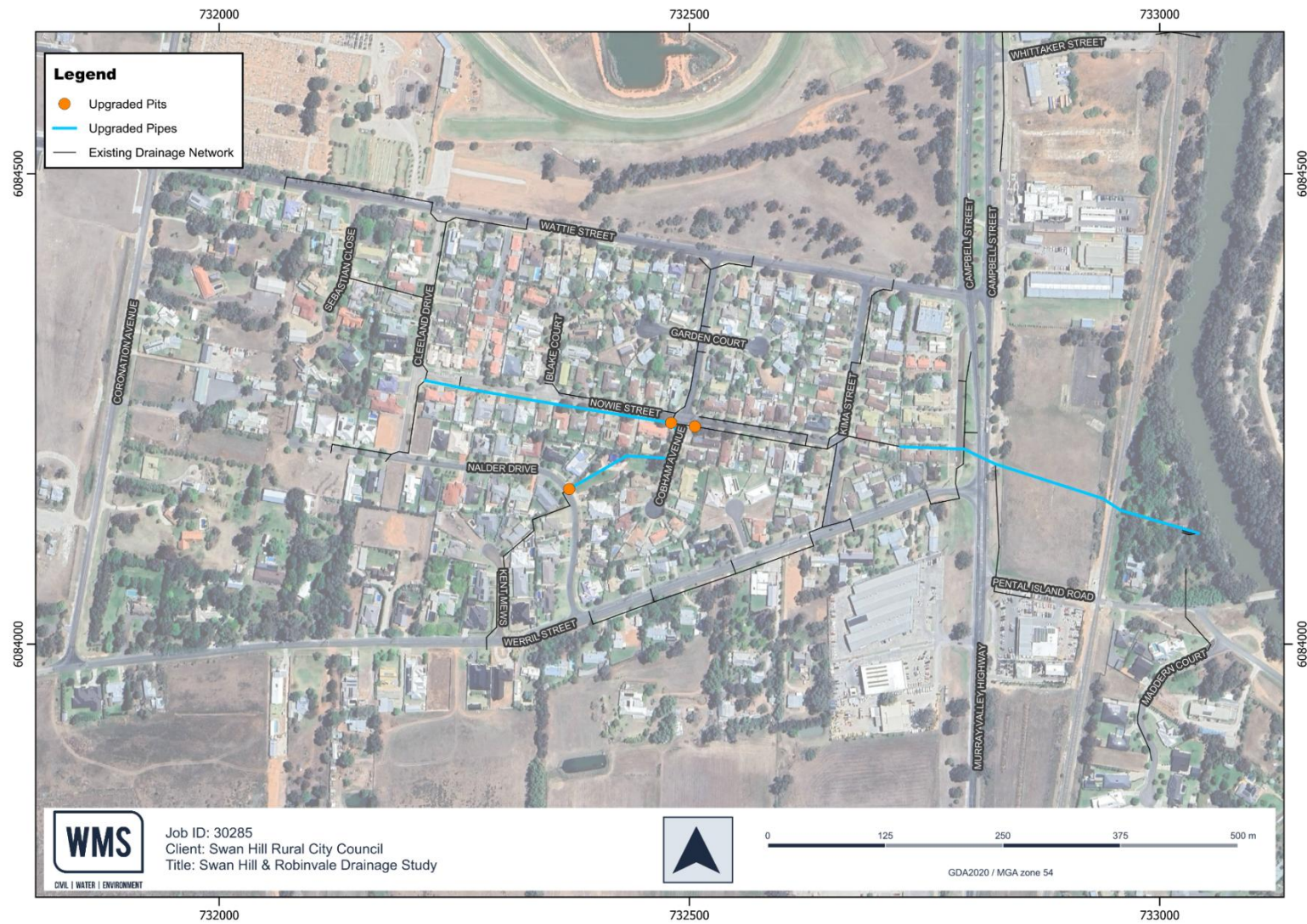


Figure 9-20 Swan Hill Mitigation Option S02 Layout

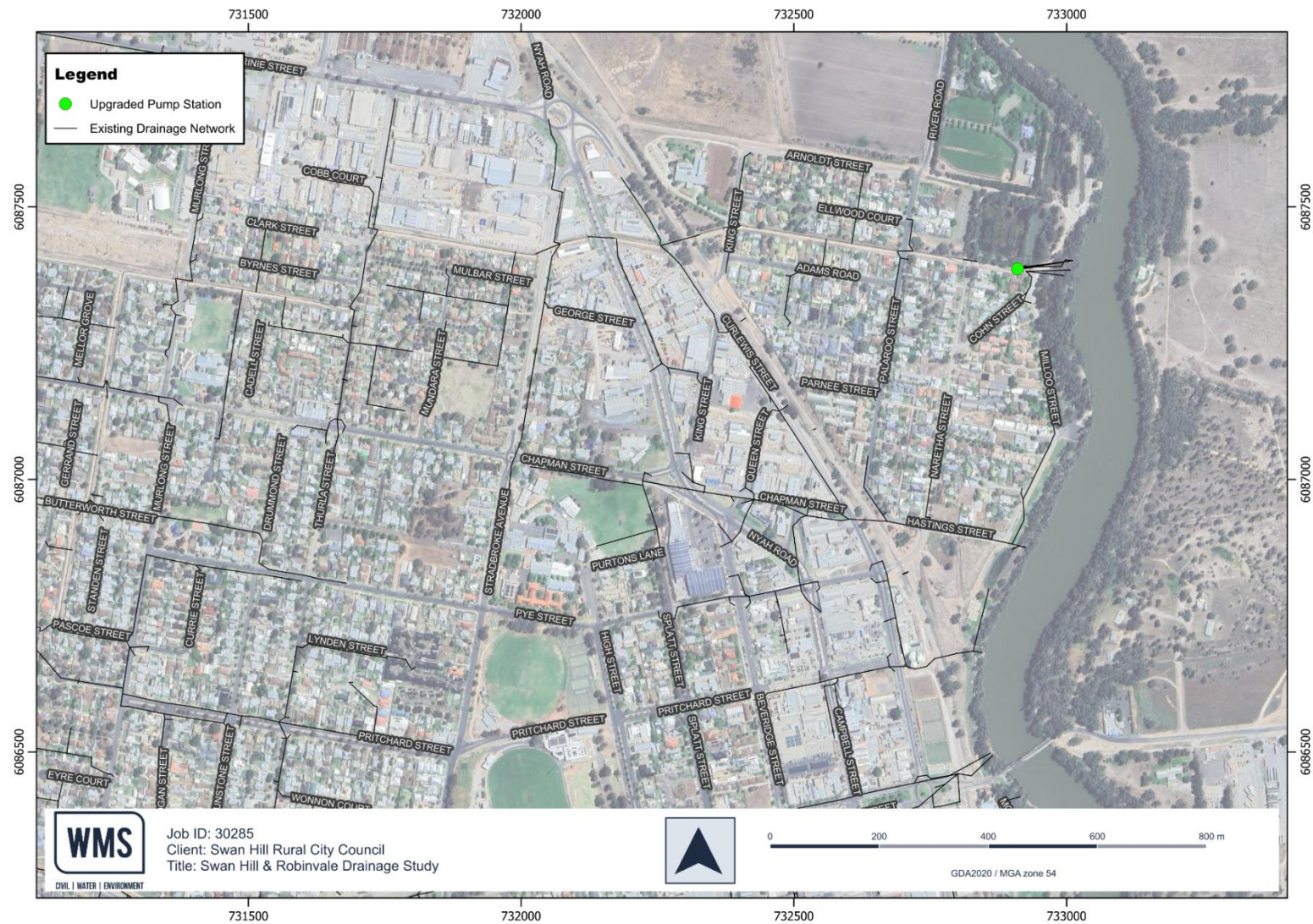


Figure 9-21 Swan Hill Mitigation Option S03 Layout

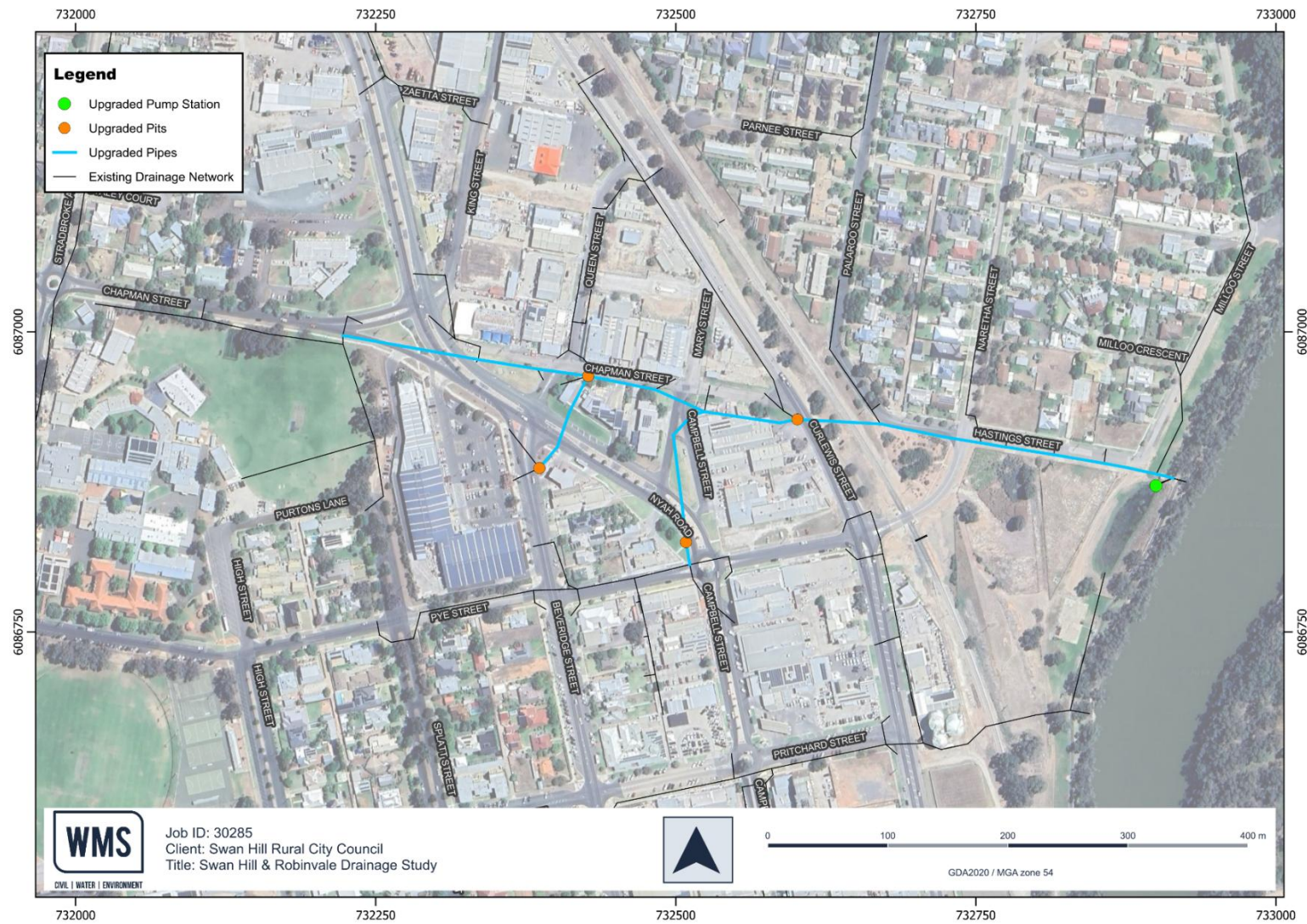


Figure 9-22 Swan Hill Mitigation Option S04 Layout

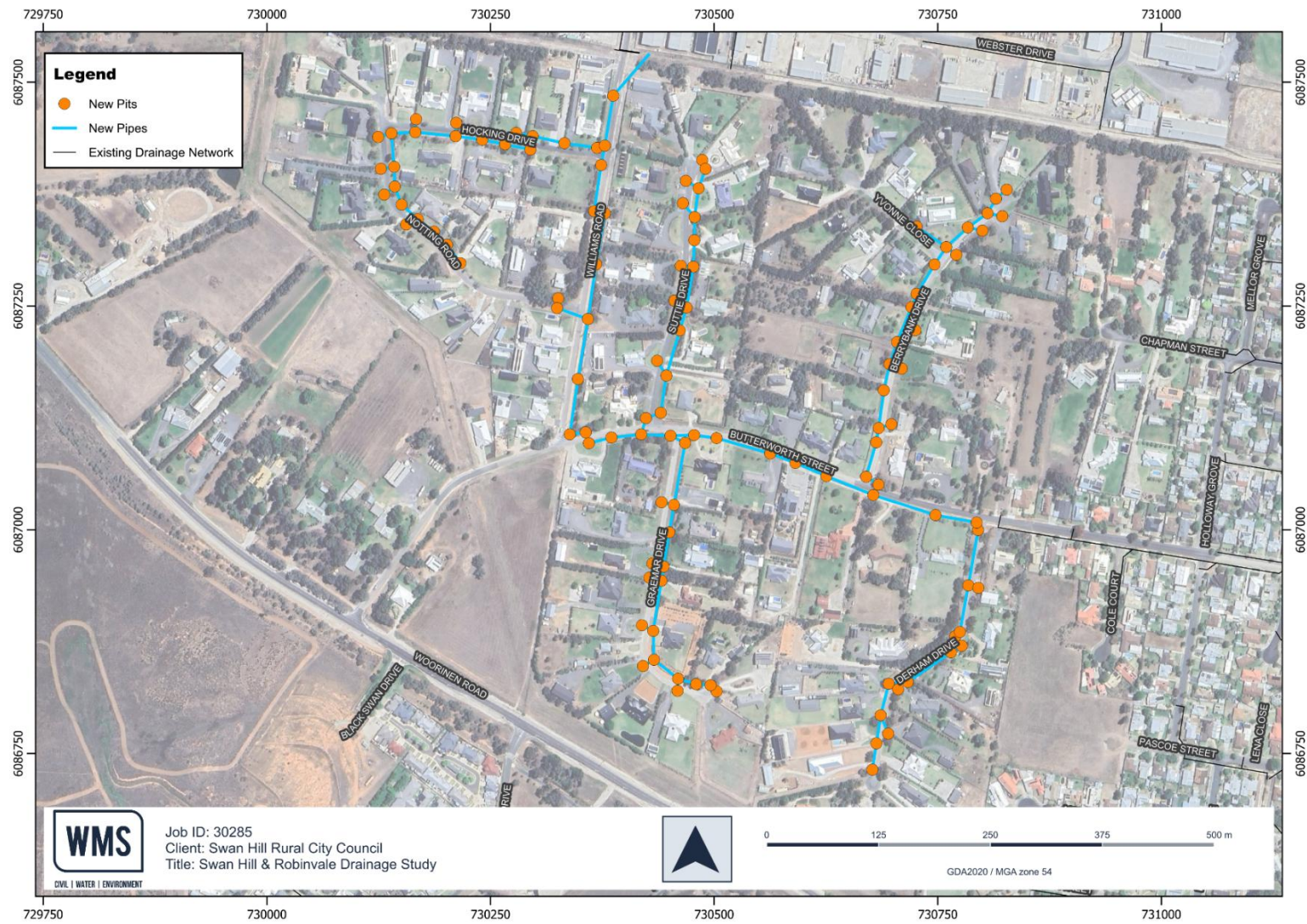


Figure 9-23 Swan Hill Mitigation Option S05 Layout

9.4 SWAN HILL MITIGATION OPTION RESULTS

For each mitigation option, afflux (difference in peak water level) between the simulated mitigation option and existing case model results were produced. These afflux results highlight the expected locations and magnitude of flood improvements following implementation of each mitigation option. The following sections detail water level afflux results for each Swan Hill mitigation option. Mappings of flood depth, velocity, hazard and afflux for each mitigation option are presented in **Appendix E**.

9.4.1 Werril Street Drainage Upgrade with Channel Re-establishment and Pump Station - S01

Mitigation Option S01 saw widespread reductions in flood level throughout the southern areas of the township. Generally, flood level reductions were greatest in the 1% and 2% AEP events, with minor improvements to 20% AEP flood levels.

In the 1% AEP event, peak water level in the vicinity of Landy Crescent and Charlie Gray Close reduced by 50 – 90 mm, with slight reductions in flood extent. Along the road corridor of Werril Street, peak water levels decreased by 100 – 500 mm. Much of the road crest of Werril Street becomes flood-free at this location. Afflux in this area in the 1% AEP is presented in **Figure 9-24**.

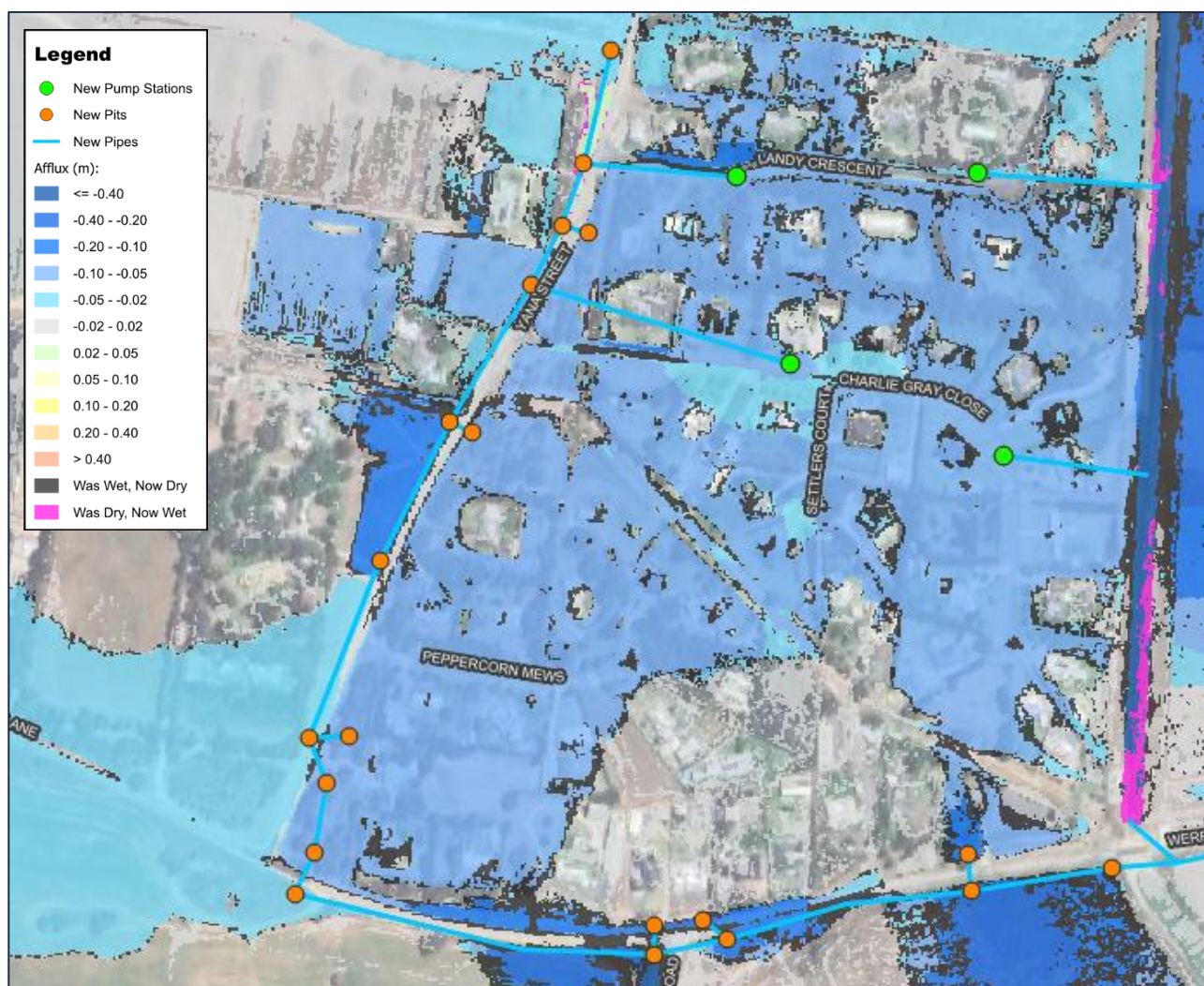


Figure 9-24 Mitigation Option S01 - 1% AEP Afflux in the Vicinity of Landy Crescent and Charlie Gray Close

West of the racecourse, peak water level in the vicinity of Wilkins Grove and Poole Boulevard decreased by 100 – 150 mm. On the other side of the newly re-established No. 9 drain, peak water levels in Jaycee Park and the grounds of the Swan Hill Specialist School decreased by 80 mm. Afflux at these locations are presented in **Figure 9-25**.

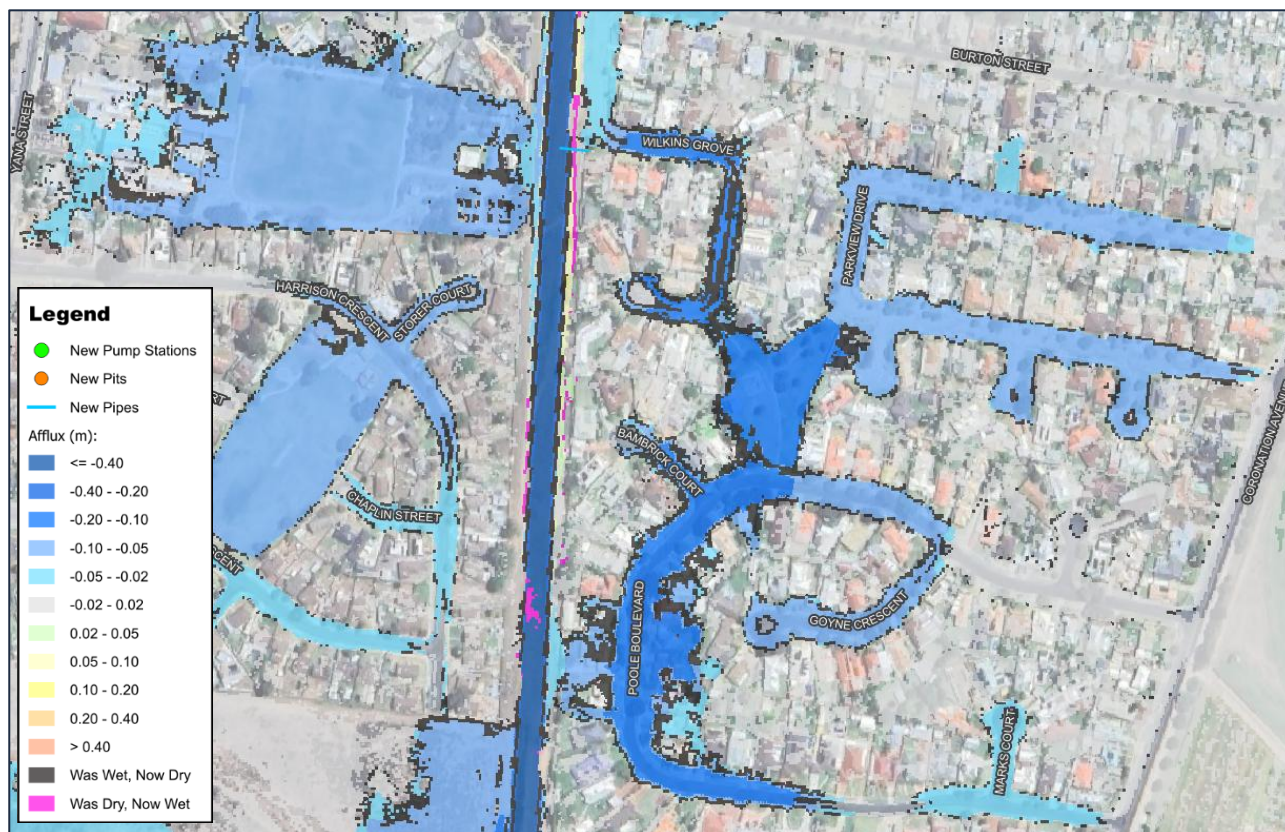


Figure 9-25 Mitigation Option S01 - 1% AEP Afflux in the Vicinity of Poole Boulevard and Wilkins Grove

Similar improvements are observed south of the racecourse in the vicinity of Nowie Street and Nalder Drive. Peak water levels on Nowie Street are decreased by up to 105 mm. Kent Mews experienced a 110 mm decrease in peak water level. Nalder Drive experienced slightly less reduction, with an 80 mm reduction in peak water level.

The 2% AEP event sees even greater reductions in peak water level on Charlie Gray Close and Landy Crescent. These locations experienced a decrease in peak level of 100 – 350 mm, with the roadway of Landy Crescent and Charlie Gray Close becoming flood-immune in this event. Afflux at these locations in the 2% AEP event are presented in **Figure 9-26**.

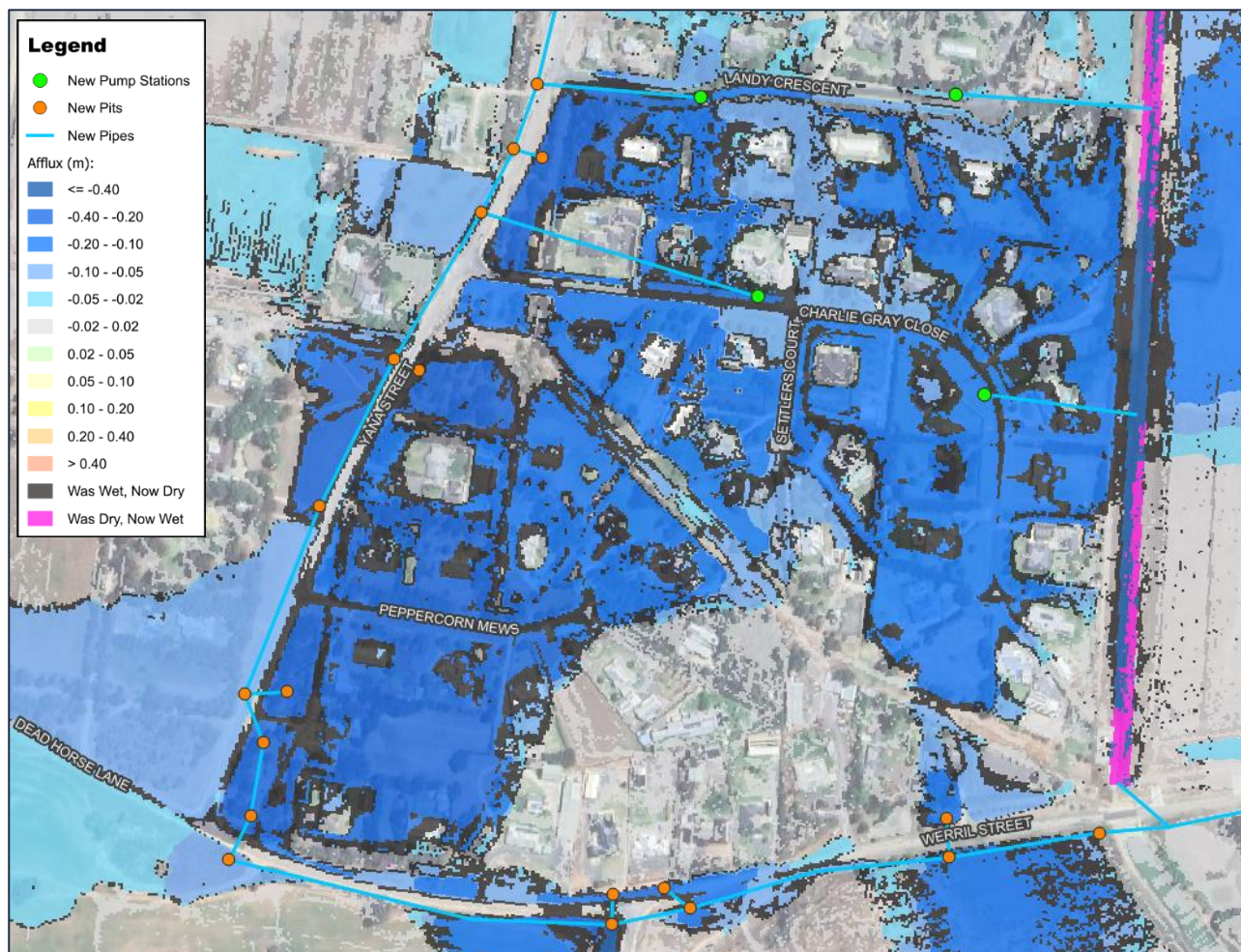


Figure 9-26 Mitigation Option S01 - 2% AEP Afflux in the Vicinity of Landy Crescent and Charlie Gray Close

9.4.2 Nalder Drive to Nowie Street Stormwater Upgrade - S02

Mitigation Option S02 saw moderate improvements to overland flooding in the vicinity of Nowie Street and Nalder Drive. In the 1% AEP event, peak water levels along the roadway of Nowie Street, Cobham Avenue and Kima Street reduced by 50 – 60 mm. Between Nalder Drive and Coronation Avenue, peak water levels reduced by 30 mm. Afflux at these locations in the 1% AEP are presented in Figure 9-27.

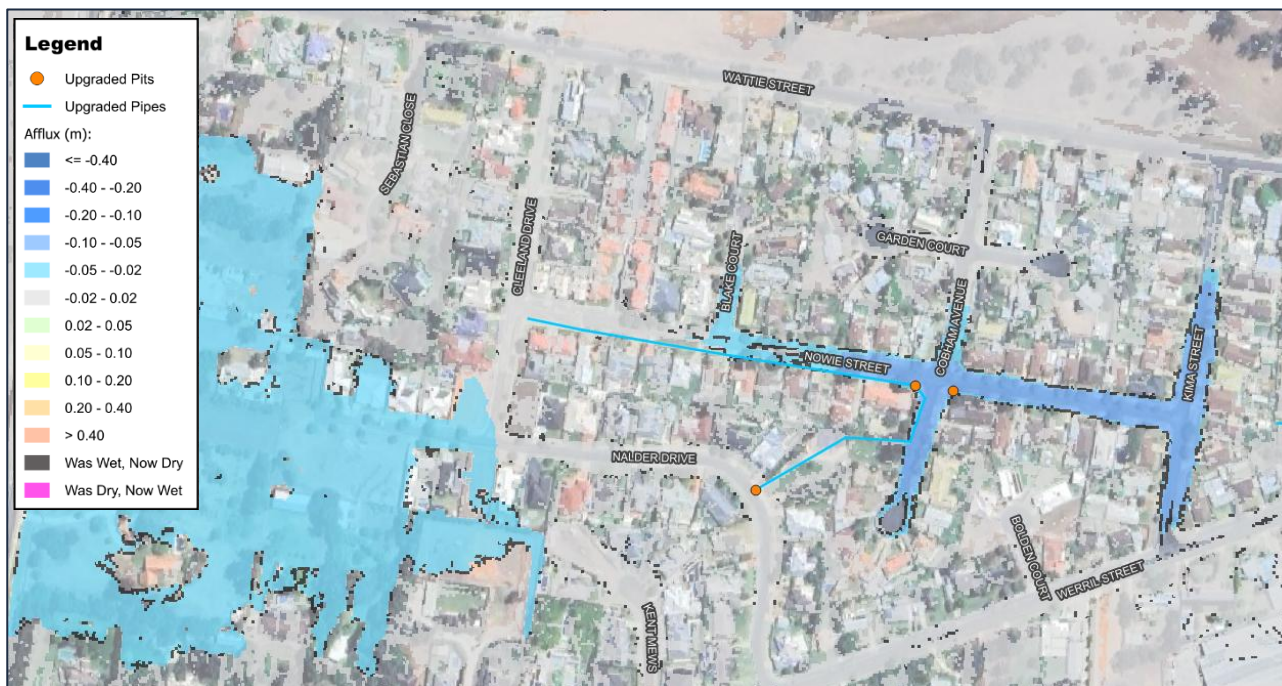


Figure 9-27 Mitigation Option S02 - 1% AEP Afflux in the Vicinity of Nowie Street and Nalder Drive

The 2% AEP event saw minor reductions in peak water level on Nalder and Cleeland Drive, ranging from 20 – 45 mm. In the 20% AEP event, the low point of Nalder Drive (on the bend near the intersection with Werril Street) experienced a 120 mm reduction in peak flood level. Afflux on Nalder Drive in the 20% AEP event is presented in Figure 9-28.

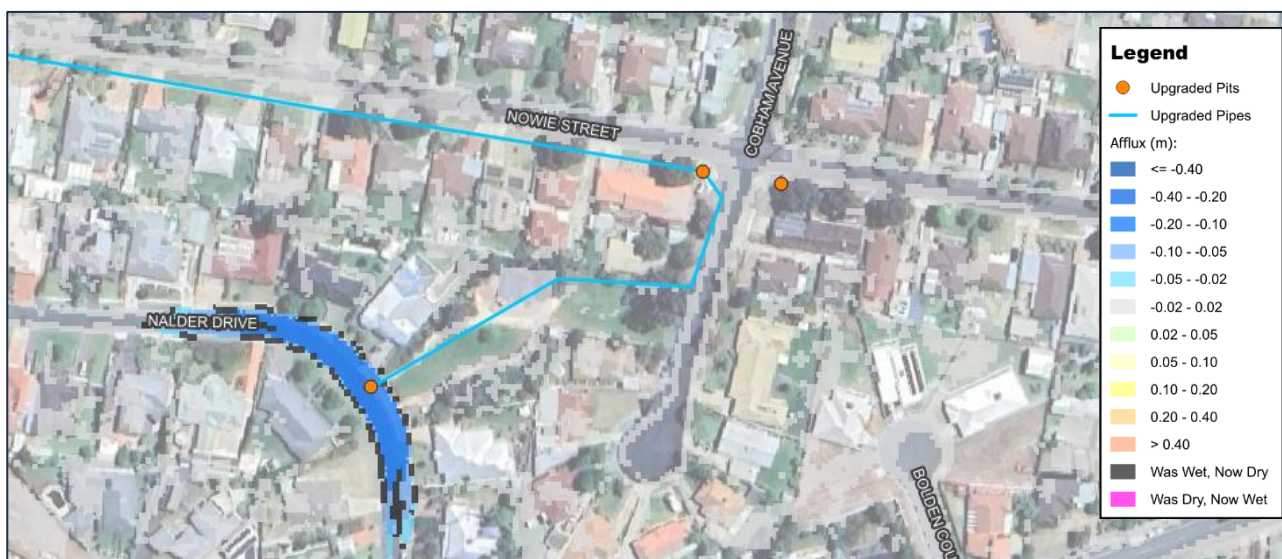


Figure 9-28 Mitigation Option S02 - 20% AEP Afflux in the Vicinity of Nowie Street and Nalder Drive

9.4.3 Main Drain Pump Station Upgrade - S03

Option S03 resulted in substantial flood level decreases for low-lying areas adjacent to the Main Drain in the 1% and 2% AEP events. In the 20% AEP event, peak water level only decreased within the Main Drain itself. In the industrial estate north of the Main Drain, peak water level decreased by 110 mm in the 1% AEP and 130 – 160 mm in the 2% AEP event. Several residential properties to the south of the Main Drain also saw similar reductions in peak water level. Refer to **Figure 9-29** for 1% AEP afflux, and **Figure 9-30** for the 2% AEP afflux at these locations.

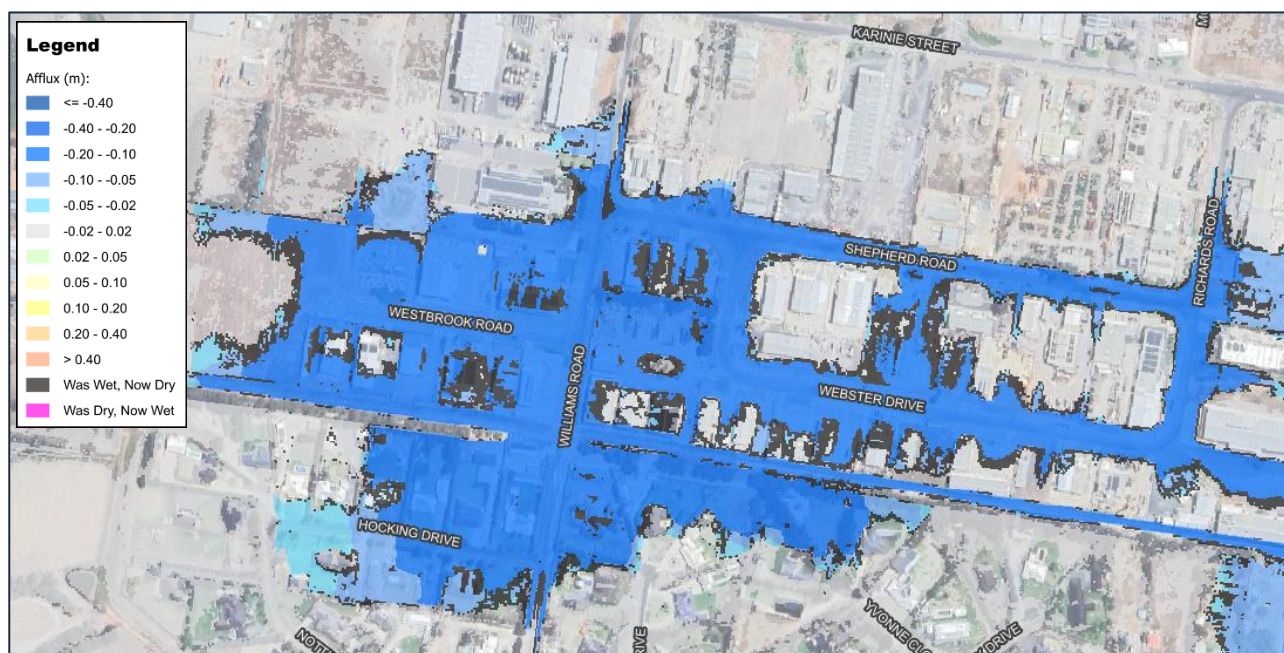


Figure 9-29 Mitigation Option S03 - 1% AEP Afflux in the Industrial Estate Adjacent to the Main Drain

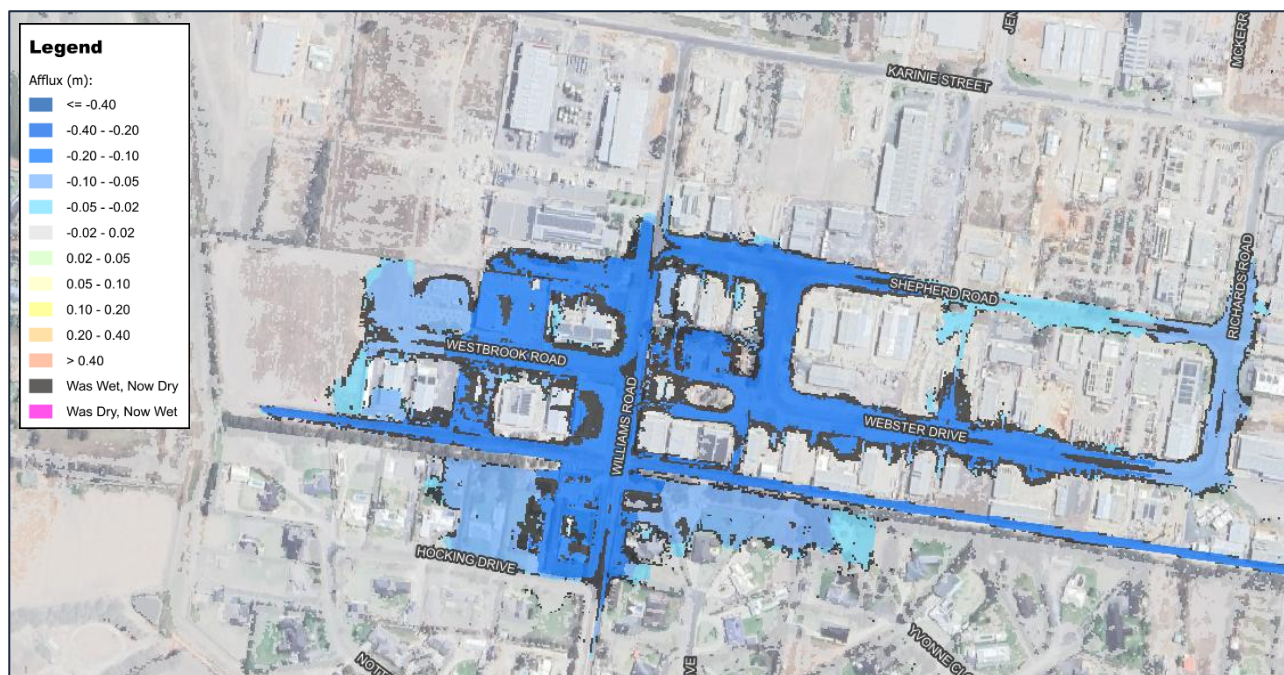


Figure 9-30 Mitigation Option S03 - 2% AEP Afflux in the Industrial Estate Adjacent to the Main Drain

Near Swan Hill North Primary School, peak water level was substantially reduced in the 1% and 2% AEP events. In the school grounds, peak water levels were reduced by 100 – 150 mm in the 1% AEP event and 90 – 160 mm in the 2% AEP event. Roadways near the school experienced decreased peak water levels, including Chapman Street, Murlong Street, Cadell Street, McDonald Court and Gordon Court. Afflux for these locations in the 1% and 2% AEP events are presented in **Figure 9-31** and **Figure 9-32** respectively.

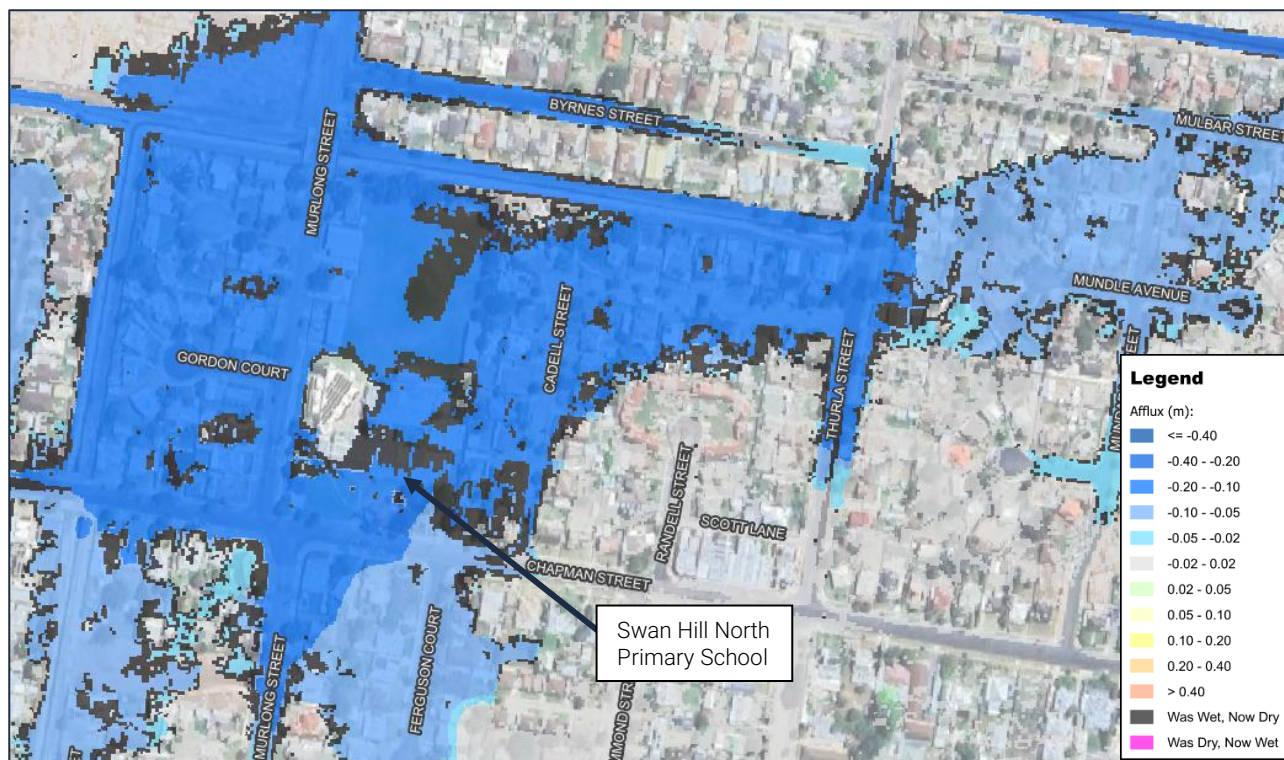


Figure 9-31 Mitigation Option S03 - 1% AEP Afflux Near Swan Hill North Primary School

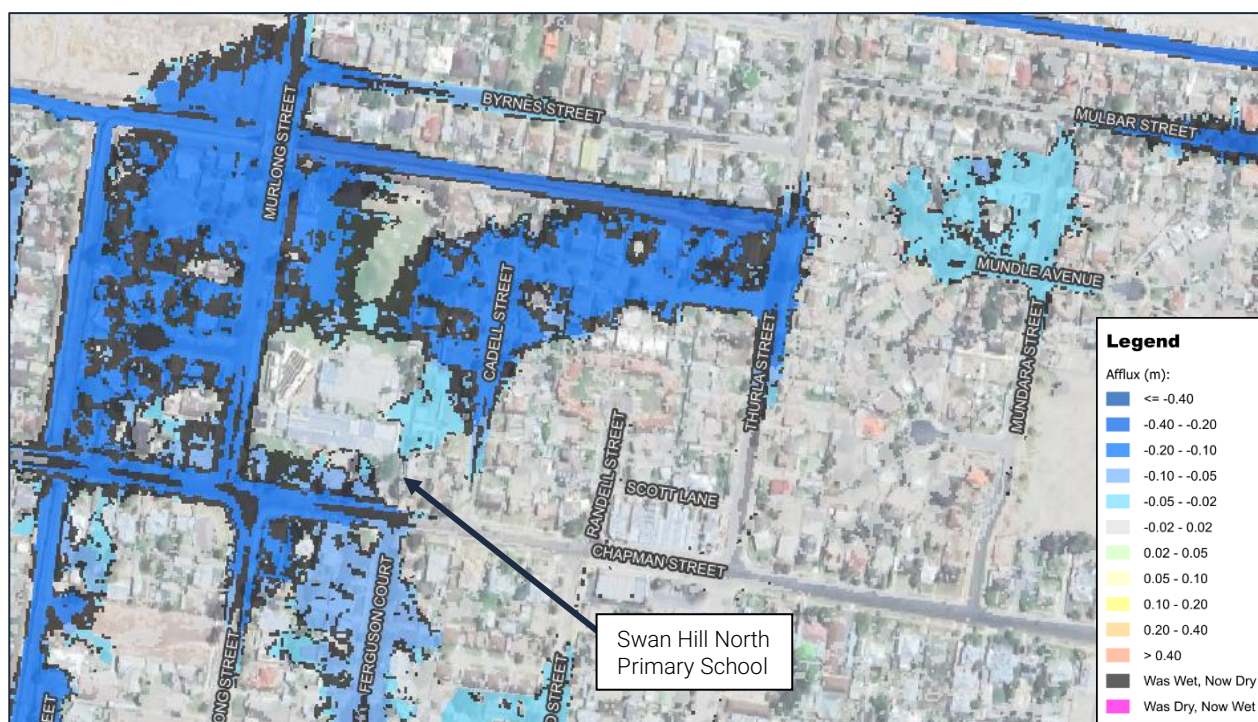


Figure 9-32 Mitigation Option S03 - 2% AEP Afflux Near Swan Hill North Primary School

In the 20% AEP event, reductions in peak water level were limited to the lower sections of the Main Drain near the upgraded pump station. Afflux in the 20% AEP event near the pump station are presented in **Figure 9-33**.

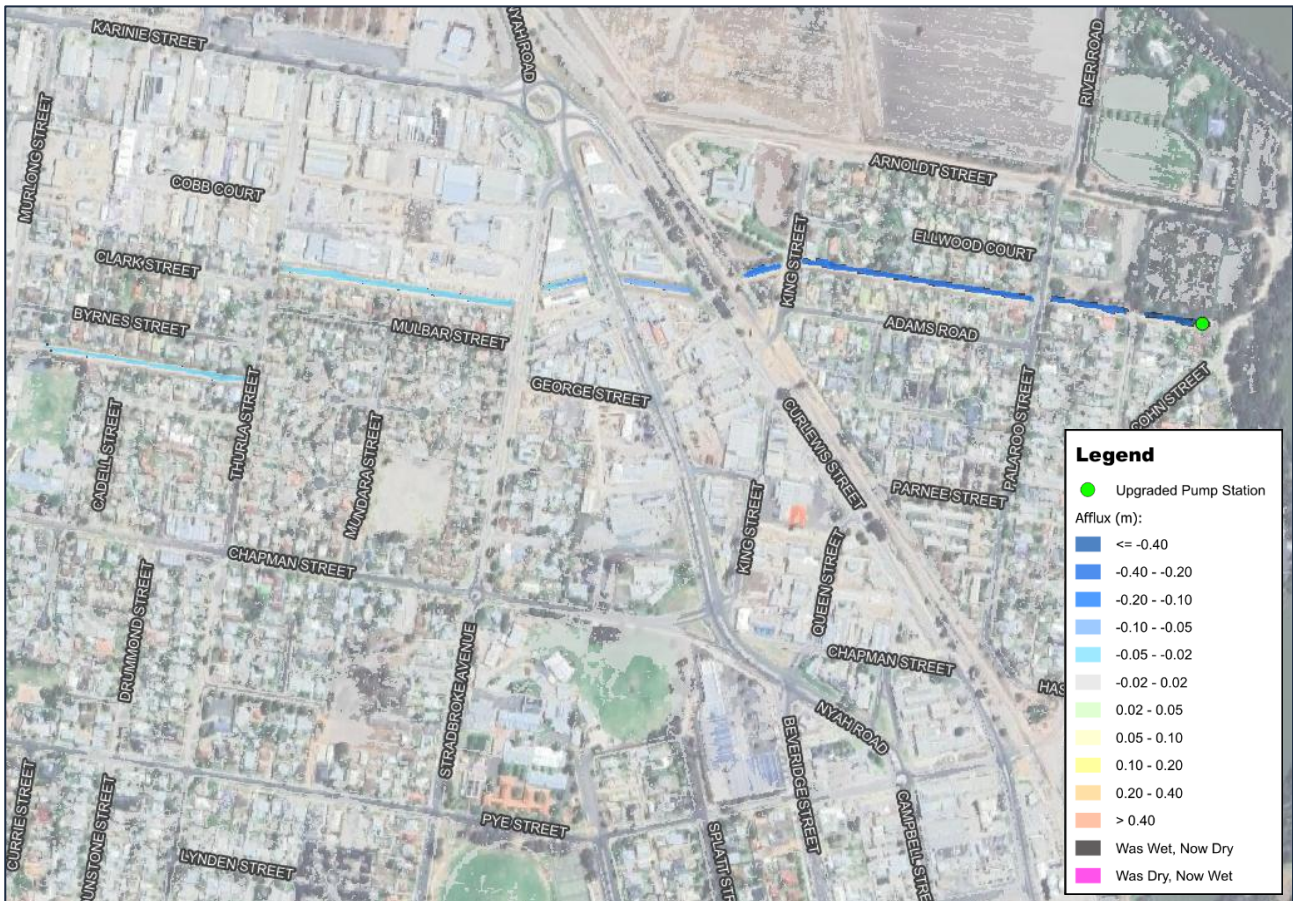


Figure 9-33 Mitigation Option S03 - 20% AEP Afflux within the Main Drain

9.4.4 Milloo Street and Chapman Street Pump Station and Drainage Upgrade - S04

Option S04 saw minor reductions in peak water level along Chapman, Beveridge and Campbell Street across the 20%, 2% and 1% AEP events. Water level reductions at these locations peaked at 60 mm in the 1% AEP event. Increased pipe and pit capacity reduced the quantity of northward overland flow towards Curlewis Street, resulting in 40 – 100 mm reductions in peak water level adjacent to the roadway in the 1% AEP. These reduced water levels are presented in **Figure 9-34**.

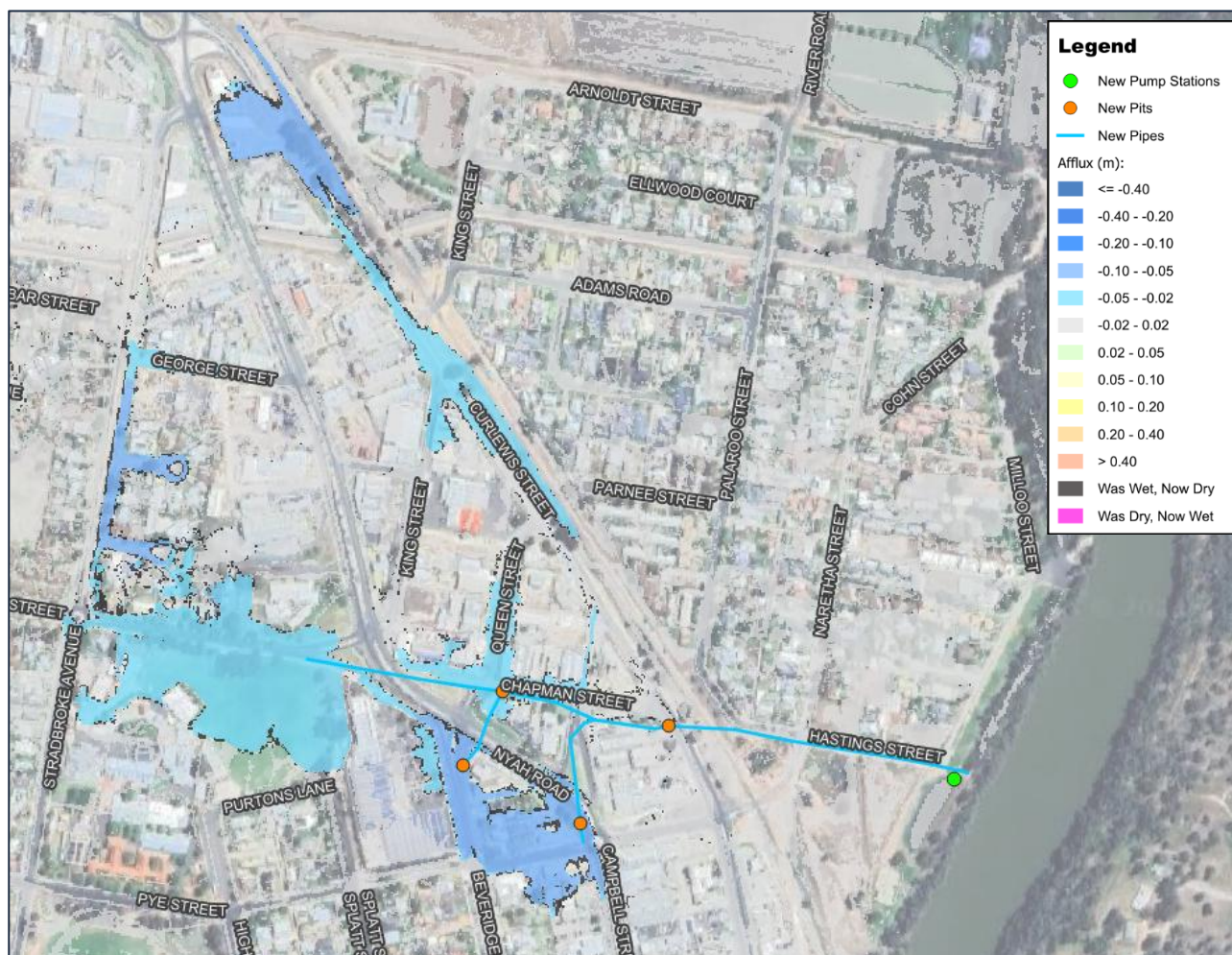


Figure 9-34 Mitigation Option S04 - 1% AEP Afflux

9.4.5 Butterworth Street to Main Drain Stormwater Network - S05

Option S05 resulted in moderate improvements to peak water level in the vicinity of Berrybank Drive and Butterworth Street. The 20% AEP event significant reductions to peak water level and flood extent along the roadways adjacent to the upgraded drainage. Notting Road and Berrybank Drive became flood immune in the 20% AEP event. Reductions in water level ranged from 20 – 30 mm on Derham Drive up to 200 mm on Hocking Drive. Minor positive afflux occurred within the Main Drain due to the additional inflows from the new stormwater pipes. Flood improvements generally diminished for the larger 2% and 1% AEP flood events. For these events, flooding improvements were largely confined to the intersections of Graemer Drive, Suttie Drive and Butterworth Street. Option S05 20% afflux is presented in **Figure 9-35**. Option S05 1% AEP afflux is presented in **Figure 9-36**.

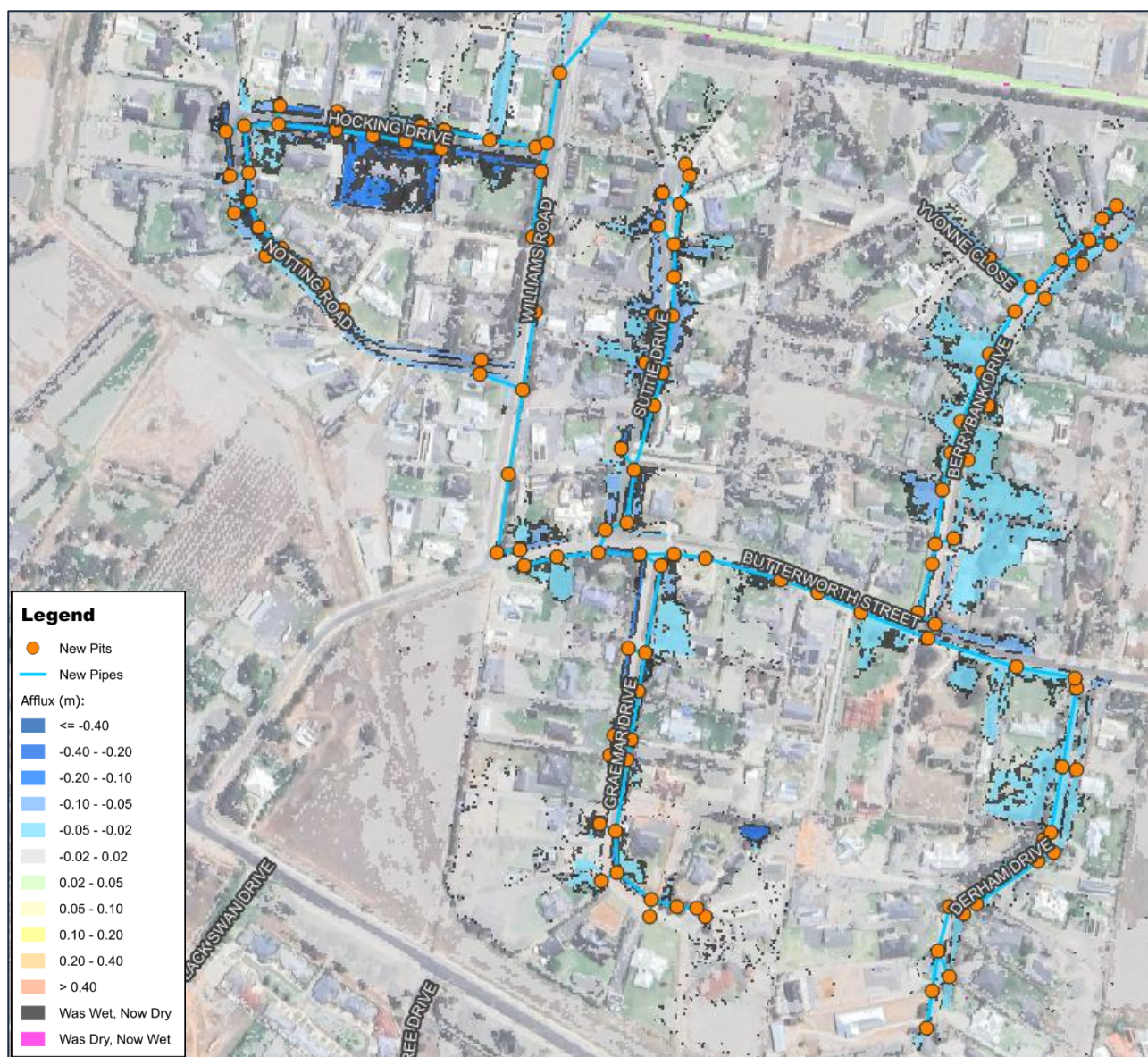


Figure 9-35 Mitigation Option S05 - 20% AEP Afflux

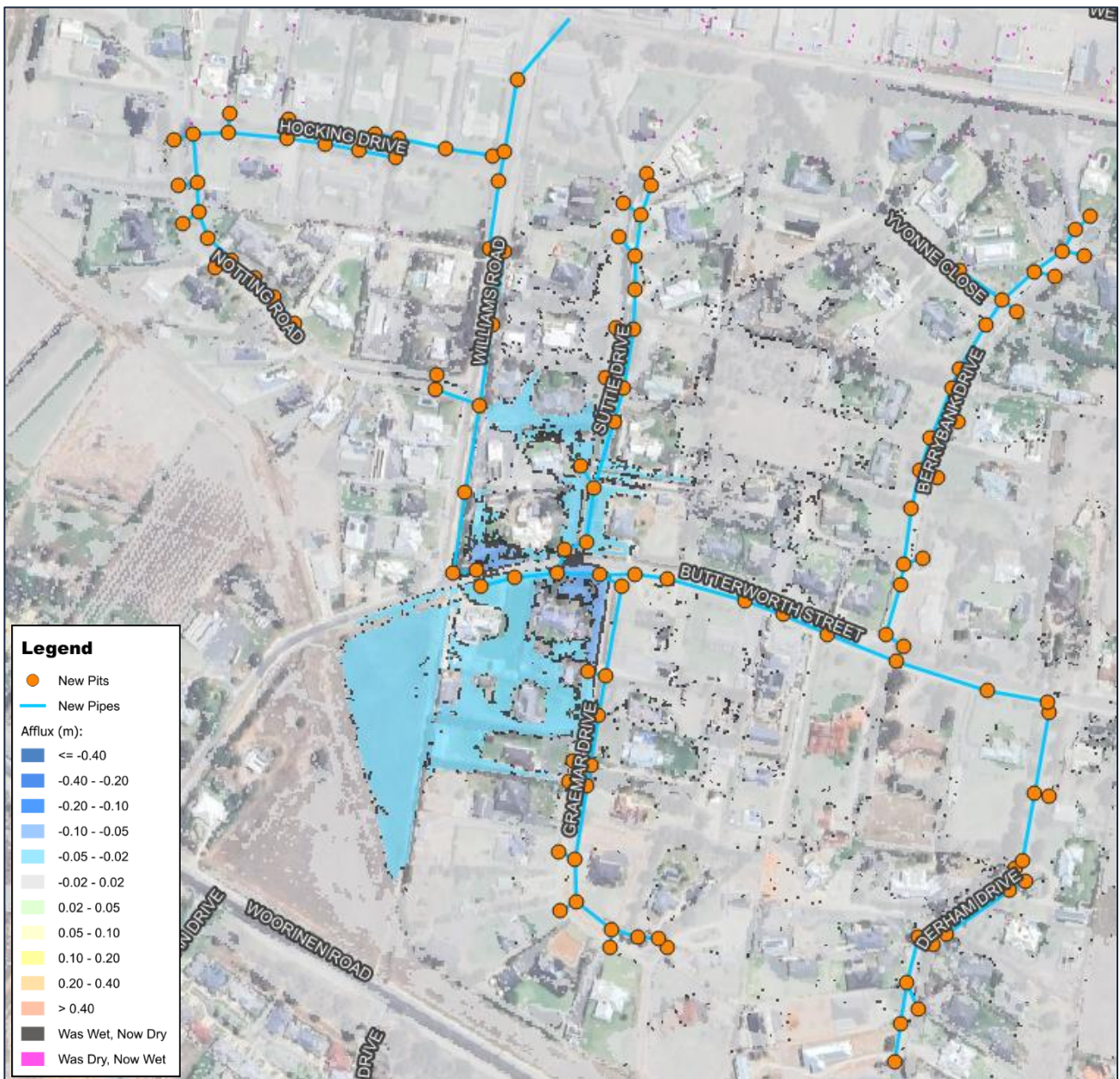


Figure 9-36 Mitigation Option S05 - 1% AEP Afflux

9.4.6 Results Summary

The decrease in duration of inundation changes for each mitigation option compared to the existing scenario is summarised below in **Table 9-3** and

Table 9-4 for the 1% and 2% AEP event, respectively.

Mitigation option S02 primarily focuses on reducing flood levels in the vicinity of Nowie Street, which is relatively easier to achieve in the short term. However, the development of a new major drainage network along Werril Street (S01) can further reduce the inundation time at Nowie Street and also widespread reductions in the southern area of the townships. Releasing the pressure on the Main Drain and providing greater capacity for future western developments are crucial considerations for long-term planning.

Compared to the Main Drain Pump Station Upgrade (S03), the Milloo Street and Chapman Street Pump Station and Drainage Upgrade (S04) only reduces flood levels in the vicinity of Chapman Street, with a limited ability to decrease inundation time. Upgrading the pump station at the end of the Main Drain would be more efficient, particularly in the industrial estate north of the Main Drain.

The absence of a drainage network highlights the need to install a new drainage system in the Butterworth Street region. For the 20% AEP event, significant reductions in peak water levels and flood extents were observed along roadways adjacent to the upgraded drainage network. Notting Road and Berrybank Drive achieved flood immunity during the 20% AEP event. It is recommended to consider these improvements for future planning.

Table 9-3 Swan Hill Inundation Duration Change 1% AEP

Road Name	Decrease in in Duration of Inundation [hours] (Duration of Inundation for Mitigation Option [hours])				
	S01	S02	S03	S04	S05
	360 min, TP08	180 min, TP08	360 min, TP07	360 min, TP07	540 min, TP07
Williams Road	10.9 (10.9)	3.2 (3.3)	7.8 (8.1)	10.4 (10.5)	8.7 (8.7)
Chapman Street	14.1 (13.8)	5.5 (5.3)	13.1 (13.0)	12.5 (12.6)	11.9 (11.8)
Murlong Street	10.0 (11.8)	3.3 (3.8)	5.8 (10.4)	10.1 (11.1)	8.0 (9.2)
Thurla Street	13.3 (13.4)	4.4 (5.2)	12.5 (12.5)	12.5 (12.5)	10.6 (10.9)
Curlewis Street	9.7 (14.7)	3.3 (5.6)	6.6 (14.4)	9.9 (14.4)	7.7 (14.5)
Pye Street	12.8 (12.6)	4.6 (5.5)	11.6 (11.5)	12.0 (12.0)	10.2 (10.0)
McCallum Street	14.3 (14.5)	5.5 (5.5)	13.5 (13.7)	13.5 (13.7)	13.2 (13.7)
Beveridge Street	5.5 (13.6)	3.7 (5.6)	4.9 (13.0)	2.6 (12.6)	5.1 (13.4)
Campbell Street	8.4 (14.8)	3.8 (5.7)	7.6 (14.5)	7.6 (14.5)	11.8 (14.6)
McCrae Street	14.8 (14.8)	5.7 (5.7)	14.4 (14.4)	14.4 (14.4)	14.5 (14.5)
Rutherford Street	10.2 (10.2)	3.4 (3.3)	10.2 (10.2)	10.2 (10.2)	8.2 (8.2)
Gray Street	13.3 (13.6)	4.5 (4.4)	12.4 (12.5)	12.4 (12.5)	10.7 (10.8)
Yana Street	10.8 (10.1)	3.6 (3.3)	10.6 (10.2)	10.6 (10.2)	8.9 (8.3)

Road Name	Decrease in in Duration of Inundation [hours] (Duration of Inundation for Mitigation Option [hours])				
	S01	S02	S03	S04	S05
	360 min, TP08	180 min, TP08	360 min, TP07	360 min, TP07	540 min, TP07
Coronation Avenue	4.9 (1.2)	4.3 (1.9)	8.2 (1.2)	8.3 (1.2)	9.1 (4.6)
Wattie Street	10.1 (10.1)	4.6 (4.6)	10.8 (10.8)	10.8 (10.8)	11.0 (11.0)
Chapman Street	NA (13.7)	NA (5.1)	NA (12.8)	NA (9.6)	NA (11.5)
Nowie Street	2.1 (2.7)	3.0 (3.5)	6.8 (7.6)	6.9 (7.6)	6.9 (7.6)
Butterworth Street	10.8 (12.1)	3.2 (4.1)	7.9 (11.3)	10.4 (11.5)	8.7 (9.2)
Derham Drive	9.9 (12)	3.5 (3.8)	9.5 (11.2)	9.7 (11.2)	8.5 (9.2)

Table 9-4 Swan Hill Inundation Duration Change 2% AEP

Road Names	Decrease in in Duration of Inundation [hours] (Duration of Inundation for Mitigation Option [hours])				
	S01	S02	S03	S04	S05
	540 min, TP04	540 min, TP04	540 min, TP04	180 min, TP08	540 min, TP04
Williams Road	6.8 (6.9)	7.0 (7.1)	1.8 (2.5)	2.9 (3.0)	7.1 (7.2)
Chapman Street	14.1 (14.2)	14.2 (14.2)	14.2 (14.2)	4.6 (4.5)	14.2 (14.2)
Murlong Street	7.3 (7.1)	7.3 (7.4)	7.3 (4.8)	3.8 (3.5)	7.3 (7.9)
Thurla Street	13.3 (13.4)	13.9 (13.9)	12.4 (12.4)	4.6 (4.5)	13.8 (13.9)
Curlewis Street	5.0 (14.8)	6.0 (14.8)	3.5 (14.8)	4.3 (5.6)	6.4 (14.8)
Pye Street	10.1 (10.1)	10.1 (10.1)	10.1 (10.1)	4.7 (4.6)	10.1 (10.1)
McCallum Street	8.0 (14.6)	8.5 (14.6)	7.6 (14.6)	3.4 (5.5)	8.6 (14.6)
Beveridge Street	5.8 (14.3)	5.8 (14.3)	5.8 (14.3)	2.5 (5.4)	5.8 (14.3)
Campbell Street	3.7 (14.8)	3.7 (14.8)	3.7 (14.8)	2.4 (5.7)	3.7 (14.8)
McCrae Street	5.1 (14.8)	5.1 (14.8)	5.1 (14.8)	2.8 (5.6)	5.1 (14.8)
Rutherford Street	2.6 (2.0)	3.3 (3.0)	2.3 (1.7)	2.9 (3.0)	3.5 (3.2)
Gray Street	12.9 (12.0)	13.3 (13.3)	13.3 (13.3)	4.3 (4.2)	13.3 (13.2)

Road Names	Decrease in in Duration of Inundation [hours] (Duration of Inundation for Mitigation Option [hours])				
	S01	S02	S03	S04	S05
	540 min, TP04	540 min, TP04	540 min, TP04	180 min, TP08	540 min, TP04
Yana Street	7.1 (3.0)	7.2 (6.1)	7.2 (4.8)	3.4 (2.9)	7.2 (6.2)
Coronation Avenue	7.8 (0.4)	7.8 (0.4)	7.8 (0.4)	3.6 (1.0)	7.8 (0.4)
Wattie Street	12.3 (12.4)	12.4 (12.4)	12.9 (12.9)	4.3 (4.3)	12.9 (12.9)
Chapman Street	NA (14.2)	NA (14.2)	NA (14.2)	NA (4.6)	NA (14.2)
Nowie Street	1.0 (1.8)	1.2 (1.8)	1.6 (2.0)	2.6 (3.1)	1.6 (2.2)
Butterworth Street	6.9 (8.1)	7.1 (8.5)	1.8 (8.0)	3.0 (4.0)	7.1 (7.5)
Derham Drive	7.7 (10.4)	7.7 (10.4)	7.5 (11.9)	3.4 (3.7)	6.3 (10.1)

10 SUMMARY AND RECOMMENDATIONS

This report has presented the key components and findings of Swan Hill Drainage Strategy project, which has been undertaken to assess and upgrade stormwater infrastructure in the urban areas of Swan Hill and Robinvale. The points below detail the study key findings and recommendations:

10.1 MODEL ESTABLISHMENT AND VALIDATION

- The modelling methodology adopted for both Robinvale and Swan Hill townships was TUFLOW rain-on-grid hydraulic modelling. The model simulation indicated that Swan Hill and Robinvale are characterised by flat terrain and localised drainage issues, exacerbated by infrastructure limitations and increased urbanisation. Several areas with inadequate drainage capacity were identified, including trapped sags, undersized pit and pipes during recent flood events.
- In November 2023, a significant local flood event in Swan Hill recorded 80.6 mm of rainfall over 9 hours, aligning closely with the 2% AEP design rainfall depth of 79.1 mm. Swan Hill hydraulic model was validated to this event. Model outputs of the 2% AEP event were compared with site imagery and found to be consistent with observed flood extents, though peak flood depths in the model were slightly higher due to timing uncertainties in the photos.
- The model sensitivity testing was conducted to assess the impact of elevated Murray River levels coinciding with local rainfall events (20% AEP event) on the drainage system. In Robinvale, coincident flooding caused minor flood level increases (40–100 mm) near Latje Road, Robin Street, and Lawrence Road, with minimal changes elsewhere. In Swan Hill, high river levels caused backwater flooding, particularly near Milloo and Naretha Streets, with up to 650 mm increases in some areas, affecting the performance of the stormwater network. These results highlight the sensitivity of stormwater systems discharging directly into the Murray River and the need for mitigation measures independent of river tailwater conditions.

10.2 COMMUNITY CONSULTATION AND STAKEHOLDER ENGAGEMENT

- Community consultation and stakeholder engagement in Swan Hill and Robinvale identified specific drainage issues and gathered input on potential mitigation measures. The community engagement activities comprised drop-in sessions (19 total attendees) and an online questionnaire (37 responses). In Robinvale, key issues included undersized stormwater pipes, ineffective drainage due to flat terrain, blocked inlets, and recurrent flooding at locations like Robin Street and Caix Square, prompting calls for pipe assessments and pump upgrades. Swan Hill respondents highlighted the absence of a formal drainage system at sites such as Bish Road, Butterworth Street, and Charlie Gray Close, and pump station inadequacies with flooding exacerbated by the decommissioned No. 9 Drain.
- Discussions with key stakeholders including local developers and consultants, Council staff and other agencies were held online, and highlighted the desire for a unified and strategic approach to drainage rather than on a per-subdivision basis.

10.3 MITIGATION OPTION ASSESSMENT

- The initial mitigation screening assessment developed a 'long list' of options to evaluate their feasibility and potential success before conducting simulations. Following discussions with Council, five mitigation options for each township were implemented into the TUFLOW hydraulic model to assess the resulting flood impacts and benefits.
- In Robinvale, the model results suggested that **Refined Robin Street Stormwater Network Upgrade (R02)** and **Ronald Street Stormwater Upgrade with Swales and Pump Station (R05)** are recommended to move forward. Option R02 would effectively reduce peak flood depths by 130 mm during the 1% AEP event on Robin Street and by 70 mm during the 20% AEP event on Herbert Street. Additionally, it would decrease inundation duration by 7–15 hours in low-lying areas (e.g. Caix Square and Margaret Street), aligning with community needs to address frequent flooding in the town centre and football fields, as reported by residents. Option R05 can decrease peak flood depths by 160–190 mm during the 1% AEP event in eastern Robinvale (Lawrence Road and Alexander Street) and reduce inundation duration by 9–12 hours on Morris Street and Ryan Road.
- In Swan Hill, the **Main Drain Pump Station Upgrade (S03)** and **Butterworth Street to Main Drain (S05)** are recommended. Option S03 is shown to reduce peak flood depths by 110–160mm in the 1% AEP event in the industrial estate near Webster Drive and decrease inundation duration by 6–8 hours at Swan Hill North Primary School. This option would assist in addressing school closures and business disruptions caused by Main Drain overtopping, particularly in the frequent storm events. Option S05 can effectively alleviate localised ponding and achieve 20% AEP flood immunity on Notting Road and Berrybank Drive.

Furthermore, it is noted that the Werril Street Drainage Upgrade with Channel Re-establishment and Pump Station (S01) can be designed in stages to accommodate related costs. It is essential to release pressure on the Main Drain and provide additional drainage capacity to support future urban growth.

10.4 NEXT STEPS

Further investigation of the below options is recommended to assess the practical feasibility and financial viability of the below options:

Table 10-1 **Next Step Summary**

ID	Option Name	Description of Works	Potential Benefits	Cost	Priority
R02	Refined Robin Street Stormwater Network Upgrade	- Install pump station (2 m³/s capacity) at Robin Street discharging to the Murray River. - Upgrade 600 mm RCP to 900 mm RCP (Perrin & George Street. to Latje Road.). - Upgrade 900 mm RCP to 1200 mm RCP (under Robin Street.). - Upgrade 600 mm RCP to 900 mm RCP (Herbert Street to Robin Street junction). - Upgrade four inlet pits (two at Herbert Street. and Latje Road. and two on Robin Street.) to 1200 x 1200 mm.	Offers improved performance with reductions of 130 mm (1% AEP) and 150 mm (20% AEP) along Robin Street, plus enhanced reductions on Herbert Street.	\$500k ex	High
R05	Ronald Street Stormwater Upgrade with Swales and Pump Station	- Add new stormwater pipes connecting Ronald Street low point to George Street network. - Install two 600 x 600 mm inlet pits on Ronald Street. - Construct swales along Lawrence and Williams Road, draining to two new pump stations (1.2 m³/s each).	Achieves substantial reductions in peak water levels in both central and eastern Robinvale. In the vicinity of Lawrence Road and Alexander Street, 1% AEP peak water levels reduced by 160 – 190 mm.	Over \$1M ex.	High
S01	Werril Street Drainage Upgrade with Channel Re-establishment and Pump Station	- New twin 1200 mm RCPs under Werril Street and integrate drainage from Yana Street. - New pump stations at Landy Crescent and Charlie Gray Close. - Re-establish No. 9 Channel to collect flows from Parkview Dr., Wilkins Grove, and Poole Blvd. - Upgrade Pental Island Road pump station from 0.28 m³/s to 4 m³/s.	In the 1% AEP event, key residential areas (e.g., near Landy Crescent and Charlie Gray Close) saw reductions of 50–90 mm. Benefits extend to areas west of the racecourse and around community facilities, suggesting a strong overall improvement in southern township drainage.	Over \$2M ex.	High
S03	Main Drain Pump Station Upgrade	Upgrade Main Drain pump station from 3.3 m³/s to 10 m³/s peak capacity.	Achieves significant flood level decreases (up to 110–160 mm) in the industrial estate north of the Main Drain and near residential areas. Near Swan Hill North Primary School, reductions of 100–150 mm in the 1% AEP event greatly improve	Over \$1M ex	High

ID	Option Name	Description of Works	Potential Benefits	Cost	Priority
			conditions for a sensitive community asset.		
S05	Butterworth Street to Main Drain Stormwater Network	- New 300 mm stormwater pipes on Notting Road, Hocking Drive, Suttie Drive, Graemer Drive, Derham Drive and Yvonne Close. - New 450 mm and 600 mm stormwater pipes on Butterworth Street and Williams Road. - Discharge to the Main Drain via Williams Road stormwater network.	Provides moderate improvements adjacent to Berrybank Drive and Butterworth Street, with particularly strong performance in the 20% AEP event. Notting Road and Berrybank Drive would achieve flood immunity during the 20% AEP event.	\$825k ex.	High

The investigations are recommended to include but not be limited to:

- Optimisation of pump sizing and capacity options;
- Cost estimate and preparation of Concept Designs including long sections, typical cross sections, and pump station footing and penstock design;
- Flood Damages Assessment;
- Cost Benefit Analysis;
- Preliminary Environmental Planning Overview;
- Sensitivity of the proposed option to elevated Murray River levels, and incorporation of backflow prevention devices;
- Engagement with directly impacted residents.

11 REFERENCES

- Babister, M., Trim, A., Testoni, I. & Retallick, M. (2016). *The Australian Rainfall & Runoff Datahub*. 37th Hydrology and Water Resources Symposium Queenstown NZ.
- Chen, A, and Walker, C. (2024). *Swan Hill Drainage Study – Catchment Delineation*. WMS Engineering.
- Hydrology and Risk Consulting (HARC). (2020). *Rapid Flood Risk Assessment – North Central CMA Region*. Hydrology and Risk Consulting.
- Heil, R, Cruickshank, B. (2019). *Stormwater Management Plan, Tower Hill Residential Development Stages 13, 14 & 15*. Heil Engineering Consultants (HEC).
- Laurenson, E. M., Mein, R. G., & Nathan, R. J. (2010). *RORB Version 6, Runoff Routing Program User Manual*. Monash University Department of Civil Engineering.