POWERHOUSE PARRAMATTA
RESPONSE TO SUBMISSIONS REPORT

APPENDIX J FLOOD RISK AND STORMWATER MANAGEMENT ADDENDUM

Arup

NSW GOVERNMENT

Infrastructure NSW

Powerhouse Parramatta

Arup Report – Flood Risk and Stormwater Management Addendum

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Glossary of Terms & Abbreviations

Glossary of Terms

100 year flood	A flood that occurs on average once every 100 years. Also known and a 1% flood or 1% Annual Exceedance Probability (AEP).
20 year flood	A flood that occurs on average once every 20 years. Also known as a 5% flood or 5% Annual Exceedance Probability (AEP).
Afflux	The increase in flood level during a flood event.
Annual exceedance probability (AEP)	AEP (measured as a percentage) is a term used to describe flood size. It is a means of describing how likely a flood is to occur in a given year. For example, a 1% AEP flood is a flood that has a 1% chance of occurring, or being exceeded, in any one year.
Catchment	The area of land draining through the main river, as well as tributary systems.
Emergency Management	A range of measures to manage risks to people, communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
Flood Hazard	The potential for damage to property or risk to persons during a flood. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.
Freeboard	A factor of safety expressed as the height above the design flood level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as embankment settlement.
Local Environmental Plan (LEP)	A Local Environmental Plan is a plan prepared in accordance with the Environmental Planning and Assessment Act, 1979 that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.
Overland Flow Path	The path that floodwaters can follow if they leave the confines of the main flow channel or surcharge from a piped stormwater system.
Probable Maximum Flood (PMF)	The largest flood likely to ever occur. The PMF defines the extent of flood prone land.

Abbreviations

1D/2D	One-dimensional/Two-dimensional
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AR&R	Australian Rainfall & Runoff
ARI	Average Recurrence Interval
BoM	Bureau of Meteorology
CoPC	City of Parramatta Council
DCP	Development Control Plan
DEM	Digital Elevation Model
DPIE	Department of Planning, Industry and Environment
DBYD	Dial Before You Dig
EP&A Act	Environmental Planning and Assessment Act 1979
ESCP	Erosion and Sediment Control Plan
FDM	Floodplain Development Manual
FFL	Finished Floor Level
FPL	Flood Planning Level
GPT	Gross Pollutant Trap
HPC	Heavy Parallelised Computing
IFD	Intensity-Frequency-Duration
INSW	Infrastructure New South Wales
LEP	Local Environmental Plan
LGA	Local Government Area
LiDAR	Light Detection and Ranging
m AHD	metres Australian Height Datum (AHD)
m/s	metres per second. Unit used to describe the velocity of floodwater
m^3/s	Cubic metres per second. Unit measurement of river flows
MAAS	Museum of Applied Arts & Sciences
OSD	On Site Detention
PMF	Probable Maximum Flood
PSD	Permissible Site Discharge
RCP	Representative Concentration Pathways
SEARS	Secretary's Environmental Assessment Requirements (Section 78A(8A) of the Environmental Planning and Assessment Act)

SGS	Sub-Grid Sampling
SSDA	State Significant Development Application
UPRCT	Upper Parramatta River Catchment Trust
WSC	Water Services Coordinator
WSUD	Water Sensitive Urban Design

Reliance Statement

The sole purpose of this report, flood models and the associated services performed by Arup is to undertake the assessment of flood risk to the Powerhouse Parramatta development in compliance with, and adherence to, applicable planning controls including the Secretary's Environmental Assessment Requirements (SEARS).This work was carried out in accordance with the scope of services set out in the contract (PSC No. 20200224-1980) between Arup and Infrastructure NSW (INSW).

In preparing this report and associated flood model, Arup has relied upon, and assumed to be accurate, information (or confirmation of the absence thereof) provided by INSW and from other sources, such as City of Parramatta Council (CoPC). Except as otherwise stated in the report, Arup has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Arup derived the data used in this study from information sourced from INSW and the public domain at the time or times outlined in the report. The assumptions and limitations associated with the data are:

- The currency, reliability and accuracy of the datasets as well as suitability for their intended use are documented in the accompanying metadata, reports or drawings; and
- It is assumed that care and due diligence have been observed by the source agencies in developing the datasets in accordance with the relevant standards.

Any changes or impacts to the catchment and its associated environment following the issue of this report and model may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report.

Arup has prepared this report and associated flood models in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and with reference to applicable standards, guidelines, procedures and practices at the date of issue of this report and flood model. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made with regards to the data, observations and findings expressed in the report, to the extent permitted by law.

All flood models, whether numerical, analytical or physical, rely on a set of assumptions and requirements to accurately simulate the flow conditions. As no model will provide an exact representation of the complexity of the actual flow, it is important to understand these assumptions, as they form the limitations of that method. Ignoring or violating these assumptions and limitations or failing to critically analyse the model will produce inaccurate results.

No responsibility is accepted by Arup for use of any part of this report in any other context. This modelling data has been prepared on behalf of, and for the exclusive use of INSW, and is subject to, and issued in accordance with, the provisions of the contract between Arup and INSW. Arup accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1 Executive Summary

This report is an addendum to the previous Flood Risk and Stormwater Management report (Appendix O to the EIS) and supports the Response to Submissions for Powerhouse Parramatta. It presents the proposed concept stormwater design and flood impact assessment for the amended architectural and landscape design following public exhibition of the EIS.

The site is subjected to two separate types of flooding: Parramatta River flooding and overland flow flooding from Phillip Street. The latter results from short duration rainfall events and is exacerbated by the limited capacity of the existing local stormwater network.

A project-specific flood model was set up to model the complex hydraulic behaviour in the vicinity of the site. This flood model has guided the development of the architectural and landscape design. Following submission of the EIS for public exhibition, the design of Powerhouse Parramatta has been amended with the addition of another staircase from the undercroft area which importantly provides egress from the undercroft at the highest point of that area.

The existing multi-storey car park sits within the floodplain of Parramatta River and is subjected to inundation of floodwaters during river flood events. The most recent example was February 2020 and the largest flood recorded in the last 40 years was in 1988 when flood depths were 2.2m deep in the lowest car park level. However, the proposed Powerhouse Parramatta ground floor level would be 2m higher than this flood level.

The flood management strategy includes a focus on impact minimisation and managing site flood risks to people, Powerhouse Parramatta buildings and contents. This strategy has required the assessment of a range of flood probabilities, from frequent to very rare, and consideration of both types of flooding.

A key element of this strategy is the inclusion of the undercroft as a flowpath during Parramatta River flooding to generally replicate the flood conditions of the existing site. This results in a proposed design that does not adversely impact the flood behaviour at neighbouring properties. In addition, an augmented stormwater system, comprising larger pipes for increased capacity and additional inlet pits is proposed to replace the existing stormwater systems. These measures result in Powerhouse Parramatta minimising changes to riverine flooding behaviour and improving local stormwater drainage performance.

The risks of flood inundation to the building and its contents are adequately managed through the design of the ground floor level at RL 7.5mAHD. This level provides a flood immunity that is far greater than that usually adopted for commercial buildings in a floodplain. The chances of ground floor flooding would be approximately $1/8^{th}$ of the chances normally attributed to a commercial building on a floodplain.

The chance of ground floor inundation from overland flooding is approximately 1 in 800 in any year and this includes a freeboard allowance. In the unlikely event that all surface pits and underground pipes are blocked, the chance of ground floor inundation from overland flooding is still 1 in 100 in any one year and this includes a freeboard allowance.

The chance of ground floor inundation from Parramatta River flooding is approximately 1 in 1,000 in any year and this also includes a freeboard allowance.

Only one presentation space will be located on this ground floor. All other presentation spaces within museum will be located on floors that would sit above the Probable Maximum Flood level and, hence, would have no risk of flood inundation. Hence, the likelihood of flood damage to the collections housed in the museum throughout the life of the building would be low.

The sub-station to supply power to the building would be located at the same level as the ground floor and, hence, have a similarly low chance of flood inundation. In the very rare flood events that would result in the sub-station being inundated, power would be supplied to Powerhouse Parramatta via the backup generators which would be above the Probable Maximum Flood level and, hence, would have no risk of flood inundation.

In regard to managing risks to people, the flood risk management strategy for the project has four key elements:

1. Development of a detailed emergency management plan as the design develops to address and respond to the flood risks, recognising that the museum will be staffed at all times.
2. A shelter-in-place strategy for floods in which people can safely stay on Level 1 (which is above the Probable Maximum Flood level) for a short period of time until the flood threat passes.
3. Providing sufficient time and four egress paths free from overland flow for people to move from the riverbank public domain areas and undercroft area to Level 1. This includes the western stairs strategically located at the last part of the undercroft to be inundated, providing a continuously rising egress route.
4. Providing emergency power supply above the Probable Maximum Flood level for the duration of the time that people would seek refuge on Level 1 and preserve the climatic conditions required to house the collections.

It is noted that the flood hazards on the riverbank level and undercroft area are high and early movement of people from these areas to safe locations is critical. This flood hazard categorisation of the amended design is the same as the design lodged with the EIS and for the current situation in the lower level of the car park. However, the development of a detailed emergency management plan, the multiple egress routes and the permanent staffing of the site is likely to result in a safer situation than the current use of the site.

In regard to the riverbank public domain areas and undercroft area, approximately 1 hour and 50 minutes would be available to move mobility impaired people to Level 1 using the lift with further hour after that available for other people to walk up steps to Level 1.

The Powerhouse Parramatta would not result in adverse flood impacts to surrounding property, would improve the local stormwater performance and adequately manage the flood risks to people, buildings and its contents.

2 Introduction

This report is an addendum to the previous Flood Risk and Stormwater Management report (Appendix O to the EIS) and supports the Response to Submissions for Powerhouse Parramatta.

Following the public exhibition of the SSDA, submissions from government authorities and the general public have been reviewed, a number of which make comment on flooding and stormwater.

This report assesses the amended architectural and landscape design and confirms the impacts and mitigations in relation to stormwater and flooding.

3 Assessment Requirements

3.1 Secretary's Environmental Assessment Requirements (SEARs)

The Department of Planning, Industry and Environment (DPIE) has issued Secretary's Environmental Assessment Requirements (SEARs) to the applicant for the preparation of an Environmental Impact Statement for the proposed development.

This Addendum Report has been prepared with consideration to the SEARs and Table 1 shows where these requirements were addressed in the original EIS submission and Addendum Reports respectively.

Table 1: SEARs aspects requirements for flooding, drainage and stormwater

SEAR	Where Addressed (EIS Submission)	Where Addressed in this Report
12. Flooding, drainage and stormwater The EIS shall include:		
• An assessment and proposed management of the stormwater, drainage, flooding and groundwater issues associated with the site, environs and the proposed development, including:	*This report addresses flooding and stormwater*	Stormwater, drainage and flood management is discussed in Sections 6, 7 & 8 of this report
• Stormwater and drainage infrastructure, including a stormwater management plan, water sensitive urban design, roof gardens, green walls, and MUSIC link model (for water quality)	*Refer to Appendix D | Stormwater Management Plan; WSUD is discussed in Section 6.2.3*	Proposed stormwater infrastructure is discussed in Section 6.2.1 with a plan contained in Appendix C. WSUD is discussed in section 6.2.3.
• Assessment of flood risk in accordance with the guideline contained in the NSW Floodplain Development Manual 2005, including potential effects of climate change, sea level rise and an increase in rainfall intensity and integration with Council's wider flood risk management planning and flood modelling	*Flood risk is discussed in Section 5*	Flood risk is discussed in Sections 7.4 and 8.2 of this report
• Rainwater and stormwater runoff. The strategy must outline opportunities for the use of integrated water cycle management practice and principle, and demonstrate water sensitive urban design and any other water conservation measures	*Stormwater management is discussed in Section 8.4*	Stormwater management and water quality measures are discussed in Section 6.2 of this report.

SEAR	Where Addressed (EIS Submission)	Where Addressed in this Report
• Consideration as to how the proposal responds to City River and Civic Link precinct access and egress requirements, including evacuation in flood.	Flood evacuation is discussed in Section 8.3	Egress and evacuation strategies are discussed in Section 8.3 of this report and plans in Appendix B.

4 Existing Site Conditions

Existing flood studies for the Parramatta River have been reviewed in detail to understand the historic patterns and records of former flooding events. Appendix O – Flood Risk and Stormwater Management Report of the EIS includes detailed discussions of this review and further summary in provided in Section 7.1 of this report. It is recognised that flooding risk to the development site is a function of two separate mechanisms: riverine flooding of the Parramatta River and overland flow flooding from Phillip Street. The latter results from runoff that exceeds the capacity of the local stormwater infrastructure.

4.1 Summary of Riverine Flooding

The Powerhouse Parramatta development site is located adjacent to the Parramatta River within the Upper Parramatta River Catchment and the low-lying part of the site is subject to riverine flooding.

Mainstream flood level results were compiled by TTW in its 2016 flood study report based on flood maps issued by CoPC and are summarised in Figure 1. It is understood that the climate change allowed for in this model is a 15% increase in rainfall. These CoPC adopted flood levels have also been used to validate the results produced by the Powerhouse Museum Flood Model, which is discussed further in Section 7.3.

River Flood Level (Metres AHD)			
1:20 Year ARI	1:100 Year ARI	1:100 Year ARI + CC*	PMF
5.41	5.95	6.22	10.39

Regional Parramatta River Flood Levels (CH 2537)

Figure 1: Parramatta River peak mainstream flood levels collated by TTW (2016) from the published CoPC flood maps local to the development site

4.2 Summary of Overland Flow Flooding

In addition to the risk of riverine flooding from Parramatta River, overland flow paths impacting the site have also been identified as shown in Figure 2. The flow paths, originating from the Parramatta CBD catchment which extends south of the site, converge on Phillip Street and subsequently flow onto Dirrabarri Lane as well as east of the existing building at 32 Phillip Street. These overland flow paths converge behind the existing multi-storey car park before eventually discharging into Parramatta River.

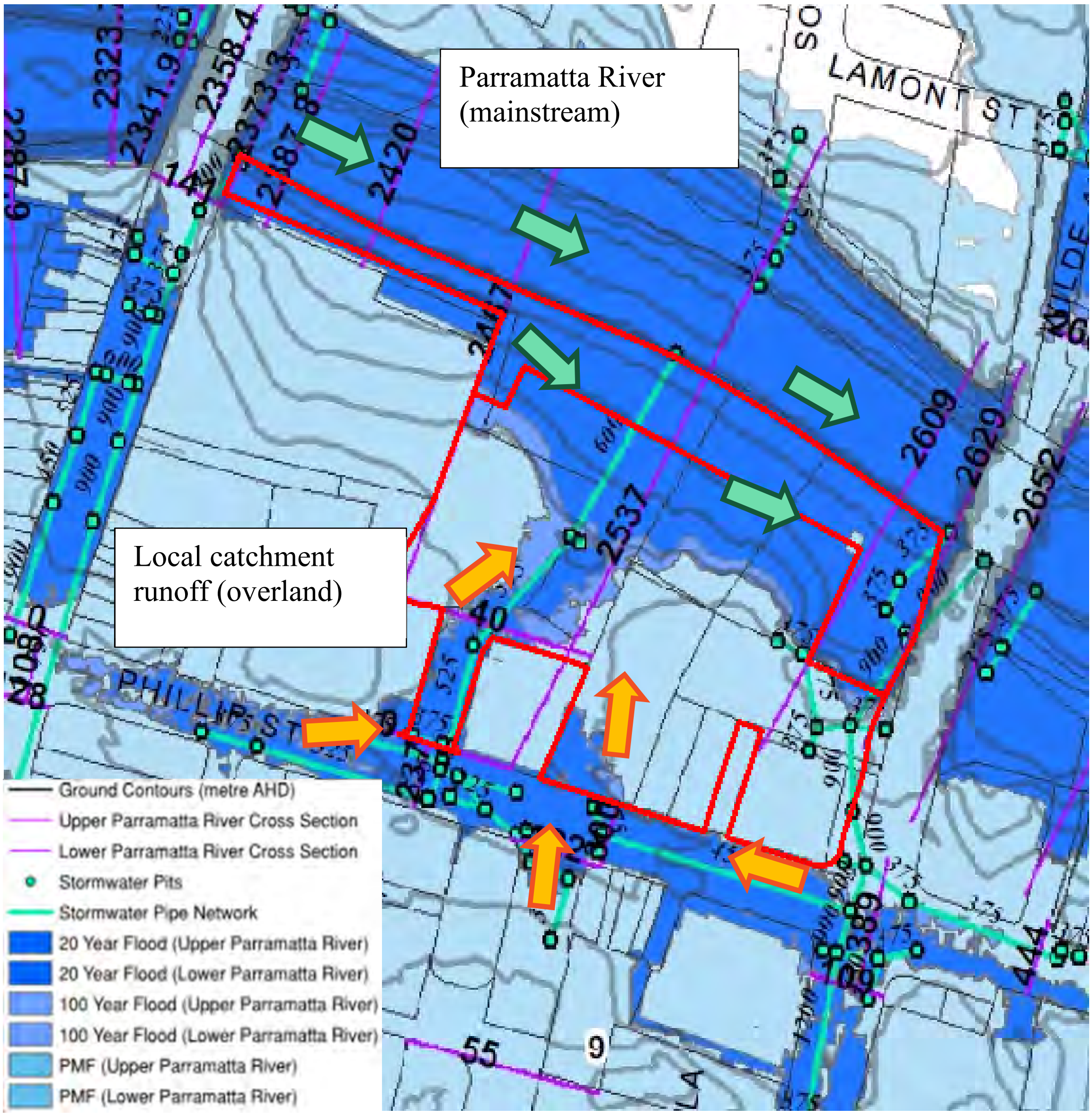


Figure 2: Major flow paths affecting the development site

The previous flood study undertaken for the development site by TTW (2016) collated the peak flood levels for overland flows. The flood levels, as shown in Figure 3, have been extracted from the adopted UPRCT Parramatta River MIKE 11 model for the 5% AEP, 1% AEP, 1% AEP with climate change (i.e. 15% increase in rainfall) and the Probable Maximum Flood (PMF).

It should be noted that the overland flows in the MIKE 11 model are modelled in 1D and the interaction with obstructions along the flow path (e.g. wall along the southern edge of the existing car park) is not simulated as accurately as a 2D model would. This has the result of over-estimating the flows through the car park in the MIKE-11 model, lowering the estimated overland flood level derived from this model.

Local Overland Flood Level (Metres AHD)				
	1:20 Year ARI	1:100 Year ARI	1:100 Year ARI + CC*	PMF
Phillip St CH237	6.90	6.95	6.99	11.32
Access Road CH40	6.89	6.94	6.98	11.36

Local Overland Flow Flood Levels

Figure 3: Overland flow peak flood levels in Phillip Street and Dirrabarri Lane (referred to as Access Road) collated by TTW (2016) from the published CoPC flood maps local to the development site.

Overland flow levels are generally higher than the mainstream flood levels for the Parramatta River primarily due to the overland flows travelling on terrain levels that are elevated above the river levels.

These peak overland flow flood levels have been used to validate the Powerhouse Museum Flood Model results developed for this assessment.

4.3 Adjacent Developments

With respect to existing flood levels, the existing developments adjacent to the site have the following finished threshold levels (based on the LTS survey) in Table 2. The finished levels are above the mainstream flood levels up to the 1% AEP with climate change. However, some of the entryways are below the overland flood levels for events such as the 5% AEP. The impact of the Powerhouse Parramatta development on the existing flood affectation of these buildings has been assessed in detail and the results are presented in Section 0.

Table 2: Finished levels for adjacent developments

Existing development	Elevation level
General Electric Building (32 Phillip St)	Dirrabarri Ln Vehicle entryway: Approx. RL 6.7
Park Royal Parramatta (30 Phillip St)	Phillip St Vehicle entryway: Approx. RL 6.57
Meriton Parramatta Fronting Dirrabarri Lane (330 Church St)	Dirrabarri Lane entryway: Approx. RL 7.86 Dirrabarri Lane external Louvre: Approx. RL 6.40

4.4 Existing Stormwater Infrastructure

The available site information suggests that the existing stormwater network within the development site is a combination of privately owned and City of Parramatta Council owned assets. The existing stormwater network has been surveyed by LTS Lockley (reference: 41692012DT; revision D; dated 17 August 2020).

4.4.1 Existing Stormwater Network

Based on the most recent survey information available, three existing CoPC owned trunk drainage lines cross through the Powerhouse Parramatta site illustrated in Figure 4 and summarised as follows:

- Ø1050 mm pipe transitioning into a 1200 mm wide x 525 mm high rectangular box culvert trunk network along the east side of the site and discharging into the river underneath Wilde Avenue bridge. Catchment area of approximately 17.35 hectares and consists of the east half of the development site, the Smith Street corridor to Parramatta Station, Parramatta Square and up to the intersection of Church Street and Fitzwilliam Street;
- Ø675 mm pipe trunk network through Dirrabarri Lane, underneath the existing Riverside Car Park and discharging into the river. Catchment area of approximately 3.83 hectares and consists of approximately half of the development site, half of the Phillip Street frontage and a portion of the commercial block south of Phillip Street; and
- Ø900 mm pipe and twin Ø750 mm pipes discharging into the river near Lennox Bridge on the west side of the site; the trunk network along Church Street is not confirmed. Catchment area of approximately 5.35 hectares and consists of the Church Street corridor up to the intersection with Macquarie street before Parramatta Square.

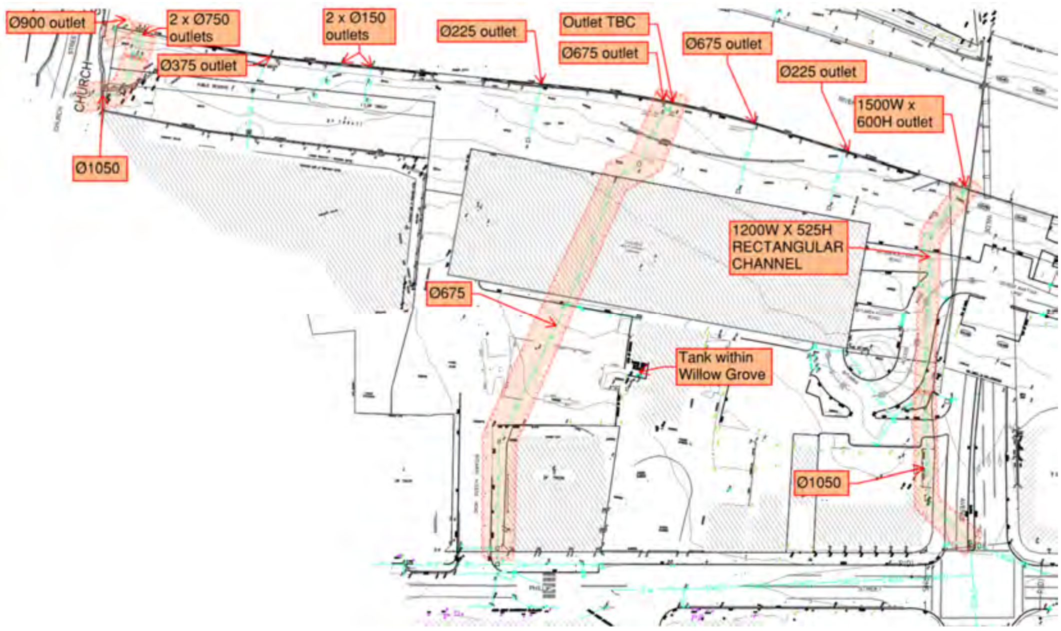


Figure 4: Existing stormwater network plan from survey

Details of building connection points are unavailable however available topographical and LiDAR information has been used to approximate the catchment area of each stormwater system. This catchment plan is shown on Figure 5.

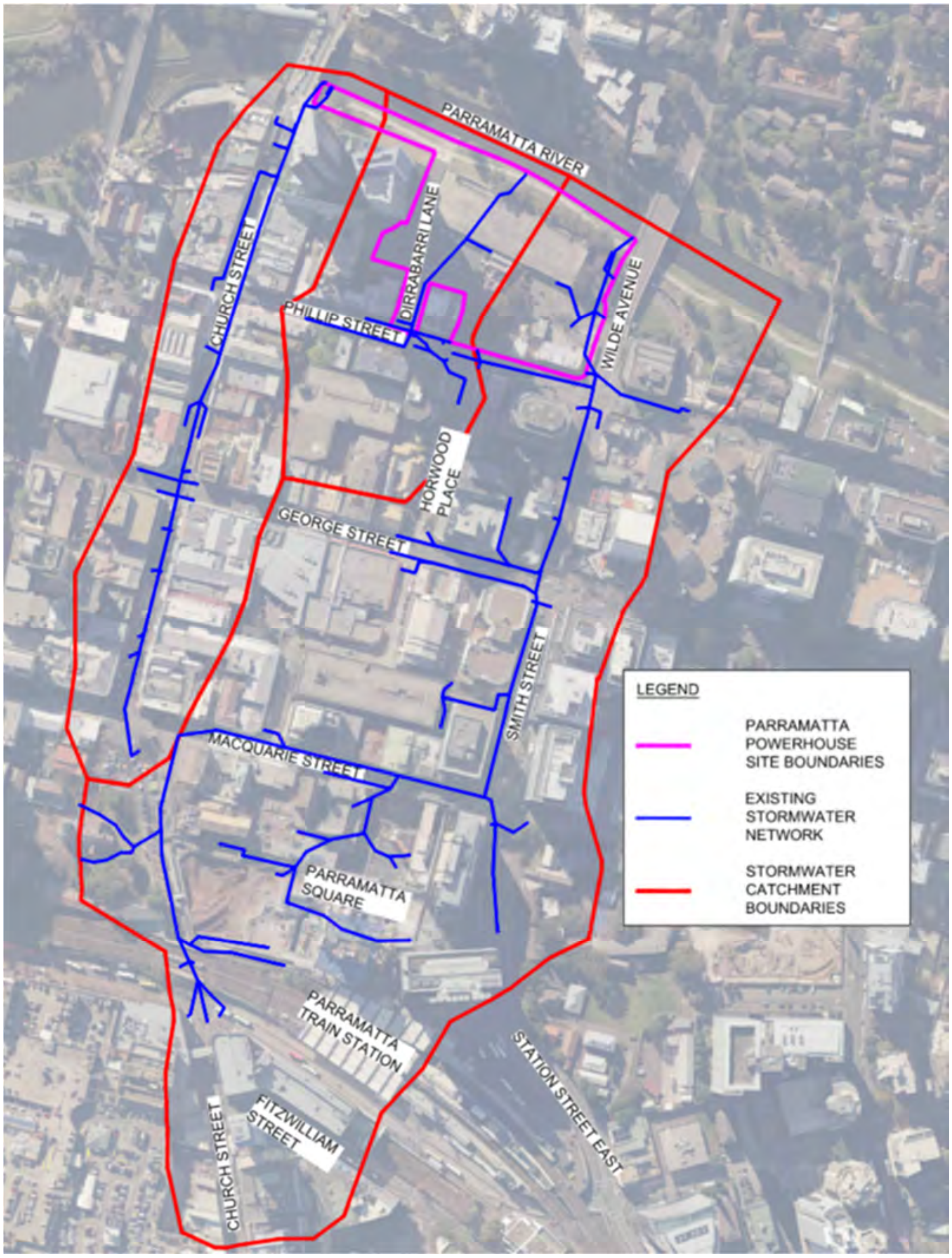


Figure 5: Existing stormwater drainage infrastructure catchment plan for areas in close proximity to the Powerhouse Parramatta development site

4.4.2 Existing On-Site Detention (OSD)

There is no evidence of any on site detention (OSD) systems for the existing car park or remaining areas within the site. During storm events, it is understood stormwater network flows are unrestricted and discharge freely into Parramatta

River via existing outfalls while overland flows cascade through the site over the riverbank into the river.

4.4.3 Existing Water Quality

The currently available site and survey information indicates the following water quality treatment items on the existing development site:

- Gross pollutant trap (GPT) at the outlet of the Ø675mm trunk network before discharging to Parramatta River (refer to Figure 6); and
- Vegetated landscape areas fronting Parramatta River and at various locations across the site.

The configuration of the GPT unit and how well the existing system performs in terms of water quality improvements is currently not known.

Figure 6: Existing GPT near Ø675 mm trunk outlet

5 Design Development

Since the original SSDA submission the Powerhouse Museum building and external public realm design has been further developed. A summary of the updated urban design is as follows.

5.1 Summary of Updated Urban Design

5.1.1 Riverbank Level

The public domain has been revised to include a grassed slope to the north of the public domain in front of the eastern building. This slope is at maximum 1 in 3 gradient and is supported by a retaining wall at the back of the slope.

There are no walls along eastern or western elevations at this level, or in front of the western building, however a podium slab does cover this area, as shown in Figures 7 and 8, creating a semi-permeable undercroft space. In addition to the southern retaining wall and the retaining wall supporting the eastern embankment, other structural elements present within this undercroft space include:

- Circular columns, arranged in a grid pattern, supporting the above podium slab and the primary structure of both eastern and western buildings;
- Bespoke column foundations supporting the building's exoskeleton; and
- A central staircase at the northern end of Civic Link supported by columns.

The undercroft space itself will be finished within an impermeable surface such as concrete on all floors, walls and ceiling. A longitudinal fall along the ground of the undercroft has been provided falling west to east with a crossfall directing flows towards the river. This will allow this area to drain following larger flood events.

To the east of the Meriton building, the northern extent of Dirrabarri Lane has been reconfigured in the updated design and slightly reduced in width. Retaining walls have been incorporated to maintain existing levels immediately against the eastern wall of the Meriton building whilst allowing Dirrabarri Lane to meet the river level. This level change is necessary to support a pedestrian link between the Powerhouse and the Meriton building whilst also permitting emergency vehicle access to the river level.

At the river level, the following access and egress routes, listed from east to west, are provided:

1. The public realm connects at grade to George Khattar Lane. From here, pedestrians can access higher ground on Phillip Street.
2. A staircase at the eastern end of the proposed embankment to access the podium and ground level of Powerhouse Parramatta.
3. Elevator at north eastern corner of the eastern building providing access between the river level and the upper public domain levels.

4. A central staircase to access the podium and ground level of the museum.
5. Staircase at southwestern corner of the undercroft which accesses ground level to the west or Dirrabarri Lane. From here, pedestrians can access Dirrabarri Lane and Phillip Street whilst also access ground level of the western building.
6. Dirrabarri Lane Ramp which connects to Dirrabarri Lane and beyond to Phillip Street.

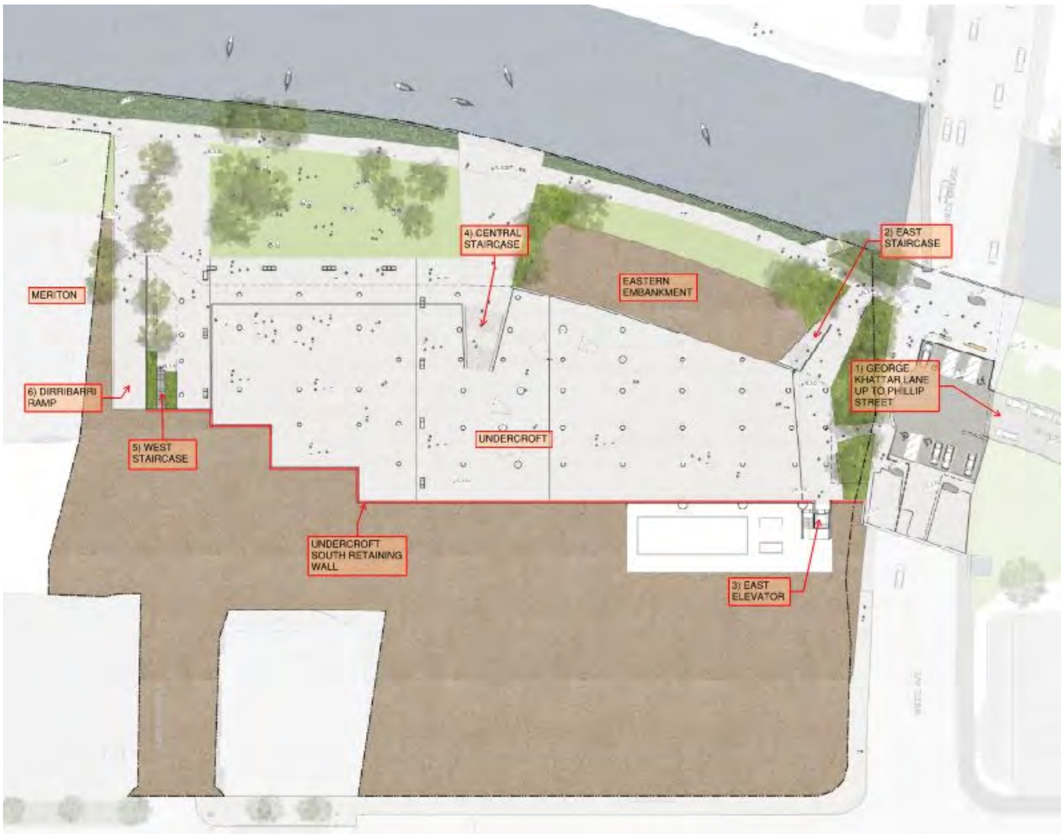


Figure 7: Landscape plan – river level (by McGregor Coxall reference 0842SYD LD-DD-02 dated 26 August 2020)

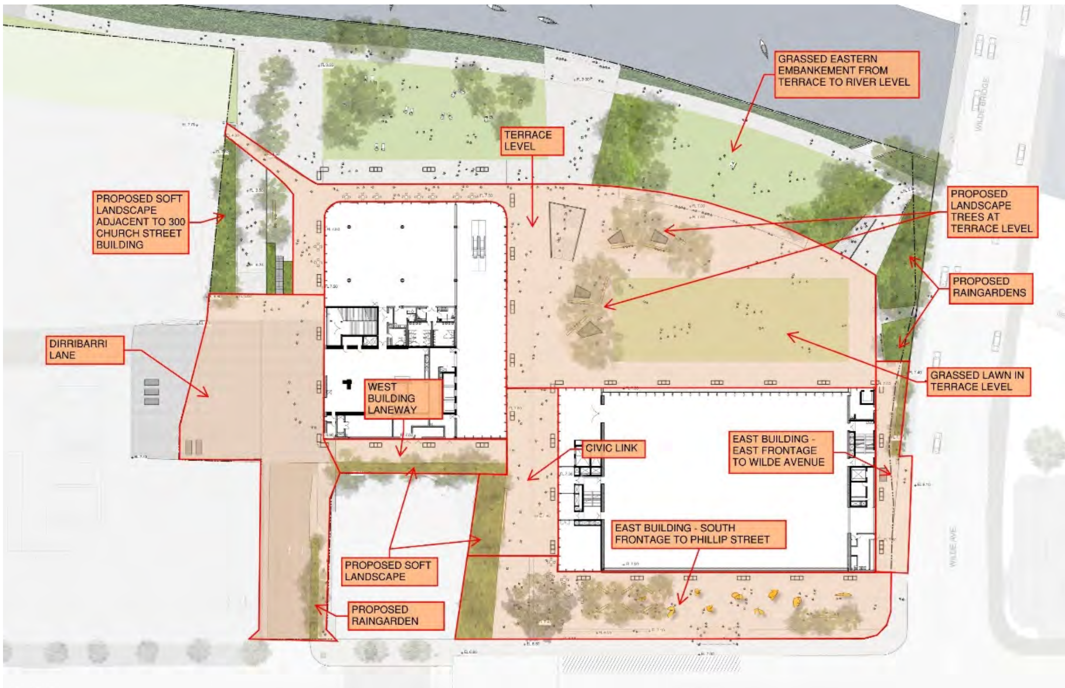


Figure 8: Landscape plan - Ground level (by McGregor Coxall reference 0842SYD LD-DD-01 dated 26 August 2020)

5.1.2 Civic Link Level

This section describes the development layout at the Civic Link level which provides access to the ground floor of the museum buildings, and the surrounding public domain and roadways.

Both buildings have ground floor level set at RL 7.5m AHD and have several pedestrian and vehicular entry points around the building façade. Public domain levels are set to fall away from the building, and towards the local stormwater network contained within the public domain.

The Civic Link will feature a v-shaped crossfall directing falls from the building edge towards the slot drain positioned near the middle of this connector.

The public domain terrace to the north of both buildings is nominally set at RL 7.5m AHD with local falls to shed water to drainage collection features such as slot drains and areas of soft landscaping.

To suit existing levels, the west building laneway will have one-way cross fall shedding water south from the museum to proposed raingardens located several metres from 32 Phillip Street Parramatta.

Treatment to Dirrabarri Lane will vary along its length. Along the southern section, near Phillip Street the existing kerbline and levels will be kept, maintaining access to the vehicular entry point of 32 Phillip Street Parramatta and other buildings with access from the Lane. To the south of the vehicular entryway, landscape garden beds are proposed which align with the crossfall of the road.

Beyond the interface of 32 Phillip Street Parramatta, the lane transitions into a shared surface with no kerbs separating footpath and building entryways fronting the west building. The shared surface will fall away from the building toward the centre of the lane and be collected by slot drains and inlet pits.

To the south of the eastern building, public domain will shed water from the building towards Phillip Street. Where the level difference is too great to overcome at suitable crossfalls, such as the outside the southwest corner of the eastern building, retaining structures will be provided. These retaining structures will provide stepped and ramped access to the public domain at this location.

Wilde Avenue sits above the proposed floor level of the eastern building. One vehicular loading dock is proposed along the eastern elevation of this building. A hinge point, set minimum 100mm above the road level, is proposed to protect the loading dock from overland flows from Wilde Avenue. The driveway will then fall back towards the building. Drainage measures at the building threshold will be included to drain the local driveway area.

The remaining public realm in this area will drain to a low point between the building and Wilde Avenue with retaining structures and steps provided to overcome level differences.

5.2 Flood Planning Levels

In line with the Design Brief requirements, the Flood Planning Level has been set as RL 7.50m.

"Parramatta Development Control Plan 2011 (DCP) sets out the requirements of for developments in flood prone areas and requires that all habitable spaces must be designed to 1:100 year ARI plus freeboard (500mm) – i.e. habitable spaces must be at RL 7.50 or above."

The proposed Powerhouse Parramatta museum Finished Floor Levels (FFLs) comply with these performance requirements with freeboard added to minimise the risk of surface flooding entering the building where it can cause damage and present a risk to occupants.

It is noted that overland flow flood waters are higher than riverine flooding for the 1% AEP event. This means that the governing flood mechanism for the Powerhouse Museum site is overland flooding. The 1% AEP overland flood event, as detailed from the TTW assessment, is RL 6.99m AHD which is conservatively based, as it does not include any piped stormwater infrastructure. This was rounded up to a level of RL 7.00 resulting in a Flood Planning Level of 7.5m AHD.

City of Parramatta Council has a published flood study and a draft flood study which identify a PMF level between 10.39m AHD and 11.36m AHD.

5.2.1 Powerhouse Museum Finished Floor Levels

The ground floor level for both the eastern and western buildings have been set at the flood planning level of RL 7.5m AHD. Ground floor in both buildings is a double ceiling height space with the next level, Ground Mezzanine, set at RL 13.20m AHD. Ground Mezzanine level is therefore almost 2.0m above the PMF level.

Above Ground Mezzanine level, the buildings have split floor levels due to presentation spaces requiring larger ceiling heights. A summary of key levels and the proposed uses is contained within Table 3.

Table 3: Proposed building floor levels

Building Level*	Elevation (RL m AHD)	West Building Level Description	East Building Level Description
Ground	7.500	Loading dock, retail, amenities, BOH, FOH other	Presentation space, FOH circulation, retail, BOH
Ground Mezzanine	13.200	Services, plant rooms, BOH	Amenities, BOH, FOH circulation
Level 1	17.900	BOH, presentation space, FOH circulation	Education, BOH
Level 1.1	22.075	BOH, amenities, FOH circulation	Education, BOH
Level 1.2	26.250	BOH	Education
Level 2	30.300	FOH circulation, BOH, presentation space	FOH circulation, presentation space, amenities, BOH
Level 2.1	34.575	N/A	Education, FOH circulation
Level 2.2	38.85	N/A	Digital Studios
Level 3	42.400	FOH circulation, BOH, presentation space	FOH circulation, presentation space, amenities, BOH

* Note floor levels above Level 3 have not been provided
BOH – Back of house
FOH – Front of house

5.3 Critical Infrastructure

Power serving the Powerhouse Museum is provided from three pad mounted substations, as shown in Figure 9. Two of these substations are located within the shared surface between the Park Royal and Meriton Buildings. The third substation is located between the eastern edge of the east building and Wilde Avenue.

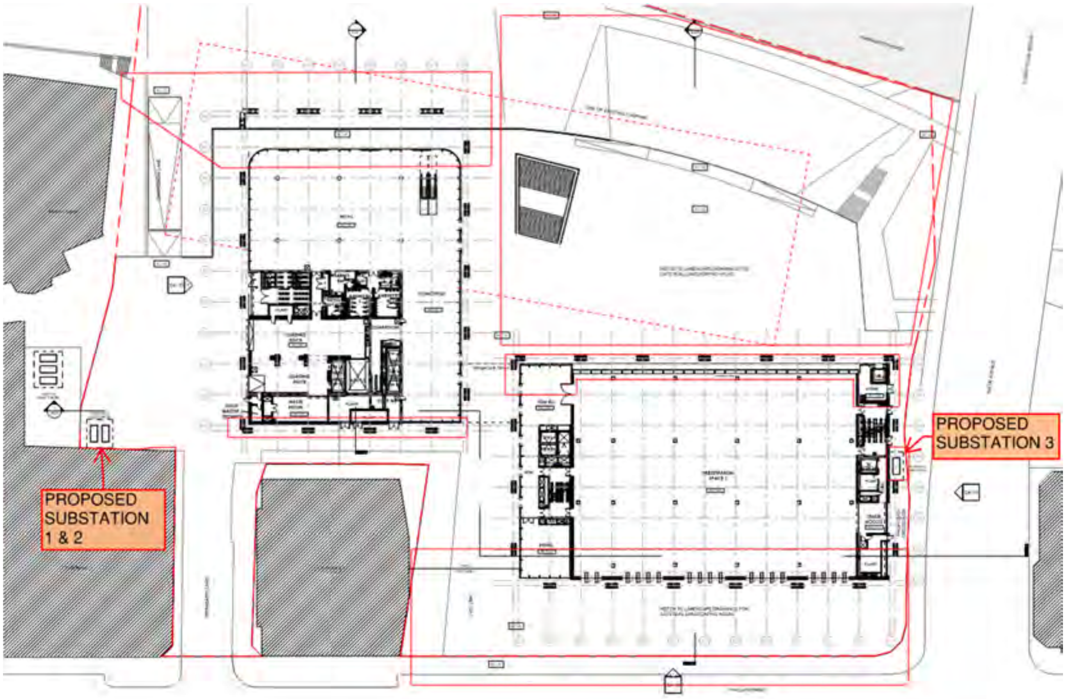


Figure 9: Proposed electrical substations (source: MKG ground level plan dated 19/08/2020)

All substations will be built on concrete plinths and set at a minimum RL of 7.5m AHD i.e. at the Flood Planning Level. This is over and above the minimum Endeavour Energy requirements: section 7.1.6 of document MCI 0006 states "*as a minimum the level at the top of the transformer footing, HV and LV switchgear, shall not be lower than the 1:100 year flood level*"[1].

Critical electrical infrastructure within the buildings, such as main switchboards and back-up generators are located at ground mezzanine level or above which is above PMF level.

In extreme flood events where water levels exceed the Flood Planning Level, power supply to critical elements will be provided by the back-up generators.

The generator capacity is sufficient to provide emergency lighting and other essential services for up to 10 hours. Out of 10 lifts serving the museum, 8 will be connected to the back-up power supply.

Further details on how the critical electrical infrastructure aligns with the Emergency Management Strategy are provided in section 8.3.

[1] Mains Construction Instruction, MCI 0006 Underground distribution construction standards manual, Section 7 – Substation & Switching Station, Amendment No 4, March 2016.

6 Proposed Stormwater Infrastructure

6.1 Impacts on Existing Stormwater Network

The proposed Powerhouse Parramatta building, as described in Section 5, clashes with several existing stormwater systems. These are highlighted in Figure 10 and include:

- a Ø675mm stormwater trunk main that runs under the existing car park. This trunk main is to be removed to accommodate the proposed building. An upsized trunk culvert is proposed to the west of the building which is further discussed in section 6.2.1;
- a Ø375mm stormwater main and pits serving George Khattar Lane southeast of the existing car park. These existing stormwater assets are to be removed to accommodate the proposed building; and
- a Ø1050mm trunk main within the west footpath of Wilde Avenue. This trunk main is to be relocated to accommodate the proposed building.

Figure 10: Existing stormwater assets within proposed building footprints

6.2 Proposed Stormwater Development

6.2.1 Proposed Stormwater Network

The Powerhouse Parramatta preliminary stormwater design, in accordance with CoPC's engineering design guidelines, has been designed for the 5% and 1% AEP stormwater events.

New stormwater infrastructure is required to replace the existing stormwater infrastructure that is to be removed. The new stormwater system will drain Powerhouse Parramatta and the surrounding public domain. The footprint of the proposed buildings cuts off an existing overland flow path and the design intent is to avoid an overland flow path within Civic Link. To achieve this objective, overland flow paths are directed towards Dirrabarri Lane.

Augmentation of the existing trunk under Dirrabarri Lane is required to accommodate the displaced floodwaters from adjustments to the existing overland flow routes and raised ground levels required for flood protection of the building entryways. This assists in minimising any potential adverse impact created on Phillip Street and areas surrounding 32 Phillip Street, Parramatta.

The augmented stormwater system will cater for flows in smaller flood events but will be overwhelmed in larger flood events. Careful design of the public domain levels has been integral to form an overland flow route to the Parramatta River. The intent is not to solely rely on a piped network.

The Powerhouse Parramatta preliminary stormwater design generally comprises three catchments (refer to Figure 11). The proposed preliminary stormwater infrastructure to serve the development is illustrated in Appendix C and summarised as follows:

- Ø900mm pipes are proposed along Dirrabarri Lane replacing the existing Ø675mm trunk main. A surcharge pit is proposed at the bottom of Dirrabarri ramp to split the Ø900mm into two smaller mains to connect to existing points of discharge along the existing river channel walls and allow surcharging of the system. The avoids modifying the existing river channel walls and constructing new stormwater pipes above or below the existing Ø525mm Sydney Water sewer main;
- a stormwater system runs under Civic Link (between West and East Buildings), draining public domain and accepting flows from building downpipes. This system drops from ground level to undercroft level. A Ø600mm pipe runs west to east below the undercroft slab and connects into the existing east trunk network near Wilde Avenue;
- Ø1200mm pipes and pits are proposed along the western traffic lane of Wilde Avenue to replace the existing Ø1050mm trunk main. This will connect to the existing Ø1050mm upstream and to the existing 1200mm wide by 525mm high rectangular culvert at the northeast corner of the site;

- grated inlet pits or grated drains are proposed within Dirrabarri Lane, the eastern edge of east building fronting Wilde Avenue and terrace areas;
- building stormwater connections to either the Dirrabarri Lane and Wilde Avenue stormwater networks;

These proposed stormwater assets, sizes and arrangement may be optimised through design development.

Consultation has commenced with Sydney Water through a Water Services Coordinator and will continue during detailed design to confirm the requirements associated with working near an existing Ø525sewer which runs parallel to the riverbank footpath.

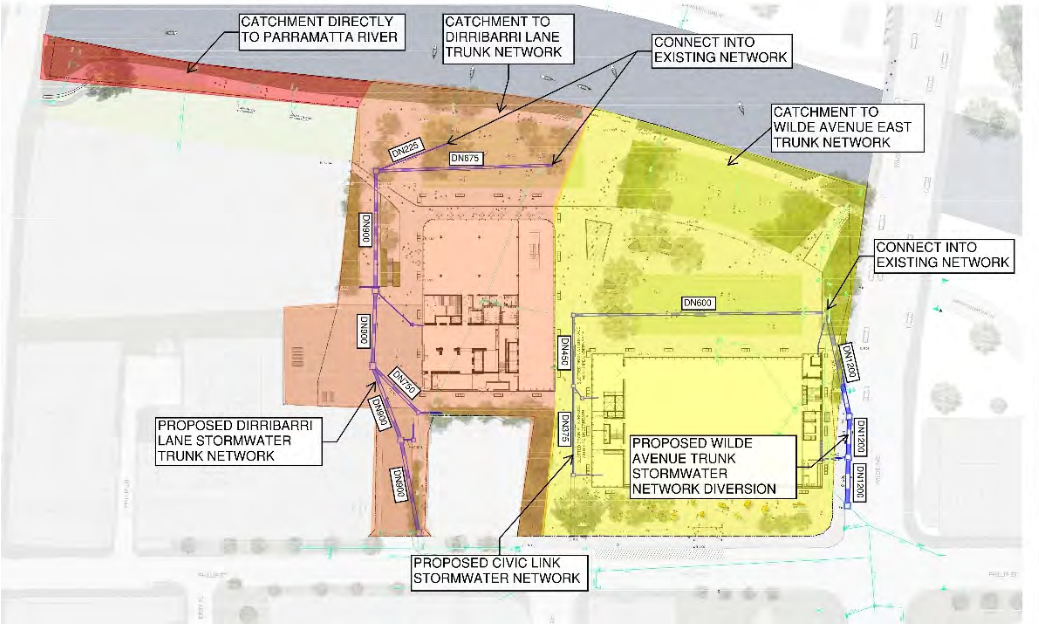


Figure 11: Proposed stormwater network catchments

6.2.2 Proposed On-Site Detention (OSD) Strategy

The requirements for OSD have been analysed and is not recommended for Powerhouse Parramatta for the following reasons:

- The development site is directly adjacent to the Parramatta River and currently discharges flow via the existing piped stormwater network into the river in the quickest manner possible. Matching these conditions by allowing surface run-off to discharge before the river reaches its peak flood conditions is favourable to mitigate flood risk to the site and mitigate flood impact from the project;
- The development site is subject to both overland and mainstream river flooding. The worst case overland flood event through the site happens over the first hour of the storm event, whereas in the worst case river flood event, flood waters begin to rise above the riverbanks approximately two hours after the storm event. Based on this, an underground OSD system would provide little benefit as it would be inundated by the river flood shortly after a storm event; and

- Given the little to no flooding benefit provided from the OSD, consideration needs to be given to the impact on the built form and cost for the project. In addition, this also results in the loss of valuable “real estate” within the building which could be utilised for more valuable and functional spaces as part of this state significant development.

Further discussions with INSW, Museum of Applied Arts and Science (MAAS), CoPC and wider design team as part of the detailed design are required to determine the feasibility of implementing an on-site detention system as part of the development.

6.2.3 Proposed Water Quality Strategy

6.2.3.1 Water Quality Targets

City of Parramatta Council’s DCP requires developments to implement water sensitive urban design which aims to minimise impacts of development upon the water cycle and achieve more sustainable forms of urban development. The stormwater treatment targets for developments are summarised in Table 4.

Table 4: CoPC DCP stormwater quality pollutant reduction targets

Pollutant	**City of Parramatta Council pollutant reduction targets (% reduction)**
Total Suspended Solids	85 %
Total Phosphorous	60 %
Total Nitrogen	45 %
Goss Pollutants	90 %

6.2.3.2 Preliminary Water Quality Strategy

A preliminary WSUD strategy has been considered based on current best practice, taking guidance from the CoPC DCP for Water Sensitive Urban Design Guidelines (2011) and Water Sensitive Urban Design Technical Guidelines for Western Sydney (UPRCT 2004) documents.

The proposed WSUD measures serves only Powerhouse Parramatta. It does not consider treating stormwater flows from upstream catchments such as Council owned roads.

Existing GPT units near Parramatta River are to be retained to serve the main stormwater network.

An assessment of the proposed WSUD strategy, based on the amended design is presented in Figure 12, in order to demonstrate the feasibility of meeting the CoPC pollutant reduction targets. The improvement in water quality can be estimated with the industry-standard water quality modelling software, MUSIC. This measures the effectiveness in terms of the percentage of pollutants removed.

Treatment is assessed against the 3-month ARI (or 4EY, exceedances per year) equivalent stormwater flows for the site area catchment only and does not account for the flow coming from upstream catchments.

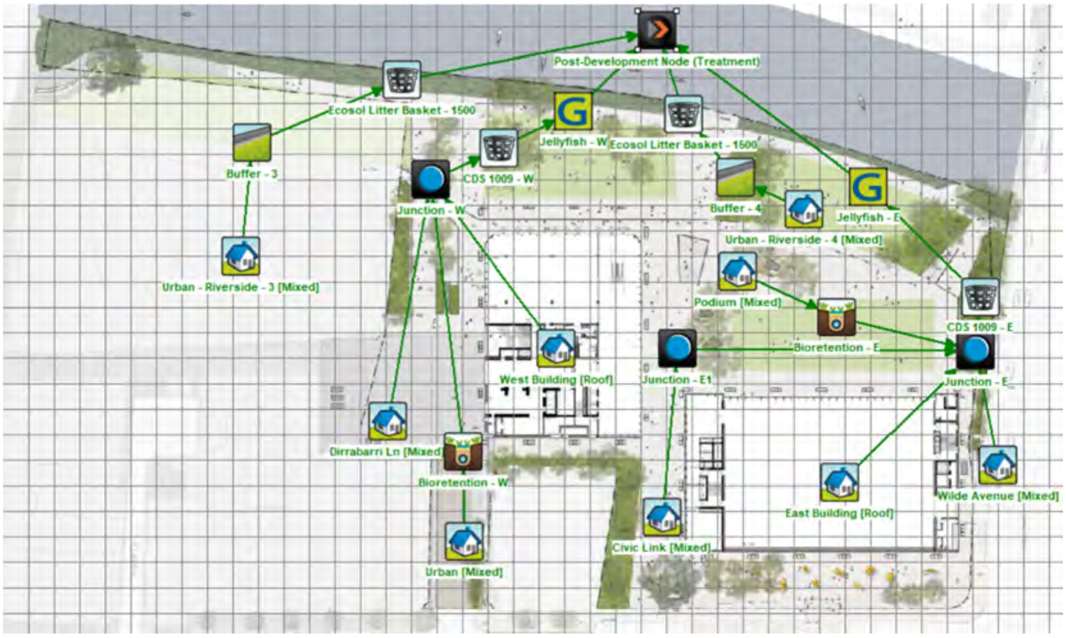


Figure 12: Preliminary WSUD assessment, extracted from MUSIC model

For the purposes of this assessment, consideration has been given to implementing the following treatment items:

- GPT (Rocla CDS 1009 unit);
- Media filled filtration cartridges (Ocean Protect Jellyfish Filter);
- Pit filtration baskets (Ecosol Litter baskets);
- Landscape bioretention gardens; and
- Landscape buffer strips.

With this strategy it is practical to achieve the Council pollution reduction targets as shown in Table 5.

Table 5: Results from the preliminary MUSIC model assessment

Pollutant	**City of Parramatta Council pollutant reduction targets (% reduction)**	**Powerhouse Preliminary Water Quality Assessment Results (% reduction)**
Total Suspended Solids	85%	88%
Total Phosphorous	60%	73%
Total Nitrogen	45%	55%
Goss Pollutants	90%	99%

It is generally preferred that the WSUD features are located outside of the flood extents for frequent flood events as inundations of these items may result in compromised pollutant removal, damage and associated maintenance efforts for the WSUD elements. However, due to the entire site being flood prone, this is not feasible. These strategies will be further detailed to consider operation and maintenance when exposed to flood waters.

Additional WSUD technologies are also being considered within the building envelopes (which have not been incorporated as part of this water quality assessment) which include:

- Rooftop garden and planting which increases the pervious area, encourages passive irrigation and treats any stormwater runoff;
- A rainwater harvesting tank is included within the concept design and will help with water reuse within the development and reduce wastewater and stormwater discharge from the site; and
- Connection to the proposed Sydney Water recycled water network that is expected to service the Parramatta area.

These technologies would be connected in series to create a water quality treatment train which aims to improve the quality of stormwater prior to discharge offsite.

The MUSIC software does not permit numerical modelling of hydrocarbon and oil capture. However, the GPT units can be specified to achieve effective capture and containment of the anticipated hydrocarbons and oils running off from the paved vehicular access areas. It is also noted that in the pre-developed condition there is a public car park which is likely to generate substantially greater quantities of hydrocarbons and oils than the post-development condition which does not include car parking.

During detailed design, this WSUD strategy will be developed further and the MUSIC modelling presented in this report will be updated to check the compliance of the preferred approach with the CoPC water quality pollutant reduction targets.

6.3 Erosion and Sediment Control Plan (ESCP)

Erosion and sediment control measures are a specific consideration of the broader construction management plan (CMP) that are designed to minimise the risk of scour, erosion and sedimentation. These risks are increased during necessary construction activities including demolition, land disturbance, cutting and filling. Likewise, these risks are also increased when developing a site that is prone to overland flows and flooding.

The underlying erosion and sediment control principles discussed in Appendix O – Flood Risk and Stormwater Management Report lodged with the EIS remain. Updated erosion and sediment control plans to respond to the amended design are contained in Appendix D.

6.3.1 ESCP Development and Adaptation

This proposed ESCP and associated drawings have been prepared to be used as a guide by the construction team. It offers an overview of the key risks and one possible method of response that can mitigate these risks. However, it will be construction team's responsibility to develop and adapt this erosion and sedimentation control plan to suit the requirements of CoPC. Changes may materialise for several reasons including ongoing design development, the preferred method/s of construction, and the sequencing of works on site.

7 Flood Impact Assessment

7.1 Review of Existing Flood Models

Existing flood studies and models of the Upper Parramatta River have been obtained and reviewed. The review concluded that the models available at the time of preparing the SSDA report were not adequate for the assessment of flood risk to the Powerhouse Parramatta development. Therefore, a project specific, bespoke flood model (referred to as the Powerhouse Museum Flood Model) was created using data from existing models provided by CoPC. Details of the limitations of the models available at the time of preparing the SSDA and the setup of the Powerhouse Museum Flood Model are discussed within Appendix O – Flood Risk and Stormwater Management Report lodged with the EIS.

CoPC is currently preparing a new Parramatta River flood study and associated TUFLOW model with Cardno based on the recently published ARR2019 guidelines. A report describing this study has been published in draft but has yet to be adopted at the time of publication of this report. Hence, given that this new model is deemed to be draft and not adopted by CoPC, it was not used for this study.

The Powerhouse Museum Flood Model was checked against both the adopted flood levels which use ARR87 and the draft flood study which use ARR2019. As shown in Figure 16 of the Appendix O – Flood Risk and Stormwater Management Report lodged with the EIS, the draft CoPC flood study using ARR2019 presents lower flood levels in both the 5% AEP and 1% AEP events than the currently adopted flood model which used ARR87.

The currently adopted CoPC model was, therefore, used to benchmark the model built for this flood assessment. This is considered a conservative baseline as it is based on higher flows and levels than the new model which is draft and not adopted by CoPC. The use of a model with higher flows and levels implies that the outcomes of flood immunity and flood afflux are conservative.

The Powerhouse Museum Flood Model provides simulation of both overland flow and mainstream flood behaviour for the Parramatta CBD catchment. It incorporates the CoPC adopted MIKE11 model Parramatta River flow and tailwater hydrographs as the boundary conditions, as well as addressing limitations identified in the existing Parramatta River flood models.

7.2 Powerhouse Museum Flood Model Update

7.2.1 Context

The Powerhouse Museum Flood Model has been validated against flood levels adopted by CoPC. This model has been used to better understand the behaviour of rainfall and runoff within the site and the surrounding environment. This model has also allowed the team to estimate pre- and post-development flooding conditions during significant storm events and estimate maximum flood depths.

This information has guided the development of the landscape design to respond to comments received within submissions and ensures the proposal does not adversely impact the surrounding properties in terms of flooding.

7.2.2 Development of Powerhouse Museum Flood Model

The following updates have been introduced to the Powerhouse Museum Flood Model since lodgement of the EIS:

- Use of TUFLOW version 2020-01-AB with HPC (Heavy Parallelised Computing) and SGS (Sub-Grid Sampling) capabilities which was recently released in May 2020. The computational solver for this software version utilises the new Wu eddy viscosity (turbulence) model which improves on the simulation of flow behaviour on the Parramatta River floodplain. In particular it more accurately depicts the hydraulic behaviour experienced of water flowing around structures and obstruction. These better replicates observed historical flood behaviour (see Figure 14);
- Further detail added to the model of the existing car-park including the car park ramp, stairwell and railing with appropriate head losses and blockage factors that could impact on the local flow behaviour under existing conditions;
- Refinement to the definition of Brickfield Creek, a tributary of the river that discharges flows to Parramatta River downstream of the development site;
- Update to the Parramatta Wharf representation which was previously assumed as fully blocked;
- Update of the stormwater network details (i.e. layout, invert levels, sizes) and delineation of overland flow sub-catchments following receipt of Council GIS dataset and new survey data gathered by LTS Lockley; and
- Update to the reflect the amended building and urban design of Powerhouse Parramatta.

In line with recommendations in ARR2019, allowance for a 20% increase in rainfall intensity has been used to account for climate change. This is as per models prepared for the report lodged for EIS.

The flow behaviour simulated by the updated Powerhouse Museum Flood Model has been validated using historical flood photos and videos (example of which are shown in Figure 13 and Figure 14). Further, the predicted flood levels for a range of design events have been compared against the CoPC adopted flood levels which is discussed further in Section 8.

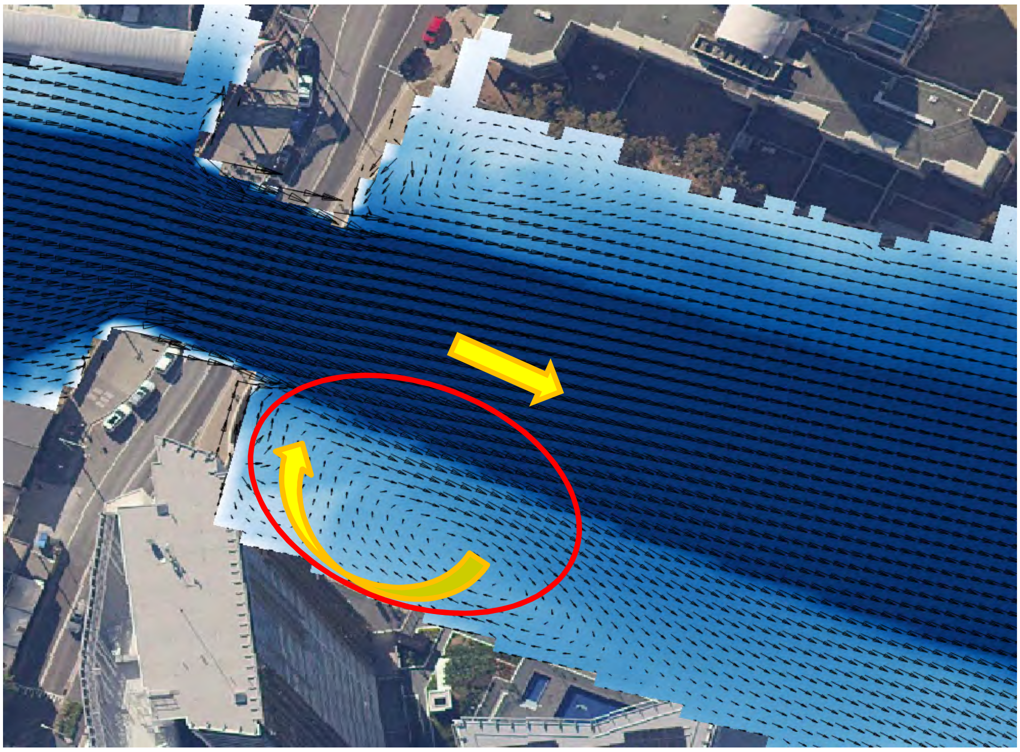


Figure 13: Visualisation of Eddy Formation from Powerhouse Museum Flood Model downstream of Lennox Bridge.

Figure 14: Video snapshot of eddy downstream of Lennox Bridge from the February 2020 flood (*Source: https://youtu.be/nUaB06gcjdo*)

7.2.3 Critical Storm Duration

The critical storm duration is the duration of a rainfall event that results in the highest flood levels for that particular catchment and type flooding. These durations are an indication of the length of rainfall event that causes the worst flooding for a particular point in a catchment. Typically, as a catchment area increases, the critical storm duration increases. Areas that are subject to overland flow in this part of Parramatta typically have short critical storm durations (in the order of 20 minutes) whereas areas that are subject to river flooding have much longer critical storm durations (in the order of 9 hours).

The critical storm durations for each AEP flood and each flooding mechanism (i.e. overland flow and mainstream riverine flooding) have been determined and are included within Table 6. These critical durations have been assessed for both the existing case and the case with the project and there is no change in these durations due to the project.

In all events up to and including the 1% AEP with climate change, peak overland flow flooding occurs within the first hour of rainfall while riverine flooding peaks between 7 and 9 hours, depending on the storm event.

Table 6: Critical storm durations for Powerhouse Parramatta

Design Event (AEP)	Overland Flow Flooding @ Phillip Street	Mainstream Flooding @ Parramatta River
5% AEP	25 minutes	540
1% AEP	20	540
1% AEP with climate change	20	540
PMF	240	240

7.2.4 Model Validation

The DRAINS and TUFLOW models developed herein have been used to simulate a range of design events from the 5% AEP up to the PMF. Design flood events above the 1% AEP but below the PMF (e.g. 0.1% AEP) have also been simulated to assess the resilience of the proposed development to a range of rare flood events as well as planning for emergency evacuation.

In modelling the climate change scenario following ARR2019 recommendations, the 2090 RCP (Representative Concentration Pathways) 8.5 emission scenario was adopted cognisant that the Powerhouse Parramatta project would have a design life spanning more than 100 years. A 19.7% rainfall increase has been predicted for this scenario and this has been modelled herein for the 1% AEP event (rounded up to a 20% rainfall increase). Sea level rise has not been modelled herein as it generally affects the tidal areas downstream of Charles Street Weir (Cardno, 2019) and not the development site. Further, the probability of a flood event occurring coincidentally with a high tide is generally low.

The model results have been validated via comparison against the adopted Parramatta River flood level profiles as obtained from the CoPC flood maps and Cardno (2019) draft flood study as shown in Figure 15.

It can be seen that the Powerhouse Museum Flood Model results correlate with the published results from previous CoPC assessments. The discrepancy in the 5% AEP and 1% AEP river flood levels when compared to the CoPC adopted levels is generally in the order of 0.1 m adjacent to the development site.

Comparison has also been undertaken for the local overland flow flood levels at the development site as summarised in Table 7. The difference in peak flood levels between the MIKE11 model and the Powerhouse Museum Flood Model is generally in the order of 0.1 m for events up to the 1% AEP with climate change event. Hence, the results are relatively similar. For the PMF, the difference is in the order of 0.5 m.

Table 7: Comparison of Overland Flow Flood Levels on Dirrabarri Lane

Flood Event (AEP)	**UPRCT MIKE 11 Model**	**Powerhouse TUFLOW Model#**
5%	6.89	6.97
1%	6.94	6.99
1% + Climate Change*	6.98	7.00
PMF	11.36	10.88

* UPRCT adopted 15% rainfall increase for the climate change scenario whilst the Powerhouse Museum Flood Model adopted 20% rainfall increase following ARR2019 recommendations

Results based on 100% pipe blockage scenario to match MIKE11 setup

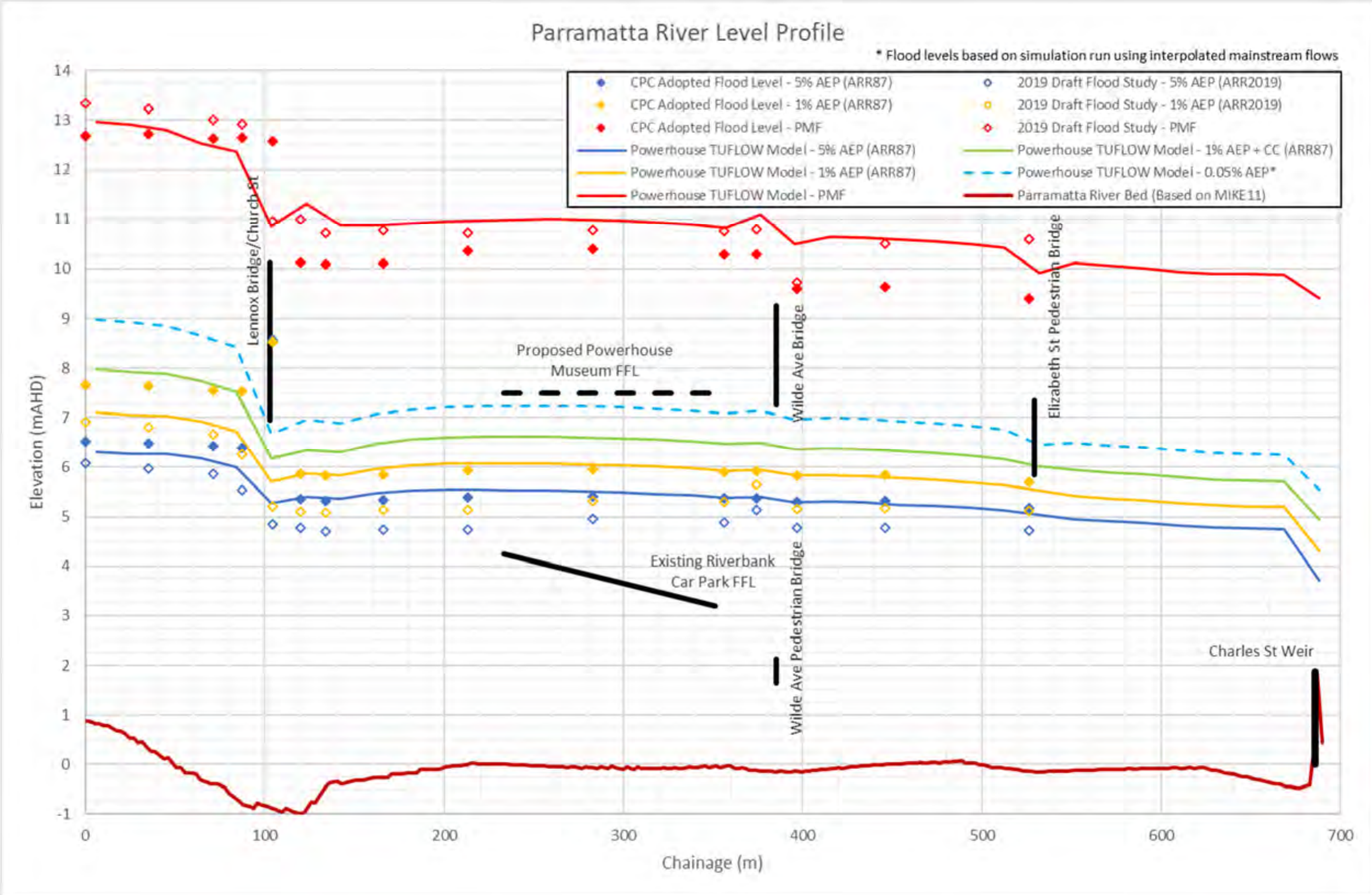


Figure 15: Parramatta River existing peak flood levels – longitudinal section comparing the results of the various flood model simulations of the river behaviour

7.2.5 Existing Flood Behaviour

The Powerhouse Museum Flood Model was used to simulate a range of flood events to define the existing flood behaviour of the area surrounding the Powerhouse Museum site. The flood maps for the existing conditions are provided in Appendix A for the 5% AEP, 1% AEP, 1% AEP with climate change and the PMF events. The maps show flood depths, levels, velocities and hazard category for both river-dominated floods and short duration overland floods.

Riverine Flood Behaviour

The results show that the existing car park basement is significantly inundated by floodwaters from Parramatta River floods, with more than 1m of flood depth expected for the 5% AEP event. In a 1% AEP flood, these depths are more than 2m in the eastern part of the car park.

Peak flood levels on the site in the 1% AEP river flood are 5.9mAHD to 6.1mAHD.

Rates of floodwater rise for these river floods are in the order of 1m/h but can be up to 2m/h for rarer floods.

To assist in the feasibility assessment of the emergency management plan and the flood risk assessment for the project, a range of river flood events with probabilities rarer than the 1% AEP event were simulated. The inflows and downstream boundaries for these events were derived by interpolation of flows from the 1% AEP flood and the PMF.

These simulations indicate that in very rare Parramatta River floods (rarer than the 1 in 500 AEP flood), floodwaters break out of the river further upstream near Old Government House and isolate the CBD as floodwaters encompass the site.

Most of the floodplain including the development site is shown to be flooded by more than 2m of floodwaters in the PMF event.

Overland Flood Behaviour

The overland flow paths are shown to converge near the intersection of Phillip Street and Horwood Place. These flows then diverge into two flow paths, running north on the eastern and western sides of 32 Phillip Street. In the 1% AEP event, overland flood depths of up to 0.3m are experienced on Dirrabarri Lane, between 30 and 32 Phillip Street Parramatta.

Following the exceedance of the capacity of the underground drainage system, floodwaters pool around the low point at the open car park located adjacent to the southern wall of the multi-storey Riverbank car park. This area is drained primarily by the existing 675mm diameter trunk under the car park.

For larger, rarer overland flow flood events, the flood levels increase such that the floodwaters start to flow around the south-west corner of the multi-storey car park, down the ramp at the end of Dirrabarri Lane and discharge towards Parramatta River. Assuming a degree of blockage on the pits in the area but no blockage of the underground pipes, this flowpath down the ramp at the end of

Dirrabarri Lane in floods rarer than the 1% AEP event with a climate change allowance. This event has a current probability of approximately 1:400 AEP (i.e. a chance of 1 in 400 in any one year).

Existing Flood Hazard (overland and riverine combined)

Hazard maps have been provided for a range of design events up to the PMF, based on the hazard category recommended by the AIDR (2017) guidelines. These guidelines provide a classicisation of six categories (H1 to H6) and the classification from that guideline is produced below in Figure 16. These classifications use a combination of flood depth and flood velocity to derive a classification which defines the general vulnerabilities of associated with that hazard category.

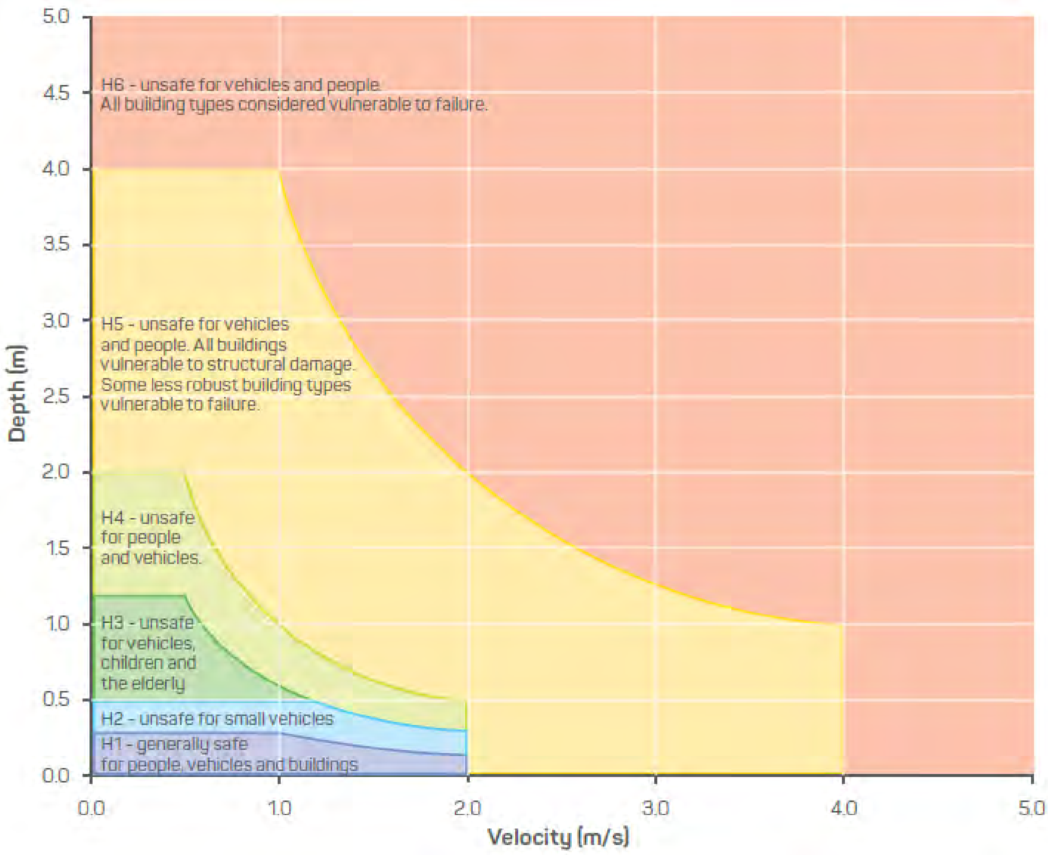


Figure 16: Flood Hazard Categories from AIDR (2017) guidelines

It can be seen from the mapping in Appendix A that for the 1% AEP event majority of the existing car park (lower level) is subject to high hazard flow up to the H5 category, which is unsafe for all people and vehicles.

It is worth noting that the current use of the site as a publicly accessible car park creates a current risk to life due to the high depths of inundation on the lower level of the car park building. As well, the lower level of the car park is encompassed by security fencing which limits the number of egress opportunities from the lower level, particularly for those with mobility impairments.

For the overland flow flood events up to the 1% AEP flood, hazard categories are typically H1 for Phillip Street and Dirrabarri Lane. However, there are small areas of H2 hazard category, which is unsafe mainly for small vehicles and a very small area of H3 hazard category for the trapped low point at the open-air car park, which is unsafe for vehicles, children and the elderly.

In the PMF event, most of the development site and adjacent floodplain are subject to H6 hazard category flow which is unsafe for vehicular access or pedestrian access.

7.2.6 Historical Flooding

The SES Flood Portal (flooddata.ses.nsw.gov.au) states the following in relation to the long-term history of flooding in the Lower Parramatta River.

> *"..the Lower Parramatta River experienced significant floods in 1889, 1914, 1956, 1961, 1967 and 1975. The largest of these occurred in 1889 and 1914 when the catchment was relatively undeveloped…… The historical flood level data and discharge estimates are not sufficiently detailed and complete to enable flood level probabilities to be defined by historical events alone. In addition the flood level data is non-homogeneous because of increasing urbanisation and its effects on flood runoff."*

Hence, it is difficult to draw conclusions on flood behaviour at the site from flood events in distant past due to the effects of urbanisation. Discussion is provided below on the observed flood behaviour at the site in the largest flood (1988) recorded over the last 40 years and the most recent flood (February 2020).

1988 Flood Behaviour

The April 1988 flood was estimated to be in the order of a 1% to 2% AEP event (Draft Cardno Parramatta River Flood Study, 2019), with 341mm rainfall depth falling in the period of over 56 hours.

The April 1988 event was the largest event in the gauged data set (1979 to present) with recorded peak flow of 688 m^3/s and peak flood level of 7.87mAHD at the Marsden St Weir gauge (213004).

A peak flood depth of 2.2m at the car park was taken from the modelling of the Draft Cardno Parramatta River Flood Study and a peak flood level of approximately 5.5mAHD. This is 2m lower than the proposed finished ground floor level of Powerhouse Parramatta.

The rate of rise of the river was approximately 0.5m/hour.

Figure 17 shows a photo of the existing car park on the site following the 1988 flood with the debris clearly visible on the lower level of the car park. The estimated 1988 peak flood level and the proposed finished ground floor level of 7.5mAHD are shown on the photo for comparison.

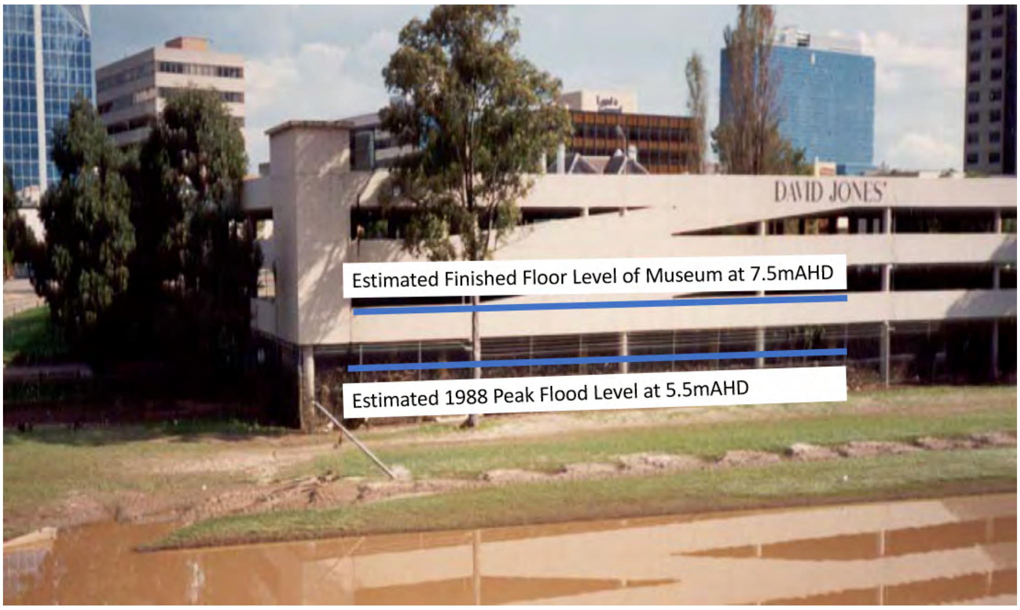


Figure 17: Riverbank car park looking south after 1988 flood with an estimate of the museum FFL annotated; Source: Cardno Parramatta River Flood Study, 2019

2020 Flood Behaviour

The most recent flood event occurred during the period of 6th to 11th February 2020 following a sustained period of rainfall. A total depth of 429mm of rainfall fell across a five-day period.

Based on gauge data information, the river flood level peaked in the afternoon on the 9th February 2020 at 5.5 mAHD at the gauge (Parramatta Riverside Theatre Station, upstream of Lennox Bridge). This level equates approximately to a 20% to 10% AEP river flood event.

The rate of rise of the river peak which occurred in the afternoon of 9/2/2020 was around 0.3m/hour (3.3m over 10.5 hours).

Based on the results of the flood modelling of the Parramatta River, the flood level difference from the Lennox Bridge gauge to the site is approximately 1m.

Hence, the estimated flood level on the site for this flood is approximately 4.4 mAHD. This would be more than 3m below the ground floor level of Powerhouse Parramatta.

Figure 18 shows a photo of the existing car park on the site following the 2020 flood. The estimated level of the proposed finished ground floor level (7.5mAHD) is also shown on the photo for comparison.

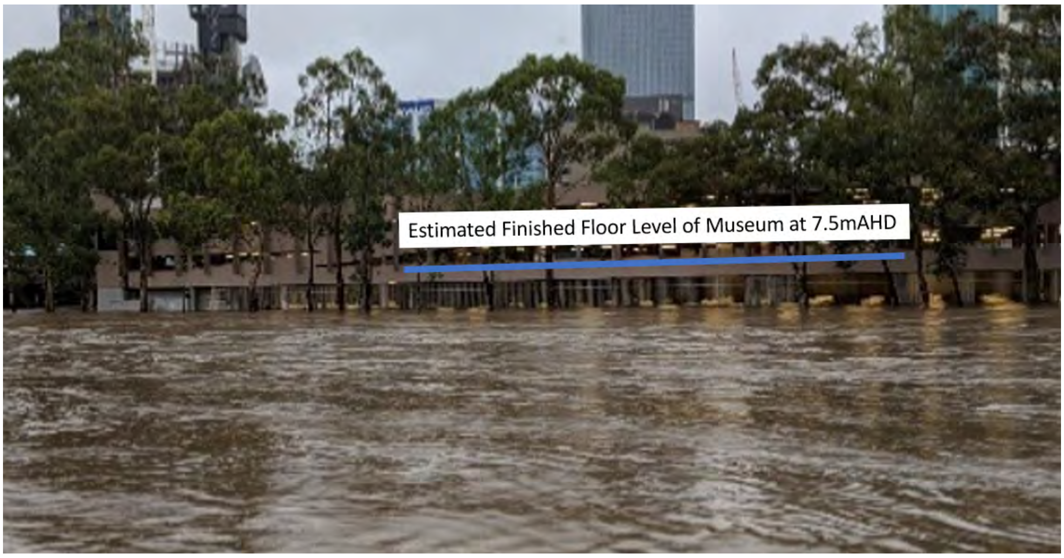


Figure 18: Powerhouse Parramatta site as viewed from the north bank of the Parramatta River with the FFL annotated (Source: Sydney Morning Herald, Feb 2020)

7.3 Assessment of Flood Impacts of Project

7.3.1 Representation of Project in Flood Model

The following elements of the amended Powerhouse Parramatta design have been incorporated into the Powerhouse Museum Flood Model to represent the project features relevant to flood behaviour:

- Digital Elevation Model (DEM) to reflect the amended public domain design grading, along with breaklines to define top of retaining walls, hardstand walls, kerbs as well as gullies;
- Proposed stormwater network consisting of pits and pipes as discussed in Section 6.2.1 and delineation of overland flow sub-catchments to match the revised drainage system;
- Proposed building footprint acting as obstruction to flow (the exception is the building extent above the undercroft, which has been represented using the layered flow constriction approach whereby flows can pass through at the undercroft level but will be obstructed once flood levels reach the underside of the terrace level slab – RL 6.7mAHD);
- Schematisation of the tree pits, stairs, exoskeleton and undercroft columns with appropriate form losses and blockage factors; and
- Manning's 'n' roughness to match the architectural landscape intent.

Flood models of existing and proposed conditions assume 0% pipe blockage, 20% on-grade pit blockage and 50% sag pit blockage. A sensitivity analysis on pipe blockage is contained in Section 7.3.6.

The Powerhouse Museum Flood Model incorporating the above elements has been used to undertake flood impact assessment of the proposed development as well as assessing the freeboard achieved with the proposed finished floor levels.

7.3.2 Assessment of Flood Behaviour with Powerhouse Parramatta

Flood maps, based on the flood model setup outlined in Section 7.4.1 are provided in Appendix A. These maps are presented in Appendix A for the 5% AEP, 1% AEP, 1% AEP with climate change and the PMF events.

Riverine Flood Behaviour

The flood model results indicate that the undercroft level and adjacent landscaped areas near the river would be subjected to inundation by floodwaters from the Parramatta River. Flood levels in this area would be very similar to those currently experienced in the lower level of the existing car park.

Rates of floodwater rise for river floods would be very similar to that of the existing situation. Durations of flooding would not be materially changed.

Peak flood depths in the undercroft area of more than 1.0 m would be experienced in the 5% AEP event and more than 2.0m for the 1% AEP event.

Post-development conditions for the PMF also match existing conditions whereby most of the floodplain, including the development site, would be flooded by more than 2m of floodwaters.

Overland Flood Behaviour

Overland flows on Phillip Street will be collected by the stormwater drainage system and discharged to the Parramatta River via an augmented underground drainage system.

In larger events, the augmented underground drainage system would be overwhelmed and there would be ponding in Phillip Street and Dirribarri Lane for floods beyond its capacity (as is currently the case).

In the 1% AEP flood, stormwater would pond in the southern section of Dirrabarri Lane, adjacent to 32 Phillip Street. This ponding would be in the region of 100mm to 200mm deep. Following the ponding in floods up to the 1% AEP, this stormwater would drain into the augmented stormwater system. The project would improve the overland flooding behaviour in the area surrounding the site as can be seen in the afflux maps contained in Appendix A (and discussed below).

The crest located at the top of the ramp on Dirrabarri Lane largely controls the flood levels for overland flooding for large, rare overland flood events. This crest would be exceeded only by rare events (events rarer than the 1% AEP) or if the stormwater system is 100% blocked. In these events, overland flows would run north down the ramp and discharge into the Parramatta River.

7.3.3 Flood Impacts and Afflux

The flood afflux maps presented in Appendix A are derived from a comparison of the post-development peak flood levels against those of existing conditions.

Afflux (or change in flood level) of ± 10mm is within the tolerance of model accuracy and is considered as "no impact". Level differences which exceed 10mm are considered as having a potential "adverse impact" (depending on the land-use and assets affected). The objective is to ensure no adverse flood impacts on surrounding development or properties up to and including the 1% AEP, which is consistent with typical conditions of approval for development.

Riverine Flood Behaviour

In flood events up to and including the 1% AEP, the impact of the development proposal on Parramatta River peak flood levels is predicted to be highly localised within the river channel where flood depths are already in excess of 2.0m.

There would be a minor increase in flood levels observed along the northern Parramatta River footpath (in the order of 26mm). This would not materially impact on the properties located north of Parramatta River as the buildings are elevated above the 1% AEP mainstream river flood levels. The localised areas which would experience afflux between 10mm and 30mm are landscaped gardens.

The slight increase in flood levels downstream or east of the development site would occur in the public domain where no property is located.

Hence, the impact of the project on riverine flood behaviour up to the 1% AEP flood event is considered negligible.

For the 1% AEP with climate change flood event, the flood impact on riverine flood behaviour would be negligible and largely localised to the site. Afflux along the northern bank of the Parramatta River would be localised and limited to a maximum increase of 25mm. The areas with afflux between 10mm and 30mm here are landscaped gardens. Hence, the impact of the proposal on mainstream flood behaviour is considered negligible.

There would be an increase in peak flood levels (in the order of 44mm) under the 1% AEP climate change scenario for the Dirrabarri Lane ramp adjacent to the Meriton development. Finished floor level of the Meriton development is at RL 7.86m AHD, which is well above the predicted peak river flood levels for the 1% AEP with climate change event.

An external louvre exists along the eastern elevation of the Meriton Development that provides ventilation to the basement, at RL 6.40 mAHD. The existing case flood level is estimated to be RL 6.5m AHD. Floodwaters in this 1% AEP flood with climate change would flow through this louvre and inundate the underground car park in Meriton development. This inundation of the car park would not occur in the 1% AEP flood (without climate change). This inundation of the car park via the louvre could be affected by the flood level increase due to the project.

This flood assessment has identified and tested a feasible option to mitigate the effects of this impact. This option will be assessed further during detailed design.

Overland Flood Behaviour

For the 5% AEP event, the modelling assessments indicate that the proposed stormwater network would result in a decrease in peak flood levels of up to 0.1m. As well, it is predicted that there would be a reduced flood extent for Phillip Street, Dirrabarri Lane as well as along the perimeter of 32 Phillip Street for these flood events due to the augmented underground drainage system (i.e. larger pipes and increased inlet pit capacity).

It is also predicted that for the 1% AEP afflux there would also be a reduction in peak flood levels on Phillip Street and Dirrabarri Lane of approximately 0.1m. The land located north and east of 32 Phillip Street would remain flood free for the 1% AEP event.

This flood assessment indicates that the development proposal would not cause adverse impacts on other development or properties for local flood events up to the 1% AEP.

For the 1% AEP event with climate change (i.e. 20% rainfall increase), there would be reduction in peak flood levels (in the order of 0.02m) on Phillip Street as well as decrease in flood extent on the properties located north and east of 32 Phillip Street.

There would be a small pocket of localised impact due to the project on the north-west corner of 32 Phillip Street (around 26mm) in the 1% AEP flood event with climate change. However, this impact would not affect the building at 32 Phillip St or the access to the building. Hence, the afflux is unlikely to result in any increased damage or reduced usage of the building and can be considered as a negligible impact.

7.3.4 Assessment of Changes to Flood Hazard

Hazard maps have been provided for a range of design events up to the PMF. These are presented in Appendix A for the 5% AEP, 1% AEP, 1% AEP with climate change and the PMF events.

Riverine Flood Behaviour

Based on the hazard categories recommended by the AIDR (2017) guidelines, it can be seen that for the 1% AEP event the undercroft level and adjacent landscaped areas are subject to high hazard flow up to the H5 category, which is unsafe for all people and vehicles.

The H5 hazard category in this area is the same hazard category for the current situation in the lower level of the car park. However, it is noted that the extents vary slightly due to differences in ground level between the proposed public domain and existing car park.

For the PMF event, most of the development site and adjacent floodplain are subject to H6 hazard category flow which is unsafe for vehicular access or pedestrian access.

These hazard categories highlight the need for an emergency management plan to be developed in detail that would aim to provide sufficient time for all people from the undercroft area and public domain areas. This is discussed further in Section 8.3.

Overland Flood Behaviour

With regards to hazard classification for overland flows, these would largely remain at "H1" category which is benign condition for both vehicles and pedestrian for most of Phillip Street and Dirrabarri Lane. There would be minor reductions in flood depths and, hence, an improvement to overland flow flood conditions when compared to existing conditions.

7.3.5 Summary of Flood Impacts to Adjacent Properties

Predicted flood impacts on properties adjacent to Powerhouse Parramatta are tabulated in Table 8, with the location of relevant property entries shown in Figure 19.

The flood modelling predicts that there would generally be a reduction or improvement to the flood affectation of the adjacent properties as a result of the proposal. These reductions in flood level are due to the proposed increased underground drainage pipes and improved inlet pit capacity.

The property at 32 Phillip Street would experience a benefit, whereby the vehicle entryway into the property would be flood free up to the 1% AEP, whilst the property entry from Phillip Street would be flood free up to the 1% AEP with climate change.

The only entry threshold which would experience adverse impact, i.e. peak flood level increase, is the Meriton development external louvre under the 1% AEP with climate change mainstream flow conditions. There is no flood inundation in the 1% AEP event. Note that the louvre is currently inundated under existing conditions for the 1% AEP with climate change event. This flood assessment has identified and tested a feasible option to mitigate the effects of this impact. This option will be assessed further during detailed design.

Table 8: Assessment of Flood Impacts on Adjacent Properties

Properties	RL (mAHD)	5% AEP (mAHD)	1% AEP (mAHD)	1% AEP + CC (mAHD)
30 Phillip Street (Parkroyal Parramatta)				
Vehicle entryway	Approx. 6.57	Existing: 6.79 Proposed: 6.79 Change: -	Existing: 6.88 Proposed: 6.87 Change: -0.01	Existing: 6.93 Proposed: 6.92 Change: -0.01
32 Phillip Street (GE Building)				
Floor level	Approx. 6.89	Existing: 6.79 Proposed: 6.76 Change: -0.03	Existing: 6.85 Proposed: 6.82 Change: -0.04	Existing: 6.91 Proposed: 6.89 Change: -0.02
Dirrabarri Lane vehicle entryway	Approx. 6.70	Existing: 6.66 Proposed: NF Change: NF	Existing: 6.81 Proposed: 6.70 Change: -0.10	Existing: 6.86 Proposed: 6.86 Change: 0.00
330 Church Street (Meriton Suites)				
Floor level	Approx. 7.86	Existing: NF Proposed: NF Change: NF	Existing: NF Proposed: NF Change: NF	Existing: NF Proposed: NF Change: NF
Meriton Development - External Louvre	Approx. 6.40	Existing: NF Proposed: NF Change: NF	Existing: 5.96* Proposed: NF Change: NF	Existing: 6.49* Proposed: 6.53* Change: +0.04

NF = not flooded, * riverine flood critical, number/text in green = floodwaters not entering building

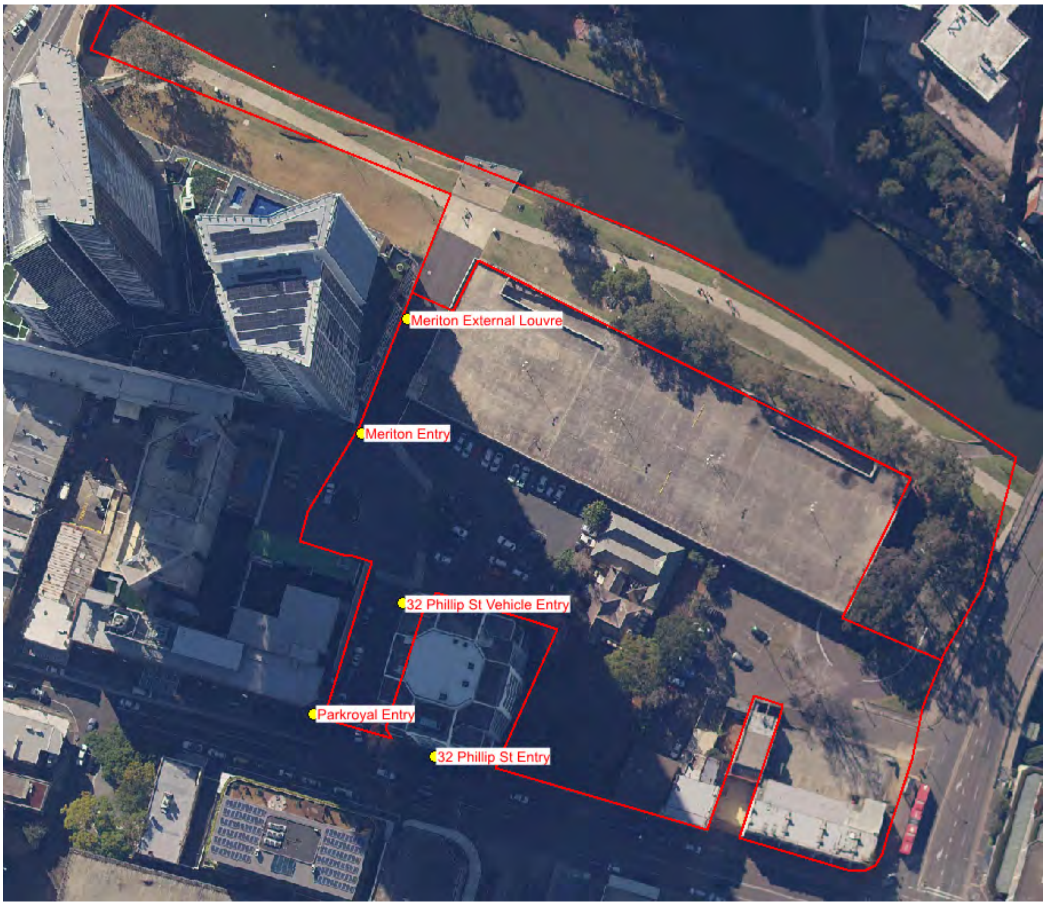


Figure 19: Location of Entryways of Adjacent Properties

7.3.6 Sensitivity Analysis of Pipe Blockage

The flood impact assessment discussed above was based on modelling of the existing and proposed conditions assuming 0% pipe blockage, 20% on-grade pit blockage and 50% sag pit blockage.

Sensitivity analysis have also been undertaken to assess the effect of a fully blocked stormwater drainage scenario on the flood levels for the development site and its surround. This analysis considers the unlikely event that the stormwater networks within the site and wider Parramatta CBD are 100% blocked.

Overland flood levels in the 1% AEP event are predicted to be 6.72m AHD assuming no pipe blockage and 7.20m AHD assuming 100% pipe blockage adjacent to the western building.

For the 1% AEP plus climate change, overland flood levels would be 6.86m AHD with no pipe blockage and 7.25m AHD with 100% pipe blockage.

Under the fully blocked drainage scenario, the crest on Dirrabarri Lane will be overtopped under a more frequent flood event. In this scenario, all rainfall events (regardless of the frequency of the event) would result in ponding in Dirrabarri Lane and involve overland flow path through Dirrabarri Lane towards the ramp adjacent to the Meriton development.

In terms of post-development flood impacts on Phillip Street and Dirrabarri Lane under the full pipe blockage scenario, a peak flood level increase (compared to existing conditions) in the order of 60mm is expected to occur for the 5% AEP and 1% AEP events, and 65mm for the 1% AEP with climate change event.

However, as stated above, in this scenario there would be extensive and regular flooding of the building at 32 Phillip Street in both the existing case and the case with the proposed development. The flood immunity of the building at 32 Phillip Street in this scenario would be very low. The flood depth in the building would be more than 0.25m for the 5% AEP flood level in the existing case in this scenario. The additional flood depth of 60mm under this scenario in a 1% AEP flood event would be an additional depth in an already flooded building.

8 Flood Risk Management

8.1 Flood Risk Management Approach

The approach to flood risk management for Powerhouse Parramatta is based on a consideration of a range of flood probabilities and flooding types as well as the flood hazards and consequences for these events.

As well, there is a strong focus on developing a design that does not impact adversely on neighbouring properties. A key element of that part of the flood risk management approach is the maintenance of floodplain conveyance through the use of the undercroft area as a flowpath for floodplain flows.

Another key element is providing a suitable level of flood immunity for the building contents and occupants. It includes a workable and effective Emergency Management Plan which is built around a shelter-in-place approach given the potential isolation of the site for short periods during floods.

8.2 Flood Risk Management Strategy

8.2.1 Nature of Site Flooding Types and Flooding Conditions

The site is subjected to two types of flooding: overland flow and riverine flooding. They are typically separate flood events occurring at different times of the year and (given the infrequency of flooding) different years.

Overland flooding occurs when intense short duration rainfall events occurs over the local stormwater catchment of the Parramatta CBD (approximately 2km^2). In these events, flows exceed the capacity of the local stormwater infrastructure system (i.e. underground pipes) and flows occur along roads and enter surrounding private developments. This type of flooding is characterised by typically short durations with relatively high velocities and relatively shallow depths. It occurs from storm durations in the order of 1 hour and would typically occur from a thunderstorm.

Riverine flooding occurs from longer duration rainfall events across the whole Upper Parramatta River catchment of 108km^2. In this type of flooding, the river levels rise (at a rate of approximately 1m/h but it can be as fast as 2m/h in a PMF or shorter duration event). It occurs from storm durations in the order of 9 hours long and would typically occur from a more regional meteorological event such as an East Coast Tropical Low. In very rare Parramatta River floods (rarer than the 1 in 500 AEP flood), floodwaters break out of the river further upstream near Old Government House and isolate the CBD as floodwaters encompass the site.

The nature of these two types of flooding has been considered in the development of the flood risk management strategy. While it is most likely that the two types of flooding do not coincide, the strategy also includes consideration of the rare occurrence of coincident flooding (overland flow and riverine flooding).

8.2.2 Flood Risks for Building Contents and Occupants

Flood Levels and Resulting Freeboard

Table 9 shows flood levels for the differing flooding scenarios experienced on the site as per flood modelling outputs and compares with the proposed ground floor finished level of 7.5mAHD.

Table 9: Comparison of Freeboard provided for various flood events

Flood Scenario	Peak Water Level (m AHD)	Freeboard from FFL of 7.5mAHD
1% AEP		
River Flood Level	6.07	1.43m
Overland flooding – no pipe blockage	6.72	0.78m
Overland flooding – 100% pipe blockage	7.20	0.30m
1% AEP + Climate Change (approx. equal to current 0.25% or 1:400 AEP)		
River Flood Level	6.60	0.90m
Overland flooding – no pipe blockage	6.86	0.64m
Overland flooding – 100% pipe blockage	7.25	0.25m
0.13% AEP (1:800 AEP)		
River Flood Level	6.87	0.63m
Overland flooding – no pipe blockage	7.18	0.32m
Overland flooding – 100% pipe blockage	7.25	0.25m
0.1% AEP (1:1,000 AEP)		
River Flood Level	6.98	0.52m
Overland flooding – no pipe blockage	7.33	0.17m
Overland flooding – 100% pipe blockage	7.40	0.10m
0.05% AEP (1:2,000 AEP)		
River Flood Level	7.22	0.28m
Overland flooding – no pipe blockage	7.62	-0.12m
Overland flooding – 100% pipe blockage	7.66	-0.16m

Freeboard Considerations

Of note in the assessment of flood risks for the building is a consideration of the freeboard allowance. For river flooding, the NSW Floodplain Development Manual states that *"freeboard acts as a factor of safety which should never be relied on to manage risk in events larger than the flood used to derive the FPL. In the majority of circumstances, a freeboard of 0.5m would be acceptable for new residential development controls."*

The Manual also provides a discussion on the factors influencing a decision on freeboard. These include:

- uncertainties in the estimates of flood levels.
- differences in water levels across the floodplain because of 'local factors'.

- increases in water level as a result of wave action (e.g. wind-induced waves or those induced by boats and vehicles moving through flooded areas).
- changes in rainfall patterns and ocean water levels as a result of climate change
- the cumulative effect of subsequent infill development of existing zoned land.

When these factors are considered for Parramatta River flooding, a freeboard of 0.5m is suitable. However, when considered for overland flows from Phillip Street, a lower freeboard may be suitable.

A paper by the Office of Environment and Heritage (OEH) entitled "Local Overland Flooding – the NSW Experience" (2015) suggests that a freeboard of 0.3m for overland flooding may be more appropriate in some situations. The paper states *"studies should provide a breakdown of factors contributing to the proposed freeboard allowance to ensure transparency of the freeboard level adopted."*

The following factors relating to the overland flow conditions at the site are listed below as part of this consideration:

- the depth of overland flooding is shallow and in the order of 0.3m to 0.4m;
- the depths have a limited sensitivity to rainfall intensity increases (see variations in flood level in Table 9) and are, therefore, not sensitive to inaccuracies in rainfall estimation;
- there are no 'local factors' of note (e.g. those not able to be simulated in a model);
- wave action from wind induced waves would be negligible but vehicle induced waves are possible;
- climate change increases to rainfall intensities have been included in the flood assessments and, as listed above, flood levels do not increase significantly with rainfall intensity increases;
- there would be little or no increase in flood levels due to cumulative effect of subsequent infill development of existing zoned land as the levels are not sensitive to floodplain storage loss.

Hence, given the nature of overland flooding in this site, an overland flow freeboard of 0.3m is justified.

Risk of Flood Inundation for Ground Floor

An assessment of the immunity of the museum's ground floor level has been conducted.

For Parramatta River flooding, the ground floor would have a flood immunity of approximately 1:1000 AEP flood (0.1% AEP) with a 0.5m freeboard (i.e. the museum ground floor would remain 500mm above flood waters in this event).

In a 1:800 AEP (0.13% AEP) overland flow flood event, there would still be 0.3m of freeboard to the ground floor (i.e. the museum ground floor would remain 300mm above flood waters in this event).

Hence, the flood events that would reach flood levels close to the ground floor level (but still with an adequate freeboard or factor-of-safety) have a chance of occurrence that is less than 1/8th of the 1% AEP event.

The probability of ground floor inundation from Parramatta River floods (including an allowance for freeboard) is very low and about 1 in 800 in any year.

Alternatively, this risk can be expressed in terms of the design life of the building of 100 years and a chance of 1 in 8 (i.e. 12%) of a flood occurring in that period that gets within 0.3m of the ground floor level.

The architectural design has set both the West and East Buildings with a Finished Ground Floor Level of 7.5 mAHD. This design approach, consistent with the design brief, is considered to be a suitable level to manage the flood risks of the site and the project.

Raising buildings to a higher Finished Floor Level (and thereby offering even greater freeboard and/or lower levels of risk) will create difficulties with the design of the public domain levels and grades surrounding the building. This is a common consideration when setting building finished floor levels to achieve flooding protection, and given the nature of the development as a public facility, it is important that accessibility is given careful consideration.

Risk of Flood Inundation for Other Floors

All other floors above the ground floor are above the Probable Maximum Flood (PMF) level. Hence, there is no chance of flooding for these levels.

8.2.3 Risk Management for Parramatta River Floods

The main elements of the flood risk management strategy for Parramatta River flooding are:

- Inclusion of flow area under the building (i.e. the undercroft) as a flowpath during Parramatta River floods to generally replicate the flooding conveyance of the existing site from west to east.
- Minimisation of flood level impacts on surrounding properties through inclusion of the undercroft and local mitigation measures.

- Minimisation of changes to times of flood inundation on surrounding properties.
- Development of an Emergency Management Plan that enables egress from the undercroft area to the ground floor level (which is above the 1:1000 AEP river flood level with freeboard) and to Level 1 (which is above the PMF level). This is discussed further in Section 8.3.

The use of the undercroft as a flowpath maintains a similar flow conveyance capacity during flood events as the existing car park. Maintaining the flow conveyance minimises changes to the river flooding behaviour and results in afflux less than 10mm on all surrounding buildings.

Furthermore, existing times of inundation for surrounding properties would be unchanged meaning there are no material changes required to the flood warning / evacuation procedures for surrounding properties.

It should be noted that the rate of floodwater rise in the undercroft area is similar to that of the river (i.e. in the order of 1m/h to 2m/h). Flood velocities in this area during this phase of the undercroft filling will be low as it is backwater flooding from the river. This backwater phase of flooding continues until the undercroft is fully submerged and then flood velocities increase to approximately 2m/s (1.5m/s for 1% AEP, but greater for rare floods).

8.2.4 Overland Flow Strategy

Pre-development (i.e. existing case) overland flows run along Phillip Street and discharge towards the Parramatta River via three routes through the site:

- Oyster Lane/George Khattar Lane to the west of Wilde Bridge
- Overland flow route to the east of 32 Phillip Street.
- Overland flow route down Dirrabarri Lane, west of 32 Phillip Street and further north, between the Meriton development and existing car park.

The design intent is to remove the overland flow to the east of 32 Phillip Street (referred to as the Civic Link in the proposed scheme) by altering the public realm design of Phillip Street and diverting flows to Dirrabarri Lane.

Dirrabarri Lane overland flowpath is to be served by an enhanced stormwater drainage system to convey stormwater from minor events. However, it is noted that in larger, rarer events, overland flows will continue to flow along this route.

Proposed finished surface levels in Dirrabarri Lane, adjacent to 32 Phillip Street are to match existing levels to retain pre-development conditions. As the threshold levels of the museum are higher than existing ground levels, additional surface collection features will be required to drain surface flows.

8.3 Emergency Management Strategy

8.3.1 Shelter-in-Place strategy

The Parramatta Local Disaster Plan (DISPLAN) does not list a relevant flood sub-plan. However, the draft Update of Parramatta Floodplain Risk Management Plans, prepared by Molino Stewart on behalf of City of Parramatta Council, does include recommendations with respect to emergency management.

An extract of the flood emergency response classification of communities across the CBD is contained in Figure 20 which shows that the site of the Powerhouse Museum is classified as a "Low Flood Island".

This island effect can occur for short durations (less than one hour), and to shallow depths (~0.4m) due to flash overland flooding. It can also occur during rare riverine flood events where Parramatta River breaks it banks upstream of the proposed development and floods the majority of roads within Parramatta CBD.

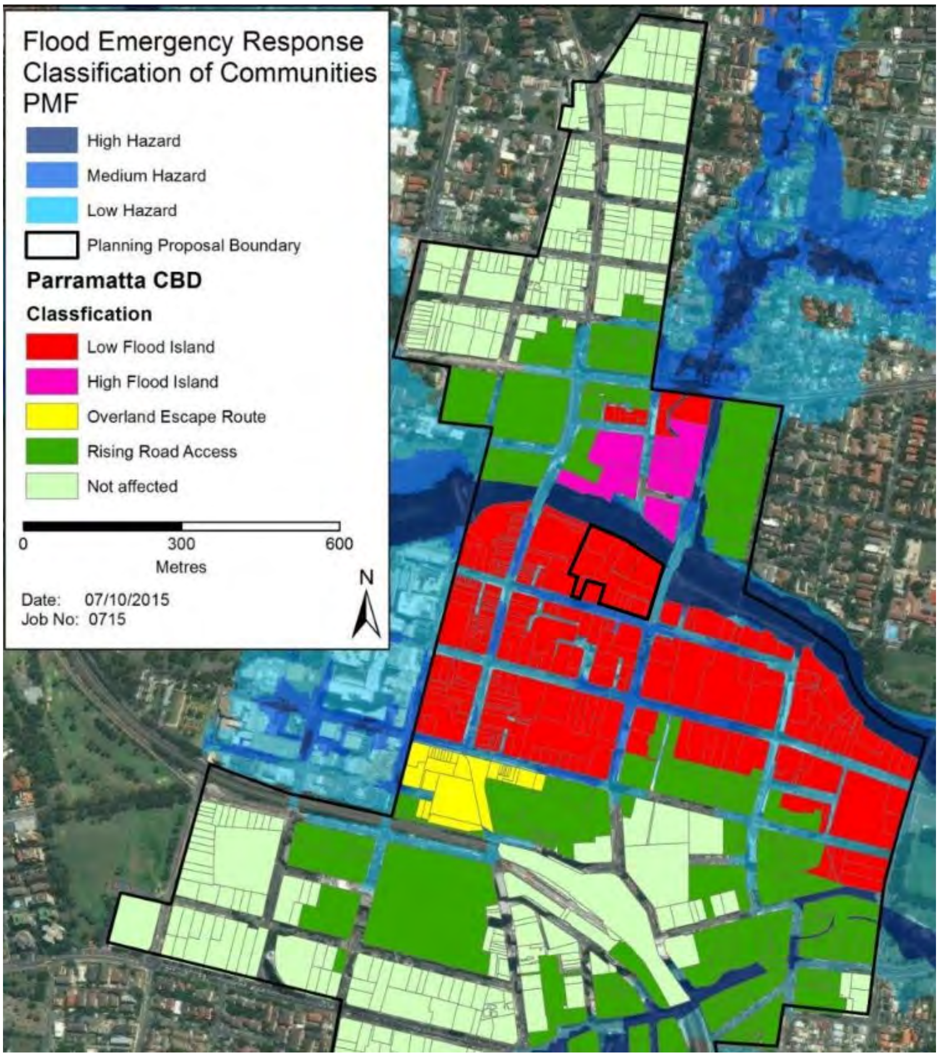


Figure 20 Extract of Flood Emergency Response Classification of Communities Across the CBD (Source: draft Update of Parramatta Flood Risk Management Plans, Molino Stewart)

Consistent with other developments in the precinct and the draft Parramatta Floodplain Risk Management Plan a 'shelter-in-place' strategy is proposed. Occupants within the building and surrounding public realm would shelter inside the building until it is deemed safe to leave.

People taking refuge will be hosted in the front-of-house areas on Levels 1 and 2 of Powerhouse Parramatta. As outlined in Table 3, these floors are above the PMF level.

Regular power supply would be available in the highly unlikely event of the ground floor being inundated. Hence, for all floods up to the 1 in 800 AEP flood, regular power supply is likely to be available and uninterrupted due to the siting and level of the sub-stations which would be built above the 1 in 800 AEP flood level with an allowance for freeboard.

For rarer flood events, the emergency power supply will supply power to the building for up to 10 hours. The emergency power supply would be located above the Probable Maximum Flood (PMF) level.

8.3.2 Management of risk to collections

The museum will house valuable collections. The design of the building has reflected the value of these collections by creating a ground floor level that would have an immunity of approximately 1 in 800 AEP (or 0.12%) including an allowance for freeboard.

Only Presentation Space 1 will be located on this ground floor. All other presentation spaces within museum will be located on floors that sit above the PMF level.

During flood events, some presentation spaces could be closed so that the humidity of the air in those presentation spaces can be maintained with air-conditioning.

Given the small fraction of presentation spaces below the PMF level, the warning time available for river flooding and the low probability of flooding of the ground floor, the likelihood of flood damage to the collections housed in the museum would be low.

8.3.3 Evacuation Routes and Times of Egress

The most floodprone parts of the site are public domain areas near the riverbank and the undercroft area. The management of egress of people out of these area at the beginning of a flood will be critical to the safe use of the area.

It should also be noted that the museum will have surveillance 24 hours a day which will enable an emergency management plan to be enacted at any time.

The architecture report states in regard to the use and function of the undercroft area:

> *When not in use, the undercroft will be screened off to prevent occupation. Programmed use of the space will be carefully managed by the*

Powerhouse with exhaustive risk mitigation measures implemented for each scenario.

Hence, for programmed use of the undercroft area, a management plan would be required which would include appropriate response measures for flood warnings. These measures could include cancellation of any event in response to a flood warning.

It is highly unlikely that people will seek shelter in the undercroft area as it will not be accessible to the general public. However, in the event that people are in this area, evacuation from the undercroft / lower lying public realm immediately north of the Powerhouse Building will be possible from multiple egress routes, which are separate from the overland flow path that runs down Dirrabarri Lane.

The undercroft area and the public domain area near the riverbank require evacuation assessments. The numbers of people requiring evacuation are expected to be small numbers (in the order of 10) as it will be raining heavily at the time of the flood and it is highly unlikely that there will be many people using the public open space at that time.

The undercroft area is only subject to inundation from riverine flooding and there are warnings associated with riverine flooding that would enable the engagement of an emergency evacuation plan.

As outlined in Section 5, the following egress routes, listed from east to west, are provided as part of the proposal:

- A staircase at eastern end of the proposed embankment to access the podium and ground level of Powerhouse Parramatta.
- Elevator at north eastern corner of the eastern building providing access between the river level and Powerhouse Parramatta including Level 1 which is above the PMF.
- A central staircase to access the podium and ground level of the museum.
- Staircase at south-western corner of the undercroft which accesses ground level to the west of the western building or Dirrabarri Lane.

From the top of the stairs listed above, pedestrians can access the ground floor and then move to Level 1 (above the PMF).

Dirrabarri Lane ramp connects the public domain area near the riverbank to Dirrabarri Lane and beyond to Phillip Street and is another route to reach higher ground. This is a potential flood egress route but would only be available as an egress route if overland flows are not flowing along the lane toward the river. Overland flows can occur during intense local rainfall events and in rare Parramatta River floods following the breakout of flows upstream of Lennox Bridge. Hence, this route has not been considered as a primary egress route and feasibility of the evacuation plan does not rely upon the use of it.

The power supply to the building is likely to be operational until flood levels reach 7.5mAHD. Hence, access using the lifts would be possible from the undercroft level until flood levels reach the lift area (at 3.3mAHD). Once people are on the ground floor, stair access or lift access to Level 1 would be possible until flood levels enter the ground floor. The emergency power supply would be above the PMF level and would be available for the rare flood events that exceed 7.5mAHD.

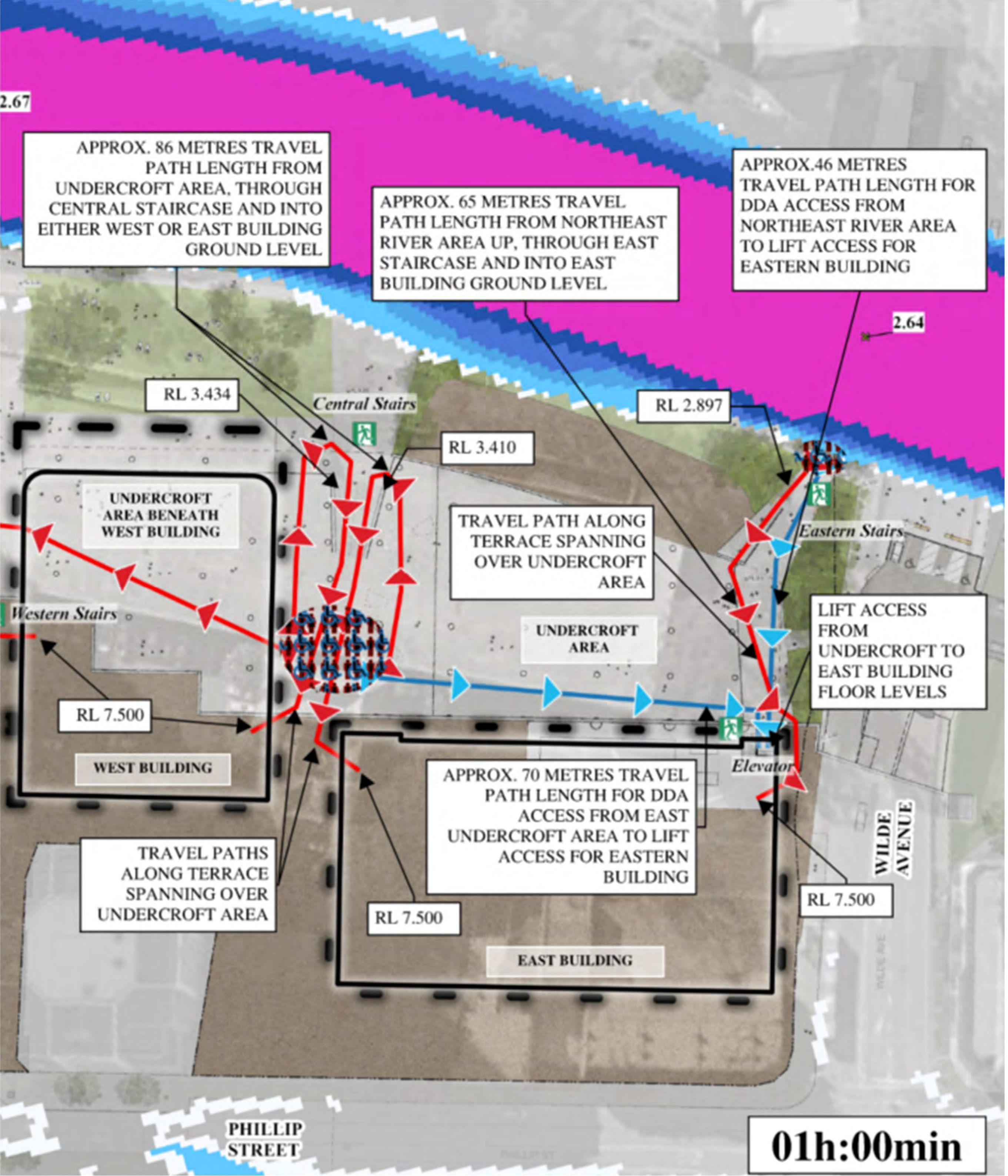
The filling of the undercroft area would mimic the floodwater rise of the river. This rate of rise would be unchanged from the existing situation. It is not subject to overland flooding. The river filling rate is in the order of 1m/h but can be as fast as 2m/h in some floods.

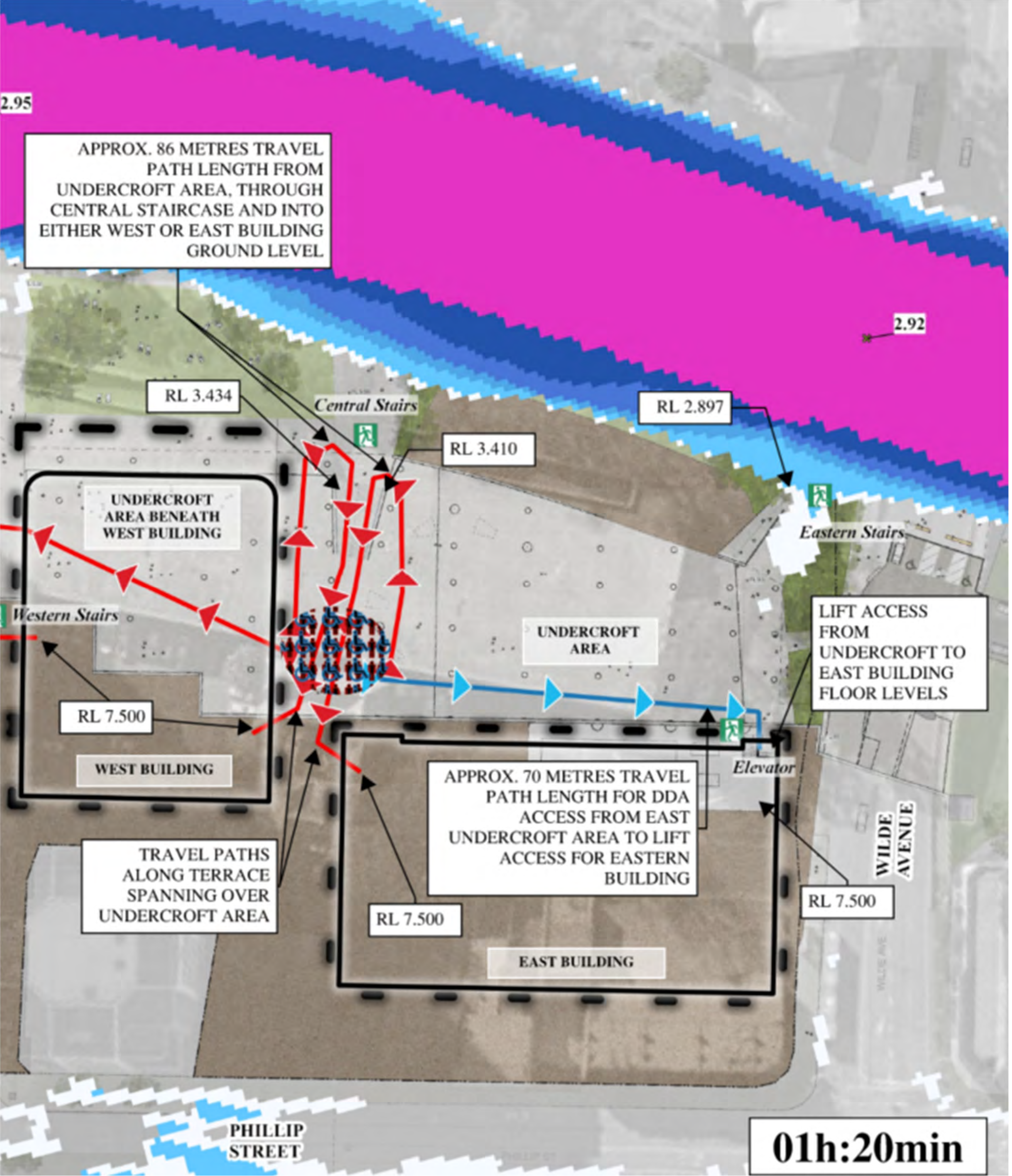
Modelling undertaken for the project demonstrates that inundation of these areas would occur over an extended period in all riverine flood events. The 0.05% AEP (1:2000 AEP) flood event has been assessed as an example of a rare and fast rising flood and a series of images showing flood depths and extents are shown in Figure 21 to Figure 26. These egress plans are also shown in Appendix B.

The Emergency Evacuation Plan would be engaged as floodwaters rise out of the river and in response to BoM, SES and FloodSmart Parramatta flood warnings. This is likely to be at a flood level below 2.0mAHD (i.e. flood water overtopping the riverbank north of Powerhouse Parramatta) and prior to the image shown at Time = 1.0 hour (i.e. 1 hour after the start of the intense rainfall event).

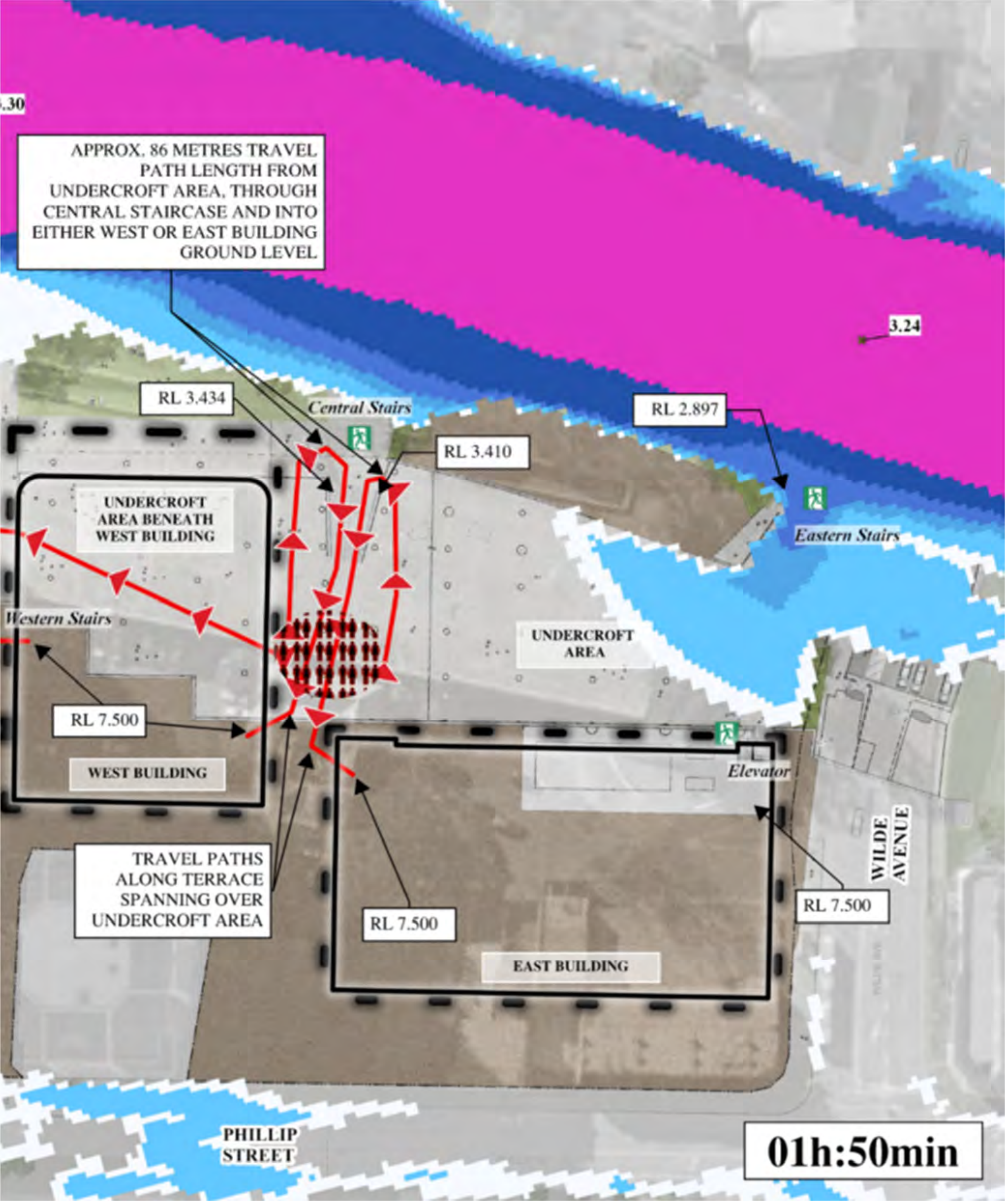
The main focus of the plan in the initial stages would be the orderly evacuation of people from the lower public domain levels to Level 1 (above the PMF level). A priority would be given to moving those with mobility impairments.

A summary of the available evacuation routes through a 1:2,000 AEP riverine flood event is described in Table 10.

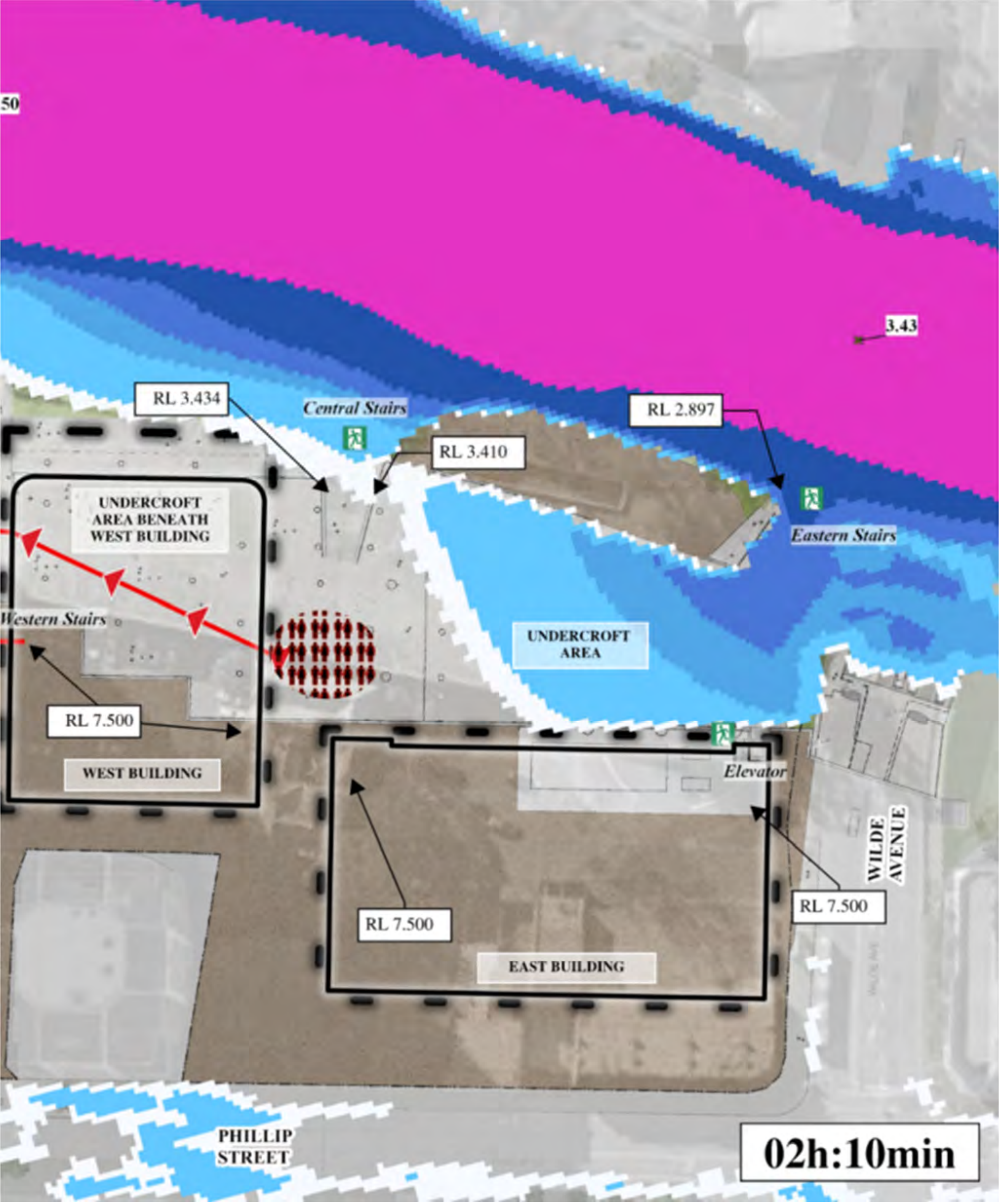

2.67
APPROX. 86 METRES TRAVEL PATH LENGTH FROM UNDERCROFT AREA, THROUGH CENTRAL STAIRCASE AND INTO EITHER WEST OR EAST BUILDING GROUND LEVEL
APPROX. 65 METRES TRAVEL PATH LENGTH FROM NORTHEAST RIVER AREA UP, THROUGH EAST STAIRCASE AND INTO EAST BUILDING GROUND LEVEL
APPROX.46 METRES TRAVEL PATH LENGTH FOR DDA ACCESS FROM NORTHEAST RIVER AREA TO LIFT ACCESS FOR EASTERN BUILDING
2.64
RL 3.434
Central Stairs
RL 3.410
RL 2.897
UNDERCROFT AREA BENEATH WEST BUILDING
TRAVEL PATH ALONG TERRACE SPANNING OVER UNDERCROFT AREA
Eastern Stairs
Western Stairs
UNDERCROFT AREA
LIFT ACCESS FROM UNDERCROFT TO EAST BUILDING FLOOR LEVELS
RL 7.500
WEST BUILDING
Elevator
APPROX. 70 METRES TRAVEL PATH LENGTH FOR DDA ACCESS FROM EAST UNDERCROFT AREA TO LIFT ACCESS FOR EASTERN BUILDING
TRAVEL PATHS ALONG TERRACE SPANNING OVER UNDERCROFT AREA
WILDE AVENUE
RL 7.500
RL 7.500
EAST BUILDING
PHILLIP STREET
01h:00min



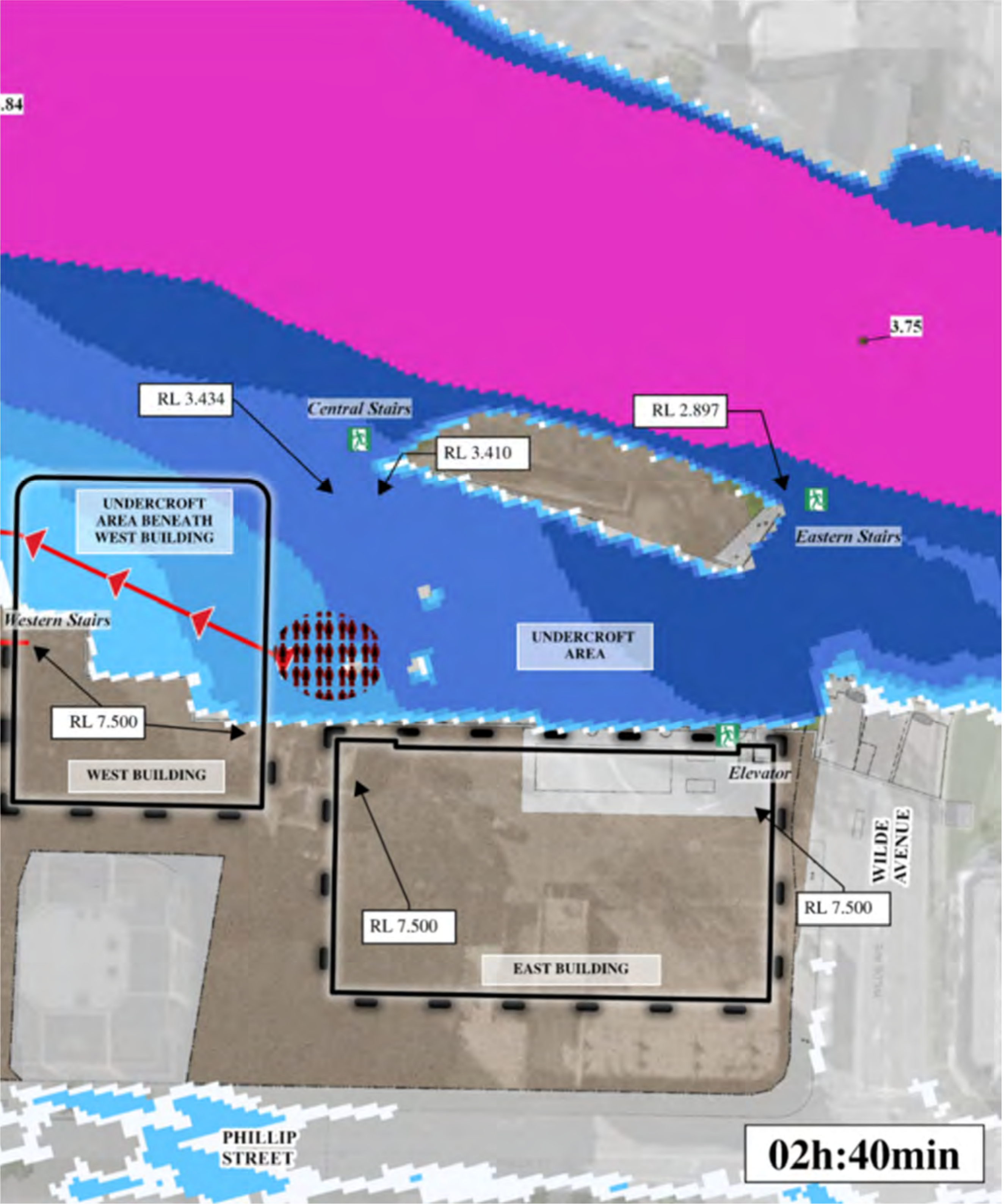
2.95
APPROX. 86 METRES TRAVEL PATH LENGTH FROM UNDERCROFT AREA, THROUGH CENTRAL STAIRCASE AND INTO EITHER WEST OR EAST BUILDING GROUND LEVEL
2.92
RL 3.434
Central Stairs
RL 3.410
RL 2.897
Eastern Stairs
UNDERCROFT AREA BENEATH WEST BUILDING
Western Stairs
UNDERCROFT AREA
LIFT ACCESS FROM UNDERCROFT TO EAST BUILDING FLOOR LEVELS
RL 7.500
WEST BUILDING
Elevator
APPROX. 70 METRES TRAVEL PATH LENGTH FOR DDA ACCESS FROM EAST UNDERCROFT AREA TO LIFT ACCESS FOR EASTERN BUILDING
WILDE AVENUE
TRAVEL PATHS ALONG TERRACE SPANNING OVER UNDERCROFT AREA
RL 7.500
RL 7.500
EAST BUILDING
PHILLIP STREET
01h:20min

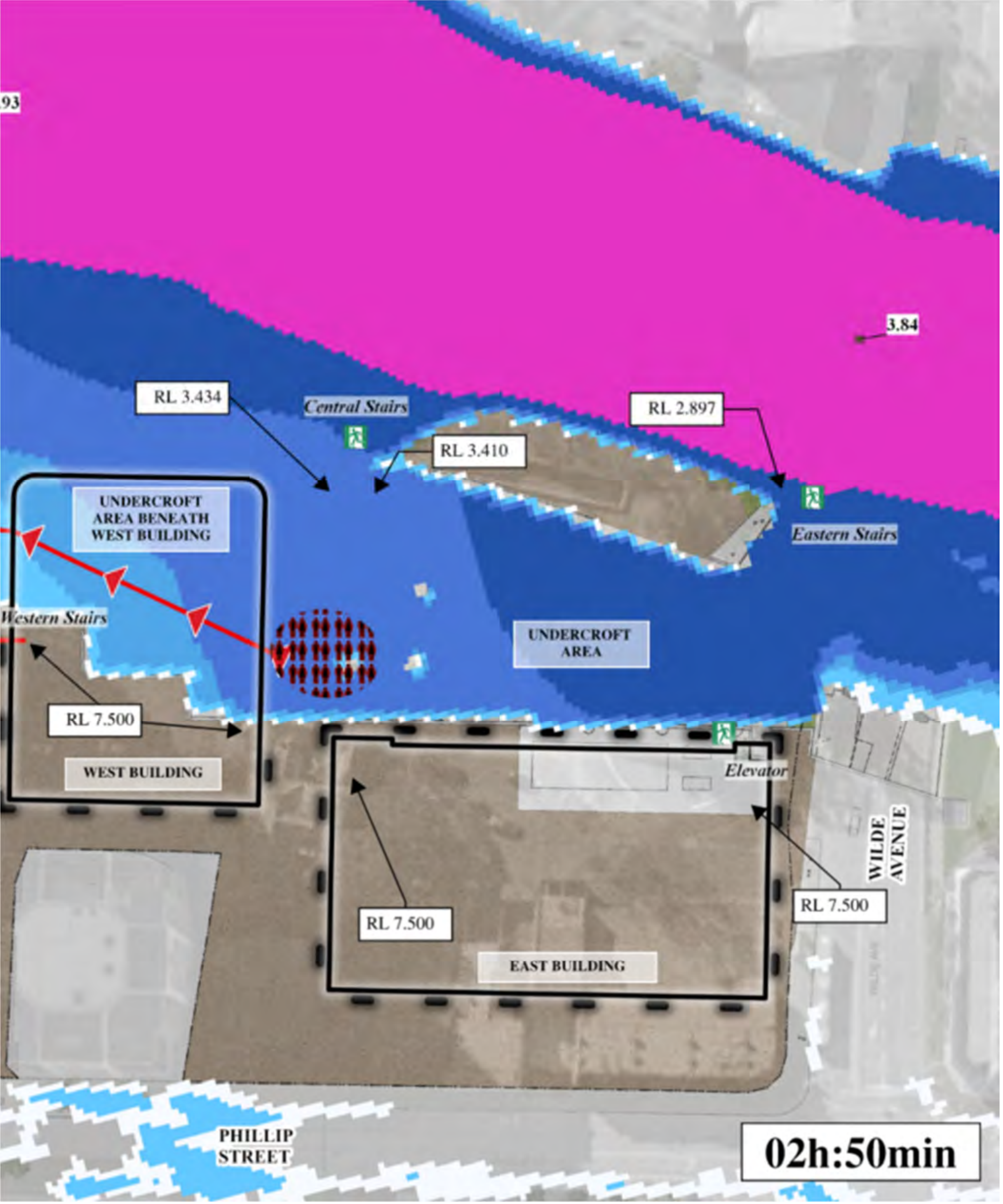


.30
APPROX. 86 METRES TRAVEL PATH LENGTH FROM UNDERCROFT AREA, THROUGH CENTRAL STAIRCASE AND INTO EITHER WEST OR EAST BUILDING GROUND LEVEL
3.24
RL 3.434
Central Stairs
RL 3.410
RL 2.897
Eastern Stairs
UNDERCROFT AREA BENEATH WEST BUILDING
Western Stairs
UNDERCROFT AREA
RL 7.500
WEST BUILDING
Elevator
TRAVEL PATHS ALONG TERRACE SPANNING OVER UNDERCROFT AREA
RL 7.500
RL 7.500
EAST BUILDING
WILDE AVENUE
PHILLIP STREET
01h:50min



50
3.43
RL 3.434
Central Stairs
RL 3.410
RL 2.897
Eastern Stairs
UNDERCROFT AREA BENEATH WEST BUILDING
Western Stairs
UNDERCROFT AREA
RL 7.500
WEST BUILDING
Elevator
WILDE AVENUE
RL 7.500
RL 7.500
EAST BUILDING
PHILLIP STREET
02h:10min


.84
3.75
RL 3.434
Central Stairs
RL 3.410
RL 2.897
Eastern Stairs
UNDERCROFT AREA BENEATH WEST BUILDING
Western Stairs
UNDERCROFT AREA
RL 7.500
WEST BUILDING
Elevator
RL 7.500
RL 7.500
EAST BUILDING
WILDE AVENUE
PHILLIP STREET
02h:40min



93
3.84
RL 3.434
Central Stairs
RL 3.410
RL 2.897
Eastern Stairs
UNDERCROFT AREA BENEATH WEST BUILDING
Western Stairs
UNDERCROFT AREA
RL 7.500
RL 7.500
WEST BUILDING
Elevator
RL 7.500
RL 7.500
EAST BUILDING
WILDE AVENUE
PHILLIP STREET
02h:50min

Table 10: Available Egress Routes during Flood Event

Time in hours after start of intense rainfall. *(Time after initiation of Emergency Management Plan)*	**Evacuation Route Available**				
	Eastern Stairs	**Elevator**	**Central Stairs**	**Western Stairs**	**Comments**
1 hr 20 min *(20 mins after initiation of EMP)*	✓	✓	✓	✓	Eastern stairs would be inundated early and not provide an access to the ground floor from 20 minutes after the start of the evacuation stage of the Emergency Management Plan. See Figure 22
1 hr 50 min *(50 mins after initiation of EMP)*	✗	✓	✓	✓	There would be a total of about 50 minutes to move people with mobility impairments to the ground floor and then to Level 1 using the lift. These people would be given priority to use the lifts over this 50-minute period while others would be directed to the central and western stairs. Assuming a return lift trip from the undercroft level to Level 1 takes two minutes and a capacity of approximately four mobility impaired people, there is sufficient time to move 100 mobility impaired people in this time. See Figure 23
2 hr 10 min *(70 mins after initiation of EMP)*	✗	✗	✓	✓	Central staircase provides access to the podium and ground level would be accessible a further 20 minutes after the lift becomes inaccessible. See Figure 24
2 hr 40 min *(100 mins after initiation of EMP)*	✗	✗	✗	✓	Western stairs would be the last part of the undercroft to become inundated and would be accessible a further 30 minutes after the central staircase is inaccessible. See Figure 25
2 hr 50 min *(110 mins after initiation of EMP)*	✗	✗	✗	✗	At this time the water level at the base of the western stairs is 200mm. See Figure 26

Access up Dirrabarri Lane would not be part of the Emergency Management Plan.

So, a total of 1.8 hours is available for people to leave the public domain areas via stairs after the engagement of the Emergency Evacuation Plan. For people with mobility impairments, there would be 50 minutes available after the engagement of the Emergency Management Plan.

The egress times listed above are considered more than that required to evacuate a small number of people in an orderly manner. These times could be compared to the very short times usually incorporated into fire escape plans from high-rise buildings where it is common for buildings to be evacuated in less than 15 minutes (without the aid of lifts).

8.3.4 Extreme / Rare Flood Events

Modelling of rare flood events between the 1% AEP event and the PMF was undertaken in the Powerhouse Parramatta TUFLOW model based on interpolating available hydrological data. Details of the derivation of these inputs is contained within Appendix E.

In flood events rarer than approximately the 0.2% AEP (1:500 AEP) flood event, the site and a portion of the CBD area becomes a low flood island. For these events the shelter-in-place approach is maintained. The Emergency Management Plan would be able to accommodate the response to rare floods as it would include an early trigger to move people from the lower lying public domain and undercroft areas to Level 1 (which is above the PMF level).

Critical electrical infrastructure inside the building, such as main switchboards and back-up generators, are provided and will be located above PMF level.

The sub-stations will be located more than 0.5m above the 1% AEP overland flood level (with climate change under baseline conditions which assumes no pipe blockage and some pit blockage) of 6.9mAHD. The sub-stations will be 0.5m above the 1:1000 AEP Parramatta River flood level. In the very rare flood events that would result in the sub-station being inundated, power would be supplied to Powerhouse Parramatta via the backup generators.

The backup generator capacity is sufficient to provide emergency lighting and other essential services up to 10 hours. This would far exceed the duration that people would require shelter from flooding, which is likely to be in the order of 5 hours for a PMF event. Out of 10 lifts, 8 will be connected to the back-up power supply allowing mobility impaired people to access Levels 1 and 2 from ground floor level.

8.3.5 Emergency Management Plan

A detailed emergency response plan will be prepared in conjunction with the detailed design of the proposal. It is considered appropriate that the plan is prepared at detailed design stage such that it reflects the finalised building and public domain design.

The emergency management plan should, as a minimum, include:

- Locations and levels of stairs, ramps and other available evacuation routes;
- Details of the proposed signage/alarms/PA systems in external spaces;

- Details of how the Building Management System (BMS) is linked with FloodSmart Parramatta;
- CCTV surveillance and site walkovers undertaken by staff to evacuate any people at lower lying levels;
- Management of undercroft screening/fencing being opened/retracted prior to a flood event;
- Management of lift flood gate at north-east corner of east building;
- Approach/assessment for programmable events being held in undercroft; and
- Post-flood event actions including inspections and maintenance activities.

8.4 Floodwater Flows & Structural Considerations

In line with the shelter-in-place strategy, Powerhouse Parramatta has been structurally designed to satisfy the forces from the flood waters up to the PMF event.

Full details of the structural considerations are included within the Structural Design Statement (PMH-ARP-LETT-ST-0002) appended to the Response to Submissions.

9 Conclusion and Recommendations

This addendum report has assessed the flooding and stormwater management and requirements for the Powerhouse Parramatta design that has been amended following public exhibition of the EIS.

The following list provides a brief summary of the key conclusions and recommendations for the development:

- The assessment of the pre-development site conditions has identified there are two types of flooding mechanisms impacting this site: riverine flooding from the Parramatta River north of the site and overland flow flooding in areas generally to the south and west of the site.
- A key element of the strategy to maintain riverine flood behaviour is the use of the undercroft spaces and external spaces to maintain pre-development flood conveyance along this section of the river channel. Hence, there would not be any adverse flood impacts on surrounding or adjacent properties as a result of riverine flooding for events up to and including the 1% AEP event.
- Overland flood impacts would be managed by the provision of the augmented stormwater network which would reduce overland flood levels up to and including the 1% AEP event.
- New stormwater infrastructure would be provided to serve the site as part of the flood risk mitigation strategy and replace and augment existing drainage assets impacted by the development.
- On-site detention is not recommended for the development given its location on the banks of the Parramatta River meaning that rainwater and runoff can be conveyed off-site rapidly into the river before the peak of river.
- Water quality measures can be used to implement an effective WSUD strategy to reduce the quantity of pollutants draining off the development site into the river and thereby satisfy CoPC’s DCP requirements.
- Proposed building finished ground floor level will provide 1.4m freeboard from riverine flooding and 0.8m freeboard from overland flooding in the 1% AEP event.
- The finished ground floor level would have a flood immunity of approximately 1:800 AEP including allowances for freeboard for riverine and overland flooding. This is an appropriate response to the flood hazards of the site to manage the risks associated with overland and riverine flooding.
- Sensitivity analyses have been run to consider a scenario of 100% pit and pipe blockage which demonstrate that the ground floor of the proposed development would still achieve 0.3m of freeboard in the 1% AEP event with all pits and pipes blocked.
- A shelter-in-place strategy is to be adopted that can cater for flood events up to the PMF.

- Multiple evacuation routes have been provided within the urban design to allow pedestrians to reach podium level and access the ground floor of the buildings and from there access to Level 1 is available (which is above the PMF level);
- Critical electrical infrastructure within the building would be located above the PMF level.
- The Powerhouse Parramatta project has been developed such that there would be no substantial modification to the existing flood behaviour upstream or downstream of the site whilst protecting the patrons and the new building assets (and the museum collection) from an appropriate level of flood risk.

10 Limitations and Further Work

10.1 Limitation and Risks

Given the pre-development flooding and stormwater conditions on the Powerhouse Parramatta development site, there has been significant effort expended to develop the comprehensive flood modelling and design work presented in this report to as high a standard as possible. Nevertheless, there are some residual limitations and risks associated with the work which will be given further consideration as the design develops:

- The proposed layout, levels and built form of the buildings, undercroft areas, external areas and roads/footpaths are to be further developed with the architects during detailed design. Further development will be undertaken as development proposals evolve including the design of tie-ins with the surrounding existing terrain.
- The flood model does not currently account for all recent developments within the Parramatta CBD catchment (such as Parramatta Square, currently in construction) or proposed changes due to major future infrastructure projects (such as Parramatta Light Rail and Phillip Street upgrades). The patterns of both pre- and post- development overland flood flow behaviour may change as a result of these developments. However, the overall intent and conclusions of the flood assessments are unlikely to be significantly affected by these developments; and
- The flood model has not been comprehensively calibrated against measured data or other flood models. It would be ideal to use the upcoming CoPC flood model following its adoption by CoPC. However, at this time that model is not adopted and has not been used or used as a benchmark. When this model is available, calibration checks using the ARR2019 hydrological methods would be useful to validate the Powerhouse Museum Flood Model.

10.2 Further Work

This report presents the work that has been completed in relation to stormwater and flood risk management at concept design stage. Beyond this submission, the designs will be developed a part of detailed design. Specific items to be developed include:

- Further development of the site-wide terrain model to achieve adequate grades and flood outcomes while mitigating adverse effects to adjacent properties. This includes:
    - Raising the floor level of the loading dock in the East Building to better interface with Wilde Avenue;

  - Stormwater collection features within the public domain near the vehicle entryway to 32 Phillip Street, existing 300 Church Street and proposed entryways into the west building;
  - Finished ground levels along the northern boundary of 32 Philip Street;
  - Grading and finished surface level of the terrace level north of the proposed buildings;
  - Grading and finished surface levels of the river level area, including the bottom of Dirrabarri Lane ramp and interface with the existing Meriton staircase. This is subject to confirmation of the pedestrian link between Powerhouse Parramatta and the Meriton Development; and
  - Increasing the top of wall height of the retaining wall adjacent to the Meriton Development.

- Coordinate and integrate building downpipe connections with proposed stormwater systems;
- Where possible, optimise the layout, dimensions and hydraulic capacity of proposed stormwater pits and pipes networks whilst continuing to achieve the design intent;
- Develop the 3D design of proposed stormwater and utility services, verify space proofing with consideration to existing retained utilities such as the Sydney Water sewer;
- Develop the Water Sensitive Urban Design (WSUD) strategy with the design team, INSW and Powerhouse with consideration to the CoPC pollutant reduction targets;
- Ongoing coordination of the landscape and building architectural designs with respect to stormwater, flooding and flood emergency management; and
- The Emergency Management Plan is to be developed, including any warning systems, through ongoing discussions with INSW, MAAS, SES in coordination with the architectural design.
- As the design develops, the flood model will require updating to ensure consistency and compliance with the principles outlined in this report.

11 Reference Documents

Research and investigation presented in this report is based on information from a wide range of sources which include:

- 330 Church Street Parramatta, Flood and Stormwater Management Report by Mott MacDonald, dated December 2011;
- Architectural Building design as detailed within Architectural Design Report Addendum, Moreau Kusonoki-Genton,;
- Architectural Landscape design - McGregor Coxall Powerhouse Parramatta reference LD-DD-01 & LD-DD02, dated 26/08/2020;
- Australian Disaster Resilience Guideline 7-3 Flood Hazard (AIDR) 2017;
- Australian Rainfall and Runoff 1987;
- Australian Rainfall and Runoff 2019;
- Bureau of Meteorology – The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method, June 2003;
- City of Parramatta Council Local Environmental Plan (LEP) 2011;
- City of Parramatta Council Development Control Plan (DCP) 2011;
  - Part 2.4.2 Water Management
  - Part 2.4.3 Soil Management
- City of Parramatta Floodplain Risk Management Policy 2014;
- City of Parramatta Development Engineering Design Guidelines, dated June 2018;
- Flood modelling input information provided by City of Parramatta Council;
  - Mike11 Draft 8, received 11 March 2020
  - Mike11 Draft 9, received 19 March 2020
- NSW Water Management Act 2000;
- NSW Floodplain Development Manual 2005;
- NSW DP&E Secretary's Environmental Assessment Requirements (SEARs) reference: SSD-10416 dated: 10 February 2020
- Parramatta River Flood Study, Final Draft by Cardno, dated 10 December 2019;
- Riverbank Precinct Master Plan, Drainage and Flooding Study by Cardno, dated 9 March 2016;
- The New Museum, Parramatta, Flood Study Final version 6 by TTW, dated November 2016, and accompanying TUFLOW model;
- Update of Parramatte Floodplain Risk Management Plans, Updated Parramatta FRMP v3 by Molino Stewart, dated 26th February 2016.
- Upper Parramatta River Catchment Trust – On-site Stormwater Detention Handbook Fourth Edition, dated December 2005;
- Developer Handbook for Water Sensitive Urban Design, Blacktown City Council, dated November 2013;
- Water Sensitive Urban Design Technical Guidelines for Western Sydney, Draft, UPRCT, dated 7 November 2003;

- Draft NSW MUSIC Modelling Guidelines, Sydney Metropolitan Catchment Management Authority, dated August 2010.

Appendix A | Flood Modelling Figures

Legend

- TUFLOW Model Boundary
- MIKE11 Boundary Conditions
- Development Site Boundary
- Existing Building Outlines
- River/Creek
- Post-development Pipes
- Pre-Development Pipes

Issue	Date	By	Chkd	Appd
2	3/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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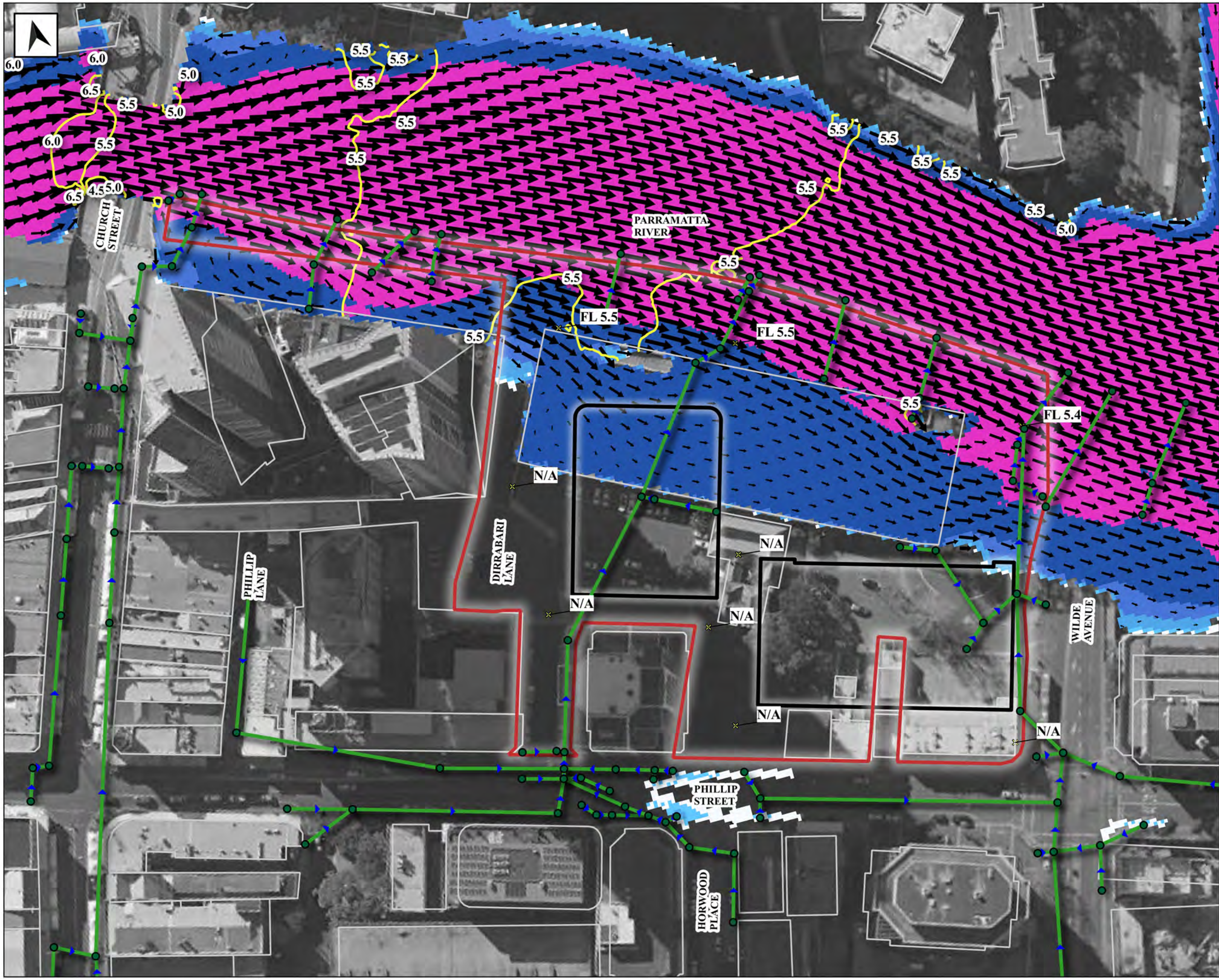
Powerhouse Parramatta

Model Setup

Scale at A3 1:6000

Job No	Figure Status
273467	Final

Figure No	Issue
EP.0-S	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Pre-development Pits
- Pre-development Pipes
- Flow Direction
- Flood Level (mAHD)
- 8.0 Peak Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00- 2.00
- > 2.00

Issue	Date	By	Chkd	Appd
2	14/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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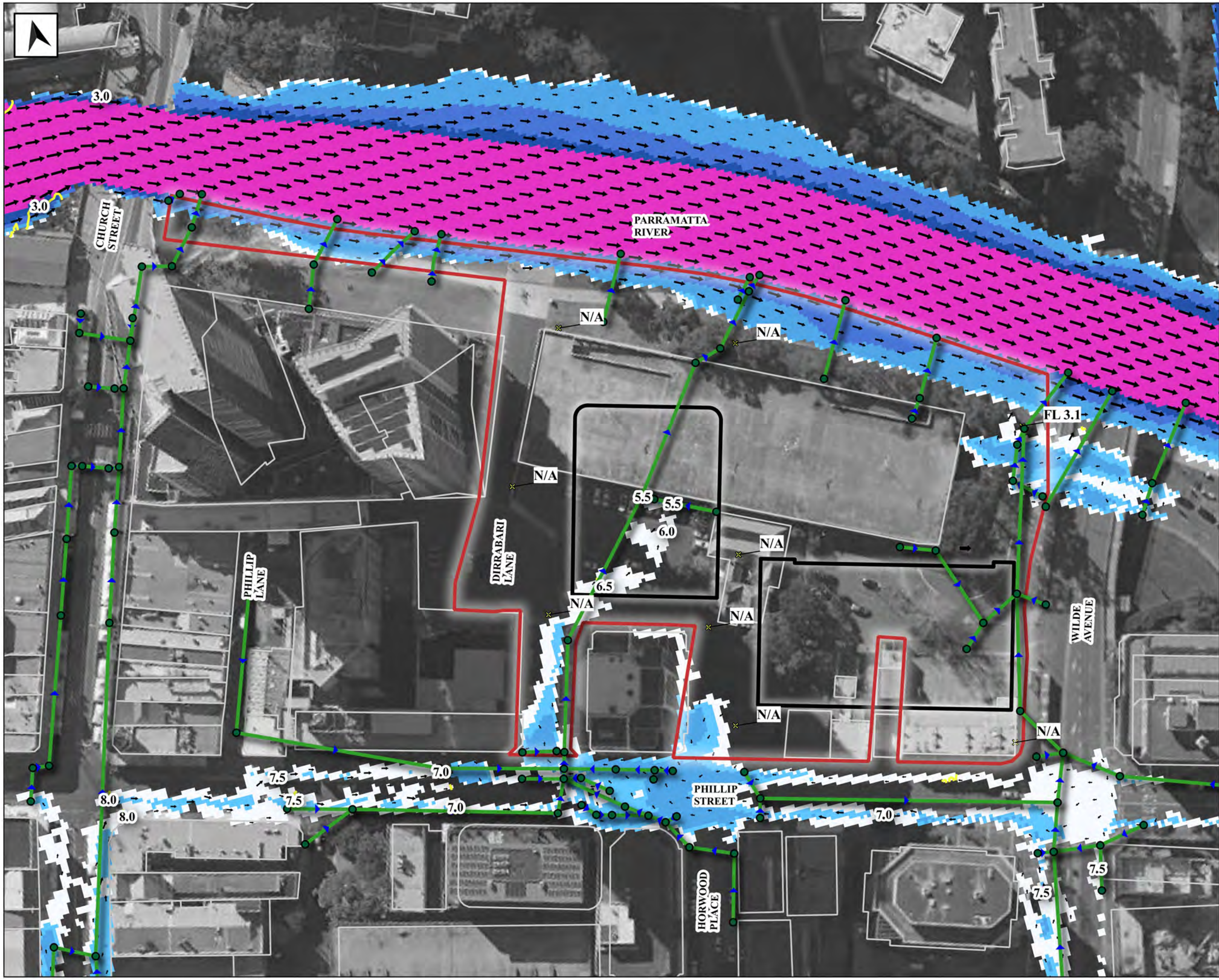
Pre-development - River Flood
Peak Depths and Levels
5% AEP (9 Hours)

Scale at A3
1:1000

0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
E1.0-5D-MF	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Pre-development Pits
- Pre-development Pipes
- Flow Direction
- Flood Level (mAHD)
- **8.0** Peak Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00- 2.00
- > 2.00

Issue	Date	By	Chkd	Appd
2	14/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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Pre-development - Overland Flood
Peak Depths and Levels
5% AEP (25 Minutes)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
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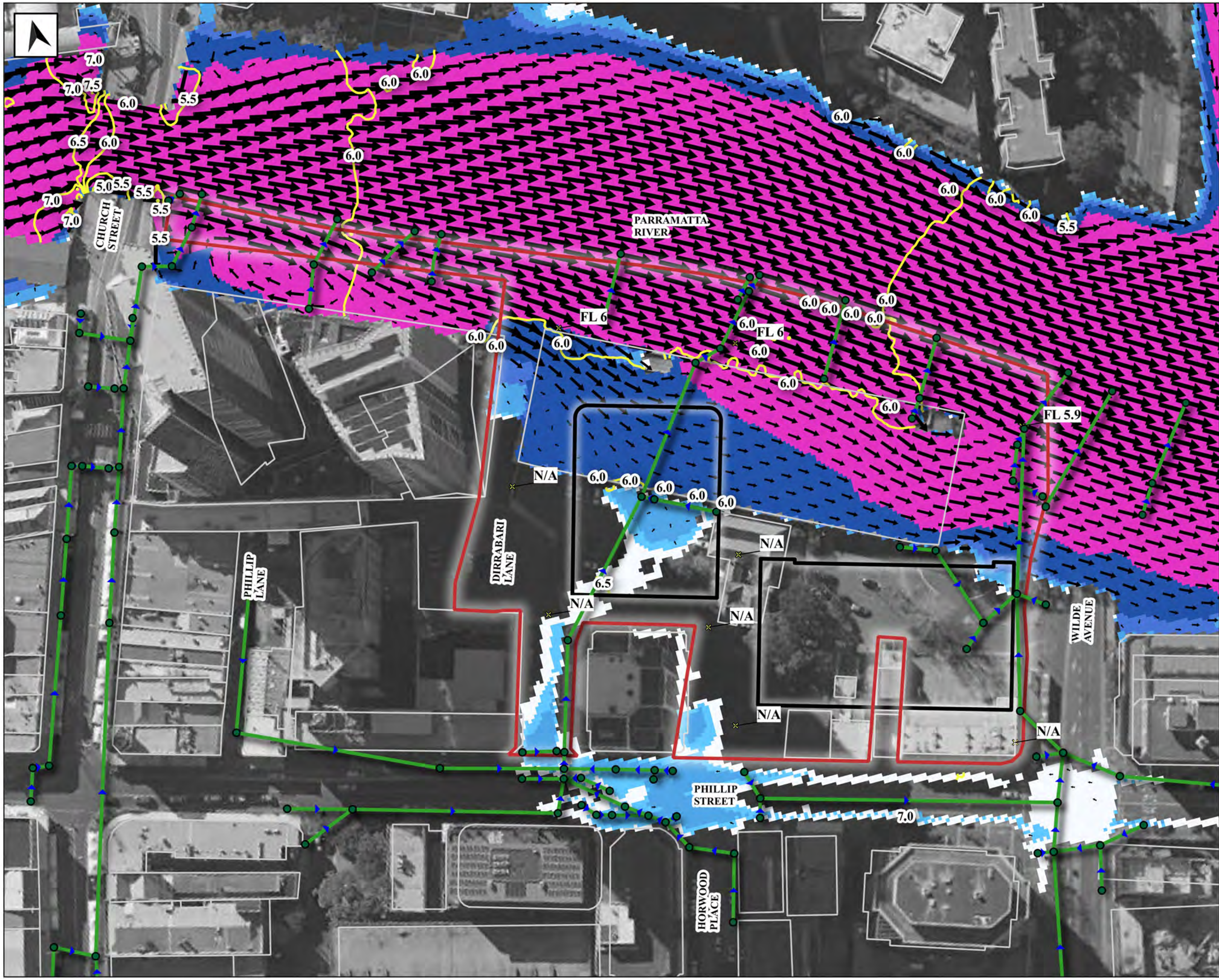

Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Pre-development Pits
- Pre-development Pipes
- Flow Direction
- Flood Level (mAHD)
- 8.0 Peak Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00- 2.00
- > 2.00

Issue	Date	By	Chkd	Appd
2	14/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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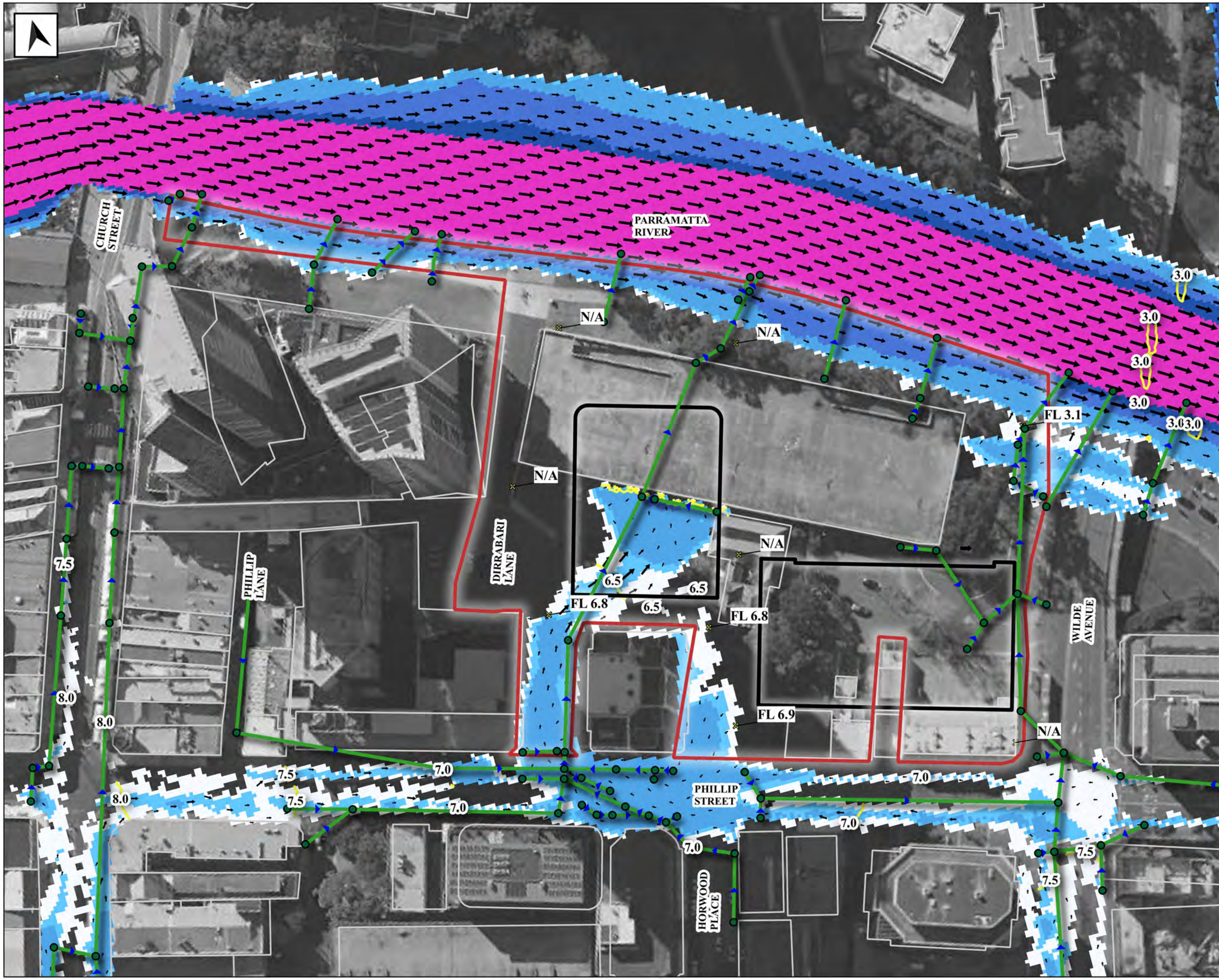
Pre-development - River Flood
Peak Depths and Levels
1% AEP (9 Hours)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
E1.0-1D-MF	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Pre-development Pits
- Pre-development Pipes
- Flow Direction
- Flood Level (mAHD)
- 8.0 Peak Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00- 2.00
- > 2.00

Issue	Date	By	Chkd	Appd
2	14/09/2020	AA	NC	EM
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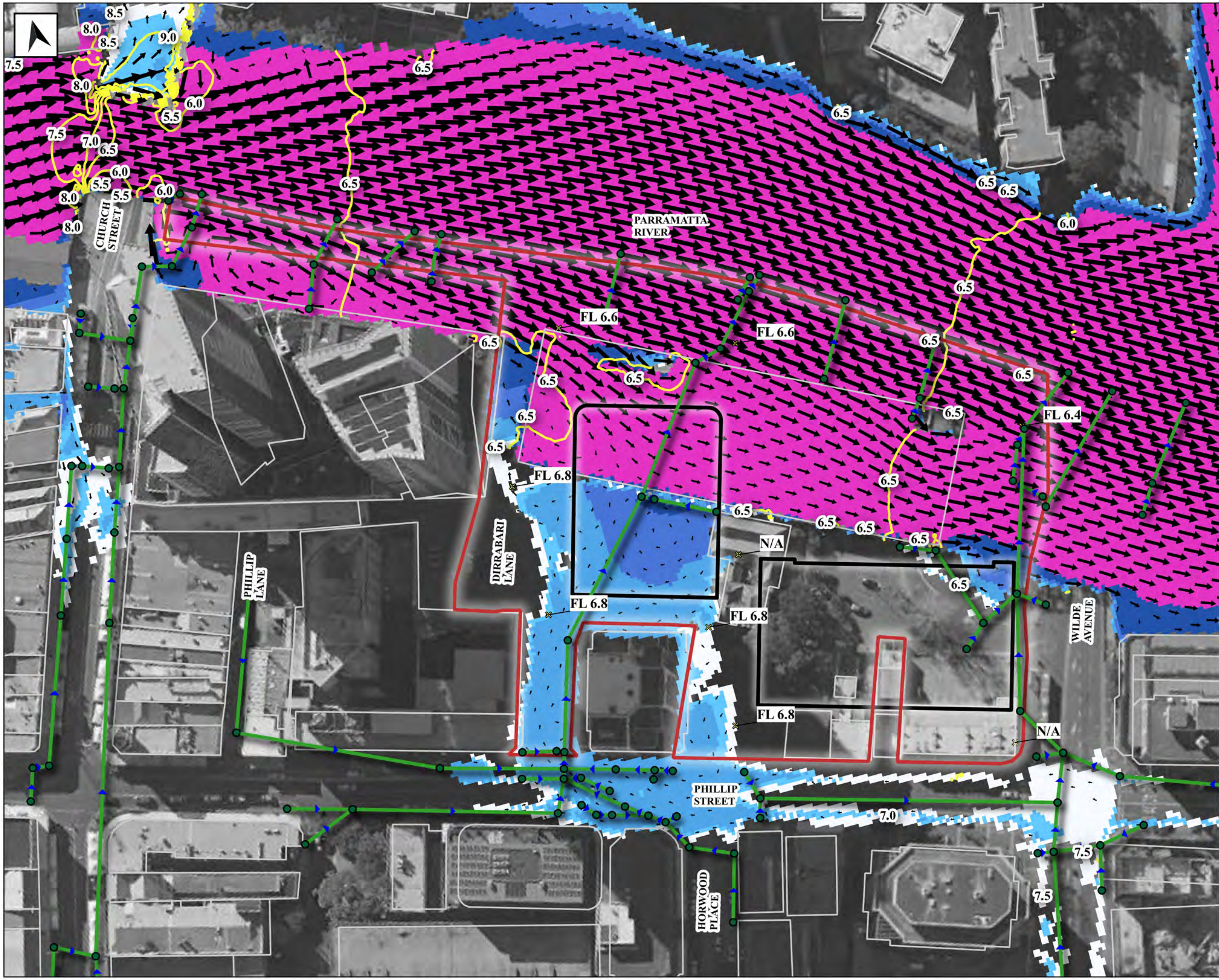
Powerhouse Parramatta

Pre-development - Overland Flood
Peak Depths and Levels
1% AEP (20 Minutes)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
E1.0-1D-OF	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Pre-development Pits
- Pre-development Pipes
- Flow Direction
- Flood Level (mAHD)
- 8.0 Peak Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00- 2.00
- > 2.00

Issue	Date	By	Chkd	Appd
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1	3/04/2020	AA	NC	DC

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MAAS Museum of Applied Arts & Sciences

Powerhouse Parramatta

Pre-development - River Flood
Peak Depths and Levels
1% AEP & Climate Change (9 Hours)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
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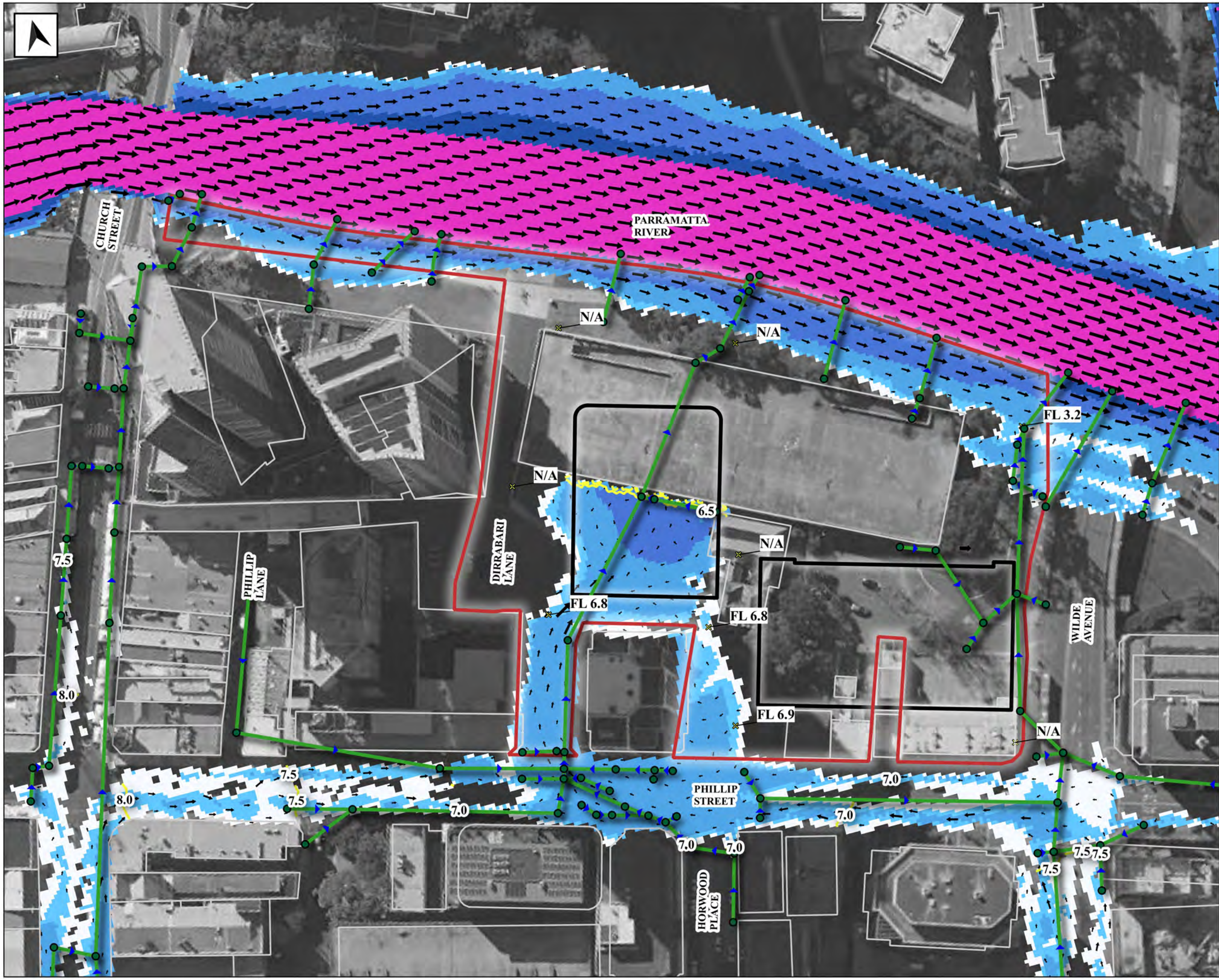

Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Pre-development Pits
- Pre-development Pipes
- Flow Direction
- Flood Level (mAHD)
- 8.0 Peak Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00- 2.00
- > 2.00

Issue	Date	By	Chkd	Appd
2	14/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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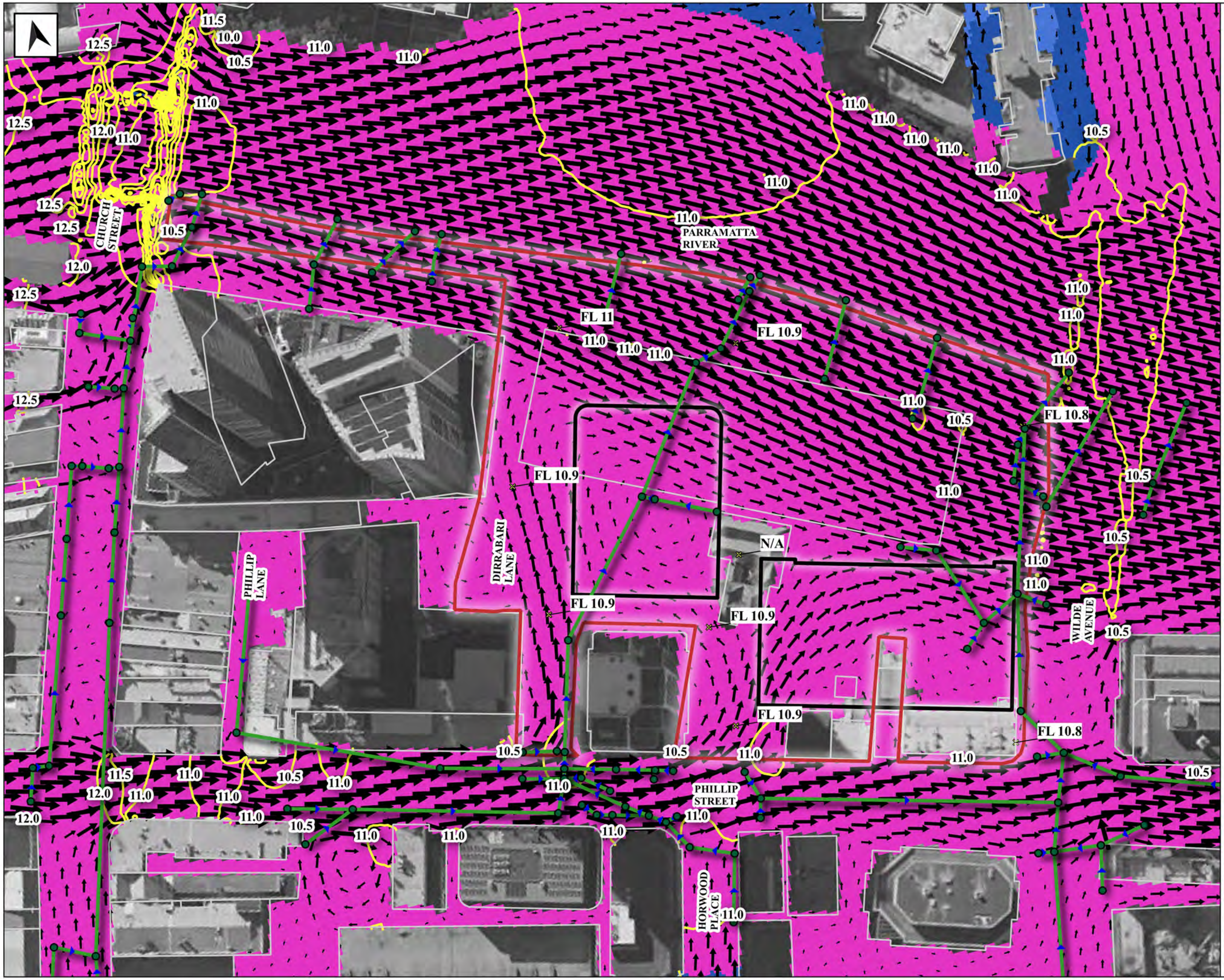
Powerhouse Parramatta

Pre-development - Overland Flood
Peak Depths and Levels
1% AEP & Climate Change (20 Minutes)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
E1.0-1ccD-OF	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
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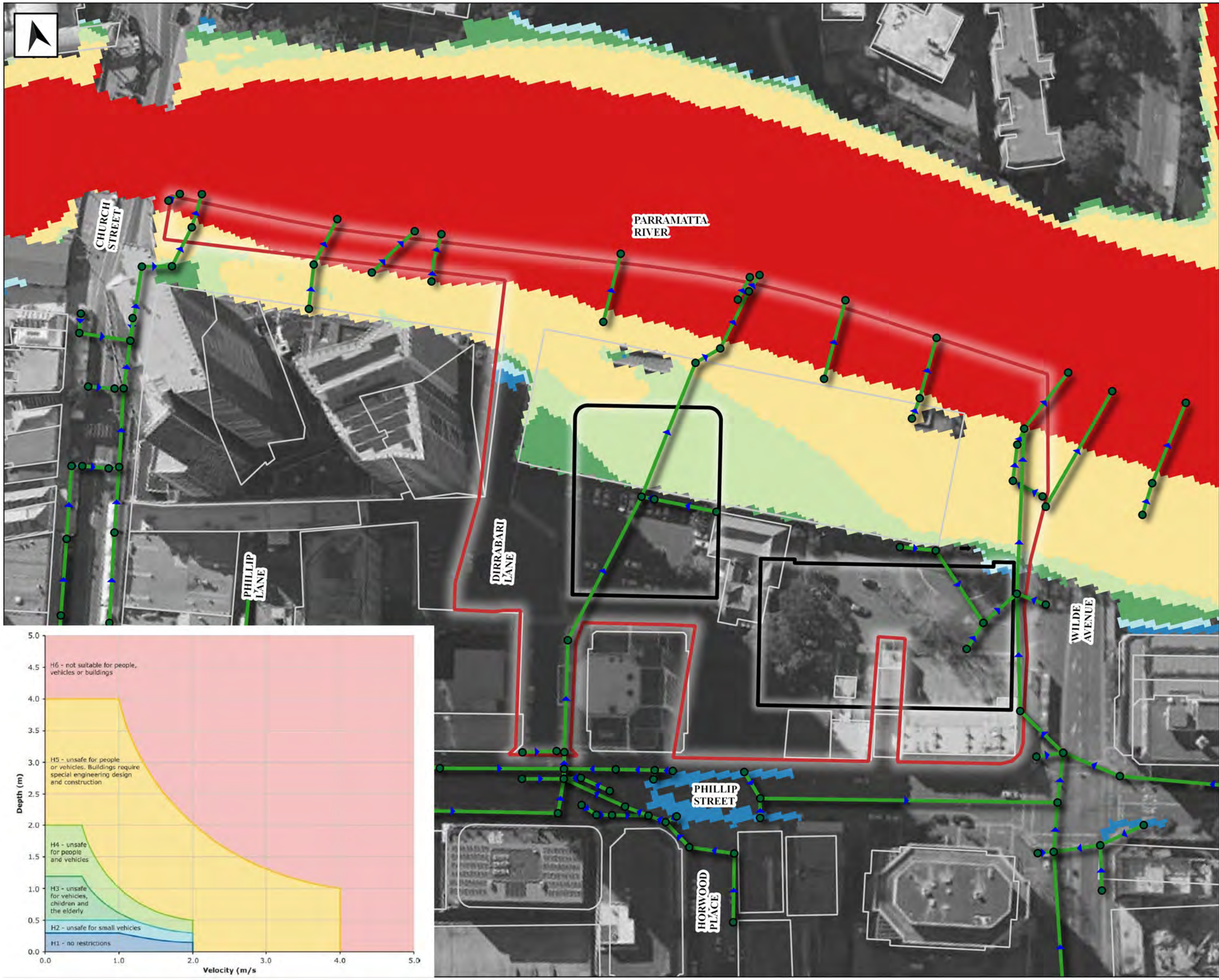
Pre-development - River & Overland Flood
Peak Depths and Levels
PMF (4 Hours)

Scale at A3 1:1000

0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
E1.0-PMFD-MOF	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Pre-development Pits
- Pre-development Pipes

Flood Hazard Category

(Australian Management Institute, 2014)

- H1 — Relatively benign flow conditions. No vulnerability constraints.
- H2 — Unsafe for small vehicles.
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Pre-development - River Flood Hazard
5% AEP (9 Hours)

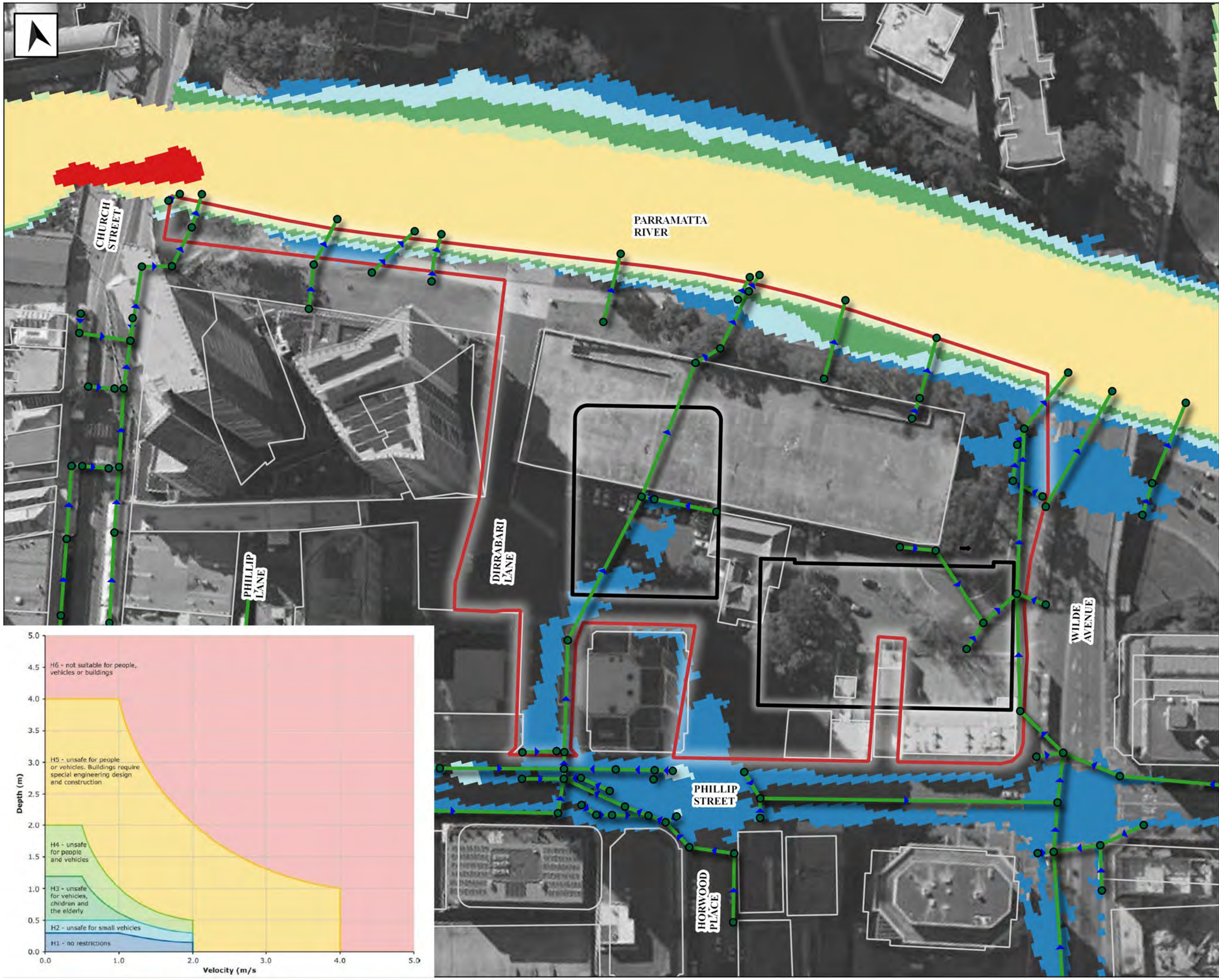
Scale at A3
1:1000

Job No
273467

Figure Status
Final

Figure No
E1.0-5H-MF

Issue
2



Legend

- Development Site Boundary
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- Pre-development Pits
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Flood Hazard Category

(Australian Management Institute, 2014)

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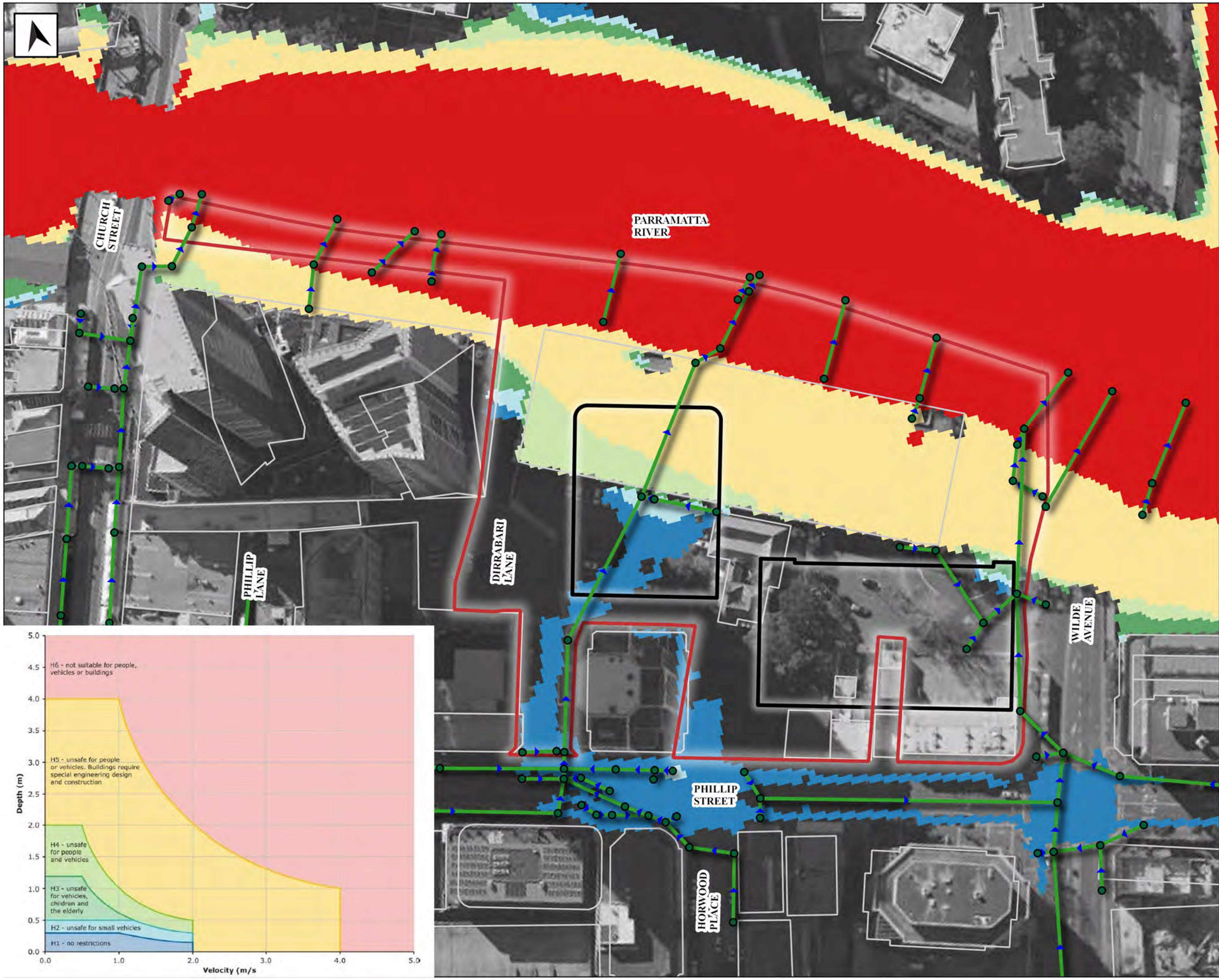
Pre-development - Overland Flood Hazard
5% AEP (25 Minutes)

Scale at A3
1:1000

0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
E1.0-5H-OF	2



Legend

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- Existing Building Outlines
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Pre-development - River Flood Hazard
1% AEP (9 Hours)

Scale at A3 1:1000

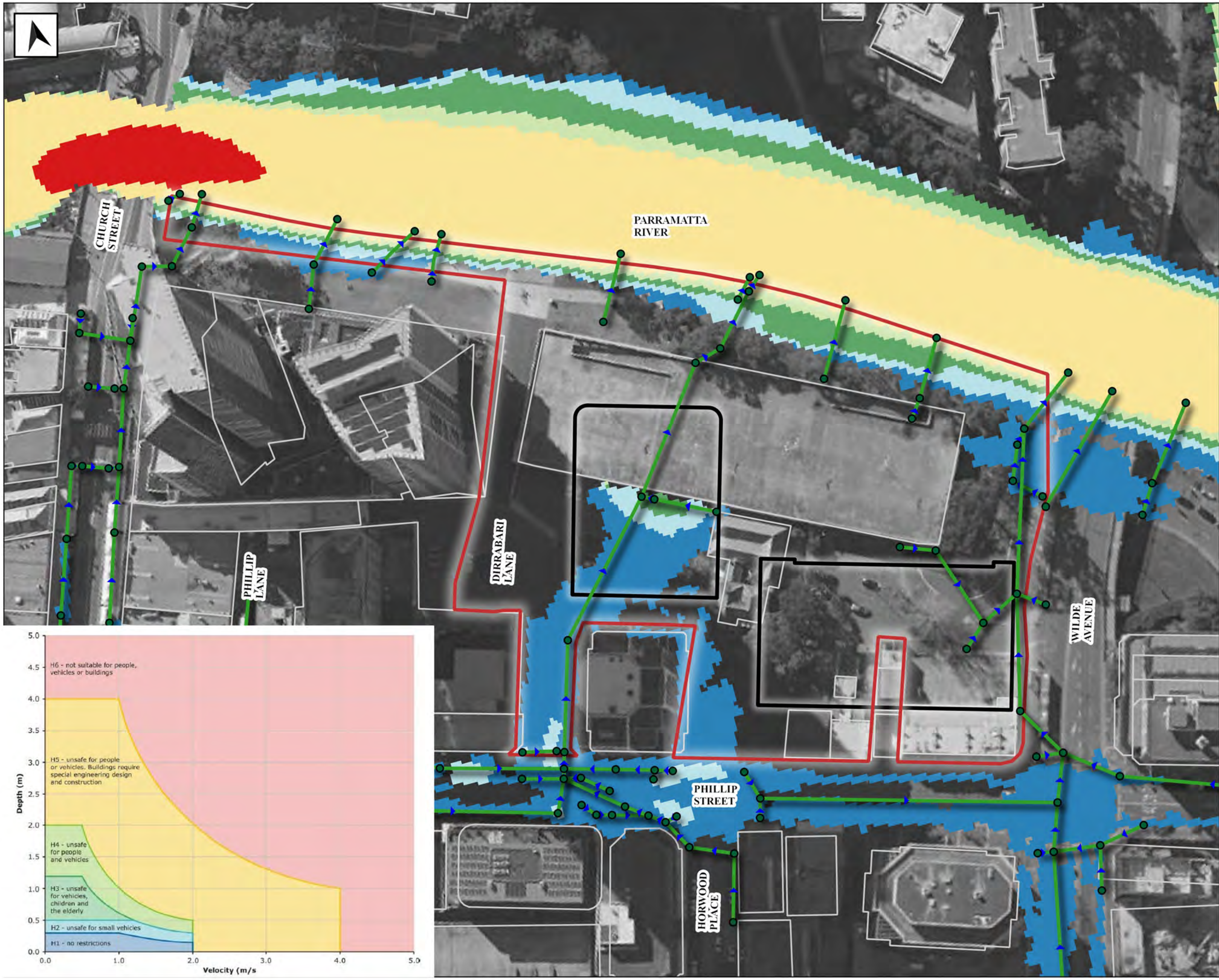
0 25 50 m

Job No 273467

Figure Status Final

Figure No E1.0-1H-MF

Issue 2



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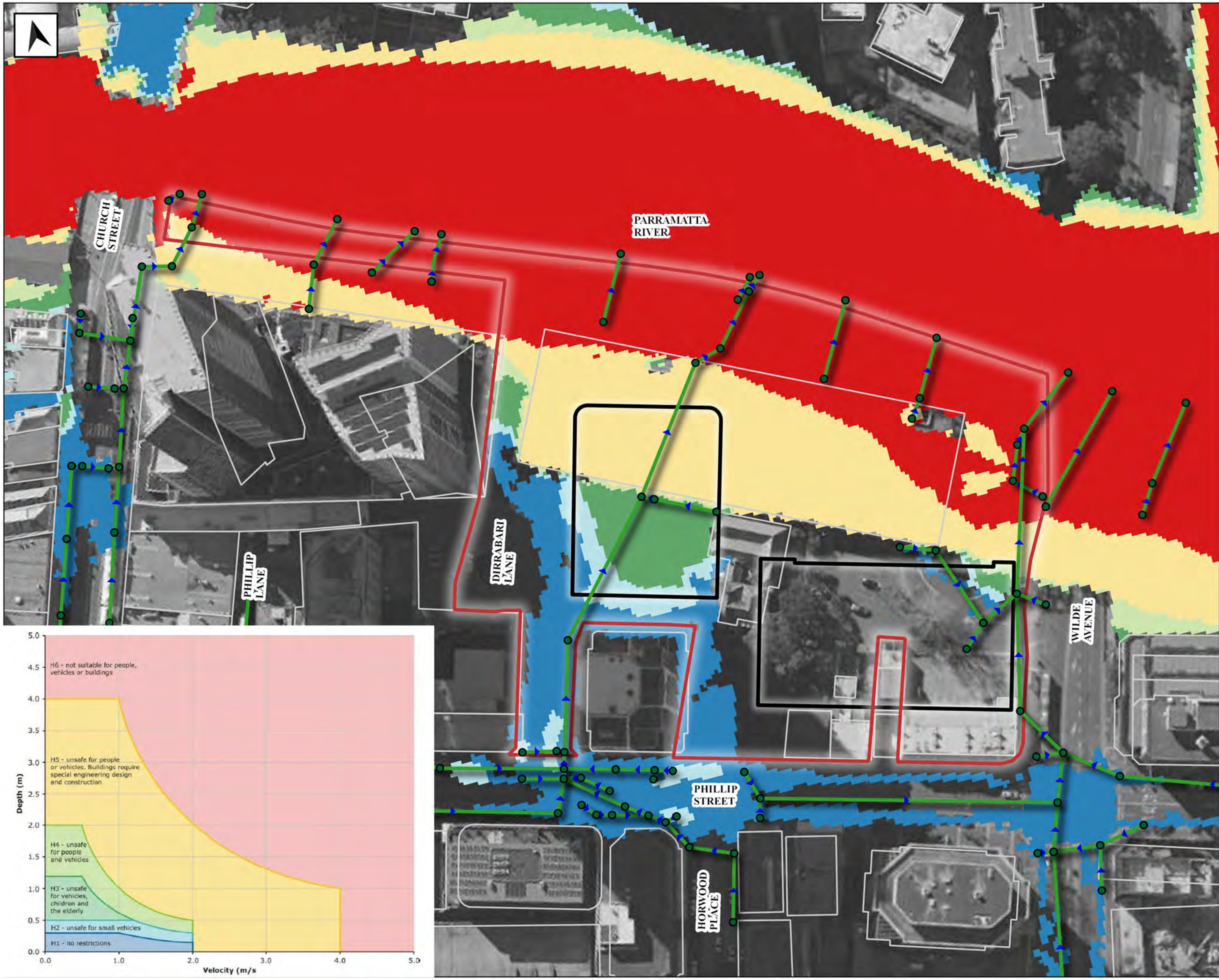
Pre-development - Overland Flood Hazard
1% AEP (20 Minutes)

Scale at A3
1:1000

0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
E1.0-1H-OF	2



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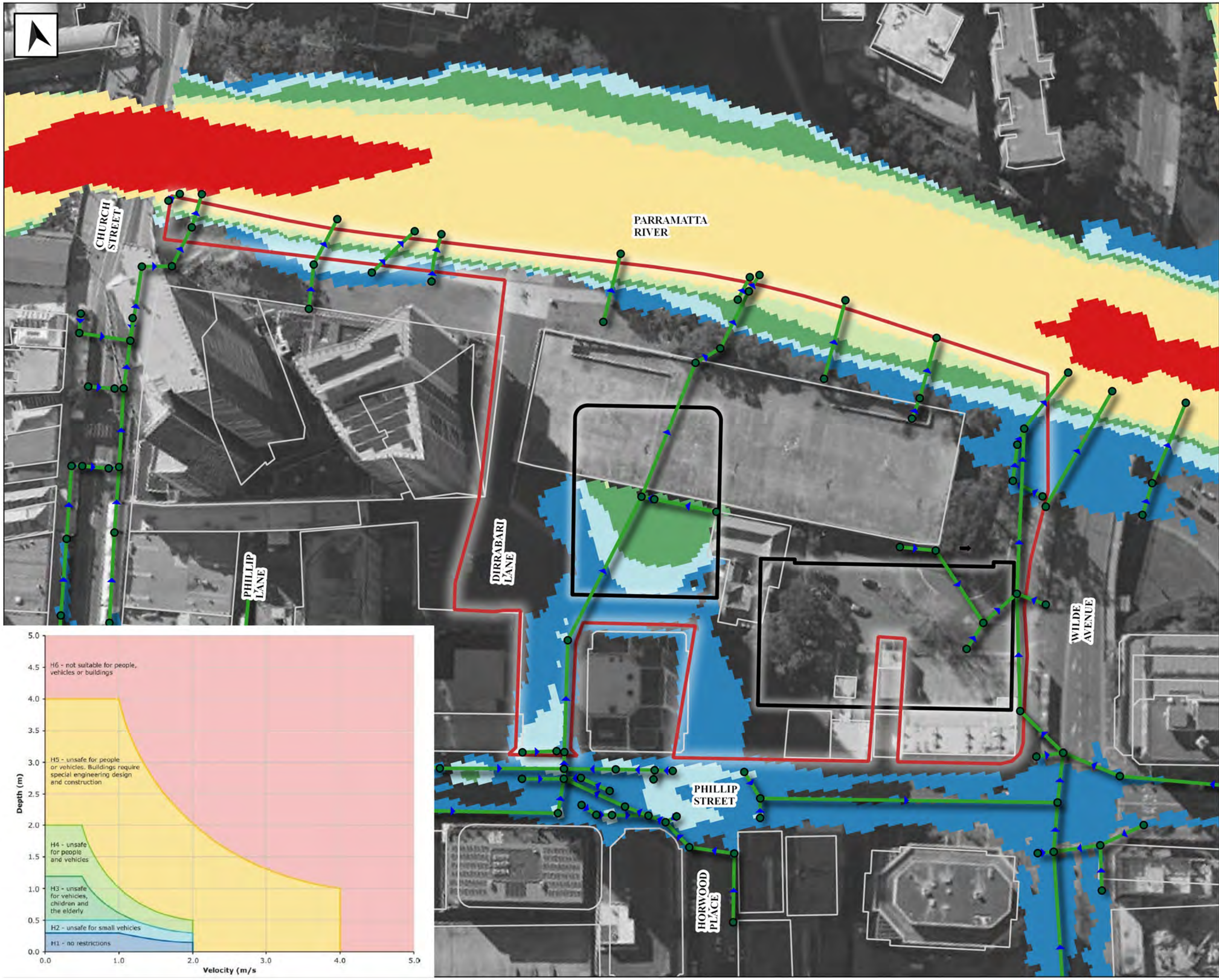
Pre-development - River Flood Hazard
1% AEP & Climate Change (9 Hours)

Scale at A3
1:1000

0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
E1.0-1ccH-MF	2



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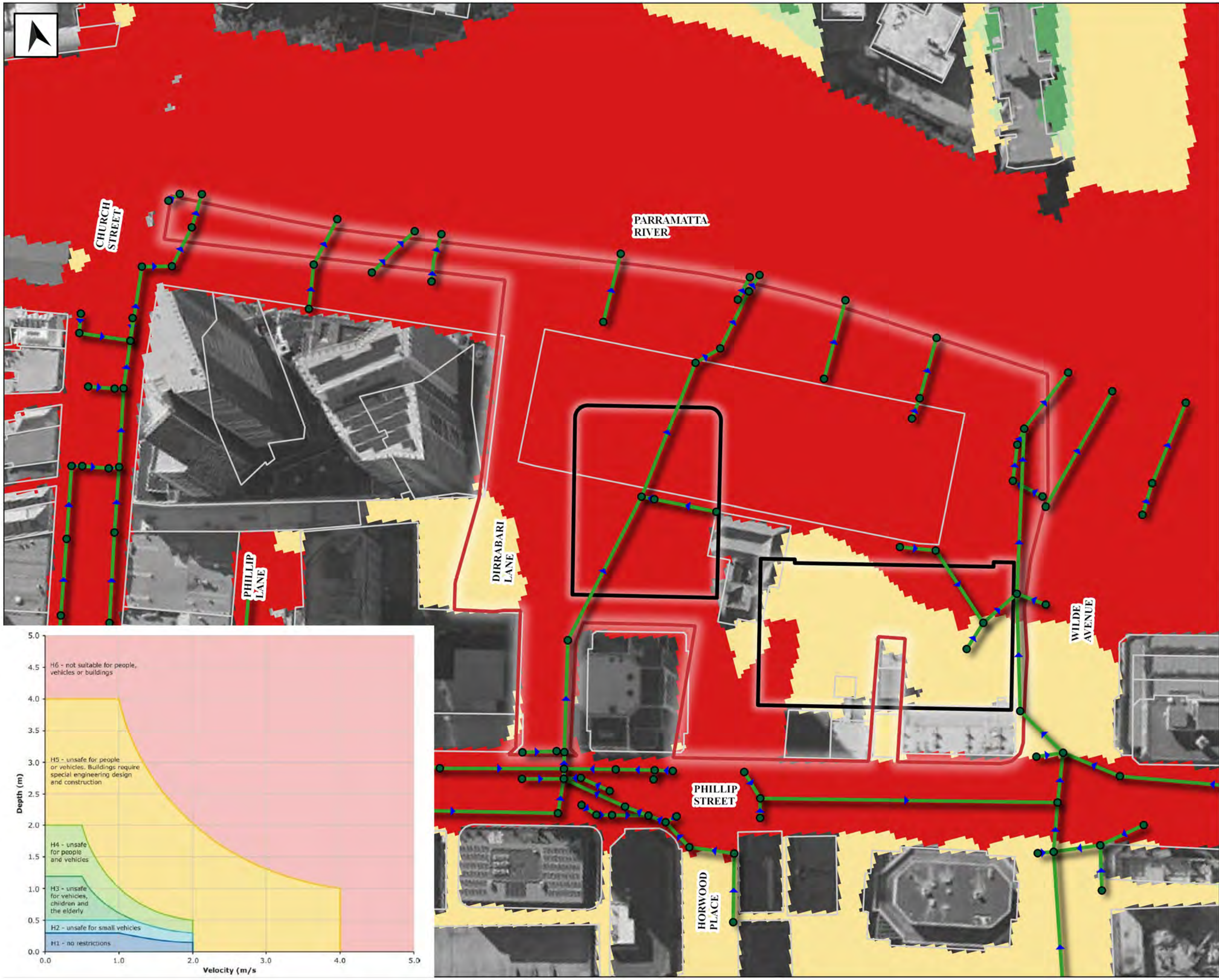
Pre-development - Overland Flood Hazard
1% AEP & Climate Change (20 Minutes)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
E1.0-1ccH-OF	2



Legend

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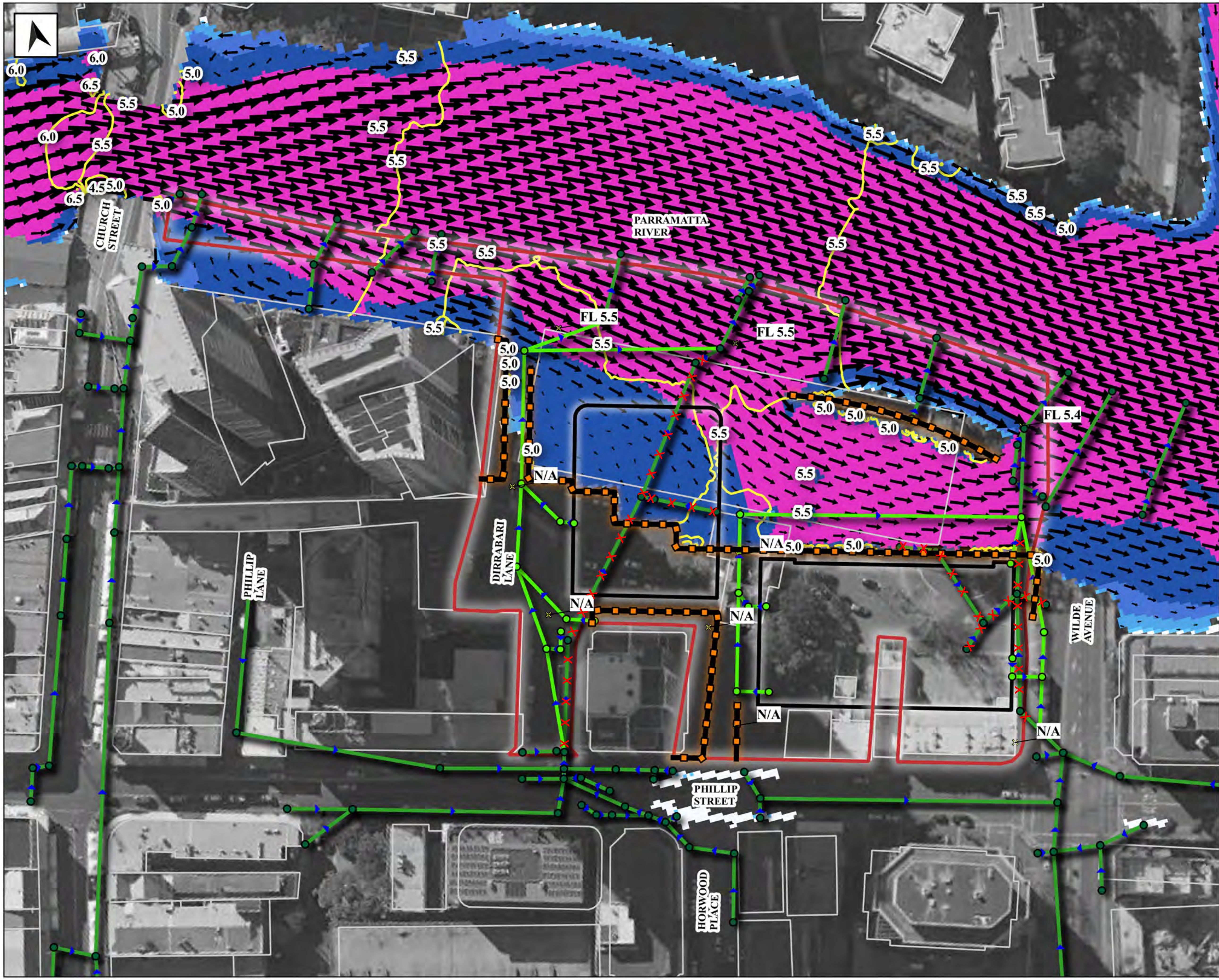
Pre-development - River & Overland Flood Hazard
PMF (4 Hours)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
E1.0-PMFH-MOF	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
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Peak Flood Depth (m)

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Issue	Date	By	Chkd	Appd
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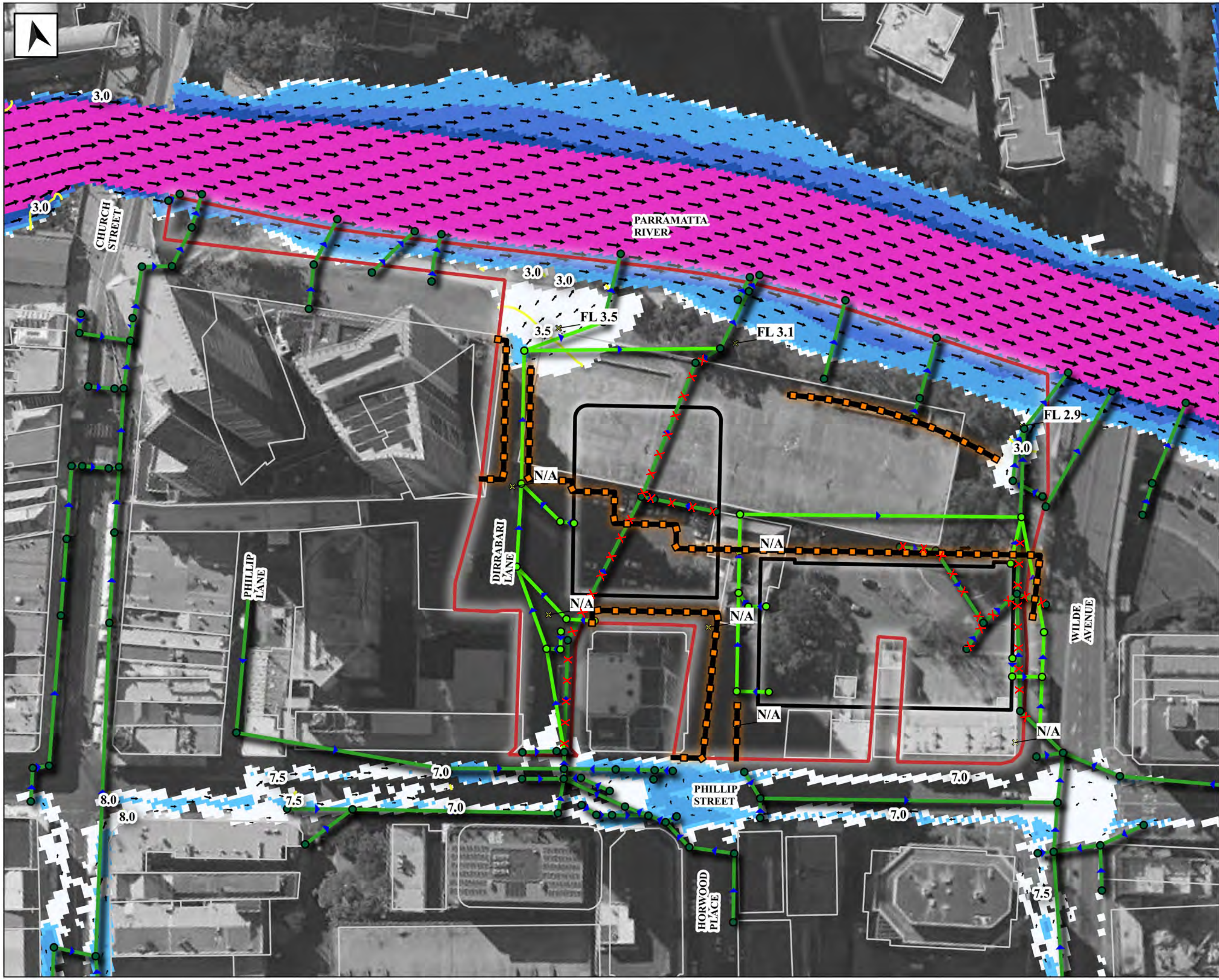
Post-development - River Flood
Peak Depths and Levels
5% AEP (9 Hours)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final
Figure No	Issue
P1.7-5D-MF	2



Legend

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2	14/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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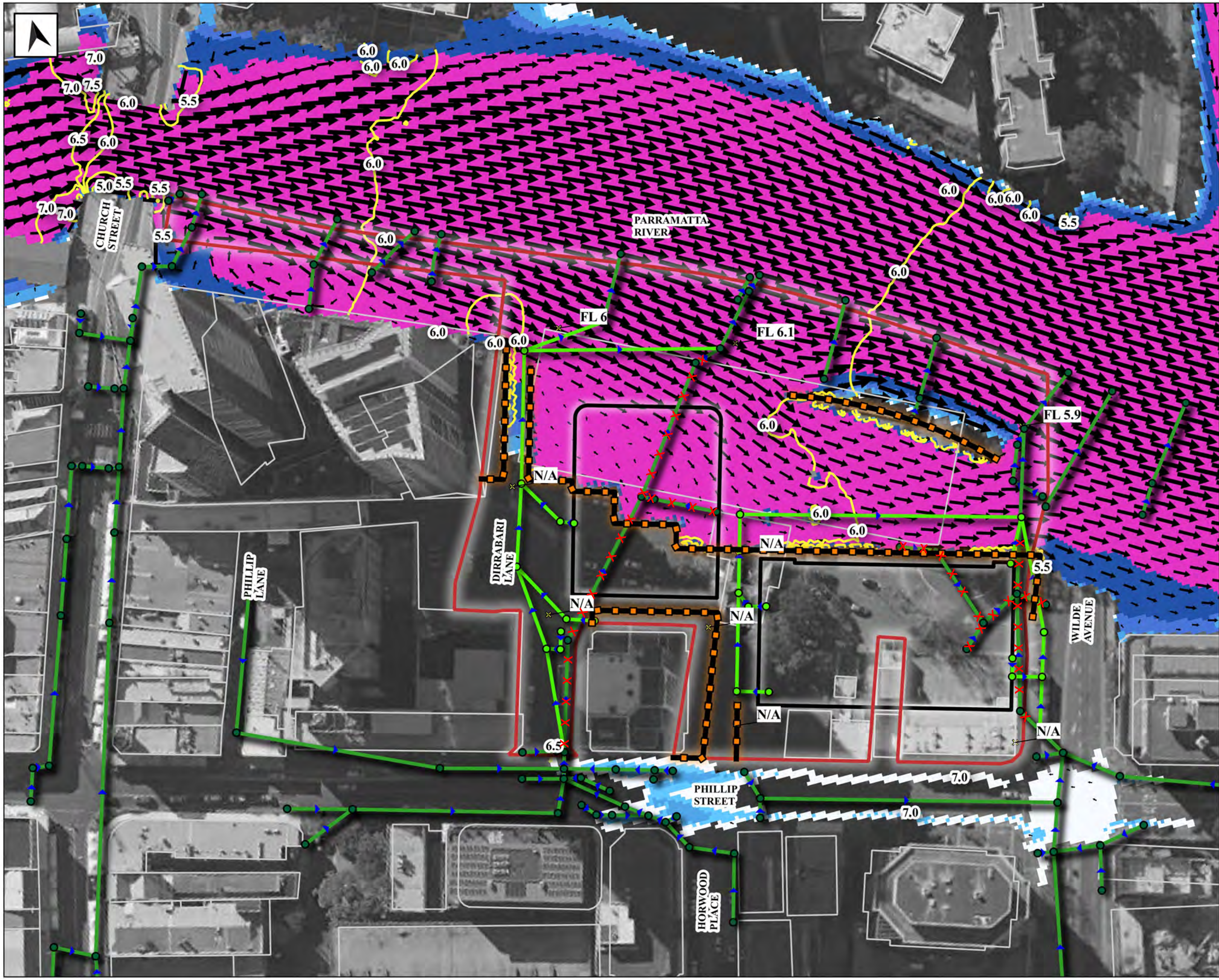
Post-development - Overland Flood
Peak Depths and Levels
5% AEP (25 Minutes)

Scale at A3
1:1000

0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
P1.7-5D-OF	2



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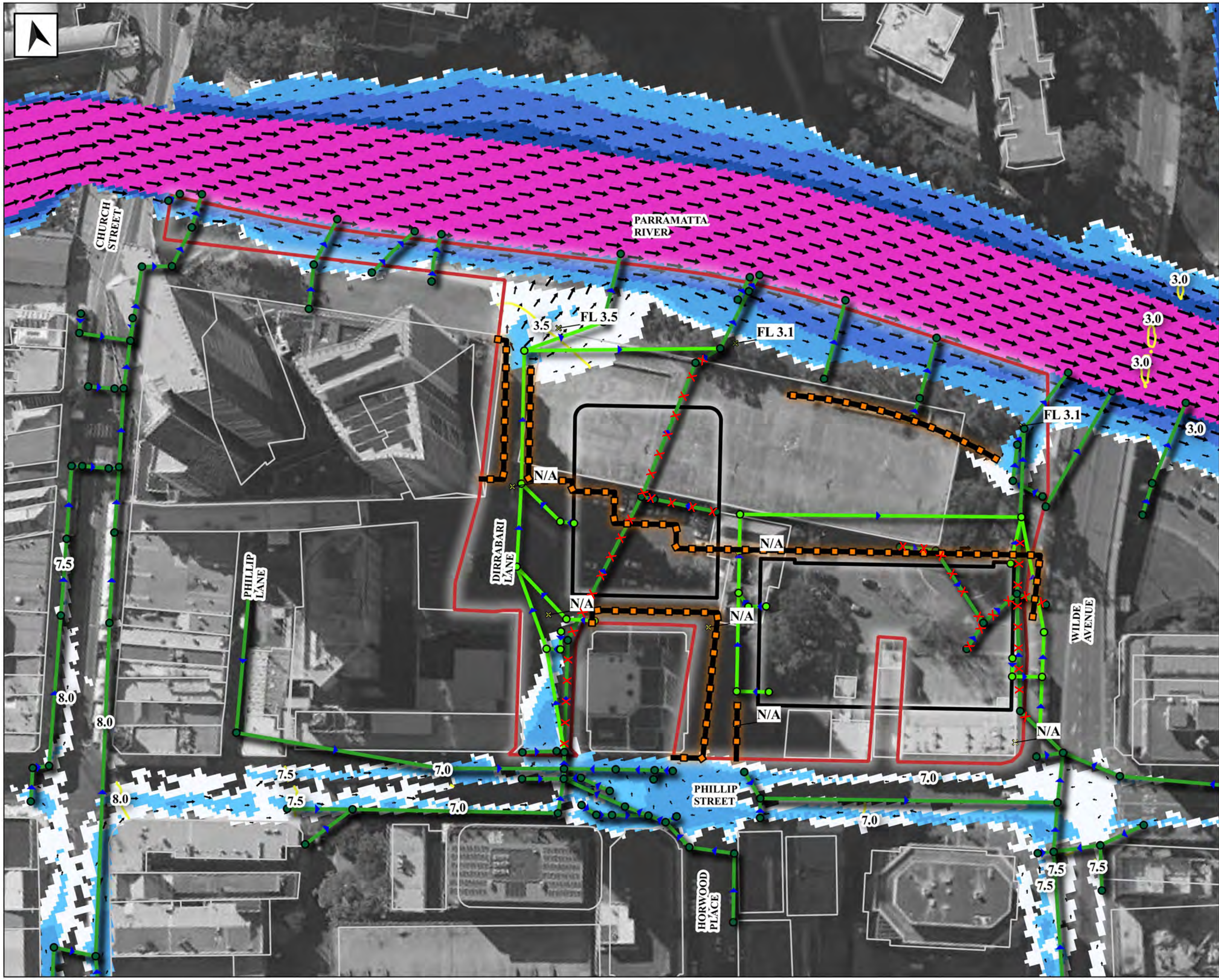
Post-development - River Flood
Peak Depths and Levels
1% AEP (9 Hours)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
P1.7-1D-MF	2



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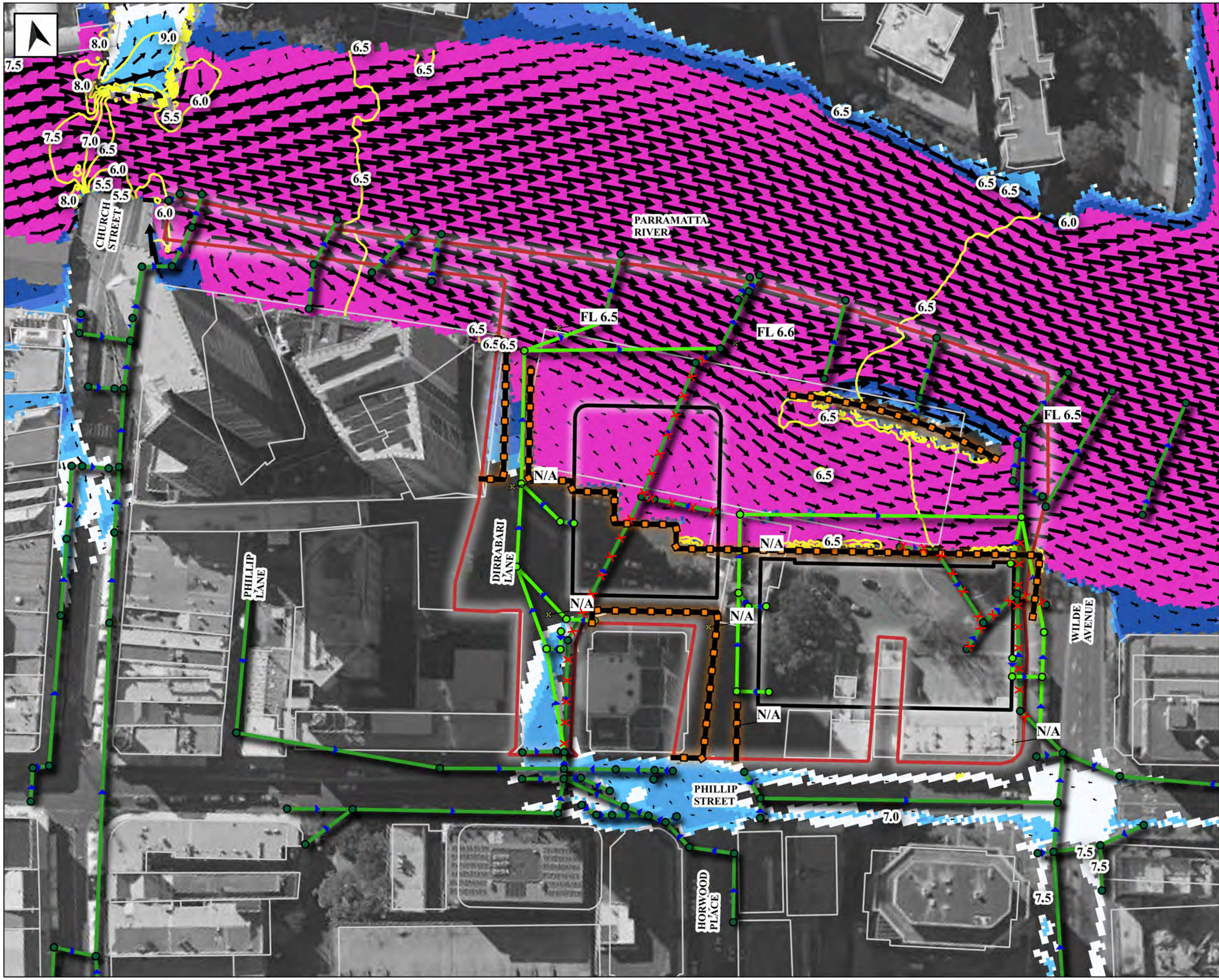
Peak Depths and Levels
1% AEP (20 Minutes)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
P1.7-1D-OF	2



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Post-development - River Flood
Peak Depths and Levels
1% AEP & Climate Change (9 Hours)

Scale at A3
1:1000

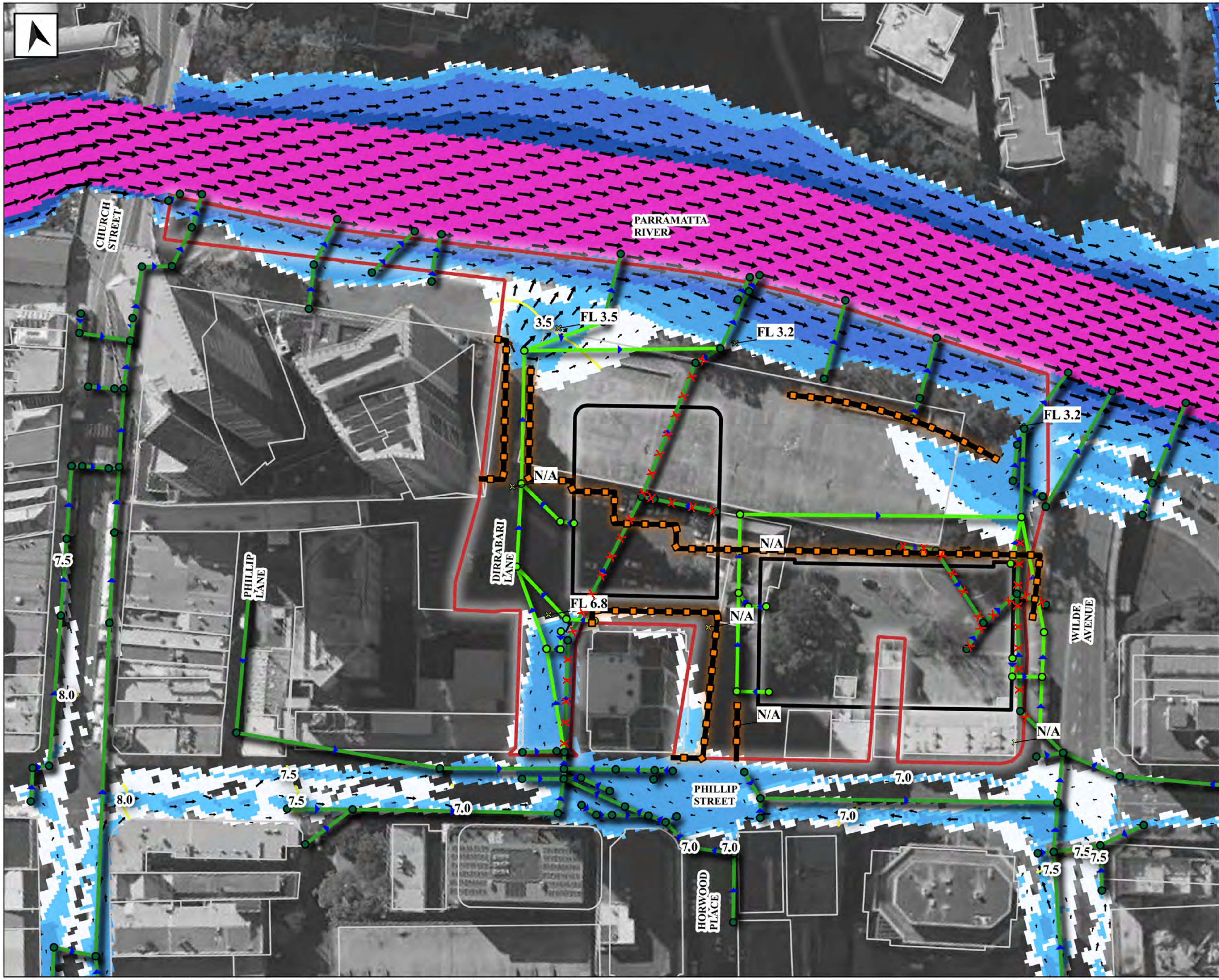
0 25 50 m

Job No 273467

Figure Status Final

Figure No P1.7-1ccD-MF

Issue 2



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Scale at A3
1:1000
0 25 50 m

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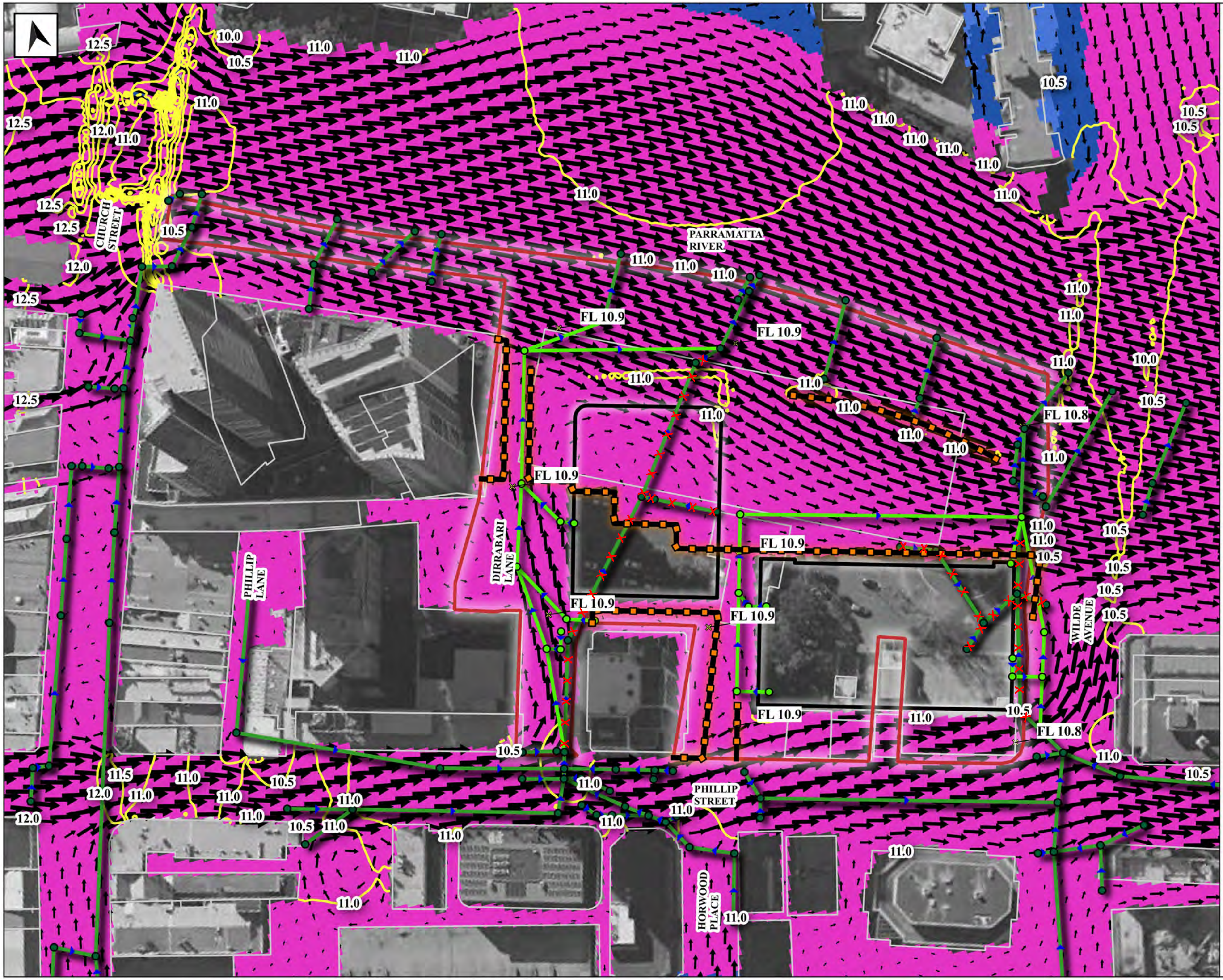
273467

Figure Status
Final

Figure No
P1.7-1ccD-OF

Issue
2



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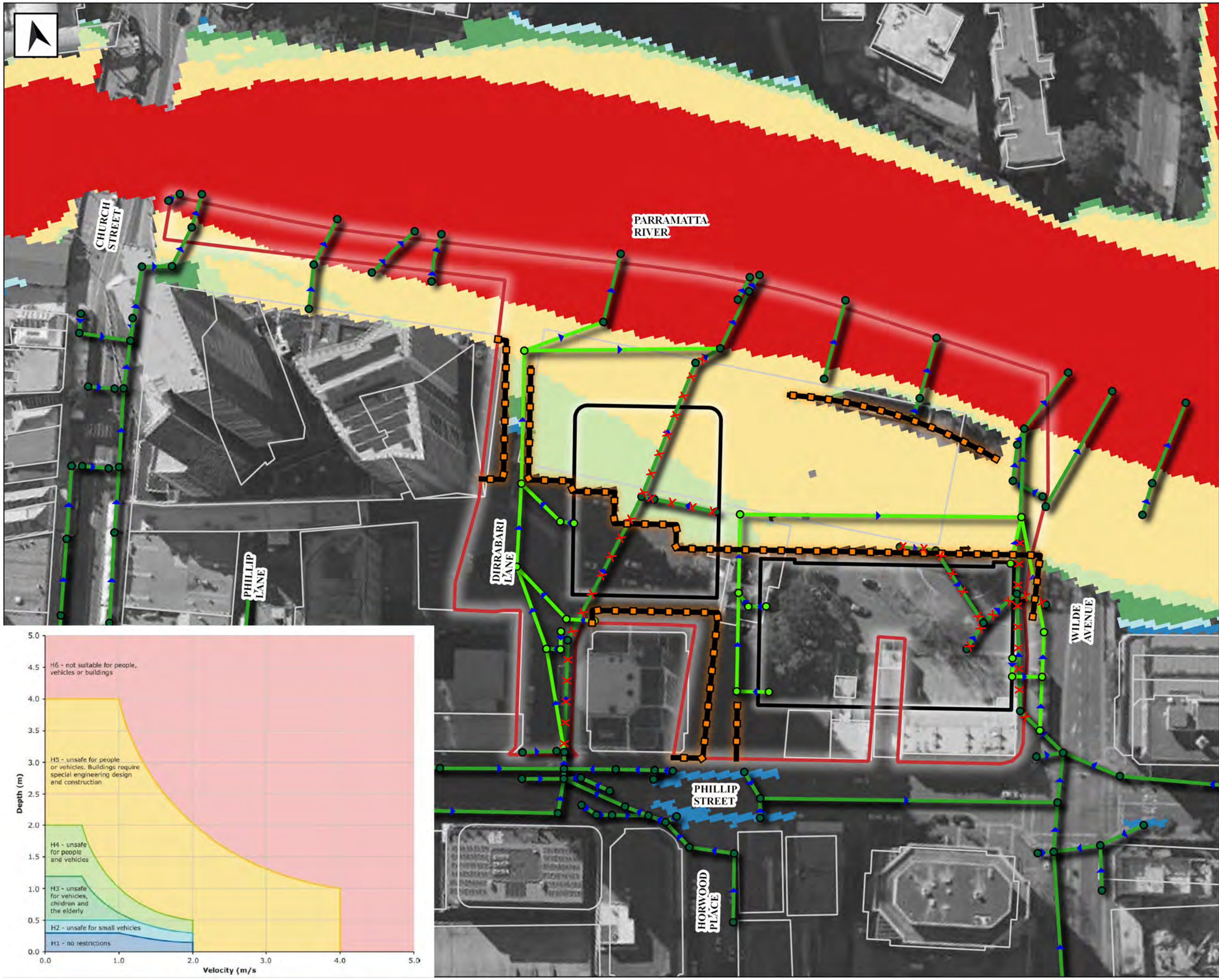
Post-development - River & Overland Flood Peak Depths and Levels
PMF (4 Hours)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
P1.7-PMFD-MOF	2



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Post-development - River Flood Hazard
5% AEP (9 Hours)

Scale at A3
1:1000
0 25 50 m

Job No
273467

Figure Status
Final

Figure No
P1.7-5H-MF

Issue
2

Legend

- Development Site Boundary
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Museum of Applied Arts & Sciences

Powerhouse Parramatta

Post-development - Overland Flood Hazard
5% AEP (25 Minutes)

Scale at A3
1:1000

0 25 50 m

Job No 273467	Figure Status Final
Figure No P1.7-5H-OF	Issue 2

Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Flood Hazard Category

(Australian Management Institute, 2014)

- H1 — Relatively benign flow conditions. No vulnerability constraints.
- H2 — Unsafe for small vehicles.
- H3 — Unsafe for all vehicles, children and the elderly.
- H4 — Unsafe for all people and all vehicles.
- H5 — Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 — Unconditionally dangerous. Not suitable for any type of development

Issue	Date	By	Chkd	Appd
2	14/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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Powerhouse Parramatta

Post-development - River Flood Hazard
1% AEP (9 Hours)

Scale at A3
1:1000

0 25 50 m

Job No
273467

Figure Status
Final

Figure No
P1.7-1H-MF

Issue
2

Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Flood Hazard Category

(Australian Management Institute, 2014)

- H1
  Relatively benign flow conditions.
  No vulnerability constraints.
- H2
  Unsafe for small vehicles.
- H3
  Unsafe for all vehicles, children and the elderly.
- H4
  Unsafe for all people and all vehicles.
- H5
  Unsafe for all people and all vehicles.
  Buildings require special engineering design and construction.
- H6
  Unconditionally dangerous.
  Not suitable for any type of development

Issue	Date	By	Chkd	Appd
2	14/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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Powerhouse Parramatta

Post-development - Overland Flood Hazard
1% AEP (20 Minutes)

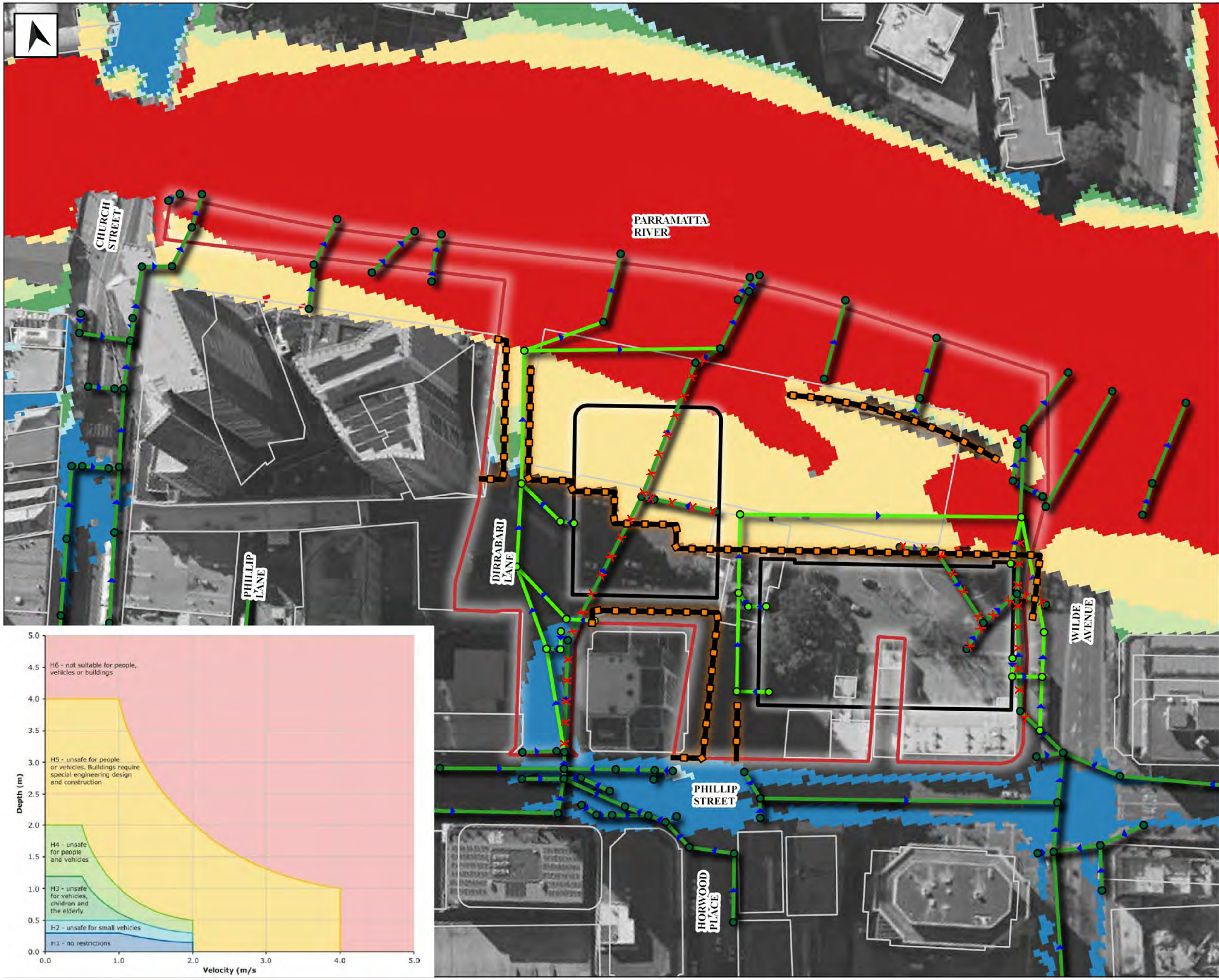
Scale at A3
1:1000
0 25 50 m

Job No
273467

Figure Status
Final

Figure No
P1.7-1H-OF

Issue
2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
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- Post-development Pipes

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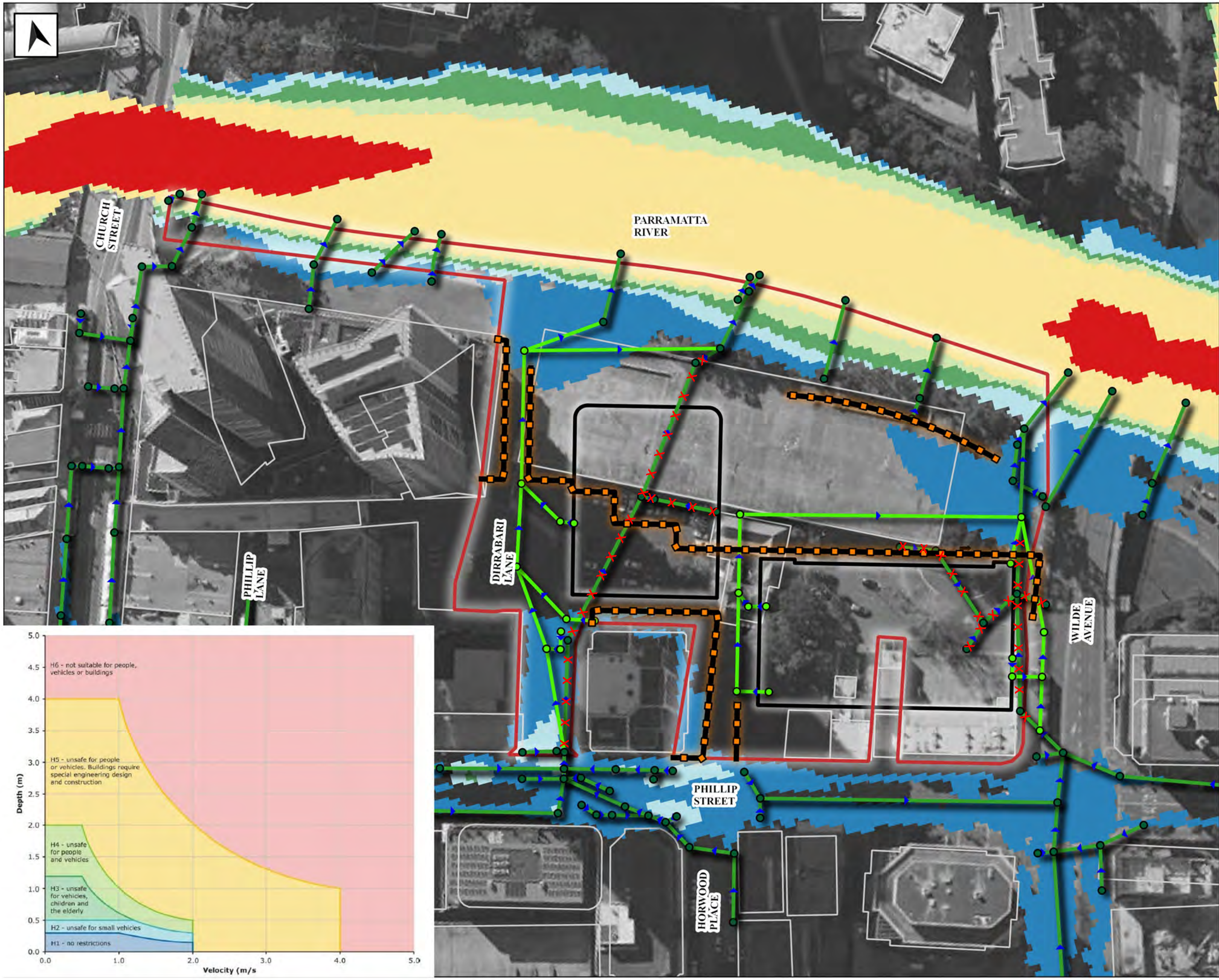
Powerhouse Parramatta

Post-development - River Flood Hazard
1% AEP & Climate Change (9 Hours)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
P1.7-1ccH-MF	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Flood Hazard Category

(Australian Management Institute, 2014)

- H1
  Relatively benign flow conditions.
  No vulnerability constraints.
- H2
  Unsafe for small vehicles.
- H3
  Unsafe for all vehicles, children and the elderly.
- H4
  Unsafe for all people and all vehicles.
- H5
  Unsafe for all people and all vehicles.
  Buildings require special engineering design and construction.
- H6
  Unconditionally dangerous.
  Not suitable for any type of development

Issue	Date	By	Chkd	Appd
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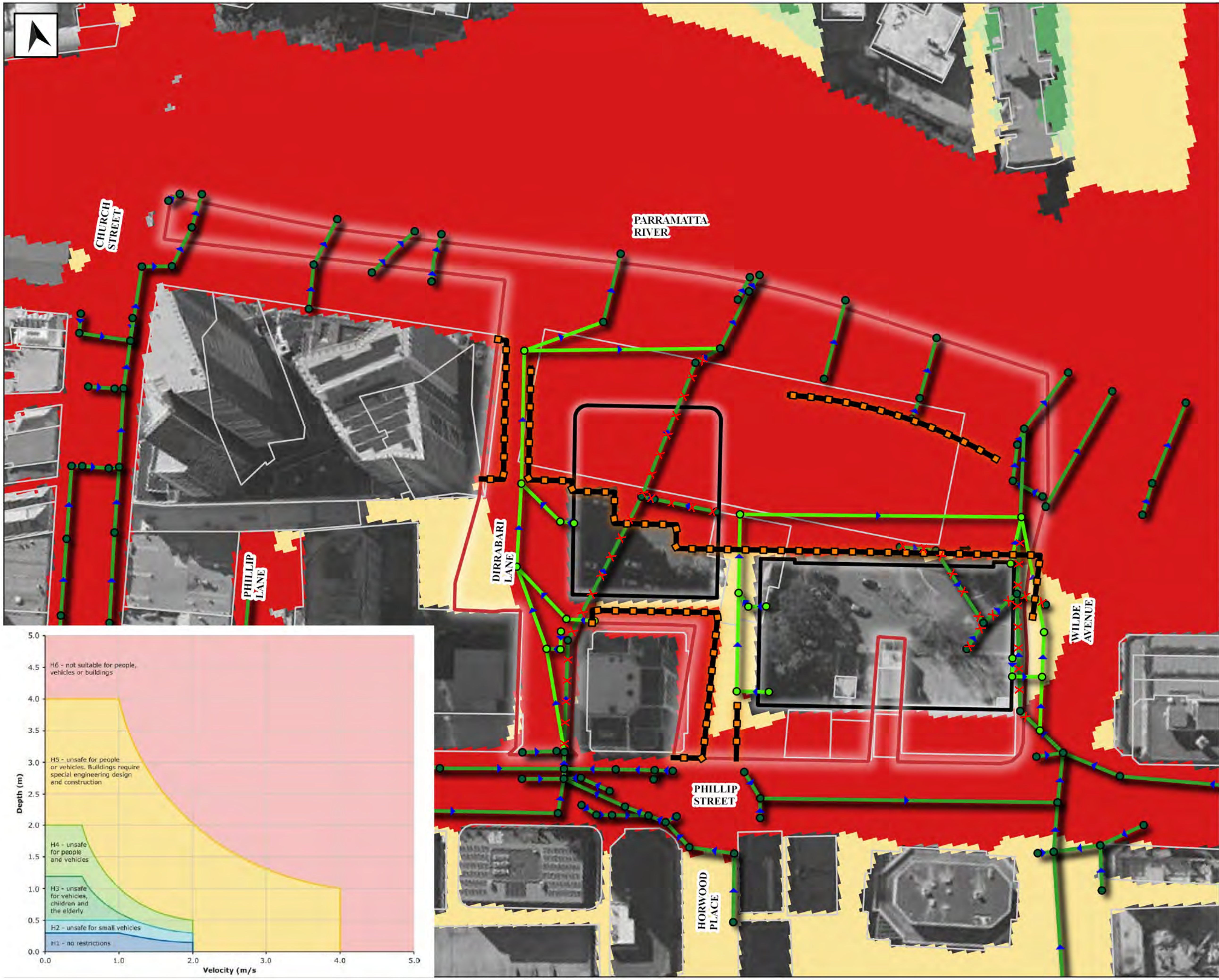
Post-development - Overland Flood Hazard
1% AEP & Climate Change (20 Minutes)

Scale at A3
1:1000

0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
P1.7-1ccH-OF	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Flood Hazard Category

(Australian Management Institute, 2014)

- H1 — Relatively benign flow conditions. No vulnerability constraints.
- H2 — Unsafe for small vehicles.
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- H4 — Unsafe for all people and all vehicles.
- H5 — Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6 — Unconditionally dangerous. Not suitable for any type of development

Issue	Date	By	Chkd	Appd
2	14/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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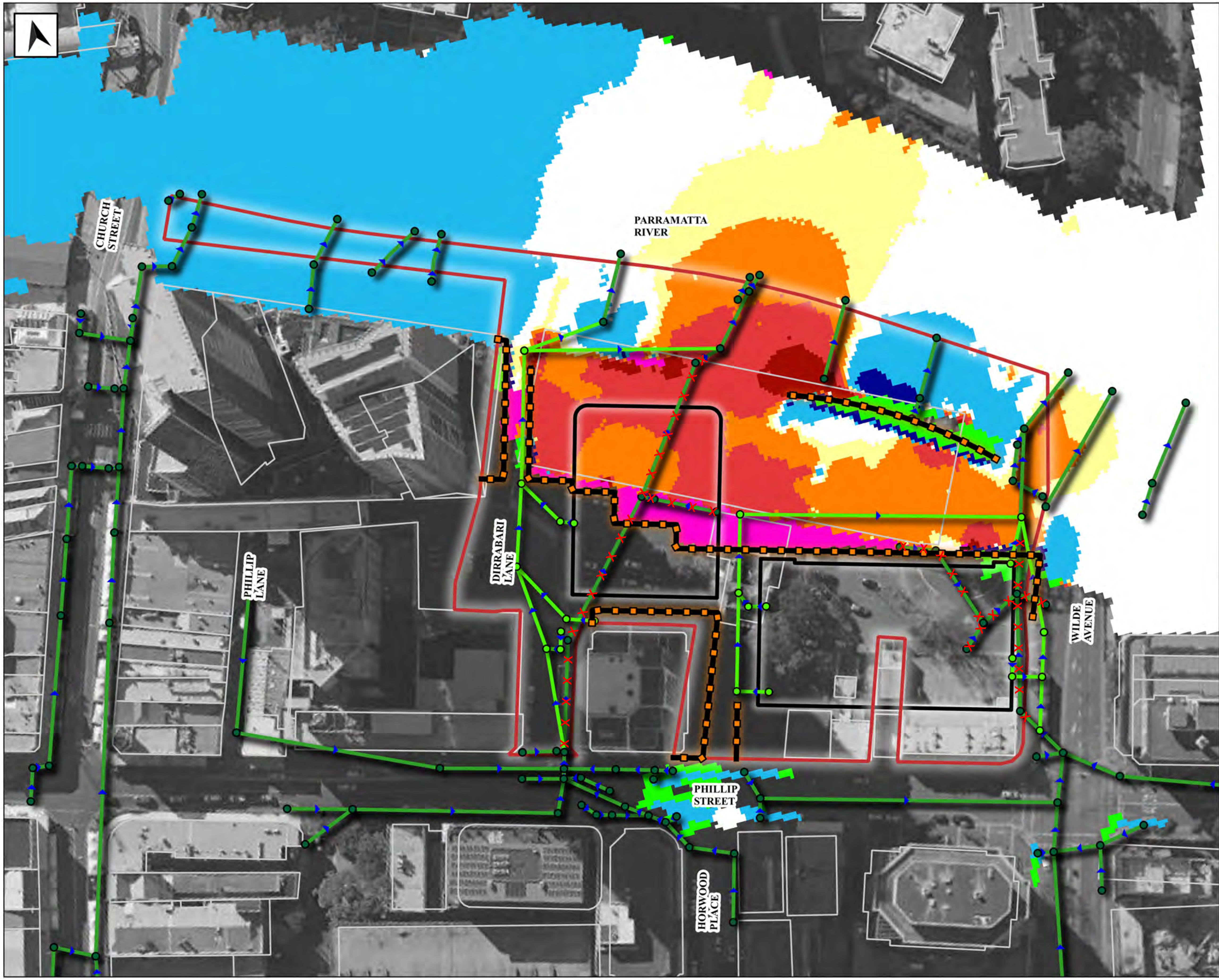
Post-development - River & Overland Flood Hazard
PMF (4 Hours)

Scale at A3
1:1000

0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
P1.7-PMFH-MOF	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Peak Level Flood Afflux (m)

- <= -0.10
- -0.10 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- > 0.10
- Previously Flooded Area
- Newly Flooded Area

Note: *This figure has been produced by comparing the proposed development flooding levels presented in* ***Figure P1.7-5D-MF*** *with the levels as presented in* ***Figure E1.0-5D-MF.***

Flooding impacts report changes in peak flood levels (mAHD).
Note this is not the same as peak water depth.

Issue	Date	By	Chkd	Appd
2	14/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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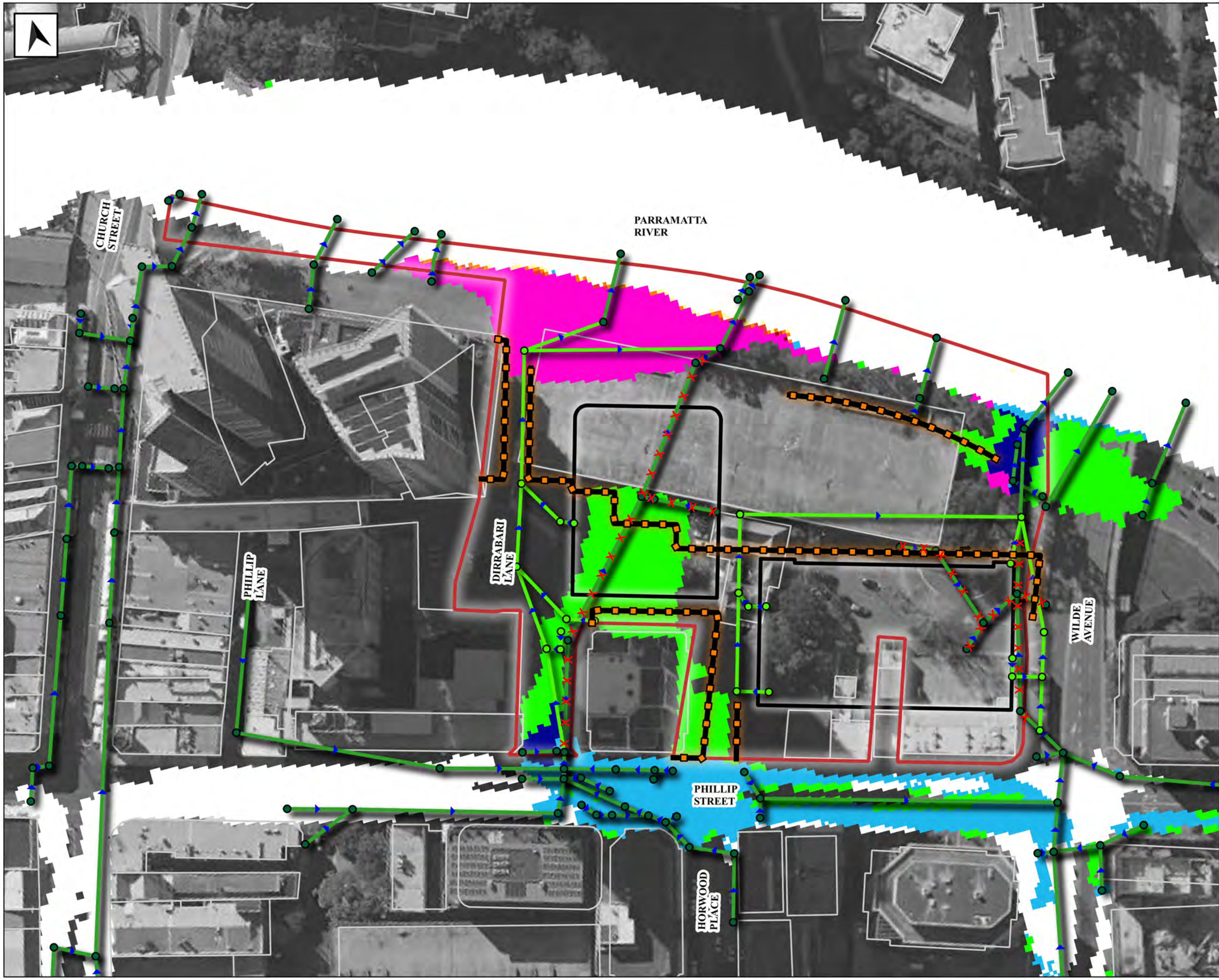
Post-development - River Flood
Afflux
5% AEP (9 Hours)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
P1.7-5A-MF	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Peak Level Flood Afflux (m)

- <= -0.10
- -0.10 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- > 0.10
- Previously Flooded Area
- Newly Flooded Area

Note: *This figure has been produced by comparing the proposed development flooding levels presented in* ***Figure P1.7-5D-OF*** *with the levels as presented in* ***Figure E1.0-5D-OF.***

Flooding impacts report changes in peak flood levels (mAHD). Note this is not the same as peak water depth.

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2	14/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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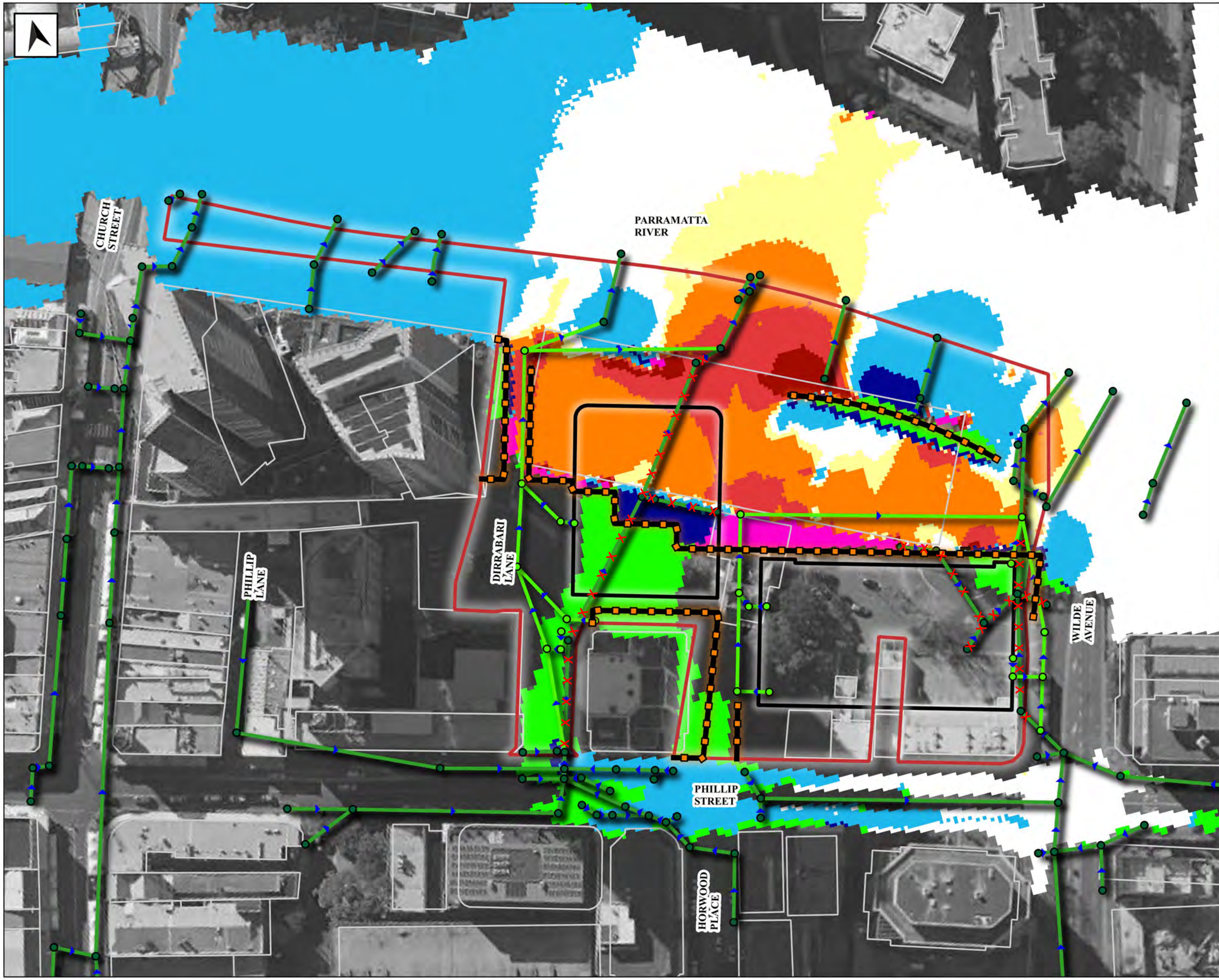
Post-development - Overland Flood Afflux
5% AEP (25 Minutes)

Scale at A3
1:1000

0 25 50 m

Job No	Figure Status
273467	**Final**

Figure No	Issue
P1.7-5A-OF	**2**



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Peak Level Flood Afflux (m)

- <= -0.10
- -0.10 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- > 0.10
- Previously Flooded Area
- Newly Flooded Area

Note: *This figure has been produced by comparing the proposed development flooding levels presented in **Figure P1.7-1D-MF** with the levels as presented in **Figure E1.0-1D-MF.***

Flooding impacts report changes in peak flood levels (mAHD).
Note this is not the same as peak water depth.

Issue	Date	By	Chkd	Appd
2	14/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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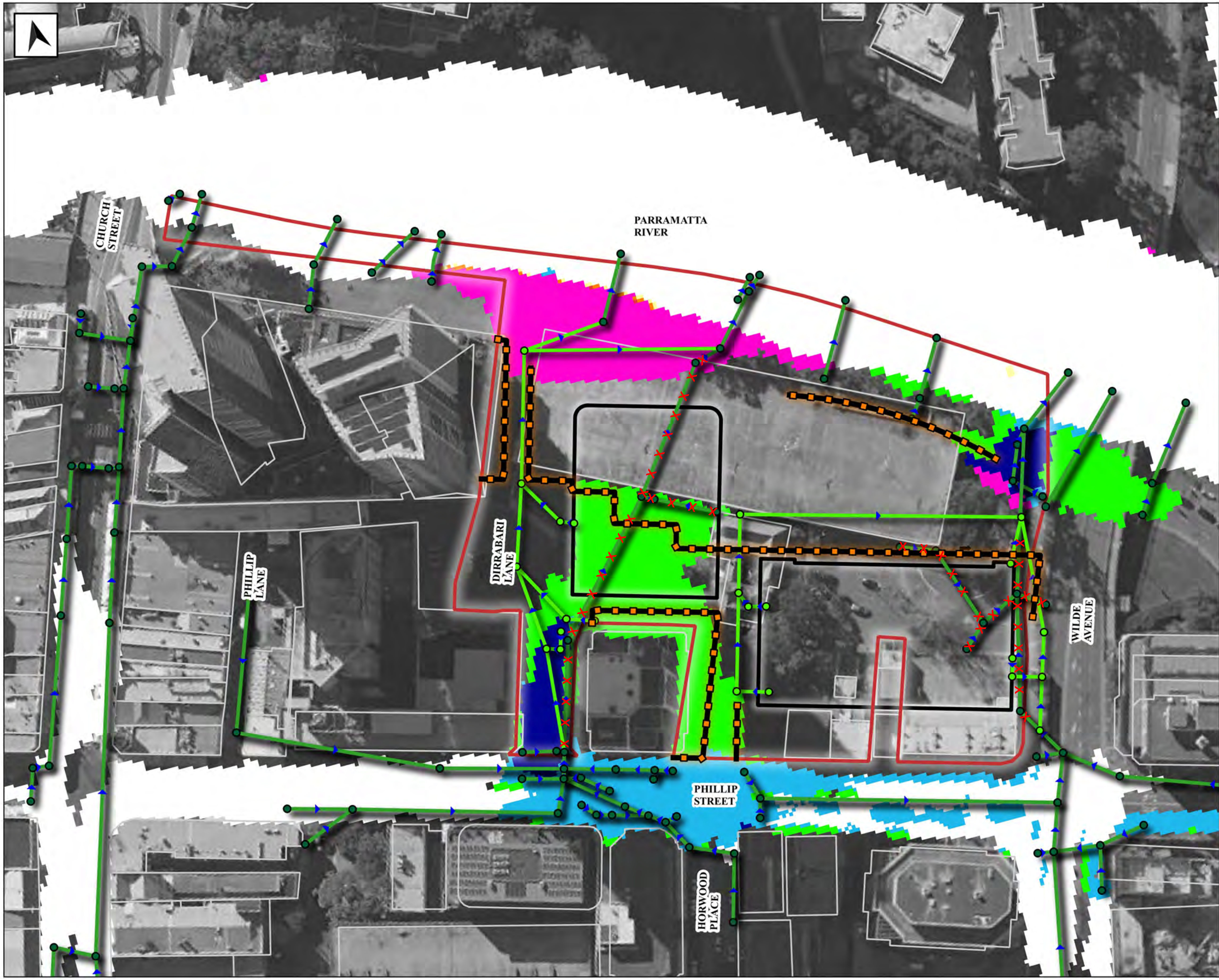
Post-development - River Flood Afflux
1% AEP (9 Hours)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
P1.7-1A-MF	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Peak Level Flood Afflux (m)

- <= -0.10
- -0.10 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- > 0.10
- Previously Flooded Area
- Newly Flooded Area

Note: *This figure has been produced by comparing the proposed development flooding levels presented in* ***Figure P1.7-1D-OF*** *with the levels as presented in* ***Figure E1.0-1D-OF.***

Flooding impacts report changes in peak flood levels (mAHD).
Note this is not the same as peak water depth.

Issue	Date	By	Chkd	Appd
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Post-development - Overland Flood Afflux
1% AEP (20 Minutes)

Scale at A3
1:1000

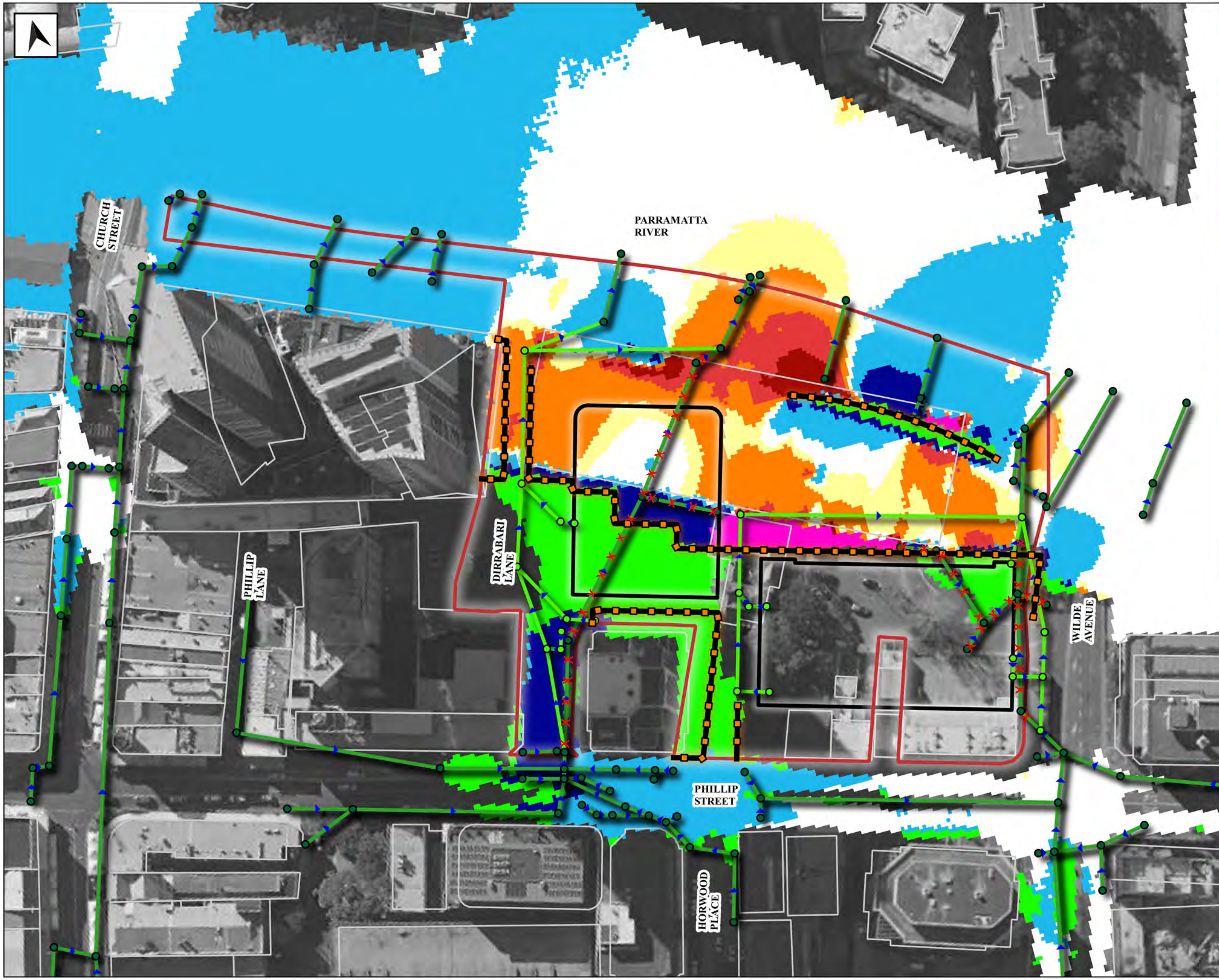
0 25 50 m

Job No
273467

Figure Status
Final

Figure No
P1.7-1A-OF

Issue
2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Peak Level Flood Afflux (m)

- <= -0.10
- -0.10 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- > 0.10
- Previously Flooded Area
- Newly Flooded Area

Note: *This figure has been produced by comparing the proposed development flooding levels presented in* ***Figure P1.7-1ccD-MF*** *with the levels as presented in* ***Figure E1.0-1ccD-MF.***

Flooding impacts report changes in peak flood levels (mAHD).
Note this is not the same as peak water depth.

Issue	Date	By	Chkd	Appd
2	14/09/2020	AA	NC	EM
1	3/04/2020	AA	NC	DC

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Powerhouse Parramatta

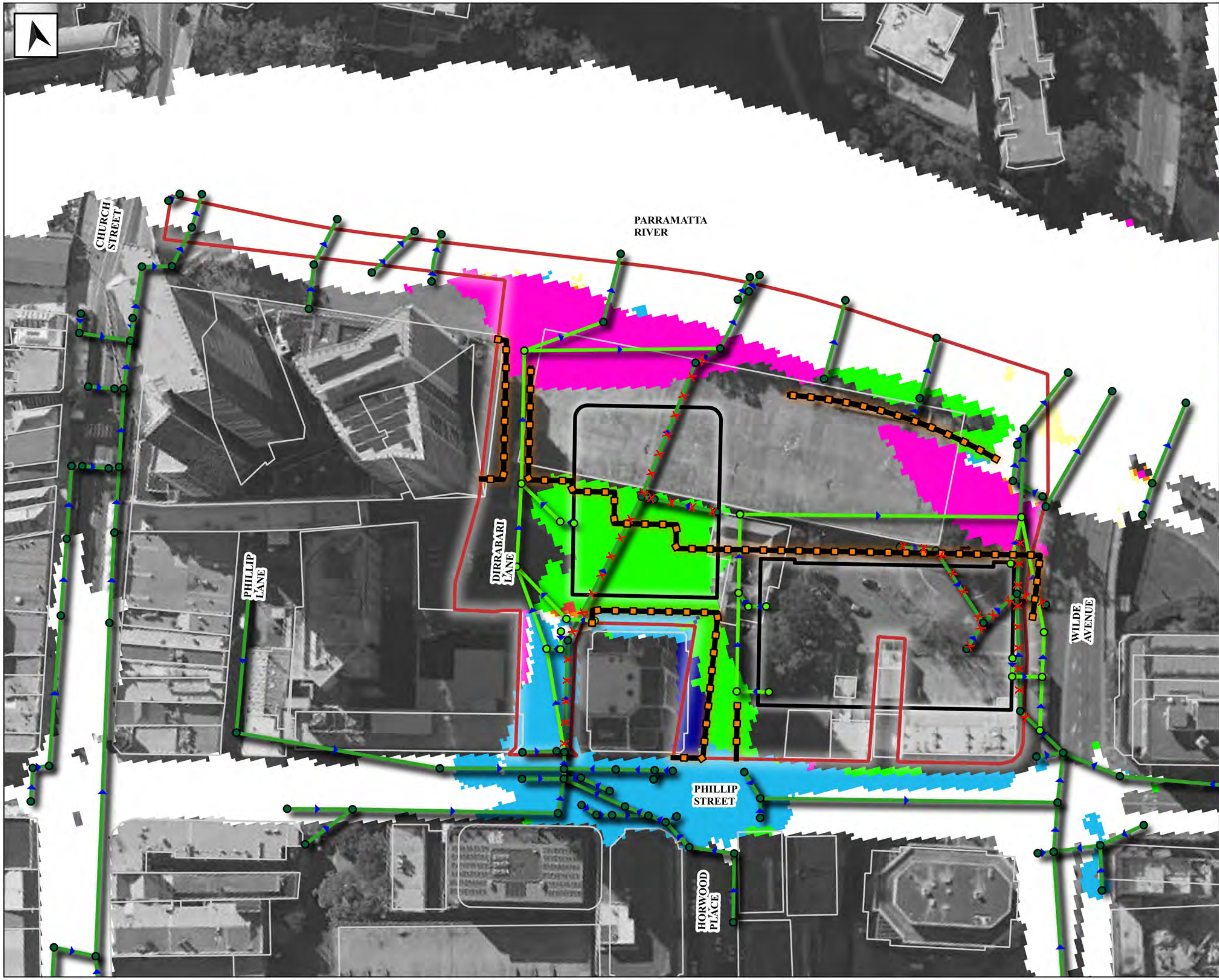
Post-development - River Flood Afflux
1% AEP & Climate Change (9 Hours)

Scale at A3
1:1000

0 25 50 m

Job No	Figure Status
273467	**Final**

Figure No	Issue
P1.7-1ccA-MF	2



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Peak Level Flood Afflux (m)

- <= -0.10
- -0.10 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- > 0.10
- Previously Flooded Area
- Newly Flooded Area

Note: *This figure has been produced by comparing the proposed development flooding levels presented in **Figure P1.7-1ccD-OF** with the levels as presented in **Figure E1.0-1ccD-OF**.*

Flooding impacts report changes in peak flood levels (mAHD).
Note this is not the same as peak water depth.

Issue	Date	By	Chkd	Appd
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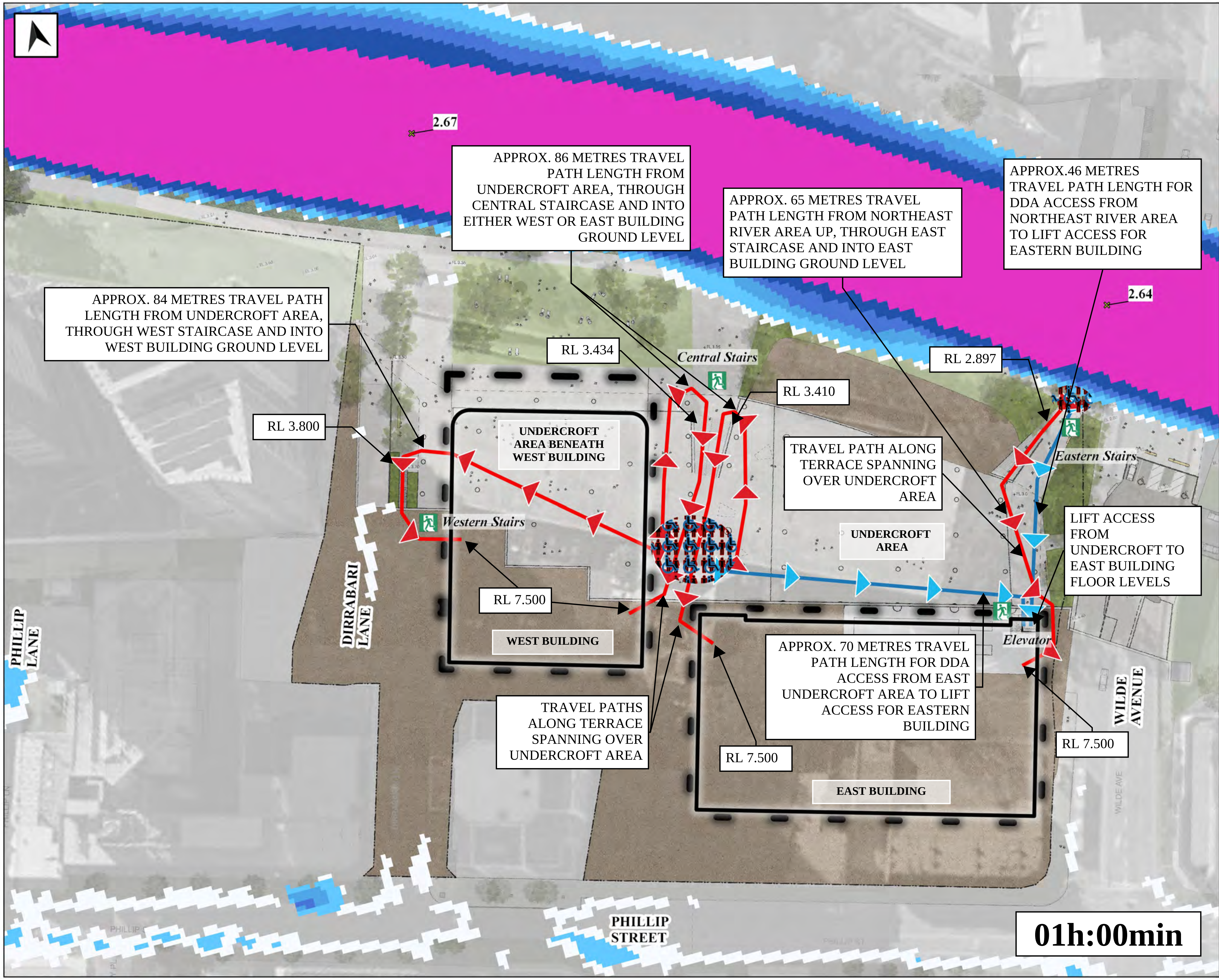
Post-development - Overland Flood Afflux
1% AEP & Climate Change (20 Minutes)

Scale at A3
1:1000
0 25 50 m

Job No	Figure Status
273467	Final

Figure No	Issue
P1.7-1ccA-OF	2

Appendix B | Flood Egress Plans



Legend

- Powerhouse Building Outline
- Powerhouse Building Columns
- DDA Evacuation Travel Pathways
- Non-DDA Evacuation Travel Pathways
- Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50- 1.00
- > 1.00

Issue	Date	By	Chkd	Appd
2	3/09/2020	AA	NC	EM
1	28/08/2020	AA	NC	GR

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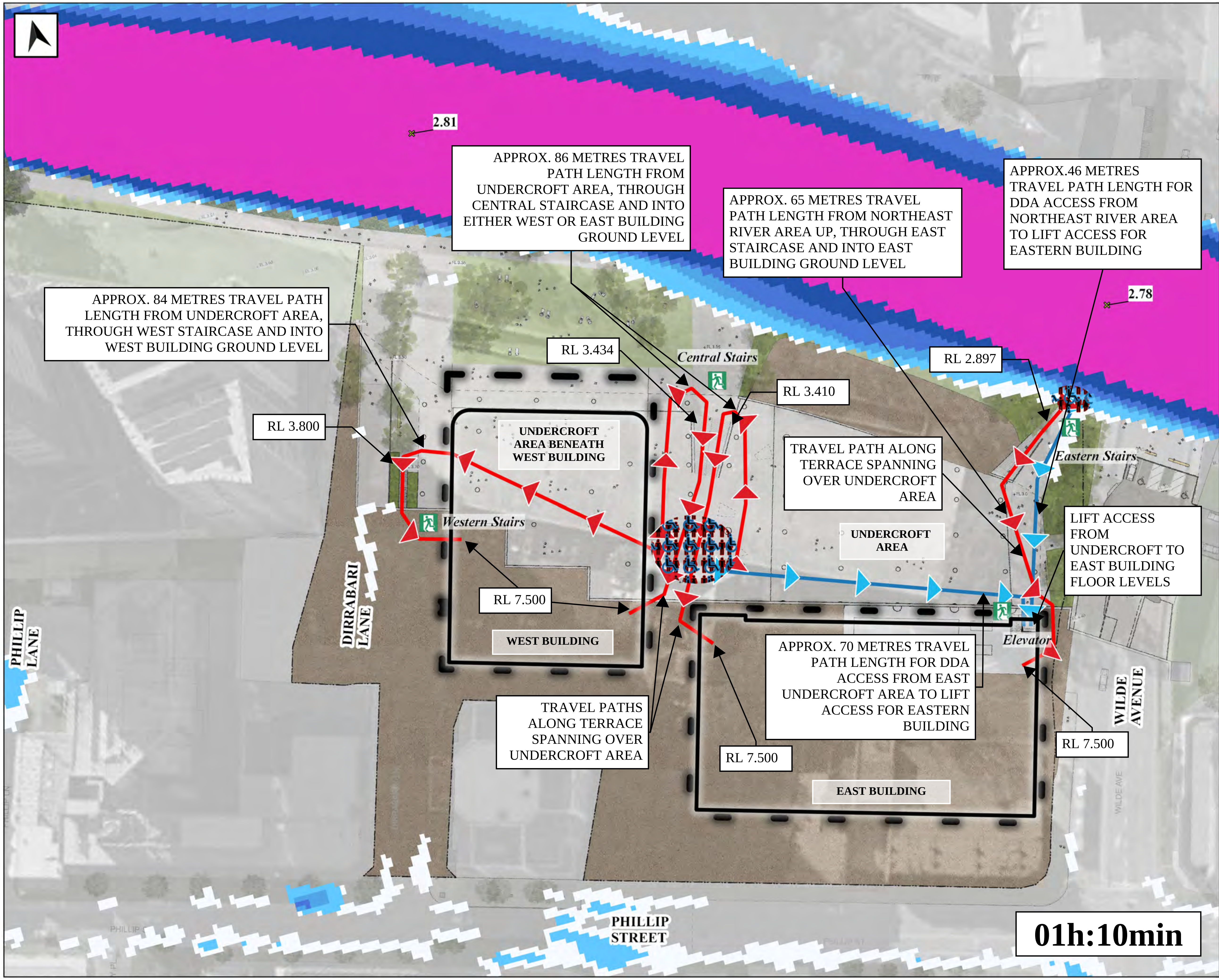
Post-development - Mainstream Flood
Peak Depths and Levels
0.05% AEP (1.0 Hours)

Scale at A3 1:750

0 10 20 m

Job No 273467
Figure Status Final
Figure No P1.0-0.05E-MF-1.0
Issue 2



Legend

- Powerhouse Building Outline
- Powerhouse Building Columns
- DDA Evacuation Travel Pathways
- Non-DDA Evacuation Travel Pathways
- Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50- 1.00
- > 1.00

Issue	Date	By	Chkd	Appd
2	3/09/2020	AA	NC	EM
1	28/08/2020	AA	NC	GR

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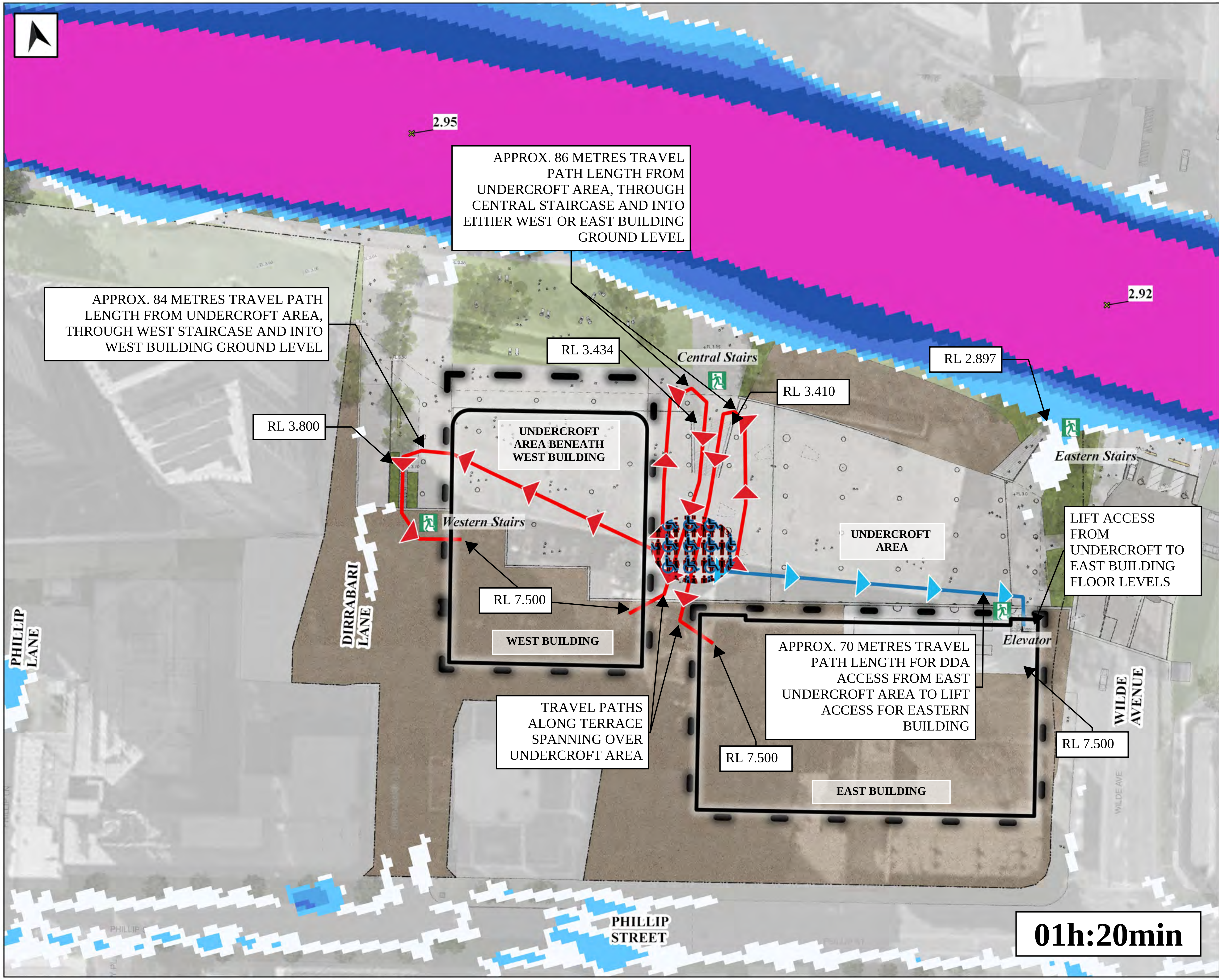
Post-development - Mainstream Flood
Peak Depths and Levels
0.05% AEP (1.2 Hours)

Scale at A3
1:750
0 10 20 m

Job No 273467
Figure Status Final
Figure No P1.0-0.05E-MF-1.2
Issue 2



Legend

- Powerhouse Building Outline
- Powerhouse Building Columns
- DDA Evacuation Travel Pathways
- Non-DDA Evacuation Travel Pathways
- Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50- 1.00
- > 1.00

Issue	Date	By	Chkd	Appd
2	3/09/2020	AA	NC	EM
1	28/08/2020	AA	NC	GR

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Post-development - Mainstream Flood
Peak Depths and Levels
0.05% AEP (1.3 Hours)

Scale at A3
1:750

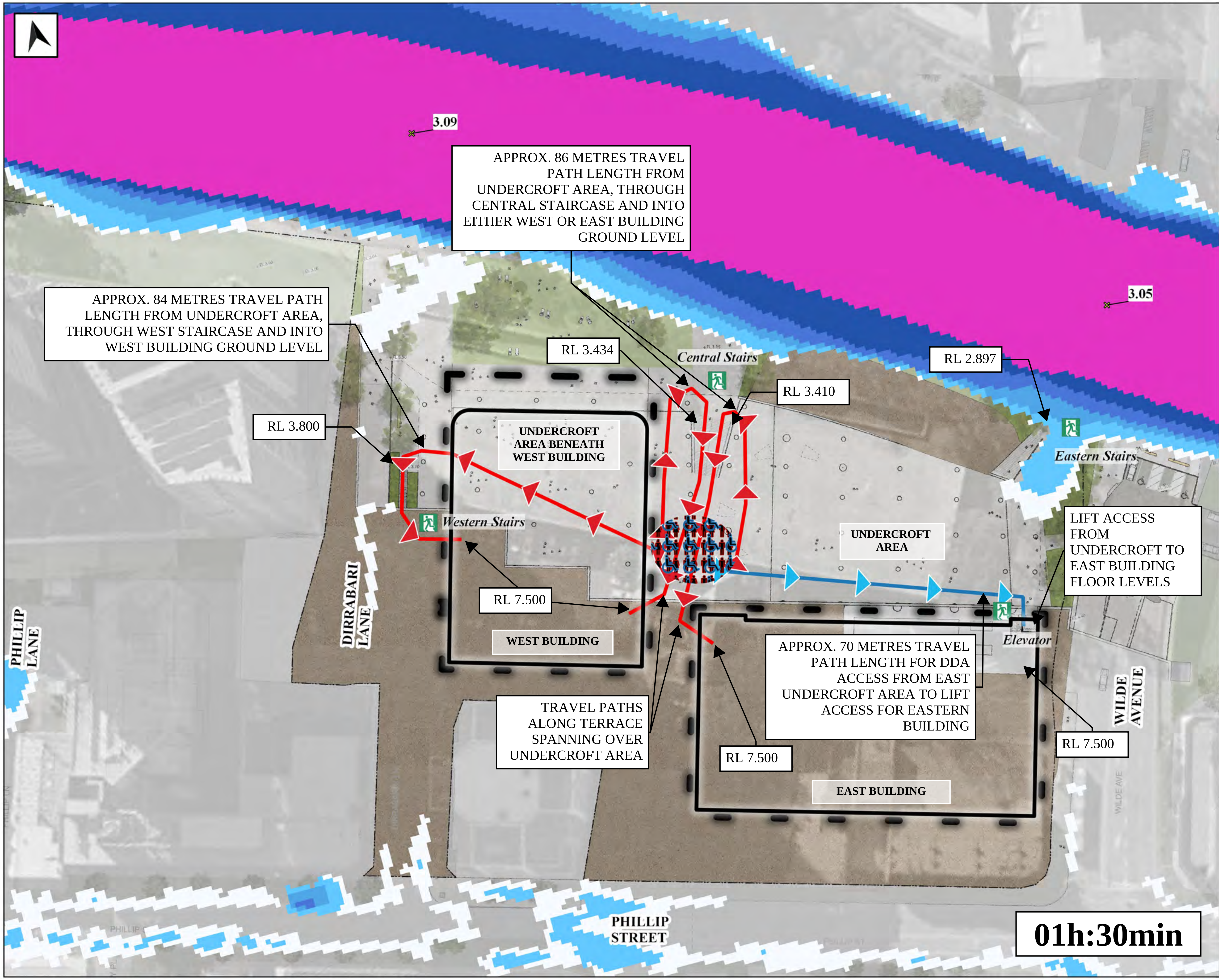
0 10 20 m

Job No 273467

Figure Status Final

Figure No P1.0-0.05E-MF-1.3

Issue 2



Legend

- Powerhouse Building Outline
- Powerhouse Building Columns
- DDA Evacuation Travel Pathways
- Non-DDA Evacuation Travel Pathways
- Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50- 1.00
- > 1.00

Issue	Date	By	Chkd	Appd
2	3/09/2020	AA	NC	EM
1	28/08/2020	AA	NC	GR

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Powerhouse Parramatta

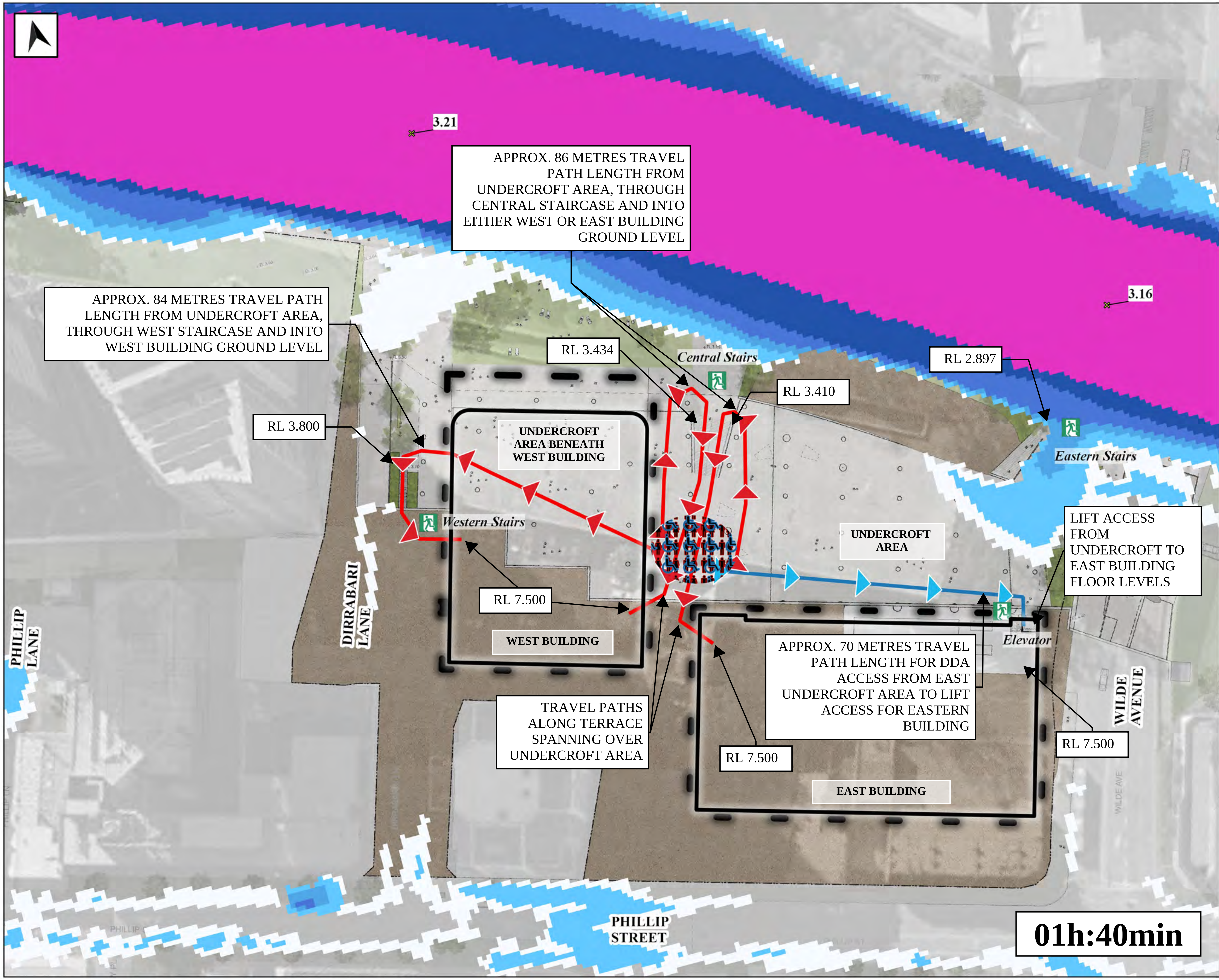
Post-development - Mainstream Flood
Peak Depths and Levels
0.05% AEP (1.5 Hours)

Scale at A3
1:750

0 10 20 m

Job No	Figure Status
273467	Final

Figure No	Issue
P1.0-0.05E-MF-1.5	2



Legend

- Powerhouse Building Outline
- Powerhouse Building Columns
- DDA Evacuation Travel Pathways
- Non-DDA Evacuation Travel Pathways
- Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50- 1.00
- > 1.00

Issue	Date	By	Chkd	Appd
2	3/09/2020	AA	NC	EM
1	28/08/2020	AA	NC	GR

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Post-development - Mainstream Flood
Peak Depths and Levels
0.05% AEP (1.7 Hours)

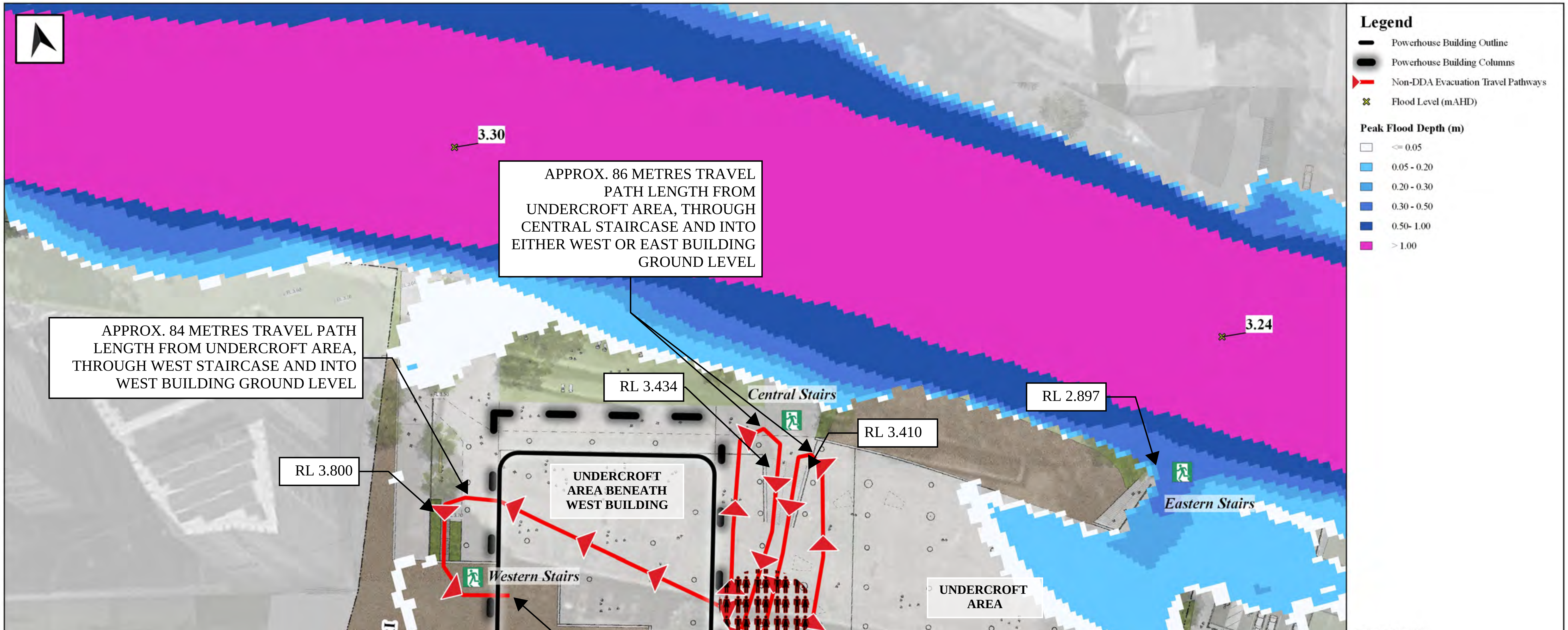
Scale at A3
1:750
0 10 20 m

Job No
273467

Figure Status
Final

Figure No
P1.0-0.05E-MF-1.7

Issue
2



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Issue	Date	By	Chkd	Appd
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1	28/08/2020	AA	NC	GR

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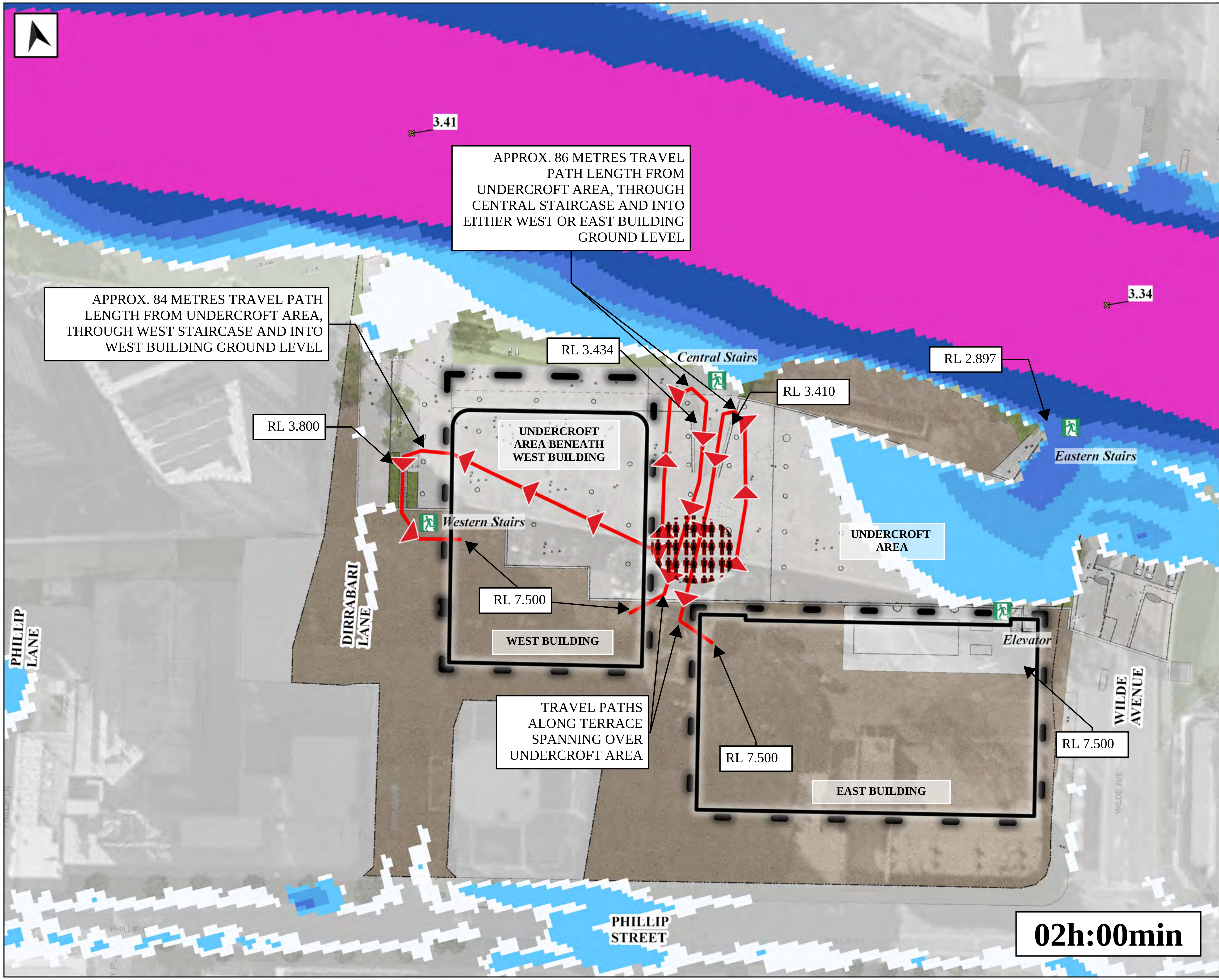
Post-development - Mainstream Flood
Peak Depths and Levels
0.05% AEP (1.8 Hours)

Scale at A3 1:750

Job No 273467 | Figure Status Final

Figure No P1.0-0.05E-MF-1.8 | Issue 2



Legend

- Powerhouse Building Outline
- Powerhouse Building Columns
- Non-DDA Evacuation Travel Pathways
- Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50- 1.00
- > 1.00

Issue	Date	By	Chkd	Appd
2	3/09/2020	AA	NC	EM
1	28/08/2020	AA	NC	GR

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Client

insw Infrastructure New South Wales

MAAS Museum of Applied Arts & Sciences

Powerhouse Parramatta

Post-development - Mainstream Flood
Peak Depths and Levels
0.05% AEP (2.0 Hours)

Scale at A3

1:750

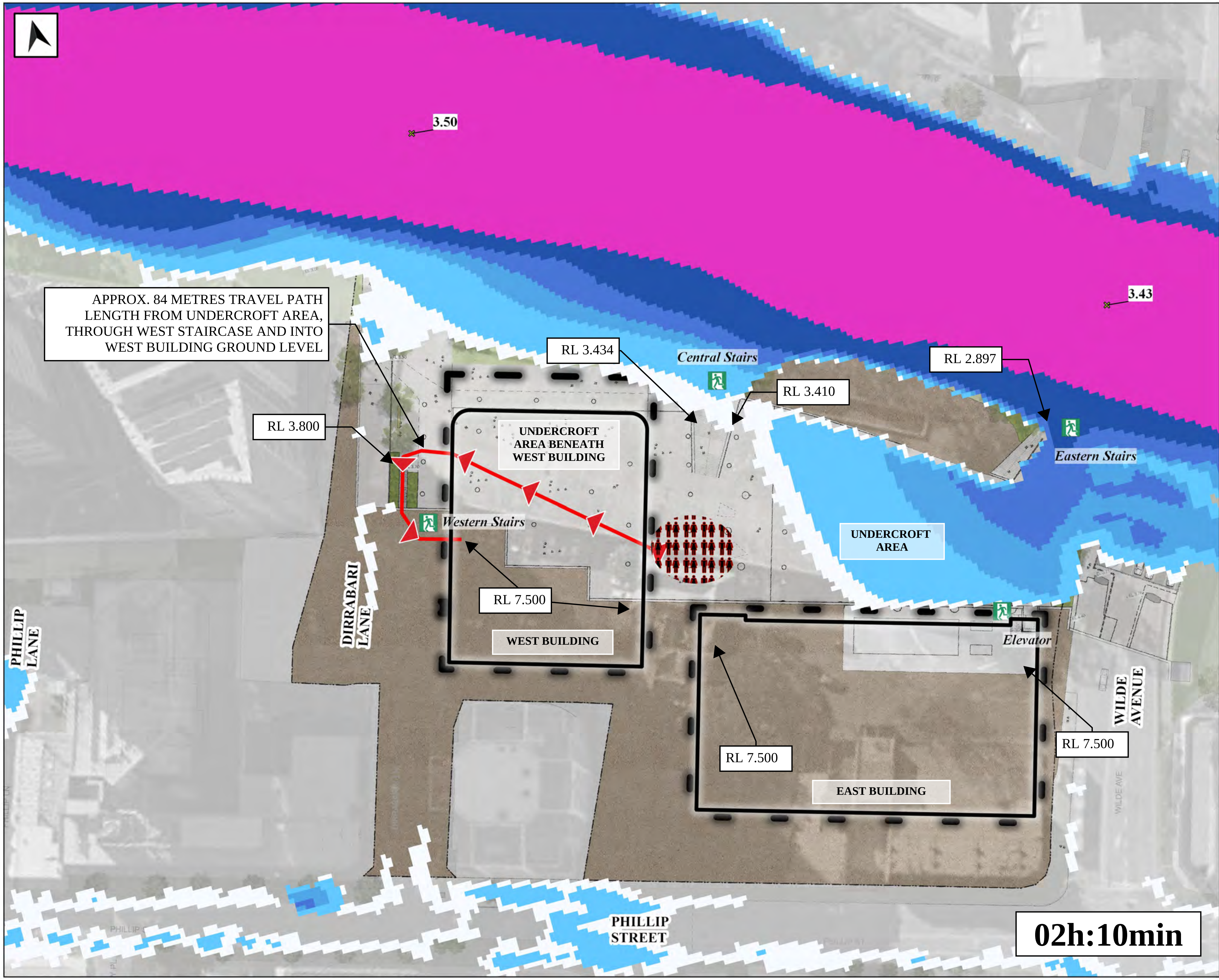
0 10 20 m

Job No 273467

Figure Status Final

Figure No P1.0-0.05E-MF-2.0

Issue 2



Legend

- Powerhouse Building Outline
- Powerhouse Building Columns
- Non-DDA Evacuation Travel Pathways
- Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50- 1.00
- > 1.00

Issue	Date	By	Chkd	Appd
2	3/09/2020	AA	NC	EM
1	28/08/2020	AA	NC	GR

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Powerhouse Parramatta

Post-development - Mainstream Flood
Peak Depths and Levels
0.05% AEP (2.2 Hours)

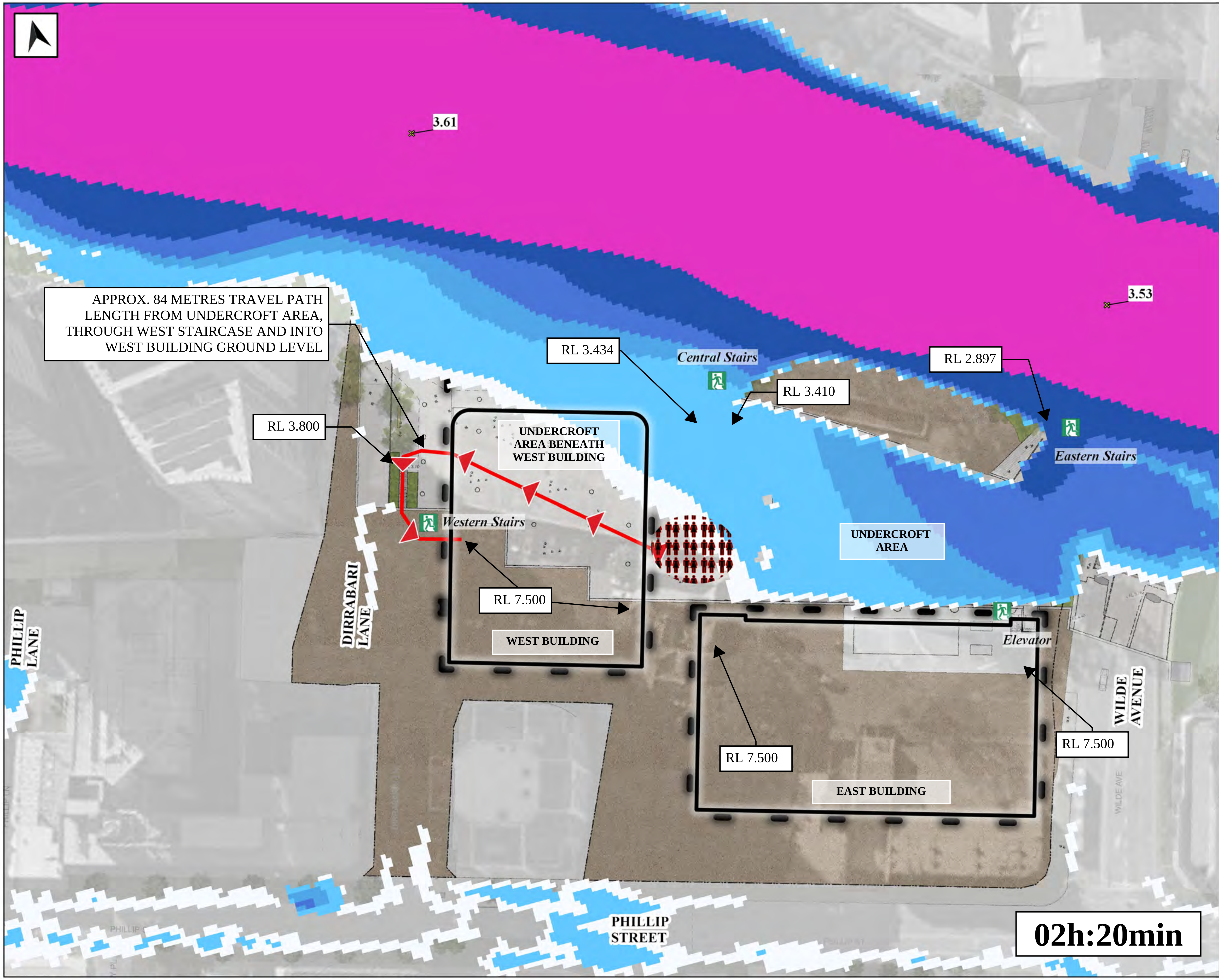
Scale at A3
1:750
0 10 20 m

Job No
273467

Figure Status
Final

Figure No
P1.0-0.05E-MF-2.2

Issue
2



Legend

- Powerhouse Building Outline
- Powerhouse Building Columns
- Non-DDA Evacuation Travel Pathways
- Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50- 1.00
- > 1.00

Issue	Date	By	Chkd	Appd
2	3/09/2020	AA	NC	EM
1	28/08/2020	AA	NC	GR

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Powerhouse Parramatta

Post-development - Mainstream Flood
Peak Depths and Levels
0.05% AEP (2.3 Hours)

Scale at A3 1:750

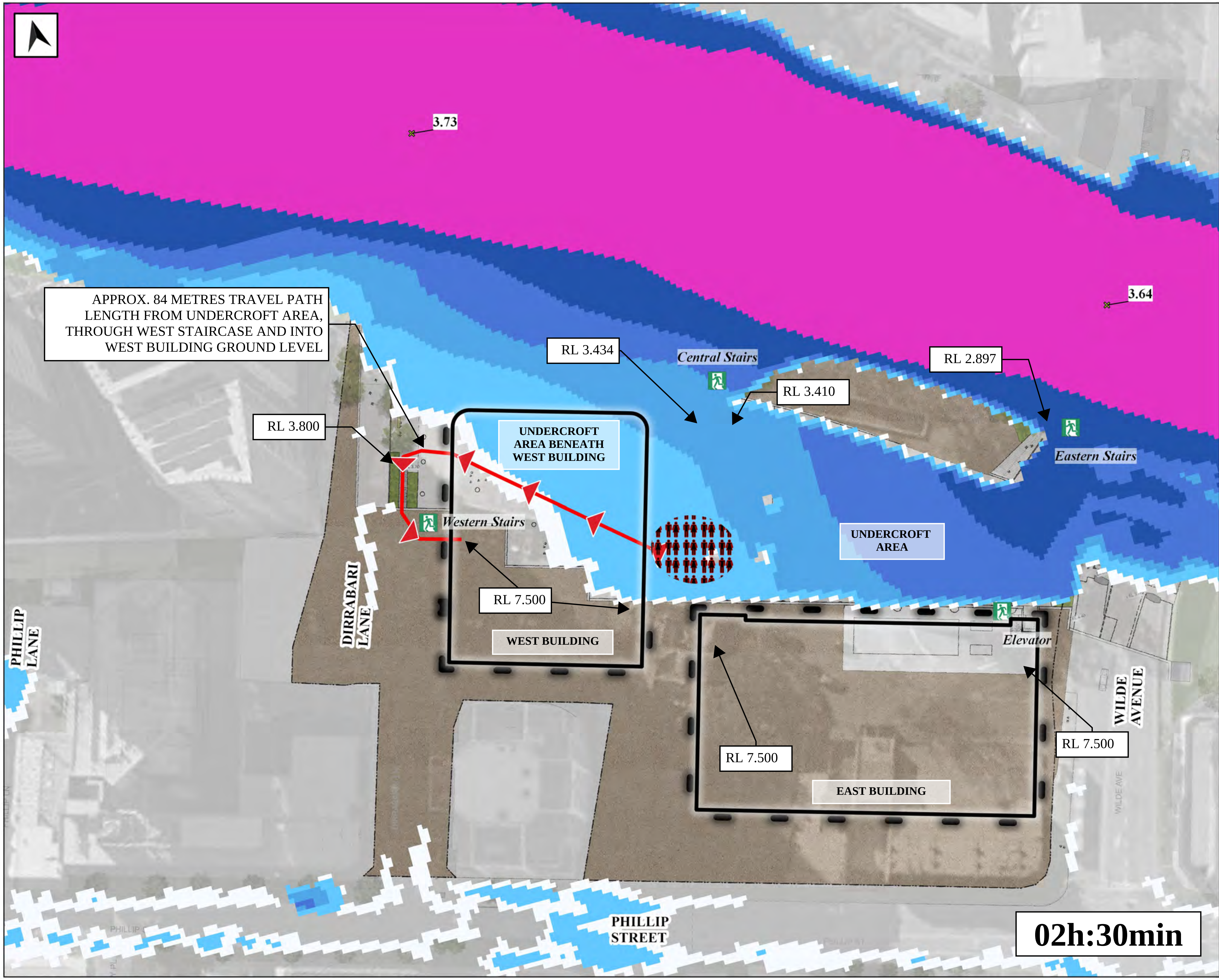
0 10 20 m

Job No **273467**

Figure Status **Final**

Figure No **P1.0-0.05E-MF-2.3**

Issue **2**



Legend

- Powerhouse Building Outline
- Powerhouse Building Columns
- Non-DDA Evacuation Travel Pathways
- Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50- 1.00
- > 1.00

Issue	Date	By	Chkd	Appd
2	3/09/2020	AA	NC	EM
1	28/08/2020	AA	NC	GR

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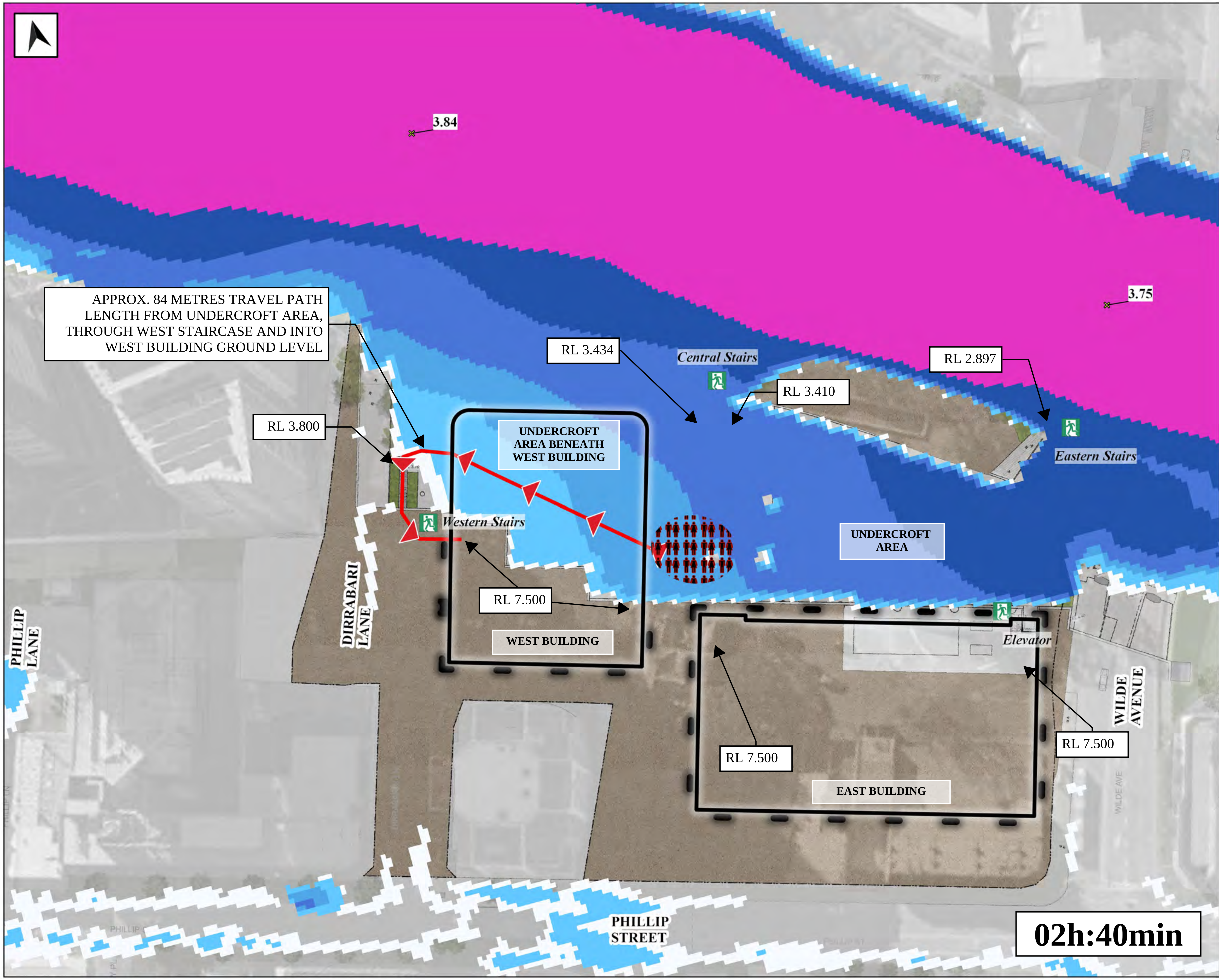
Client

Powerhouse Parramatta

Post-development - Mainstream Flood
Peak Depths and Levels
0.05% AEP (2.5 Hours)

Scale at A3
1:750
0 10 20 m

Job No **273467**
Figure Status **Final**
Figure No **P1.0-0.05E-MF-2.5**
Issue **2**



Legend

- Powerhouse Building Outline
- Powerhouse Building Columns
- Non-DDA Evacuation Travel Pathways
- Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50- 1.00
- > 1.00

Issue	Date	By	Chkd	Appd
2	3/09/2020	AA	NC	EM
1	28/08/2020	AA	NC	GR

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Powerhouse Parramatta

Post-development - Mainstream Flood
Peak Depths and Levels
0.05% AEP (2.7 Hours)

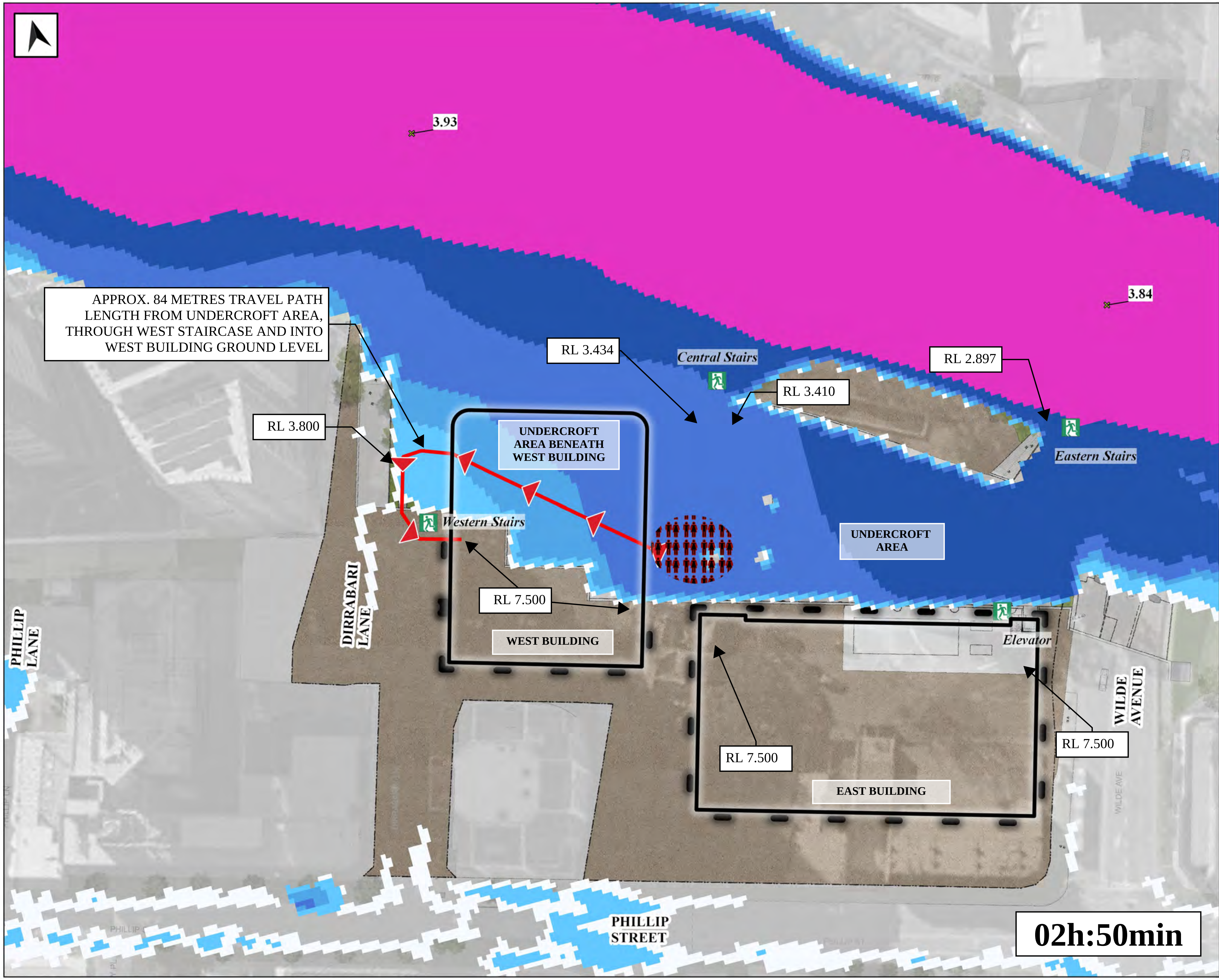
Scale at A3
1:750
0 10 20 m

Job No 273467

Figure Status Final

Figure No P1.0-0.05E-MF-2.7

Issue 2



Legend

- Powerhouse Building Outline
- Powerhouse Building Columns
- Non-DDA Evacuation Travel Pathways
- Flood Level (mAHD)

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50- 1.00
- > 1.00

Issue	Date	By	Chkd	Appd
2	3/09/2020	AA	NC	EM
1	28/08/2020	AA	NC	GR

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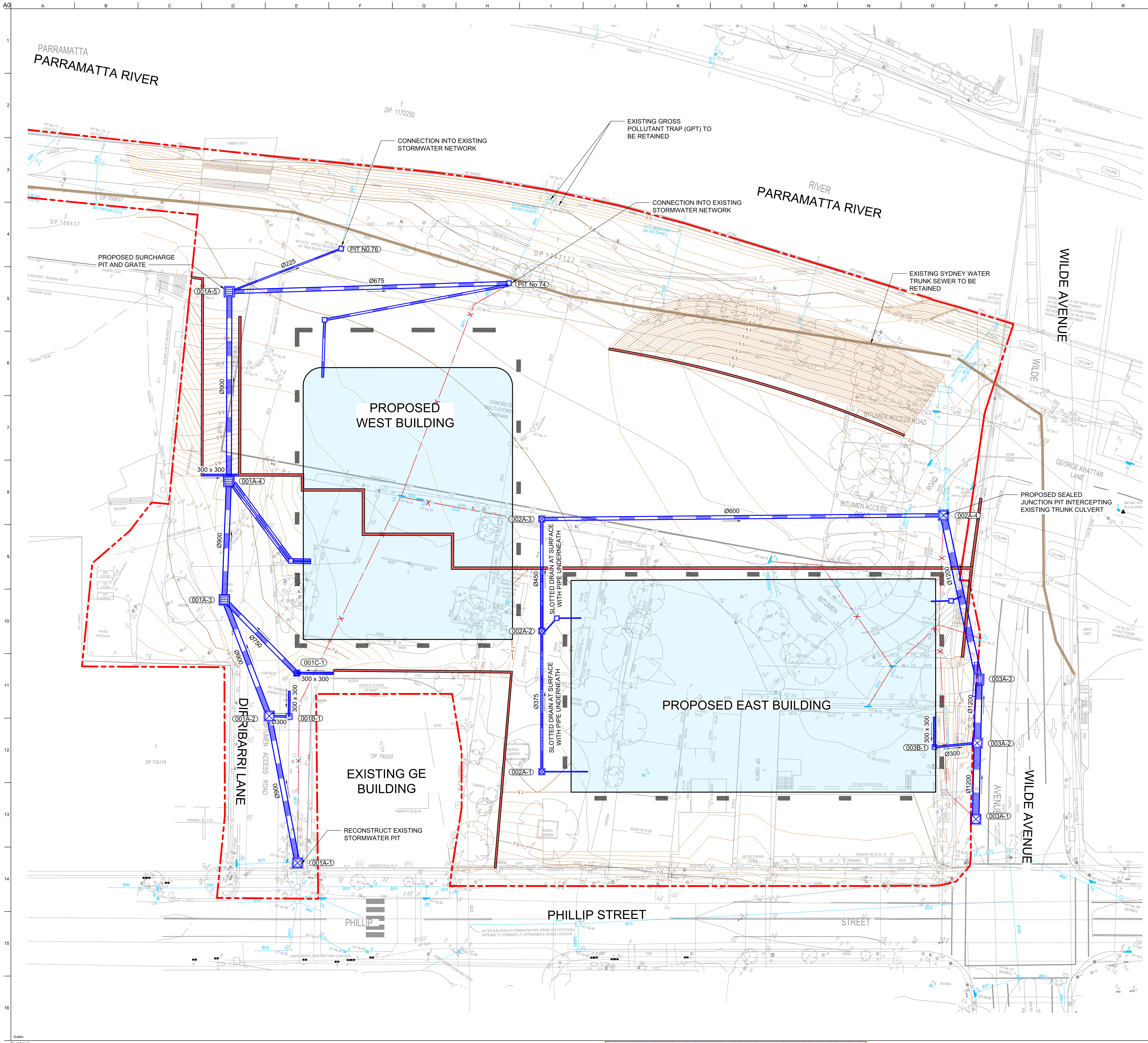
Post-development - Mainstream Flood
Peak Depths and Levels
0.05% AEP (2.8 Hours)

Scale at A3
1:750
0 10 20 m

Job No 273467
Figure Status Final
Figure No P1.0-0.05E-MF-2.8
Issue 2

Appendix C | Stormwater Management Plan



LEGEND

- PROJECT BOUNDARY
- EXISTING MINOR CONTOUR
- 17.0 EXISTING MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- 17.0 PROPOSED MAJOR CONTOUR (CONTOUR LABELS FACE UPHILL)
- PROPOSED RETAINING WALL

EXISTING DRAINAGE

- EXISTING STORMWATER
- EXISTING STORMWATER TO BE REDUNDANT
- EXISTING STORMWATER INLET PIT
- EXISTING STORMWATER KERB INLET PIT
- EXISTING STORMWATER INFILL PIT
- EXISTING STORMWATER GRATED LINEAR DRAIN

PROPOSED DRAINAGE

- Ø300 STORMWATER PIPEWORK (FLOW DIRECTION AND NTERNAL PIPE DIAMETER)
- STORMWATER INSPECTION PIT
- GRATED PIT
- GRATED INLET PIT
- TRENCH DRAIN

SEWER

- EXISTING TRUNK SEWER

NOTES:

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE ARUP FLOOD AND STORMWATER ADDENDUM REPORT REFERENCE PHM-ARP-REP-CE-0003.
2. THE INFORMATION CONTAINED IN THESE DRAWINGS PRODUCED BY ARUP IS SOLELY FOR USE OF INFRASTRUCTURE NEW SOUTH WALES FOR THE PURPOSE FOR WHICH IT HAS BEEN PREPARED. ARUP UNDERTAKES NO DUTY TO OR ACCEPTS NO RESPONSIBILITY TO ANY THIRD PARTY WHO MAY RELY UPON THIS DOCUMENT.
3. THIS STORMWATER PLAN IS A PRELIMINARY STRATEGY FOR THE PURPOSES OF CONCEPT DESIGN AND WILL CHANGE SUBJECT TO FURTHER DESIGN DEVELOPMENT.
4. DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
5. DO NOT SCALE OFF DRAWINGS.
6. TOPOGRAPHICAL AND SERVICES SURVEY FOR THIS DESIGN IS SUPPLIED BY:
   LTS LOCKLEY
   SUITE 1 , LEVEL 1, 810 PACIFIC HIGHWAY, GORDON NSW 2072
   PHONE 1300 587 000
   FAX 02 9499 7760
   SURVEY REFERENCE: 41692012DT REVISION D DATED 17/08/2020
7. SERVICES SHOWN ON THESE PLANS ARE LOCATED FROM SURVEY AND FIELD INVESTIGATION INFORMATION AND ARE NOT GUARANTEED TO BE COMPLETE OR CORRECT. ALL SERVICE LOCATIONS ARE TO BE VERIFIED BY THE CONTRACTOR PRIOR TO CONSTRUCTION.
8. DESIGN REFERENCES THE FOLLOWING FROZEN ARCHITECTURAL DESIGNS:
   LANDSCAPE - MCGREGOR COXALL POWERHOUSE PARRAMATTA
   REFERENCE 0842SY; DATED 26/08/2020
   BUILDING - MKG POWERHOUSE PARRAMATTA DATED 19/08/2020

Engineering Certification (CEng)
Name: ....
Signature: .... Date: ....

Design Model Version

Issue	Date	
1	04/09/20	ISSUED FOR SSDA ADDENDUM

0 0.2 0.4 0.6 0.8 1 m
North

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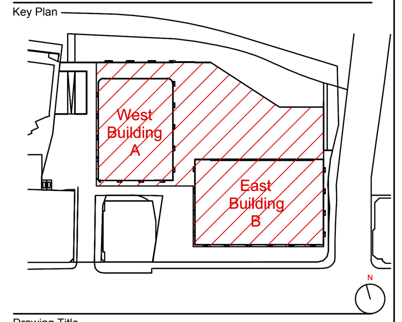
www.arup.com
CONSULT AUSTRALIA Member Firm
Arup Pty Ltd
ABN 18 000 966 165

Client: Infrastructure New South Wales; Museum of Applied Arts & Sciences

Project Title
POWERHOUSE PARRAMATTA

Key Plan



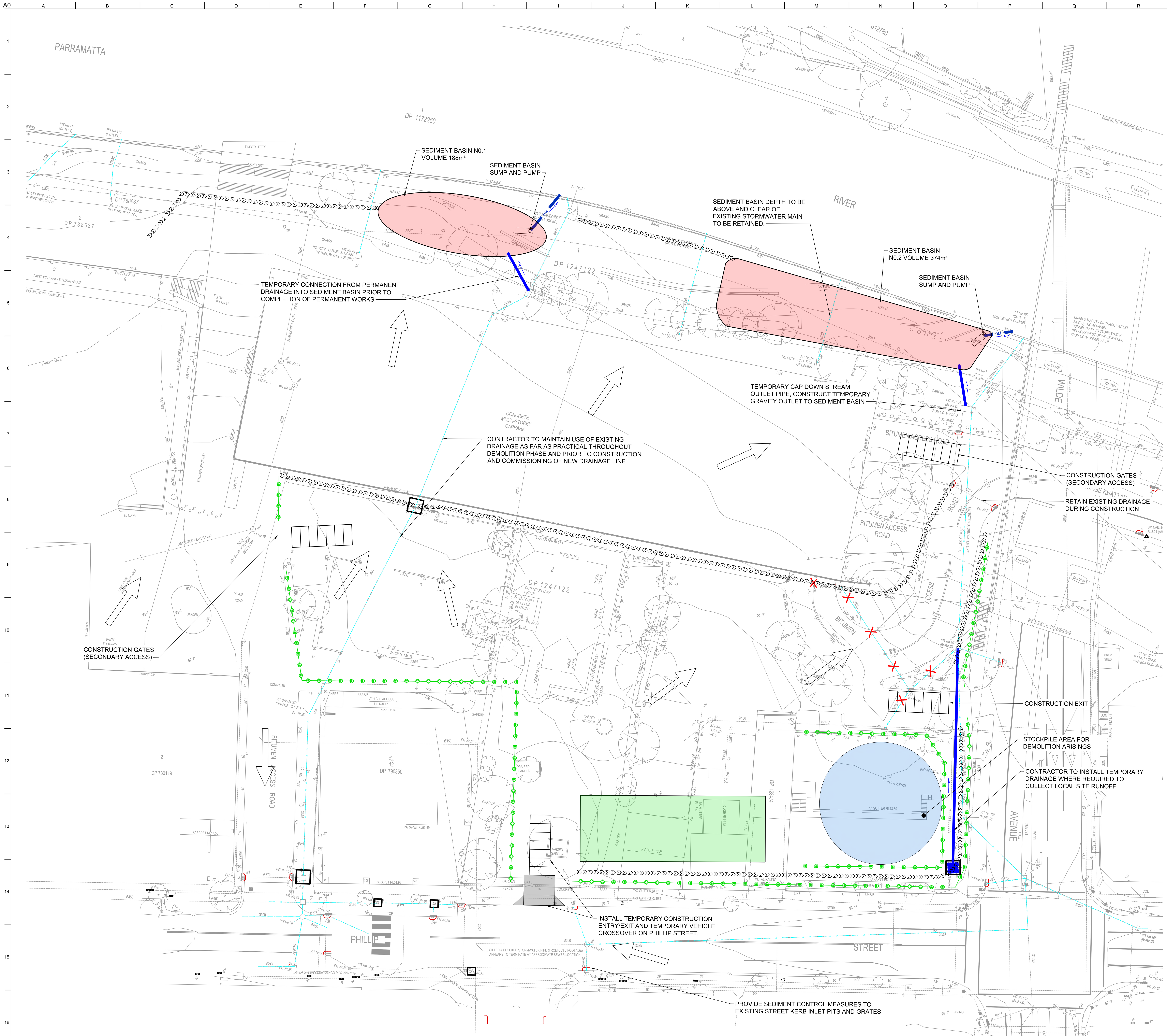
Drawing Title
STORMWATER DETAIL PLAN SHEET 1

Scale at A0	1:250	By / Chkd / Appd	MP/TT/EM
Role	CIVIL		
Status	S2 - Suitable for Information		
Arup Job No	273467-00	Rev	1
ID	PP-ARP-DRG-C-000601		

Scales
Do not scale

DRAWING COLOUR CODED - PRINT ALL COPIES IN COLOUR

Appendix D | Erosion and Sediment Control Plans



LEGEND

- TEMPORARY CONSTRUCTION ACCESS
- STRAW BALES
- SEDIMENT FENCE
- DIVERSION BANK AND CHANNEL
- STORMWATER SUMP AND OUTLET
- TEMPORARY RISING MAIN
- TEMPORARY DRAINAGE PIPE
- TEMPORARY DRAINAGE PIT
- PERMANENT DRAINAGE PIPE
- PERMANENT DRAINAGE PIT
- STORMWATER DRAINAGE
- EXISTING STORMWATER TO BE REDUNDANT
- INLET SEDIMENT TRAP
- FABRIC STOCKING SEDIMENT TRAP
- CONTRACTOR'S COMPOUND
- STOCK PILE AREA
- SEDIMENT BASIN
- TEMPORARY SITE ENTRANCE
- OVERLAND FLOW DIRECTION

NOTES

1. FOR SOIL AND WATER MANAGEMENT DETAILS AND NOTES REFER TO DRAWING No. PP-ARP-DRG-C-000110.
2. THIS DRAWING IS INDICATIVE ONLY AND ILLUSTRATES THE DESIGNERS' CONSIDERATIONS OF TEMPORARY SOIL AND WATER MANAGEMENT. THIS APPROACH MAY BE ADAPTED BY THE CONTRACTOR AT THEIR DISCRETION SUBJECT TO COMPLIANCE WITH GOOD PRACTICE AND 'THE BLUE BOOK'.
3. THIS SEDIMENT AND EROSION CONTROL PLAN DOES NOT TAKE INTO ACCOUNT DETAILED CONSTRUCTION STAGING. INTERIM SEDIMENT AND EROSION CONTROL MEASURES TO SUIT THE DETAILED STAGING OF THE WORKS ARE TO BE DETERMINED BY THE CONTRACTOR.
4. STOCKPILING AND STORAGE OF TOPSOIL AND TURF TO BE LOCATED AT INSW'S DISCRETION OR REMOVED OFF SITE.
5. EXISTING IN GROUND UTILITIES INDICATED ON THIS DRAWING IS REPRODUCED FROM DRAWINGS PREPARED BY LTS LOCKLEY AND ARUP ACCEPTS NO RESPONSIBILITY FOR ITS ACCURACY.
6. CONTRACTOR TO VERIFY THE LOCATION AND DEPTH OF INGROUND SERVICES BEFORE DISTURBING GROUND.
7. THE CONTRACTOR IS RESPONSIBLE FOR ANY AND ALL NECESSARY PROTECTIVE/DIVERSIONARY WORKS TOGETHER WITH ASSOCIATED APPROVALS WHICH SHOULD BE AGREED PRIOR TO WORKS COMMENCEMENT
   THE CONTRACTOR SHALL FAMILIARISE THEMSELVES WITH THE LOCAL STORMWATER FLOODING CONDITIONS AND RISKS PRIOR TO COMMENCING WORKS ON SITE. AN APPROPRIATE FLOOD RISK MANAGEMENT PLAN SHALL BE DEVELOPED FOR EACH STAGE OF THE PROJECT TO MINIMISE THE RISK OF FLOODING INJURING SITE STAFF OR MEMBERS OF THE PUBLIC, DAMAGING WORKS OR PLANT OR CARRYING MATERIALS OR DEBRIS DOWNSTREAM INTO THE RIVER. THE PROPOSED SYSTEMS MUST BE REVIEWED AND APPROVED BY INSW AND THEIR REPRESENTATIVES PRIOR TO COMMENCEMENT.
8. IMPLEMENT SEDIMENT TRAPS TO ALL EXISTING INLET PITS AND KERB INLET PITS AROUND THE DEVELOPMENT SITE.

Engineering Certification (CEng)
Name:
Signature: Date:

Design Model Version

Issue	Date	
1	04/09/20	ISSUED FOR SSDA ADDENDUM

0 2.5 5 7.5 10 12.5 m
North

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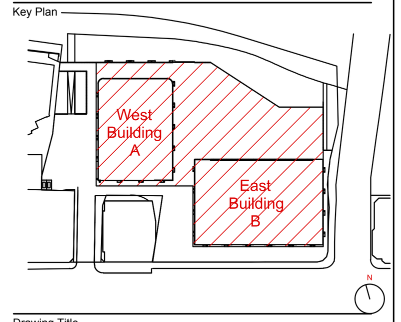
Member Firm
Arup Pty Ltd
ABN 18 000 966 165

Client
Infrastructure New South Wales
Museum of Applied Arts & Sciences

Project Title
POWERHOUSE PARRAMATTA

Key Plan

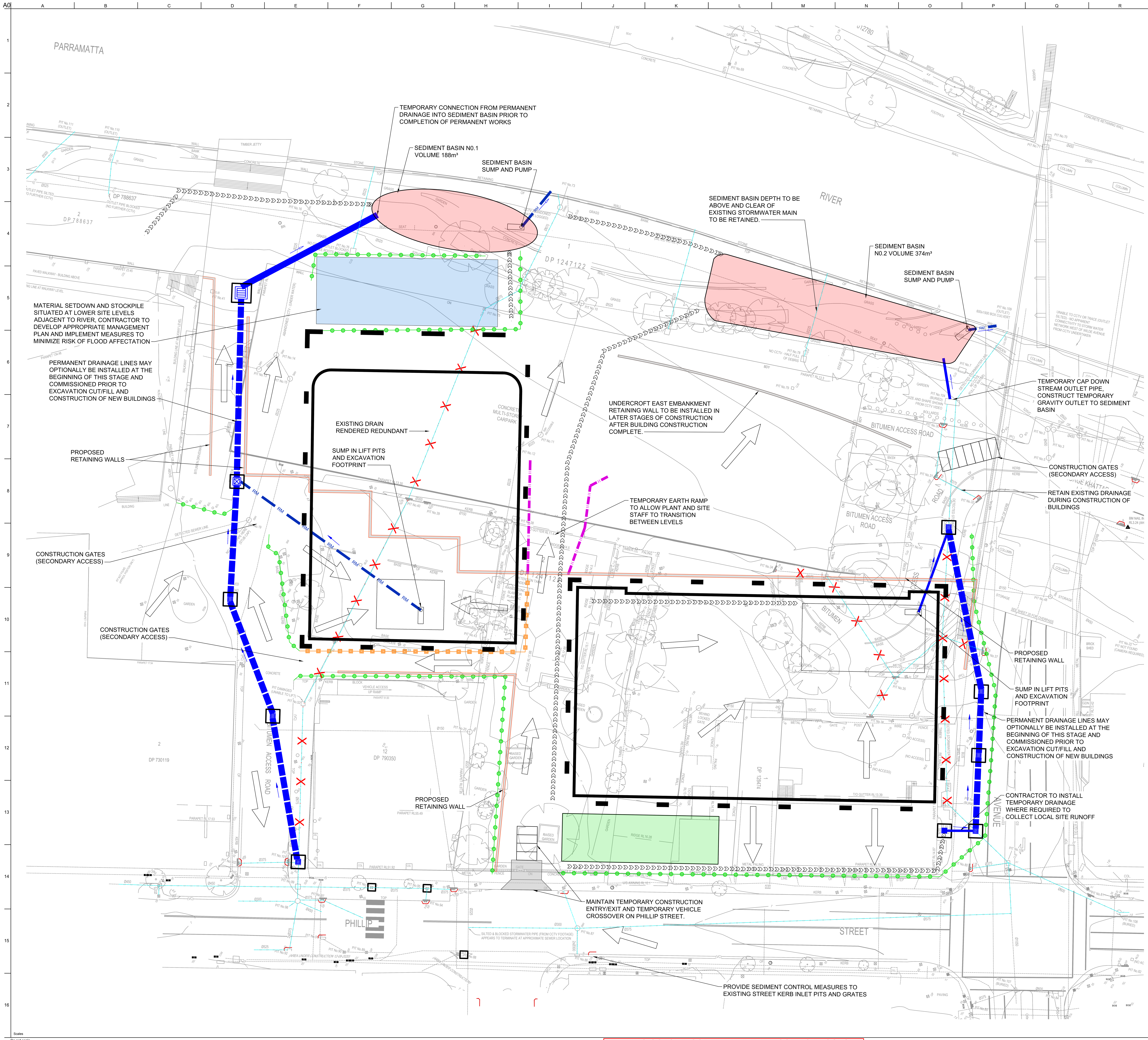


Drawing Title
EROSION & SEDIMENT CONTROL PLAN DEMOLITION PHASE

Scale at A0: 1:250m
By / Chkd / Appd: MP/TT/EM
Role: CIVIL
Status: S2 - Suitable for Information
Arup Job No: 273467-00
Rev: 1
ID: PP-ARP-DRG-C-000101

Scales
Do not scale

DRAWING COLOUR CODED - PRINT ALL COPIES IN COLOUR



LEGEND

- TEMPORARY CONSTRUCTION ACCESS
- STRAW BALES
- SEDIMENT FENCE
- DIVERSION BANK AND CHANNEL
- STORMWATER SUMP AND OUTLET
- TEMPORARY RISING MAIN
- TEMPORARY DRAINAGE PIPE
- TEMPORARY DRAINAGE PIT
- PERMANENT DRAINAGE PIPE
- PERMANENT DRAINAGE PIT
- STORMWATER DRAINAGE
- EXISTING STORMWATER TO BE REDUNDANT
- INLET SEDIMENT TRAP
- FABRIC STOCKING SEDIMENT TRAP
- CONTRACTOR'S COMPOUND
- STOCK PILE AREA
- SEDIMENT BASIN
- TEMPORARY SITE ENTRANCE
- OVERLAND FLOW DIRECTION
- TEMPORARY RAMPED ACCESS

NOTES

1. FOR SOIL AND WATER MANAGEMENT DETAILS AND NOTES REFER TO DRAWING No. PP-ARP-DRG-C-000110.
2. THIS DRAWING IS INDICATIVE ONLY AND ILLUSTRATES THE DESIGNERS' CONSIDERATIONS OF TEMPORARY SOIL AND WATER MANAGEMENT. THIS APPROACH MAY BE ADAPTED BY THE CONTRACTOR AT THEIR DISCRETION SUBJECT TO COMPLIANCE WITH GOOD PRACTICE AND 'THE BLUE BOOK'.
3. THIS SEDIMENT AND EROSION CONTROL PLAN DOES NOT TAKE INTO ACCOUNT DETAILED CONSTRUCTION STAGING. INTERIM SEDIMENT AND EROSION CONTROL MEASURES TO SUIT THE DETAILED STAGING OF THE WORKS ARE TO BE DETERMINED BY THE CONTRACTOR.
4. STOCKPILING AND STORAGE OF TOPSOIL AND TURF TO BE LOCATED AT INSW'S DISCRETION OR REMOVED OFF SITE.
5. EXISTING IN GROUND UTILITIES INDICATED ON THIS DRAWING IS REPRODUCED FROM DRAWINGS PREPARED BY LTS LOCKLEY AND ARUP ACCEPTS NO RESPONSIBILITY FOR ITS ACCURACY.
6. CONTRACTOR TO VERIFY THE LOCATION AND DEPTH OF INGROUND SERVICES BEFORE DISTURBING GROUND.
7. THE CONTRACTOR IS RESPONSIBLE FOR ANY AND ALL NECESSARY PROTECTIVE/DIVERSIONARY WORKS TOGETHER WITH ASSOCIATED APPROVALS WHICH SHOULD BE AGREED PRIOR TO WORKS COMMENCEMENT. THE CONTRACTOR SHALL FAMILIARISE THEMSELVES WITH THE LOCAL STORMWATER FLOODING CONDITIONS AND RISKS PRIOR TO COMMENCING WORKS ON SITE. AN APPROPRIATE FLOOD RISK MANAGEMENT PLAN SHALL BE DEVELOPED FOR EACH STAGE OF THE PROJECT TO MINIMISE THE RISK OF FLOODING INJURING SITE STAFF OR MEMBERS OF THE PUBLIC, DAMAGING WORKS OR PLANT OR CARRYING MATERIALS OR DEBRIS DOWNSTREAM INTO THE RIVER. THE PROPOSED SYSTEMS MUST BE REVIEWED AND APPROVED BY INSW AND THEIR REPRESENTATIVES PRIOR TO COMMENCEMENT.
8. IMPLEMENT SEDIMENT TRAPS TO ALL EXISTING INLET PITS AND KERB INLET PITS AROUND THE DEVELOPMENT SITE.

Engineering Certification (CEng)
Name: ....
Signature: .... Date: ....

Design Model Version
123456-CAL-MOD-XXXX

Issue	Date	
1	04/09/20	ISSUED FOR SSDA ADDENDUM

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Member Firm
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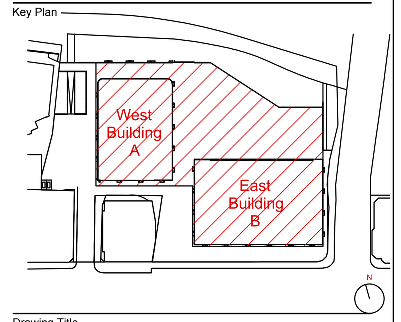
ABN 18 000 966 165

Client
INSW Infrastructure New South Wales
MAAS Museum of Applied Arts & Sciences

Project Title
POWERHOUSE PARRAMATTA

Key Plan



Drawing Title
EROSION & SEDIMENT CONTROL PLAN CONSTRUCTION PHASE

Scale at A0	1:250m
By / Chkd / Appd	MP/TT/EM
Role	CIVIL
Status	S2 - Suitable for Information
Arup Job No	273467-00
Rev	1
ID	PP-ARP-DRG-C-000102

Scales
Do not scale

DRAWING COLOUR CODED - PRINT ALL COPIES IN COLOUR

EROSION AND SEDIMENT

ES1 ALL EROSION AND SEDIMENT CONTROL MEASURES TO BE IN ACCORDANCE WITH LANDCOM "SOILS AND CONSTRUCTION MANUAL VOLUME 1, MARCH 2004"

ES2 WORKS SHALL BE UNDERTAKEN IN THE FOLLOWING SEQUENCE:

(A) INSTALL AIR MONITORING EQUIPMENT, COMMENCE WITH PITS TO BE RETAINED.

(B) INSTALL EROSION AND SEDIMENT CONTROLS.

(C) STRIP AND STOCKPILE TOPSOIL AND CARRY OUT ALL BULK EARTHWORKS.

(D) UNDERTAKE REMAINING SITE WORKS IN ACCORDANCE WITH THE ENGINEERING PLANS.

(E) REMOVE SOIL AND WATER MANAGEMENT WORKS NOT REQUIRED FOR OTHER STAGES OF CONSTRUCTION ONCE UPSTREAM SURFACES ARE STABILISED TO THE SATISFACTION OF THE PROJECT MANAGER.

EROSION CONTROL MEASURES

EC1 CONTROLS AFFECTED BY WORKS ARE TO BE RE-ESTABLISHED PRIOR TO THE COMPLETION OF EACH DAYS WORK.

EC2 DUST CONTROL MEASURES SHALL BE IMPLEMENTED CONTINUOUSLY DURING CONSTRUCTION WORKS TO THE SATISFACTION OF THE PROJECT MANAGER.

SEDIMENT CONTROL MEASURES

SC1 DURING EARTHWORKS, CAR PARK WORKS, ROADWORKS, TEMPORARY DIVERSION BANKS SHOULD BE CONSTRUCTED TO LIMIT SLOPE LENGTH, WHERE POSSIBLE, IN ACCORDANCE WITH THE FOLLOWING:

RECOMMENDED MAXIMUM SPACING BETWEEN CROSS BANKS ON ALL ROADS.

SLOPE	MAXIMUM SPACING (m)
0 TO 1%	150
1 TO 3%	100
3 TO 5%	70
5 TO 10%	50
10 TO 17%	16

SC2 ALL STORMWATER PITS TO BE COVERED OR DROP INLET SEDIMENT TRAPS PROVIDED IN ACCORDANCE WITH DRAWING No. PP-ARP-DRG-C-000101 & PP-ARP-DRG-C-000102. KERB INLET SEDIMENT TRAPS ARE TO BE INSTALLED AFTER COMPLETION OF PAVING.

SC3 SEDIMENT TRAPS ARE TO BE MAINTAINED SUCH THAT:

(A) SEDIMENT IS REMOVED SUCH THAT NO LESS THAN 70% OF THE DESIGN CAPACITY REMAINS AT ANY ONE TIME.

(B) MATERIALS ARE REPLACED OR REPAIRED AS REQUIRED TO ENSURE SERVICEABILITY OF BOTH THE ELEMENT AND THE TRAP.

SC4 PERMANENT DRAINAGE STRUCTURES INCLUDING: PIPES, PITS ARE TO BE HANDED OVER IN A CLEAN CONDITION AT THE COMPLETION OF THE CONTRACT MAINTENANCE PERIOD.

SC5 FOLLOWING COMPLETION AND RESTORATION OF SITE, REMOVE ALL MATERIALS AND FILL DIVERSION DRAINS, WATERWAYS AND SEDIMENT TRAPS TO MATCH LEVELS OF THE PREVIOUSLY COMPLETED WORKS.

SC6 ALL TREES OTHER THAN THOSE IDENTIFIED FOR REMOVAL BY THE ARBORIST SHALL BE RETAINED UNLESS APPROVED FOR REMOVAL BY PROJECT MANAGER.

SC7 AN ACCESS POINT TO ALLOW MACHINE ENTRY / EXIT ARE TO INCLUDE A ROUNDED EARTH MOUND 0.3m HIGH WITH 10H:1V BATTERS.

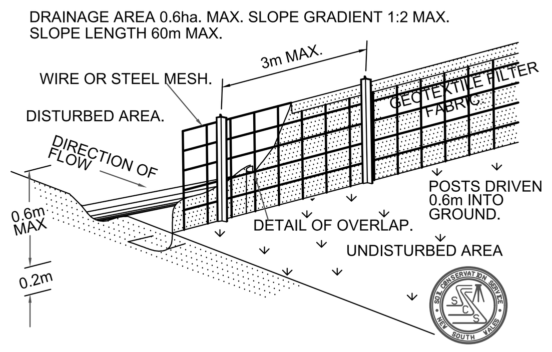
SC8 THE CONTRACTOR SHALL PROVIDE A 0.4m WIDE TURF STRIP BEHIND ALL KERB AND GUTTER AT COMPLETION OF FOOTPATH FORMATION AND 1.0m WIDE AROUND ALL SURFACE INLET PITS.

SC9 THE CONTRACTOR SHALL MAINTAIN A LOG BOOK DETAILING
- RECORDS OF ALL RAINFALL
- CONDITION OF SOIL AND WATER MANAGEMENT STRUCTURES
- ANY ADDITIONAL REMEDIAL WORKS REQUIRED

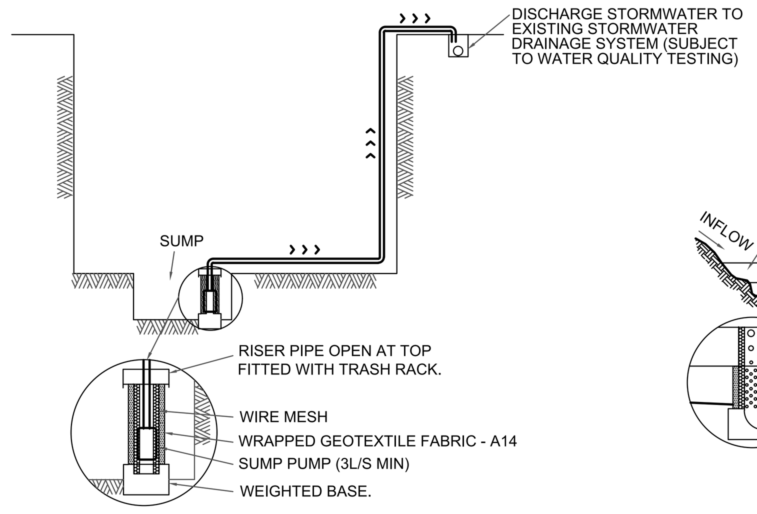
THE LOG BOOK SHALL BE MAINTAINED ON A DAILY BASIS AND BE MADE AVAILABLE TO ANY AUTHORISED PERSON UPON REQUEST. THE ORIGINAL LOG BOOK SHALL BE ISSUED TO THE PROJECT MANAGER AT THE COMPLETION OF THE WORKS.

SC10 THE CONTRACTOR SHALL AT ALL TIMES RESTRICT CONSTRUCTION EQUIPMENT MOVEMENT TO THE ESSENTIAL CONSTRUCTION AREAS.THE CONTRACTOR SHALL NOT EXTEND LAND DISTURBANCE BEYOND 2m FROM THE EDGE OF ANY ESSENTIAL CONSTRUCTION ACTIVITY.

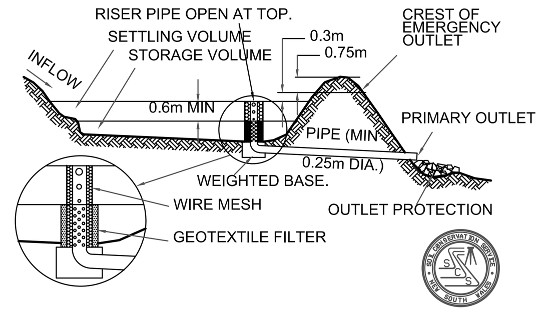
SC11 THE CONTRACTOR SHALL PROVIDE CATCH DRAINS AT THE BOTTOM OF ALL BATTERS AND DIVERT THE CATCH DRAINS AND ANY TAIL OUT DRAINS TO DRAIN TO THE NEAREST STORMWATER PIT.



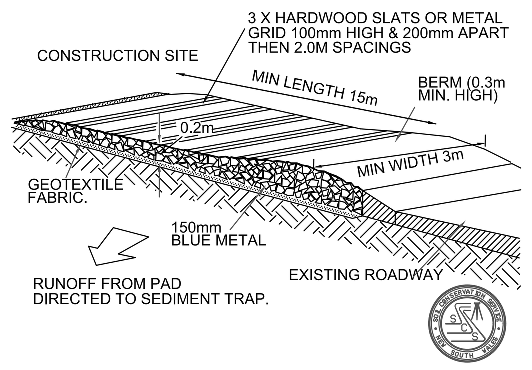
SEDIMENT FENCE



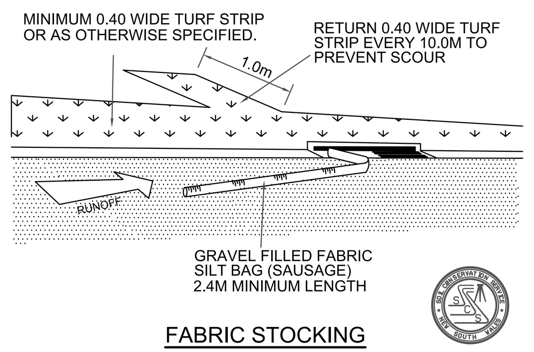
STORMWATER SUMP AND OUTLET



CROSS SECTION OF TYPICAL SEDIMENT BASIN



TEMPORARY CONSTRUCTION EXIT



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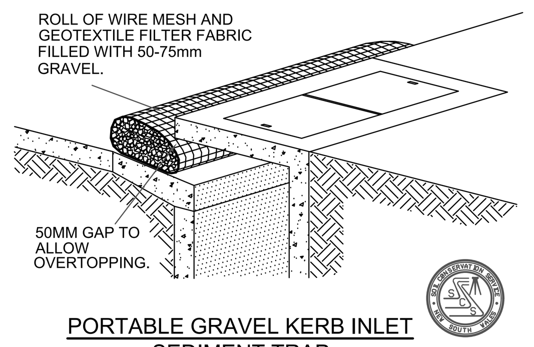

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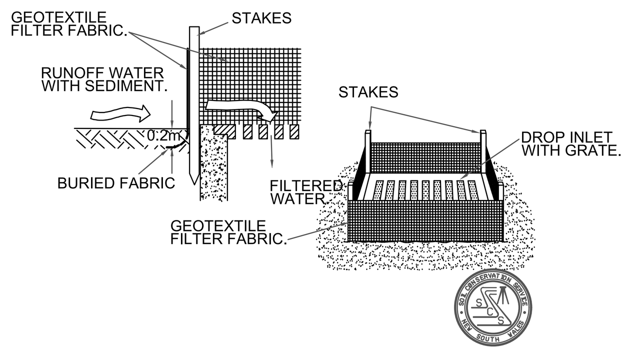

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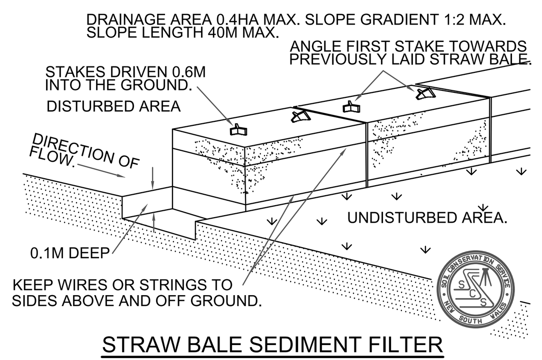

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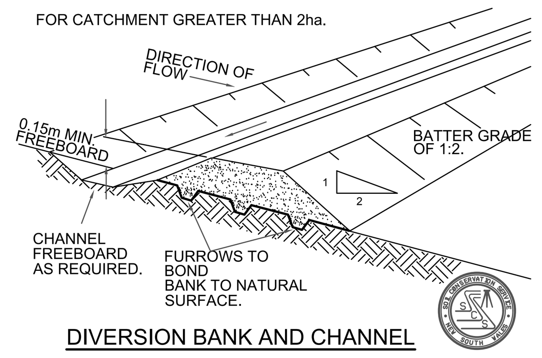

DIVERSION BANK AND CHANNEL

Engineering Certification (CEng)
Name:
Signature: Date:
Design Model Version

Issue	Date	
1	04/09/20	ISSUED FOR SSDA ADDENDUM

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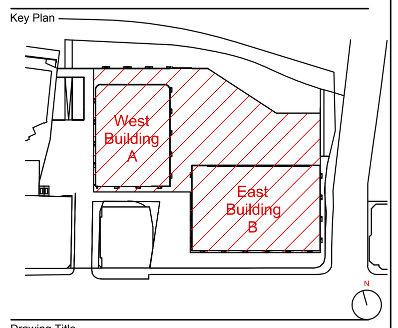
Infrastructure New South Wales
Museum of Applied Arts & Sciences

Project Title
POWERHOUSE PARRAMATTA

Key Plan



Drawing Title
EROSION AND SEDIMENT CONTROL PLAN GENERAL NOTES AND DETAILS

Scale at A0: NOT TO SCALE
By / Chkd / Appd: MP/TT/EM
Role: CIVIL
Status: S2 - Suitable for Information
Arup Job No: 273467-00
Rev: 1
ID: PP-ARP-DRG-C-000110

Scales
Do not scale

Appendix E | Rare Flood Event Technical Note

Technical Note

ARUP

To	Infrastructure NSW		
Copies		Reference number	
From	ARUP	File reference	
Subject	Appendix E - Derivation of Boundary Conditions for Rare Flood Events for the Powerhouse Parramatta Flood Assessment		

1 Introduction

This technical note outlines the approach undertaken to derive the boundary conditions for the rare flood events between the 1% AEP and the Probable Maximum Flood (PMF) for the Powerhouse Parramatta flood assessment.

The boundary conditions are incorporated into the Powerhouse Parramatta TUFLOW model to simulate Parramatta River and local catchment flooding for the rare flood events, e.g. 1 in 800, 1 in 1000, 1 in 2000 AEP. The predicted flood behaviour has been used to ascertain the development flood immunity to rare floods as well as for the development of the flood emergency management strategy.

2 Approach

For modelling the riverine flood, the Powerhouse Parramatta flood model adopts the City of Parramatta Council (CoPC) MIKE-11 model Parramatta River flow and tailwater level hydrographs as the upstream and downstream boundary conditions respectively.

The upstream model boundary is located approximately 1.5 km upstream of the proposed development, north-west of the Bankwest Stadium. The downstream model boundary is located east of the Charles Street weir, approximately 400 m downstream from the proposed development.

The hydrographs could not be derived for the flood events between the 1% AEP and the PMF as the MIKE11 model has not been set up to run the intermediate events of interest and the hydrologic model linked to the MIKE11 model is not available.

Therefore, an alternative approach has been developed to generate the hydrographs by interpolating the peak flows and tailwater levels for the rare flood events based on known values generated from the MIKE11 model for the 20%, 5%, 1% AEP and PMF events. The values are for the critical storm duration, i.e. 9 hours for events up to the 1% AEP and 4 hours for the PMF.

For modelling the local catchment flood, a DRAINS hydrologic model has been developed to generate inflow hydrographs for input into the TUFLOW model. The rainfall hyetographs for events up to the 1% AEP have been developed in accordance with ARR87 methodology (matching the ARR87 flows for the riverine flood). The 1 in 2000 AEP rainfall hyetographs have been developed using the methodology found in *ARR Book VI Estimation of Large to Extreme Floods*, which utilises rainfall depths for the 1% AEP and the Probable Maximum Precipitation (PMP).

3 Results

The results shown in Chart 1 and Chart 2 are for the derivation of the model upstream peak flows and downstream tailwater levels respectively. Chart 1 is a log-normal probability plot and Chart 2 is a normal probability plot, which are generally used in hydrologic data analysis and allows for a good fit of the hydrologic data as shown.

ARR Book VI Estimation of Large to Extreme Floods recommended an AEP of 10^{-7} for the Probable Maximum Precipitation (PMP) for catchment area up to 100 km^2 (approximate size of Upper Parramatta River and CBD catchments). It is assumed that this event will yield the PMF. This AEP has been adopted for setting the plotting position of the PMF peak flows and tailwater levels.

Once the peak flows and tailwater levels were determined (as tabulated in Table 1), the 1% AEP flow and tailwater level hydrographs obtained from the MIKE11 model were scaled up with the corresponding factor to produce the equivalent hydrographs for the rare flood events of interest.

Table 1: Summary of Peak Flows (m^3/s) and Tailwater Levels (mAHD) at Model Boundary

AEP	Peak Flows (m^3/s) at Upstream Model Boundary	Peak Tailwater Levels (mAHD) at Downstream Model Boundary
20%	431	2.52
5%	608	3.36
1%	749	3.87
0.2% (1 in 500)	920	4.52
0.125% (1 in 800)	972	4.68
0.1% (1 in 1000)	1000	4.75
0.05% (1 in 2000)	1078	4.98
10^{-7} (PMF)	2970	8.10

To determine the rainfall depths for the events between the 1% AEP and 1 in 2000 AEP, the values have been interpolated for the intermediate events as shown in Chart 3 (normal probability plot). The rainfall depths are based on the 9-hour critical storm duration for riverine flooding since for the rare flood events floodwaters break out of the river upstream of the development site and inundate the whole Parramatta CBD, thus dictating the flow behaviour.

Once the rainfall depths have been determined (as tabulated in Table 2), the rainfall hyetographs are developed by scaling down the 1 in 2000 AEP rainfall for the intermediate events (e.g. 1 in 800, 1 in 1000 AEP). The rainfall hyetographs are then incorporated into the DRAINS hydrologic model, which is then used to generate the local catchment rainfall boundary conditions for the TUFLOW model.

Table 2: Summary of Total Rainfall Depths (mm) for Local Catchment (based on 9-hour Storm)

AEP	Total Rainfall Depths (mm)
1%	181
0.2% (1 in 500)	250
0.125% (1 in 800)	269
0.1% (1 in 1000)	277
0.05% (1 in 2000)	303

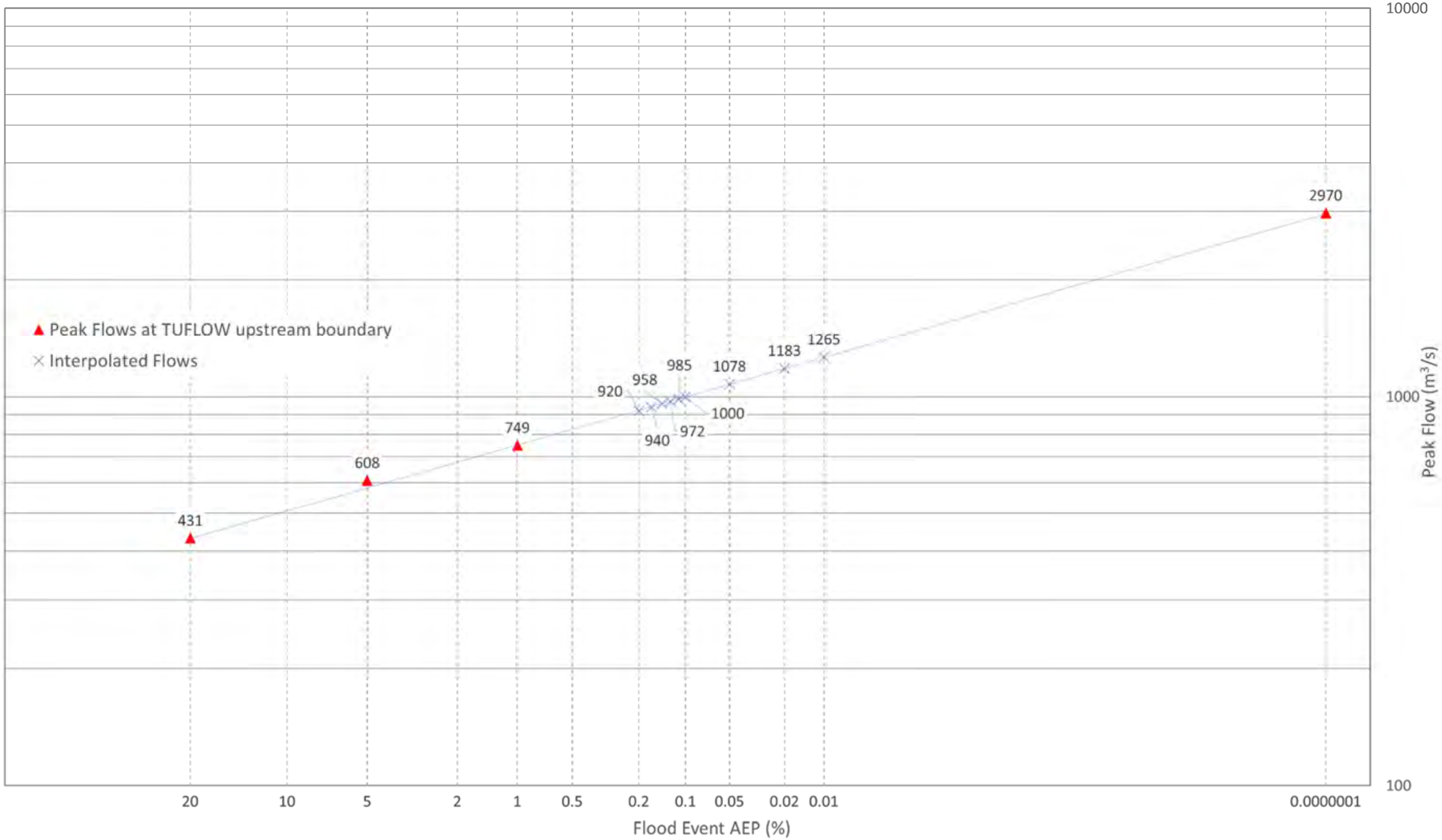


Chart 1: Peak Flows (m^3/s) at Upstream Model Boundary

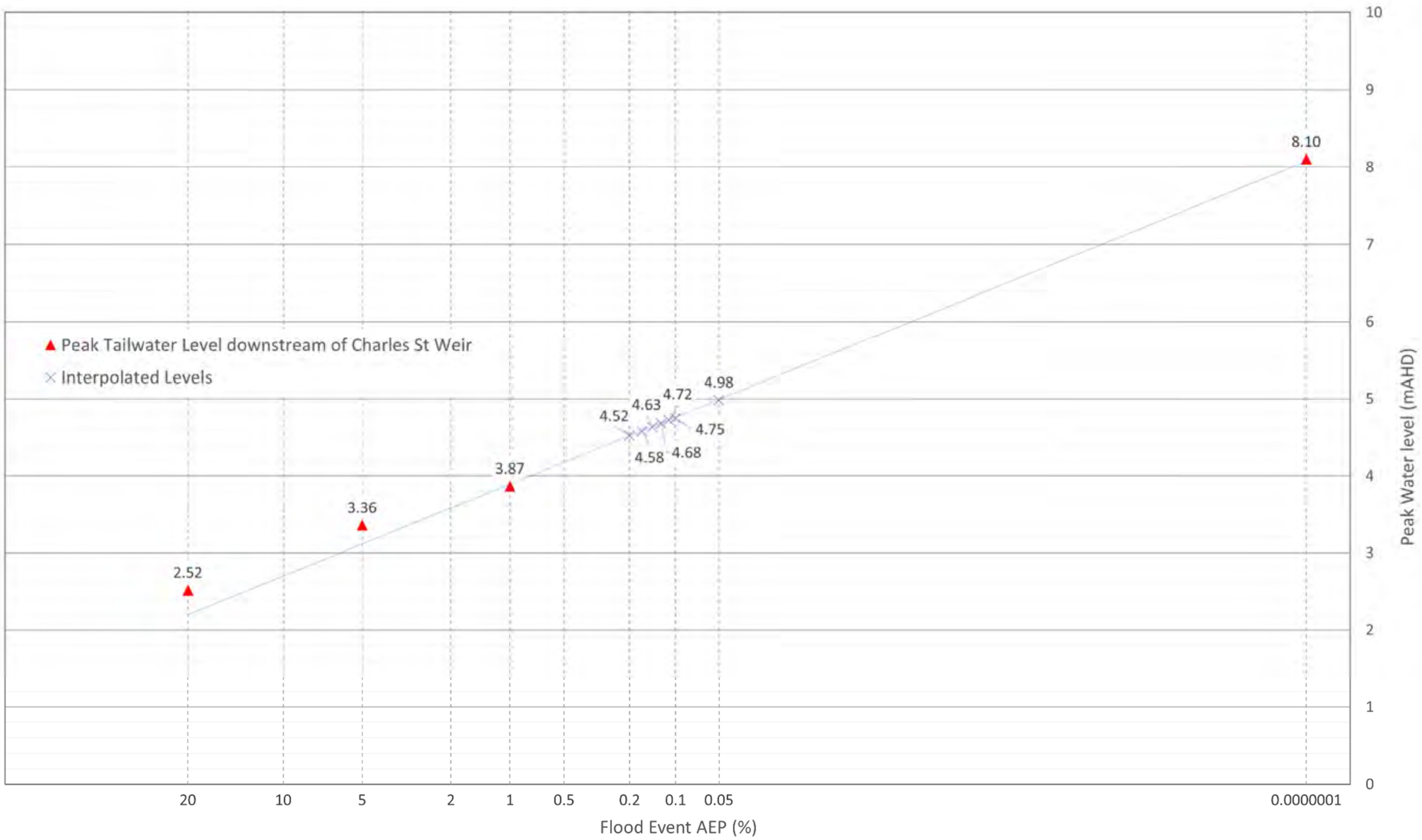


Chart 2: Peak Tailwater Levels (mAHD) at Downstream Model Boundary

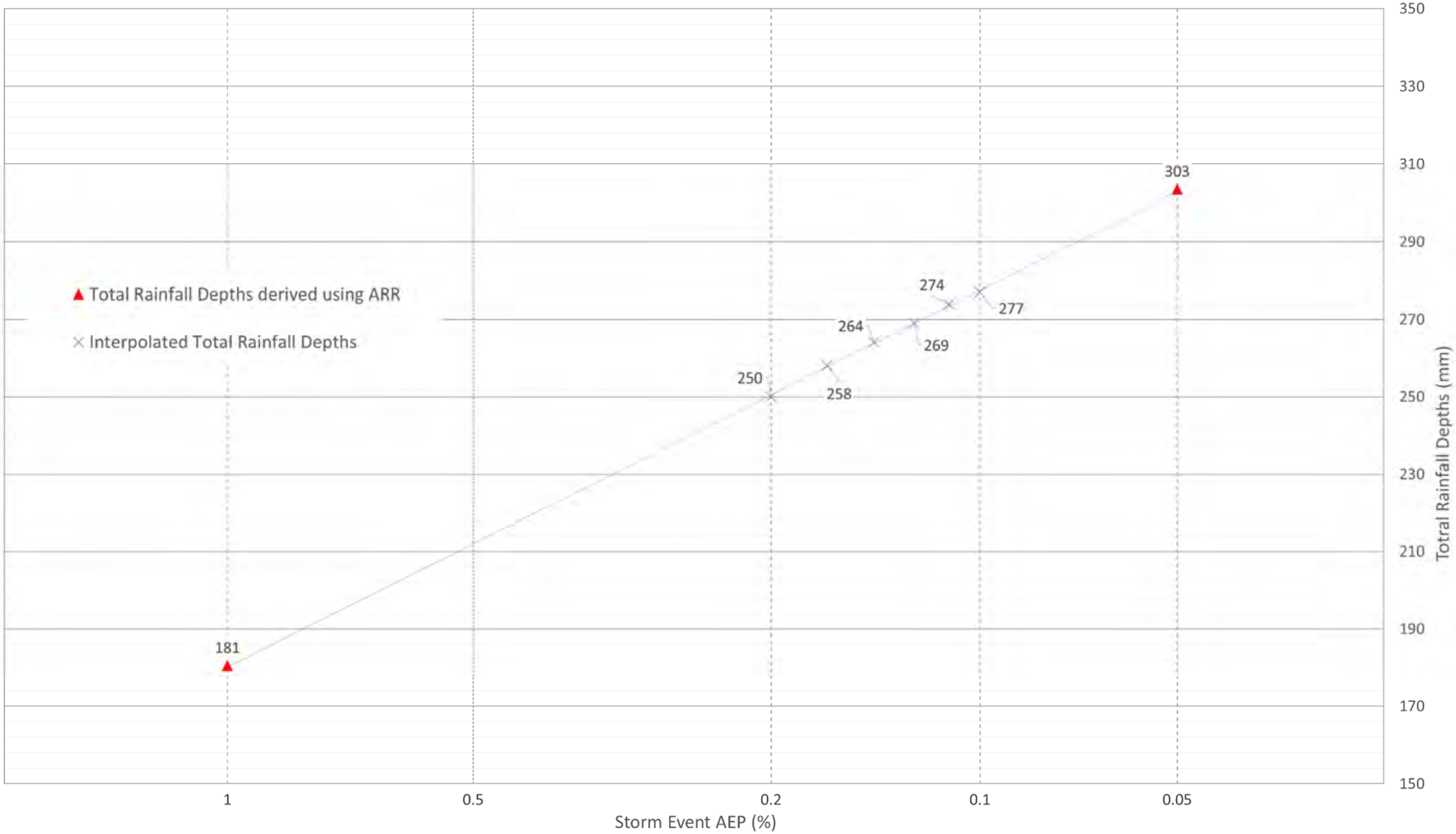


Chart 3: Total Rainfall Depths (mm) for Local Catchment (based on 9-hour Storm)