WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Nagambie & Violet Town

Flash Flood Investigations

Strathbogie Shire Council

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1 INTRODUCTION

It is understood that Strathbogie Shire has experienced several flash flood incidents in recent times, with repeated events occurring in Violet Town and Nagambie. A recent flash flood event, on 29th December 2016, caused damage and/or concern at a number of properties, including:

- 7, 9 and 11 Ludovic Marie Court, Nagambie;
- 197 and 203 High Street, Violet Town;
- 6A Lily Street, Violet Town; and
- 2 Primrose Street, Violet Town.

Flash flooding at the above-mentioned properties is of concern and has instigated the Council to commission investigations that are the subject of this report.

Water Technology has undertaken site inspections (except for 2 Primrose Street, Violet Town) and desktop investigations to identify the causes of damage/concern at each of the above-mentioned properties. This report documents the findings of those investigations, comments on the Council and landowner's respective liability and responsibilities with respect to the relevant legislation, and suggestions for mitigation and/or operational/maintenance improvements.

2 NAGAMBIE

2.1 December 2016 Flood Event

2.1.1 Rainfall

A significant rain event occurred on the 29th December, 2016. Rainfall recorded at the Goulburn Weir (the closest pluviograph rainfall gauge to Nagambie) recorded a total of 64.6 mm within 24 hours, most of which fell over one hour, from 4pm, as seen in Figure 2-1. The records are consistent with anecdotal evidence, with local residents citing similar rainfall totals.

Comparison of the recorded rainfall to the Intensity-Frequency-Duration relationship at Nagambie developed by the Bureau of Meteorology indicates that the rainfall event was as rare as a 1% Annual Exceedance Probability (AEP) for the most intense 15 to 30 minute period. Maximum rainfall intensities experienced, and their approximate exceedance probabilities for a range of durations are summarised in Table 2-1.

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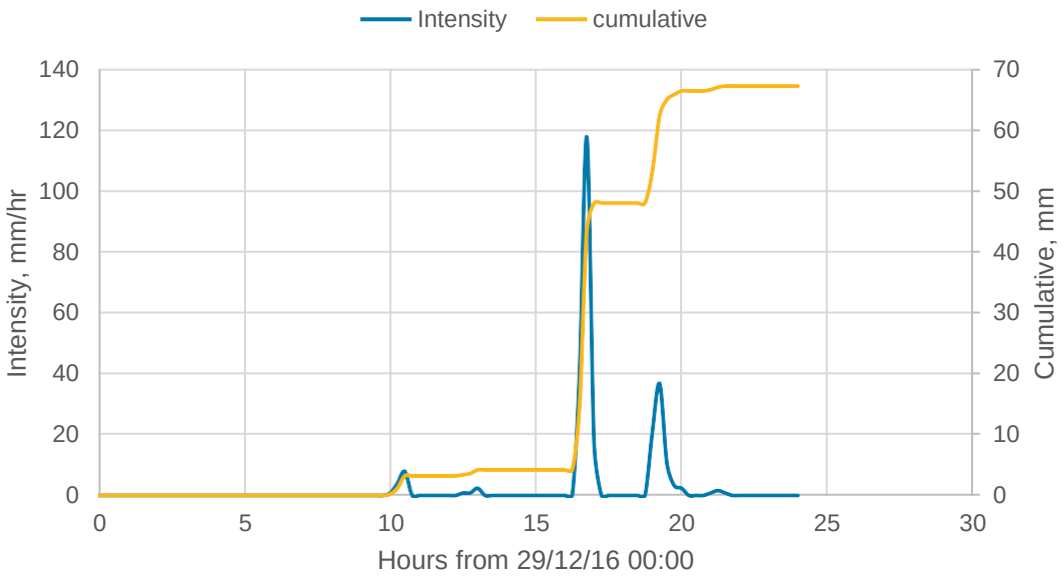

Figure 2-1 Rainfall recorded at Goulburn Weir gauge

Table 2-1 Nagambie peak rainfall intensities on 29th December 2016 and approximate AEP

Duration	15 min	30 min	1 hour	2 hour	3 hour	6 hour	12 hour	24 hour
Max Rainfall, mm	29.4	39.6	43.8	43.8	58.2	63.0	67.2	67.2
Approximate AEP	1%	1%	2%	5%	2%	2%	5%	20%

2.1.2 Runoff

The local catchment to those properties impacted on Ludovic-Marie Court consists of 2.2 ha of public land to the south, predominately comprised of the Nagambie Recreation Reserve, as seen in Figure 2-2. The total rain falling on this catchment would have equated to a volume of 1.4 ML (of which a small fraction would be lost to infiltration). This small local catchment drains to the pit located on the boundary of the football oval and the pit adjacent to the back fence of the impacted properties on Ludovic-Marie Court.

Figure 2-2 Catchment for impacted houses - Nagambie

Without detailed modelling, the peak flow from the catchment cannot be accurately determined, however, given the size of the catchment, a short duration is likely to be critical (calculations suggest a 10 minute critical duration). Based on the rainfall record, peak runoff would have occurred at the maximum intensity rainfall, which saw 29.4 mm fall over a 15 minute period. The peak flow from the 29th December 2016 event was likely very close to the peak flow estimated using the Rational Method technique for a 1% AEP event. The Rational Method 1% AEP peak flow was estimated as 0.26 m^3/s with a time of concentration just over 10 minutes.

It is noted that the Rational Method is no longer considered industry best practice, however the alternative Regional Flood Frequency method (Australian Rainfall and Runoff, 2016) is not recommended for catchments smaller than 0.5 km^2. Peak flows derived from the rational method and regional flood frequency method for this catchment are compared in Table 2-2 below.

Table 2-2 Peak flow estimates for the Nagambie catchment

AEP	Rational Method	RFFE Method
20%	0.16 m^3/s	0.10 m^3/s
1%	0.26 m^3/s	0.33 m^3/s

2.1.3 Flood Impacts

The residents at 7, 9 and 11 Ludovic-Marie Court all experienced flooding as a result of overland flow from the south of their properties. The properties adjoin the recreation reserve. Figure 2-3 shows a number of empty blocks, some of which have now been developed. Floodwaters encroached on the houses, but no property experienced above floor flooding other than in garages. The rate of flow caused local erosion of garden landscaping.

Anecdotal evidence of the timing of the flooding is consistent with runoff from the two peaks in rainfall, at approximately 4pm and 7pm on the 29th December. Volumes of runoff, as evidenced by photographs are also consistent with runoff from the recreation reserve catchment. No residents were impacted by direct rainfall, that is, the gutter drainage system did not overflow.

It is understood that Council workers assisted by forming a crude swale along the back of the properties to direct water to the nearby drainage pit. The pit inlet, however, is higher than the surrounding ground and therefore not conducive to drainage. Temporary sandbagging was also employed at the back of 9 Ludovic-Marie Court to prevent further water flowing through and under the fence.

2.2 Existing Controls

2.2.1 Infrastructure

A drainage network, consisting of 225 mm diameter reinforced concrete pipes divert water from the oval and along the northern boundary of the recreation reserve, discharging into the nearby waterway, as seen in Figure 2-3.

Figure 2-3 Drainage network at the Nagambie site

The capacity of the pipe network was determined using various hydraulic pipe flow capacity estimation techniques, which all provided a consistent estimate of 0.02 m^3/s. The flow capacity is limited by the grade of the pipe parallel to the northern boundary of the reserve. It is likely that with the surface entrance to the pit behind 17 Ludovic-Marie Court being higher than the surrounding ground level that the pipe may not have been flowing to its full capacity during the recent flash flooding event.

Table 2-3 Pipe Capacities

Pipe	Slope, m/m	Capacity, m^3/s
Oval to boundary	0.08	0.11
Parallel to boundary	0.003	0.02
Boundary to outlet	0.027	0.06

Note that inverts were not available for the pipe network and the slopes were determined by the ground surface. These flow capacities may therefore be revised if invert information becomes available.

2.2.2 Planning Controls

The properties at Ludovic-Marie Court are not subject to a Flood Overlay or Land Subject to Inundation Overlay (refer Section 4), however the area has been classified as Comprehensive Development Zone. A Stormwater Management Plan was submitted to Council in March 2008 as part of the development application, as required by this zoning.

The Plan considers stormwater management within the development site only, and does not consider overland flow from areas upstream of the development, which is the mechanism by which the houses are at risk of flooding. The Plan was ultimately approved by Council.

It is noted that many of the buildings have been constructed from boundary to boundary and have not allowed for overland flow to pass across the blocks. The dwellings constructed were approved by the relevant private building surveyors.

2.3 Causes of Damage/Concern

In light of the findings above, the causes of flood damage and concern expressed by impacted parties regarding recent flooding at Ludovic-Marie Court, Nagambie are summarised as:

- Extreme rainfall (~ 1% AEP) falling in December 2016;
- Residents expectation that Council is responsible for mitigating flood impacts;
- Potentially undersized local drainage network (<18% AEP);
- Construction of garages below the flood level;
- Residents expectation that garages should be protected from flooding as per the main dwelling;
- Entrance to the drainage pit being higher than the ground surface elevation;
- Local landscaping on properties, directing overland flow; and
- No allowance for maintenance of overland flow paths through properties.

3 VIOLET TOWN

3.1 December 2016 Flood Event

3.1.1 Rainfall

Similarly to Nagambie, a significant rainfall event occurred across Violet Town on the 29th December 2016. Rainfall recorded at the Honeysuckle Creek gauge (upstream of Violet Town, the nearest pluvio gauge to Violet Town) recorded a total of 92.5 mm within 24 hours. Anecdotal evidence suggests that rainfall totals in Violet Town were in excess of this. Two bursts of rainfall were recorded, with 55.4 mm falling over two hours from 6pm, and a further 23.9 mm falling over 1 hour from 8pm on the 29th December, as seen in Figure 3-1.

Comparison of the rainfall to the Intensity-Frequency-Duration relationship for Violet Town indicates that the rainfall event was as rare as a 1% Annual Exceedance Probability (AEP) storm over some bursts, but generally rarer than a 5% AEP storm. Maximum rainfall intensities experienced, and their approximate exceedance probabilities are summarised in Table 3-1.

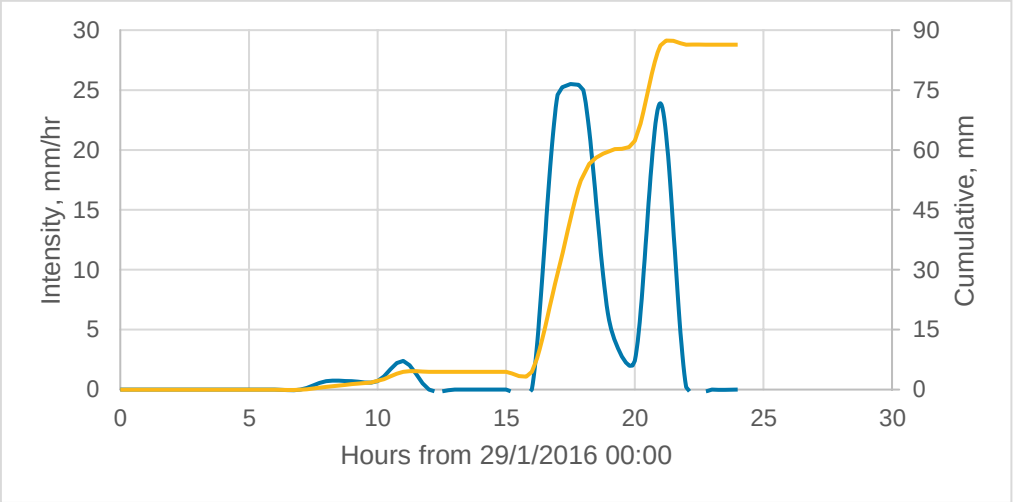

Figure 3-1 Rainfall recorded at Honeysuckle Creek gauge upstream of Violet Town

Table 3-1 Violet Town peak rainfall intensities on 29th December 2016 and approximate AEP

Duration	1 hour	2 hour	3 hour	6 hour	12 hour	24 hour
Max Rainfall, mm	25.0	49.6	55.4	81.9	84.8	86.4
Approximate AEP	20%	2%	5%	1%	2%	5%

3.1.2 Runoff

While a flood study has previously been prepared for Violet Town, the study focuses on riverine flooding and does not consider overland flow, such that occurred on December 29th 2016.

Given the complex nature of the topography, a rain-on-grid hydraulic model was developed to gain an understanding of overland flow paths. The model was developed as a 2D hydraulic model, utilising GPU

processing in the software package TUFLOW. A 1 m x 1 m resolution grid was used to represent the topography, based on the 2009-10 Floodplains 1m DEM.

The model did not incorporate the underground drainage network as the focus of the model was to identify likely overland flow paths in an intense rainfall event.

While the model is not calibrated, it has been developed using industry best practice, and can be considered representative of what overland flow may have occurred, although cannot be relied upon to accurately portray flood extents, depths and discharges.

With respect to the properties that are the subject of this report, the model demonstrated:

1. That runoff from the catchment south of High Street flowed along Meakins Avenue and flowed north-west through 221, 215 and 209 High Street, and along the southern easement on High Street towards Cowslip Street. This water encroached on properties 197 and 203 High Street from the front (Figure 3-2). This is consistent with anecdotal evidence.

2. The open channel at Murray Street overtops at the low points near Urmston Street and flows parallel to Urmstron Street towards High Street. This is consistent with flattened vegetation at isolated points along the channel. The majority of the channel did not overtop.

3. A localised flow path exists through the property at 6A Lily Street (Figure 3-3), with water approaching from Hyacinth Street and Marys Lane, flowing south-west through the back of properties on Cowslip Street, and then directly west towards Lily Street.

4. Floodwaters naturally accumulate at the low ground near 2 Primrose Street (Figure 3-4), and are prevented from dissipating to lower ground by the railway embankment.

Figure 3-2 Overland flow paths impacting properties on High Street, Violet Town

Figure 3-3 Overland flow paths impacting 6A Lily Street, Violet Town

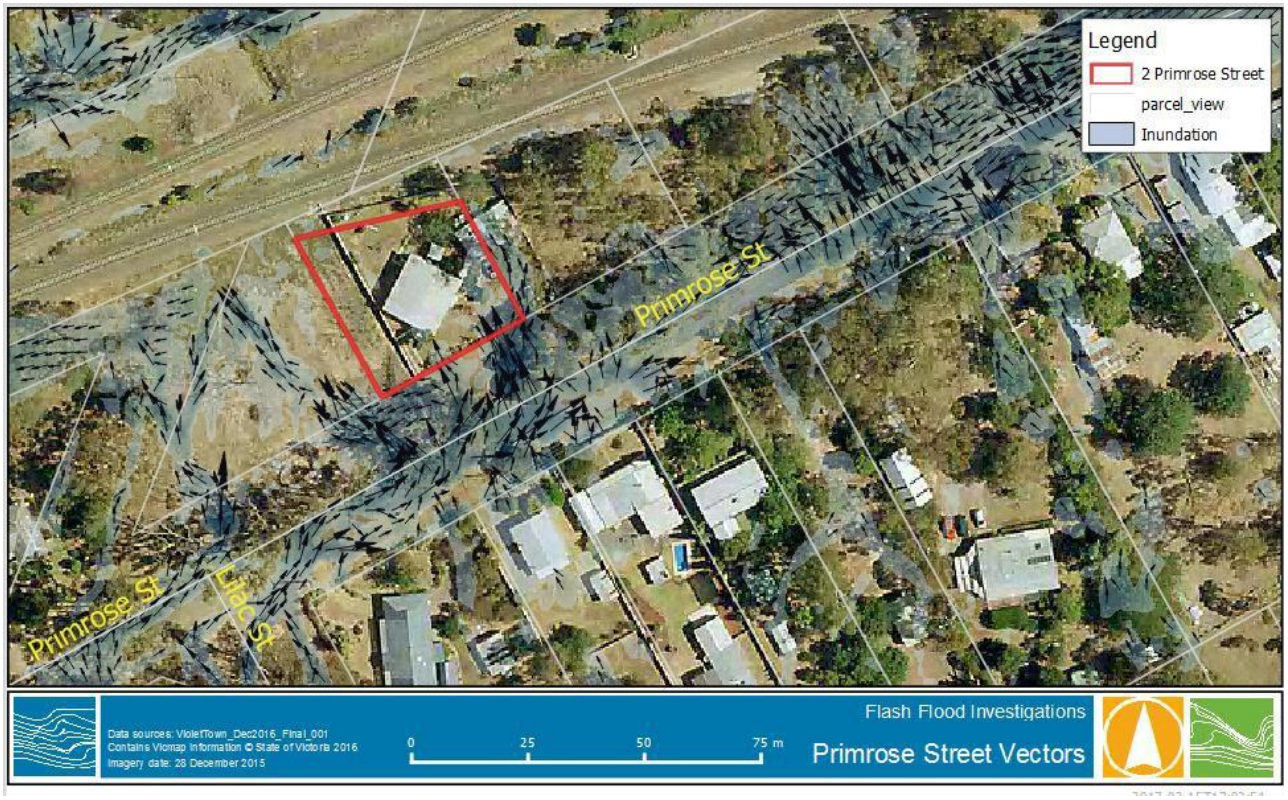

Figure 3-4 Overland flow paths impacting 2 Primrose Street, Violet Town

3.1.3 Impacts

High Street

Properties at 197 and 203 High Street experienced above floor flooding on the evening of the 29th December 2016. Anecdotal evidence, consistent with the hydraulic modelling, indicate that water predominately entered the properties from the front. Water marks suggested inundation up to 30 cm above ground level. Sandbags were deployed at both properties and at the headwall of the open drain at the Murray Street – Urmston Street intersection. Council also deployed pumps to alleviate water levels in the early morning of the 30th December.

At the time of inspection (10th January 2017), debris was still evident on High Street, suggestive that water levels were close to overtopping the road. As it has been described to Water Technology, High Street and Urmston Road acted as a levee during the event, ponding water to the south and west of these roads. It has been suggested that the design and construction of High Street (originally the Highway through Violet Town), and Urmston Street (which provides ramps on and off the Hume Freeway), did not adequately consider drainage. It is understood that these roads were designed by the Country Roads Board (now VicRoads). Without a detailed investigation, the impact of the current culvert capacities can not be confirmed.

It is understood that entrance pits to the drainage network was significantly blocked by organic litter, and were cleared on numerous occasions throughout the flood.

Lily Street

The property at 6A Lily Street was inundated from floodwaters entering through the back of the property. While the property did not experience above floor flooding, the shed at the back of the property was inundated to a depth of approximately 20 cm.

It is understood that the property owner removed debris from an open section of the drain directly behind his property, and that this resulted in a decrease in flood levels.

At the time of the inspection (10th January 2017), there was a small amount of water ponding in the reserve directly behind 6A Lily Street.

Primrose Street

The property at 2 Primrose Street was not subject to a site inspection, however information was provided by the residents to Council that the property experienced flooding on the 29th December 2016. While the flood levels remained below the floor level of the house, sheds at the back of the property were inundated.

3.2 Existing Controls

3.2.1 Infrastructure

High Street

An open drain alongside Murray Street diverts water from the upstream catchment (south of High Murray Street) toward the north-east, discharging into Honeysuckle Creek. The open drain is of significant size (although residents have said that it has silted up considerably over the years), with an estimated capacity of 2.4 m^3/s. This is well in excess of the 18% AEP design standard and is potentially in excess of a 1% AEP. The channel showed signs of isolated overtopping during the December 2016 event, as noted by flattened vegetation on the northern bank at the Murray St – Urmston St intersection. The overtopping was not extensive, and is consistent with those locations demonstrated in the modelling (i.e. notably at one location behind 193 High Street, as seen in Figure 3-2).

A drainage network on the southern side of High Street exists, diverting water to an open drain east of Urmston Street, again discharging to Honeysuckle Creek, as seen in Figure 3-5. Details of this drainage network are unknown, however on inspection, the piped network appeared to be constructed from 600 mm diameter reinforced concrete pipe. Based on the grade of the topography, the capacity of this underground drainage network has been estimated to be approximately 0.1 m^3/s. A number of pits to this network are situated below trees and/or shrubs and are susceptible to blockage. It is likely that the pipe runs on a steeper grade to that of the land surface as evidenced by the depth of the pit on the western side of Urmston St, so the above pipe capacity may be underestimated and could be recalculated when invert levels are available. The design flows for the High Street pipe were estimated based on a contributing catchment area of 22.4 ha located between Murray, High and Urmston Streets, extending back to approximately 130 m from Long Gully Creek. A Rational Method technique was used producing a 18% AEP design flow of 0.58 m^3/s. This flow is greater than the estimated pipe capacity, so based on the limited information available it would appear that this pipe is smaller than the adopted design standard for *new* drainage assets. It is recommended that the invert levels of the pipe be surveyed to confirm this and to allow a detailed assessment of the capacity.

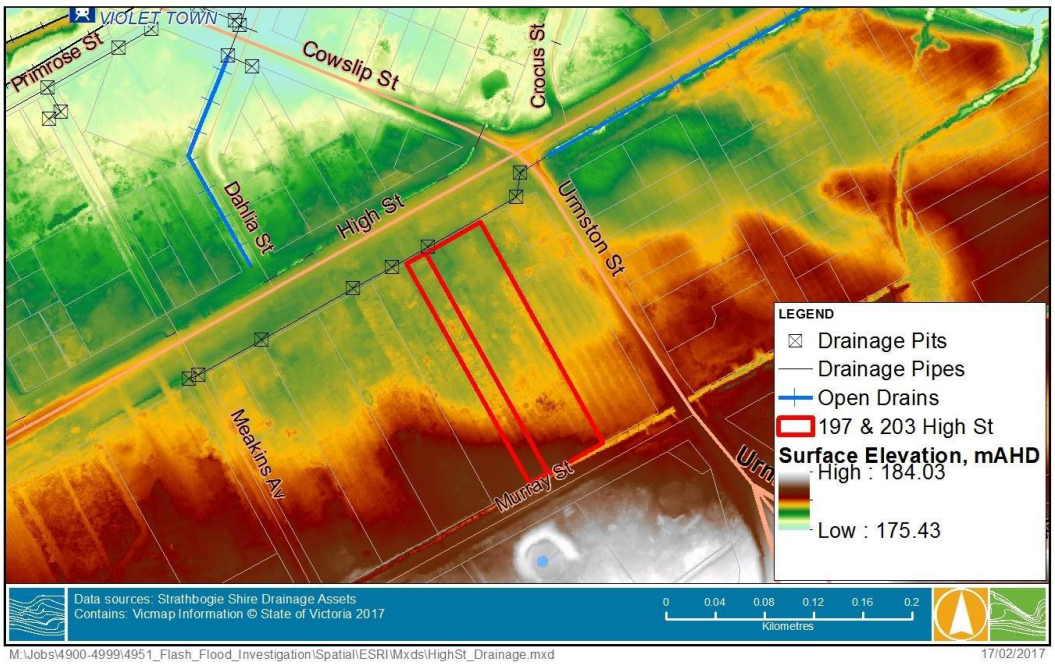

Figure 3-5 High Street drainage

Lily Street

The property at 6A Lily Street is on a low point compared to the surrounding terrain, which in large storms acts acts as an overland flow path for runoff.

A local drainage pipe extends underground from the Lions Park through the southern boundary of 6A Lily Street, connecting at a pit at the front of the property, seen in Figure 3-7. The connection immediately behind 6A Lily Street is not an open pit as such, but there is an open connection, as shown in Figure 3-6. It is understood that this connection was blocked by debris in December 2016 and was cleared by the property owner, upon which flood levels were observed to recede. It is understood that recent inspections found that the drainage network extends beyond what was known to exist through the Lions Park, however there are no pit entries to the network in this location.

Inspection indicated the pipe to be approximately 600 mm diameter. At the grade of the natural surface, the pipe has a capacity of 0.08 m^3/s. Design flows were estimated using a Rational Method technique for a contributing catchment area of 7.5 ha. The estimated 18% AEP design flow was 0.47 m^3/s. This is significantly higher than the estimated pipe capacity. Given the unknowns of the pipe system in this area and the lack of functioning pits, it is recommended that the details of the network be investigated further to allow a detailed investigation into the actual capacity of the system.

Figure 3-6 Drainage network connection behind 6A Lily Street, Violet Town

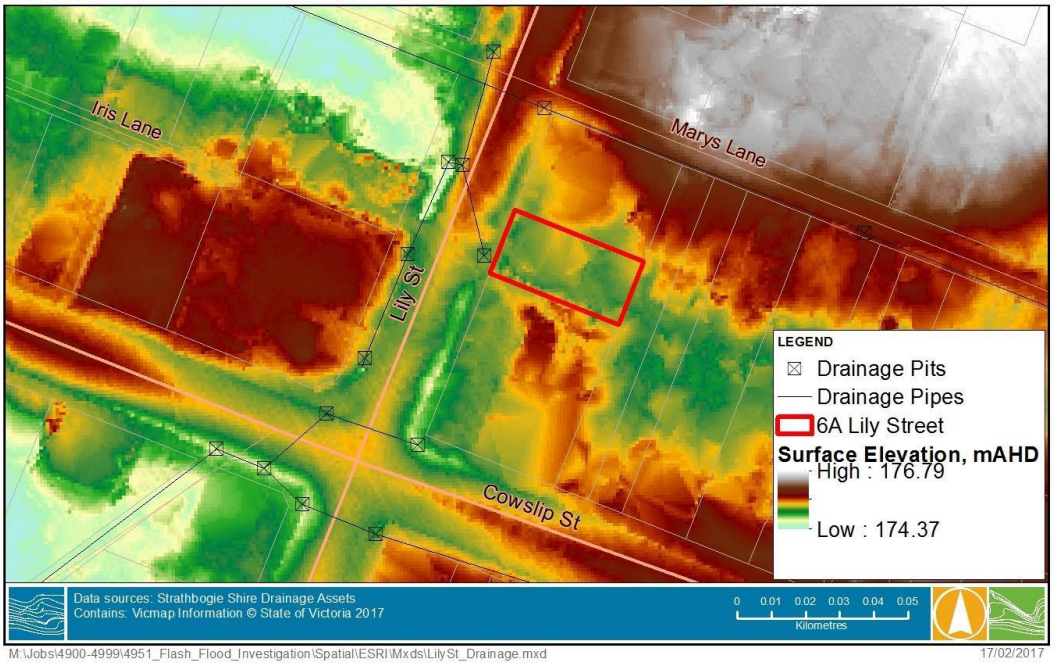

Figure 3-7 Lily Street drainage

Primrose Street

A drainage pipe connects the southern and northern side of the railway at the back of 2 Primrose Street, as seen in Figure 3-8. The drainage pipe is not well aligned with the natural flow path, which predominately passes the north-eastern border of the property. The size, and hence capacity of the pipe is unknown.

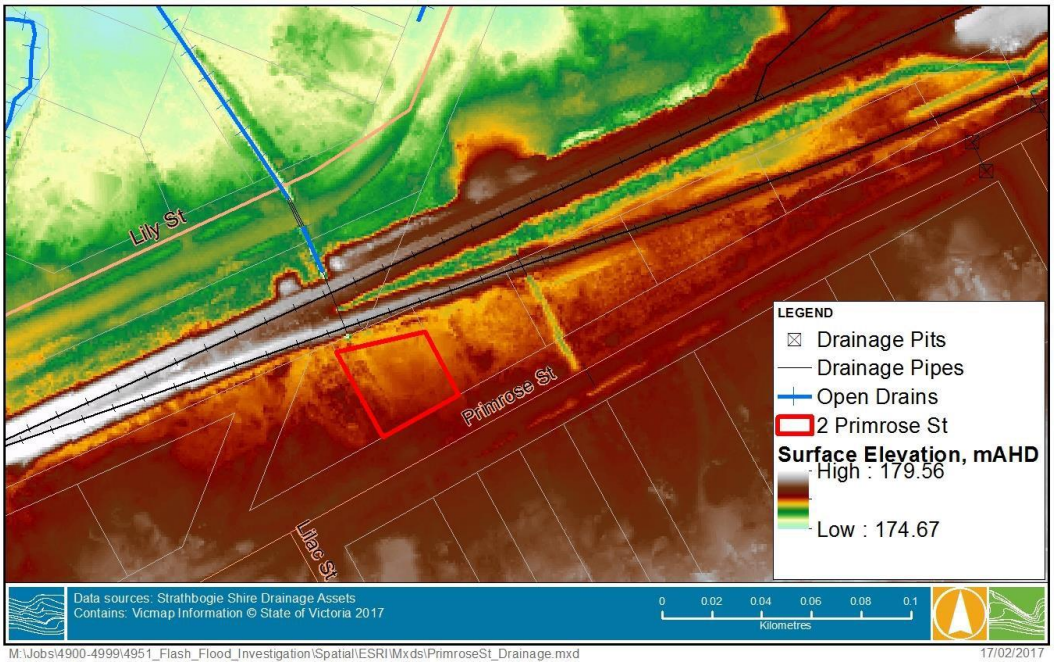

Figure 3-8 Primrose Street drainage

3.2.2 Planning Controls

The properties at 197 and 203 High Street, 6A Lily Street and 2 Primrose Street in Violet Town are all covered by a Land Subject to Inundation Overlay, as shown in Figure 3-9, Figure 3-10 and Figure 3-11 respectively. This overlay identifies that the properties are subject to flooding in a 1% AEP riverine flood event from Honeysuckle Creek and Lambing Gunyah Creek (also known as Long Gully Creek).

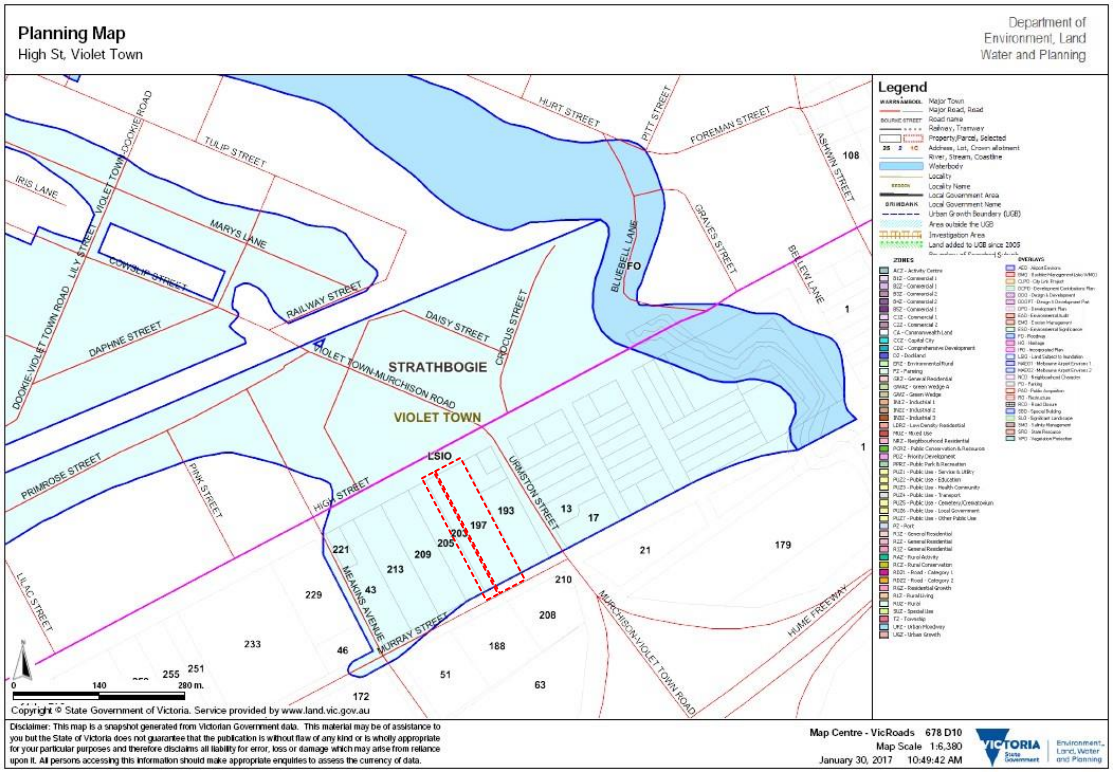

Figure 3-9 Planning overlays at High Street, Violet Town

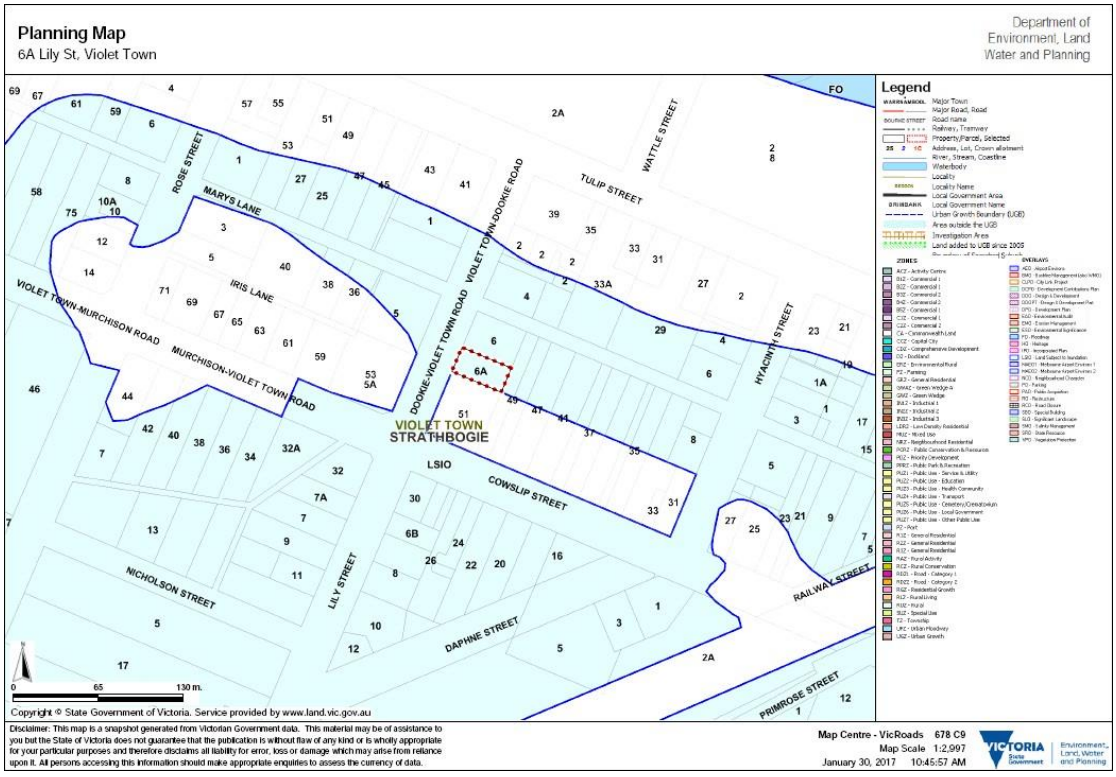

Figure 3-10 Planning overlays at Lily Street, Violet Town

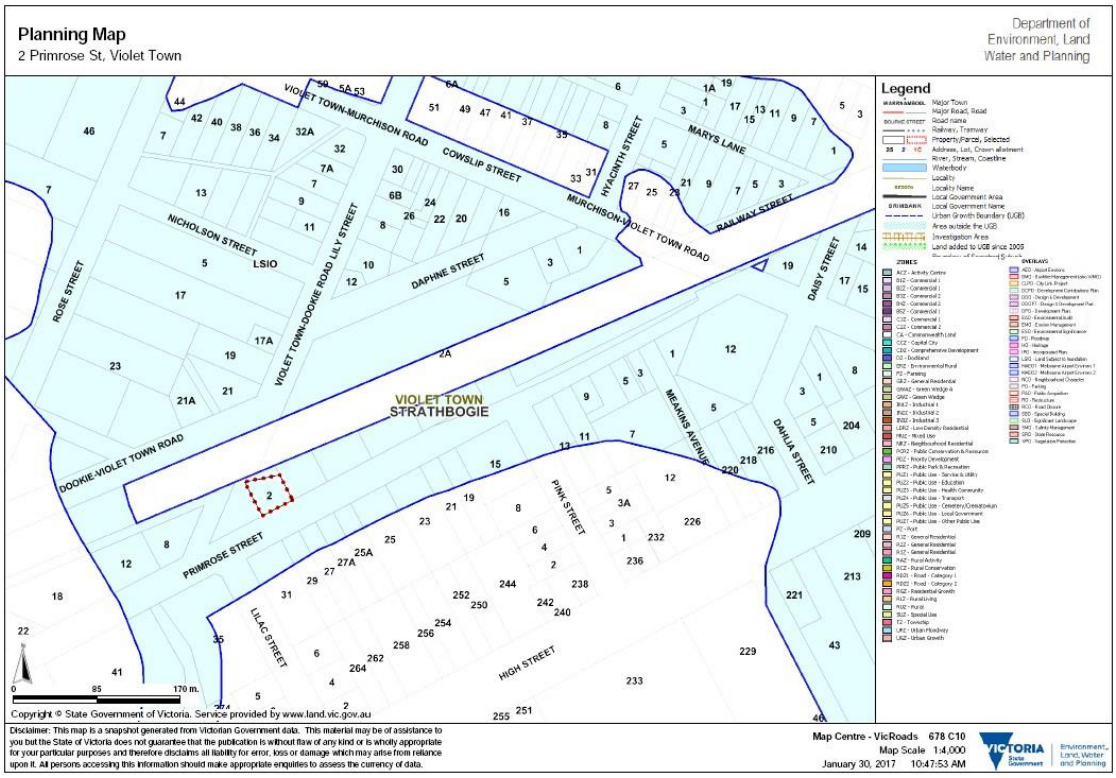

Figure 3-11 Planning overlays at Primrose Street, Violet Town

3.3 Causes of Damage/Concern

In light of the findings above, the causes of flood damage and concern expressed by impacted parties regarding the recent flooding at Violet Town, are summarised below:

- Extreme rainfall (~ 1% AEP) falling in December 2016;
- Residents expectation that Council is responsible for mitigating flood impacts;
- Residents expectation that the planning controls in place should provide protection;
- Potentially undersized local drainage network (<18% AEP);
- Construction of garages below the flood level;
- Residents expectation that garages should be protected from flooding as per the main dwelling;
- Floor levels of dwellings at 197 and 203 High Street below the 1% AEP flood level;
- Possible insufficient drainage design during construction of High Street and Urmston St by the Country Roads Board (now Vic Roads);
- Reduced capacity of local drainage network due to build-up of organic matter (blockage);
- Unknown council drainage assets; and
- Overtopping of the open channel on Murray Street at locations where the bank is low.

4 RELEVANT LEGISLATION

Legislative documents that relate to waterway and stormwater management with respect to the issues discussed in this report are summarised below. The summary is not definitive, but provides an overall perspective of the legislative system and the various responsibilities of Authorities, Councils and landholders.

4.1 Water Act 1989 (Vic)

The Water Act (1989) delegates floodplain management functions to Catchment Management Authorities (CMAs) in Section 202. They are responsible for declaring flood levels and flood fringe areas, and providing advice about flooding and controls on development to local councils.

Flood levels are declared at the expected level of the 1% Annual Exceedance Probability (AEP) flood event. CMAs typically determine these levels through a detailed flood study, e.g. the Violet Town Flood Study (Water Technology, 2007), and Nagambie Flood Study (BMT WBM, 2014). These studies consider the most likely cause of flooding which is often riverine, and don't always consider overland flows from the local catchment.

The Water Act (1989) makes no reference to consideration of climate change impacts.

4.2 Strathbogie Planning Scheme

Under the Victorian Planning Provisions, the Strathbogie Shire Council has developed the Strathbogie Planning Scheme which sets out policies and requirements for the use, development and protection of land.

Section 6(e) of the Planning and Environment Act 1987 enables planning schemes to 'regulate or prohibit any use or development in hazardous areas, or areas likely to be hazardous'. The Planning Scheme therefore allows Councils to declare overlays to certain areas, which act as controls for the use and development of land.

Overlays that relate to flooding are often developed from the output of flood studies, commissioned by the CMAs or Council's under the Water Act (1989). The following zones/overlays are of note:

Floodway Overlay (FO)

The Floodway Overlay is used to 'identify waterways, major flood paths, drainage depressions and high hazard areas which have the greatest risk and frequency of being affected by flooding' (Section 44.03). There are various methods for delineating the floodway overlay, however all define criteria for the depth, velocity and hazard (depth multiplied by velocity).

The presence of this overlay requires an application for any development or works. The application must include a flood risk assessment, and must be referred to the Catchment Management Authority, as required by the Water Act (1989).

Land Subject to Inundation Overlay (LSIO)

The Land Subject to Inundation Overlay is used to 'identify land in a flood storage or flood fringe area affected by the 1 in 100 year ARI flood or any other area determined by the floodplain management authority' (Section 44.04). The land subject to inundation overlay is typically adopted as the 1% AEP (otherwise known as the 1 in 100 year ARI) flood extent.

Similarly to the floodway overlay, the presence of an LSIO requires an application for any development, works or subdivision. The LSIO is a trigger for referral of the application to the CMA.

Comprehensive Development Zone

The flood affected properties in Nagambie are not covered by an FO or an LSIO, however they are classified within a Comprehensive Development Zone. This zoning requires provisions to be met with respect to development, under section 37.02. Any subdivision or building/works requires a permit. The application for a permit requires the development of an Environmental Plan, which must consider (as a component) details of surface water management.

This zoning does not necessarily trigger a referral to the Catchment Management Authority.

It should be noted that the Strathbogie Planning Scheme does not outline requirements for consideration of climate change impacts.

4.3 Infrastructure Design Manual

The Strathbogie Shire Council has adopted the Infrastructure Design Manual by the Local Government Infrastructure Design Association as it's standard for the design and development of infrastructure within its municipality.

Of note to this investigation is Section 16.6 of the manual, which states the Strathbogie Shire Council have adopted the 18% AEP as the design requirement for their minor drainage system. This is equivalent to a 1 in 5 year Average Recurrence Interval (ARI). Note that this requirement is only for new drainage networks, and Council were not obligated to upgrade all existing networks at the time of adopting the Infrastructure Design Manual. It is likely that Council will upgrade their networks over time, as required and in line with the budget and timeframe of their work plan.

4.4 Implications

4.4.1 Nagambie

As no LSIO or FO exists on the properties at Ludovic-Marie Court in Nagambie, the development application would not have triggered referral to the Catchment Management Authority for flood related advice. The declaration of the area as a Comprehensive Development Zone, however, should have required consideration of surface water management as part of the application process.

The extent of consideration to surface water management may have been deemed appropriate by Council if there was no prior knowledge regarding local runoff to the site. In such circumstances (i.e. lack of available flood knowledge) the obligations of the applicant and Council become unclear. On review of the surface water management plan submitted for the development and subsequently approved by Council, there seems to be no consideration for the possible impact of overland flows from the local catchment on the development, and no consideration for maintaining an overland flow path across the site.

Given that this surface water management plan was approved by Council and the development has been constructed, Water Technology believes that the Council is now responsible for the current drainage network which is of inadequate capacity.

4.4.2 Violet Town

Each of the properties in Violet Town that are the subject of this report are entirely covered by an LSIO. The presence of such an overlay identifies that they are at risk of flooding (riverine flooding from Honeysuckle Creek and Long Gully). It is assumed that for the majority of the buildings subject to this assessment (with perhaps the exception of 6a Lily Street), the buildings were constructed in their current form *prior* to the application of the LSIO. There would have, therefore, been no obligation by Council to impose controls on their

development at that time. The dwelling at 6a Lily Street has been constructed above the flood level, the damage in the recent event was suffered in the shed at the back of the dwelling. Flood levels were most likely made available to the developer of 6a Lilly St at the time of design and construction, because the floor level of the house has been raised, but the shed has remained at ground level.

4.4.3 Climate Change

None of the existing legislation requires Council to consider the impacts of climate change with respect to floodplain and stormwater management. It is expected, however, that this will change with time. As an interim measure, it may be pertinent to consider the latest guidelines in Australian Rainfall and Runoff (2016) for the design of drainage infrastructure.

5 SUMMARY OF RECOMMENDATIONS

There are numerous options/opportunities to mitigate flooding at the above mentioned properties in Nagambie and Violet Town. Water Technology are technical specialists not legal specialists, but it is our belief that there is no legal obligation for any of the parties to implement the recommended options.

The learnings from the recent December 2016 flood event should be incorporated into the local emergency response plan for future flood events. Landholders should continue discussions with Council regarding works to protect their individual properties from future flood events. Working together will result in a better outcome.

5.1 Nagambie

As the drainage issue is on public land (and with wide access), the implementation of an improved drainage system should be relatively straight forward. By ensuring runoff is directed away from the properties on Ludovic-Marie Court, flooding from overland flow can be minimised.

1. It is recommended that Council consider upgrading the drainage system behind those impacted properties on Ludovic-Marie Court in Nagambie.

   Council has draft plans of a drainage system which exceed their typical design standard, and Water Technology encourages Council to implement this option. The estimated capacity of the designed swale, based on the design information provided, is approximately 0.56 m^3/s (greater than a 1% AEP flow). The benefit of the swale, however, will be limited by the connected drainage pipe from behind 17 Ludovic-Marie Court to the north-west. This drainage pipe has a capacity of 0.06 m^3/s, which is less than the minimum design capacity for minor drainage of an 18% AEP flow. This pipe would need to be upgrade to a 375 mm diameter circular pipe to convey the 20% AEP peak flow, while an 450 mm diameter pipe would be required to convey the 1% AEP peak flow.

   Consideration will need to be given as to how the construction of the swale aligns with the Water Act (1989). Further, given the shift towards a 'beneficiary pays' principle (as per the Victorian Floodplain Management Strategy), landholders may be required to contribute funds for the construction of this option.

2. If a swale is not constructed, as per recommendation (1), Council should consider investigating the capacity of the existing drainage system, and consider upgrading to an 18% AEP capacity if required, ensuring all pits are slightly below the surface level.

3. It would also be pertinent for the landholders of properties flooded on Ludovic-Marie Court to consider allowing for drainage across their properties for events rarer than the 18% AEP. It is recommended that landholders consult with a professional drainage engineer or plumber to determine an appropriate measure that can be implemented within the existing constraints which meets all relevant building codes. Drainage could be provided by installing additional pipes draining backyards through to the street drainage at the front of the properties.

4. It is recommended that all landholders consider raising stored belongings above the 1% AEP flood level, where they are not stored in the main dwelling, as garages/sheds are not subject to planning levels, and there is no obligation to anyone to provide protection to secondary buildings from flooding.

5.2 Violet Town

Flood issues around Violet Town are more complex, and a single option will not be sufficient to mitigate flood risk.

1. It is recommended that Council consider implementing a program of inspecting and cleaning the local drainage network at critical (problem) sites, with maintenance to occur regularly and during events.

2. Further, it's recommended that Council consider surveying the local drainage network to allow further analysis into the true capacity of the system. If after completing survey of the system, a detailed investigation finds the drainage network to be below design standard, as this preliminary investigation has indicated for the High Street and Lily St drains, then further investigations into upgrading the system is recommended.

3. It is recommended that Council consider improvements to the Murray Street drain to ensure that flows south of the drain are intercepted, that they do not spill out of the drain, and all flow continues through to the Honeysuckle Creek. This would require works around the Meakins Avenue intersection and upstream of the culvert at Urmston Street where the December event overtopped the drain bank. Consideration will need to be given to how this aligns with the Water Act, and as per the 'beneficiary pays' principle (Victorian Floodplain Management Strategy), landholders as the beneficiaries may be requested to contribute funds to the construction works.

4. Landholders at 197 and 203 High Street could act further to protect themselves from flooding by considering landscaped bunding along the property boundary on High Street. This landscaped bund would have a slightly elevated above crest level at the driveway entrance but would be lower than the rest of the bund to maintain access to the properties. In times of flood, these access points could be easily sandbagged. This is likely to be a low cost mitigation option because the earthworks required would be relatively minor. Under the 'beneficiary pays' principle, the landholder, as a beneficiary, may be requested to contribute funds to the construction works. An alternative to the earthen bund would be floor level raising, although this is likely to be more expensive.

5. A solution for the Lily Street flooding requires further information regarding the existing drainage network. However, it is likely that the drainage network may not cater for all the overland flow and that some additional surface water drainage may be required along Marys Lane and Lilly Street to reduce the impact of overland flows on the property at 6A Lily Street. It is recommended that Council consider further survey and investigation into the stormwater network (as per recommendation 2 above). Consideration will need to be given to how this aligns with the Water Act, and as per the 'beneficiary pays' principle (Victorian Floodplain Management Strategy), landholders as the beneficiaries may be requested to contribute funds to the construction works.

6. With respect to the property at 2 Primrose Street, consideration could be given to formalisation of a swale directing overland flow from their normal flow path towards the culvert under the railway to relieve flooding in frequent events. It is likely, however, that this will not be sufficient to prevent inundation in rarer events (such as the 1% AEP). An isolated levee system may be most appropriate in these circumstances. This would require discussions with VicTrack if any works were required within the railway land. Under the 'beneficiary pays' principle, the landholder, as a beneficiary, may be requested to contribute funds to the construction works.

7. It is recommended that all landholders consider raising stored belongings above the 1% AEP flood level, where they are not stored in the main dwelling, as garages/sheds are not subject to planning levels, and there is no obligation to anyone to provide protection to secondary buildings from flooding.

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