Flood Study for 1 Station Lane Penrith

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Contents

List of Figures

List of Tables

1 Introduction

BMT was commissioned by Station Lane Pty Ltd ATF The Station Lane Trust to undertake an assessment of flood conditions at 1 Station Lane, Penrith. The purpose of the report is to provide commentary around the design flood levels for the site in accordance with the requirements of the Penrith Local Environment Plan (LEP) 2010 Section 7.2 and the Penrith Development Control Plan (DCP) 2014 Chapter 3.5. The flood study for the site includes the analysis of the January 2016 rainfall event which reportedly inundated the site.

1.1 Site Description

The Penrith CDB catchment drains into the Nepean River via Peach Tree Creek. The site is located adjacent to an open channel which discharges into Peach Tree Creek approximately 1300 m downstream of the site. The site locality is shown in Figure 1-1.

The site topography has little variation extending from the top of the adjacent open channel top of bank (27.1m AHD) with a gradual rise in elevation to the northside of the property (27.4 m AHD). The site currently has a single story, brick dwelling with no vehicle storage onsite. The site currently has no vehicular access. Surrounding properties include medium density housing with low rise apartments. The site topography is determined by the ALS data utilised by the Penrith CBD Detailed Overland Flow Flood Study (Cardno, 2015); taken from a survey undertaken in November 2002. It should be noted that there is an updated NSW LPI LiDAR survey of the area available, however the 2002 dataset was utilised to retain consistency with the existing Penrith City Council (Council) flood model for the CBD area.

1.2 Background

As detailed in the Pre-DA meeting minutes (ref: *PRE DA MEETING PL180012 1 Station Lane Penrith.pdf*), Council notes that the site is situated adjacent to a floodway/channel and established a peak 1% AEP flood level and flood planning level (FPL) for the site of 27.10 m AHD and 27.6 m AHD respectively. Evidence of inundation onsite during January 2016 was shown to the client representative (Antoine Souma) during the pre-DA meeting and was later provided upon request. The source of inundation is identified by Council to be overtopping of the existing channel. As a result of the observed inundation, Council requested a detailed overland flood assessment to be completed for the site. This assessment was commissioned to address Councils requirements and comprises a review of the design flood levels adopted by Council, as well as investigating the flood behaviour on-site during the January 2016 event.

1.3 About this Report

This report documents the Study's objectives, results and recommendations.

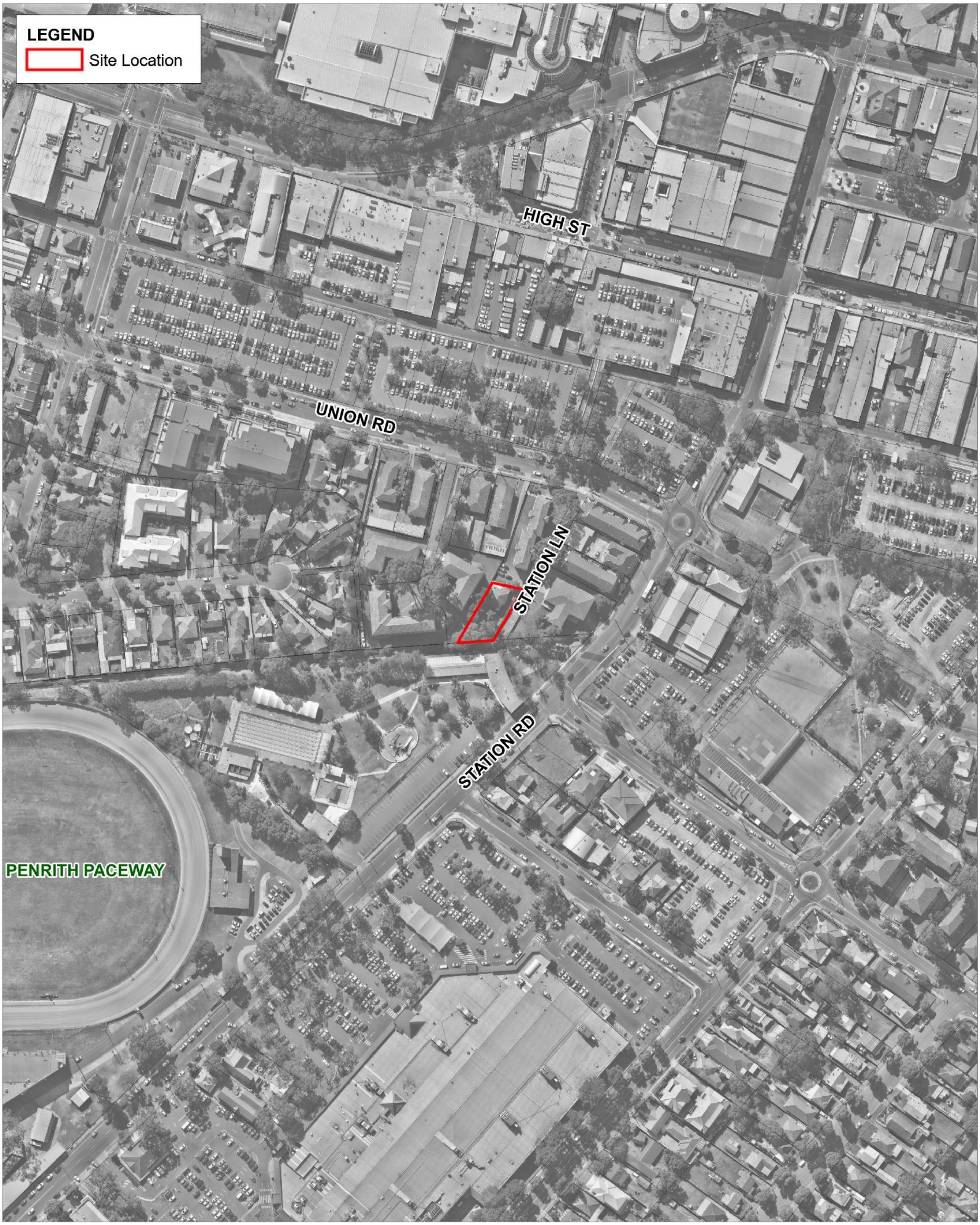
Section 1 introduces the study.

Section 2 review of Council's existing design flood levels

Section 3 provides an analysis of the recent January 2016 event

Section 4 details sensitivity of flooding onsite to local hydraulic structure blockage

Section 5 details the conclusions and recommendation for the site



Title:
Site Locality

Figure: 1-1

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2 Penrith CBD Overland Flood Study (Cardno 2015) Model Review

As a part of the Penrith CBD Detailed Overland Flow Flood Study a Rainfall on Grid (RoG) TUFLOW model was developed. Hydrology inputs were developed for the TUFLOW model via two methods: XP-RAFTS was used to determine inflows from the upper catchment not within the hydraulic model extent, while a Rain-on-Grid (RoG) (i.e. direct rainfall) model was used to model rainfall within the modelled 2D domain.

A fine grid (1m cell size) was utilised for the TUFLOW model. Open channels and pit and pipe networks within the study area are represented as 1D elements embedded within the 2D model domain, while overland flow through the catchment is modelled in the 2D domain.

The TUFLOW hydraulic model schematisation local to the site is presented in Figure 2-1. The site backs onto the open channel with 1D/2D model connections parallel to the site boundary. Model roughness layers do not provide significant detail local to the site. Allotments local to the site had a hydraulic roughness of 0.100, whilst the Station Lane has a roughness of 0.015. Within the channel two roughness's were employed, 0.020 for the centre of the concrete channel and 0.035 for vegetated areas at the top of channel.

The results of Penrith CBD Detailed Overland Flow Flood Study form a basis of Penrith City Council's planning policies. As part of this current study, BMT has undertaken a high-level review of the TUFLOW model provided by Council.

Peak 1% AEP flood depths and water levels simulated using the TUFLOW model provided are presented in Figure 2-2. It is evident that there is no out-of-bank flooding emanating from the open channel to the south of the site and that there is a small local depression along the western site boundary that results in pooling of water as a result of the RoG model.

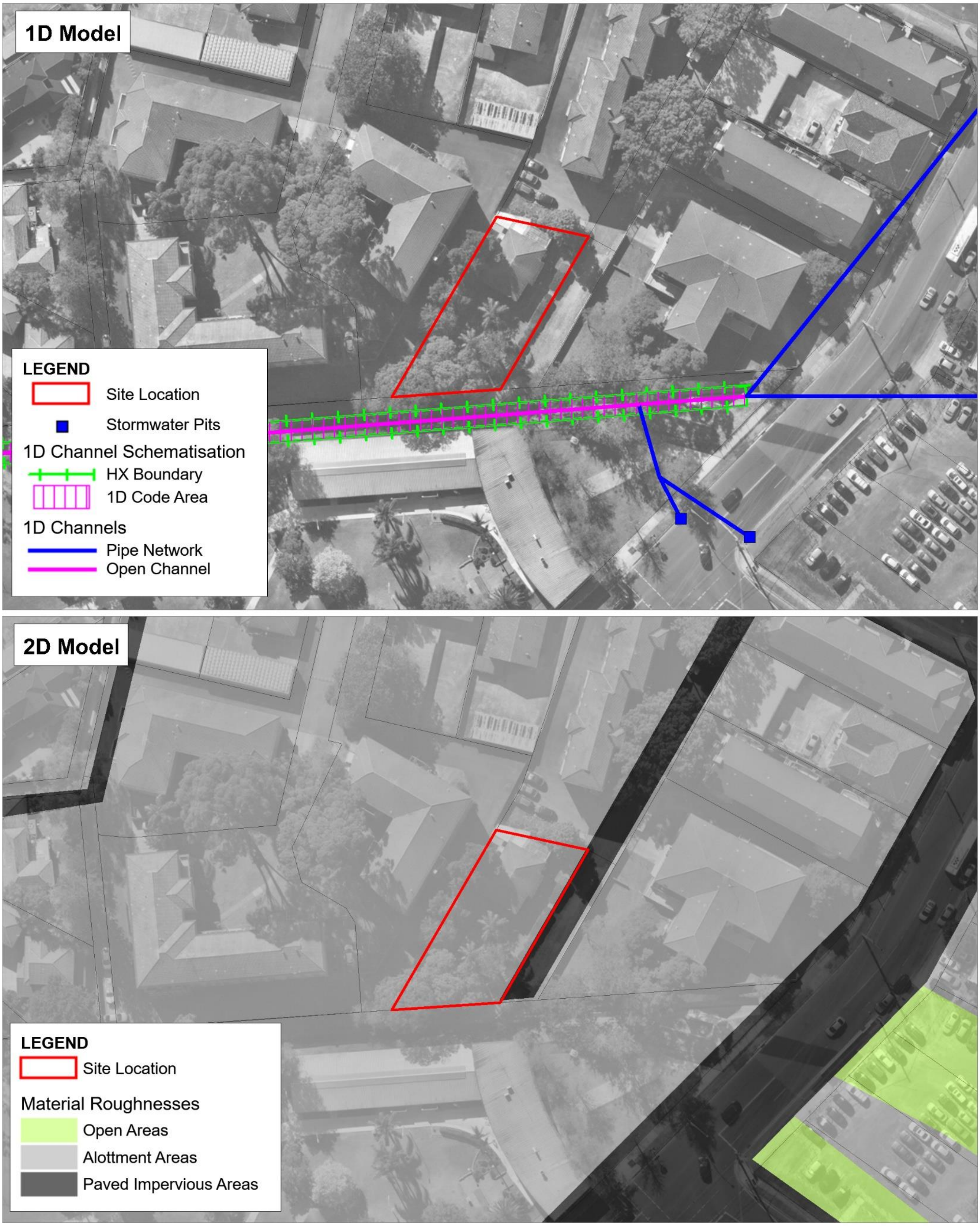
2.1 Model Hydrology Overview

As discussed previously-XP-RAFTS was used to route flows from the upper catchment into the study area, while RoG within TUFLOW is used to simulate rainfall within the study area. Inputs for design events in both hydrological models were based off *Australian Rainfall and Runoff* 1987 guidelines, with the Probable Maximum Precipitation event (PMP) estimated using the method detailed in *The Estimation of Probable Maximum Precipitation in Australia: Generalized Short – Duration Method* (Bureau of Meteorology, 2003). Inflows in the RoG model were assumed to be uniformly distributed across the 2D domain.

Initial Losses (IL) and Continuing Losses (CL) are applied to both hydrological models according to the ratio of impervious and pervious areas in a sub-catchment. Adopted losses for impervious and pervious areas are shown below in Table 2-1.

Table 2-1 IL/CL Losses Applied

Rainfall Loss Rate	Impervious Area	Pervious Area
Initial Loss (mm)	1.5	10.0
Continuing Loss (mm/hr)	0.0	2.5



Title:

Penrith Overland Flood Study TUFLOW Schematisation 1D and 2D Models

Figure: **2-1**

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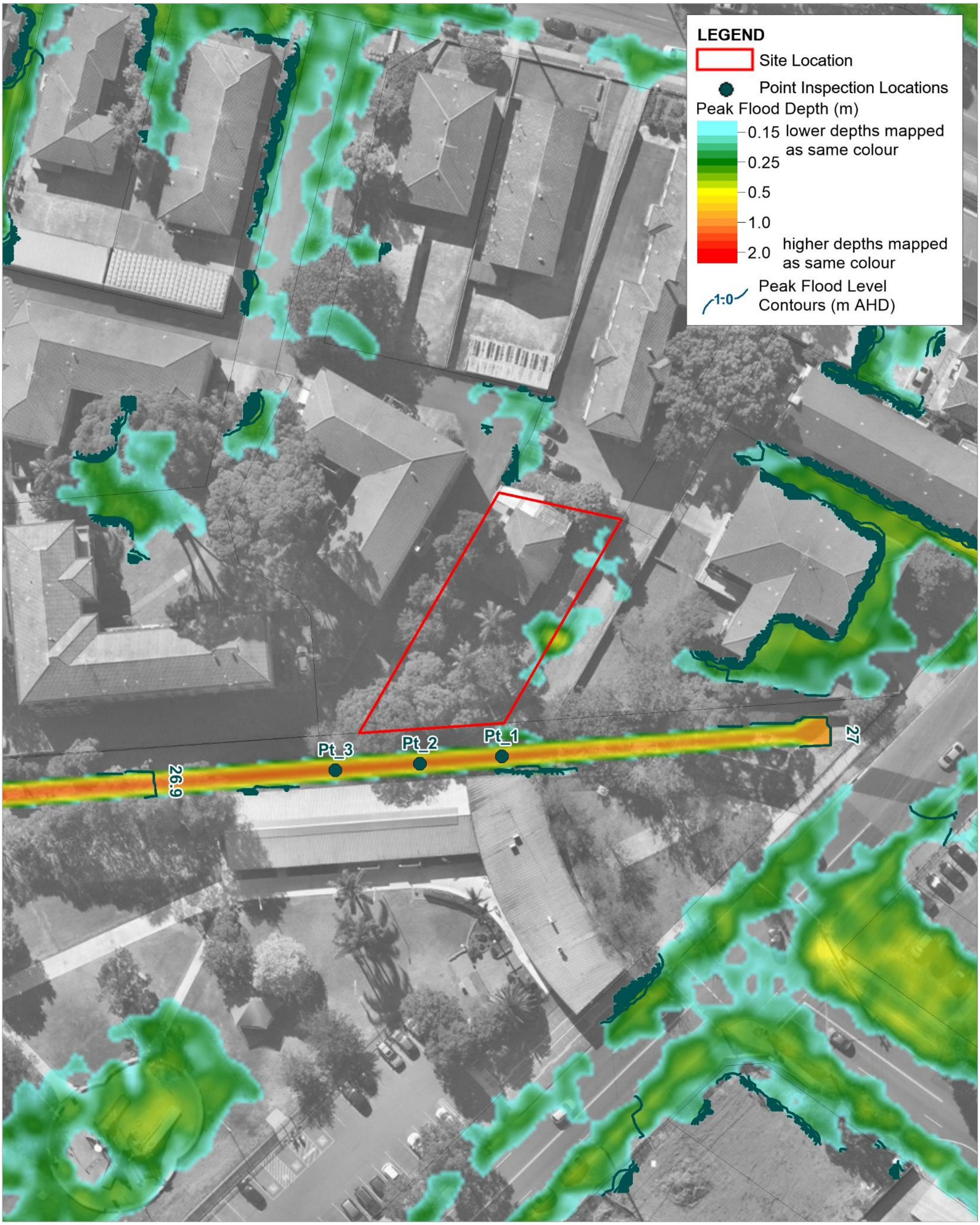

Title:
Peak Flood Depth
1% AEP

Figure: **2-2**

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2.2 TUFLOW Model Overview

BMT reviewed the TUFLOW model provided by Council (focusing on the study site locality), and whilst some elements of the model schematization would not be considered current best practice, and the modelling was undertaken using an outdated TUFLOW executable (2010-10-AD as referenced in Cardno (2015)), BMT did not identify any significant issues that would result in the simulation of inappropriate design flood levels.

BMT were unable to replicate the design peak flood level outputs provided by Council using the model provided and the 2010-10-AD referenced in Cardno (2015). The differences in the simulated peak flood levels may be a result of a different TUFLOW executable being utilised by Council to that referenced in the flood study report to generate the outputs, or minor changes to the model schematisation between that provided and the outputs provided, or post-processing of the model outputs. However, the simulated 1% AEP peak flood levels in the open channel adjacent to the site were within 0.2 m of the peak flood level outputs provided by Council.

Furthermore, BMT also undertook a sensitivity test using the recently released 2018-03-AB TUFLOW executable (with backwards compatibility defaults implemented to represent the same model schematisation and parameter values adopted in Councils model using the 2010-10-AD TUFLOW executable) and found the levels within the open channel adjacent to the site were again within ~0.2 m of the peak flood level outputs provided by Council.

2.3 TUFLOW Model Results

The top of the bank of the adjacent channel within the TUFLOW model is ~27.1 m AHD. Based on the local topography in the vicinity of the proposed development, any water levels exceeding this level within the channel will result in mainstream flow entering Station Lane, and potentially inundating the site. Table 2-2 below shows the peak water level within the channel for key design events, with reporting locations shown in Figure 2-2. Accordingly, overtopping of the channel is anticipated in events rarer than 1% AEP.

Table 2-2 Water Levels Onsite in Key Design Events (m AHD)

Point	5% AEP	2% AEP	1% AEP	PMF
Pt_01	26.9	26.9	26.9	27.8
Pt_01	26.8	26.9	26.9	27.8
Pt_01	26.8	26.9	26.9	27.7

In addition to mainstream inundation from the adjacent channel, the site is also susceptible to overland flow originating from Union Street that is directed south down Station Lane. This overland flowpath would be characterised by relatively shallow floodwaters that would be directed into the adjacent channel without resulting in inundation of the study site. However, in the event that the adjacent channel is at capacity or overtopping, this overland flow will act to exacerbate the inundation along Station Lane. Council’s flood mapping does not include flood depths less than 15cm and. accordingly, the overland flow path is not shown in Councils mapped flood extents.

3 January 2016 Event Analysis

During January 2016 there were a number of significant rainfall events, with the most intense being that of the 30th of January, aligning with the date stamps of the photographs supplied by Council.

3.1 Rainfall Data

The distribution of rainfall gauges across the region is shown in Figure 3-1. Total daily rainfalls values for the January 2016 event (representative of the total rainfall in the 24 hours preceding 9am that day) are presented in Table 3-1.The 30th January 2016 event occurred as a short intense rainfall event. The closest active rainfall gauge on the day of the event recorded 41.8 mm of rainfall. Notably, it is evident that there is high spatial variability of rainfall depth for the event, with the nearest gauges to the East and West having 0.0 and 30.0 mm of daily rainfall respectively, as shown in Figure 3-1.

Table 3-1 Recorded Daily Rainfall Totals to 9am for 31st January 2016 Event

Station No.	Station Name	31st January
067113	Penrith Lakes AWS	41.8
067116	Willmot (Resolution Ave)	0.0
067002	Castlereagh (Castlereagh Road)	34.0
063077	Springwood (Valley Heights)	46.8
067084	Orchard Hills Treatment Works	30.0

The recorded hyetograph at the Penrith Lakes AWS gauge location is shown in Figure 3-2. The 30th January 2016 rainfall event occurs over a duration of approximately 1-hour, with a total rainfall for the event of 40.4 mm.

Figure 3-3 shows the observed January 2016 rainfall against the design hyetographs applied as RoG rainfall inputs into Council's TUFLOW model. Note the observed rainfall does not include an allowance for IL or CL, whereas the design hyetographs do include the IL and CL. In comparison against the design events, the 30th of January 2016 event hyetograph approximates to a 2% AEP event.

Title: **30th Janurary 2016 Rainfall Distribution**	Figure: **3-1**	Rev: **A**

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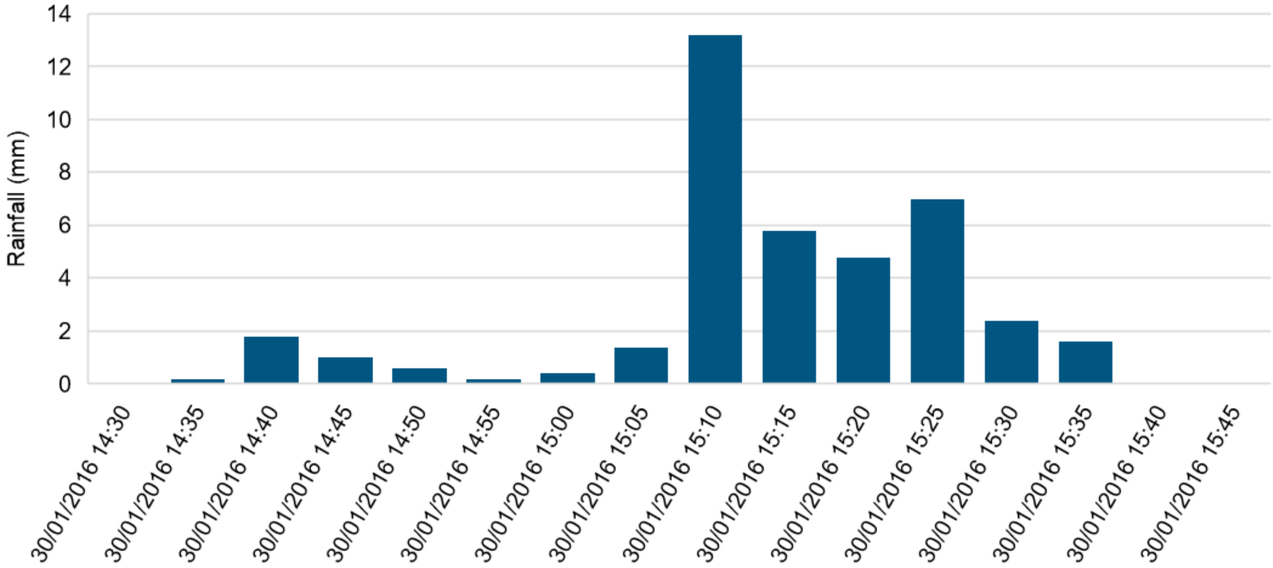


Figure 3-2 Recorded Rainfall Hyetograph 30th January 2016

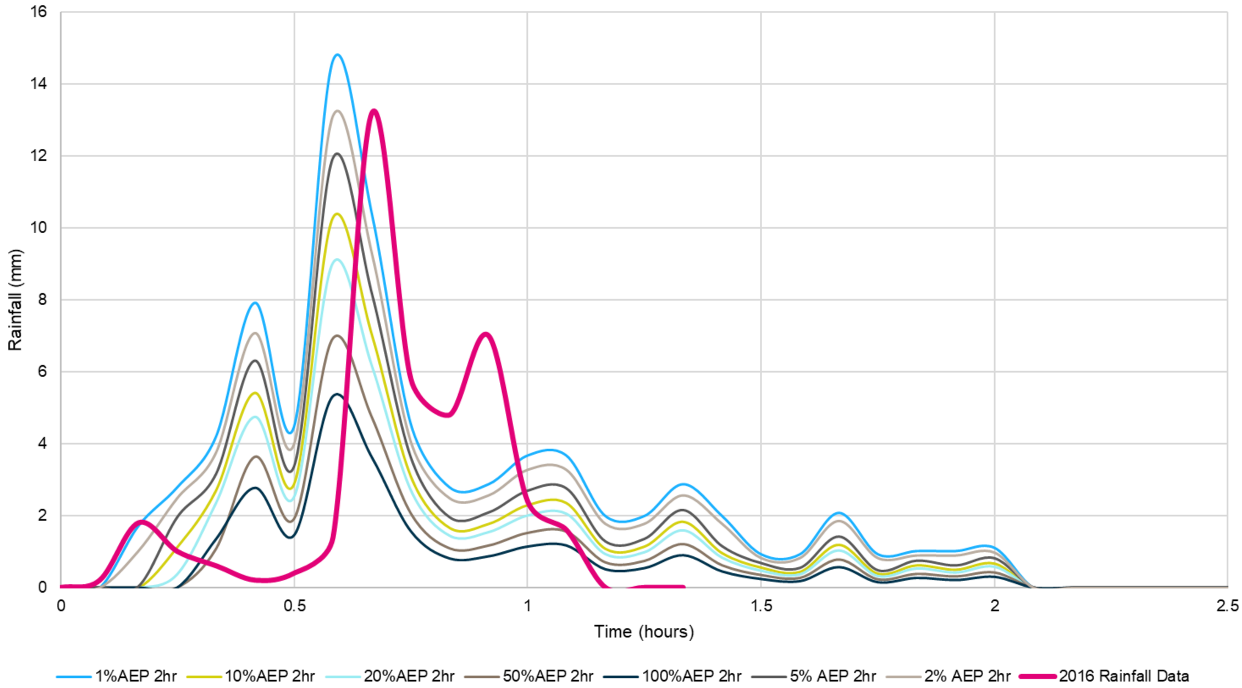


Figure 3-3 Comparison of Recorded and Design Rainfall Hyetographs– Penrith Lakes AWS Gauge

3.2 Observed Flood Behavior

Council provided evidence of inundation of the site during the event on the 30th January 2016. Four photos and a video were supplied to BMT. Within the imagery supplied there are a number of notable features which indicate where the flows originated and to the severity of inundation.

Council has previously indicated that the open concrete channel to the south of the site overtopped during the January 2016. The debris deposited on the upstream side of the wire fence shown in Figure 3-4 supports this, with water flowing from the channel into Station Lane.

Figure 3-4 Flow within the adjacent channel (Left) Upstream of the channel with flow entering from a culvert under Station St (Right) Flow from the channel into Station Lane

In additon to the mainstream flows spilling from the open channel adjcent to the site, overland flows orginating from Union Road approach the site from the north down Station Lane. This overland converges at Station Lane and inundates the rear/southern portion of the adjcent 20 Union Road site, with some floodwaters then inundating the proposed devlopment site, as shown in Figure 3-2. This is supported by the video recording provided by Council.

Figure 3-5 Flow from Station Lane to the back of 20 Union Road (Left) Station Lane looking toward Union Road (Right) Back of 20 Union Road Residence

In the context of Councils TUFLOW model outputs, the channel is not expected to overtop in events less than the 0.5% AEP. However, as discussed previously, the observed rainfall during the January 2016 was approximately equivalent to a 2% AEP event. This anomaly could potentially be attributed to:

- Blockage of hydraulic structure downstream of the site (refer Section 4); or
- Localised high intensity rainfall event not recorded at the gauge locations that may have exceeded that recorded (i.e. rainfall event may have been equivalent to a 0.5% event or greater).

As previously noted, flood depths less than 15cm are removed from Council's flood mapping. In observation of the photographic and video evidence, the inundation in the vicinity of the development site appears to be shallow in depth, hence even if such flooding behavior was simulated in Councils model, it would be filtered out due to shallow depths. Figure 3-3 depicts the inundation at 1 Station Lane, these depths appear to be relatively shallow < 20cm.

Figure 3-6 Inundation experienced at 1 Station Lane

4 Blockage Sensitivity

The key driver to inundation experienced onsite during the January 2016 event is the overflow from the open channel to the south of the site. Flow regimes within open channels are often dictated by upstream and downstream conditions, including; flowrates, blockage and form-loss. Within Council's flood model, blockage was reflected within the surface inlet pits to the 1D stormwater drainage network. Blockage was not included to account for large debris that can be caught within open channels or large cross-drainage structures.

A sensitivity analysis was undertaken to assess the impact of blockage at major culverts. Blockage was considered at the major culvert passing under Mulgoa Road located approximately 550 metres downstream of the open channel reach adjacent to the property. This was represented by modelling 50% blockage of the total culvert area for the 2% AEP and 1% AEP events. The simulated peak flood levels in the open channel adjacent to the site for the modelled blockage scenarios are presented in Table 4-1, and shown spatially in terms of change in peak flood level in Figure 4-1 and Figure 4-2 for the 2% AEP and 1% AEP events respectively.

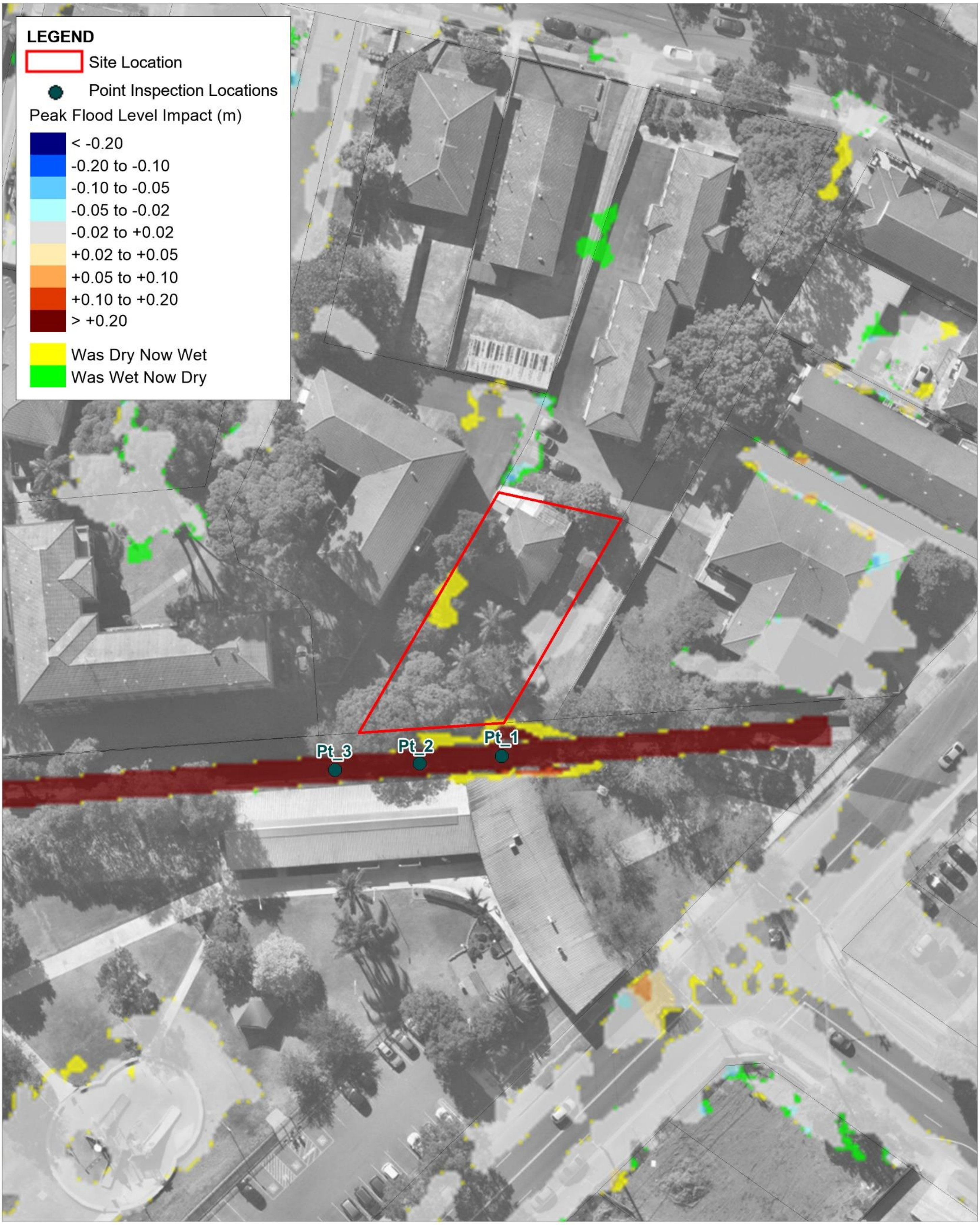
Table 4-1 Water Levels Onsite in Varying Downstream Blockage Scenarios (m AHD)

Point	No Blockage 2% AEP	50% Blockage 2% AEP	No Blockage 1% AEP	50% Blockage 1% AEP
Pt_1	26.9	27.2 (+0.3)	26.9	27.2 (+0.3)
Pt_2	26.9	27.2 (+0.3)	26.9	27.2 (+0.3)
Pt_3	26.9	27.1 (+0.2)	26.9	27.2 (+0.3)

Note – Bracketed values represent change in peak flood level in meters

It is evident that the blockage of the structure under Mulgoa Road downstream of the site results in an increase in peak flood levels of ~0.3 m for a 50% blockage. The simulated 2% AEP level under the 50% blockage scenario is 27.2 m AHD, which is sufficient to overtop the top-of-bank height of the open channel adjacent to the site of 27.1 m AHD thereby resulting in shallow inundation of the study site. This could potentially justify the floodwaters spilling from the channel during the January 2016 event given that it was approximately equivalent to a 2% AEP rainfall event. BMT has not been provided with any anecdotal evidence to suggest the downstream structure was blocked during the January 2016 event. However, it is not uncommon for structures of this nature to become blocked during major rainfall events given the availability of flood debris in an urban catchment during a flood event.

Blockage was also considered at the upstream culvert passing under Station Street, this is the same culvert seen to be submerged within Figure 3-4. Blockage of this structure did not significantly alter the peak flood level in the open channel adjacent to the site.



Title:

Peak Flood Level Impacts - 2% AEP Event
50% Downstream Blockage

Figure: **4-1**

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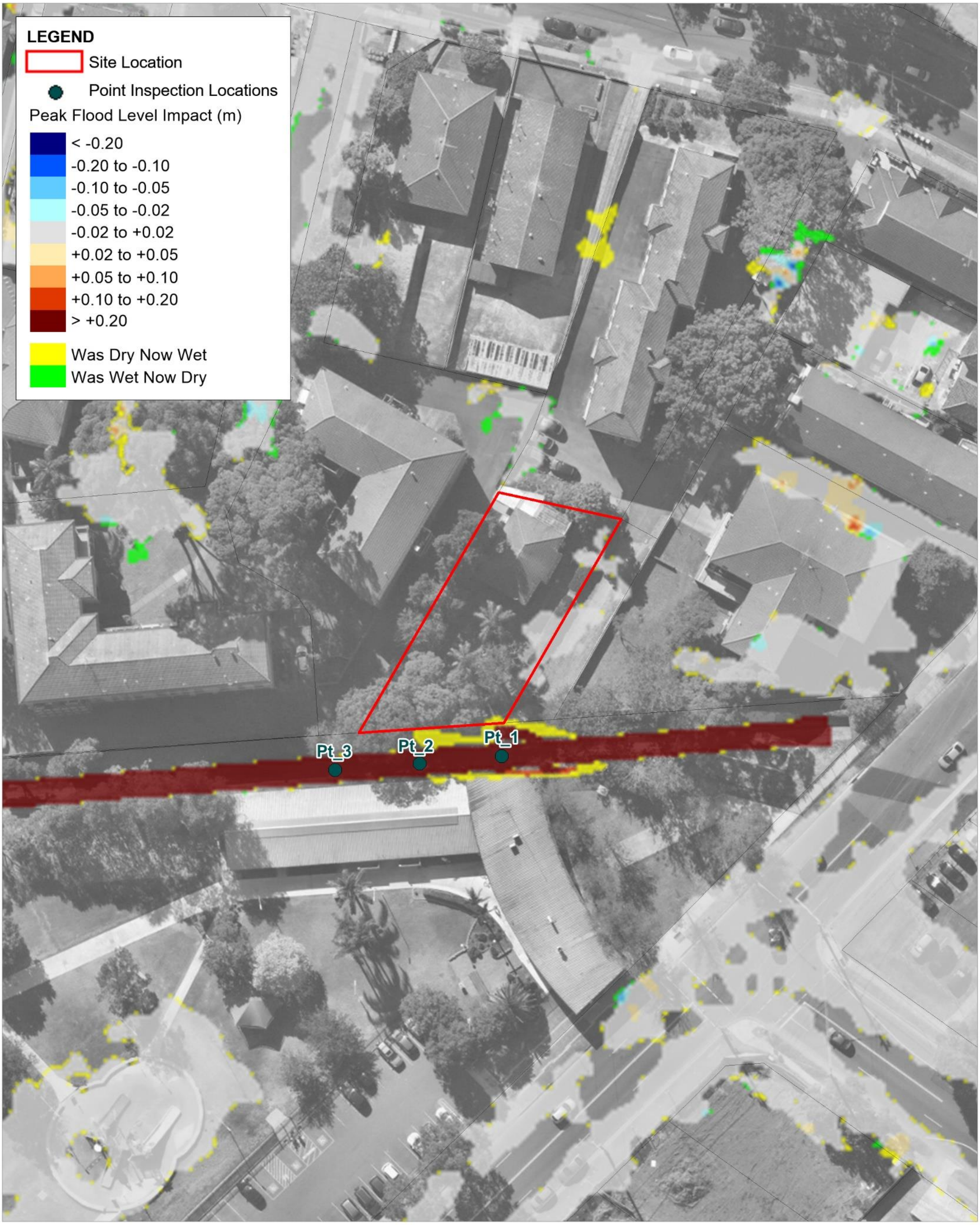

Title:

Peak Flood Level Impacts - 1% AEP Event
50% Downstream Blockage

Figure: **4-2**

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5 Conclusions and Recommendations

Based on the information contained within the pre-DA meeting minutes (ref: *PRE DA MEETING PL180012 1 Station Lane Penrith.pdf*), the peak 1% AEP flood level and FPL for the site identified by Council is 27.10 m AHD and 27.6 m AHD respectively.

Whilst BMT could not replicate this level exactly (-0.2 m difference in simulated 1% AEP levels) using the TUFLOW model provided (refer Section 2.2), BMT did not identify any significant issues that would result in the simulation of inappropriate design flood levels.

With regard to the inundation of the site as a result of the January 2016, the assessment identified the following:

- The January 2016 rainfall event was approximately equivalent to a 2% AEP event (based on a comparison with the design rainfall hyetographs applied to Council's model as RoG);
- The inundation of the site can be attributed to a combination of mainstream inundation from the open channel to the south of the site and overland flow originating from Union Street to the north of the site;
- The study site was inundated to a depth of <20 cm;
- Peak flood levels in the channel were potentially elevated due to a downstream structure blockage resulting in the overtopping of the channel bank; and
- Councils model would likely show the site as inundated by shallow floodwaters during the 1% AEP event but this inundation is removed via filtering of shallow depths <0.15 m.

The observed flood inundation of the site for the January 2016 event exceeds Council's 1% AEP design flood levels based on the existing flood modeling. The BMT review of the existing model did not identify any significant issues that would suggest an underestimation of the design flood conditions. The discrepancy between the observed January 2016 and design 1% AEP flood conditions may be attributable to blockage conditions in the local drainage network (particularly the Mulgoa Road culvert) and potentially higher catchment rainfall than recorded at the gauge for the event.

Accordingly, Council's existing flood modelling is considered appropriate for the site providing for an FPL of 27.6 m AHD for the proposed development at the site.

6 References

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Pilgrim, D., 2001, *Australian Rainfall and Runoff – A Guide to Flood Estimation*. Institution of Engineers Australia

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