MOTT MACDONALD

40-76 William Street, Leichhardt

Flood Impact and Risk Assessment

January 2026

Acknowledgment of Country

On behalf of Mott MacDonald, we would like to begin by acknowledging the Traditional Custodians of the land on which we meet today, and pay our respects to their Elders past and present.

We recognise and respect their cultural heritage, beliefs, continued connection to the land and water and commit to building a brighter future together.

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40-76 William Street, Leichhardt

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The aim of the FIRA is to support design of the 40-76 William Street development where specific elements of the design may influence existing flood behaviour or introduce additional flood risk. The report aims to identify and analyse:

- existing flooding constraints around the site,
- the impacts of the proposed development on the flood risk to the existing community,
- the impacts and risks of flooding on the development and its users,
- how these impacts can be managed to minimise the growth in risk to the community due to the development.

The assessment describes the nature of flooding that impacts the subject site and outlines planning requirements related to flooding that currently apply to the site.

The Hawthorne Canal flood model was developed using SOBEK by Stantec (formerly Cardno) in 2014 for IWC (formerly Leichhardt Council) used as the basis for the subsequent Floodplain Risk Management Study and Plan (FRMS+P). To complete a site-specific flooding assessment using the latest guidance a new model was developed using TUFLOW by Mott MacDonald incorporating input data from the regional Council study.

This FIRA has been undertaken in accordance with the NSW Government's Flood Prone Land Policy and the principles of the Flood Risk Management Manual

Flood model scenarios for the site were based on the following:

- Existing conditions
  - An assessment of the current flooding conditions based on existing survey of the site
- Design conditions with mitigation measures:
  - An amendment to the existing conditions model was built to incorporate the proposed development layout as building block-outs and finished levels of the landscape design

The 1% Annual Exceedance Probability (AEP) and probable maximum flood (PMF) have been assessed as they relate to the flood planning levels and emergency management measures for the development. The PMF is the largest flood that could conceivably occur at a location and defines the maximum extent of flood-prone land.

In the existing case, the site is prone to flooding with ponding occurring along the western and southern walls of the buildings on site as a result of overland flow from upstream properties. This flow accumulates in the internal carpark, drained by an existing pipe to the downstream network in William Street.

The following changes in flood behaviour are predicted by the model:

- Changes in peak 1% AEP water level
  - flood levels are generally reduced to ponding areas within and adjacent the site. This is the result of providing an offset between the proposed structures and the boundary, and an increase in pipe size which drains the carpark area compared to the existing case
  - it should be noted that existing ponding to the rear of adjacent properties was caused by the existing development that extended to the boundary and effectively blocked overland flow.
  - one location is predicted to have an increase in peak water level; up to 60 mm for existing buildings. While this is above the recommended change for buildings, in the context of

existing flood affectation, it makes no difference to the flood immunity as the building façade is a continuous brick construction without openings. The existing 1% AEP flood depth is up to 0.60m, so a localised change in peak level (no greater than 0.06m) does not significantly increase the flood risk

- Changes in 1% AEP inundation duration
  - there are no increases in duration of inundation that exceed the recommended timeframes
- Change in 1% AEP flood velocity
  - flood water velocities are not significantly changed by the proposed development
  - there are no changes in flood water velocity outside the site boundary
- Change in 1% AEP flood hazard
  - there are no changes in flood hazard outside the site boundary

The flood emergency management (EM) strategy for the site has been assessed following advice provided in *Flood risk management guideline EM01 - Support for emergency management planning* (DPE 2023) and relevant plans from the NSW SES.

Based on the FIRA, a shelter in place policy during a flood emergency is the most logical EM approach to protect life, given the following constraints:

- the site is at risk from flash flooding; flooding that has a relatively high discharge over a short duration – the interval between the observable causative event and the flood is less than six hours. Consequently, there is insufficient warning time to adequately evacuate the population of the precinct. Additionally:
  - the opportunities for horizontal evacuation during a storm are limited as surrounding streets are subject to high flood hazards that present an unacceptable risk to people. NSW SES advice is not to venture out during a storm or cross any area of flood inundation
  - the rate of rise and extent of flooding in the most extreme events means that emergency evacuation centres may not get set up and evacuees would generally have to take shelter in other private premises
- the time of isolation is short, based on the duration of flooding around the precinct. A development which is isolated for a few minutes by low hazard flood water in PMF does not pose a significant risk to life
- redevelopment affords a means of creating a safe, on-site shelter above the PMF
  - redevelopment which caters for sheltering in place can be used to reduce existing risk to life for individuals who currently occupy the floodplain but it is likely to increase the number of individuals at risk
- additional Development Controls can be imposed which seek to manage the residual secondary risks to life caused by flood isolation to ensure that risks remain tolerable

1 Introduction

1.1 Project Description

This Flood Impact and Risk Assessment (FIRA) has been prepared on behalf of Anprisa Pty Ltd to support a State Significant Development Application (SSDA).

The proposed development site, located at 40-76 William Street, Leichhardt is legally described as Lot 2 of DP789576.

1.2 Site Description

The site is located in Leichhardt within the Inner West Local Government Area (LGA). The site comprises one lot, has a total area of approximately 6,930.3m^2 and is occupied by existing structures and carpark pavements. The site currently comprises primarily industrial and light industrial uses. The site has frontage to North Street to the west and William Street to the north. It also has a driveway access to Francis Street to the east. An aerial map is provided in Figure 1.2.1, with the site identified by red boundary polygon.

Figure 1.2.1: Aerial Site Map

Source: Aerial Imagery and map ©Google et al, 2025

1.3 Purpose

The aim of the FIRA is to support design of the 40-76 William Street development where specific elements of the design may influence existing flood behaviour or introduce additional flood risk. The report aims to identify and analyse:

- existing flooding constraints around the site,
- the impacts of the proposed development on the flood risk to the existing community,
- the impacts and risks of flooding on the development and its users,
- how these impacts can be managed to minimise the growth in risk to the community due to the development.

The assessment describes the nature of flooding that impacts the subject site and outlines planning requirements related to flooding that currently apply to the site.

1.4 FIRA Requirements

The FIRA will demonstrate compatibility of the development with any existing relevant state environmental planning policies (SEPPs), local environmental plans (LEPs), Development Control Plans (DCP) or policies, as well as existing industry guidance, government guidance and reference documents.

For the FIRA to meet the desired aims of the, it requires an understanding of:

- a range of flood risk examining major and extreme storm events (1% Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF)),
- the constraints that flooding places on the land (floodways, flood storage, flood hazard and emergency response issues),
- the appropriateness of the development or development types for the location based on the flood constraints on the land,
- the adequacy of management measures and controls to:
  - effectively address these constraints to ensure the flood risks to the proposed development and its users are acceptable,
  - manage flood and associated emergency management (EM) impacts to the existing community due to the development.

2 Background

2.1 Study Area

The subject site boundary is identified in Figure 1.2.1 and Figure 2.1.1. The Study Area is within the Inner West Local Government Area (LGA), located approximately 5km southwest of the Sydney Central Business District (CBD). It is located in Leichhardt, NSW.

The site is bounded by William Street to the north, existing lots, car park and access lane to the east and North Street to the west. The site is predominantly occupied by light industrial buildings along the interfaces with the surrounding roads.

The area around the site has relatively steep slopes from south to north towards Hubert Street which lies across William Street from the site – and follows the topographical valley away to the north toward Hawthorne Canal. Elevations across the site range from approximately 14.5m AHD in the west to approximately 8.0m AHD at Wiliam Street in the north.

Figure 2.1.1: Site Boundary Location and Topography

Source: Topographical data ©Geoscience Australia, licensed under Creative Commons

2.2 Flood Context and Behaviour

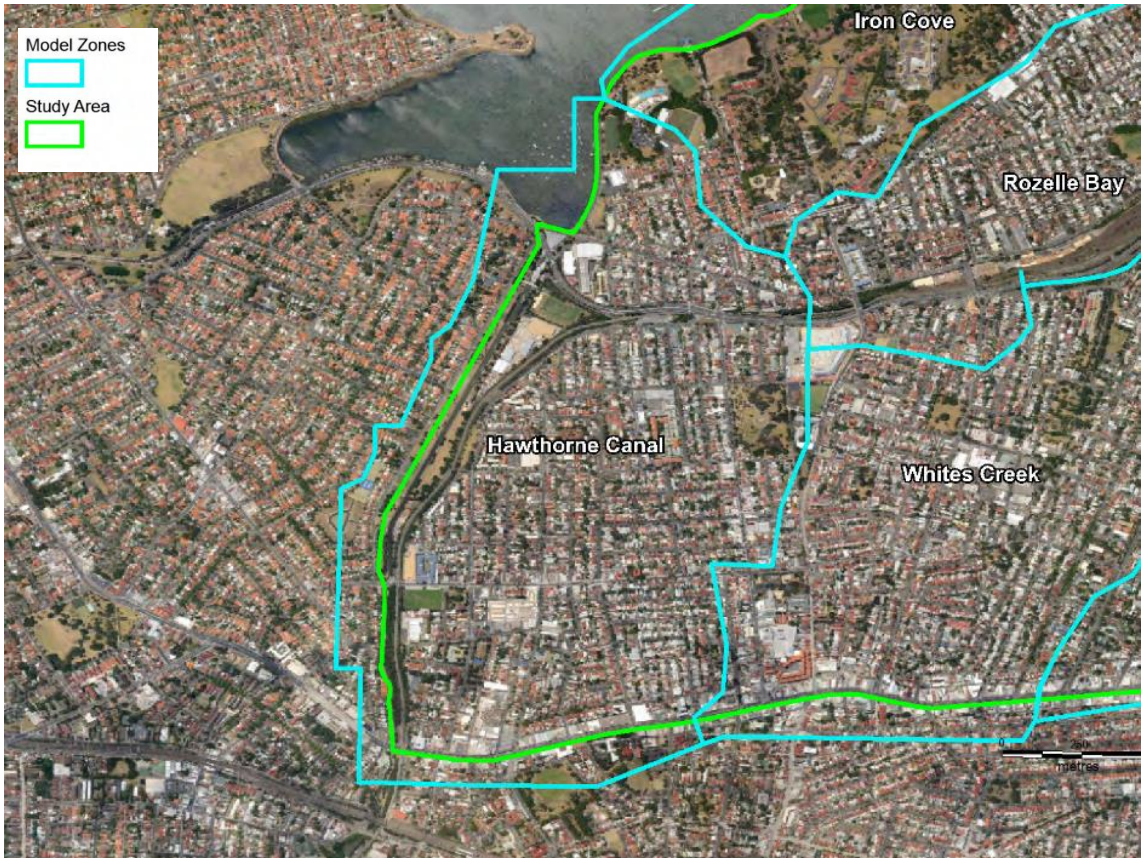
Leichhardt has a crest running north-south roughly following Balmain Rd and Norton Street on approach to Parramatta Road. The subject site sits within the portion of Leichhardt to the west of this crest, with the area draining towards Hawthorne Canal. The site is elevated from the canal's wider floodplain so is subject to overland flow flooding only from intense storms that exceed the capacity of the local stormwater drainage networks.

2.2.1 Hawthorne Canal

The *Leichhardt Flood Risk Management Study* (2017 FRMS) is a comprehensive study of the overland flow flood risk affecting the Leichhardt area. It is built on the back of the previous flood study. The 2017 FRMS defines the existing flooding behaviour and associated hazards related to extreme storms. The subject site is only subject to overland flow.

The study area contains the portion of Hawthorne Canal catchments that are within the former Leichhardt Council area and is shown in Figure 2.2.1, with upstream portions of the catchment draining areas from the former Marrickville Council area. The wider catchment for Hawthorne Canal is in the order of 670 hectares in size.

Figure 2.2.1: Hawthorne Canal Catchments



Source – Leichhardt Floodplain Risk Management Study – Final Report (2017)

2.3 Flood History

Located in one of the older areas of Sydney, the Study Areas were first settled in the early 19th Century. The original natural drainage system comprised rock gullies draining to small pockets of mangroves along the shoreline at the head of various bays. As development proceeded, the natural drainage lines were subsumed into the constructed drainage system of open channels. Eventually, by the late 19th Century, much of the channel system was progressively covered over and piped, with much of the original system forming the backbone of the present-day stormwater drainage system.

Given the age of the existing stormwater drainage network, there is a prevalence of antiquated drainage systems. In many streets, underground pipe systems do not exist, and in their place are high kerbs and/or dish gutters to convey the stormwater, with “head-on” pits/pipes designed

to carry stormwater through street intersections. Where there are existing drainage pipelines within the street, many of the pipelines are running at capacity by the 50% AEP and 20% AEP flood events, resulting in high volumes of surface flows. It is further noted that, most of the urban development within the Study Area took place prior to the major and minor drainage system design concept of Australian Rainfall and Runoff (ARR). The resulting subdivision patterns and housing types has led to a lack of formal overland flow paths with limited or, in some cases, no opportunity for overland drainage of adjacent low points within the street network. Consequently, many undrained sag points result in localised flooding. Notable flood events in the catchment include January 1991, February 1993 and April 1998 historical flood events.

2.4 Existing Emergency Management

Effective evacuation typically requires lead times of longer than just a couple of hours and this creates a dilemma for flash flood emergency managers.

Based on a detailed review of flood emergency response provisions and the flash flooding nature of the study area, it is unlikely that SES door knocked evacuation will be able to effectively evacuate residents prior to flooding. From this review, potential measures have been identified that could improve flood emergency response potential for the study area:

- Use of alternative flood warning systems: There are noted difficulties of flood warning systems in flash flooding environments. A few alternatives may be considered for flood warning systems may be developed for the Study Area, particularly the emergency management hotspot areas
- Self-managed evacuation - An alternative to SES assisted evacuation is self-managed evacuation. This describes where people make their own decision to evacuate earlier and move to alternate accommodation, using their own transport. The advantage of this approach would be that people can evacuate more quickly than SES assisted evacuation, and as a result reduces the strain on SES. However, self-managed evacuation can also pose a risk if not conducted in an appropriate way. Residents could place themselves at higher risk for example if they evacuate to a location which is even more flood affected, drive through flood waters, or could increase traffic congestion if the wrong route is selected
- Improved flood awareness - For the SES evacuation timeline model, significant delays are expected as a result of a lack of community awareness in both acceptance and lag time. A comprehensive flood awareness program for the Study Area, educating residents of the seriousness of the flood risk and the flash flooding nature of the catchment could drastically improve the evacuation timeline

3 Design Controls

The following guidelines and standards relate to civil works as they potentially influence flood behaviour and form the basis of engineering decisions regarding stormwater management and the provision for overland flow.

3.1 Inner West Council Documents

The Hawthorne Canal Catchment is located in the Inner West LGA where development is controlled through the Local Environment Plans (LEP) and Development Control Plan (DCP). The following sub-sections summarise the flood-related development controls for these documents and provide recommendations.

3.1.1 Inner West Local Environment Plan 2022 (LEP)

The site lies within the Inner West LGA; therefore, the relevant document is the Inner West Local Environmental Plan 2022.

In mid-2021, NSW Department of Planning and Environment (DPE) released a new Flood Prone Land Policy Update. Included within this policy is a draft set of standard flood-related clauses for Local Environment Plans (LEPs) to assist local Councils. The 2021 package establishes two different categories, and two associated standard Local Environment Plan (LEP) clauses where flood-related development controls may be applied / considered. These are:

- Flood Planning Areas (FPAs): The 'flood planning' LEP clause is mandatory and the LEPs of all Councils in NSW were amended on 14 July 2021
- Special Flood Considerations (SFCs): The '*special flood consideration*' LEP clause is optional, and Councils decide whether to adopt this clause or not. If Councils choose to adopt the optional standard instrument SFC provision, it must be adopted without variation but subject to any relevant direction in the standard instrument (cl 4(2), SI order)

3.1.1.1 Mandatory LEP Clause - Flood Planning Area

Clause 5.21 outlines the requirements for developments in the FPA which is all land under Flood Planning Level (FPL), which in accordance with the FRM Manual 2023 is typically defined by the 1% AEP (1 in 100 AEP) event with a 0.5 metre freeboard. Councils are permitted to propose alternate FPLs; however, they are required to demonstrate and document the merits of any decision based on a risk management approach. The land this clause applies to is essentially unchanged from the previous standard LEP clause.

The main updates to the mandatory standard flood related clause include:

- Several new objectives have been added to the updated text including a reference to cumulative impacts, enabling safe and appropriate uses of land, and enabling safe evacuation from the land,
- The requirements for development consent have been updated with reference to:
  - Compatibility to flood function (floodway, flood storage and flood fringe)
  - No offsite flood impacts and the impact of the development on projected changes to flood behaviour (accounting for climate change),
  - There is a reference to safe occupation and efficient evacuation of people and not to exceed the capacity of existing evacuation routes for the surrounding area. Similarly, also

stated in the clause is whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood

– The intended design and scale of buildings resulting from the development, and the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding. Review of the draft Inner West LEP shows that the wording of the flood planning section 6.3 reflects this updated wording as is mandatory

3.1.1.2 Optional LEP Clause – Special Flood Considerations

A new optional flood *Clause 5.22* has been added called the 'Special Flood Considerations' (SFC) clause. The clause applies to all land between FPA and the PMF, an area that was not covered within the previous standard LEP clause. The types of development this optional clause would apply to includes vulnerable developments and critical infrastructure. In relation to the Special Flood Considerations (SFC) Clause 5.22, as stated within the guideline document:

….this is an optional provision of the Standard Instrument and Councils have the discretion whether to adopt the clause in a LEP in their LGA, provided they have appropriate information and justification to support the flood related development controls. Studies under the FRM process, as well as emergency management planning processes and relevant strategies and plans developed by NSW Government may provide information and support justification for the adoption of the clause.

Inner West Council has not adopted the optional LEP clause 5.22 for land between the FPA and the PMF. Therefore, only the mandatory LEP clause 5.21 for the FPA will be applicable.

3.1.2 Leichhardt Development Control Plan 2013 (DCP)

The subject site, located on the north side of Parramatta Road, would have fallen into the former Leichhardt Council LGA area, therefore, the Leichhardt Development Control Plan (LDCP) has been summarised below.

3.1.2.1 Overview

The Leichhardt Development Control Plan (DCP) 2013, administered by Inner West Council, provides detailed planning and design guidelines to support the Leichhardt Local Environmental Plan (LEP) 2013 and the Inner West LEP 2022. It applies to suburbs including Annandale, Balmain, Leichhardt, Lilyfield, and Rozelle, and guides development proposals requiring council approval. The plan aims to ensure sustainable, context-sensitive development while allowing flexibility in achieving planning objectives.

3.1.2.2 Flood Planning Level (FPL)

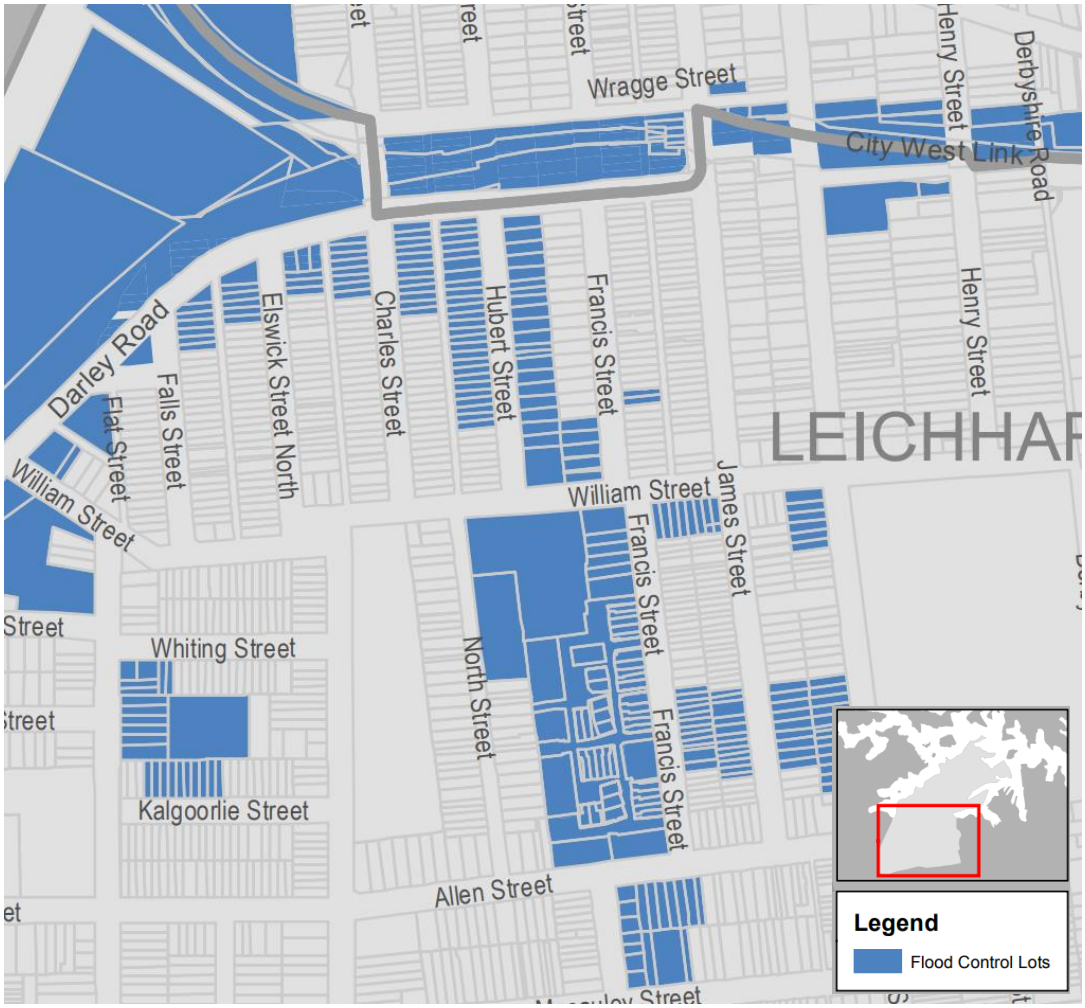
The Flood Planning Level (FPL) in the Leichhardt DCP is derived from the 1% Annual Exceedance Probability (AEP) flood level, with an added 0.5m freeboard to account for uncertainties such as wave action, debris, and climate change impacts like sea level rise. The FPL is used to guide development in flood-prone areas and is a key benchmark in Flood Risk Management Reports, which must show how proposed buildings relate to this level through cross-sections and elevation data.

3.1.2.3 Flood Planning Controls

The flood planning controls in the LDCP 2013 aim to manage and mitigate flood risks through a structured approvals process and site-specific assessments. A Flood Risk Management Report is required for applications that are identified as flood control lots on the maps in Appendix E –

Part 4: Flood Control Lot Maps. Leichhardt Precinct Flood Control Lots are shown in Figure 3.1.1. This site is shown as a Flood Control Lot as per the DCP.

Figure 3.1.1: Flood Control Lot



Source: (Inset of) Flood Control Lot Plan, Appendix E of Leichhardt DCP

3.1.2.4 Flood Risk Management

Objectives and controls relevant to the development are outlined below:

Objectives

- **O1** - To manage development of flood control lots and flood prone land to reduce the risks and costs associated with flooding

Controls

- **C1** - Applications submitted for a flood control lot must be accompanied by a Flood Risk Management Report supported by a flood study prepared by a relevantly qualified civil engineer. The report must establish the Hazard Category of the site

Multi Unit Residential Development for 3 or more Dwellings

- **C3** - All floor levels are to be at or above the Flood Planning Level

Commercial, Industrial and Mixed Use Development

- C4 - All floor levels, including any existing components to be retained, are to be at or above the Flood Planning Level or raised to the Flood Planning Level.

  Where constructing the floor level or raising the floor level of existing development to the Flood Planning Level may be impracticable, due to site and access constraints, consideration may be given to some or all of the non-residential floor levels having a freeboard of less than 500mm above the 100 year ARI flood level provided that satisfactory flood proofing (either wet or dry) is achievable to the Flood Planning Level. All entrances and evacuation routes servicing any residential components must be above the Flood Planning Level

Land with a High Hazard Category

- **C8** - If a development is identified in the Flood Risk Management Report as being in a High Hazard Category, the development must demonstrate that:
  1. there is no net loss in flood storage and floodway area as a result of the development
  2. the development will not increase velocity, volume or direction of flood waters
  3. for subdivisions, that there are adequate building platforms or developable areas including car park facilities and access which are not affected by the High Hazard Category
  4. the underside of all new floors are above the Probable Maximum Flood Level or Flood Planning Level, whichever is the highest, and all structures designed to withstand the High Hazard condition;
  5. the principle entries to all dwellings and common areas are located above the Probable Maximum Flood Level or Flood Planning Level, whichever is the highest, and an evacuation route is provided clear of the floodway
  6. Basement (below natural ground level) car parking is only permitted where all access and potential water entry points are above the Probable Maximum Flood Level or Flood Planning Level, whichever is the higher, and a clearly signposted flood free pedestrian evacuation route is provided from the basement area separate to the vehicular access ramps; and
  7. parts (4) and (5) are subject to compliance with other relevant requirements in the Development Control Plan residential controls

Car parking Facilities and Basements

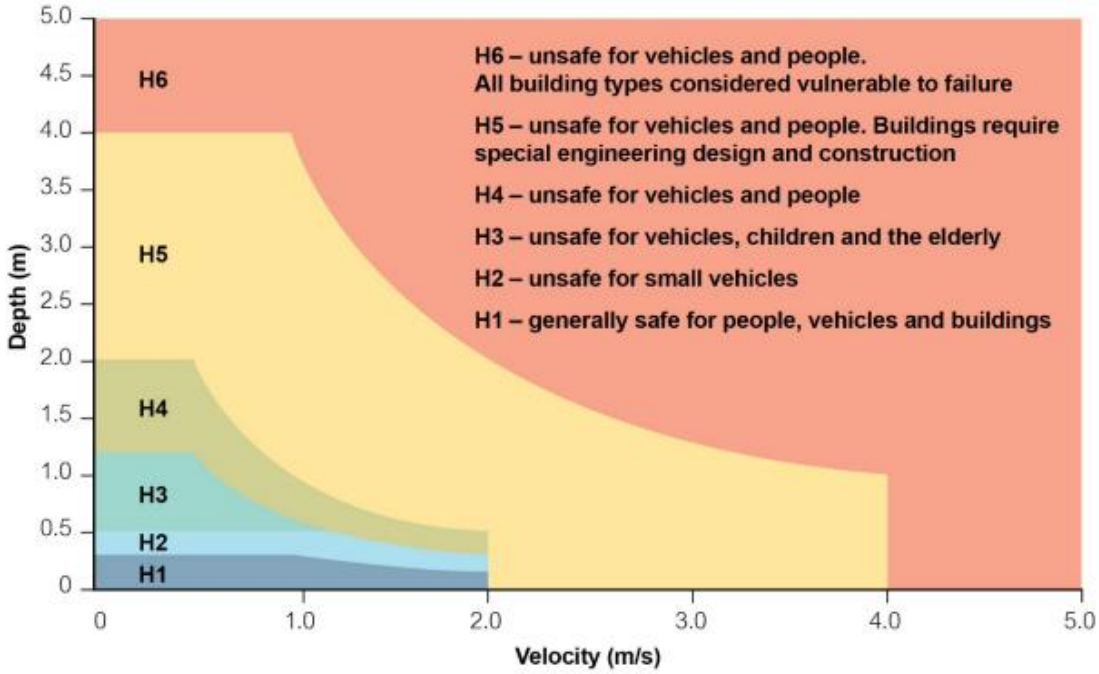
- **C9** - Refer to C8(6) for basement car parking in properties affected by High Hazard flooding

3.2 NSW Flood Risk Management Manual (2023)

The NSW Government's manual supersedes the previous *NSW Floodplain Development Manual* (2005) and is concerned with the management of the consequences of flooding as they relate to the human occupation of urban and rural developments. The manual outlines the floodplain risk management process and assigns roles and responsibilities for the various stakeholders.

The manual applies to all development and provides additional guidelines for ensuring safe overland flow paths are provided. These guidelines adopt the hazard categorisation which has been developed by Australian Emergency Management Institute Handbook 7 in 2014 (*Managing the floodplain: Best practice in flood risk management in Australia)* (AEMI 2013), defining hazard into six categories. The categories relate to the flood vulnerability curves shown in Figure 3.2.1.

Figure 3.2.1: General Flood Hazard Vulnerability Curve – Australian Emergency Management Institute (2014)



Source: Figure 6 AIDR 2017b

Categories H1 to H4 are equivalent to low hazard and H5 to H6 are equivalent to high hazard in the 2005 Floodplain Development Manual.

3.3 Flood Risk Management Guideline LU01 (2023)

Published by the Department of Planning and Environment, (DPE) this guideline provides advice on the scope and scale of a flood impact and risk assessment. It does not replace the processes or requirements of the consent authority. It should be read in conjunction with and address any other assessment requirements for the development proposal/application.

It should be read in conjunction with and address any other assessment requirements for the development proposal/application, including those of referral authorities. For example, for state significant development proposals being considered by the NSW Government, this guideline should be read in conjunction with *the Planning Secretary's environmental assessment requirements* (SEARs) issued for the development.

3.4 Shelter in Place Guideline for Flash Flooding (2025)

Published by the Department of Planning, Housing and Infrastructure (DPHI), this guideline aims to assist consent authorities to undertake site specific, risk-based assessment to assess if shelter in place is a suitable emergency management strategy for development proposed in flash flood environments.

The intent of the guideline is to:

- guide proponents on where shelter in place may be considered in land use planning
- provide consent authorities guidance on matters that may be considered in assessing planning proposals and development applications where shelter in place is proposed
- assist councils when considering the role of shelter in place within their own local guidelines, policies, and development control plans.

The shelter in place guideline defines the following:

- Shelter in place - the internal movement of a building's occupants to an area within the building above the probable maximum flood (PMF) level before their property becomes inundated by flood waters
- Flash flooding – flash flooding is "flooding that occurs within 6 hours of the precipitating weather event and often involves rapid water level changes and flood water velocity".[1]
- Flood behaviour –
  - flash flooding is the only flood risk present at the site, whether it be from overland flooding, local creek or riverine flooding
  - the flooding occurs within less than 6 hours from the commencement of causative rain and the duration of shelter in place due to isolation by floodwaters is less than 12 hours from the commencement of rainfall
  - the development is not subject to high hazard flooding (e.g. floodways, high hazard H5 or H6 areas) or surrounding roadways are not subject to high hazard flooding [2]

[1] Flash flooding as defined in Emergency Planning and Response to Protect Life in Flash Flood Events (2018) AFAC (Australasian Fire and Emergency Service Authorities Council)

[2] Flood Risk Management Guideline FB03 Flood Hazard, DCCEEW, 2023

4 Hydraulic Modelling Methodology

4.1 Available Information

The Hawthorne Canal SOBEK model and associated flood study was made available for this assessment. Stantec Australia Pty Ltd (formerly Cardno) was commissioned by Inner West Council (formerly Leichhardt Council) to undertake the Flood Study (FS 2015) and Flood Risk management Study (FRMS 2017) for the Leichhardt Study Areas.

4.2 Modelling Approach

4.2.1 Basis of Flood Model

The Hawthorne Canal flood model was derived using hydrological information under previous versions of the ARR guidance and the SOBEK software package for hydraulic modelling. Since that time the hydrological guidance has been revised significantly, and hydraulic modelling packages have developed to a point where TUFLOW is now an industry standard tool for this type of modelling assessment. Therefore a new model was developed using TUFLOW by Mott MacDonald to use for this FIRA, using data inputs from the regional catchment model.

4.2.2 TUFLOW Software Package

TUFLOW is a one and two-dimensional (1D/2D) hydraulic modelling program that simulates the flow of water across a landscape and through any conveyance structures such as pipes or culverts.

The 2D component of the TUFLOW software package determines overland flow paths by dividing the landscape into a grid of individual cells. The flow of water between cells is then computed repeatedly at regular time steps by solving two-dimensional shallow water equations to estimate the spread and flow of the water. Flows are routed in the direction water that will naturally follow the modelled topography.

The 1D component (called ESTRY) is a separate calculation engine incorporated into TUFLOW to manage flows through structures which cannot be accurately represented with 2d grid cells. ESTRY is a network dynamic flow program suitable for mathematically modelling floods and tides (and/or surges) in a virtually unlimited number of combinations. ESTRY has been developed in conjunction with TUFLOW to resolve complex 1D-2D flows across the floodplain interface.

4.2.3 Modelling Scenarios

Flood model scenarios for the precinct were based on the following:

- Existing conditions
  - An assessment of the current flooding conditions based on existing survey of the site
- Design conditions
  - An amendment to the existing conditions model was built to incorporate the proposed development layout as building block-outs, representation of the finished surface levels of landscape grading and stormwater network changes

The 1% AEP and probable maximum flood (PMF) have been assessed as they relate to the flood planning levels for the development. The PMF is the largest flood that could conceivably occur at a location and defines the maximum extent of flood-prone land.

- Climate change
  - The effect of increasing the design rainfalls in accordance with the Intergovernmental Panel on Climate Change's (IPCC) summary of Shared Socioeconomic Pathway (SSP) influence on climate conditions in Assessment Report 6 (AR6) has been evaluated for the 1% AEP rainfall event with impacts on peak flood levels observed throughout the study area.
  - SSP2-4.5 rainfall uplift to 2030 has been adopted to represent current conditions, noting that global mean temperatures have increased since the baseline period for rainfall data available as input for assessment.
  - The sea level rise associated with climate change will not present an influence on flood behaviour in the vicinity of the site due to elevated topography and the grade of the topography on approach to the Hawthorne Canal floodplain.
  - Future conditions have been assessed to 2100 under SSP2-4.5 and SSP3-7.0, selected as the furthest forward estimate for rainfall uplift factors provided by the ARR datahub

4.3 Planning and Development Advice

The modelling scenarios were reviewed to determine flooding constraints from the existing conditions that provide inputs to the design, comprising overland flow paths, existing stormwater infrastructure and ponded levels that influence design floor levels and access considerations.

Floor level advice was coordinated with the design team regarding the relevant flood planning levels and potential basement entry levels appropriate to the preliminary design options, to ensure that the proposed development satisfied the design controls and relevant guidelines.

5 Hydraulic Modelling

5.1 Flood Model Development

TUFLOW models for the William Street catchment were based on the following:

- Existing conditions
  - an assessment of the current flooding conditions based on existing survey of the site with present-day building layouts
- Design conditions with mitigation measures
  - an amendment to the existing conditions model was built to incorporate the proposed options as building block-outs to conservatively assess the impact of the proposal while providing design recommendations such as flood planning levels

The following storm Annual Exceedance Probabilities (AEP) have been assessed in relation to the proposed development site

- 1% AEP (1 in 100-year storm) – analysis of emergency management, flood impacts and definition of flood planning levels
- Probable Maximum Flood (PMF) – analysis of emergency management, flood impacts and definition of flood planning levels. The PMF is the largest flood that could conceivably occur at a location and defines the maximum extent of flood-prone land

5.1.1 Existing Model Basis

Model preparation in TUFLOW was based on the digital terrain model and classification of the land use into materials classes for hydraulic roughness representation.

Digital Terrain Model

Model topography is based on Council provided Airborne Laser Survey (ALS) data. Comparisons to ground survey and other LiDAR datasets show that the data used in the TUFLOW model is generally accurate.

Rainfall Input

Rainfall application to the model is via rainfall on grid methodology, applying the ARR datahub derived rainfall estimates. Losses are not significant in this very heavily urbanised catchment with very high impervious rates for the upstream catchment. Losses have not been applied to the modelling.

5.1.2 Stormwater Pit and Pipe Network

The model adopts the stormwater network data from Council's database of stormwater asset information. This was reviewed against site-specific information but found to be a good representative of the networks around the site. Internal site stormwater drainage data was obtained from detailed survey to supplement the Council data on piped system information in the road reserve.

5.1.3 Critical Storm Durations

The critical duration for the majority of the upper catchment (encompassing the subject site) is the 20 minute storm for the 1% AEP, and the 15 minute for the PMF. This review of critical

durations reinforces that flood risk is primarily a function of the rainfall intensity in the most severe, short-lived rainfall events.

5.1.4 Existing Flood Behaviour (Base Case)

5.1.4.1 1% AEP Storm (1 in 100-year)

Flood Depths and Extents

Under existing conditions, the site is prone to flooding with the 1% AEP storm causing inundation within the carparks on site, held by the existing building obstructions until relieved by the existing drainage pipe, shown in Figure 5.1.1.

Figure 5.1.1: Existing Condition 1% AEP Flood Depth and Extent

The following flood depths are predicted within and around the development site:

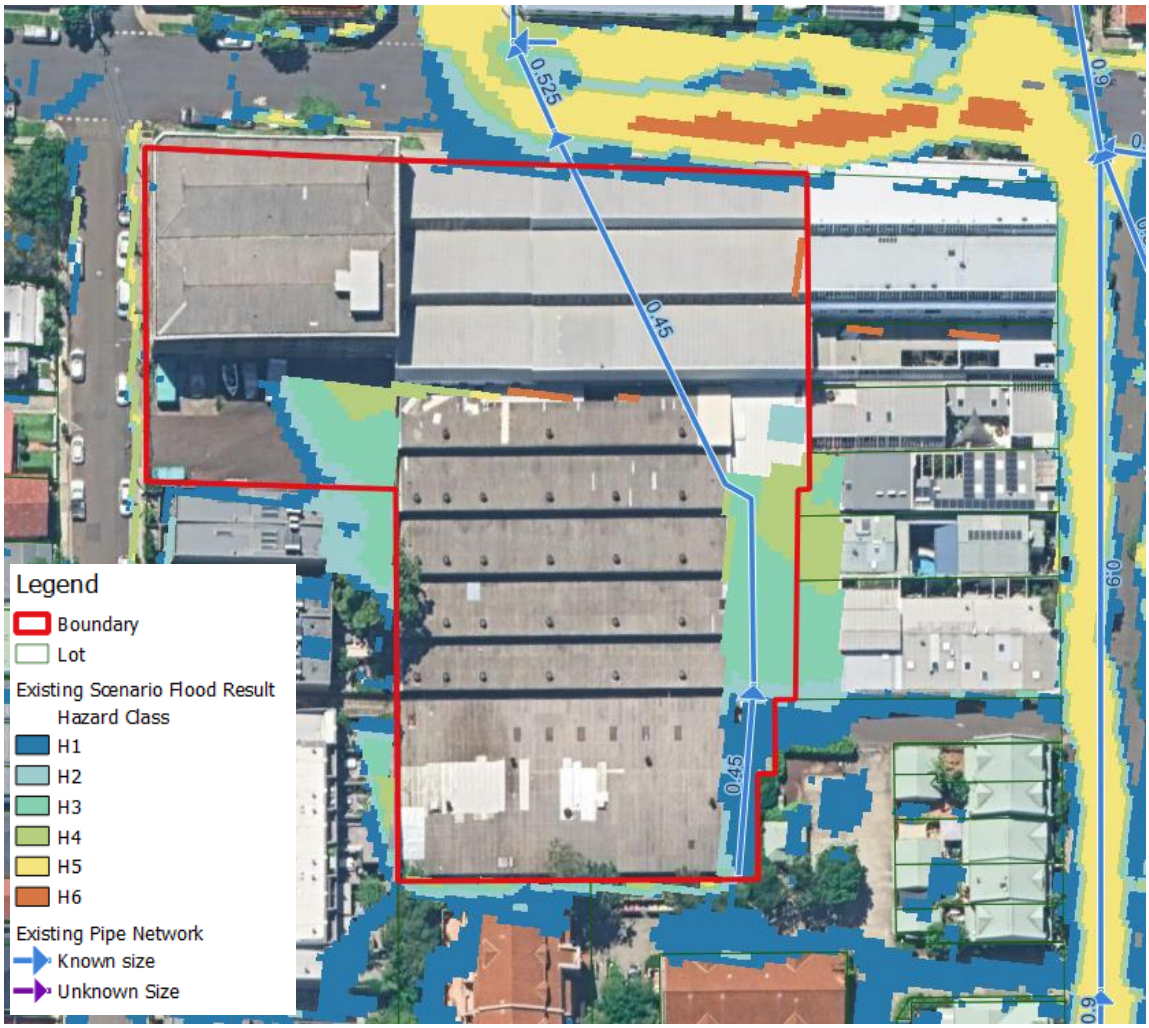
- Up to 0.50m of water in the William Street sag
- Gutter flow up to 0.3m in William Street, shallow gutter flow otherwise - typically less than 0.10m.
- Up to 1.30 m of water in the eastern carpark
- Up to 1.50 m of water within the western carpark

Flood Hazard

The flood depths and associated velocities lead to a range of flood hazards around the site, driven largely by the steep grade in the existing road reserves, and depth for the trapped ponding within the carparks.

- Flood hazard of H4 to H5 typically in the gutter flows, driven by velocity
- There is an area of higher hazard (up to H6) along William Street, this is result of high water velocity (greater than 2 m/s)
- Flood hazard of H3 to H4 within the carpark areas, driven by ponded depth

Figure 5.1.2: Existing Condition 1% AEP Flood Hazard



5.1.5 Post Development Flood Behaviour (Design Case)

The proposed development footprint was incorporated as a deactivated area into the flood model, replacing the existing building polygons within the site that represented the existing building footprint. A deactivated area in TUFLOW means it cannot be used for surface flood flows with flood water having to pass around the deactivated feature. While this is conservative (as no flood water can enter or pass through a building footprint) it gives a maximum estimate for peak water levels surrounding the properties to guide recommended flood planning levels and evacuation strategies.

The finished surface levels of the open space has been applied to supplement the digital terrain model to represent the final grading of external areas and interface with existing topography in the road reserve.

Stormwater network upgrades have been added to the model to represent the capture and conveyance of water collecting within the low points within the site.

- The existing 450mm diameter pipe draining the eastern carpark will be removed and replaced with a new 525mm diameter pipe along the eastern boundary of the site. The increased capacity of this pipe serves to drain the internal carpark area and reduce the ponding level relative to existing conditions
- Water from southern and western properties was trapped against the building under existing conditions. The proposed development collects this water in the open landscaped areas, and a new 450mm diameter pipe along the western basement wall provides for a connection to the downstream stormwater network.
- An additional flow path/culvert from the landscaped area (deep soil planting zone) is provided beneath the finished paved areas. The opening that serves to reduce PMF peak flood levels is assessed to be a 2.4m (width) x 0.8m (height) rectangular void to transfer excess ponded water to William Street in extreme flood events.

5.1.5.1 Acceptable Flood Impacts

Austroads Guide to Road Design Part 5: Drainage – General and Hydrology Considerations provides relevant guidance on acceptable flood impacts as a consequence of a design. The acceptable flood impact for the 1% AEP flood recommended for buildings is 25 mm. A summary is presented in Table 5-1.

Table 5-1: Flood Impact Criteria Reference Table

Category	Residential Buildings (mm)*	Residential Yards (mm)	Industrial & Commercial Buildings (mm)	Industrial & Commercial Yards (mm)	Non-Habitable Structures (Sheds) (mm)	Agricultural (mm)**	Open Space / Forest (mm)***
Flood Levels	25 (general), 10–20 (sensitive)	50	50	100	100	200–400	400
Change in Duration of Inundation	No more than the larger of 10% of existing duration or 1 hr (for durations > 2 hrs)						
Flow Distribution	No more than a 10% change						
Velocities	Keep < 1 m/s, or if > 1 m/s, no more than a 10% increase						

** If impacts ≤10 mm can be achieved, this is recommended as the acceptable impact. This is the practical limit for model prediction.*

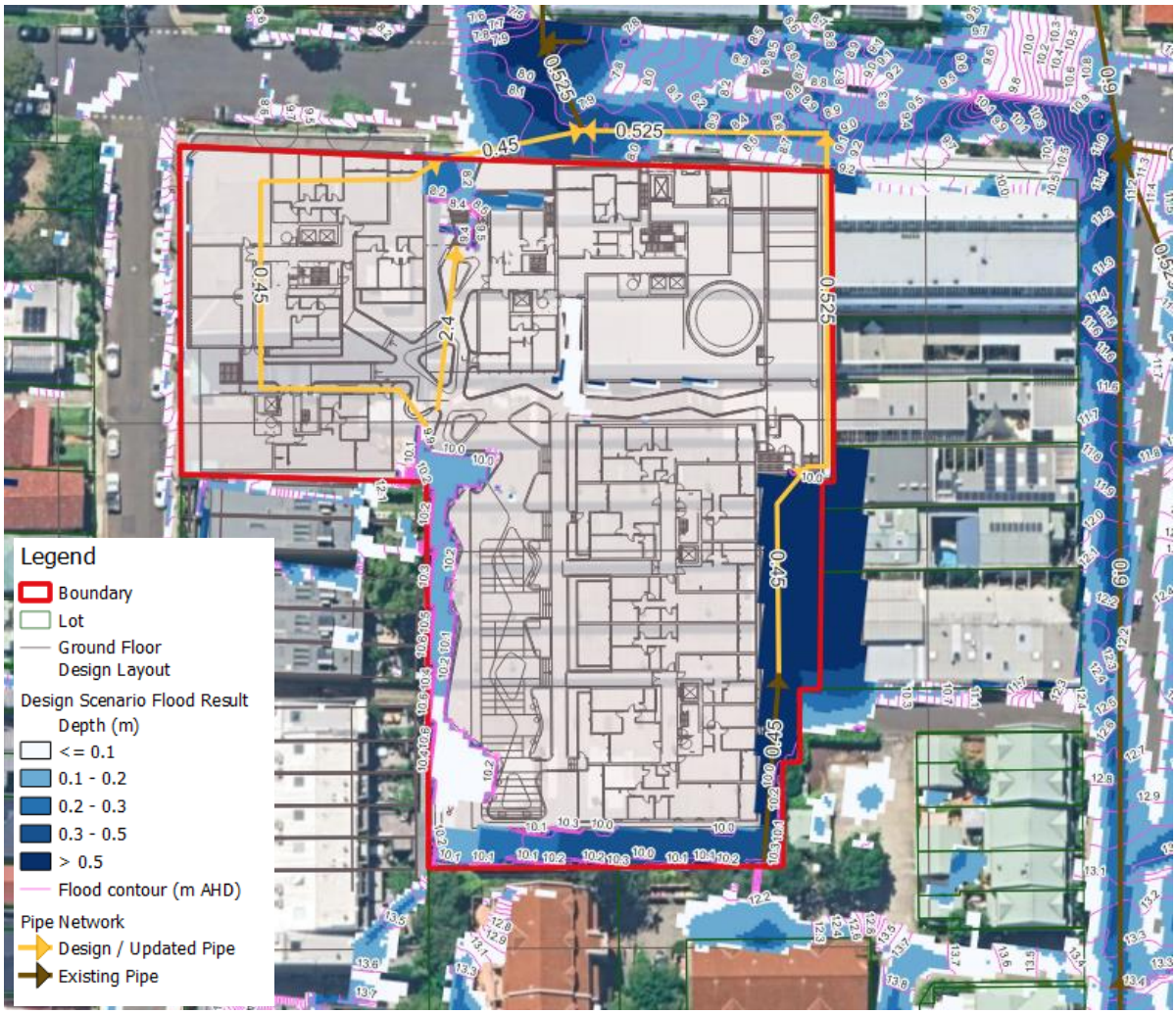
*** Depends on agricultural type and tolerance. Duration may be more critical than peak level.*

**** Applies only where no ecologically sensitive communities are affected by flooding.*

5.1.5.2 1% AEP Storm (1 in 100-year)

In the design case the site is prone to flooding with the 1% AEP storm causing inundation within the carpark on site, held by the proposed building obstructions until relieved by the upgraded drainage pipe, shown in Figure 5.1.3. Water from over the western and southern boundaries is collected within the landscaped (deep soil planting areas) portion of the site along the boundary.

Figure 5.1.3: Design Condition 1% AEP Flood Depth and Extent



The following flood depths are predicted within and around the development site:

- Up to 0.60m of water in the William Street sag
- Gutter flow up to 0.3m in William Street, shallow gutter flow otherwise - typically less than 0.10m.
- Up to 1.10m of water in the eastern carpark
- Up to 0.18m of water within the deep soil landscaped areas

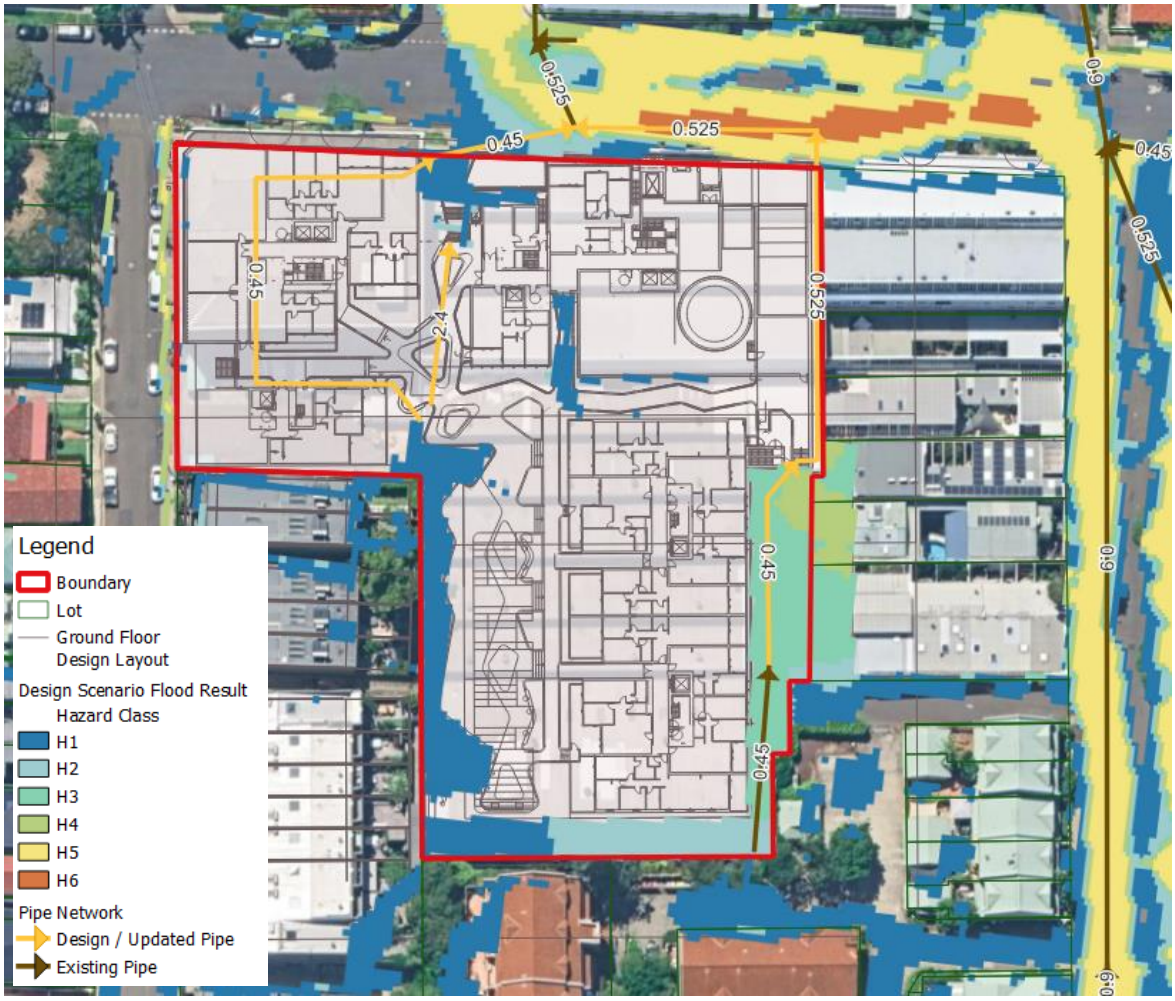
Flood Hazard

The flood depths and associated velocities lead to a range of flood hazards around the site, driven largely by the steep grade in the existing road reserves, and depth for the trapped ponding within the carpark. The western carpark is removed and hazard within the site generally reduced from the existing levels by this change of grading to external areas.

- Flood hazard of H4 to H5 typically in the gutter flows, driven by velocity
- There is an area of higher hazard (up to H6) along William Street, this is result of high water velocity (greater than 2 m/s)
- Flood hazard of H3 to H4 within the eastern carpark, similar to existing, driven by ponded depth.

- H1 areas through the landscaped sone (deep soil planting areas)

Figure 5.1.4: Design Condition 1% AEP Flood Hazard



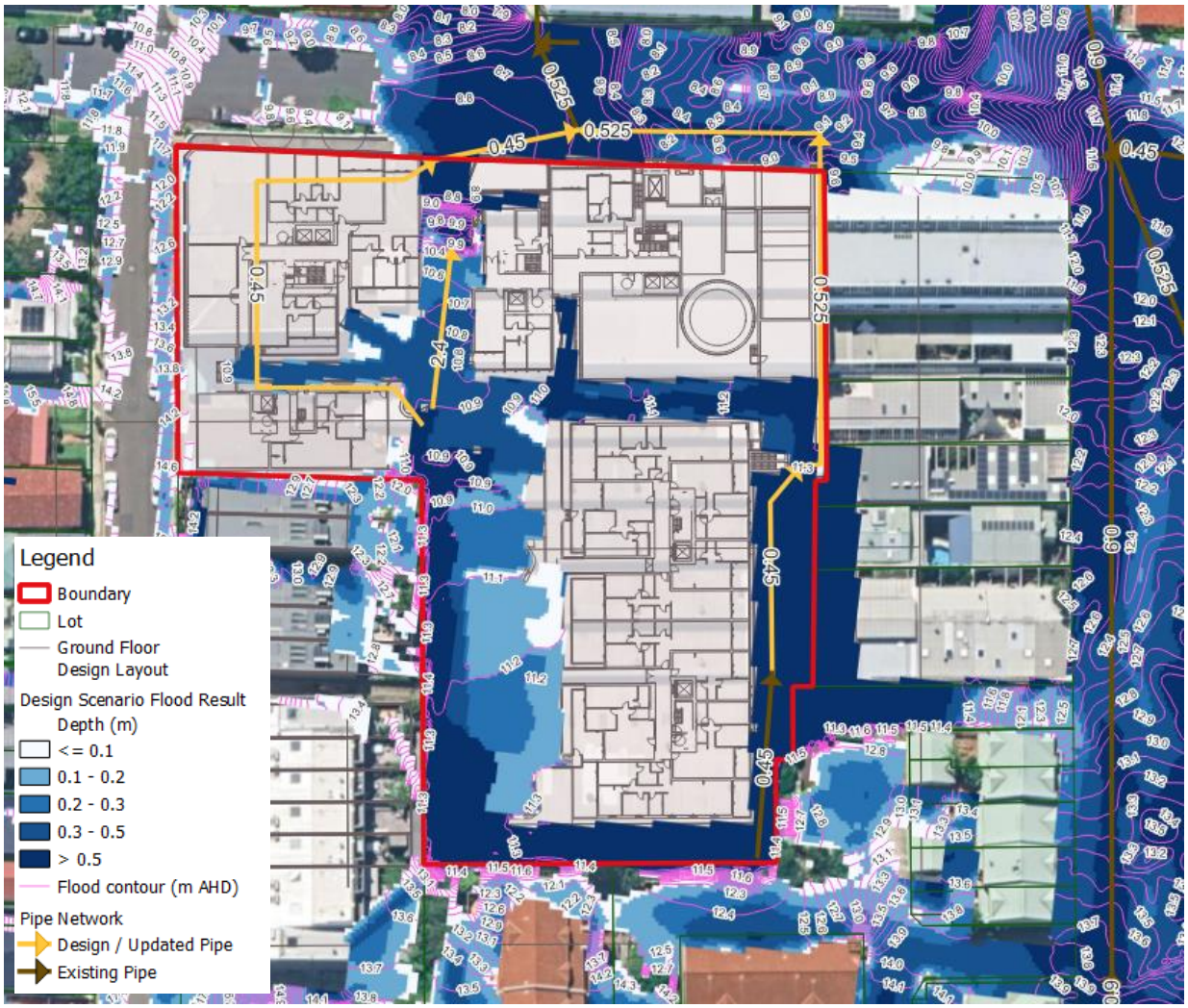
5.1.5.3 Probable Maximum Flood (PMF)

Flood Depths and Extents

In the design case, the site is prone to flooding with the PMF causing areas of deep inundation along the site boundary with William Street, shown in Figure 5.1.5. Deep flooding is also observed within the carpark area, with shallower overland flows where excess volume from the ponded area passes toward William Street through the development site.

The model is considered a conservative representation of the PMF, as there are a few discrete low paths from North Street to the west of the site. These flow paths have not been reconciled with detailed survey, and it has been observed that driveway crests and property threshold steps are present. These are features that are not typically well-represented by LiDAR topographical data. There is an opportunity to refine this at detailed design stages, and it's anticipated that this exercise would reduce PMF volumes arriving at the site from the west.

Figure 5.1.5: Design Condition PMF Depth and Extent



The following flood depths are predicted around the development site:

- Up to 1.30m along William Street
- Up to 2.60m of water in the parking area within the eastern extent of the site
- Up to 0.70m of water within the open space areas that provide pedestrian access between the proposed structures
- Up to 1.30m in the landscaped areas (deep soil planting zone)

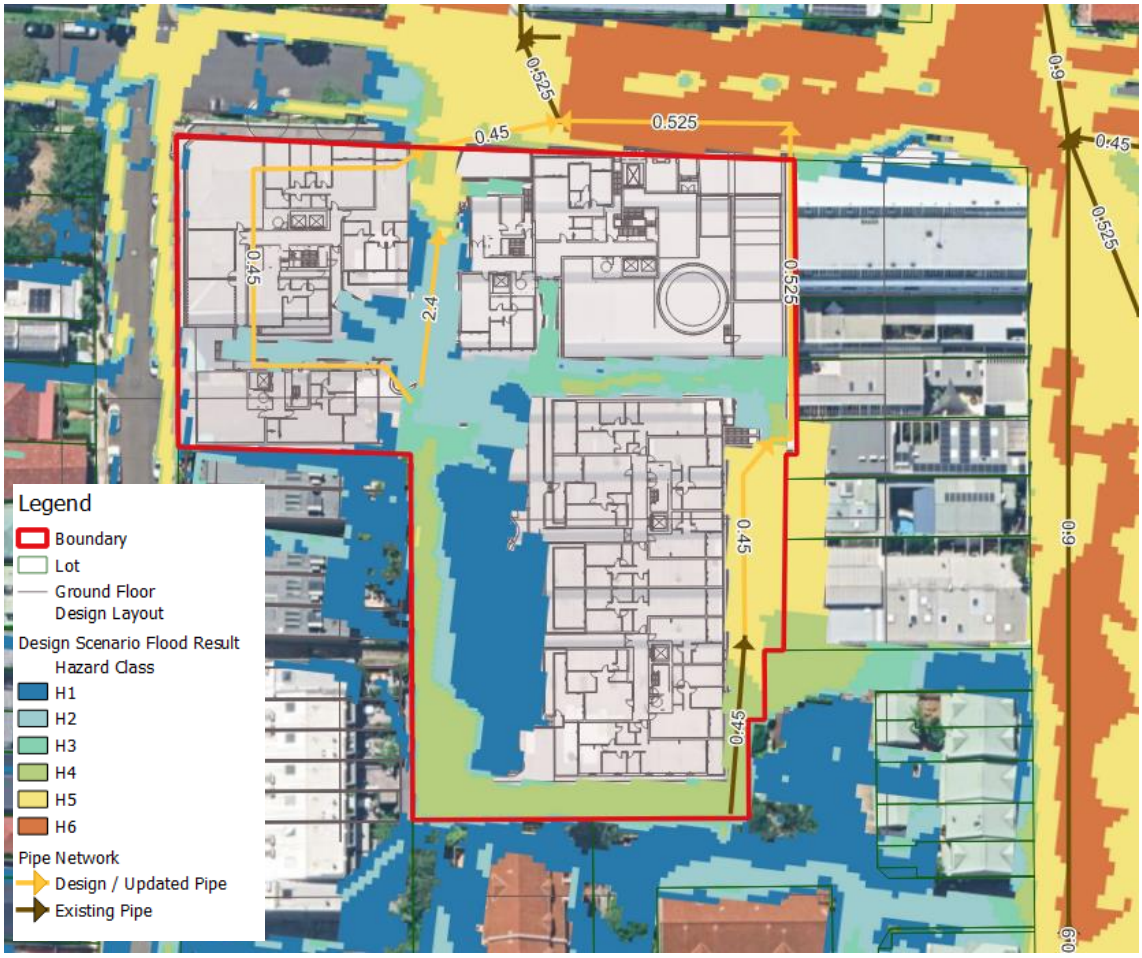
Flood Hazard

The flood depths and associated velocities lead to a range of flood hazards around the site, driven largely by the steep grade in the existing road reserves, and depth for the trapped ponding within the carpark. The western carpark is removed and hazard within the site generally reduced from the existing levels by this change of grading to external areas.

- Flood hazard of H5 to H6 typically in the gutter flows, this is result of high water velocity (greater than 2 m/s)
- Flood hazard of H5 within the eastern carpark, driven by ponded depth.
- H1 and H2 hazard for areas through the new open space areas to the west of the site providing pedestrian access to the proposed development

- H3 to H4 hazard through the new landscaped zone adjacent the western boundary (deep soil planting areas)

Figure 5.1.6: Design Condition PMF Flood Hazard



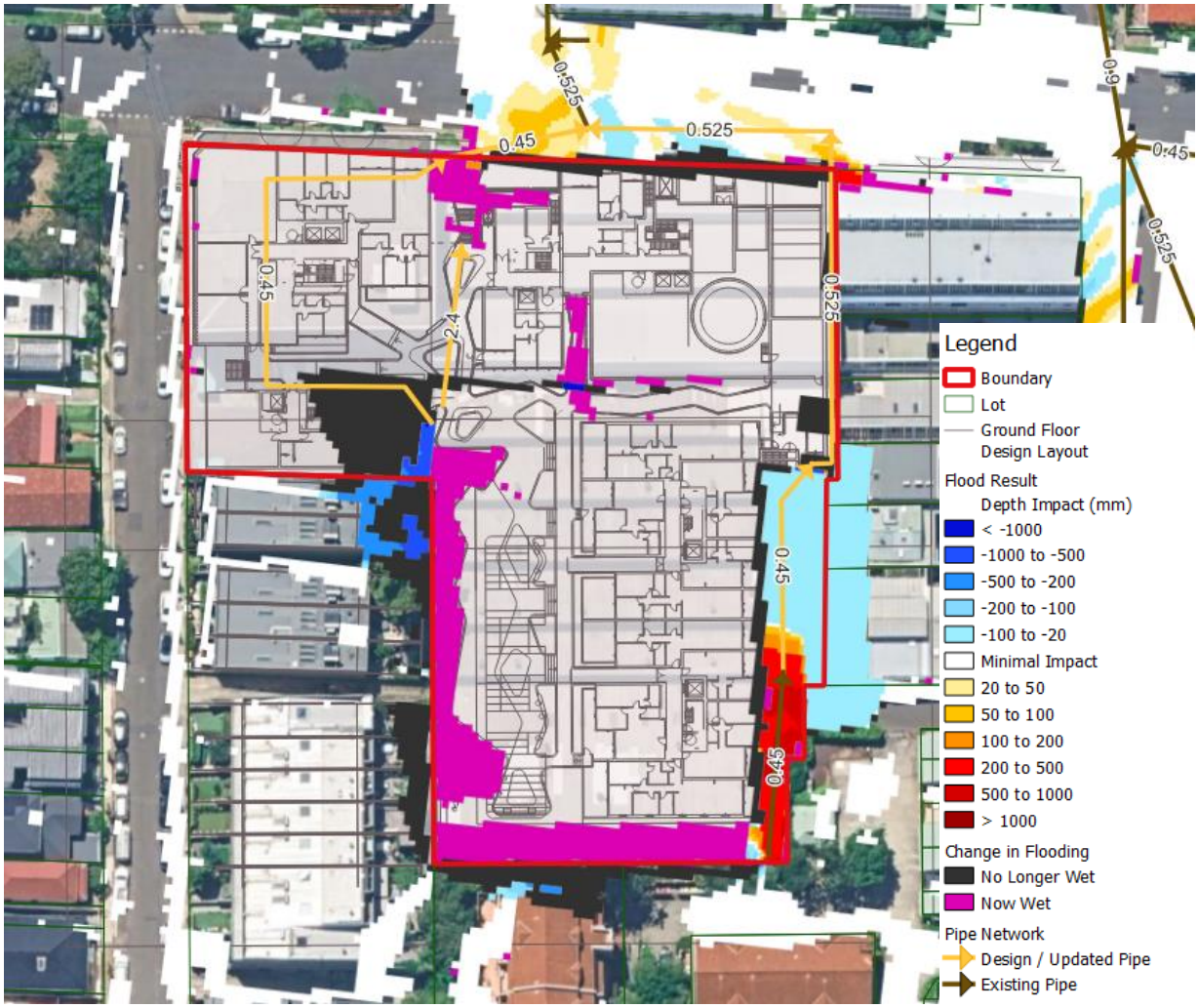
5.1.5.4 Post Development Flood Impacts

The key parameters of the flood assessment are summarised below:

- Changes in peak 1% AEP water level are shown in Figure 5.1.7 below and summarised:
  - flood levels are generally reduced to ponding areas south of the development and within the carpark areas. This is the result of increasing drainage capacity for the proposed development and reducing the building footprints, compared to the existing case.
  - Significant areas to adjacent properties to the west and south experience an improvement is flood exposure with areas to the rear of adjacent properties ‘no longer wet’. This is due to the new proposed development layout accepting the flow over boundaries from upstream properties rather than blocking flows
  - flood levels in the eastern carpark are reduced up to 0.2m from existing conditions
  - one location is predicted to have an increase in peak water level; up to 60mm for existing buildings. While this is above the recommended change for buildings, in the context of existing flood affectation, it makes no change due to the continuous brisk wall construction and no building openings. This location is affected by 1% AEP flood depths

up to 0.60m, so a localised change in peak level (no greater than 0.06m) does not significantly increase the flood risk

Figure 5.1.7: Design Condition 1% AEP Flood Level Change



- Changes in 1% AEP inundation duration
  - there are no increases in duration of inundation that exceed the recommended timeframes
- Change in 1% AEP flood velocity
  - flood water velocities are not significantly changed by the proposed development
  - there are no significant changes in flood water velocity outside the site boundary
- Change in 1% AEP flood hazard
  - there are no notable changes in flood hazard outside the site boundary

5.1.6 Managing Flood Risks

The design strategy for increased pipe system capacity reduces the 1% AEP flood depth and hazard within the site, relative to existing conditions. The increased level for the open space and circulation areas makes for external areas to be free of inundation in the 1% AEP.

The location of the basement entry ramp to the eastern end of the William Street frontage is selecting a higher elevation street frontage for the access location. This location is higher than

the ponding levels of the William Street sag point and therefore the basement ramp crest protection level is closer to the back of verge level, ie: there is no significant ponded depth in William Street at the selected basement ramp location.

The PMF presents additional risk to be managed by the design. The excess ponding volumes from within the carpark area traverse through the site. The 2.4m wide relief flow culvert provided to the landscaped area serves to reduce the depth of this flow as it passes from the southern areas of the development through to William Street in the north. Flood barriers have been designed to protect the basement from inundation in the PMF event. The location of the flood barriers permits the excess volume of water to pass through the site, yet prevents the water from entering the building and any opening to the underground carpark.

5.1.7 Climate Change Sensitivity

Incorporating climate change projections into the design scenario increases levels across the site, with variation in magnitude depending on location. Flood levels for the 2100 SSP2-4.5 scenario (Figure 5.1.8) show increases up to 200mm, and up to 400mm for the 2100 SSP3-7.0 2100 scenario (Figure 5.1.9), highlighting the necessity for resilient drainage and site design strategies. The flood extents under the climate change scenarios remain broadly similar to the baseline. The most notable change is the newly inundated area in the south-west corner of the site, affecting the park area.

Figure 5.1.8: Design Condition 1% AEP Flood Depth and Extent (2100 SSP2-4.5)

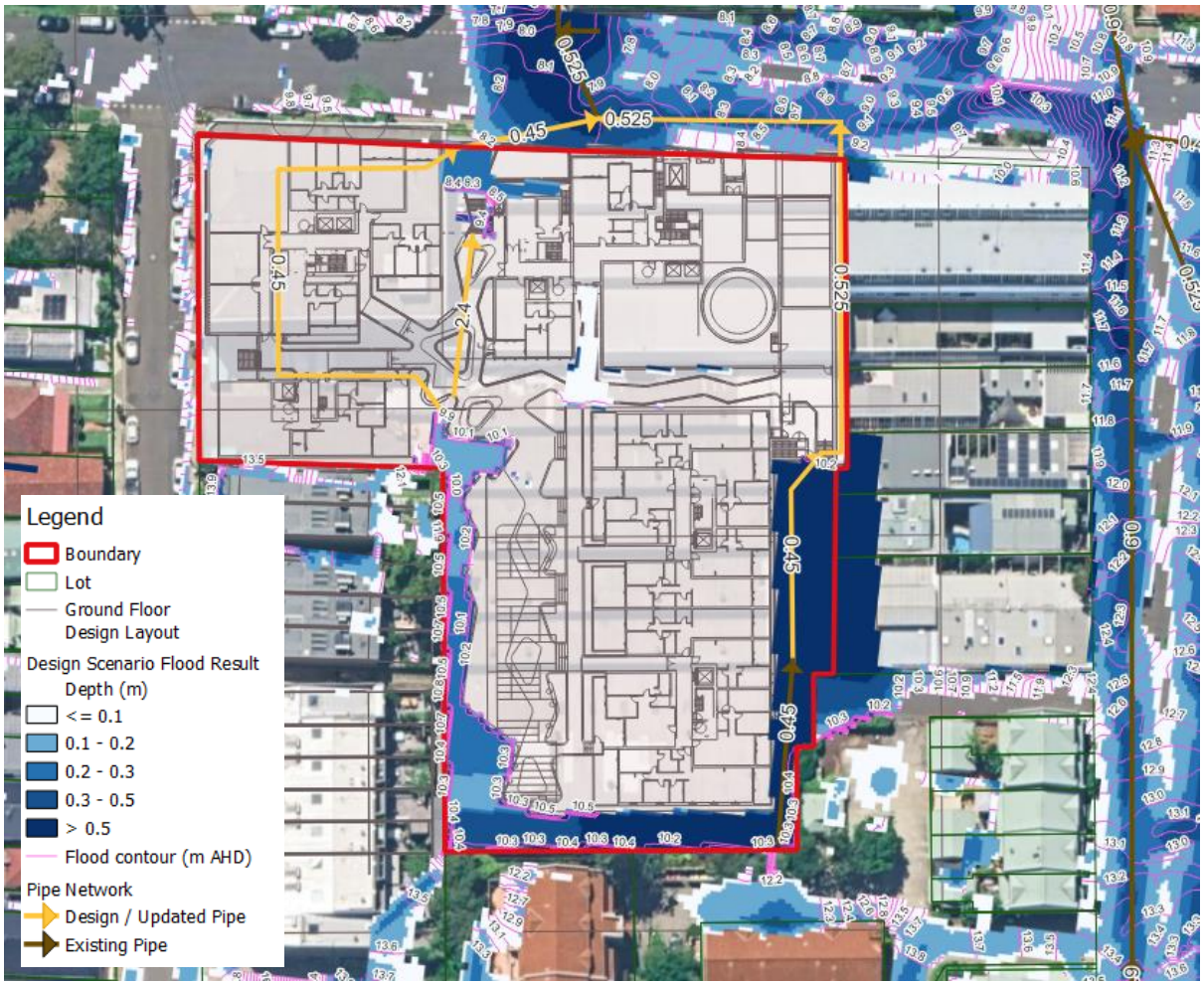


Figure 5.1.9: Design Condition 1% AEP Flood Depth and Extent (2100 SSP3-7.0)

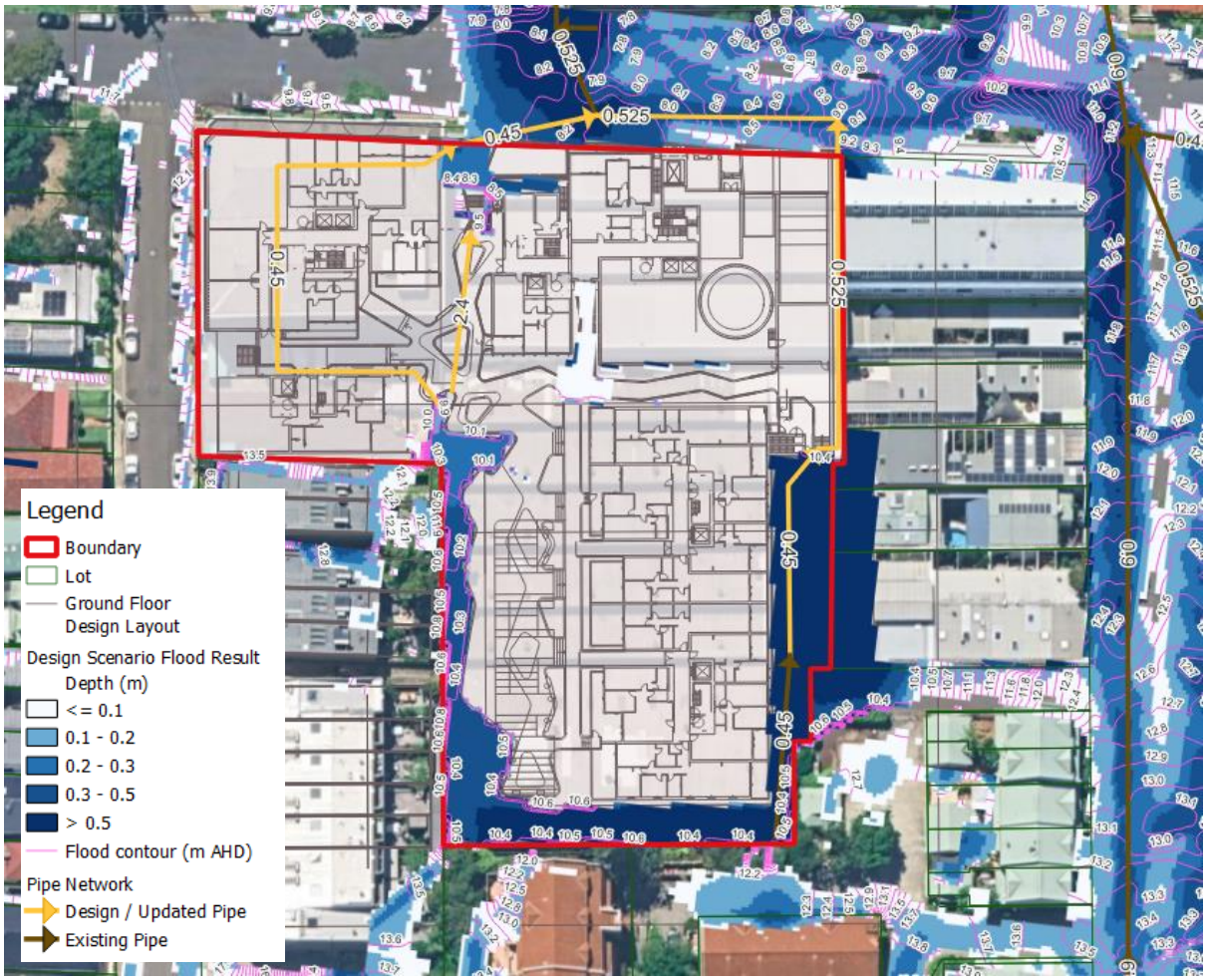


Table 5-2 presents the projected water level changes at key locations across the site under the climate change scenarios. While the proposed flood planning levels (set to the greater of the 1% AEP plus 0.5 m freeboard or the PMF) remain above the projected SSP3-7.0 2100 levels (which show a maximum increase of 0.40m at the eastern carpark), these results highlight the importance of carefully considering future climate impacts to ensure the long-term resilience of the site.

Table 5-2: Water Level Change Under Climate Change Scenarios

Climate Scenario	*William St Sag Point*	*William St Gutter Flow*	*Eastern Carpark*	*Landscaped Areas*
SSP2-4.5 2030 (Baseline Conditions)	0.60m	0.30m	1.10m	0.14m
SSP2-4.5 2100	0.68m (+0.08m)	0.36m (+0.06m)	1.50m (+0.40m)	0.21m (+0.07m)
SSP3-7.0 2100	0.75m (+0.15m)	0.41m (+0.11m)	1.60m (+0.50m)	0.36m (+0.22m)

6 Design Recommendations

6.1 Flood Planning Levels

The Flood Planning level is to be greater than or equal to the 1% AEP flood level + 500mm freeboard while the below ground carpark entrances, lift shafts, stairwells and ventilation openings are to be at the greater of the 1% AEP + 500 mm or the PMF. These are in accordance with the Leichhardt DCP FPLs outlined in Section 3.1.2.2.

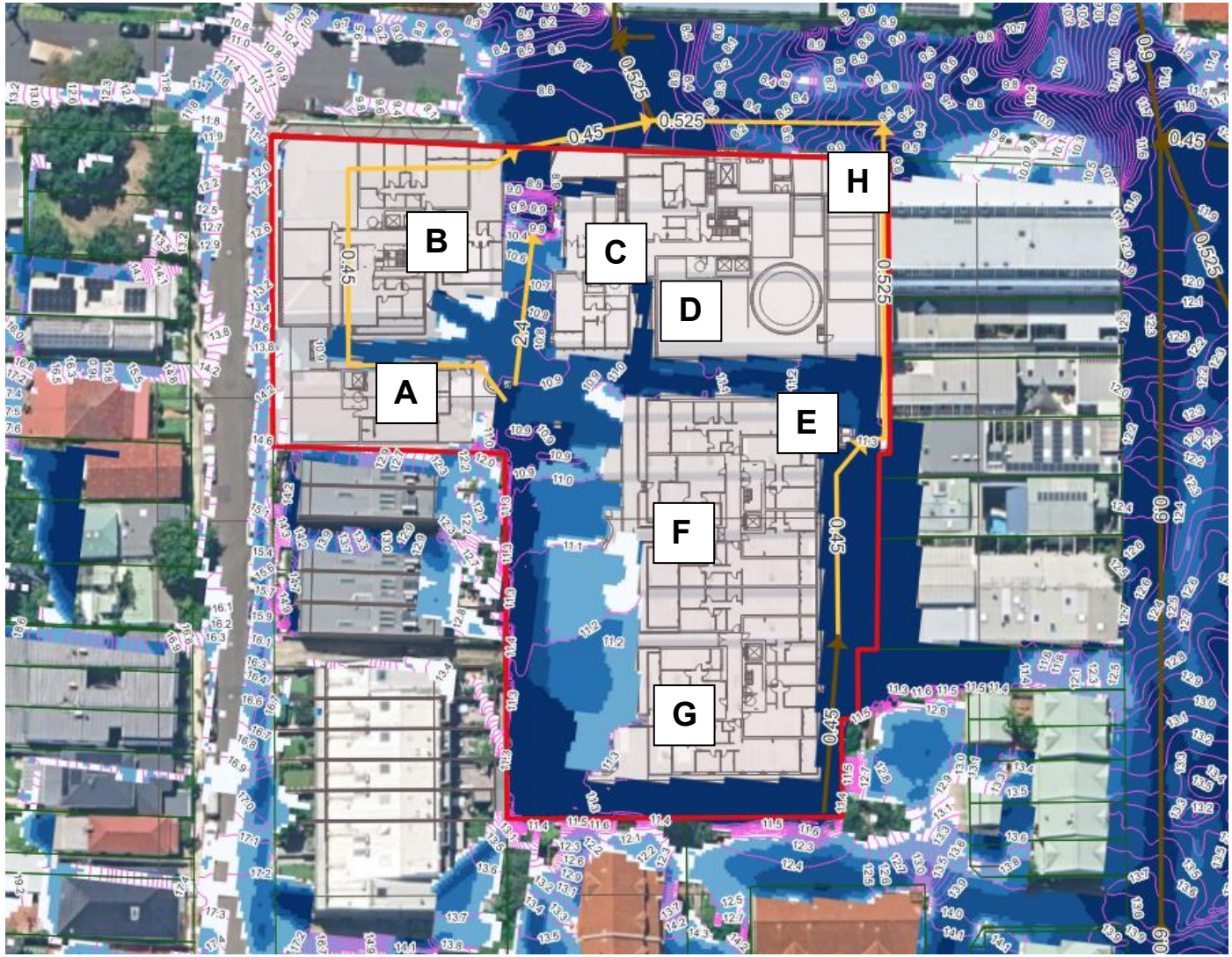
Site specific flood planning levels are listed in Table 6-1 with ID locations shown below in Figure 6.1.1.

Table 6-1: Site Specific Flood Planning Levels

Location ID	Description	Governing FPL	1% AEP Flood Level (m AHD)	PMF Flood Level (m AHD)	Minimum Recommended Flood Planning Level (FPL) (m AHD)
A	Lobby Entry	Greater of 1% AEP + 0.5m Freeboard or PMF	Not flooded, nearest 10.00	10.89	10.50m min floor 10.89m barrier
B	Lobby Entry		Not flooded, nearest 10.00	10.89	10.50m min floor 10.89m barrier
C	Lobby Entry		Not flooded, nearest 10.00	10.52	10.50m min floor 10.52m barrier
D	Lobby Entry		Not flooded, nearest 10.00	11.02	10.50m min floor 11.02m barrier
E	Basement egress stairs		Not flooded, nearest 9.82	11.25	10.32m min floor 11.25m barrier
F	Lobby Entry		Not flooded, nearest 10.00	11.15	10.50m min floor 11.15m barrier
G	Lobby Entry		Not flooded, nearest 10.00	11.20	10.50m min floor 11.20m barrier
H	Basement car park		8.95	9.27	9.45m

* 'barrier' noted here can be achieved through cresting of the finished surface level

Figure 6.1.1: Site Specific Flood Planning Levels



6.2 Flood Emergency Management

The flood emergency management (EM) strategy for the site has been assessed following advice provided in *Flood risk management guideline EM01 - Support for emergency management planning* (DPE 2023) and relevant plans from the NSW SES.

The EM01 guideline provides advice on how the flood risk management (FRM) framework and process described in the *Flood risk management manual: the policy and manual for the management of flood liable land* (DPE 2023) can consider and support flood EM.

The NSW SES leads flood EM planning and have the following legislative responsibilities in accordance with the State Emergency Service Act 1989:

- to protect persons from dangers to their safety and health, and to protect property from destruction or damage, arising from floods storms and tsunamis
- to act as the combat agency for dealing with floods (including the establishment of flood warning systems) …. and to coordinate the evacuation and welfare of affected communities

The role of the NSW SES includes community education, collation of flood intelligence, flood EM planning and flood response, including the evacuation and welfare of affected communities.

To help minimise the flood risk to future occupants, it is important that developments consider flood emergency response. There are two main forms of response that may be adopted:

- Evacuation
  - Horizontal evacuation of occupants from the floodplain before the properties and/or evacuation routes becomes flooded
- Shelter-in-place
  - Vertical evacuation of occupants in a building to a level higher than the PMF level who then shelter from the flood until it is safe to return to the ground floor and external areas

6.2.1 NSW SES EM Planning Levels

NSW SES have identified two primary levels of EM plans:

- NSW State flood plan (SFP) (NSW SES 2018)
  - includes emergency sub-plans
- Local Flood Plans (LFP)
  - typically, local government area based and are sub-plans of the local State Emergency Management Plan (EMPLAN)

6.2.2 Emergency Planning

It has been established that the area is at risk of flash flooding as critical storm durations are less than 6 hours. Inundation caused by flash flooding can occur with little or no warning and cause a rapid rise in water level over a brief period of time. Flood events of this nature do no last more than a few hours.

Severe storms can arrive with little warning or intensify over a short period of time posing a challenge to evacuation as an EM strategy. An EM strategy for the site has been considered for two separate time periods with the emphasis of self-preparation and self-evacuation:

- the period of time prior to the arrival of a storm when surrounding roads are free from flooding
- the period of time during and after the storm when surrounding roads may be inundated

6.2.2.1 Emergency Management Strategy – Prior to Storm

SES advises that when flash flooding is likely the best action to take is to leave low-lying homes and businesses (evacuation) well before flooding begins, but only if it is safe to do so. This self-evacuation would need to take place in the hours preceding a predicted storm event. In this instance evacuation via North Street is logical while the surrounding road networks are free from flooding.

North Street provides access to Elswick Street and beyond to Leichhardt commercial district which is located on the crest (in the vicinity of Marion Street). Many other arterial roads and the M4 motorway to the west provide possible routes to areas beyond, subject to the localised ponding that could occur along key routes.

These arterial roads provide means of moving to safer locations.

Enacting this strategy would require local monitoring of forecasts issued by Bureau of Meteorology (BoM), including the daily Thunderstorm Forecast and the more specific Regional Severe Thunderstorm Warning and Detailed Severe Thunderstorm Warnings. This could be undertaken by a nominated flood warden for the precinct via the PA system for the buildings. The forecasts have the following approximate lead times:

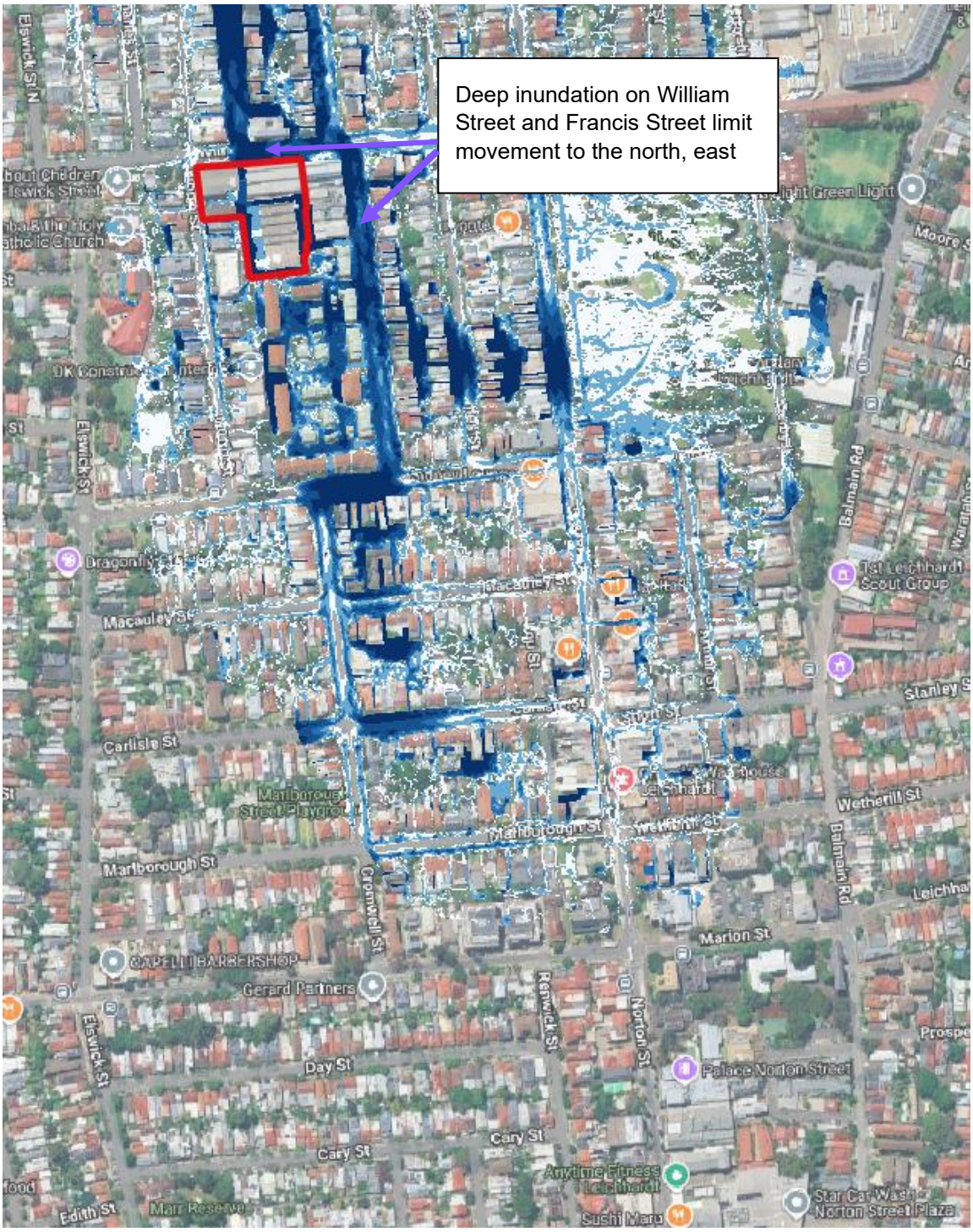
- Thunderstorm Forecast
  - 24-48 hours – forecasts likelihood of severe thunderstorms developing across NSW from '*possible'* through to '*likely'*
  - if the forecast indicates severe thunderstorms are likely then advice should be issued to residents to prepare accordingly. This may entail more active monitoring of BoM forecasts, activating a Home FloodSafe Plan, preparing their property (if located on ground floor) or preparing to self-evacuate
  - Enact a site-specific Flood Emergency Response Plan (FERP). A FERP serves as a guide for building occupants, outlining the suitable actions during a flood emergency
  - the aim is to encourage a state of readiness for the residents should the risk of flash flooding escalate or to provide the means for vulnerable residents to be temporarily moved to a safer location
- Regional Severe Thunderstorm Warning
  - 3 hours - forecasts broad areas where severe thunderstorms are occurring or may occur in the next 3 hours
  - the regional warning indicates severe storms are likely, giving less than three hours warning. This time period is the last feasible window where occupants could evacuate to safer areas prior to the storm arriving. However, due to local storm activity and storm tracks, arterial roads surrounding the precinct area may already be affected by flooding
  - a previous state of readiness should allow the rapid mobilisation to evacuate to a nearby hub or to seek shelter in higher parts of the buildings prior to the arrival of a severe storm
- Detailed Severe Thunderstorm Warning
  - less than 60 minutes - detailed warnings are issued when individual severe thunderstorms are within range of the city weather radars
  - they indicate the forecast direction of movement for 60 minutes and immediate Threat Area ahead of the storm
  - if the Detailed Severe Thunderstorm Warning or Threat Area encompasses the area, then it is likely too late to safely evacuate before the storm arrives

6.2.2.2 Emergency Management Strategy – Evacuation During a Storm

The opportunities for evacuation during a storm are limited as alternative streets are subject to high flood hazards that present an unacceptable risk to people.

In assessing the evacuation potential for the site, flood depths and hazard have been examined in the local streets and along routes leading away from the precinct. Key aspects of the analysis of potential evacuation routes are summarised in Figure 6.2.1.

Figure 6.2.1: PMF Flood Depths



To summarise Figure 6.2.1;

- access from the precinct to the local road network is provided by William Street. This road is inundated in PMF flooding conditions, with H5 flood hazard predicted due to high velocities.
- access to surrounding arterial roads involves crossing urban flooding with depths in excess of 1 m and H5 hazard in PMF events
- the onset of worst-case flooding is rapid, typically less than 60 minutes from the onset of the storm burst resulting in no route planning/preparation time

Considering the points summarised above, the safest flood evacuation strategy is proposed below:

- vertical
- based on the surrounding flood hazards, evacuation away from the precinct during a severe storm is not deemed to be safe as there are no flood free or low hazard routes available between the precinct and the nearest Assembly Areas

Options to reduce or eliminate the flood hazard in the vicinity of the project have been considered, with the implications of these local improvements being worsening of flood risk elsewhere, particularly downstream at existing dwellings. It is not recommended to provide flood hazard mitigation in the immediate site vicinity that causes increases in flood hazard to existing populations downstream.

6.2.2.3 Emergency Management Strategy – Shelter in Place (SIP) During a Storm

NSW SES StormSafe advises the following during a storm:

- never enter or travel through floodwater
- stay indoors
- stay clear of creeks, drains, causeways, gutter and streams

Table 11 in EM01 describes Shelter in Place (SIP) is an appropriate strategy to be considered when existing zoned areas are being redeveloped, as is the case in Leichhardt. *EMA Manual 20 – Flood Preparedness* states that SIP is to be preferred over evacuation if *"evacuation is likely to be more dangerous than sheltering in space".*

The SES advice would preclude evacuating when local roads are flooded as it poses a significant risk to life as entering flood waters is the main cause of death during a flood event.

The site is embedded within an extensive existing road network that was not designed to be free from flooding during extreme storms. Unfortunately, it lies beyond the scope of the proposal to consider upgrades to local drainage networks to provide flood-free evacuation routes.

The *Draft Shelter-in-place Guideline* (DPE 2023) suggests that SIP is appropriate when the onset of flooding and flood duration are both less than six hours as is the case at for this site. The onset and duration of flooding around the precinct is typically between 1 and 3 hours, depending on storm duration. The time required to evacuate vertically within a building to a level higher than the PMF could be several minutes only.

With SIP as a consideration, the FPLs (Table 6-1) ensure occupants can have a safe refuge above the PMF water level as the lowest habitable floor level of the buildings will be determined by the FPLs, which is greater than the PMF level.

The buildings should be designed to resist flood impacts up to the PMF, resulting in a flood free and structurally sound conditions within all structures on site and therefore will not create a situation where a burden is placed on the SES to provide any emergency evacuation coordination.

6.2.2.4 Emergency Management Strategy - Decision Making Summary

The points raised above can be summarised against the EM01 Section D4.2 flow chart considering emergency management in greenfield developments, rezoning and creating new communities, recreated as Figure 6.2.2 below. Residential development is compatible in the existing zoning as the zoning of site will remain as residential but allow a greater density and mix of housing types including residential flats.

Figure 6.2.2: Considering emergency management in greenfield developments, rezoning and creating new communities

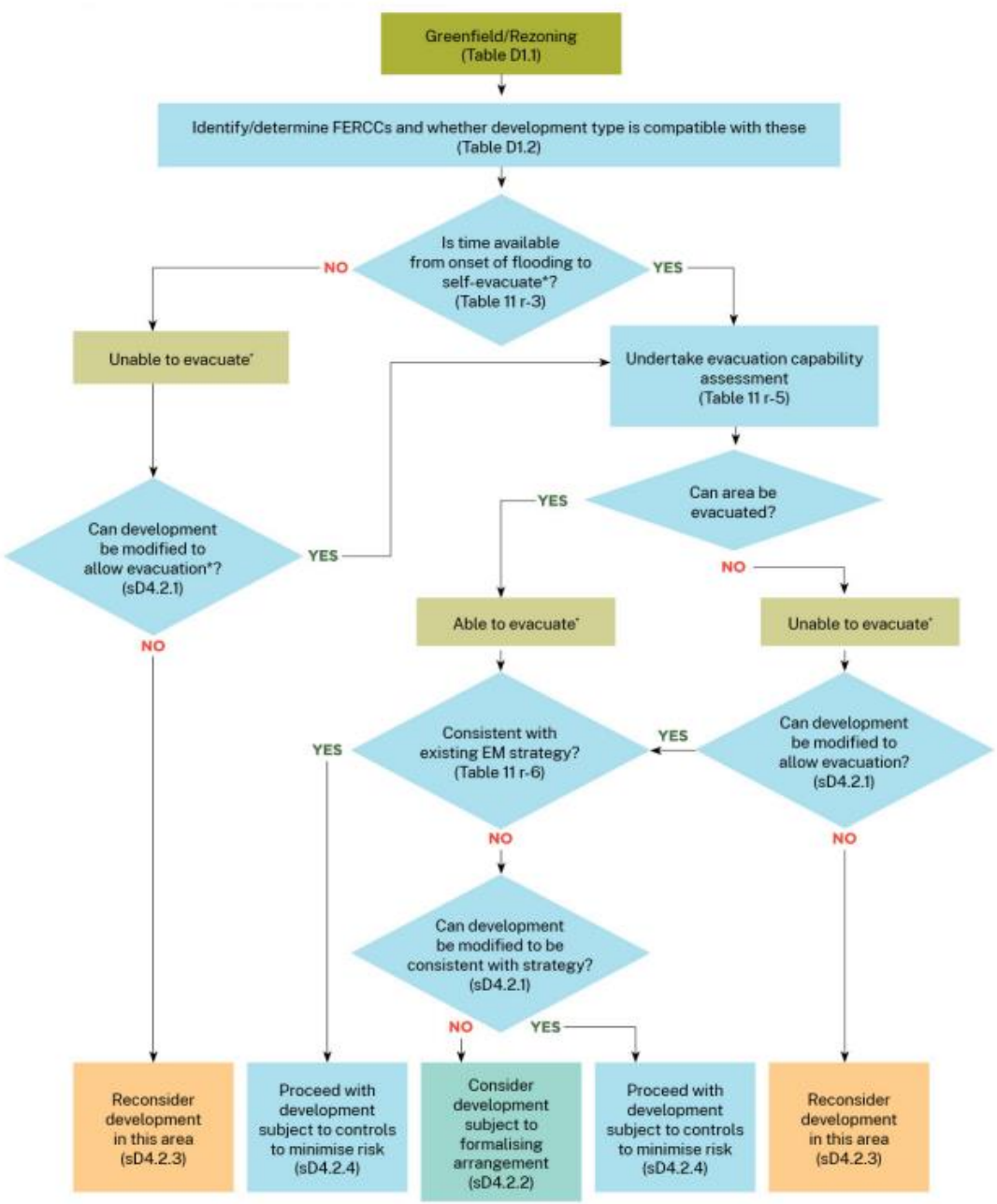


Table 6-2: Emergency Management Considerations

	Decision	Evidence	Relevant FIRA Section	Outcome
Is warning time available to onset of flooding?	No	The time to flooding and flood duration are typically very short with minimal warning time. Critical storm durations in the catchment are less than 6 hours with flood warnings limited to severe weather warnings for the area and no specific advice on local impacts of flash flooding	Section 5.1.3	Unable to evacuate
Can development be modified to allow evacuation?	No	There are no proposals to alter the existing Council road layout or stormwater drainage system which are primarily source of ponding flood water around the area	Section 1.1	Reconsider development Consider development controls
Is time of isolation short?	Yes	The period of worst-case inundation (PMF) is less than 6 hours	Section 5.1.5	Consider development types and apply controls
Are occupants able to be safe and self-sufficient for duration of flooding	Yes	FPLs are designed to keep the buildings free from flooding under the most extreme circumstances	Section 6.1 Table 6-1	Consider development types and apply controls
Are residual risks associated with SIP tolerable	Yes	FPLs are designed to keep the buildings and below ground car parks free from flooding under the most extreme circumstances Building PA system can be used to relay emergency information to residents	Section 6	Consider development types and apply controls

6.2.2.5 Emergency Management Strategy – Residual Risks

Table 12 of EM01 provides a summary of residual risks to consider in order to support the EM decision-making process, specifically with regards to redevelopment in existing zoned areas. The following relevant strategies are identified for the development and this FIRA recommends these are considered at the detailed design stage for the precinct, once building massing and finished floor levels have been finalised.

Flood Emergency Response Plan (FERP)

The establishment of a Flood Emergency Response Plan (FERP) is a necessity, with the obligation falling on the building owner or Body Corporate. The FERP serves as a guide for building occupants, outlining the suitable actions during a flood emergency. This could include a warning system, response triggers, emergency contacts, designated SIP refuge, and the risks involved in sheltering in place. It is the legal duty of the building owner or body corporate to ensure that the FERP is not only set up but also regularly practiced, maintained, and updated.

PA system

Consider developing a PA system to communicate evacuation directions and safety messages to the population in the lead-up to and during a flood to assist in improving the safety of the community.

Medium and high-density residential buildings

Make buildings as safe as possible to occupy during flood events. An area of habitable floor of any residential development should be located above the PMF with the building structurally designed for the likely flood and debris impacts. The buildings should include:

- Alternative power source, with capacity for at least 8h for essential needs
- Automatic fire suppression systems
- Emergency telecommunication system
- Toilet facilities accessible to people with disabilities
- First-aid kit
- Emergency supplies kit

Car parking

Any additional parking should be above ground level and have pedestrian access to a podium level above the PMF.

Community Awareness

Council should have community awareness strategies that include requiring the existing and future community to participate in increasing this awareness.

6.2.3 Summary of Emergency Management

Based on the FIRA, a shelter in place policy during a flood emergency is the most logical EM approach to protect life, given the following constraints:

- the site is at risk from flash flooding; flooding that has a relatively high discharge over a short duration – the interval between the observable causative event and the flood is less than six hours. Consequently, there is insufficient warning time to adequately evacuate the population of the precinct. Additionally:
  - the opportunities for evacuation during a storm are limited as surrounding streets are subject to high flood hazards that present an unacceptable risk to people. NSW SES advice is not to venture out during a storm or cross any area of flood inundation
  - the rate of rise and extent of flooding in the most extreme events means that emergency evacuation centres may not get set up and evacuees would generally have to take shelter in other private premises
- the time of isolation is short, based on the duration of flooding around the precinct. A development which is isolated for a few minutes by low hazard flood water in PMF does not pose a significant risk to life
- redevelopment affords a means of creating a safe, on-site shelter above the PMF
  - redevelopment which caters for sheltering in place can be used to reduce existing risk to life for individuals who currently occupy the floodplain but it is likely to increase the number of individuals at risk.
  - the time required to evacuate vertically within a building to a level higher than the PMF could be several minutes only
- additional Development Controls can be imposed which seek to manage the residual secondary risks to life caused by flood isolation to ensure that risks remain tolerable

6.3 Compatibility with Design Controls

The Design Recommendations within this FIRA have been proposed to meet the requirements of the Design Controls applicable to the site. A summary of the site compatibility is presented below:

- The NSW Flood Prone Land 2021 package notes a planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Environmental Protection Zones to a Residential, Business, Industrial or Special Purpose Zones. These land use changes represent an intensification in zoning which could potentially increase flood risk
  - The rezoning does not propose changes to any land zoned as Recreation, Rural, Special Purpose or Environmental Protection Zones
- This FIRA has been undertaken in accordance with the NSW Government's Flood Prone Land Policy and the principles of the Flood Risk Management Manual
- LEP Clause 5.21 will apply to the site and includes detailed planning provisions for development in flood prone land requiring consideration of potential flood impacts both on and off the subject land
  - The precinct is already developed and the proposed new development is not predicted to impact flooding to other properties
  - The proposal will permit intensification on land that has some flood affectation; however, suitable design solutions can be implemented as part of the future detailed design to manage the risk
  - Flood planning levels are specified to ensure that the future development mitigates the potential impact of flooding within the precinct
  - Residential development is not proposed in high hazard areas

The precinct rezoning enables the increase in density in line with endorsed NSW Government strategies. While the NSW Flood Prone Land 2021 package notes a planning proposal must not permit a significant increase in development density, the proposed intensification at is required to accommodate the additional residents in Sydney over the next 20 years. The proposed intensification will be in the form of vertical development with maximum height and Floor Space Ratio (FSR) increases to accommodate the growing population.

It is possible that direct flood risk to any person could be reduced by implementing the design recommendations and that the residual flood risk could be also reduced. To summarise:

- intensification within a brownfield site
  - this type of development can elevate the higher risk residential use above the PMF level and can make allowance for shelter-in-place refuge and vertical evacuation which is considered an improvement on the current flood exposure
  - intensified development offers more shelter-in-place opportunities as it will likely provide more floor space for refuge above the PMF level compared to the existing residential dwellings
  - the expected number of persons located on ground floors can be limited to current occupation or increased if the raised ground floor level reduces the risk to future occupants
- FPL requirements and other Development Controls
  - all storeys above the ground floor would be above the PMF level in most instances
  - It is expected that new multi-storey buildings will be stable during flooding up to the PMF and that all non-ground floor residents in multi-storey residential development would be only exposed to an indirect flood risk

- Implementation of Flood Emergency Response Plan (FERP)
  - A FERP for new multi-storey development can address the flood risk faced directly and indirectly by future residents in contrast to the flood risks faced by existing residents in flood affected locations. It is likely most of these properties have no established site-based flood emergency response plan
  - It is conceivable that a high-rise residential development with an effective flood emergency response plan and vertical evacuation opportunities may have a lower residual flood risk than existing housing limited opportunities for vertical evacuation

6.4 Implementation

The new 450mm drainage line that is proposed to drain the landscaped areas provides for a connection to the downstream stormwater system. The level of this pipe is to be coordinated as such that it can be attached to the basement wall and provide a gravity drainage to the existing pit within William Street road reserve. The detailed survey represented some stormwater surface inlets on site under existing conditions but there is uncertainty that all upstream connections were found/represented in the survey. In the case of additional upstream inter-allotment lines being discovered, this may influence the grade and level of this new stormwater infrastructure.

The PMF relief flow path/culvert below the finished surface of the open space has been assessed as having a weir entry from the landscaped (deep soil planting area) zone. This entry can effectively be integrated into retaining wall at the edge of the open space paved area as a headwall. The discharge of this flowpath/culvert can be hidden within/behind the stairway entry from William Street, or connected to inground surcharge pit chamber to flow out onto the William Street verge area. This flow path is design to be dry until such time that major to extreme flood events occur when it becomes activated by ponding within the landscaped areas.

7 Conclusions

The aim of the FIRA is to support design of the 40-76 William Street where specific elements of the design may influence existing flood behaviour or introduce additional flood risk. The report aims to identify and analyse:

- existing flooding constraints around the site,
- the impacts of the proposed development on the flood risk to the existing community,
- the impacts and risks of flooding on the development and its users,
- how these impacts can be managed to minimise the growth in risk to the community due to the development.

The assessment describes the nature of flooding that impacts the subject site and outlines planning requirements related to flooding that currently apply to the site.

The modelling for the site specific assessment was developed by Mott MacDonald to use for this FIRA. It is based on the current Council data, adopted from regional model for the catchment prepared in 2015.

This FIRA has been undertaken in accordance with the NSW Government's Flood Prone Land Policy and the principles of the Flood Risk Management Manual

Flood model scenarios for the site were based on the following:

- Existing conditions
  - An assessment of the current flooding conditions based on existing survey of the site
- Design conditions with mitigation measures:
  - An amendment to the existing conditions model was built to incorporate the proposed development layout as building block-outs, finished ground level representation and pipe system changes

The 1% AEP and probable maximum flood (PMF) have been assessed as they relate to the flood planning levels and emergency management measures for the development. The PMF is the largest flood that could conceivably occur at a location and defines the maximum extent of flood-prone land. Dry areas above the PMF level are expected to be free from flooding under all scenarios.

In the design case, the site is prone to flooding with the 1% AEP storm causing inundation along the site boundary.

The following changes in flood behaviour are predicted by the model:

- Changes in peak 1% AEP water level
  - flood levels are generally reduced within the development. This is the result of widening increasing the pipe drainage size and reducing building footprints.
  - one location is predicted to have an increase in peak water level; up to 60mm for existing buildings. While this is above the recommended change for buildings, in the context of existing flood affectation, it makes no change to flood immunity. The location is affected by 1% AEP flood depths up to 0.60m, so a localised change in peak level (no greater than 0.06m) does not significantly increase the flood risk
- Changes in 1% AEP inundation duration
  - there are no increases in duration of inundation that exceed the recommended timeframes

- Change in 1% AEP flood velocity
  - flood water velocities are not significantly changed by the proposed development
  - there are no changes in flood water velocity outside the site boundary
- Change in 1% AEP flood hazard
  - there are no changes in flood hazard outside the site boundary

The flood emergency management (EM) strategy for the site has been assessed following advice provided in *Flood risk management guideline EM01 - Support for emergency management planning* (DPE 2023) and relevant plans from the NSW SES.

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- redevelopment affords a means of creating a safe, on-site shelter above the PMF
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- additional Development Controls can be imposed which seek to manage the residual secondary risks to life caused by flood isolation to ensure that risks remain tolerable