Sankey Street, Hawley Stormwater Improvements

Report

Latrobe Council

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→ The Power of Commitment

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Executive summary

Since June 2020, several properties in Sankey Street and Hawley Esplanade have experienced stormwater inundation. The most recent significant event occurred on the night of 28 February 2023 and 1 March 2023 which was likely to have been between a 1%AEP and a 0.2% AEP rainfall event which is an infrequent/rare event.

GHD has assessed the hydraulic performance of the Sankey Street Stormwater Catchment using the ARR (Australian Rainfall and Runoff) 2019 guidelines and the computer program InfoWorks ICM for the minor (10% AEP) and major (1% AEP) design storm events. The analysis indicated widespread flooding/inundation to properties in Sankey Street with the existing detention basin spilling for both design events.

This report has considered two mitigation measures to minimise the risk of flooding associated with the minor and major storm events.

Option 1

– Increasing the capacity of the existing detention basin to retain a 1% AEP event with consideration of future climate effects.
– Creating a formed overland flow path in Sankey Street east of the Joyce St intersection to the estuary.

Option 2

– Removing/decommissioning the existing detention basin and orifice.
– Upsizing/duplicating the pipework to accommodate the increase in downstream flows with consideration of future climate effects. This consists of:
  - A new DN900 main with pits and manholes in Sankey St from the Glyde St / Sankey St intersection to the estuary and separating it from the existing DN600 pipe on the northern side of the road.
  - Diverting the existing DN300 mains on the southern side of Sankey Street to the existing outfall outside 32 Hawley Esplanade to separate the property drainage lines from the trunk mains in Sankey Street.
  - Creating a formed overland flow path in Sankey Street east of the Joyce St intersection to the estuary.

A budget estimate and possible staging of the works for each option is enclosed in Table 1 below.

Table 1 Cost estimate and staging of works

	Option 1 – Retaining/increasing capacity of detention basin	Option 2 – Removal of detention basin
Staging of the works	**Phase 1 – Kerb and Channel - $360,087** Contain overland flows and run-off from the road and overflows from the detention basin and discharge to the foreshore. Minimise flows entering adjoining properties.	**Phase 1 – Kerb and Channel - $360,087** Contain overland flows and run-off from the road and discharge to the foreshore. Minimise flows entering adjoining properties.
	Phase 2 - Detention basin - $228,000 Retaining and increasing the capacity of the existing detention basin.	**Phase 2 – Remove Basin and upgrade stormwater network - $545,127** Remove/Remediate Detention Basin and upgrade pit and pipe network.
	Phase 3 – Arthur Place drainage works - $127,964 Kerb and channel and upgrade existing stormwater infrastructure in Arthur Place.	**Phase 3 – Arthur Place drainage works - $127,964** Kerb and channel and upgrade existing stormwater infrastructure in Arthur Place.
Cost estimate	$716,051	$1,033,178
Contingency – 25%	$179,013	$258,295
Rock contingency	$22,721	$121,473
Total estimate	$917,785	$1,412,946

Note: Rock Contingency assumes 20% rock is encountered in the stormwater trenches. Rock rate - \$660/m^3.

Cost Estimate does not include design and documentation, approvals, contract administration, or Council overheads.

The costs do not include any permits or fees.

The modelling of each option showed:

- Under Option 1, the existing detention basin needs to be raised vertically by approximately 2.0m to retain the 1% AEP event without spilling. The main aspects to be considered with this option are:
  - Increasing the water level in the detention basin also increases the water level of any connecting pipework which will result in overflows at other points in the network unless these are addressed.
  - Raising the wall height will impact access, especially to the inlet and outlet screens. Blockages of the screens or poor maintenance can result in the basin prematurely spilling or not operating as designed.
  - Any proposed modification of the basin may require a permit under the Water Management Act. The timelines and costs associated with this will need to be considered.
  - Overflows from the detention basin during storm events (including those of a <1% AEP event) and their impact on downstream properties and infrastructure.
  - The risk profile (likelihood and consequence) and acceptance of the basin may change over the life of the structure which may result in future mitigation measures or changes. This includes the spillway regularly discharging to the roadway due to low probability events occurring, or from the outlet being regularly blocked.
- Under Option 2, the existing detention basin can be replaced with a DN600 pipe connecting the inlet and outlet of the detention basin. The main aspects to be considered with this option are:
  - Removal of the detention basin may require a permit under the Water Management Act, and any outfall works will require a works permit from the Parks and Wildlife Service. Even though the basin is decommissioned or removed under this option, it can remain in-situ (providing minimal benefit to the stormwater network) or be remediated with the land sold if desired.
  - Potential rock and conflict with existing services. The cost implications of these can be confirmed by performing service locations and rock surveys along the proposed or alternative routes identified as part of the design process.

Other aspects the report identified, include:

- Alterations to Sankey Street and Hawley Esplanade, including the intersection, to create the overland flow path to the foreshore area will need to consider potential rock and conflict with existing services.
- Kerb and channel in Arthur Place, Joyce Street and Sankey Street will contain the overland flow to the road and reduce the level of inundation to the adjoining and downstream properties.
- The main source of inundation for the southwest property at the Sankey St/Hawley St intersection is overland flow from Sankey St. Shaping/profiling of the nature strips to fall to the road will assist in minimising future inundation as part of the kerb and channel works.
- The existing pit and pipe system in Arthur Place is undersized and needs to be appropriately upgraded with the provision of an overland flow path to the foreshore if achievable.
- It is recommended a rain gauge station be installed in the Hawley Beach/Shearwater area.
- A review of the flood hazard maps for both options show Option 2 is less of a hazard to the community and emergency services and is generally safe for vehicles, people, and buildings.
- Some residents may not support kerb and channel works.

Of the two mitigation options considered in this report, Option 2 is the preferable solution especially when considering climate change. Option 1 has unsafe overland flows in the steeper section of Sankey Street which needs to be considered if Option 1 is to be further considered.

However, the provision of kerb and channel provides a significant improvement over the existing level of flood protection, and it is expected to provide a similar performance to other drainage systems across the Council's network. Subject to performance and budgets, Council may determine that subsequent steps can be future projects.

Figure 1 Mitigation option 2 – summary of works

The recommendations and proposed plan going forward is summarised in Table 2 for Council's consideration.

Table 2 Proposed plan and recommendations

Step 1	
	– Council to consider if it wishes to further develop or proceed with the mitigation options proposed, or any other short-listed options with potential merit subsequently identified to this report. – Council to consider installing a rain gauge station in the Hawley/Shearwater/Port Sorell area.
Step 2	
	– If proposing to increase the volume of the detention basin under Option 1: • Contact the Department of Natural Resources and Environment (NRE) to determine if an application is required for the work, and if so, what information/detail is required. – Prepare application and submit details to NRE for assessment as required.
	– If proposing to further develop Option 2: • Contact Parks and Wildlife Service regarding the proposal to determine what information/detail is required for a works application. • Contact the Department of Natural Resources and Environment (NRE) to determine if an application is required for the work, and if so, what information/detail is required. Note: The detention basin could remain in-situ but would be effectively decommissioned.
	– Undertake detailed survey for the proposed works, including: • The existing stormwater infrastructure of Arthur Place and the outfall outside 32 Sankey Street. • A rock survey and service location.
Step 3	
	– Undertake design.
	– Prepare IFC documentation and undertake the work for Sankey Street, Hawley Esplanade and Joyce Street.
Step 4	
	– If approved, prepare Detention Basin IFC (Issue For Construction) documentation, and undertake the work in accordance with the conditions of the issued permit (from Step 2).
Step 5	
	– Prepare IFC documentation and undertake the work for Arthur Place.

This report is subject to, and must be read in conjunction with, the limitations set out in Section1.2 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

In June 2014, the Council approved a Planning Permit for a 204-lot subdivision called the Jochro - Hawley Estate Subdivision at Hawley Beach. However, since June 2020, many properties, especially on the southwest corner of the Hawley Esplanade / Sankey Street junction, have experienced stormwater inundation due to high rainfall events exceeding the capacity of the Council Stormwater Network.

During the night of February 28, 2022, and March 1, 2022, a storm event occurred, resulting in widespread flooding in Sankey Street as the Detention Basin spilled.

Latrobe Council has engaged GHD to assess the current hydraulic performance of the Sankey Street Stormwater Catchment using the 2019 ARR guidelines and the computer program InfoWorks ICM for the minor and major design storm events.

GHD will also:

– Model, assess, and document two mitigation options to minimise the risk of flooding for the minor and major design rainfall events with consideration of climate change effects.
– Provide a cost estimate of each option with a recommendation of the preferred solution.

1.1 Purpose of this report

This report documents the hydraulic performance of the Sankey Street Catchment and the two improvement options considered for the minor and major design storms. It outlines the methodology, performance, and results of the assessment, including climate change scenarios and cost estimates.

The findings will help the Council understand current flood risks and inform proposed upgrade works to minimize the risk of flooding.

1.2 Scope and limitations

This report has been prepared by GHD for Latrobe Council and may only be used and relied on by Latrobe Council for the purpose agreed between GHD and Latrobe Council as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Latrobe Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer Section 1.3 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

GHD has prepared the Sankey Street Catchment InfoWorks ICM Model ("Model") for, and for the benefit and sole use of, Latrobe Council to support the hydraulic assessment of the Sankey Street Catchment and improvement options and must not be used for any other purpose or by any other person.

The Model is a representation only and does not reflect reality in every aspect. The Model contains simplified assumptions to derive a modelled outcome. The actual variables will inevitably be different to those used to prepare the Model. Accordingly, the outputs of the Model cannot be relied upon to represent actual conditions without due consideration of the inherent and expected inaccuracies. Such considerations are beyond GHD's scope.

The information, data and assumptions ("Inputs") used as inputs into the Model are from publicly available sources or provided by or on behalf of the Latrobe Council, (including possibly through stakeholder engagements). GHD has not independently verified or checked Inputs beyond its agreed scope of work. GHD's scope of work does not include review or update of the Model as further Inputs becomes available.

The Model is limited by the mathematical rules and assumptions that are set out in the Report or included in the Model and by the software environment in which the Model is developed.

The Model is a customised model and not intended to be amended in any form or extracted to other software for amending. Any change made to the Model, other than by GHD, is undertaken on the express understanding that GHD is not responsible, and has no liability, for the changed Model including any outputs.

GHD has prepared the Budget Cost Estimate set out in Section 7 of this report ("Cost Estimate") using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD. The Cost Estimate has been predominately based on Council's revaluation rates which are assumed to reflect current construction rates.

The Cost Estimate has been prepared for the purpose of providing a budget for each improvement option and must not be used for any other purpose.

The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the Cost Estimate.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

GHD has prepared this report on the basis of information provided by Latrobe Council and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.3 Assumptions

Assumptions for the hydrological study used in this project are as follows:

– The study assumes that the data collected for the analysis is reliable and sufficient to produce accurate results.

2. Overview

2.1 Hydraulic assessment

The purpose of conducting a hydraulic assessment is to understand how a catchment will perform under different scenarios. The first step in the process is to develop a hydraulic model that best represents the existing catchment conditions based on the available information.

Once the existing catchment model has been developed, it forms the benchmark to assess the impacts of any improvement or upgrade works proposed.

The Sankey Street Stormwater Catchment will be hydraulically assessed for the minor (10%AEP) and major (1%AEP) events as per Latrobe Council's Stormwater Management Plan.

Design rainfalls are a probabilistic or statistically-based estimate of the likelihood of a specific rainfall depth being recorded at a particular location within a defined duration. This is generally classified by an Annual Exceedance Probability (AEP) or Exceedances per Year (EY). They are therefore not real (or observed) rainfall events; they are values that are probabilistic in nature.

The previous terminology used for flood risk was the Average Recurrence Interval (ARI) which is defined as "The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration." In simple terms, both the ARI and the AEP are both a measure of the rarity of a rainfall event. However, the terminology was changed due to confusion and misinterpretation by the public and some decision makers.

The relationship between the probability terminology of AEP and ARI events and their typical use in the engineering design space is summarised in Figure 2 below.

In the context of an urban drainage system, typically the minor drainage system (consisting of the pit and pipe and kerb and channel system) is typically designed for more frequent events like a 5% AEP event or less. The major drainage system (typically consisting of roadways and overland flow paths, etc.) is typically designed for a 1% AEP event.

Australian Rainfall and Runoff terminology

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI	Uses in Engineering Design
Very frequent	**12**				
	6	99.75	1.002	0.17	Water sensitive urban design
	4	98.17	1.02	0.25	
	3	95.02	1.05	0.33	
	2	86.47	1.16	0.50	
Frequent	**1**	**63.2**	1.58	1.00	Stormwater/pit and pipe design
	0.69	**50.00**	2	1.44	
	0.5	39.35	2.54	2.00	
	0.22	**20.00**	5	4.48	
	0.2	18.13	5.52	5.00	
Infrequent	0.11	**10.00**	10.00	9.49	Floodplain management and waterway design
	0.05	**5.00**	20	20.0	
	0.02	**2.00**	50	50.0	
	0.01	**1.00**	**100**	100	
Rare	0.005	0.50	**200**	200	
	0.002	0.20	**500**	500	
	0.001	0.10	**1000**	1000	
Extremely Rare	0.0005	0.05	**2000**	2000	Design of high-consequence infrastructure (eg major dams)
	0.0002	0.02	5000	5000	
			↓		
Extreme			PMP		

Figure 2 Probability terminology used in ARR2016

2.2 Study area

Sankey Street is located in Hawley Beach on the northwest coast of Tasmania. Sankey Street generally descends from Glyde Street to Hawley Esplanade. The approximate catchment for Sankey Street is shown in Figure 3.

Sankey Street is a typical urban street with road, kerb and channel, footpath, and other infrastructure services apart from the section below Joyce Street. This section does not have kerb and channel or a footpath and relies on the relatively informal table drains and grated pits (where provided) to carry surfaces flows from the road reserve to the underground pipe system which discharges to the foreshore area (Hawley Beach). Also, Sankey Street has a noticeable vertical sag in the road just before the intersection with Hawley Esplanade. The intersection is situated higher than the sag and adjoining properties.

Also, a detention basin exists off Sankey Street to the west of the Joyce Street intersection.

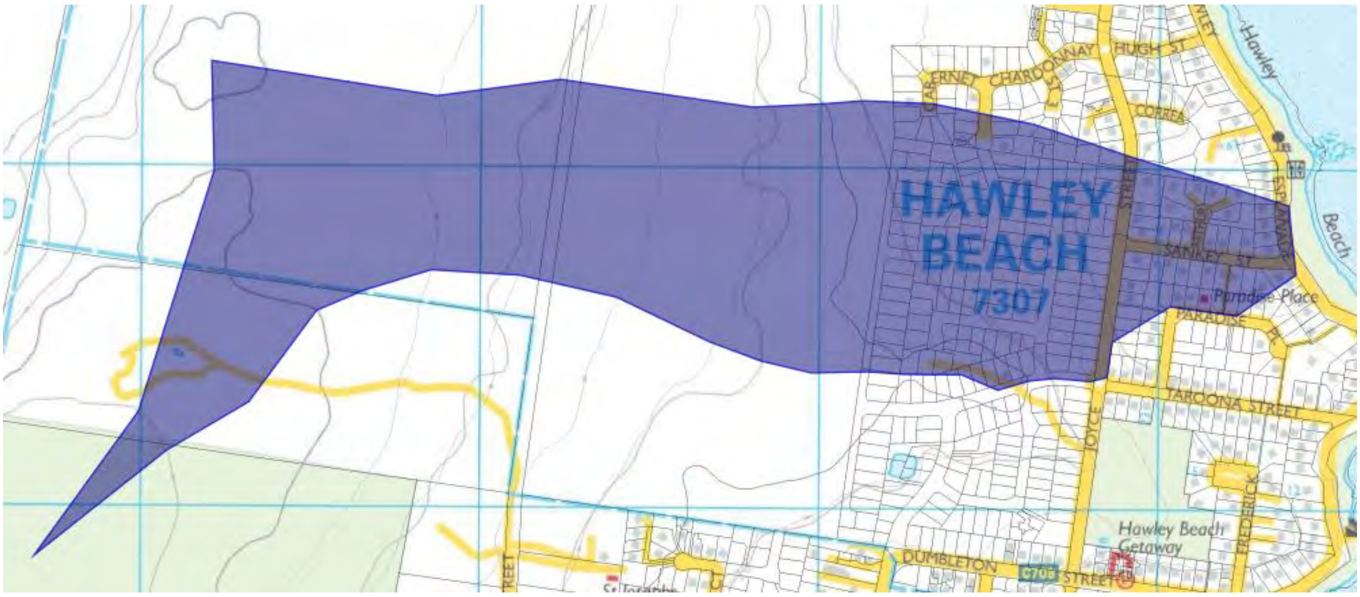

Figure 3 *LIST locality plan – Sankey Street and upstream catchment*

The main area of focus of the hydraulic assessment is the shaded area shown in Figure 4 which encompasses the area of, above and below the detention basin in Sankey Street.

The Hawley Beach/Shearwater/Port Sorell area has experienced significant growth in recent years, with a Planning Permit for a multistage 204 Lot subdivision (Jochro - Hawley Estate Subdivision) west of Joyce Street being granted by the Council on June 10, 2014. The permit had conditions, including those relating to the stormwater system design at the time which included detention basins.

Since June 2020, several properties have experienced stormwater inundation east of Joyce Street, with the main property located on the southwest corner of the Hawley Esplanade/Sankey Street junction. The flooding has been attributed to high rainfall events exceeding the design capacity of the Council's stormwater system.

A 2020 report prepared by the engineering consultants (6ty) for the subdivision advised the drainage system was designed for the 10 year ARI event to be contained within the piped system and for the detention basin to restrict flows to that of the 10 year event in the downstream system for storm events up to the 20 year ARI. The report did not mention how the drainage system was to function for a 100 year ARI event. However, the report did provide recommendations for Council to consider enabling the system to carry the 100 year ARI design event.

As part of these recommendations, a temporary orifice was installed in the downstream manhole of the detention basin.

After reviewing the report, Council duplicated the DN 600 stormwater pipe in the lower section of Sankey Street (where the gradient is around 0.5%) to increase capacity as part of the first stage of improvement works. The duplication works were completed on 8 December 2021.

A storm event occurred during the night between the 28 February 2022 and 1 March 2022, resulting in widespread flooding down Sankey Street as the Detention Basin spilled.

Figure 4 *Study area - Sankey Street, Hawley Beach*

The Bureau of Meteorology (BOM) does not have a rain gauge in the Hawley Beach/Shearwater area but has rain gauges located at the Devonport Airport, East Sassafras, Northdown, and the Narawntapu National Park. The recorded 24 hour rainfall to 9am on the 1 March 2023 is shown in Table 3. The highest rainfall recorded over the 24 period was 88 mm at Northdown, with the lowest being 59.4mm at the airport. This information shows spatial variation in the rainfall during the storm event.

Table 3 *Recorded 24 hour rainfall on the 1 March 2022*

Rain gauge location	24 hr total rainfall (mm)
Devonport Airport	59.4
East Sassafras	47.4
Northdown	88.0
Narawntapu National Park	63.8

Enquiries by Council staff following the event revealed 86-90mm for the 6pm to 6am period was recorded at a private rain gauge in Port Sorell, with a resident in the Hawley Beach area indicating 96-100mm from midnight to 6:30am. These reports are reasonably consistent with the rainfall recorded at Northdown, with the resident at Port Sorell noting the rainfall started around midnight.

Council is aware of reports by residents that the rainfall reported by the BOM rain gauges in the area do not accurately represent the rainfall received by the Hawley Beach/Shearwater/Port Sorell area.

The 2016 design rainfall data for Sankey Street from BOM (**http://www.bom.gov.au/water/designRainfalls/)** for a range of probability events is presented in Table 4. Accepting the rain event had a duration of approximately 6 to 6.5 hours with 86 - 100mm, it can be seen the rainfall event of the 28 February 2023 and 1 March 2023 was likely between a 1% AEP (Annual Exceedance Probability) event and a 0.2% AEP event which are a significant infrequent/rare event.

It is important to note the Jochro - Hawley Estate Subdivision was designed based on 1987 design rainfall data.

Table 4 Design rainfall data system (2016)

Duration	Annual exceedance probability (1 in x)					
	10 (10% AEP)	20 (5% AEP)	50 (2% AEP)	100 (1% AEP)	200 (0.5% AEP)	500 (0.2%AEP)
5.5 hour	51.8	58.8	68.1	75.2	89.2	107
6.0 hour	53.4	60.7	70.4	77.8	92.3	111
6.5 hour	55.0	62.4	72.5	80.2	95.2	114

source http://www.bom.gov.au/water/designRainfalls/

For comparison, Table 5 shows the differences between the 2016 and 1987 design rainfall intensities for a one hour duration event for Sankey Street. The 2016 design rainfall intensities are greater for AEP events of 5% or higher (more frequent events) which is generally the upper design limit of the minor drainage (pit and pipe) system. The variation or change is not constant and can vary from one duration to the next as shown by Table 6.

An increase in rainfall will put a strain on any existing infrastructure, which may increase the likelihood of flooding previously not seen before as the drainage assets no longer provide the same level of design AEP protection previously provided. This in turn leads to Councils having to investigate, programme and prioritise upgrades and improvements across the network based on risk or consequence of failure with the limited funds available.

Table 5 Design rainfall intensities for Sankey Street, Hawley Beach (1 hour intensity-frequency-duration)

AEP	1987 Design rainfall (mm/h)	2016 Design rainfall (mm/h)	Change
1EY (1 year ARI)	12.5	14.6	16.8%
10% (10 year ARI)	24.6	26.4	7.3%
5% (20 year ARI)	29.4	30.6	4.1%
2% (50 year ARI)	36.5	36.3	-0.6%
1% (100 year ARI)	42.6	40.9	-4.0%

Table 6 Design rainfall intensities for Sankey Street, Hawley Beach (24 hour intensity-frequency-duration)

AEP	1987 Design rainfall (mm/h)	2016 Design rainfall (mm/h)	Change
1EY (1 year ARI)	1.85	1.98	7.0%
10% (10 year ARI)	2.96	3.41	15.2%
5% (20 year ARI)	3.35	3.94	17.6%
2% (50 year ARI)	3.89	4.71	21.1%
1% (100 year ARI)	4.33	5.35	23.6%

Finally, as rainfall design data is based on observed rainfall, it does not include the effects of any future climate change.

3. Data collection

The Latrobe Council supplied much of the information used in the development of the hydraulic model for the Sankey Street Catchment. A summary of the data used (including their source) and relevance to the project is summarised below.

Table 7 Summary of previous studies

Study name	Description (one paragraph summary)	Author	Year	Accessible
Sankey Street, Hawley Beach Stormwater Capacity Assessment	Report relates to investigating the capacity of the public drainage system within Sankey Street, with options to upgrade the system to carry storm events of up to the 100 year ARI (1% AEP) event.	6ty	2020	Electronic copy of the DRAINS model and report provided by Council

Table 8 Available and compiled existing data

Data type	Description	Source/agency	Year	Accessible
Historic flood information	Site notes and photos from the overnight flood event - 1 March 2022	Latrobe Council	2022	
Survey data (Imagery/topographic DEMs)	LiDAR data Subdivision (Jochro - Hawley Estate Subdivision) DEM Aerial Imagery obtained from Metromap.	Elvis – Elevation and Depth – Foundation Spatial Data 6ty Imagery date – 2 October 2022.	2013 2023 2022	https://elevation.fsdf.org.au/ https://metromap.com.au/
GIS layers	The list databases – Cadastral information	TheList.tas.gov.com.au		https://maps.thelist.tas.gov.au/listmap/app/list/map
Pipe and Pit Data	Drains Model - Sankey Street, Hawley Beach Stormwater Capacity Assessment Pipe and Pit Data from Council GIS system and as-constructed plans	Latrobe Council Latrobe Council	2023 2023	

Table 9 Organisations with relevant existing data

Agency/office	Relevant contacts – name, email, phone	Comments
Bureau of Meteorology ARR Data Hub		Rainfall data Design Rainfall Data System (2016)

3.1 Digital elevation model (DEM) data

To develop an accurate hydraulic model, it is essential to have an accurate representation of the topography of the study area. A Digital Elevation Model (DEM) is a widely used tool for creating a detailed representation of the terrain.

The Digital Elevation Model (DEM) with a 1m resolution was obtained through a cloud-based system called Elvis Elevation and Depth, which provides quick and easy access to DEM data. The DEM was represented as a continuous surface of elevation values using a regular array of z-values, which were referenced to the vertical and horizontal datum used in the model. The representation was in the form of a grid or raster data set, which made it possible to visualize the topographic surface.

However, the DEM predated the subdivision works and therefore did not reflect the terrain changes as a result of the work. As a result, Council obtained the DTM for the subdivision works from 6ty. The two DEMs were merged by GHD to create one overall DEM to be used for the catchment.

It is important to note the DEM used only represents the ground surface and excluded features such as vegetation, trees, shrubs, and human-constructed features like sheds and houses.

A high-level review of the merged DEM was carried out to ensure that the data quality was sufficient to be used in the flood modelling process to achieve the project's objectives.

3.2 Manning's n data

The manning's 'n' data used for the catchment area is presented in Table 10.

Table 10 Surface-type classes with suggested Manning's-n values

ID	Group	n_2
1	Hawley Beach Urban Catchment - Residential	0.0125
5	Rural & Forested (Undeveloped Catchment)	0.0500

3.3 Structures data

The structure dataset provides important information in terms of coordinates, invert and surface levels, pipe diameters, and material of the various pipes, pits and manholes. This information is important in determining the flow capacity and hydraulic performance of the drainage system.

The infrastructure dataset was obtained from Latrobe Council as outlined in Table 8 above.

The DRAINS model included information about the detention basin, orifice, pipes, pits, and manholes used in the drainage design of the subdivision works. This information was supplemented with a copy of the as-constructed documentation and Council GIS asset information.

The DRAINS model data was extracted and imported into InfoWorks ICM and checked against the as constructed and GIS data provided.

In relation to pipe materials, the friction values from Table 11 were used in the model.

Table 11 Pipe friction values

Pipe material	Mannings (n)
Concrete Pipes	0.012
Plastic Pipes	0.009

In relation to pits, the following pit details from Table 12 were adopted in the model.

Table 12 Pit details

Pit	Reference
Side Entry Pit – Type 1	IPWEA Tas Standard Drawing – TSD-SW07-v3 IPWEA Tas Standard Drawing – RF03-v3

It is worth noting some of the Council GIS data was not complete for all existing assets, and appropriate assumptions were made during the import process where possible.

After a thorough evaluation, the data was found to be of sufficient quality to support the desired analysis and modelling needs.

3.4 Initial and continuing losses

In hydrology, initial losses (IL) and continuing losses (CL) are two important parameters used in the rainfall-runoff modelling process. Initial losses represent the amount of rainfall that is lost to infiltration and evaporation before any runoff is generated, while continuing losses represent the amount of water that is lost due to evapotranspiration after runoff has begun.

Table 5 provides the values of initial and continuing losses used in the model for the whole catchment.

Table 13 Initial and continuing losses

IL (mm)	CL (mm/h)
14	4.50

4. Flood model

4.1 Model setup

4.1.1 Infoworks ICM

The hydraulic model was set up using the InfoWorks ICM 2023.2.

InfoWorks ICM is a powerful hydraulic modelling software tool that is widely used in the water industry. It is reasonably user-friendly, and its features enable users to create accurate hydraulic models of complex stormwater systems.

Setting up a hydraulic model in InfoWorks ICM 2023.2 involves creating a digital representation of the stormwater system, defining the hydraulic characteristics, and running simulations to analyse the system behaviour under different scenarios. This includes analysing the impact of rainfall events on flood risk.

One of the key advantages of using InfoWorks ICM is its ability to integrate with other software tools, enabling users to import and export data from other sources, including GIS software, AutoCAD and other hydraulic modelling software. This integration makes it easier for users to incorporate different data sources into the model and ensures that the model reflects the most up-to-date information available.

4.1.2 Hydraulic model

Topography

The baseline topography of the catchment area is represented as a 2D element mesh model created from the DEM. The mesh is a set of interconnected elements that represent the terrain's surface in a digital format. Water flows according to the hydraulic properties of the land surface, as defined by the 2D topography and roughness. The roughness values are assigned to the mesh elements to represent the land surface's resistance to flow, which affects the velocity and direction of water movement.

Mesh size

To accurately simulate the behaviour of rainfall runoff in the catchment, rainfall was applied to the 2D mesh model. The 2D mesh provides a more detailed overland flow analysis and is generated by using the Shewchuk Triangle meshing functionality. Heights at the vertices of the generated mesh elements are calculated by interpolation from the ground surface model developed.

The 2D surface runoff can flow out of 2D zone boundaries or be captured by 1D elements to enter the 1D (pipe and pit) network. The InfoWorks ICM software allows for a varying mesh size, and a general mesh size ranging from 25 m^2 to 100 m^2 was applied for the model base, with a finer mesh size ranging from 2.323 m^2 to 4.645 m^2 for the urban portion of the catchment. The proposed mesh cell sizing is considered suitable to properly represent all the key topographic and land use features of the study area, without significantly impacting the expected simulation run times.

By applying rainfall directly to each cell of the 2D mesh model, the model can account for spatial variability in rainfall and simulate the movement of runoff over the terrain's surface. The incorporation of varying mesh size ensures that key features are captured within the model, providing a more accurate representation of the study area's behaviour.

Linear infrastructure

Linear Infrastructure (pits, pipes, manholes, and channels) have been modelled as 1D elements coupled to the 2D hydraulic model. This approach allows flow interchanges between the 1D elements and the 2D surface.

The 1D conduit network model is used to simulate the hydraulic processes in the stormwater network. The network has been developed to a high level of detail and includes the stormwater drainage conduits, pipes, manholes and pits in the project area from the information supplied by Council.

Hydraulic boundary conditions

Boundary conditions are an important part of the hydraulic modelling process as they affect what happens to the flow when it reaches the boundary of the model.

The pipe network discharges to Hawley Beach, which is subject to tidal flow.

Hawley Beach is located between the ports of Low Head and Devonport. The tide heights for the two ports are shown in Table 14. It is important to note the tide levels do not include storm surges.

Table 14 Port tide heights (m AHD)

Port	LAT (Lowest Astronomical Tide)	MSL (Mean Astronomical Tide)	HAT (Highest Astronomical Tide)
Devonport	-1.97	-0.02	1.68
Low Head	-2.02	-0.03	1.62

The Coastal Hazards Technical Report issued by the Mitigation Natural Hazards through Land Use Planning (MNLUP) project is a guide to the development of Tasmanian land use planning codes and building regulations that will mitigate the risks to new development associated with coastal hazards, specifically inundation and erosion. Appendix 9 of the report deals with sea level rise planning allowances for 2050 and 2100.

The designated 2100 1%AEP flood level for Hawley Beach is 2.9m which will be adopted as the water level for the duration of the 10% and 1% AEP design rainfall events.

4.1.3 Model domain linkages

The Sankey Street Stormwater hydraulic model is a complex system used to simulate the flow of water in the urban and rural domain. It consists of three different model domains, each with their own unique characteristics and properties. The first domain is the 1D conduit network, which includes a network of pipes and conduits that carry water through the system. The second domain is the 1D sub-catchment network, that collect water from the surrounding area and feeds it into the 1D conduit network and the 2D surface of the model. The third domain is the 2D surface, which represents the surface of the surrounding area.

In this model, flow is transferred between all three domains in all directions, allowing for a comprehensive understanding of how water moves through the system. To model the connections between the conduit network and the open channel, an approach called 'Outlet 2D' is used, which specifies the conduit diameter as the width and height. This method allows the model to convey water between a conduit invert and the open channel bed level while remaining stable.

When the conduit network discharges directly into the upstream end of a 1D channel network, a 2D node is used to connect the downstream end of the conduit link to the upstream end of the open channel. In this case, flow across 'Outfall 2D' nodes are calculated using a vortex control with a nominal head discharge relationship.

Finally, when a node is located beneath a road, the nodes 'Flood Type' is set to 'Sealed', preventing the exchange of flow between the 2D model and the 1D pipe network. This allows the model to accurately simulate the effects of road infrastructure on water flow and to predict potential flooding in these areas.

4.2 Design event simulations

Simulated 1% and 10% AEP events were performed for the hydraulic analysis. In accordance with the ARR 2019 guidelines, ten temporal patterns were performed in the hydraulic model. This is an advantage over the ARR 1987 guidelines where only a single temporal pattern for each rainfall was adopted.

Temporal patterns are used in design flood estimations to describe the distribution of rainfall with time. After rainfall depth, the temporal pattern of rainfall may have the biggest influence on flood estimates.

4.2.1 Critical storm duration

InfoWorks determines the critical storm duration based on the area, slope and roughness of the catchment. As mentioned in Section 4.1.2, rain is applied to the 2D mesh to create an accurate representation of how rainfall and runoff behaves, considering the land surface's hydraulic properties and roughness values.

Each storm event duration will typically produce different run-off values as each event has a different rainfall depth for each AEP event. In order to determine the critical storm duration, a selection of storm durations was chosen and evaluated until one was found that generated the maximum amount of run-off.

This process is an important step as it enables the selection of the appropriate stormwater infrastructure to accommodate the maximum runoff generated from the catchment for the given AEP event.

Of the various storm durations assessed, the 1.5 hour storm event was determined to be critical for the Sankey Street Catchment.

4.2.2 Temporal pattern

It is known each storm event is different as it does not follow the same temporal pattern. For example, one storm may have a large burst of heavy rainfall at the start, in the middle, at the end, or some other combination, but it still results in the same overall rainfall depth.

To accurately account for the diverse and different systems of rainfall in Australia, twelve regions were established with ten different temporal patterns, with each pattern reflecting real rainfall events in each region.

While the real number of temporal patterns per region may be more, the adoption of ten patterns is considered a compromise between numerical overhead, pattern availability and result sensitivity. An ARR report[1] found that using ten patterns can capture much of the variability of temporal patterns and remove much of the variability of the flow estimates.

From analysis of the catchment, the 8th temporal pattern was identified as the critical pattern for the catchment.

4.3 Sensitivity tests

No sensitivity tests were undertaken for the various scenarios modelled.

4.4 Model validation

The validation process typically involves adjusting key model parameters, such as Manning's 'n' roughness coefficient and loss rates, within acceptable limits to achieve a level of agreement between the modelled and the observed behaviour.

The hydraulic model has not been validated against historical flood events for which limited records exist, such as flood extents and impacted properties due to recent changes to the drainage network.

However, a general comparison between the 2022 storm event detailed in Section 2.2 and the modelled 1%AEP event is made in Section 4.7.

As discussed in Section2.2, there is no rain gauge in the Hawley Beach/Shearwater area and Council is aware the BOM rain gauges in the area do not accurately represent the rainfall received by the Hawley Beach/Shearwater/Port Sorell area.

However, the installation of a rain gauge station in Hawley/Shearwater area will assist with reporting actual rainfall events in the area which can be used to validate and/or calibrate future hydraulic models.

[1] Australian Rainfall and Runoff Revision Project 3: Temporal Patterns of Rainfall, Stage 3 Report December 2015.

4.5 Post-processing of modelling results

Direct rainfall hydraulic modelling results were filtered using the ArcGIS software to exclude depths lower than 0.05 meters (50mm). The purpose of this is to focus attention on areas where direct rainfall has a more significant impact while making the easier to interpret and understand.

This approach is also consistent with the mapping of drainage path locations, direction, and widths for 1%AEP events in the Tasmanian Stormwater Policy Guidance and Standards for Development.

4.6 Flood hazard

The severity of flooding varies depending on its behaviour, such as extent, depth, velocity, isolation, rate of rise, and duration. To manage flood risk, it is important to understand the potential flood behaviour and identify the relative degree of flood hazards. This section defines flood hazard as the potential loss of life, injury, and economic loss. It also outlines methods to quantify flood hazard, which can help identify specific flood parameters and benchmark them against thresholds to better understand the danger of flooding to people, buildings, and infrastructure in the community.

The quantification and classification of flood hazards involve considering flood depth and velocity in combination. Understanding the relative degree of the hazard and the underlying flood behaviour is crucial as different management approaches may be required.

The combined flood hazard curves presented in Figure 5 set hazard thresholds that relate to the vulnerability of the community when interacting with floodwaters. The combined curves are divided into hazard classifications that relate to specific vulnerability thresholds as described in Table 15. Table 16 provides the limits for the classifications provided in Table 15.

A flood hazard map classified against these vulnerability thresholds for the Sankey Street Catchment is presented in Appendix B.

Further information on the flood hazard classification can be obtained from the *Australian Disaster Resilience Guideline 7-3: Technical flood risk management guideline: Flood hazard, 2014, Australian Institute for Disaster Resilience.*

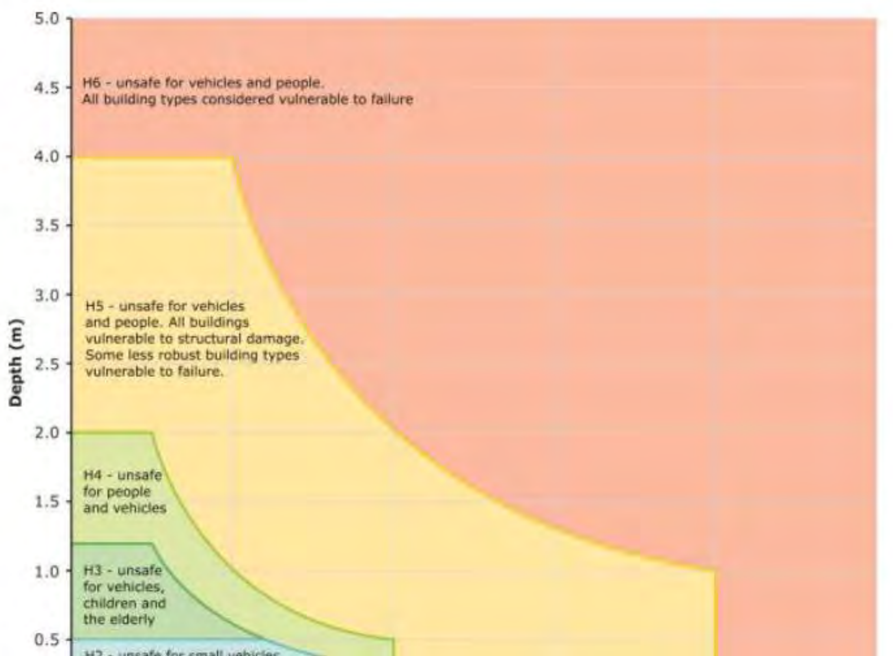

Figure 5 ***General flood hazard vulnerability curves***

Table 15 Combined hazard curves – vulnerability thresholds

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

Table 16 Combined hazard curves – vulnerability thresholds classification limits

Hazard vulnerability classification	Classification limit (D (depth)and V (velocity) in combination) m^2/s	Limiting still water depth (D) m	Limiting velocity (V) m/s
H1	D*V ≤ 0.3	0.3	2.0
H2	D*V ≤ 0.6	0.5	2.0
H3	D*V ≤ 0.6	1.2	2.0
H4	D*V ≤ 1.0	2.0	2.0
H5	D*V ≤ 4.0	4.0	4.0
H6	D*V > 4.0	-	-

4.7 Existing drainage model results

The modelling results for the existing stormwater system for the minor (10%AEP) and major (1%AEP) event are presented in the following sections.

A copy of the flood maps is enclosed in Appendix A.

4.7.1 Overland flow

Modelling results for the minor storm event shows a number of properties being inundated (refer to Figure 6), with the worst effected fronting Hawley Esplanade.

Modelling results for the major storm event produces similar results but with an increase in inundation and maximum water depth for properties affected by the minor storm event (refer to Figure 7).

Inundation is evident in the rear of 1-2 and 3 Arthur Pl and properties along Sankey St between Joyce Street and Hawley Esplanade, with the northern properties being the most heavily impacted. Inundation is also being experienced by the property on the eastern side of the detention basin.

The kerb and channel on the eastern side of Joyce Street (between Taroona Street and Sankey Street) is intercepting and redirecting overland flow north towards Sankey Street. Prior to the kerb and channel, this flow would have naturally flowed east with the fall of the land.

A closer view of the Sankey Street intersection shows a portion of the flow in the kerb and channel (and road) is crossing Sankey Street to the northern side of the road and into the adjoining properties. The remainder is either travelling with the fall of the road or entering properties on the southern side of the road.

Overland flow is also flowing down Sankey Street from the west and across the intersection. As it crosses the road, it is flowing through the properties on the northern side of Sankey Street as shown in Figure 8. This is further adding to the flow and volume of water inundating these properties.

With no formal overland flow path east of the Joyce St / Sankey St intersection, overland flow is simply following the fall of the land, increasing in volume as downstream areas contribute to it as it ponds in the lower lying areas. The alignment is likely to approximately represent the predevelopment flow paths which may or may not have been considered at the time of development.

Figure 6 *10% AEP Event - existing scenario - extract of flood map from Appendix A*

Figure 7 *1% AEP Event - existing scenario - extract of flood map from Appendix A*

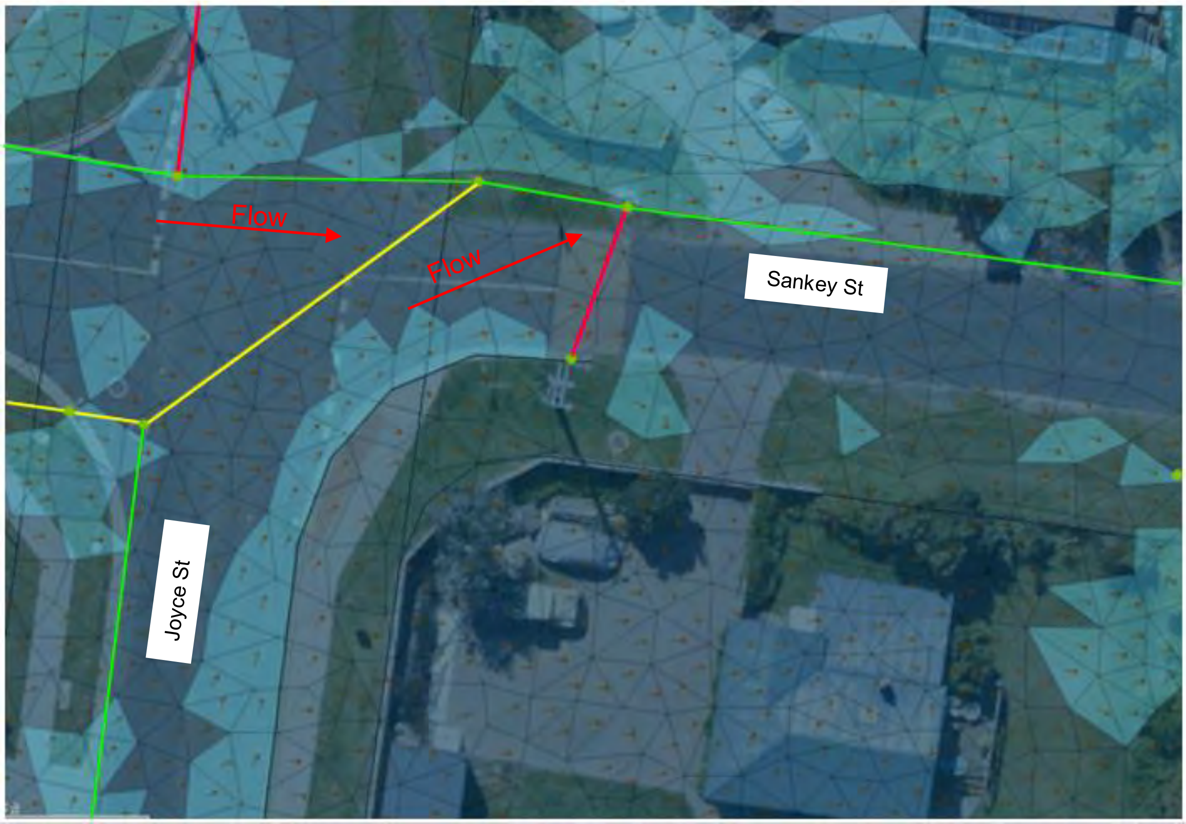

Figure 8 ***Overland flow – Sankey Street / Joyce Street intersection***

4.7.2 Pit and pipe system

Modelling results for the minor storm event shows several pipes are running at or above capacity as shown in Figure 7. This includes several pipes in Sankey Street east of the Joyce Street intersection.

This is expected given the original design capacity of the pipe system was a 10year ARI which approximates the 10%AEP event.

The capacity status of each pipe is indicated by the following colour coding legend:

- Yellow - The pipe is between 70-90% full and is not surcharging. The water level is below the sofit level (highest internal point) at both ends of the pipe.
- Orange – The pipe is full. The water level at the upstream and/or downstream end of the pipe is above the sofit level, and the flow is less than or equal to the pipe's full capacity.
- Red – The water level at the upstream and/or downstream end of the pipe is greater than the soffit level, and the flow is greater than the pipe's capacity.

The 2021 duplication work consisting of the DN600 pipe is less than 70% full. However, the pipework upstream to Arthur Place has two sections that are approaching capacity due to their relative flat grade compared to the pipes further upstream.

The pipes immediately west and north of the Sankey St / Joyce St intersection are at or above capacity. The pipes connected to the detention basin are full due to the basin being full. This is not helped by the pipe connections being at the base of the basin.

The inter allotment drainage system to the east of Arthur Place is indicating sections of red with the flow exceeding the pipe's capacity.

For the major storm event, modelling shows pipes that previously had spare capacity are now becoming full or their capacity has been exceeded due to the extra run off created by the larger storm event (refer to Figure 7). It is worth noting the 2021 duplicated pipe work is running close to full capacity with the upstream pipes running at or above full capacity. Therefore, there is little capacity to accept any additional flow, which is expected during a major event.

Detention basin

From survey data obtained from Council, the spill point for the detention basin is located at the south-east corner adjust to the unit development of 60 Joyce Street. The DRAINS model records the spillway R.L as 9.08 m.

The modelled water level for the minor and major storm event is above the spillway (refer to Table 17), meaning the basin is spilling water to the kerb and channel and through the adjoining property to the east. This is contributing to the overland flow heading downhill. Also, the hydraulic grade line is above the surface level of MH D17-3 as shown in Table 17, Figure 9 and Figure 10.

Table 17 Key water levels for minor and major storm events (m AHD)

	Existing drainage model	
Location	**Minor storm event**	**Major storm event**
Detention Basin (Spillway – 9.08m)	9.331m	9.420m
Pit288442 (MH upstream of Detention Basin). SL – 9.730m	9.350m	9.463m
D17-3 (MH @ Detention Basin Outlet). SL – 8.970m	9.383m	9.508m
D17-4 (MH @ Sankey St / Glyde St. SL – 10.520m	9.661m	10.000m
D23-1 (MH @ Glyde St). SL -10.770m	9.716m.	10.126m

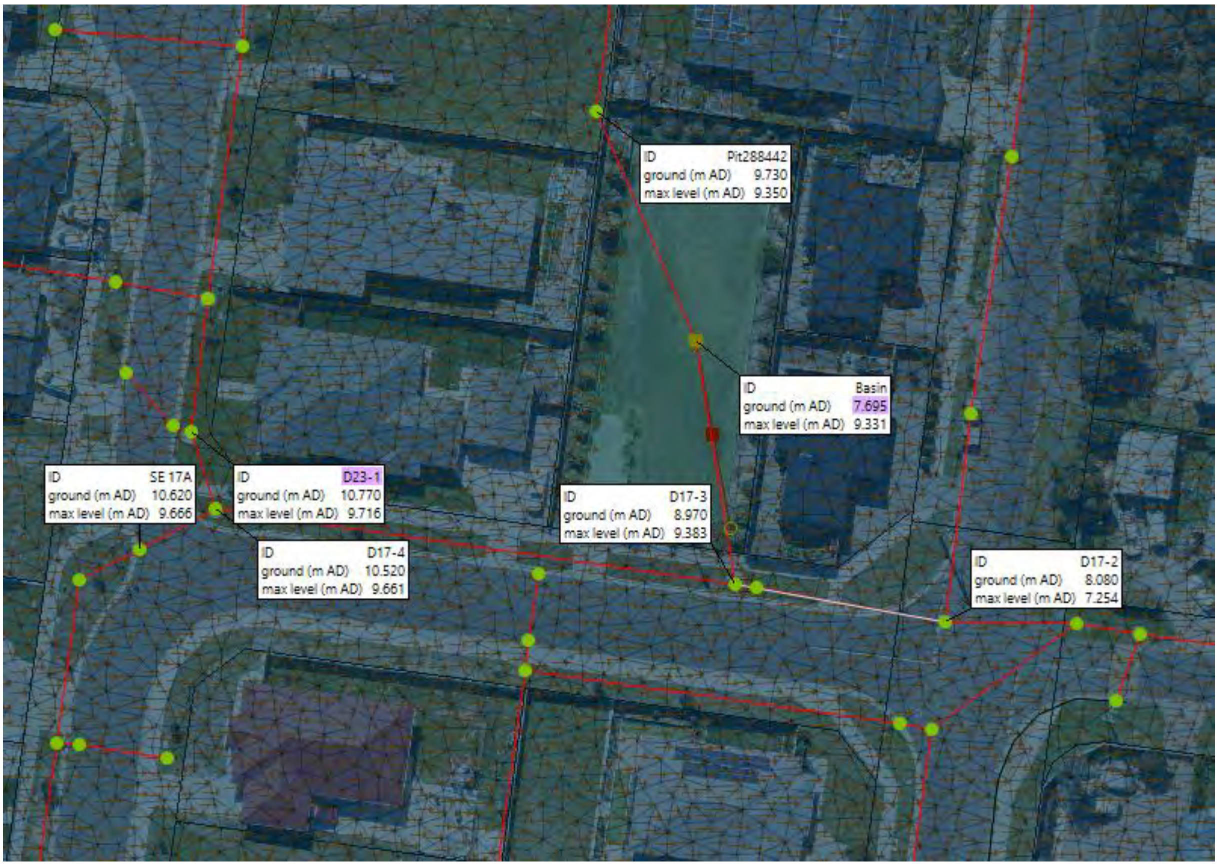

Figure 9 10% AEP Event - existing scenario - ground levels and maximum water levels

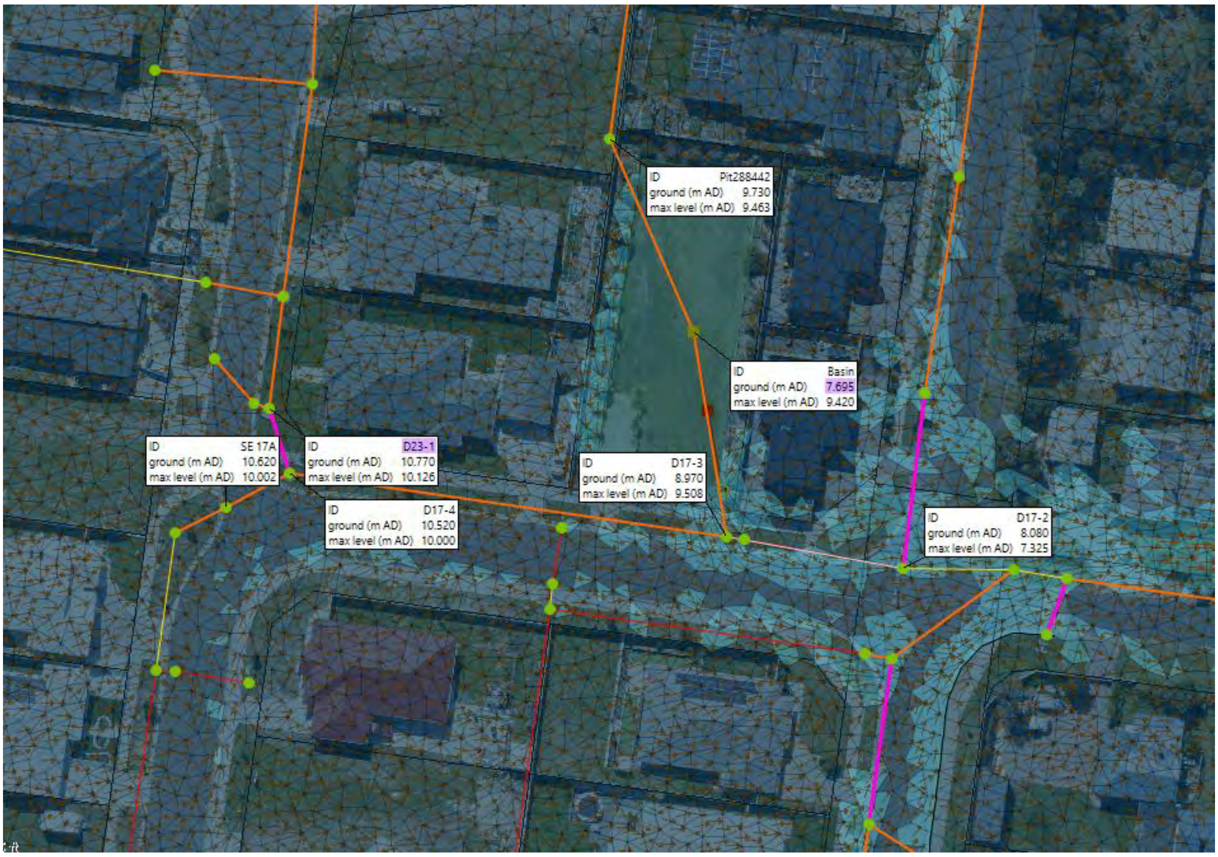

Figure 10 1% AEP Event - existing scenario - ground levels and maximum water levels

Comparison to 2022 flooding event

Site notes from the flooding event in 2022 is contained in Figure 11. The flood depth (taken as the debris line on fences and buildings, etc.) varied from 100mm to 380mm. Also, properties with the highest level of inundation were on the northern side of Sankey Street which aligns with flood maps.

The depths from the 1% AEP model are less than those measured after the 2022 flood event, but the properties inundated are consistent.

Reasons for the general discrepancies include different AEP/rainfall events, the model does not account for the footprint of structures like houses, sheds and fences which can cause local restrictions, contractions and diversions to the overland flow.

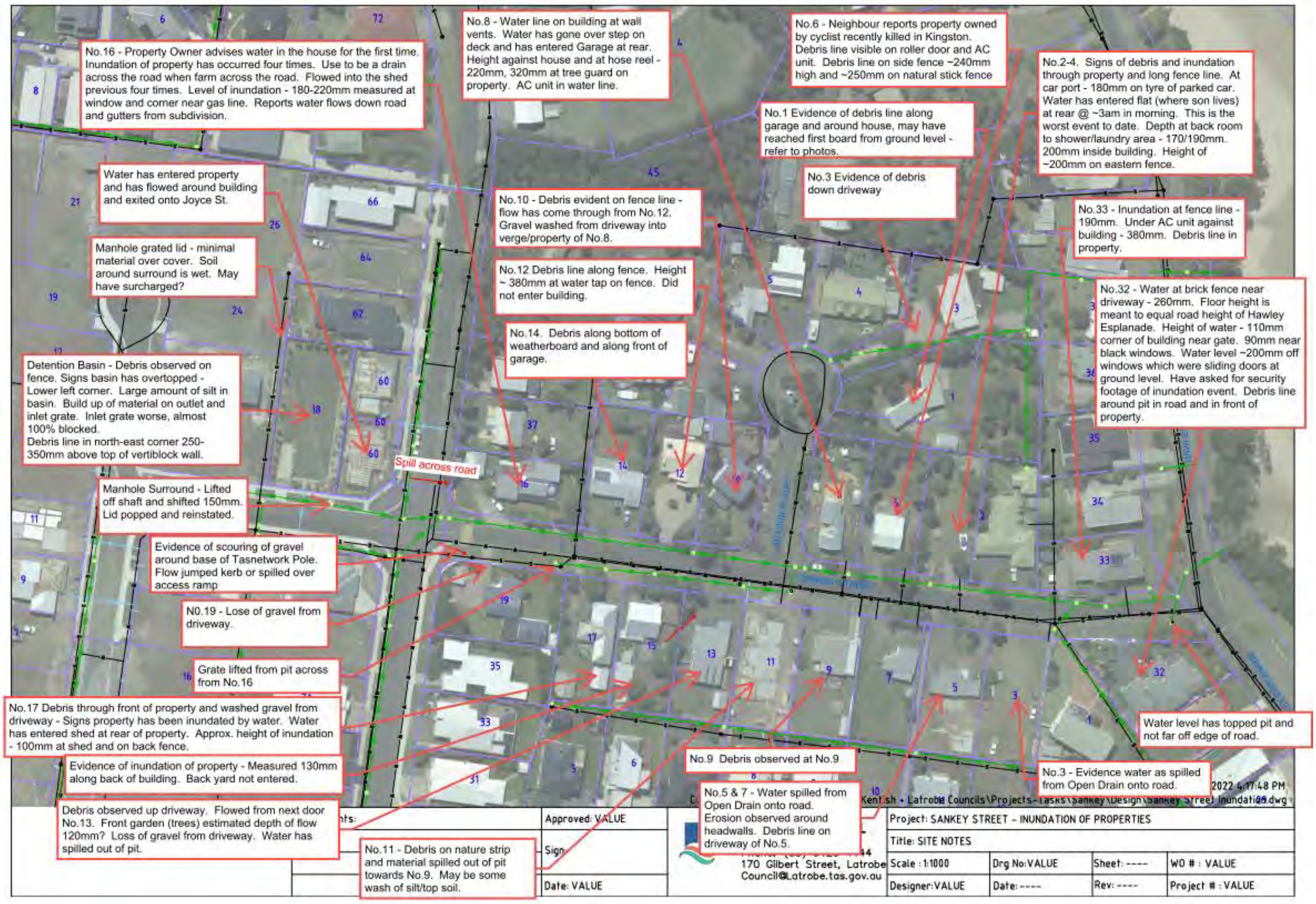

Figure 11 Site notes from the 2022 flooding event - 28 February 2022 and 1 March 2022

5. Mitigation options

The modelling results from Section 4.7 shows the drainage system cannot accommodate either the 10% or 1% AEP events without inundation of properties due to overland flows.

GHD has assessed two mitigation/improvement options to protect or reduce the risk of flooding (or inundation) to people and property in Sankey Street for the minor and major design storm events. It is noted to drain the low areas west of Hawley Esplanade will require the installation of pipes and pits or the creation of an overland flow path to the estuary.

The mitigation options relate to observations made following the 2022 storm event in Sankey Street.

Each mitigation option is outlined in the following sections.

A third option was considered which is a hybrid of the two. The option consists of installing a “Overflow Riser” in the detention basin. The overflow riser consists of a vertical pipe (typically a large diameter pipe that acts as a weir). Overflow risers are typically used when an overflow spillway may not be suitable. For Sankey Street, this means any overflows would be contained within the basin.

This option was not modelled as it is expected the pipework from the basin would be of similar size as proposed in Option 2.

5.1 Option 1 – retain/upsize detention basin

Option 1 consists of:

- Increasing the capacity of the existing detention basin to retain a 1% AEP event with no overflows.
- Kerb and channel and nature strip works in Arthur Place, Joyce Street and Sankey Street to contain the overland flow to the road and reduce the level of inundation to the adjoining and downstream properties.
- Creating a formed overland flow path in Sankey Street east of the Joyce St intersection to the estuary.

It is worth noting:

- The creation of the overland flow path will require vertical realignment of the Sankey Street/Hawley Esplanade intersection and consideration of impact on existing services and adjoining properties.
- Increasing the basin wall height may introduce overflows at other points in the network and hinder maintenance access.

The general arrangement of Option 1 is shown in Figure 12.

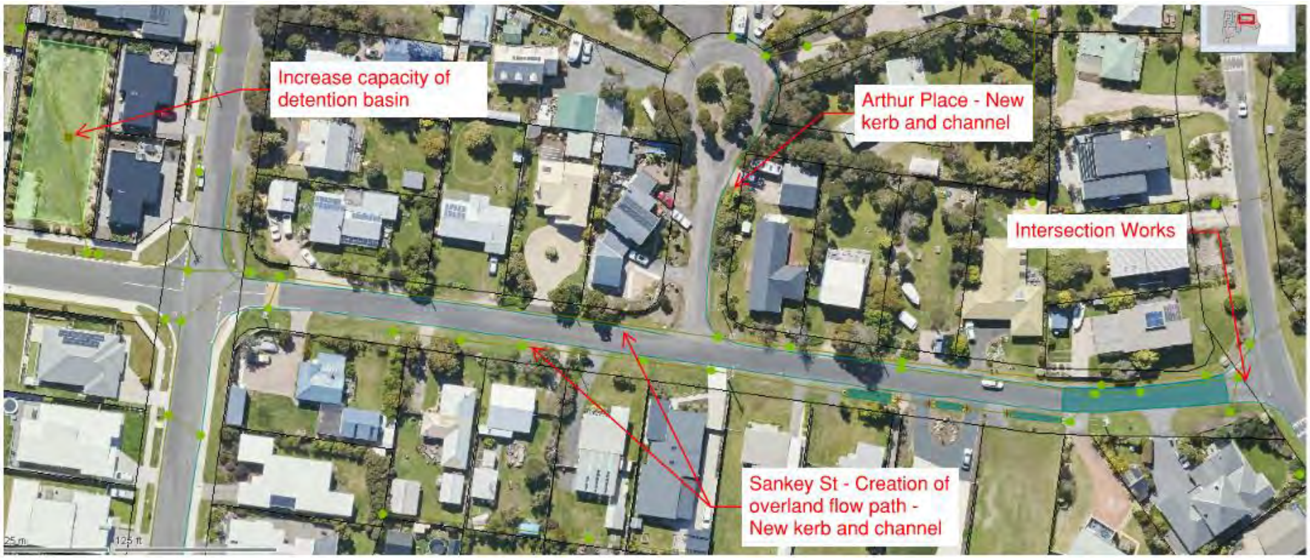

Figure 12 ***Mitigation Option 1 - retain/upsize detention basin***

5.1.1 Model setup

The model setup for Option 1 consists of:

- Increasing the level of the detention basin to 11.3m AHD with vertical walls.
- Introducing a wall along the edge of the road seal with a height of 0.250m to simulate the installation of kerb and channel and battering/mounding of the nature strips. This has also been applied to the eastern side of Arthur Place and Joyce Street and both sides of Sankey Street.
- The kerb and channel and battering/mounding height has been increased to 0.3m for the Sankey Street frontage of 32 Hawley Esplanade and most of 3 Sankey Street.
- Introducing fill to raise the lower section of Sankey Street to provide the overland flow path over the Hawley Esplanade intersection.

5.1.2 Option 1 - flood modelling results

The modelling results for the minor (10%AEP) and major (1%AEP) event are presented in the following sections.

A copy of the flood maps is enclosed in Appendix A.

Overland flow

Modelling of Option 1 for the minor and major storm events shows a reduction in inundation for properties in Sankey Street compared to the existing drainage model as the overland flow is contained within the kerb and channel as shown in Figure 13 and Figure 16.

The extent and depth of inundation at the rear of 1-2 and 3 Arthur Place and the adjoining properties of Hawley Esplanade is also reduced. It is expected this can be further reduced by increasing the number of pits and pipe capacity in Arthur Place with the provision of a formalised overland flow paths to the foreshore area where possible.

For the major storm event the velocity of the overland flow in the steeper section of Sankey Street is high with the maximum exceeding 2.0 m/s. This classifies the overland flow as a H5 hazard vulnerability (refer to Section 4.6 and Appendix B) which is considered unsafe for vehicles and people in the street and will present a hazard for emergency personnel and residents. A risk assessment should be conducted if Option 1 is to be further considered.

Figure 13 Minor storm (10% AEP) event – Option 1 retain/upsize detention basin - extract of flood map from Appendix A

Figure 14 Major storm (1% AEP) event – Option 1 retain/upsize detention basin – extract of flood map from Appendix A

Pit and pipe system

Modelling of the minor storm event for Option 1 shows improvements over the existing drainage model consisting of:

– A reduction in the water flowing through the pipes on the southern side of Sankey Street and an increase in flow through the pipes in the road reserve of Arthur Place as shown in Figure 13.

– For Sankey Street, this is attributed to the flow being carried by the new kerb and channel instead of the pipe and pit system. While for Arthur Place, this is due to the kerb and channel redirecting any collected water to the existing pits in the road.
– An increase in pipe flow on the northern side of Sankey Street. This is attributed to the kerb and channel directing surface flow to the pit and pipe system in the road. The downside of increasing the flow through the pipework is an increase in the hydraulic grade line in the pipe network.

For the major storm event, modelling shows little change from the minor storm event as most of the existing pipes are already full. The DN600 pipe on the northern side of Sankey Street and west of Arthur Place is shown to be exceeding its capacity.

Detention basin

The water levels from the model for the detention basin are summarised in Table 18 below. The water level has increased approximately 1.6m for the minor and major storm events.

This has also resulted in the hydraulic grade line (or water level) exceeding the surface level at several pits and manholes (refer to Table 18, Figure 15 and Figure 16 below), resulting in these structures surcharging and acting as an overflow for the piped system.

Structures in the road reserve would generally spill to the kerb and channel, with those in private properties would simply follow the fall of the land.

Water spilling from the manholes can be addressed with the provision of sealed (GATIC) lids and installing appropriate anchor brackets to prevent the separation of the manhole surround from the shaft. However, water will spill from the pits in the road and private property unless they are relocated or sealed.

Table 18 Key water levels for minor and major storm events (m AHD)

	Existing drainage model		Option 1	
Location	**Minor storm event**	**Major storm event**	**Minor storm event**	**Major storm event**
Detention Basin (Spillway – 9.08m)	9.331m	9.420m	10.882m	10.988m
Pit288442 (MH upstream of Detention Basin). SL – 9.730m	9.350m	9.463m	10.876m	10.991m
D17-3 (MH @ Detention Basin Outlet). SL – 8.970m	9.383m	9.508m	10.884m	10.999m
D17-4 (MH @ Sankey St / Glyde St. SL – 10.520m	9.661m	10.000m	10.941m	11.045m
D23-1 (MH @ Glyde St). SL - 10.770m	9.716m.	10.126m	10.964m	11.066m

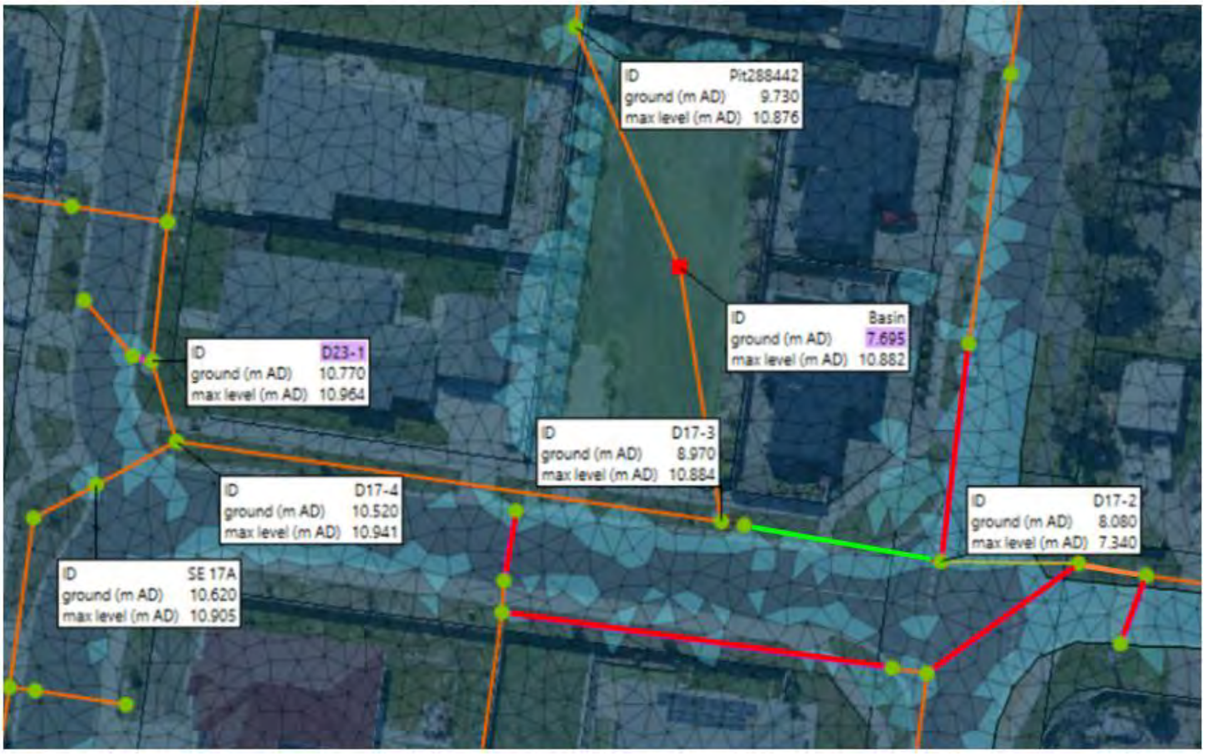

Figure 15 *Minor storm (10% AEP) event – option 1 retain/upsize detention basin – ground levels and maximum water levels*

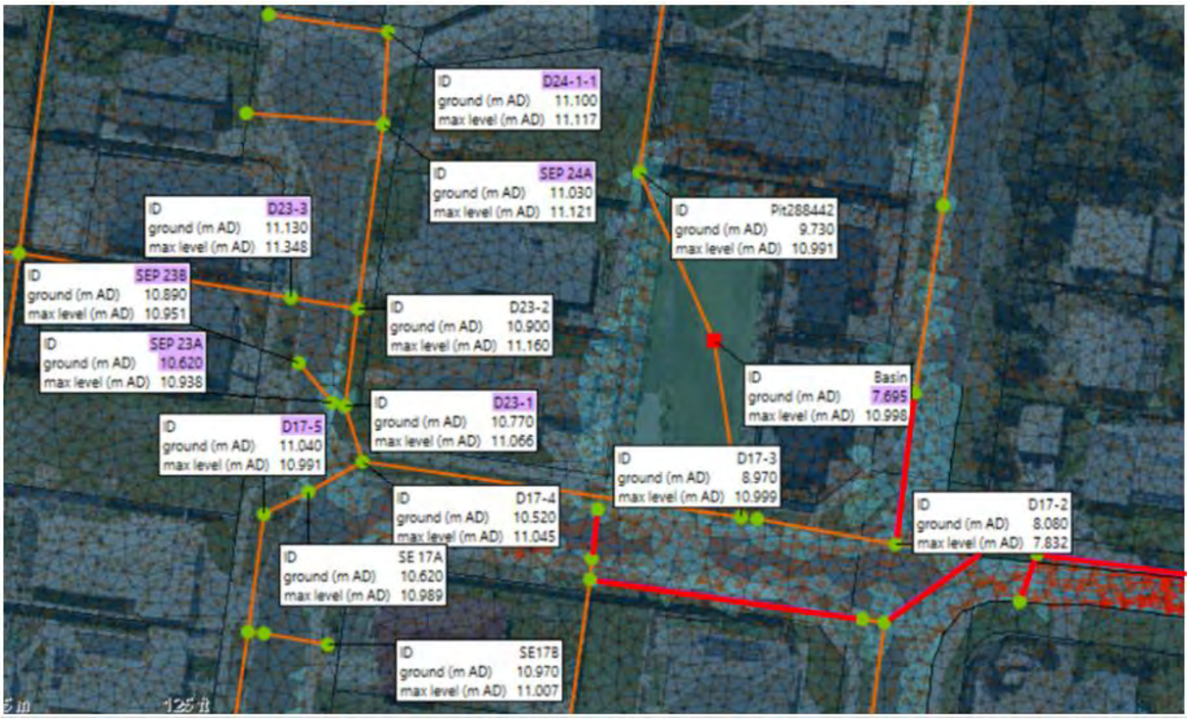

Figure 16 *Major storm (1% AEP) event – option 1 retain/upsize detention basin – ground levels and maximum water levels*

5.2 Option 2 – remove detention basin

Option 2 consists of:

- Removing/decommissioning the existing detention basin and orifice.
- Kerb and channel and nature strip works in Arthur Place, Joyce Street and Sankey Street to contain the overland flow to the road and reduce the level of inundation to the adjoining and downstream properties.
- Upsizing/duplicating the pipework to accommodate the increase in downstream. This consists of:

- A new DN900 main with pits and manholes in Sankey St from the Glyde St / Sankey St intersection to the estuary and separating it from the existing DN600 pipe on the northern side of the road.
- Diverting the existing DN300 mains on the southern side of Sankey Street to the existing outfall outside 32 Hawley Esplanade to separate the property drainage lines from the trunk mains in Sankey Street.
- Creating a formed overland flow path in Sankey Street east of the Joyce St intersection to the estuary.

It is worth noting:

– The detention basin is of a relatively short distance from Hawley Beach, and with all work proposed within the road reserve, this makes this option relatively simple to access and construct.
– Even though the proposal is to decommission the basin, it can remain in-situ (providing minimal benefit to the stormwater network) or be remediated with the land sold if desired.

The general arrangement of this option is shown in Figure 17.

Figure 17 ***Mitigation option 2 – remove detention basin***

5.2.1 Model setup

The model setup for Option 2 consists of:

– Replacing the detention basin with a DN600 pipe between the inlet and outlet.
– Removing the orifice.
– Installing a DN900 main from the manhole at the intersection of Glyde Steet and Sankey Street and running it along the southern side of Sankey Street with new pits and manholes to suit. This will also involve replacing/removing sections of the existing stormwater pipework installed by the subdivider to hydraulically separate it from the DN600 pipe on the northern side of the road. This will free up capacity to accommodate future flows from Arthur Place and Joyce Street. It is worth noting a section of the DN900 main outside 32 Hawley Esplanade may need to be a DN1050 pipe (subject to detailed design). The DN900 main has been selected as the minimum size based on the largest upstream pipe being a DN900. Typically, drainage authorities do not permit smaller downstream diameter pipes.
– Diverting the existing DN300 mains on the southern side of Sankey Street to the existing outfall outside 32 Hawley Esplanade. This will hydraulically separate the property drainage lines from the trunk mains in Sankey Street.
– Introducing a wall along the edge of the road seal with a height of 0.250m to simulate the installation of kerb and channel and the battering/mounding of the nature strips. This has also been applied to the eastern side of Arthur Place and Joyce Street and both sides of Sankey Street.
– The height has been increased to 0.3m for the Sankey St frontages of 33 Hawley Esplanade, 32 Hawley Esplanade and most of 3 Sankey Street.

– Introducing fill to raise the lower section of Sankey Street to assist in providing overland flow over the Hawley Esplanade intersection.

5.2.2 Flood modelling results

The modelling results for the minor (10%AEP) and major (1%AEP) events are presented in the following sections.

A copy of the flood maps is enclosed in Appendix A.

Overland flow

As per Option 1, modelling shows a reduction in inundation for the properties in Sankey Street properties. This also extends to 32 and 33 Hawley Esplanade as the overland flow is contained within the kerb and channel. The modelling results for Option 2 are showing a general overall reduction in depth and extent of inundation in the study area compared to Option 1, especially at the rear of 1-2 and 3 Arthur Place and the adjoining properties of Hawley Esplanade as seen in Figure 17. This is likely due to reducing the overall overland flows and spills.

As per Option 1, the extent and depth of inundation of 1-2 and 3 Arthur Place and the adjoining properties of Hawley Esplanade can be reduced by larger pipes, more pits, and a formalised overland flow path to the foreshore area where possible.

The maximum velocity of the overland flow in the steeper section of Sankey Street is less than 2.0 m/s and has a shallow depth (less than 150mm) for the major storm event. This classifies the overland flow as a H1 hazard vulnerability (refer to Section 4.6 and Appendix B) which is considered generally safe for vehicles and people in the street unlike Option 1.

Pit and pipe system

Modelling shows a reduction in flow through the DN600 main on the northern side of Sankey Street as flow transfers to the new DN900 pipe for the minor and major storm events. Also, we see a reduction in the flow through the existing pipework on the southern side of Sankey St due to the kerb and channel and connecting the pipe to the existing outfall outside 32 Hawley Esplanade.

A lower hydraulic grade line is observed in the previous inlet pipework due to the removal of the basin.

Also, replacing the DN375 pipeline on the southern side of Sankey Street (opposite the detention basin) results in the pipe being less than full and the new DN900 main is approaching full capacity for the 1% AEP event.

Figure 18 ***Minor storm (10% AEP) event – option 2 removing detention basin - extract of flood map from Appendix A***

Figure 19 ***Major storm (1% AEP) event – option 2 removing detention basin - extract of flood map from Appendix A***

5.3 Climate change impacts

Global warming has led to changes in the hydrological cycle and an increase in extreme flooding. The long-term consequences of development decisions make it important to consider climate change effects in stormwater infrastructure design.

Failure to account for potential climate hazards can lead to poor decisions, particularly when the exposure risk to climate change is medium to high. In these circumstances, a reasonable approach is to make a decision that is robust against a range of plausible futures. This may include considering the impacts or risks of much larger or heavier rainfall events (e.g., a 0.5% AEP event instead of a 1%AEP), or by appropriately upscaling the design rainfall based on current climate change models.

The applicable upscale factor is 16.3% for the year 2090 from the ARR data hub (https://data.arr-software.org/).

5.3.1 Model setup

The Climate Change Factor (CCF) of 16.3% was applied to the design rainfall for the 1%AEP event for each option.

5.3.2 Model results

The modelling results are presented in Option 1 and Option 2 below.

A copy of the flood maps is enclosed in Appendix A.

Option 1 – Retain/Upsize Detention Basin

The following observations are made:

- CCF increases run-off resulting in deeper inundation for this Option, and an increase in the basin water level height to 11.033m (assuming no overflow).
- Increase in the number of overflow points. Spilling can be mitigated with sealed manhole lids and non-return valves.
- Kerb and channel spilling can be addressed by raising verges and increasing pits.
- Inundation in Arthur Place and Hawley Esplanade can be reduced by increasing pits and pipe capacity with overland flow path/s.

Figure 20 ***Major storm (1% AEP) event with CCF - option 1 retain/upsize detention basin - ground levels and maximum water levels***

Figure 21 *Figure 22 major storm (1% AEP) event with CCF - option 1 retain/upsize detention basin - extract of flood map from Appendix A*

Option 2 – Remove Detention Basin

In the overland flow, the following observations are made:

– The CCF increases inundation and depth, but less than Option 1.
– Additional freeboard and pits in Sankey Street would provide protection from overtopping.
– Overland flow from behind the wall directs water to Sankey Street.
– Survey data suggests localised filling or drainage system upgrade at 32 Hawley Esplanade may be necessary.

Trunk mains are close to capacity, with the system relying on kerb and channel to carry excess flow to foreshore. Increasing pipe capacity and formalised overland flow path/s can reduce inundation in Arthur Place and adjoining properties.

Figure 23 Major storm (1% AEP) event with CCF – option 2 removing detention basin - extract of flood map from Appendix A

6. Energy dissipators

The following observations are made:

- Discharges from culverts or outlets can cause erosion problems.
- Energy dissipators help to mitigate this erosion by reducing discharge energy before releasing it downstream.
- There are four types of energy dissipators, each requiring specific conditions to operate efficiently.
- The dissipator types should be carefully selected based on the site's peculiarities and problems.
- Design parameters need to be considered during the selection process.

Hydraulic energy dissipators work by expending energy from the high-velocity flow using external friction, friction between water and air, or internal friction and turbulence.

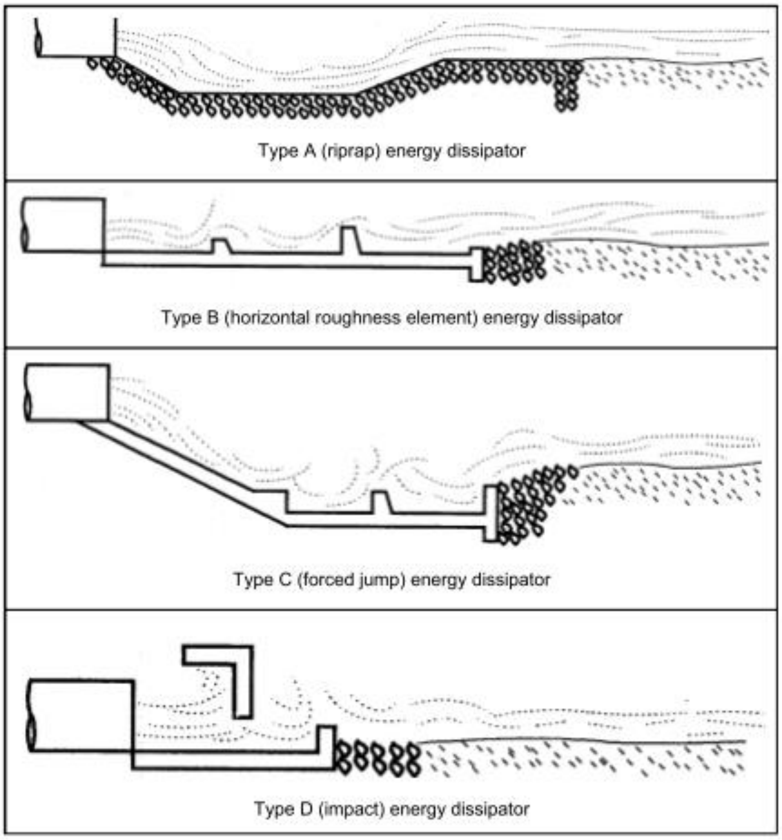

Figure 24 Energy dissipator types

Dissipator type	Froude number(7)	Allowable Debris(1)			Tail water (TW)
		Silt/sand	Boulders	Floating	
Flow transitions	na	H	H	H	Desirable
Scour hole	na	H	H	H	Desirable
Hydraulic jump	> 1	H	H	H	Required
Tumbling flow(2)	> 1	M	L	L	Not needed
Increased resistance(3)	na	M	L	L	Not needed
UABR type IX baffled apron	< 1	M	L	L	Not needed
Broken-back culvert	> 1	M	L	L	Desirable
Outlet weir	2–7	M	L	M	Not needed
Outlet drop/weir	3.5–6	M	L	M	Not needed
USBR type III stilling basin	4.5–17	M	L	M	Required
USBR type IV stilling basin	2.5–4.5	M	L	M	Required
SAF stilling basin	1.7–17	M	L	M	Required
CSU rigid boundary basin	< 3	M	L	M	Not needed
Contra Costa basin	< 3	H	M	M	< 0.5 D
Hook basin	1.8–3	H	M	M	Not needed
USBR type VI impact basin(4)	na	M	L	L	Desirable
Riprap basin	< 3	H	H	H	Not needed
Riprap apron(8)	na	H	H	H	Not needed
Straight drop structure(5)	< 1	H	L	M	Required
Box inlet drop structure(6)	< 1	H	L	M	Required
USACE stilling well	na	M	L	N	Desirable

1 *Debris notes: N = none, L = low, M = moderate, H = heavy*
2 *Bed slope must be in the range 4% < S_o < 25%.*
3 *Check headwater for outlet control.*
4 *Discharge, Q < 11 m^3/s and Velocity, V < 15 m/s*
5 *Drop < 4.6 m.*
6 *Drop < 3.7 m.*
7 *At release point from culvert or channel.*
8 *Culvert rise less than or equal to 1500 mm.*

Note: na = not applicable.

Figure 25 **_Dissipator limitations (source: guide to road design part 5: drainage -general and hydrology considerations)_**

An important parameter in the selection of an appropriate energy dissipator is the Froude Number (Fr).

Also, another important aspect to consider would be the aesthetics of any proposed design.

The maximum pipe outlet velocities from the model are shown in Table 19. The maximum advisable velocity for sandy beaches is 1-1.5 m/s. As the velocities from the existing and proposed outlets exceed this, scouring and erosion at the outlets is expected. The simplest solution would be to reduce the grade of the outfall pipe to keep velocities below the maximum values with an overflow or dispersion structure upstream of the outlet. Details of this structure would be developed in the design phase of this project.

However, the erosion on the beach may not be considered a priority as the scouring is generally “self-healing” with the transportation of sand in the tide cycle. This temporary “scar” may be better received by the community than a permanent energy dissipator.

An alternative to the traditional stormwater outlet is an infiltration style system.

Table 19 Summary of outlet flow velocities

Modelling scenario	Existing DN600 m/s	Proposed DN900 m/s
Existing – 10% AEP	3.942	-
Existing – 1% AEP	4.201	-
Option 1 – 10% AEP	4.232	
Option 1 – 1% AEP	4.283	
Option 1 – 1%AEP with CCF	4.284	
Option 2 – 10% AEP	3.705	4.256
Option 2 – 1% AEP	4.140	4.568
Option 2 – 1%AEP with CCF	4.227	4.659

7. Staging and estimates

Budget cost estimates (+/-25%) for each option is enclosed in Table 20 along with a proposed staging of the works. A detailed breakdown of the estimate is enclosed in Appendix C.

Table 20 Cost estimate and staging of works

	Option 1 – retaining/increasing capacity of detention basin	Option 2 – removal of detention basin
Staging of the works	**Phase 1 – Kerb and Channel - $360,087** Contain overland flows and run-off from the road and overflows from the detention basin and discharge to the foreshore. Minimise flows entering adjoining properties.	**Phase 1 – Kerb and Channel - $360,087** Contain overland flows and run-off from the road and discharge to the foreshore. Minimise flows entering adjoining properties.
	Phase 2 - Detention basin - $228,000 Retaining and increasing the capacity of the existing detention basin.	**Phase 2 – Remove Basin and upgrade stormwater network - $545,127** Remove/Remediate Detention Basin and upgrade pit and pipe network.
	Phase 3 – Arthur Place drainage works - $127,964 Kerb and Channel and upgrade existing stormwater infrastructure in Arthur Place.	**Phase 3 – Arthur Place drainage works - $127,964** Kerb and Channel and upgrade existing stormwater infrastructure in Arthur Place.
Cost estimate	$716,051	$1,033,178
Contingency – 25%	$179,013	$258,295
Rock contingency	$22,721	$121,473
Total estimate	$917,785	$1,412,946

Note: Rock Contingency assumes 20% rock is encountered in the stormwater trenches. Rock rate - $660/m3.

Cost Estimate does not include design and documentation, approvals, contract administration, or Council overheads.

The costs do not include GST or any permit fees or charges.

The Latrobe Council has allocated $914,000 in the 2023/2024 Capital Works Budget for the Sankey Stormwater improvement works. From the above, Council may require additional funds to complete the works in the current financial year, or over consecutive years if the work is to be staged.

8. Analysis and discussion

Modelling of the Sankey Street Catchment has shown the existing drainage system cannot accommodate the 10% or 1% AEP events without inundating private properties east of the Joyce Street intersection.

Two mitigation measures were considered to minimise the flooding risk associated with the minor and major storm events. The two options were:

Option 1

– Increasing the capacity of the existing detention basin to retain a 1% AEP event with no overflows.
– Kerb and channel and nature strip works in Arthur Place, Joyce Street and Sankey Street to contain the overland flow to the road and reduce the level of inundation to the adjoining and downstream properties.
– Creating a formed overland flow path in Sankey Street east of the Joyce St intersection to the estuary.

Summary

– Should Council desire to accommodate the 1% AEP event without the basin spilling, the existing spillway of the basin needs to be raised to a minimum RL of 11.033m if considering climate effects which is not considered practical. Any increasing in the wall height may require an assessment and permit under the Water Management Act, and practical aspects such as maintenance access needs to be considered.

Option 2

– Removing/decommissioning the existing detention basin and orifice.
– Upsizing/duplicating the pipework to accommodate the increase in downstream flows with consideration of future climate effects. This consists of:
  - A new DN900 main with pits and manholes in Sankey St from the Glyde St / Sankey St intersection to the estuary and separating it from the existing DN600 pipe on the northern side of the road.
  - Diverting the existing DN300 mains on the southern side of Sankey Street to the existing outfall outside 32 Hawley Esplanade to separate the property drainage lines from the trunk mains in Sankey Street.
– Creating a formed overland flow path in Sankey Street east of the Joyce St intersection to the estuary.

Summary

– While Option 2 has been modelled without the detention basin, it could remain in-situ or be remediated with the land sold if desired by Council.

Regardless of the option, the provision of kerb and channel with appropriate shaping and grading of the nature strips will reduce the level of inundation of the adjoining properties in Sankey Street. The overland flow system should be designed to discharge freely to the foreshore area and not pond in the sag of Sankey Street and/or the adjoining properties.

The existing pit and pipe system in Arthur Place is undersized, and the Council GIS data shows that the downstream infrastructure will need to be upgraded or replaced to accommodate at least the minor storm event. It is recommended that detailed survey work be undertaken to confirm the pit and pipe information and determine the provision of an overland flow path to the foreshore area. The proposed stormwater main in Sankey Street should be installed after confirming the depth of rock and location of conflicting services.

The flood hazard maps presented in Appendix B show that Option 2 is safer than Option 1 for 1%AEP event and climate change. Option 1 has unsafe overland flow in the steeper section of Sankey Street. A risk assessment should be conducted if Option 1 is to be further considered.

A review of the advantages and disadvantages of each option is given in Table 19 and Table 20.

It is recommended to install a rain gauge station to record actual rainfall events and their temporal pattern for future hydraulic models.

Overall, Option 2 is the preferable solution as it results in reduced depth and inundation of properties with minimal hazards and risks.

Table 21 Option 1 – retain/upsize detention basin - advantages and disadvantages

Item	Advantages	Disadvantages
Retaining and increasing the capacity of the existing detention basin	– Limits the peak outflow from the detention basin where the downstream drainage system has limited capacity. – Potential pollutant source control – Lower cost than Option 2.	– Inlet and Outlet Bar Screens – Inclined bar screens are preferred to minimise blockages, but blockages can still occur causing the basin (or inlet structure) to potentially spill or operate as not designed. Regular inspections and maintenance are required, particularly before, and during large storm events. Access to the screens should be located above the high water level to enable access and clearing of any potential blockages. The bar screens prevent people entering the large pipes at the detention basin (confined space) and reducing the likelihood of the large orifice from being blocked due to debris in the line, although debris by the DN900 main in Sankey Street. – The detention basin will require regular inspections and maintenance to remove accumulated sediment and silt from the floor and inspect the integrity and function of the structure. Detention basins act as a dam during flood events and their inherent and safety aspects need to be considered and documented in a risk assessment. – Overflows from the detention basin during storm events (including those with a <1% AEP event) and their impact on downstream properties and infrastructure needs to be considered and managed. – Increasing the capacity of the detention basin may require a dam permit under the Water Management Act 1999 and the Water Management (Safety of Dams) Regulations 2015. There is a risk the application may not be approved. Will also need to consider the cost implications of complying with any permit conditions. – Increasing the basin wall height above the driveway level will restrict or prevent maintenance access. – Increasing the basin wall height will induce overflows at other points in the network which will need to be assessed and addressed. – Risk profile (likelihood and consequence) and acceptance of the basin may change over the life of the structure which may result in future mitigation measures or changes. This includes the spillway regularly discharging to the roadway due to low probability events occurring, or from the outlet being regularly blocked. – Aesthetics of the detention basin.
Creation of Overland Flow Path – Sankey Street and Arthur Place	– To contain overland flows and run-off from the road and overflows from the detention basin and discharge to the foreshore. – To contain overland flow to the street and minimise flows entering adjoining properties. – A potential benefit of lowering the intersection is the creation of an overland flow path for the two low lying properties adjoining the intersection. – Kerb and channel may be extended into Arthur Place to provide further protection to downstream	– The lower portion of Sankey Street will need to be vertically realigned/adjusted, including the intersection and adjoining sections of Hawley Esplanade. – Any changes to the vertical alignment will need to consider the depth and location of existing services and rock. Any significant changes may require the relocation of services which require approval from the relevant asset owners and will be at the Council cost. – Some residents may not support kerb and channel works.

Item	Advantages	Disadvantages
	properties. This will require an upgrade of the stormwater network in Arthur Place. – Lower cost than Option 2.	

Table 22 Option 2 – remove the detention basin - advantages and disadvantages

Item	Advantages	Disadvantages
Removal/Remediation of Detention Basin and upgrade of the pit and pipe network.	– Removes the detention basin and all the associated issues with it. – The large diameter of the proposed pipe is less likely to block or become obstructed. – The inspection and maintenance regime will be less compared to a detention basin. – Risk profile (likelihood and consequence) of a flood event is typical of any urban developed street. The acceptance of the work is unlike to change over the life of the assets. – The detention basin site can be remediated and sold if desired. Funds from the sale could be used to offset the cost of the capital works. Alternatively, the land could be used as a small park/recreational area.	– Does not limit the peak outflow from the detention basin site. Downstream drainage system needs to be upgraded to accommodate the increase in flow. – No potential pollutant source control. However, a water quality management device already exists downstream of the detention basin. – Any works in the foreshore area will require approval from the Parks and Wildlife Service. – Construction costs can increase if rock is encountered during construction, or conflicting services need to be relocated. These unexpected costs can be minimised by confirm their depth and location. – This will determine if installing a single large (DN900) pipe is possible, or if smaller parallel pipes are required. – Higher cost than Option 2.
Creation of Overland Flow Path – Sankey Street and Arthur Place	– To contain overland flows and run-off from the road and discharge to the foreshore. – To contain overland flow to the street and minimise flows entering adjoining properties. – A potential benefit of lowering the intersection is the creation of an overland flow path for the two low lying properties adjoining the intersection. – Kerb and channel may be extended into Arthur Place to provide further protection to downstream properties. This will require an upgrade of the stormwater network in Arthur Place.	– The lower portion of Sankey Street will need to be vertically realigned/adjusted, including the intersection and adjoining sections of Hawley Esplanade. – Any changes to the vertical alignment will need to consider the depth and location of existing services and rock. Any significant changes may require their relocation which will require approval from the relevant asset owners and will be at the Council cost. – Some residents may not support kerb and channel works. – Higher cost than Option 2.

9. Conclusion

The modelling results shows the existing drainage system for the Sankey Street Catchment cannot accommodate the minor (10% AEP) event or the major (1% AEP) events without inundating private properties east of the Joyce Street intersection and spilling the detention basin.

Of the two options considered in this report to protect or reduce the risk of flooding (or inundation) to people and property, Option 2 is considered the preferable solution, especially when considering climate change.

10. Next steps

This report concludes Stage 1.

A possible implementation plan for Council consideration is provided in Table 23.

Table 23 Proposed plan and recommendations

Step 1	
	– Council to consider if it wishes to further develop or proceed with the mitigation options proposed, or any other short-listed options with potential merit subsequently identified to this report. – Council to consider installing a rain gauge station in the Hawley/Shearwater/Port Sorell area.
Step 2	
	– If proposing to increase the volume of the detention basin under Option 1: • Contact the Department of Natural Resources and Environment (NRE) to determine if an application is required for the work, and if so, what information/detail is required. – Prepare application and submit details to NRE for assessment as required.
	– If proposing to further develop Option 2: • Contact Parks and Wildlife Service regarding the proposal to determine what information/detail is required for a works application. • Contact the Department of Natural Resources and Environment (NRE) to determine if an application is required for the work, and if so, what information/detail is required. Note: The detention basin could remain in-situ but would be effectively decommissioned.
	– Undertake detailed survey for the proposed works, including: • The existing stormwater infrastructure of Arthur Place and the outfall outside 32 Sankey Street. • A rock survey and service location.
Step 3	
	– Undertake design.
	– Prepare IFC documentation and undertake the work for Sankey Street, Hawley Esplanade and Joyce Street.
Step 4	
	– If approved, prepare Detention Basin IFC (Issue For Construction) documentation, and undertake the work in accordance with the conditions of the issued permit (from Step 2).
Step 5	
	– Prepare IFC documentation and undertake the work for Arthur Place.

11. References

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Appendices

Appendix A

Flood maps

Paper Size ISO A1

0 0.01 0.02 0.03 0.04

Kilometers

1:1,000

Map Projection: Transverse Mercator

Horizontal Datum: GDA 1994

Grid: GDA 1994 MGA Zone 55

N

GHD

LATROBE COUNCIL
Sankey Street Stormwater
Improvement Works

Flood Map 1% AEP
Existing Scenario

Project No. 12616079
Revision No. B
Date 16/11/2023

FIGURE 1

C:\Users\ekiseleva\OneDrive - GHD\Desktop\Hawley\DOCS\Working maps\12616079_002_Flood_Map_10pct_Existing_Case.mxd
Print date: 16 Nov 2023 - 10:52

Data source: . Created by: ekiseleva

Paper Size ISO A1

0 0.01 0.02 0.03 0.04

Kilometers

1:1,000

Map Projection: Transverse Mercator

Horizontal Datum: GDA 1994

Grid: GDA 1994 MGA Zone 55

N

LATROBE COUNCIL
Sankey Street Stormwater
Improvement Works

Flood Map 10% AEP
Existing Scenario

Project No. 12616079
Revision No. B
Date 16/11/2023

FIGURE 2

C:\Users\ekiseleva\OneDrive - GHD\Desktop\Hawley\DOCS\Working maps\12616079_001_Flood_Map_1pct_Existing_Case.mxd
Print date: 16 Nov 2023 - 11:03

Data source: . Created by: ekiseleva

Paper Size ISO A1

0 0.01 0.02 0.03 0.04

Kilometers

1:1,000

Map Projection: Transverse Mercator

Horizontal Datum: GDA 1994

Grid: GDA 1994 MGA Zone 55

N

GHD

LATROBE COUNCIL
Sankey Street Stormwater
Improvement Works

Flood Map 1% AEP Climate Change
Option 1

Project No. 12616079
Revision No. B
Date 21/09/2023

FIGURE 3

C:\Users\ekiseleva\OneDrive - GHD\Desktop\Hawley\DOCS\Working maps\12616079_003_Flood_Map_1pct_Option_1_CC.mxd
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Data source: . Created by: ekiseleva

Paper Size ISO A1
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Kilometers
1:1,000
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

GHD

LATROBE COUNCIL
Sankey Street Stormwater
Improvement Works

Flood Map 1% AEP
Option 1

Project No. 12616079
Revision No. B
Date 16/11/2023

FIGURE 4

C:\Users\ekiseleva\OneDrive - GHD\Desktop\Hawley\DOCS\Working maps\12616079_004_Flood_Map_1pct_Option_1.mxd
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Data source: . Created by: ekiseleva

LATROBE COUNCIL
Sankey Street Stormwater
Improvement Works

Flood Map 10% AEP
Option 1

Project No. 12616079
Revision No. B
Date 16/11/2023

FIGURE 5

C:\Users\ekiseleva\OneDrive - GHD\Desktop\Hawley\DOCS\Working maps\12616079_005_Flood_Map_10pct_Option_1.mxd
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Data source: . Created by: ekiseleva

Paper Size ISO A1

0 0.01 0.02 0.03 0.04

Kilometers

1:1,000

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LATROBE COUNCIL
Sankey Street Stormwater
Improvement Works

Flood Map 1% AEP Climate Change
Option 2

Project No. 12616079
Revision No. B
Date 16/11/2023

FIGURE 6

C:\Users\ekiseleva\OneDrive - GHD\Desktop\Hawley\DOCS\Working maps\12616079_006_Flood_Map_1pct_Option_2_CC.mxd
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Data source: . Created by: ekiseleva

Paper Size ISO A1

0 0.01 0.02 0.03 0.04

Kilometers

1:1,000

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LATROBE COUNCIL
Sankey Street Stormwater
Improvement Works

Flood Map 10% AEP
Option 2

Project No. 12616079
Revision No. B
Date 16/11/2023

FIGURE 7

C:\Users\ekiseleva\OneDrive - GHD\Desktop\Hawley\DOCS\Working maps\12616079_007_Flood_Map_10pct_Option_2.mxd
Print date: 16 Nov 2023 - 11:46

Data source: . Created by: ekiseleva

Flood Depth 1% AEP
0.05 m - 0.15 m
0.15 m - 0.25 m
0.25 m - 0.45 m
0.45 m - 0.65 m
0.65 m - 0.85 m
0.85 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.90 m
Surcharge
Pipe Surcharging
Pipe Full
Pipe 80% Full
Pipe
Nodes
Property Boundary
Correa Court
Hawley Esplanade
Jade Place
Diamond Way
Chardonnay Drive
Bushland Avenue
Topaz Place
Clyde Street
Joyce Street
Sankey Street
Arthur Place
Paradise Place
Sheoak Lane
Opal Mews
Garnet Place
Data source: Roads (LIST), Boundary Lines (LIST), Road Centre lines (LIST), Flood Model (GHD).
Created by:ekiseleva
Paper Size ISO A1
0 0.01 0.02 0.03 0.04
Kilometers
1:1,000
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55
N
LATROBE COUNCIL
Sankey Street Stormwater Improvement Works
Flood Map 1% AEP
Option 2
Project No. 12616079
Revision No. B
Date 16/11/2023
FIGURE 8
C:\Users\ekiseleva\OneDrive - GHD\Desktop\Hawley\DOCS\Working maps\12616079_008_Flood_Map_1pct_Option_2.mxd
Print date: 16 Nov 2023 - 13:18
Data source: . Created by: ekiseleva

Appendix B

Hazard maps

Paper Size ISO A1

0 0.01 0.02 0.03 0.04

Kilometers

1:1,000

Map Projection: Transverse Mercator

Horizontal Datum: GDA 1994

Grid: GDA 1994 MGA Zone 55

N

GHD

LATROBE COUNCIL
Sankey Street Stormwater
Improvement Works

Flood Hazard Map 1% AEP
Option 1

Project No. 12616079
Revision No. B
Date 16/11/2023

FIGURE 9

C:\Users\ekiseleva\OneDrive - GHD\Desktop\Hawley\DOCS\Working maps\12616079_009_Flood_Map_1pct_Option_1_Hazard.mxd
Print date: 17 Nov 2023 - 08:46

Data source: . Created by: ekiseleva

Paper Size ISO A1

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Kilometers

1:1,000

Map Projection: Transverse Mercator

Horizontal Datum: GDA 1994

Grid: GDA 1994 MGA Zone 55

N

GHD

LATROBE COUNCIL
Sankey Street Stormwater
Improvement Works

Flood Hazard Map 1% AEP
Option 2

Project No. 12616079
Revision No. B
Date 16/11/2023

FIGURE 10

C:\Users\ekiseleva\OneDrive - GHD\Desktop\Hawley\DOCS\Working maps\12616079_010_Flood_Map_1pct_Option_2_Hazard.mxd
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Data source: . Created by: ekiseleva

Paper Size ISO A1

0 0.01 0.02 0.03 0.04

Kilometers

1:1,000

Map Projection: Transverse Mercator

Horizontal Datum: GDA 1994

Grid: GDA 1994 MGA Zone 55

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GHD

LATROBE COUNCIL
Sankey Street Stormwater
Improvement Works

Flood Hazard Map 1% AEP Climate Change
Option 1

Project No. 12616079
Revision No. B
Date 16/11/2023

FIGURE 11

C:\Users\ekiseleva\OneDrive - GHD\Desktop\Hawley\DOCS\Working maps\12616079_011_Flood_Map_1pct_CC_Option_1_Hazard.mxd
Print date: 17 Nov 2023 - 08:55

Data source: . Created by: ekiseleva

1:1,000
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

LATROBE COUNCIL
Sankey Street Stormwater
Improvement Works

Project No. 12616079
Revision No. B
Date 16/11/2023

Flood Hazard Map 1% AEP Climate Change
Option 2

FIGURE 12

C:\Users\ekiseleva\OneDrive - GHD\Desktop\Hawley\DOCS\Working maps\12616079_012_Flood_Map_1pct_CC_Option_2_Hazard.mxd
Print date: 16 Nov 2023 - 14:10

Data source: . Created by: ekiseleva

Data source: Roads (LIST), Boundary Lines (LIST), Road Centre lines (LIST), Flood Model (GHD). Created by ekiseleva

Appendix C

Budget cost estimates

Sankey Street, Hawley Stormwater Improvements
Option 1 - Increasing Size of Detention Basin
Budget Cost Estimate

Date 22/11/2023 ISSUE 1

Estimator J.F

BUDGET ESTIMATE TOTAL $917,785

Item	Description	Unit	Qty	Rate	Amount
	Kerb and Channel				$360,087
1	Preliminaries / Site Establishment	Item	0.5	$19,000	$9,500
2	Set out	Item	1	$4,000	$4,000
3	Allowance for Excavation/Fill (Sankey Street)	m2	584	$61	$35,367
4	Allowance for Sub-base (Sankey Street)	m2	584	$23	$13,657
5	Allowance for Base (Sankey Street)	m2	464	$24	$11,347
6	Allowance for Primer Seal (Sankey Street)	m2	464	$3.52	$1,633
7	Asphalt (Sankey Street)	m2	464	$44	$20,458
8	Allowance for Excavation/Fill (Hawley Esplanade)	m2	620.5	$61	$37,577
9	Allowance for Sub-base (Hawley Esplanade)	m2	620.5	$23	$14,511
10	Allowance for Base (Hawley Esplanade)	m2	493	$24	$12,056
11	Allowance for Primer Seal (Hawley Esplanade)	m2	493	$3.52	$1,735
12	Asphalt (Hawley Esplanade)	m2	493	$44	$21,736
13	Kerb Works - Allowance for Excavation/Fill (Sankey Street) - 1.2m x 0.35m x 90m	m2	229.05	$61	$13,871
14	Allowance for Sub-base (Sankey Street)	m2	610.8	$23	$14,284
15	Allowance for Base (Sankey Street)	m2	229.05	$24	$5,601
16	Allowance for Primer Seal (Sankey Street)	m2	229.05	$3.52	$806
17	Asphalt (Sankey Street)	m2	229.05	$44	$10,099
18	Kerb (KC)	m	599	$220	$131,846
	Detention Basin				$228,000
19	Retaining Wall - Increase height of Vertiblock wall	Item	1	$228,000	$228,000
	Arthur Place Drainage Works				$127,964
20	Stormwater pipe 450 RCP (class 2) - Arthur Place	m	153	$427	$65,359
21	Manhole DN1050 - Arthur Place	ea	5	$5,280	$26,399
22	Pit - Side Entry Type 3	ea	3	$7,141	$21,424
23	Kerb Works - Allowance for Excavation/Fill (Arthur Street) - 1.2m x 0.35m x 90m	m2	108	$61	$6,540
24	Allowance for Sub-base (Arthur Street)	m2	108	$23	$2,526
25	Allowance for Base (Arthur Street)	m2	40.5	$24	$990
26	Allowance for Primer Seal (Arthur Street)	m2	40.5	$3.52	$143
27	Asphalt (Arthur Street)	m2	40.5	$44	$1,786
28	Driveway - gravel Reinstatement (Arthur Place)	m2	69	$27	$1,883
29	Topsoil and Grass - Arthur Place	m2	45.75	$20	$915
				SUB TOTAL	$716,051
30	Design	0%			$0
31	Project Admin	0%			$0
32	Works	0%			$0
33	Rock Contingency (20% of trench volumes)	20%			$22,721
34	Contingency	25%			$179,013
				TOTAL	$917,785

Note:
Rock Contingency assumes 20% rock is encountered in the stormwater trenches. Rock rate - $660/m3.
Cost Estimate does not include design and documentation, approvals, contract administration, or Council overheads.
The costs do not include any permits or fees.

Sankey Street, Hawley Stormwater Improvements
Option 2 - Remove Detention Basin
Budget Cost Estimate

Date 22/11/2023 ISSUE 1

Estimator J.F

BUDGET ESTIMATE TOTAL $1,412,946

Item	Description	Unit	Qty	Rate	Amount
	Kerb and Channel				$360,087
1	Preliminaries / Site Establishment	Item	0.5	$19,000	$9,500
2	Set out	Item	1	$4,000	$4,000
3	Allowance for Excavation/Fill (Sankey Street)	m2	584	$61	$35,367
4	Allowance for Sub-base (Sankey Street)	m2	584	$23	$13,657
5	Allowance for Base (Sankey Street)	m2	464	$24	$11,347
6	Allowance for Primer Seal (Sankey Street)	m2	464	$3.52	$1,633
7	Asphalt (Sankey Street)	m2	464	$44	$20,458
8	Allowance for Excavation/Fill (Hawley Esplanade)	m2	620.5	$61	$37,577
9	Allowance for Sub-base (Hawley Esplanade)	m2	620.5	$23	$14,511
10	Allowance for Base (Hawley Esplanade)	m2	493	$24	$12,056
11	Allowance for Primer Seal (Hawley Esplanade)	m2	493	$3.52	$1,735
12	Asphalt (Hawley Esplanade)	m2	493	$44	$21,736
13	Kerb Works - Allowance for Excavation/Fill (Sankey Street) - 1.2m x 0.35m x 90m	m2	229.05	$61	$13,871
14	Allowance for Sub-base (Sankey Street)	m2	610.8	$23	$14,284
15	Allowance for Base (Sankey Street)	m2	229.05	$24	$5,601
16	Allowance for Primer Seal (Sankey Street)	m2	229.05	$3.52	$806
17	Asphalt (Sankey Street)	m2	229.05	$44	$10,099
18	Kerb (KC)	m	599	$220	$131,846
	Remove Basin and Upgrade Stormwater Network				$545,127
19	Stormwater pipe 600 RCP (class 2) - Replace Detention Basin	m	55	$474	$26,087
20	Topsoil and Grass - Detention Basin	m2	49.5	$20	$990
21	Stormwater pipe 450 RCP (class 2) - Hawley Esplanade	m	89	$427	$38,019
22	Stormwater pipe 900 RCP (class 4) - Sankey Street	m	360	$1,076	$387,247
23	Manhole DN1050 - Hawley Esplanade	ea	4	$5,280	$21,119
24	Manhole 1500 Dia - Sankey Street	ea	8	$6,800	$54,400
25	Headwall - Winged 450Dia - Sankey Street	ea	1	$1,622.08	$1,622
26	Asphalt 40mm - Reinstatement (Kerb Works)	m2	0	$44	$0
27	Asphalt 40mm - Reinstatement (DN 900 pipe)	m2	92.4	$44	$4,074
28	Concrete - Reinstatement (DN 900 pipe)	m2	55.2	$132	$7,286
29	Asphalt 40mm - Reinstatement (DN 450 pipe - Hawley Esplanade)	m2	16.5	$44	$727
30	Topsoil and Grass - Hawley Esplanade	m2	177.75	$20	$3,555
	Arthur Place Drainage Works				$127,964
31	Stormwater pipe 450 RCP (class 2) - Arthur Place	m	153	$427	$65,359
32	Manhole DN1050 - Arthur Place	ea	5	$5,280	$26,399
33	Pit - Side Entry Type 3	ea	3	$7,141	$21,424
34	Kerb Works - Allowance for Excavation/Fill (Arthur Street) - 1.2m x 0.35m x 90m	m2	108	$61	$6,540
35	Allowance for Sub-base (Arthur Street)	m2	108	$23	$2,526
36	Allowance for Base (Arthur Street)	m2	40.5	$24	$990
37	Allowance for Primer Seal (Arthur Street)	m2	40.5	$3.52	$143
38	Asphalt (Arthur Street)	m2	40.5	$44	$1,786
39	Driveway - gravel Reinstatement (Arthur Place)	m2	69	$27	$1,883
40	Topsoil and Grass - Arthur Place	m2	45.75	$20	$915
				SUB TOTAL	$1,033,178
41	Design	0%			$0
42	Project Admin	0%			$0
43	Works	0%			$0
44	Rock Contingency (20% of trench volumes)	20%			$121,473
45	Contingency	25%			$258,295
				TOTAL	$1,412,946

Note:
Rock Contingency assumes 20% rock is encountered in the stormwater trenches. Rock rate - $660/m3.
Cost Estimate does not include design and documentation, approvals, contract administration, or Council overheads.
The costs do not include any permits or fees.