WarriewoodVale Pty Ltd

Flood Assessment and Flood Emergency Response Plan (FERP): 8 Forest Road, Warriewood NSW

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P1504988JR06V01
October 2020

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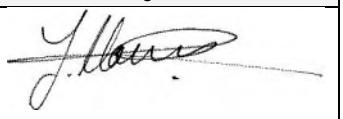
Paul Dinh	Terry Harvey Stanley Leung	Terry Harvey	

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All enquiries regarding this project are to be directed to the Project Manager.

Executive Summary

Martens & Associates Pty Ltd (MA) have prepared this flood assessment and flood emergency response plan (FERP) to support a development application (DA) for a proposed residential development at 8 Forest Road, Warriewood NSW (the site). This report documents the procedures and findings of hydrologic and hydraulic modelling of the site in existing and proposed conditions.

Assessment concluded that:

1. Council's adopted flood characteristics are accurately replicated by the existing conditions flood model.
2. Proposed flood characteristics are largely consistent with existing conditions, and differences due to the proposed development are negligible.
3. The proposed development area of the site is flood free in the 1% AEP flood (with and without climate change).
4. The proposed development would have acceptable offsite flood impacts.
5. Compliance with Council flood planning level requirements for buildings are achieved.
6. The proposed development is compatible with the existing floodplain environment.
7. The compliance assessment demonstrates the site can be developed in accordance with Council flood planning requirements.

The FERP finds that whilst the site is affected by flood water in rare events greater than the 1% AEP flood, a range of straightforward mitigation measures can be implemented to reduce the flood risks at the site to acceptable levels. In summary:

1. Warning procedures prior to the flood occurring will significantly reduce the likelihood of persons on site being exposed to a major flood event.
2. Risk to persons on site is managed through a shelter-in-place during major flood events greater than the 1% AEP event.
3. The proposed backup flood warning device ensures that effective warning time and reliable flood-safe egress can occur in the unlikely event that there are no other prior emergency services flood warnings.
4. The FERP demonstrates that the site can operate safely as a residential development.

Contents

1 Introduction

1.1 Overview

This report has been prepared by Martens & Associates Pty Ltd (MA) to support a development application (DA) for the proposed residential development at 8 Forest Road, Warriewood, NSW. It provides an assessment of the proposed development with respects to flooding, including flood impact assessment and flood emergency response.

We understand the proposed development will be undertaken in 2 stages:

- Stage 1: demolition of the existing dwelling, construction of internal roads, and subdivision of land to provide 17 Torrens title residential lots, one super lot, two lots for the construction of private internal roads with associated civil and stormwater works and one community lot.

- Stage 2: construction of a residential flat building within the super lot. The proposed building comprises 64 residential apartment units with a single level basement car park.

We note that all the proposed flood mitigation works required for the ultimate development including both of the residential subdivision lots and residential flat buildings will be constructed as part of Stage 1 works. Modelling approach undertaken in this report is based on the ultimate stage development, which would be consider appropriate for both Stage 1 and Stage 2 developments. Refer to Attachment A for site survey and the Architecture plan for proposed site layout.

1.2 Project Scope and Objectives

Project scope and objectives are:

1. Update the approved Martens and Associates (February 2017) hydraulic model (TUFLOW) and determine site flood characteristics for the 1% annual exceedance probability (AEP) flood (with and without climate change) and probable maximum flood (PMF) events.

2. Update site terrain data to allow detailed hydraulic modelling of the site in existing and proposed conditions.

3. Prepare relevant flood maps including flood extents, depths, levels, velocities, hazards and impacts.

4. Comment on flood characteristics and model outcomes in existing and proposed conditions.

5. Prepare a flood emergency response plan (FERP) for the developed site.

6. Prepare a compliance assessment in accordance with PC/ NBC floodplain development controls.

1.3 Relevant Guidelines

This report has been prepared in accordance with the following guidelines and policies:

1. Commonwealth of Australia (Geoscience Australia) (2016), *Australian Rainfall and Runoff – A Guide to Flood Estimation.*

2. NSW Department of Infrastructure, Planning and Natural Resources (2005), *Floodplain Development Manual*.

3. Pittwater Council (2015), *Pittwater 21 Development Control Plan (DCP)*.

4. Pittwater Council (2001), *Warriewood Valley Urban Land Release: Water Management Specification*.

5. Weeks, W and Rigby, T (2016), *Blockage of Hydraulic Structures,* Chapter 6 of Book 6 in *Australian Rainfall and Runoff – A Guide to Flood Estimation*.

1.4 Definitions

AEP	Annual exceedance probability: the probability of a flood event occurring within a year. A 1% AEP flood has a 1% chance of occurring in any given year.
ARI	Average recurrence interval: the average time between flood events occurring. A 100 year ARI flood occurs on average once every 100 years.
ARR	Australian Rainfall & Runoff
BOM	Bureau of Meteorology
Council	Pittwater Council (PC), Northern Beaches Council (NBC)
DA	Development application
FERP	Flood emergency response plan

FLI	Flood level indicator
FPL	Flood planning level
IFD	Intensity frequency duration – design rainfall data for frequent and infrequent storm events.
MA	Martens & Associates Pty Ltd
PMF	Probable maximum flood – the most extreme flood event possible for a certain location, with an approximate ARI of 100,000 to 10,000,000 years.

2 Site Description and Background Data

2.1 Location and Site Description

Existing site description summary is provided in Table 1.

Table 1: Existing site description summary.

Address	8 Forest Road, Warriewood, NSW
Lot / DP	Lot 1 DP 5055
Site Area	56,806 m^2
Local Government Area (LGA)	Pittwater Council (PC) / Northern Beaches Council (NBC)
Current Land Use	Rural residential
Current Zoning	RU2 – rural landscape & R3 – medium density residential
Site Description	The site is primarily grassed at lower elevations and bushland at higher elevations. There are several structures on the site including two buildings and driveways.
Surrounding Land Uses	Light industrial/commercial to north, low density residential to east and bushland to west and south.
Site Elevation	Approximately 17 mAHD at northern site boundary rising to 66 mAHD at southern site boundary.
Site Grading & Aspect	Approximately 5 – 38%, NNE aspect
Site Drainage	Narrabeen Creek runs from west to east through the northern portion of the site. A shallow drainage depression runs from south-west to north-east through the site and discharges to Narrabeen Creek.

2.2 Catchment Description

We note the following regarding the catchment upstream of the site:

- The site is located within the Narrabeen Creek catchment.
- Upstream catchment is primarily bushland and rural residential areas, and includes the suburbs of Ingleside and Warriewood.
- The total catchment area is 81.6 ha and is shown in Attachment D Map 01.

2.3 Site Flood and Overland Flow Mechanisms

The site is likely affected by the following flood mechanisms:

- Overland flows from the site itself and the local upstream catchment (refer Section 2.2).
- Flood overbank flows from Narrabeen Creek.

- High tailwater conditions in Narrabeen Creek causing upstream flows to back up onto the site.

- Constriction of the Narrabeen Creek floodplain downstream of the site due to the culvert crossing beneath Jubilee Avenue / the natural topography west of the site, causing flood waters to back up onto the site.

2.4 Previous Flood Studies

A review of previous flood investigations was undertaken to assess likely local flood behaviour and characteristics for the site and the Narrabeen Creek catchment. Review identified three previous flood studies which would be relevant to this assessment.

2.4.1 BMT WBM (2019) Narrabeen Lagoon Floodplain Risk Management Study

BMT WBM conducted a flood assessment for this catchment on behalf of PC / NBC, and summarised the assessment in the report *Narrabeen Lagoon Floodplain Risk Management Study* (2019), hereafter referred to as the BMT WBM flood study. As part of their study, BMT WBM used RAFTS for hydrologic modelling and TUFLOW for hydraulic modelling.

2.4.2 Cardno (2013) Pittwater Overland Flow Mapping and Flood Study

Cardno conducted a flood assessment for this catchment on behalf of PC / NBC, and summarised the assessment in the report *Pittwater Overland Flow Mapping and Flood Study (2013)*, hereafter referred to as the Cardno flood study. As part of their study, Cardno used SOBEK for hydrologic and hydraulic modelling.

2.4.3 Martens and Associates (2017) Flood Study: 8 Forest Road, Warriewood NSW

MA previously conducted flood modelling for the site and summarised the assessment in the report Flood Study: 8 Forest Road, Warriewood NSW (2017, P1504988JR02V05), hereafter referred to as the MA 2017 flood assessment. As part of the previous study, MA used DRAINS for hydrologic modelling and TUFLOW for hydraulic modelling. This flood assessment has since been approved by PC / NBC.

MA have used the 2017 flood assessment as a basis for the preparation of the 'existing conditions' hydraulic model for the site in this study.

2.5 Proposed Development

Architectural drawings prepared by Jackson Teece indicate that the proposed development will include:

- 17 Torrens title residential lots.
- Residential flat building units with a single level basement carpark.
- Two access roads / driveways, multiple footpaths and a fire access road around the development.
- Two bioretention / detention basins.
- One underground OSD/Stormfilter tank.

3 Hydraulic Modelling

3.1 Overview

The TUFLOW hydraulic model was used to determine flood characteristics including flood extents, levels, depths, velocities and hydraulic hazard for the critical 1% AEP flood (with and without climate change) and probable maximum flood (PMF) events for existing and proposed conditions.

The MA 2017 TUFLOW model described at Section 2.4.3 has been used as the basis for undertaking detailed hydraulic modelling at the site.

3.2 Scenarios

The hydraulic model was setup to represent the following flood condition scenarios:

1. Existing condition: the catchment and site in their current state as described in Sections 2.1, 2.2 and 2.3.

2. Proposed condition: the external catchment in its current state and the site in its proposed state as described in Section 2.5.

The hydraulic model was used to assess flooding for the following events:

1. 1% AEP 90 minute (critical duration) event.

2. 1% AEP with climate change (30% increased rainfall intensity) 90 minute (critical duration) event.

3. PMF 15 minute (critical duration), and 3, 6, 24, 36, 48, and 72 hour (for inundation analysis) event.

In summary, a total of 6 scenarios were modelled as part of this assessment (2 flood condition scenarios and 9 flood events each).

3.3 Model Setup

3.3.1 Detailed Existing Conditions

The following changes were made to the MA 2017 flood model to enable detailed modelling of existing site conditions:

1. Development of a 1.0 m topographic grid based on the available LIDAR and survey data.

2. Updating the utilised TUFLOW modelling engine to 2018-03-AC.

All other model inputs and assumptions remained unchanged from the PC / NBC adopted MA 2017 model.

3.3.2 Detailed Proposed Conditions

The detailed existing conditions model was modified as follows to simulate proposed conditions:

1. Inclusion of site design grading as shown in MA planset P1504988PS05-C100 (not attached to this report). The survey data was merged with the detailed existing conditions surface to represent proposed conditions.

2. Development of a 1.0 m topographic grid based on the available LIDAR, survey data and proposed site grading.

3. Site manning's zones were updated to represent design surfaces.

4. Site buildings were removed and replaced with proposed buildings to model as flow obstructions.

5. The 1D network was updated to include a 1500 mm diversion pipe as documented in MA planset P1504988PS05-E100 (not attached to this report). 20% blockage has been applied to the pipe based on a blockage assessment in accordance with ARR (2016).

All other model construction elements remained consistent with the existing conditions model.

3.4 Results

3.4.1 Flood Results

Flood mapping results (flood levels, depths, velocities and provisional hazard categories) for the critical duration 1% AEP flood event with and without climate change and PMF events in existing and proposed conditions are provided in Attachment D, with drawing references summarised in Table 2.

Table 2: Flood map drawing references in Attachment D (MA planset P1504988MS01).

Flood Condition Scenario	Critical Duration Flood Event	Water Level & Depth	Provisional Hydraulic Hazard Categories [1]	ARR Flood Hazard Categories	Hydraulic Categorisation	Water Level Afflux
Existing Conditions	1% AEP	Map 03	Map 04	Map 05	Map 06	–
	1% AEP (CC [2])	Map 07	Map 08	Map 09	–	–
	PMF	Map 10	Map 11	Map 12	–	–
Proposed Conditions (Stage 1)	1% AEP	Map 13	Map 14	Map 15	Map 16	Map 26
	1% AEP (CC [2])	Map 17	Map 18	Map 19	–	–
	PMF	Map 20	Map 21	Map 22	–	–
Proposed Conditions (Stage 2)	PMF	Map 23	Map 24	Map 25	–	–

Notes

1. Provisional hydraulic hazard categories are based on NSW Floodplain Development Manual (2005) definitions and are shown in Figure 1.
2. Climate change scenario based on 30% increased rainfall intensity in accordance with PC / NBC requirements.

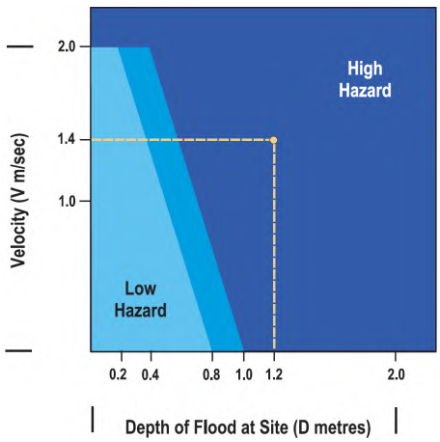

Figure 1: Provisional hydraulic hazard categories (*NSW Floodplain Development Manual*, 2005).

3.4.2 Validation

Comparison between BMT WBM (2013) and MA peak flood levels for various flood events is given in Table 3.

The comparison shows flood depths as modelled by MA agree well with BMT WBM modelling, and differences are typically ≤ ± 50 mm. MA modelled flood depths are slightly lower than those modelled by BMT WBM due to the smaller grid cell size, which increases channel capacity and thereby decreases local water levels. The differences between modelled flood levels are likely due to the smaller grid cell size (BMT WBM

used 6 m, MA used 1 m) and the inclusion of site survey data. These changes serve to increase the accuracy of the modelled flood levels at the site.

Further, flood levels and extents throughout the MA model domain were compared to those modelled by BMT WBM and were found to have close agreement. We therefore consider the MA model closely matches the Council adopted flood characteristics, slightly improving the accuracy of flood predictions at the site and is considered adequate for the purposes of detailed site modelling.

Table 3: Comparison between BMT WBM (2013) and MA (2020) modelled peak water depths.

	1% AEP (1 in 100 year ARI)			PMF		
Point [1]	NBC [2] (m)	MA [3] (m)	Difference (m)	NBC [2] (m)	MA [3] (m)	Difference (m)
1	1.60	1.61	0.01	3.66	2.10	-1.56
2	1.40	1.38	-0.02	3.42	2.80	-0.62
3	2.60	2.65	0.05	4.37	4.00	-0.37
4	1.50	1.54	0.04	2.68	2.50	-0.18
5	0.60	0.68	0.08	1.75	1.60	-0.15
6	-	-	-	-	-	-
7	-	0.01	0.01	0.07	-	-0.07
8	0.20	0.01	0.19	0.16	0.20	0.04
9	0.10	0.11	0.01	0.21	0.30	0.09
10	0.10	0.08	-0.02	0.31	0.20	-0.11
11	0.50	0.46	-0.04	0.68	0.80	0.12
12	0.20	0.22	0.02	0.40	0.40	0.00
13	0.20	0.18	-0.02	0.31	0.30	-0.01
14	0.30	0.25	-0.05	0.41	0.50	0.09
15	0.40	0.38	-0.02	0.60	0.60	0.00

Notes

1. Peak site flood level from PC / NBC flood certificate (Attachment B).

3.5 Discussion

3.5.1 Existing Conditions

1. Floodwaters in the 1% AEP and PMF events do not break the banks of Narrabeen Creek, and do not cause inundation in the proposed development area of the site.

2. Flood affectation at the site is primarily by the overland flow from upstream, and there is potentially some interaction with

mainstream flooding creating high tailwater conditions which restricts the passage of overland flow into Narrabeen Creek.

3. Flood hazard within the site in the 1% AEP are generally low outside of the defined drainage depression, with the exception near the end of the defined drainage depression where water spills over the driveway.

4. Flood depths in the site in the 1% AEP are generally shallow (<100 mm), with the exception of the defined drainage depression where depths vary from 150 mm to 500 mm.

3.5.2 Proposed Conditions

1. The proposed development area of the site is largely unaffected by 1% AEP flooding. Narrabeen Creek flows remain within the riparian corridor, and there is only minor on-site flooding at the intersection with Jubilee Street which becomes inundated for a short duration.

2. The 1500 mm trunk drainage pipe and fire trail function as per the design intent detailed at Section 3.3.2, and are appropriately sized to capture and divert 1% AEP upstream overland flows around the developed portion of the site and into the riparian zone.

3. The 1% AEP water level upstream of the fire trail peaks at 28.9 mAHD. The fire trail elevation in this area is 29.5 mAHD and there is therefore 600 mm of freeboard available, which is in excess of PC / NBC's 500 mm freeboard requirement.

4. The developed potion of the site is flood free in the 1% AEP plus climate change (30% increased rainfall intensity) event, demonstrating that site facilities are appropriately designed to accommodate worst climate change scenarios.

5. The majority of the developed portion of the site is inundated in the PMF due to upstream overland flows and high tailwater conditions in Narrabeen Creek.

6. The proposed basement access driveway for the apartment buildings is flood free in the 1% AEP event, with floodwaters fully contained within the trunk drainage line and Narrabeen Creek.

7. In the PMF events, access to the site becomes cut off by greater than 0.3 m deep floodwater for approximately 25 minutes in the 15 minute PMF event and for approximately 2 hours and 30 minutes in the 3 hour PMF event. Access to the site is unavailable

due to floodwaters during the 6 hour PMF event for approximately 4 hours and 12 minutes but proposed development is flood free. Site is flood free and access to the site is unaffected for PMF events 24 hours and longer.

8. Flooding on-site is primarily low hazard (velocity depth product < 0.4 m^2/s, H1), except for the areas east of apartment building A2 and B2, and along the access road between the Torrens title lots which experiences high hazard floodwaters (velocity depth product > 0.6 m^2/s, H5).

Offsite Flood Impacts

1. The proposed development is flood free in the 1% AEP event with climate change.

2. A number of properties on Bert Close and Hill View Crescent (east of the site) which were flood affected in existing conditions are completely flood free in proposed conditions due to the capture of upstream overland flow. This represents a significant benefit to these properties.

3. There is no increase in flood level on any private property above 20 mm.

4. There is in the order of 30 – 60 mm of water level increase within PC / NBC's drainage corridor in Narrabeen Creek north of the site, which is considered minor.

The proposed development provides a net benefit to flood affectation in the local area. The minor localised increase to water levels in Narrabeen Creek is acceptable considering the benefit to adjacent properties.

4 Flood Emergency Response Plan

This FERP makes recommendations to ensure that in the event of a flood at the site, human safety is prioritised, and risks to property and the environment are appropriately managed.

Should rare events greater than the 1% AEP flood occur at the site, floodwaters could potentially become hazardous across a large portion of the site. The critical duration of these large flood events is in the order of several days and will therefore afford ample warning time prior to site flood affectation. Therefore, the primary response is evacuation of people and vehicles from the premises prior to a flood occurring. Shelter-in-place is not considered a suitable response strategy due to the long duration of flood events affecting the site and flood depths and hazards. It is expected that as these events will be widely anticipated several days ahead of time, that the site will simply cancel bookings and close for the duration of potential flooding.

Refer to Table 4 for flood emergency response plan.

Table 4: Emergency Response Plan.

Triggers	Consequence	Key Actions	
		Flood monitoring	Manage risk of entering floodwaters
Prepare phase			
All the time.	N/A	Daily check of weather forecast and warning systems. The Northern Beaches Flood Warning System webpage is available at **http://new.mhl.nsw.gov.au/users/NBFloodWarning/.**	Install permanent flood warning signage and flood evacuation markers (refer to Attachment D). Residents are to maintain flood emergency kit.
Response phase			
Flood watch or severe weather warning for torrential rain/flooding issued for the area, or local weather implies heightened flood threat.	Flooding probable	Monitor flood threat via radar (www.bom.com.au). During heavy rain, regularly check for signs of flooding on Narrabeen Creek and Bert Close.	Residents can leave the site at any time.

Triggers	Consequence	Key Actions	
		Flood monitoring	Manage risk of entering floodwaters
Flooding of Narrabeen Creek reaches underside of upstream face of Jubilee Ave bridge over Narrabeen Creek (19.28 mAHD) indicated on flood depth indicator adjacent to Jubilee Ave.	Visible flooding in Narrabeen Creek and increased risk of flooding on-site.	Monitor flood depth indicator adjacent to Jubilee Ave approach to Narrabeen Creek Bridge.	As above. Residents are to begin preparations for shelter-in-place.
Flooding of Narrabeen Creek at Jubilee Ave crossing at or above flood warning marker level (20.02 mAHD) on flood depth indicator adjacent to Jubilee Ave.	Evacuation route via Bert Close is unsafe. Off-site evacuation not possible.	Carefully monitor flooding on-site and catchment to the south (check flood depth indicators adjacent to fire trail).	Residents are not to attempt to leave the site.
Flooding of southern catchment upstream of fire trail at or above flood warning marker level (29.63 mAHD) on flood depth indicator adjacent to fire trail.	High risk of flooding on-site.	Continue to monitor flood levels on site and catchment to south.	Residents shall remain in their dwellings. Persons in car parking areas shall move to higher levels by way of internal stairs. Occupants of the ground level of all buildings and houses will move to higher levels by way of stairs if the surrounding area becomes flood affected.
Recover Phase			
Warnings cancelled and floodwater receded from area.	Flood threat over.	Liaise with SES and Police regarding safety of leaving shelter and accessing Bert Close.	Exercise care when leaving shelter.

4.1 Shelter-In-Place

A shelter-in-place compliance assessment with Pittwater Council DCP Appendix 15, Section 1.6 is provided in Attachment C, Table 6. This assessment demonstrates the proposed development adequately addresses Council's shelter-in-place requirements and that this is an appropriate response.

Shelter in place is available above the peak PMF flood levels in each of the buildings on the first floor. As the peak PMF flooding depths in the vicinity of the houses are < 0.7m, the first floor level of the multistorey houses will provide sufficient area to shelter in place. Occupants of the ground level of all apartment buildings and houses will move to higher

levels by way of stairs if the surrounding area becomes flood affected. The access stairways in the apartment buildings are subject to shallow (< 20 mm), low hazard floodwaters, and are safe to traverse to higher levels in the critical PMF event.

5 Summary and Recommendations

A detailed hydraulic model has been developed for the site using Council's accepted MA 2017 TUFLOW model and using detailed site survey and proposed design elements to assess local flood characteristics. The model accurately replicates Council adopted flood characteristics.

The model was used to determine the existing and proposed flood conditions in the 1% AEP flood (with and without climate change) and PMF events. Modelling concluded that:

1. The proposed trunk drainage line effectively render the site development area flood free in the 1% AEP flood (with and without climate change).

2. The proposed development would have acceptable offsite flood impacts.

3. Compliance with Council flood planning level requirements for building and car park levels are achieved.

Whilst the proposed development is affected by flood hazards during the PMF event, the site specific FERP has been prepared to ensure that the site can operate safely in the floodplain environment. In summary:

1. Subscription to a number of warning systems will significantly reduce the likelihood of persons on site during a major flood event.

2. In the unlikely scenario that persons are on-site during an unanticipated rare events greater than the 1% AEP flood event, risk to persons is managed through site evacuation and shelter-in-place.

3. The proposed backup flood warning device ensures that effective warning time and reliable flood-safe egress can occur in the unlikely event that there are no other prior emergency services flood warnings.

4. With the implementation of the FERP procedures the risk to life is reduced to acceptable levels.

5. Having procedures prior to floods occurring will significantly reduce the likelihood of persons on site during a major flood event.

6. The backup flood warning device ensure people on the site have sufficient time to safely evacuate the site or to shelter-in-place based on the critical duration PMF event.

7. The flood warning device would ensure sufficient warning time and reliable flood-safe access in the unlikely event that prior flood warnings are unavailable.

The following recommendations are made:

1. Piers are to be designed by a suitably qualified engineer to withstand the forces of floodwater, debris and buoyancy.

2. A flood risk management plan should be prepared at DA stage to outline shelter-in-place and evacuation requirements to minimise flood risk to life and property associated with the use of land.

The proposed development has been designed to ensure compatibility with the existing floodplain environment. As the proposed development has been designed to achieve Council requirements, no further recommendations are considered necessary.

6 References

BMT WBM (2019), *Narrabeen Lagoon Floodplain Risk Management Study*.

Bureau of Meteorology (2017), *Rainfall IFD Data System*, www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016.

Cardno (2013), *Pittwater Overland Flow Mapping and Flood Study*.

Commonwealth of Australia (Geoscience Australia) (2016), *Australian Rainfall and Runoff – A Guide to Flood Estimation.*

Martens and Associates (2017), *Flood Study: 8 Forest Road, Warriewood, NSW (P1504988JR02V05)*.

NSW Department of Infrastructure, Planning and Natural Resources (2005), *Floodplain Development Manual*.

Pittwater Council (2015), *Pittwater 21 Development Control Plan (DCP)*.

Pittwater Council (2001), *Warriewood Valley Urban Land Release: Water Management Specification*.

Weeks, W and Rigby, T (2016), *Blockage of Hydraulic Structures,* Chapter 6 of Book 6 in *Australian Rainfall and Runoff – A Guide to Flood Estimation*.

7 Attachment A: Site Survey

INSTRUCTION NUMBER: 15/99	F	ADDITIONAL DETAIL FOR FLOOD MODELLING	DKH	24/09/2015
FILE ID: 87815	E	CONTOURS REVISED	MAC	22/09/2015
SURVEYED: LJB	D	ADDITIONAL ADJOINING DETAIL ADDED	DKH	11/09/2015
DESIGNED: N/A	C	CONTOURS REVISED	DKH	12/06/2015
DRAWN: MAC	B	ADDITIONAL DETAIL & HOUSE SITES	MAC	04/06/2015
CHECKED: DE	A	INITIAL ISSUE	MAC	20/05/2015
DATUM: AHD	NO.	DESCRIPTION	DRAWN	DATE
CONTOUR INTERVAL: 0.5m				

pcb PULVER COOPER & BLACKLEY
SURVEYORS TOWN PLANNERS
CIVIL ENGINEERS PROJECT MANAGERS

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PLAN:
PARTIAL DETAIL SURVEY OF
LOT 1 DP 5055
JUBILEE AVENUE
WARRIEWOOD

CLIENT:
WARRIEWOOD VALE PTY LTD

10 5 0 10 20 30
Horizontal Scale 1:500 (A1)
1:1000 (A3)

No. OF SHEETS
1

SHEET No.
1

8 Attachment B: Northern Beaches Council Flood Data

NORTHERN BEACHES COUNCIL

FLOOD INFORMATION REQUEST – MULTI-PURPOSE

Property: 8 Forest Road, Warriewood
Lot DP: 1//5055
Issue Date: 23 January 2017
Flood Study Reference: 2013 Narrabeen Lagoon Flood Study

A property can be impacted by more than one Category of flooding.

Flood Categories defined by the Pittwater 21 Development Control Plan include:

- **Flood Category 1 Areas-** Properties identified on the Flood Hazard Maps and located within Primary Floodplain Areas where the lowest point of the property is affected by the Flood Planning Level (FPL) (1% AEP flood level plus 500mm Freeboard). Flood Category 1 areas are further defined under flood hazard subcategories of high hazard and low hazard.
- **Flood Category 2 Areas-** Properties identified on the Flood Hazard Maps where the lowest point of the property lies above the Flood Planning Level but below the level of the Probable Maximum Flood.
- **Flood Category 3 Areas-** Properties generally located outside or adjacent to the Primary Floodplain Areas that are affected by flooding hazards associated with major stormwater drainage systems, local overland flow paths or drainage easements. Flood Category 3 Areas are further defined under the subcategories of Overland Flow Path – Major and Overland Flow Path – Minor.

Flood Information for lot:

Flood Life Hazard Category – See Map A

Minimum life hazard category: H1-H2

Maximum life hazard category: H6

Flood Category 1 (Mainstream) - See Flood Map C

1% Annual Exceedance Probability (1%AEP): See Flood Map B

1% AEP Maximum Water Level[1]: 21.8m AHD

1% AEP Maximum Depth: 3.05m

1% AEP Maximum Velocity: 2.5-3.0m/s

Flood Planning Level[2,3 &4]: 0.5m above the 1% AEP water level[3]

1% AEP Provisional Flood Hazard: See Map F

1% AEP Hydraulic Categorisation: See Flood Map G

Flood Category 1 (Mainstream) – with Climate Change (See Flood Map H)

The following is for the 30% Rainfall intensity increase and 0.9m Sea Level Rise Scenario:

1% Annual Exceedance Probability (1%AEP) Maximum Water Level with Climate change[1&3]:

21.15m AHD

1% AEP Maximum Depth with sea level rise (SLR)[3]: 2.35m See flood map G

1% AEP Maximum Velocity with (SLR)[3]: 2.5-3.0m/s See flood map G

Flood Category 2 (PMF) – See Flood Map D

Probable Maximum Flood (PMF) Level[4]: 42.9m AHD

PMF Maximum Depth from natural ground level: 4m

PMF Maximum Velocity: 4.5m/s

PMF Flood Hazard Extent Map: See flood map H

PMF Flood Hydraulic Categorisation: See flood map I

Flood Category 3[5] (Overland Flow) – See Flood Map E

1% AEP Overland Flow Maximum Water Level[3&4]: 39.5m AHD

1% AEP Overland Flow Maximum Depth from Natural Ground Level[3&4]: 0.8m

1% AEP Overland Flow Maximum Velocity: 1.5-2.0m/s

Minimum Floor Level[1,2,3 &4]: 0.5m above the 1% AEP Major overland flow extent and 0.3m above the 1% AEP Minor overland flow extent

---

Flood Category 3 (Overland Flow) – with Climate Change (See Flood Map H)

The following is for the 30% Rainfall intensity increase and 0.9m Sea Level Rise Scenario:

1% Annual Exceedance Probability (1%AEP) Maximum Water Level with Climate change[1&3]:

40.4m AHD

1% AEP Maximum Depth with sea level rise (SLR)[3]: 0.8m See flood map G

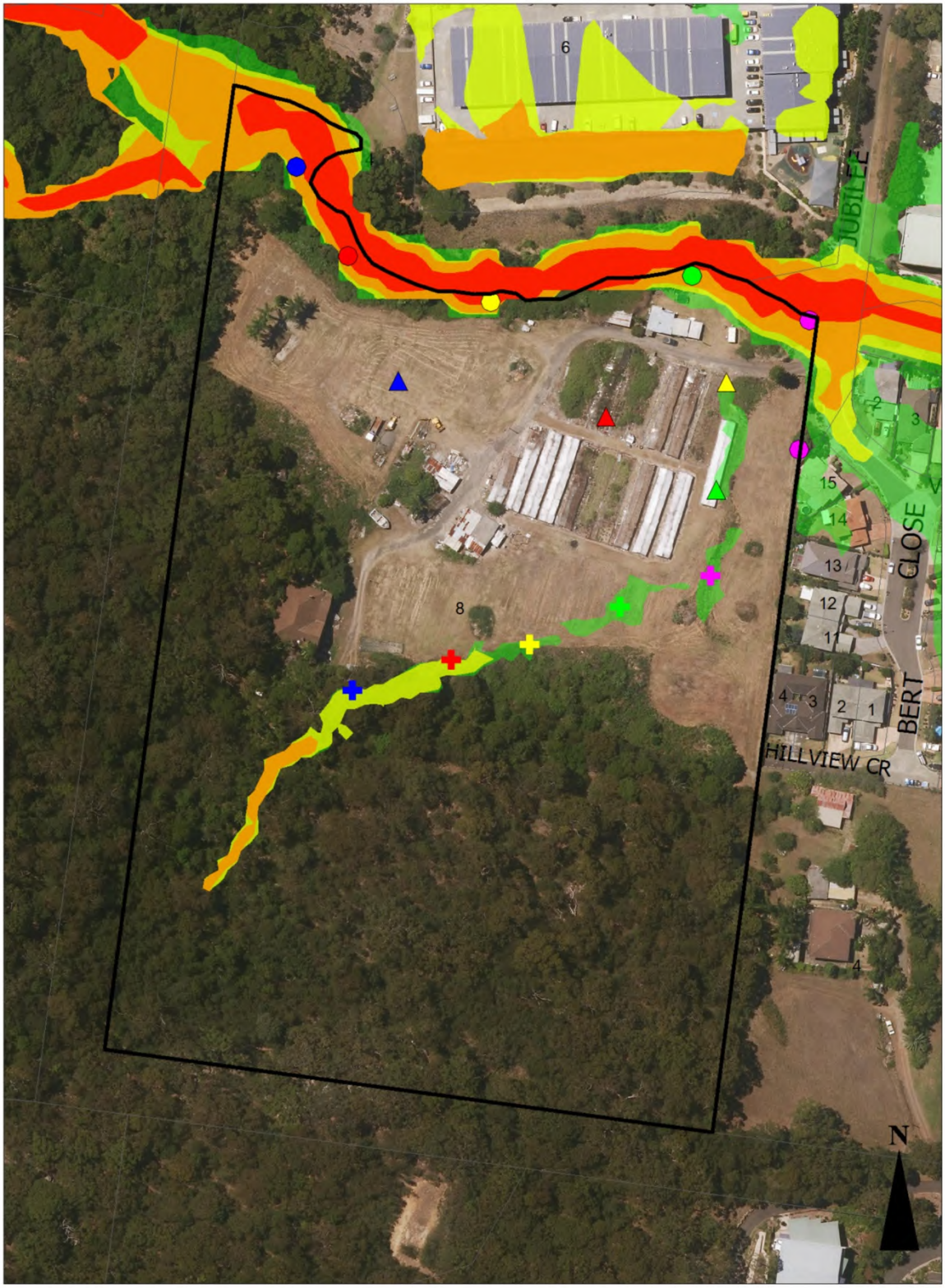
1% AEP Maximum Velocity with (SLR)[3]: 2-2.5m/s See flood map G

[1]The flood information does not take into account any local overland flow issues with a depth below 0.15m nor private stormwater drainage systems.
[2]Overland flow/mainstream water levels may vary across a sloping site, resulting in variable minimum floor/ flood planning levels across the site.
[3]Intensification of development requires the consideration of climate change impacts which may result in higher minimum floor levels than those indicated on this flood advice.
[4]Special Flood Protection developments require higher minimum floor levels using the higher of the PMF and the 1%AEP+0.5m.
[5]The applicable Flood Category 3 classification applied for the purpose of development assessment unless otherwise demonstrated in the Flood Risk Management Report that a different classification should apply (dependent on the location of the proposed development).

General Notes:

- All levels are based on Australian Height Datum (AHD) unless otherwise noted.
- The source information on this advice was obtained from numeric modelling prepared by consultants for Northern Beaches Council for existing site conditions at the time of the flood study. Separate review and flood model verification has not been undertaken by Council.
- The interpolated information is for the purpose of planning only. Detailed flood data for individual land areas were not determined from the exercise.
- Flood models only approximate flood behaviour. Site specific ground and building survey levels should be used to relate flood levels and to assess the impact of flooding. A site specific flood study/risk assessment may be required for any future development. Care and expertise is required in the interpretation of these flood levels. Engage a suitably qualified engineer to assist you in this matter.
- You need to refer to the Pittwater 21 DCP flood development controls, if you are planning to lodge a Development Application.The advice may be reviewed and amended by Northern Beaches Council in the course of assessment of a specific development application.
- While this advice is periodically updated, it is possible that the Council holds further information dealing with the flooding which has not been incorporated into the above advice.
- Estuarine/coastal inundation has not been taken into account in the flood information.
- Council is currently updating the 2013 Overland Flow Flood Study for this Area and as such the property's flood classification and flood level may be subject to changes as a result of the updated flood modelling.

FLOOD MAP A: FLOOD LIFE HAZARD CATEGORY



Flood Life Hazard Categories

H6 H5 H3-H4 H1-H2

Lot Boundary

Map not to Scale

Notes:

- Refer to Pittwater 21DCP for 'Flood Emergency Response Planning for Development in Pittwater Policy (Appendix 15) for additional information on the Flood Life Hazard Categories and Pittwater 21 DCP Control B3.25.
- Cadastre Lines (Source: NSW Government Land and Property Information), flood levels/extents (Source: Flood study reference) and aerial photography (Source Near Map 2014) are indicative only.

FLOOD LEVEL POINTS

Note: Cadastre Lines (Source: NSW Government Land and Property Information), flood levels/extents (Source: Flood study reference) and aerial photography (Source: NearMap 2014) are indicative only.

Flood Levels

	5% AEP Max WL (m AHD)	5% AEP Max Depth (m)	5% AEP Max Velocity (m/s)	1% AEP Max WL (m AHD)	1% AEP Max Depth (m)	1% AEP Max Velocity (m/s)	PMF Max WL (m AHD)	PMF Max Depth (m)	PMF Max Velocity (m/s)
●	20.7	0.3	0.5	21.2	1.6	1.3	22.4	2.1	2.1
●	20.4	1.0	1.8	21.0	1.4	2.1	22.5	2.8	2.5
●	19.8	1.9	1.8	20.5	2.6	2.1	21.9	4.0	2.3
●	19.5	0.9	0.9	20.1	1.5	1.1	21.2	2.5	1.5
●	Null	Null	Null	19.8	0.6	1.0	20.9	1.6	1.8
▲	Null	Null	Null	Null	Null	Null	Null	Null	Null
▲	Null	Null	Null	Null	Null	Null	Null	Null	Null
▲	22.0	0.2	1.3	22.0	0.2	1.3	22.1	0.2	1.6
▲	22.6	0.1	1.0	22.6	0.1	1.1	22.7	0.3	1.7
▲	20.9	0.0	0.7	20.9	0.1	0.8	21.1	0.2	1.6
✚	30.3	0.5	1.0	30.4	0.5	1.1	30.6	0.8	1.8
✚	28.1	0.2	1.0	28.1	0.2	1.1	48.3	0.4	1.8
✚	26.7	0.2	1.0	26.7	0.2	1.1	26.8	0.3	1.4
✚	24.6	0.3	1.1	24.7	0.3	1.2	24.8	0.5	1.9
✚	23.2	0.4	1.0	23.3	0.4	1.1	23.5	0.6	1.7

WL – Water Level
PMF – Probable Maximum Flood
Null = No peak water level/depth/velocity identified in flood event

Climate Change Flood Levels (30% Rainfall intensity and 0.9m Sea Level Rise)

	CC 1% AEP Max WL (m AHD)	CC1 % AEP Max Depth (m)
●	20.6	0.3
●	20.3	1.0
●	19.8	1.8
●	19.4	0.8
●	Null	Null
▲	Null	Null
▲	Null	Null
▲	Not Available	Not Available
▲	Not Available	Not Available
▲	Not Available	Not Available
✚	Not Available	Not Available
✚	Not Available	Not Available
✚	Not Available	Not Available
✚	Not Available	Not Available
✚	Not Available	Not Available

Null = No peak water level/depth/velocity identified in flood event
Not available = spot height information not available
WL – Water Level
PMF – Probable Maximum Flood

FLOOD MAP B: FLOODING - 1% AEP EXTENT

Notes:

- Extent represents the 1% annual Exceedance Probability (AEP) flood event.
- Flood events exceeding the 1% AEP can occur on this site.
- Extent does not include climate change.
- Cadastre Lines (Source: NSW Government Land and Property Information), flood levels/extents (Source: Flood study reference) and aerial photography (Source Near Map 2014) are indicative only.

FLOOD MAP C: MAINSTREAM FLOODING EXTENT

FPL extent

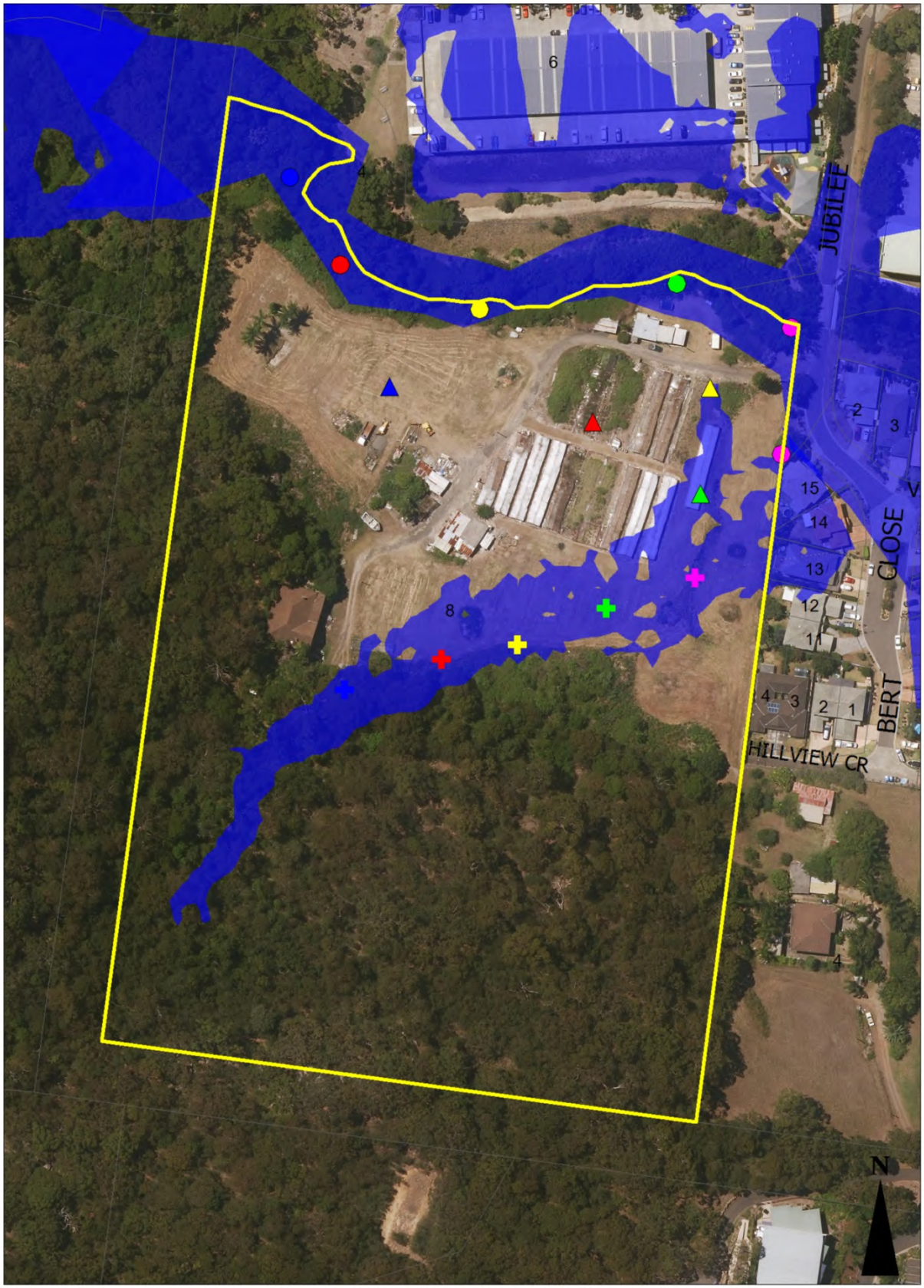
Lot Boundary

Map not to Scale

Notes:

- extent represents the 1% annual Exceedance Probability (AEP) flood event
- extent does not include climate change
- Mainstream FPL – Mainstream Flood Planning Level includes the 0.5m freeboard on the 1% AEP extent for planning purposes
- Cadastre Lines (Source: NSW Government Land and Property Information), flood levels/extents (Source: Flood study reference) and aerial photography (Source: NearMap 2014) are indicative only

FLOOD MAP D - PMF EXTENT MAP



PMF extent

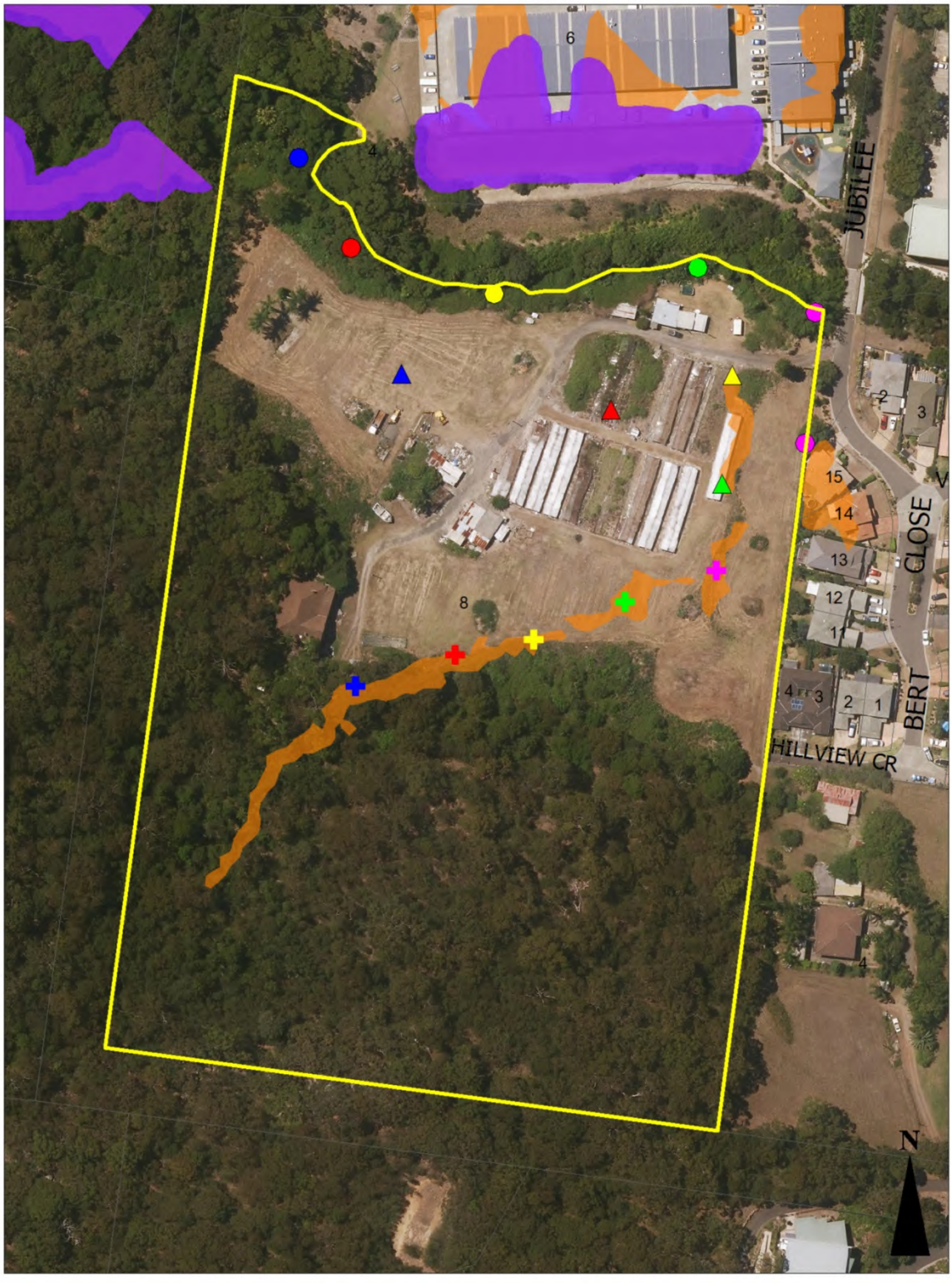
Lot Boundary

Map not to Scale

Notes:

- extent represents the Probable Maximum Flood (PMF) flood event
- extent does not include climate change
- Cadastre Lines (Source: NSW Government Land and Property Information), flood levels/extents (Source: Flood study reference) and aerial photography (Source: NearMap 2014) are indicative only

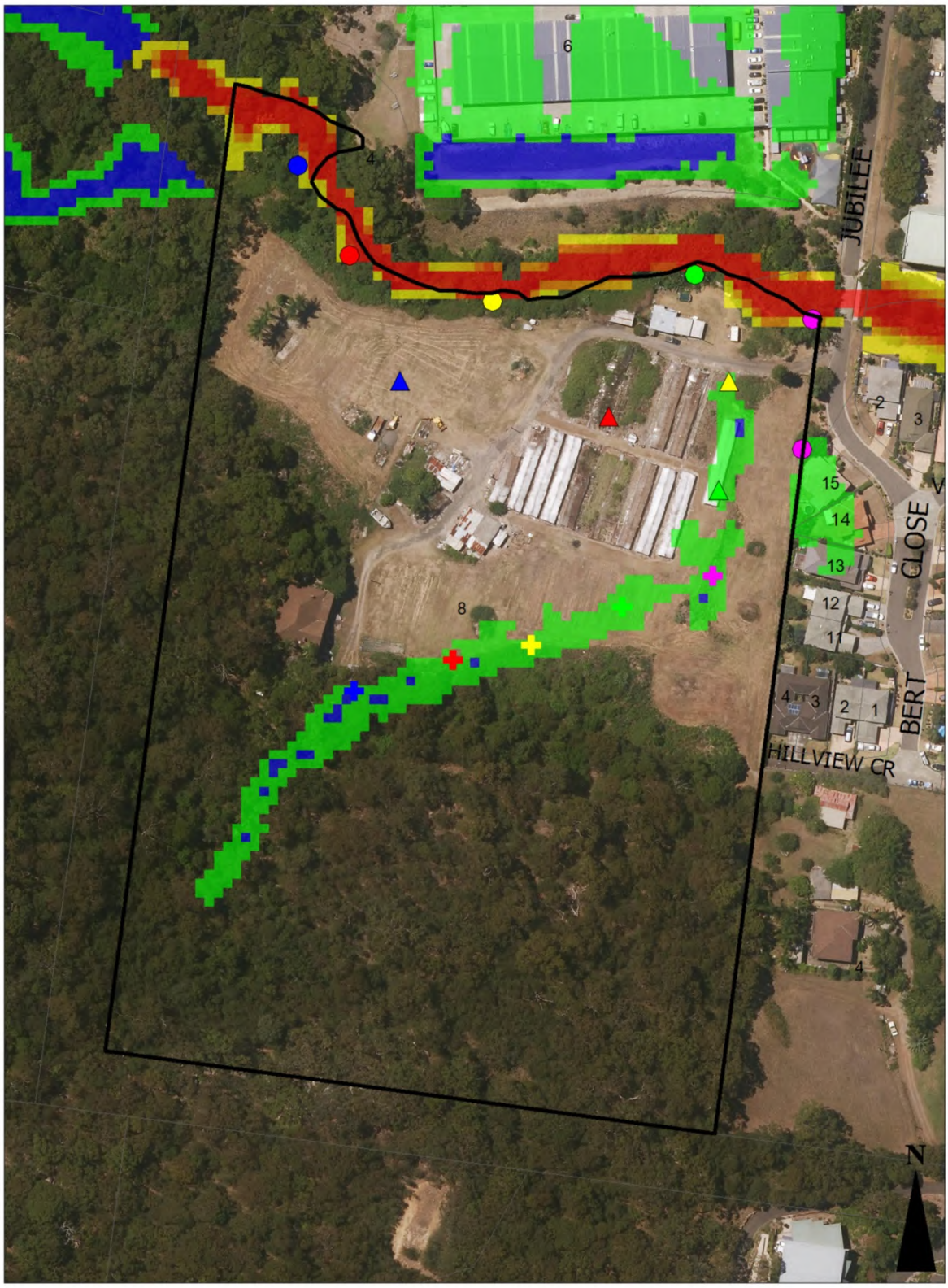
FLOOD MAP E – OVERLAND FLOW EXTENT MAP



Notes:

- extent represents the 1% annual Exceedance Probability (AEP) flood event
- extent does not include climate change
- Overland Flow Path Major includes a fixed 5m horizontal planning buffer on the 1% AEP extent for planning purposes
- Cadastre Lines (Source: NSW Government Land and Property Information), flood levels/extents (Source: Flood study reference) and aerial photography (Source: NearMap 2014) are indicative only

FLOOD MAP F – 1% AEP FLOOD HAZARD EXTENT MAP



High Hazard

Low Hazard

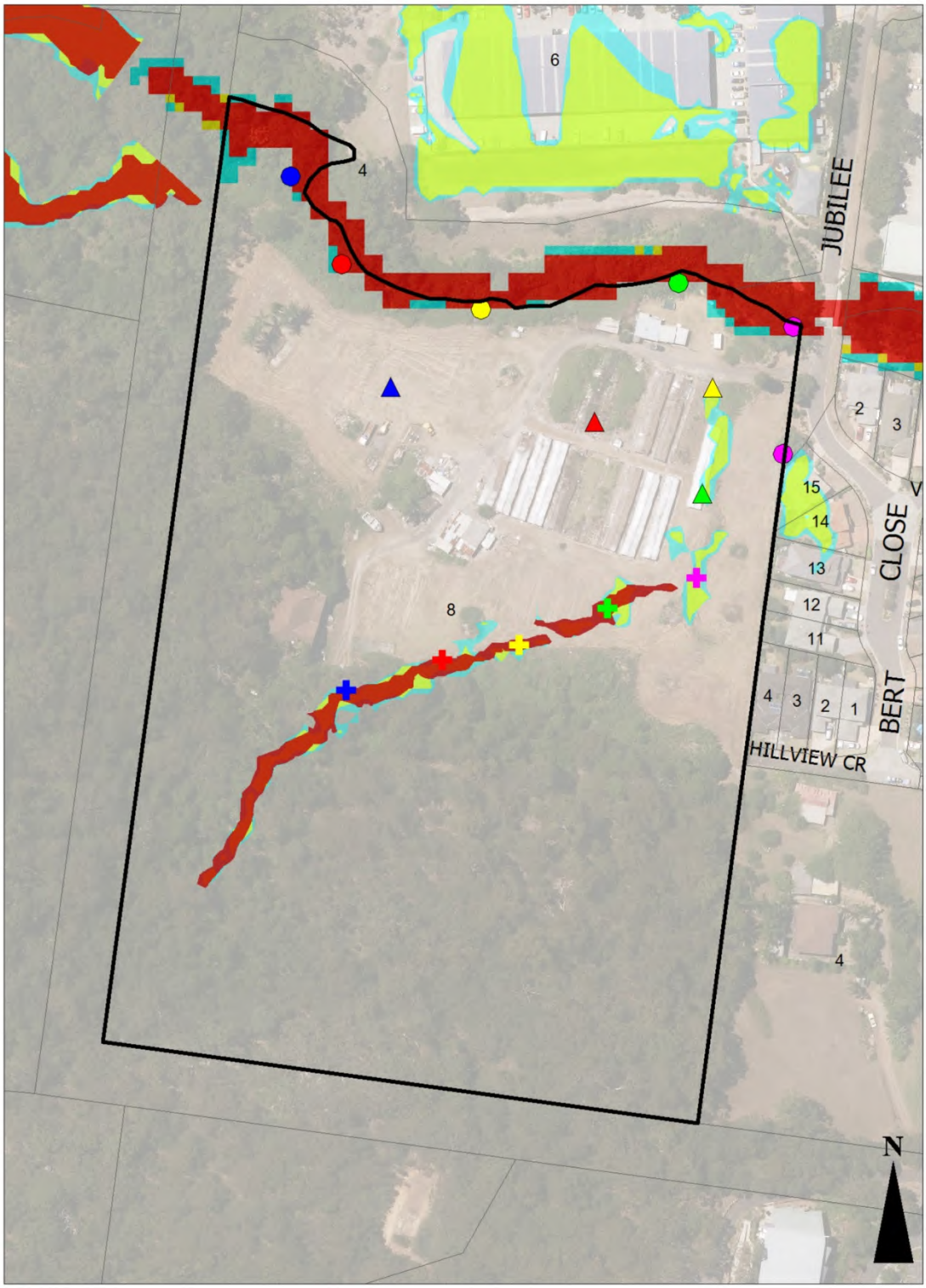
Lot Boundary

Map not to Scale

Notes:

- extent represents the 1% annual Exceedance Probability (AEP) flood event
- extent does not include climate change
- Cadastre Lines (Source: NSW Government Land and Property Information), flood levels/extents (Source: Flood study reference) and aerial photography (Source: NearMap 2014) are indicative only

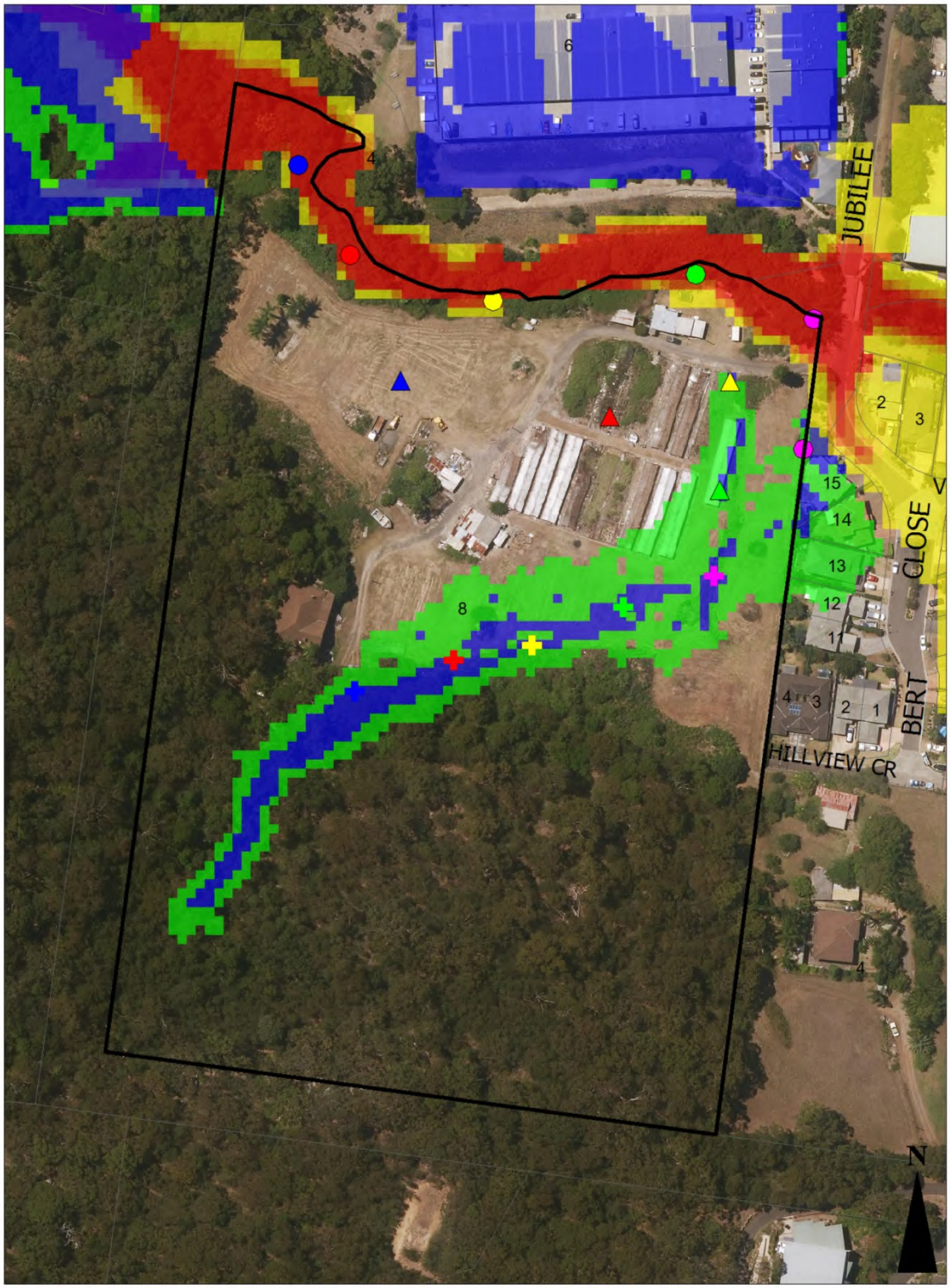
FLOOD MAP G – 1% AEP FLOOD HYDRAULIC CATEGORY EXTENT MAP



Notes:

- extent represents the 1% annual Exceedance Probability (AEP) flood event
- extent does not include climate change
- Cadastre Lines (Source: NSW Government Land and Property Information), flood levels/extents (Source: Flood study reference) and aerial photography (Source: NearMap 2014) are indicative only

FLOOD MAP H – PMF FLOOD HAZARD EXTENT MAP



High Hazard

Low Hazard

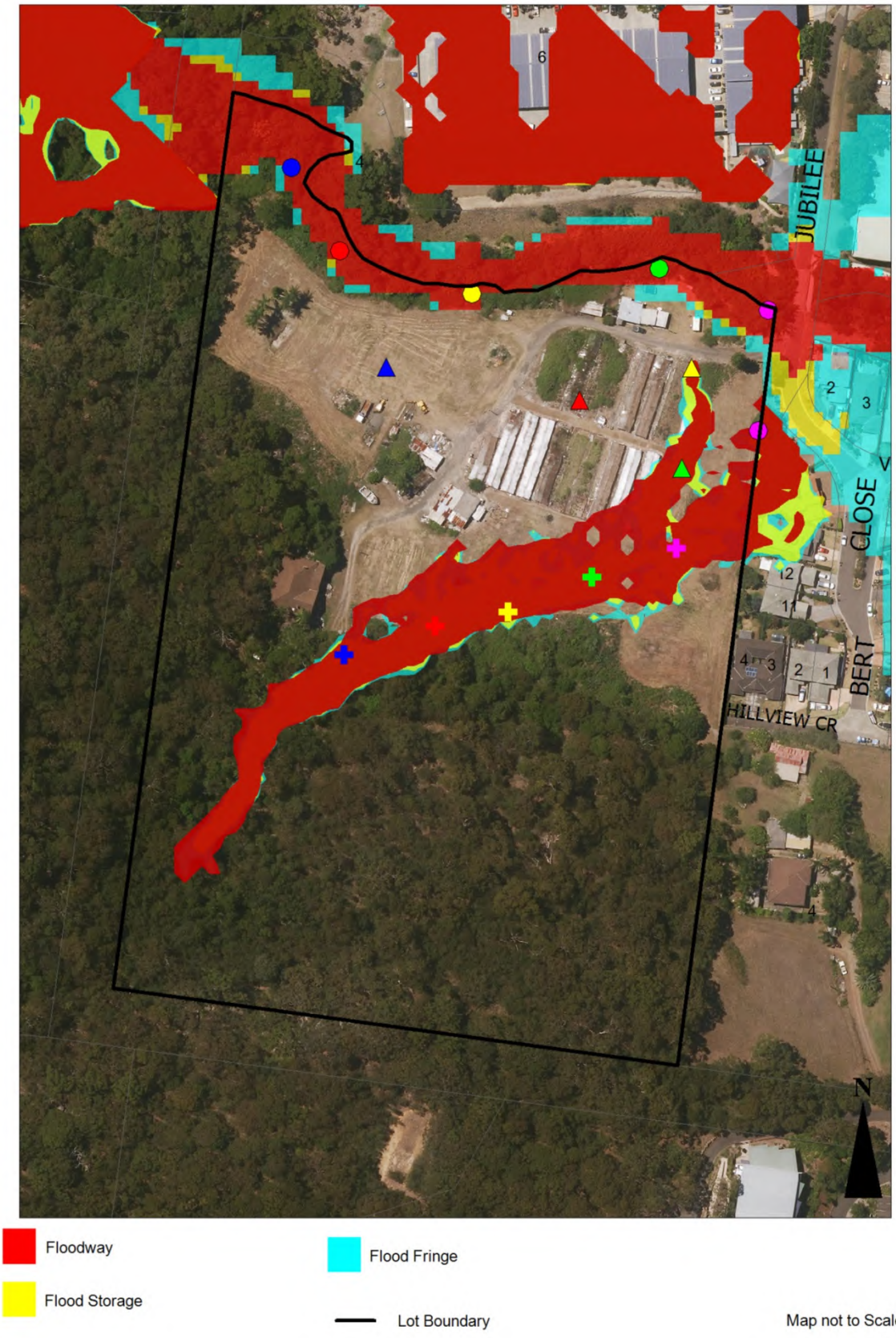
Lot Boundary

Map not to Scale

Notes:

- extent represents the 1% annual Exceedance Probability (AEP) flood event
- extent represents the Probable Maximum Flood (PMF) event
- extent does not include climate change
- Cadastre Lines (Source: NSW Government Land and Property Information), flood levels/extents (Source: Flood study reference) and aerial photography (Source: NearMap 2014) are indicative only

FLOOD MAP I – PMF FLOOD HYDRAULIC CATEGORY EXTENT MAP



Notes:

- extent represents the Probable Maximum Flood (PMF) event
- extent does not include climate change
- Cadastre Lines (Source: NSW Government Land and Property Information), flood levels/extents (Source: Flood study reference) and aerial photography (Source: NearMap 2014) are indicative only

FLOOD MAP J: FLOODING – 1% AEP EXTENT PLUS CLIMATE CHANGE

Note Notes:

- extent represents the 1% annual Exceedance Probability (AEP) flood event
- includes 30% rainfall intensity and 0.9m Sea Level Rise climate change scenario
- Flood events exceeding the 1% AEP can occur on this site.
- Building Footprints have been included in this extent
- Cadastre Lines (Source: NSW Government Land and Property Information), flood levels/extents (Source: Flood study reference) and aerial photography (Source: NearMap 2014) are indicative only

9 Attachment C: Flood Risk Management and FERP Compliance Assessment

Table 5: P21 DCP Part B: B3.17 Flood Hazard – Flood Category 1 – High Hazard – Medium Density Residential.

Heading	Design Element	Compliance Assessment
General to All Development All development and activities must be designed and constructed such as:	There is no additional adverse flood impact on surrounding properties or flood processes for an event up to the Probable Maximum Flood event.	There are no significant negative changes in flooding conditions on neighbouring properties to proposed development for the 1% AEP and PMF events. Refer to Section 3.5.
	There is no net decrease in floodplain volume of a floodway or flood storage are within the property for any flood event up to the 1% AEP flood event.	There are no significant changes in flood characteristics within Narrabeen Creek. The proposed natural storage upstream of the fire trail accounts for any flood storage removed in the proposed development.
	All foundation structures within the area of the property affected by the Flood Planning Level, where the Flood Planning Level is equal to or greater than 500 mm above the existing ground level, is to incorporate a suspended flood system on open pier/pile footings with openings in perimeter walls to allow for the flow of surface water and flood storage up to the level of the 1% AEP flood.	The site is flood free for the 1% AEP flood event due to proposed flood mitigation works (fire trail and pipe system). Buildings are not required to be raised or suspended.
	All structural elements below the Flood Planning Level shall be constructed from flood compatible materials.	Building materials shall be flood compatible below the FPL (e.g. concrete, brick, hardwoods or external walls with waterproof membrane).
	All structures must be designed and constructed to ensure structural integrity for immersion and impact of velocity and debris up to the level of the 1% AEP flood. If structure is to be relied on for 'shelter-in-place' evacuation then structural integrity must be insured up to the level of the Probable Maximum Flood.	Proposed structure will be designed to be resistant to both flood forces (water and debris) and any buoyancy forces to the PMF level.
	All electrical equipment, wiring, fuel lines or any other service pipes and connections must be waterproofed to the Flood Planning Level.	The electrical switchboard and main circuit are to be installed above the PMF level. All electrical equipment is to be fitted with circuit breakers. Electrical equipment below the PMF is to be waterproofed if feasible to do so. Lift management methods include the following: 1. The lift shall be designed to cease operating under flood conditions. Vertical evacuation after this will be by stairs only. 2. Lift motors will be located above the PMF level.

Heading	Design Element	Compliance Assessment
	The storage of toxic or potentially polluting goods, materials or other products, which may be hazardous or pollute floodwaters, will not be permitted below the Flood Planning Level.	No hazardous, toxic or potentially polluted goods, materials or products are to be stored on site below the FPL.
	To ensure the recommended flood evacuation strategy of 'shelter-in-place' it will need to be demonstrated that there is pedestrian access via a low flood hazard are to a 'safe haven' above the Flood Planning Level or 300 mm below the level of the Probable Maximum Flood (whichever is the higher).	There is ready access to flood free areas within the site. These include buildings, adjacent bushland area and southern end of 8m wide access road.
Flood Mitigation Works Flood mitigation works that modify a major drainage system, stormwater system, natural water course, floodway or flood behaviour within the development site may be permitted subject to demonstration through a Flood Risk Management Report that:	Flood mitigation works do not have an adverse impact on any surrounding property or flooding process for any event up to the Probable Maximum Flood event.	Flood impact on neighbouring properties due to proposed flood mitigation works is negligible where there are no significant changes to off-site flood characteristics between existing and proposed conditions. Refer to Section 3.5.
	Flood mitigation works result in no net decrease in the floodplain volume of a floodway of flood storage area within the property for any flood event up to the 1% AEP flood event.	There are no significant changes in flood characteristics within Narrabeen Creek. The natural storage upstream of the fire trail accounts for any flood storage removed in the proposed development.
	Flood mitigation works result in the protection of the existing and proposed development from a flood event to the minimum flood level requirement as defined in this control.	Proposed fire trail and pipe design routes floodwaters in the 1% AEP flood event around proposed and retained structures.
	The works do not have an adverse impact on the environment. (This includes but is not limited to the alteration of natural flow regimes, the clearing of riparian vegetation, artificial modification of the natural stream, such as by relocation, piping, etc.)	Narrabeen Creek and its riparian zone are not significantly altered by the proposed flood mitigation works. Construction of the proposed pipe outlets into Narrabeen Creek do not require significant changes to the riparian zone.
New developments and additions on land with High Hazard Classification. Building platforms, building envelope enclosures or car parking facilities and access:	Are not adversely affected by flood up to the Probable Maximum Flood event.	There is minor inundation of building ground floor levels in the critical PMF event, with ready access to higher levels if vertical evacuation is required.
	Result in no net decrease in the floodplain volume of a floodway of flood storage area within the property for any event up to the 1% AEP flood event.	There is no significant change in flood characteristics within Narrabeen Creek. Proposed natural storage upstream of the fire trail accounts for any flood storage removed in the proposed development.

Heading	Design Element	Compliance Assessment
	Result in no additional adverse flood impact on the surrounding properties of flooding processes for any flood event up to the Probable Maximum Flood Event.	There are no significant changes in flooding conditions on neighbouring properties due to the proposed development for the 1% AEP and PMF events. Refer to Section 3.5.
A. For portion of the land designated High Hazard Flood Storage	For the portion of the development affected by, or affecting the High Hazard Flood Storage area, all floor levels but excluding balconies (with open balustrades) shall be at or above, or raised to the Floor Planning Level.	No designated flood storage on site according to the Narrabeen Lagoon Flood Study Final Report (BMT WBM, 2013), Figures A-24 and A-25.
B. For a portion of the land designated High Hazard Floodway:	For the portion of the development affected by, or affecting the High Hazard Floodway, the structures must be designed and constructed as not to impede the floodway shall be elevated such that the level of all the underside of all floors including balconies within the floodway area are at or above, or raised to the Probable Maximum Flood Level or Flood Planning Level (whichever is higher) to allow for clear passage of floodwaters under the building.	Floodway is contained within Narrabeen Creek as shown in the Narrabeen Lagoon Flood Study Final Report (BMT WBM, 2013), Figures A-24 and A-25. No proposed development encroaches on the floodway within the site.
Floor levels – Carpark Facilities **A. For portion of land designated high hazard Flood Storage**	**Covered basement carpark facilities:** All access ventilation and any other potential water access points are to be above the FPL and a clearly signposted pedestrian access via a low flood hazard area to a 'safe haven' above the FPL or 300 mm below the level of the PMF (whichever is higher) separate to the vehicle access ramps.	All potential water access points are above the FPL as the site is not inundated in the 1% AEP flood event. Carparks have access to higher elevations via internal staircases to upper floors above the peak PMF level.
B. For a portion of the land designated High Hazard Floodway:	**New Car parking Facilities:** For the portion of the carparking facilities affected by, or affecting the High hazard Floodway, the structure must be designed and constructed so as not to impede the floodway and must be elevated such that the level of the underside of all carparks floors within the floodway area are at or above, or raised to the Probable Maximum level or Flood Planning Level (whichever is the higher level) to allow clear passage of floodway under the building.	No proposed development encroaches on the floodway within the site.

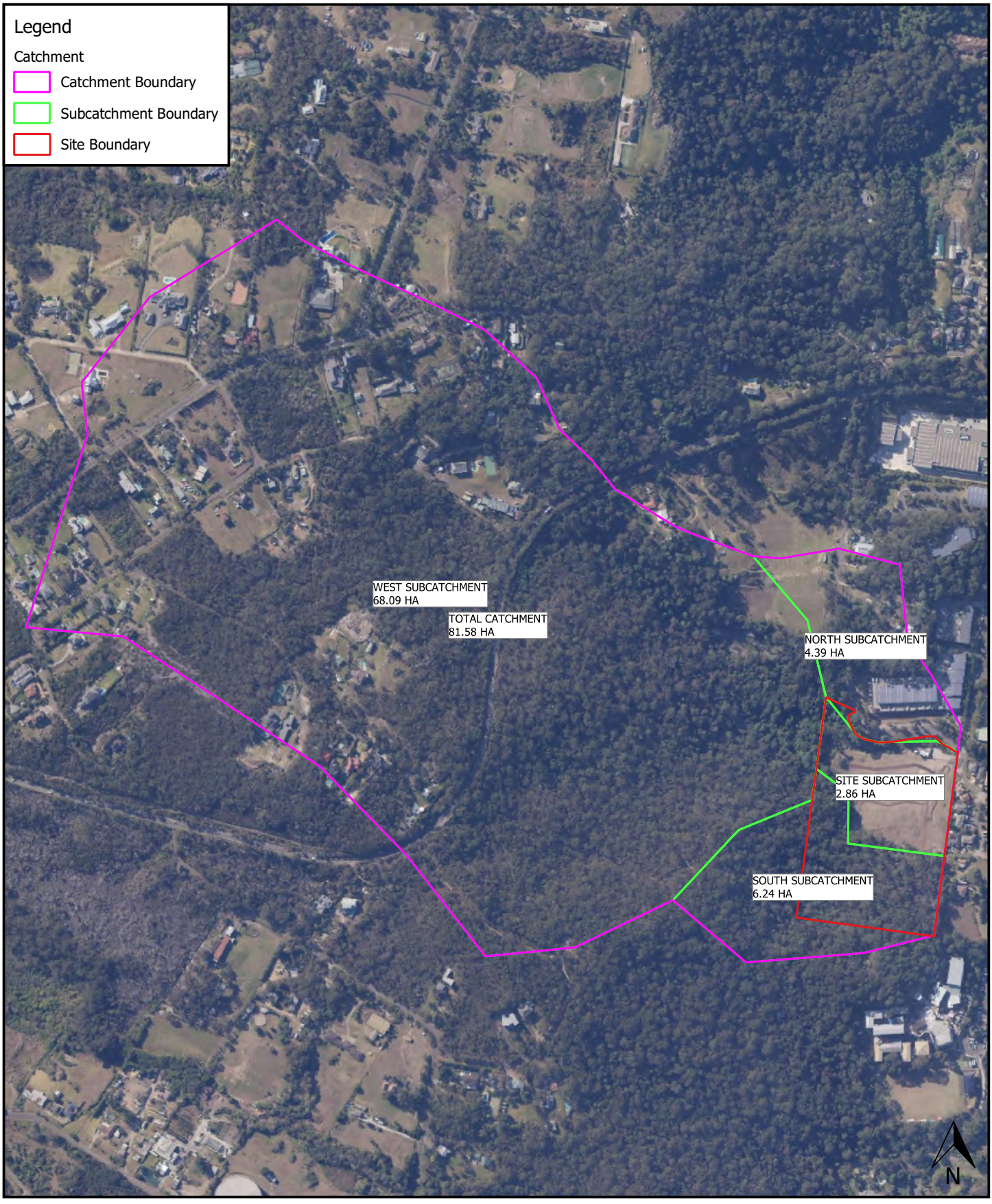
Table 6: P21 DCP Appendix 15 – Section 1.6 – Shelter-in-Place Requirements.

Design Element	Compliance Assessment
1.6.1 Flood Risk Emergency Assessment For shelter-in-place to be considered an acceptable emergency response, a development should demonstrate that the development controls summarised in the following section have been addressed through a Flood Risk Emergency Assessment report.	Assessment demonstrated in this report.
1.6.2 Minimum Floor Level for Shelter-in-Place The adopted requirements for shelter-in-place minimum flood levels are equal to the PMF flood event. These requirements apply to all life hazard categories, H3-H4 and H5.	All buildings are unaffected by the 1% AEP flood event. The habitable ground floor levels of all buildings except apartment building D are below the peak PMF level, and all building first floor levels are above the peak PMF level. Ready access to upper levels via internal stairs is available if vertical evacuation is required.
1.6.3 Floor Space The adopted requirements for shelter-in-place minimum floor space are: • A flood space of the shelter-in-place area 2 m^2 per person is required for all long duration flooding unless it can be shown the development lies within this region but is only inundated for a "short duration" (less than 6 hours in the PMF); or • A floor space of the shelter-in-place area 1 m^2 per person is required for development located in short duration flooding (less than 6 hours in the PMF).	Maximum inundation duration is 4 hours and 12 minutes for the 6 hour PMF event. Longer duration PMF events do not lead to site or evacuation route inundation, and hence the applicable shelter-in-place area requirement is 1 m^2 per person. Each apartment and house has an average floor space of approximately 50 m^2 and 120 m^2 respectfully, and houses have approximately 140 - 215 m^2 floor space above ground level. Assuming four residents per apartment and house, there is sufficient capacity for residents in houses, in apartment building D, and at levels above the ground floor of all apartment buildings to shelter-in-place in their dwellings. First floor corridor area of buildings A1, A2, B1 and B2 are approximately 40 - 60 m^2 for each building. The ground floors of these buildings have 10 – 14 beds each. Assuming 1.5 residents per bed, 15 - 21 people are required to evacuate vertically in the PMF per building. Hence, there is sufficient capacity for vertical evacuation from the ground floor to first floor corridor, providing at least 2 m^2 per person.

DRAFT

Design Element	Compliance Assessment
1.6.4 Accessibility The adopted requirements for shelter-in-place for all developments are: • Shelter-in-place refuge must be intrinsically available to all people on the site, plainly evident, and self-directing, with sufficient capacity of access routes for all occupants. • There must be sufficient time for all occupants to access shelter-in-place refuges, with fail safe access provided with no reliance on elevators. Flood warning systems should be considered where a number of occupants is significant.	Buildings are readily accessible to all flood affected areas within the site grounds. The apartment buildings can be accessed from all sides. If residents outside are unable to evacuate to a nearby building, they can move to areas above the peak PMF level, including the southern end of 8m wide access road or adjacent bushland area to the south. Residents within all apartments above ground level are above peak PMF levels and do not need to relocate if shelter-in-place is required. Residents on the ground floor of all buildings (excluding apartment building D which is above the PMF) can move to upper levels via internal staircases if vertical evacuation is required.
1.6.5 Building Stability For all shelter-in-place refuge buildings proposed within flood risk to life category H3-H4: • Structural stability of the refuge building is to be verified by a suitably qualified structural engineer, considering lateral flood flow, buoyancy, suction effects, and debris load impact of the 1% AEP design flood depths and velocities. • Refuge must comply with Building Code of Australia requirements, with external components rated appropriately for storm, wind and moisture.	The proposed structures will be designed to resist both flood forces (water and debris) and any buoyancy forces. There is expected to be minimal structural damage as there are only small areas of medium to high hazard flood waters in the PMF. As proposed buildings are larger than 'light structures', they would only be minimally affected.
1.6.6 Serviceability The following serviceability requirements only apply to long duration flooding unless it can be shown the development lies within this region but is only inundated for a "short period" (less than 6 hours in the PMF). The serviceability requirements apply for all land-uses with the exception of subdivision: • Sufficient clean water; and • First Aid Kit; and • Portable radio with spare batteries; and • Torch with spare batteries. In addition, land-use groups listed under Critical and Vulnerable Uses must also provide: • A practical means of medical evacuation; and • Emergency power.	Longest duration of inundation / isolation was determined as 4 hours and 12 minutes for the 6 hour PMF event. Consequently, the serviceability requirements listed are not mandatory.

10 Attachment D: Flood Assessment Mapset



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0 90 180 270 360 450 m

1:7500 @ A4

Map Title / Figure:

Site Catchment Plan

NOTE:
Background aerial from Nearmaps
Sub-catchment boundaries based on LIDAR data provided by AAM
Site Boundary from Pulver Cooper & Blackley

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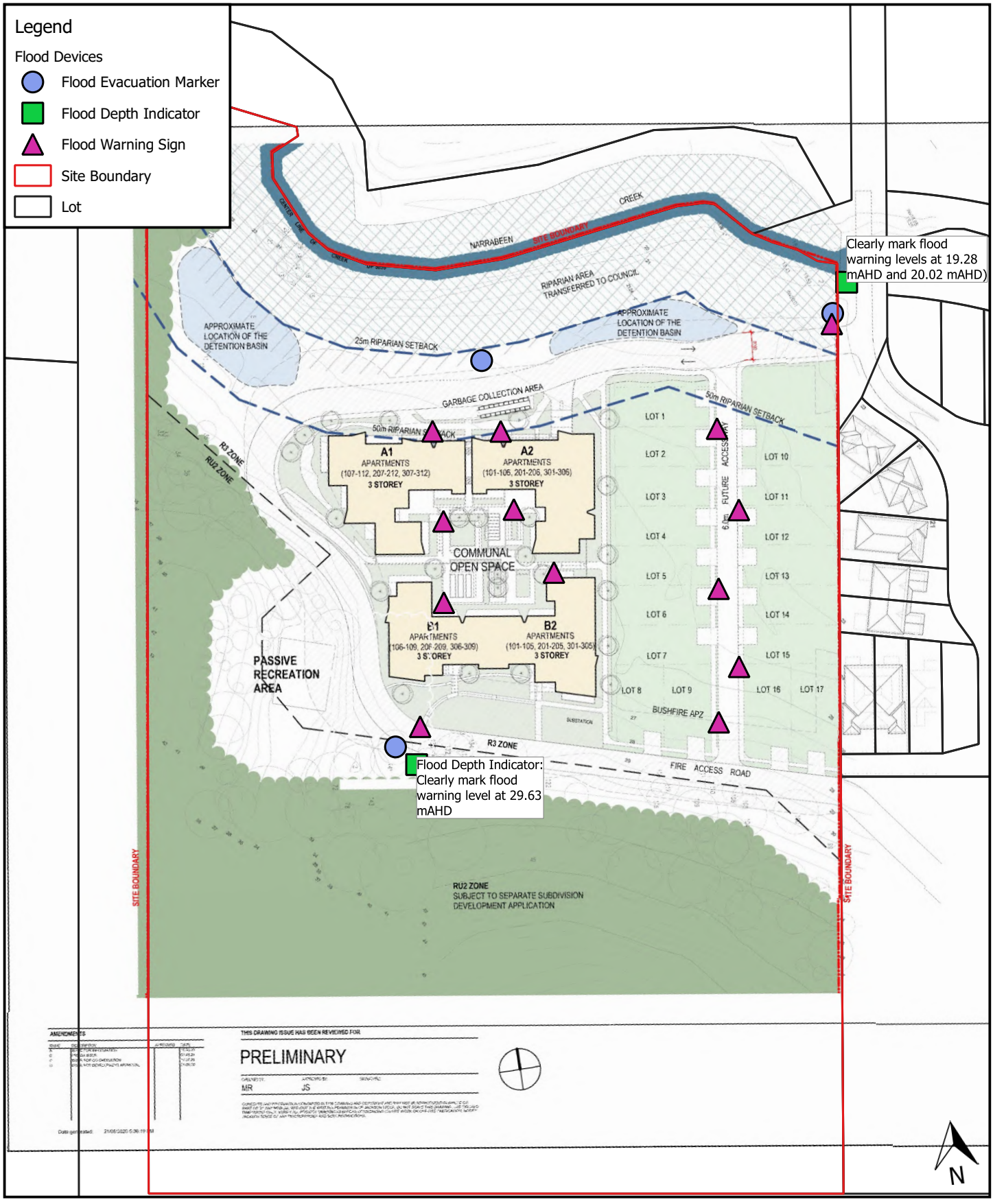
Map 01	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date



0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

Flood Warning System

Map 02	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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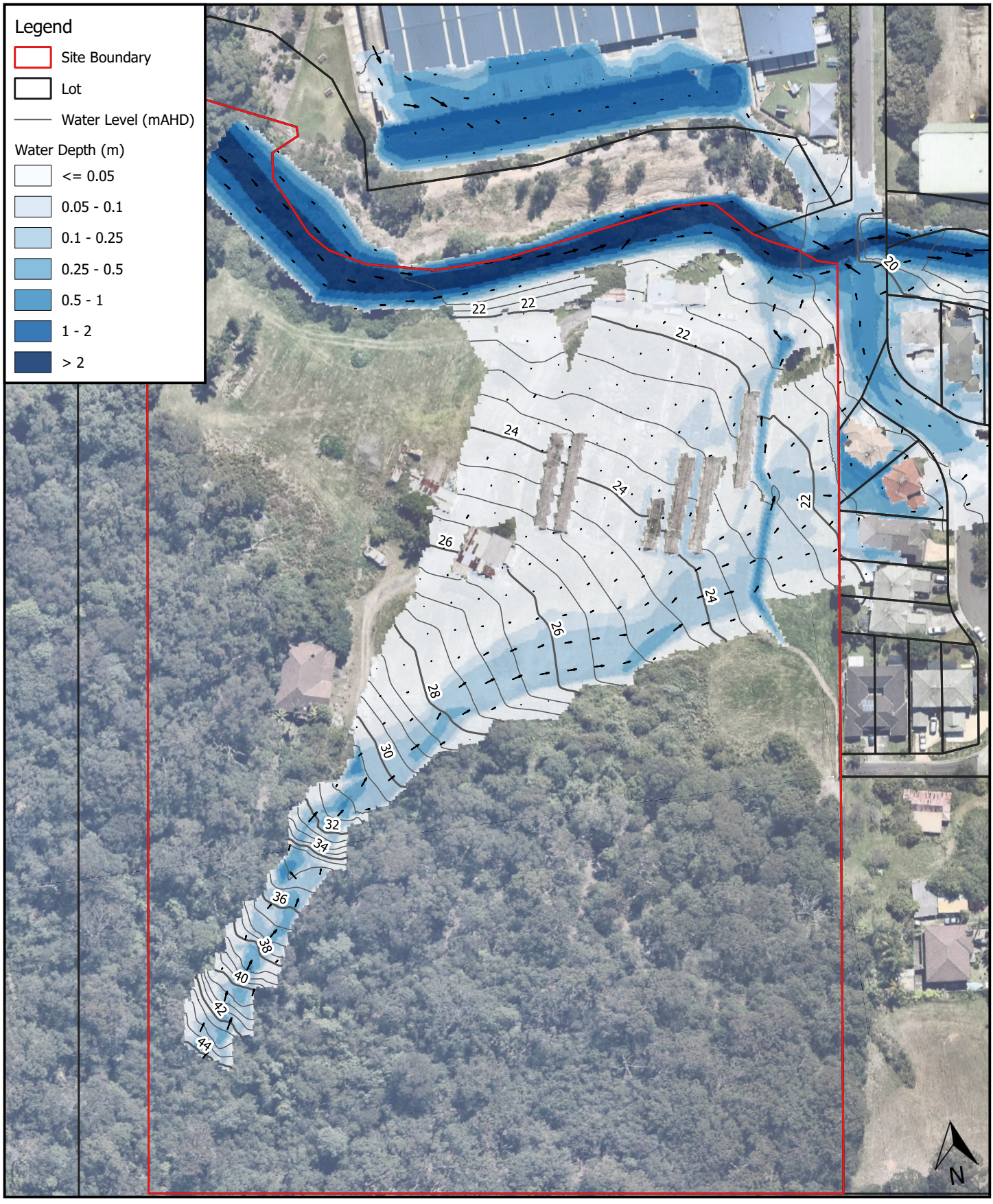

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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

1% AEP Critical Storm Duration Existing Condition Water Level (mAHD) & Water Depth (m)

Map 03	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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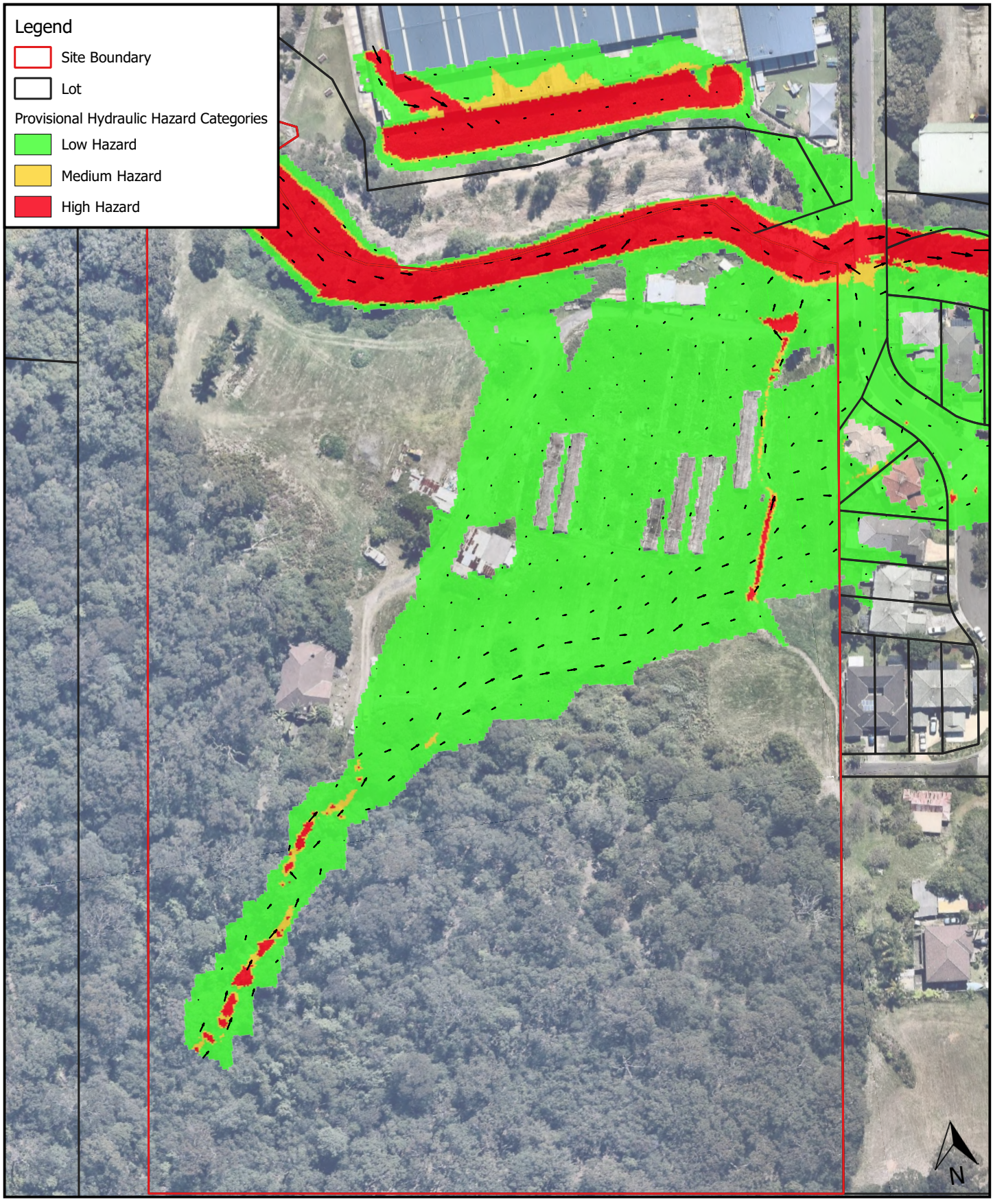

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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

1% AEP Critical Storm Duration Existing Condition Provisional Hydraulic Hazard Categories

Note:
Hydraulic hazard based on NSW Government (2005) Floodplain Development Manual
Provisional Hydraulic Hazard Categories

Map 04	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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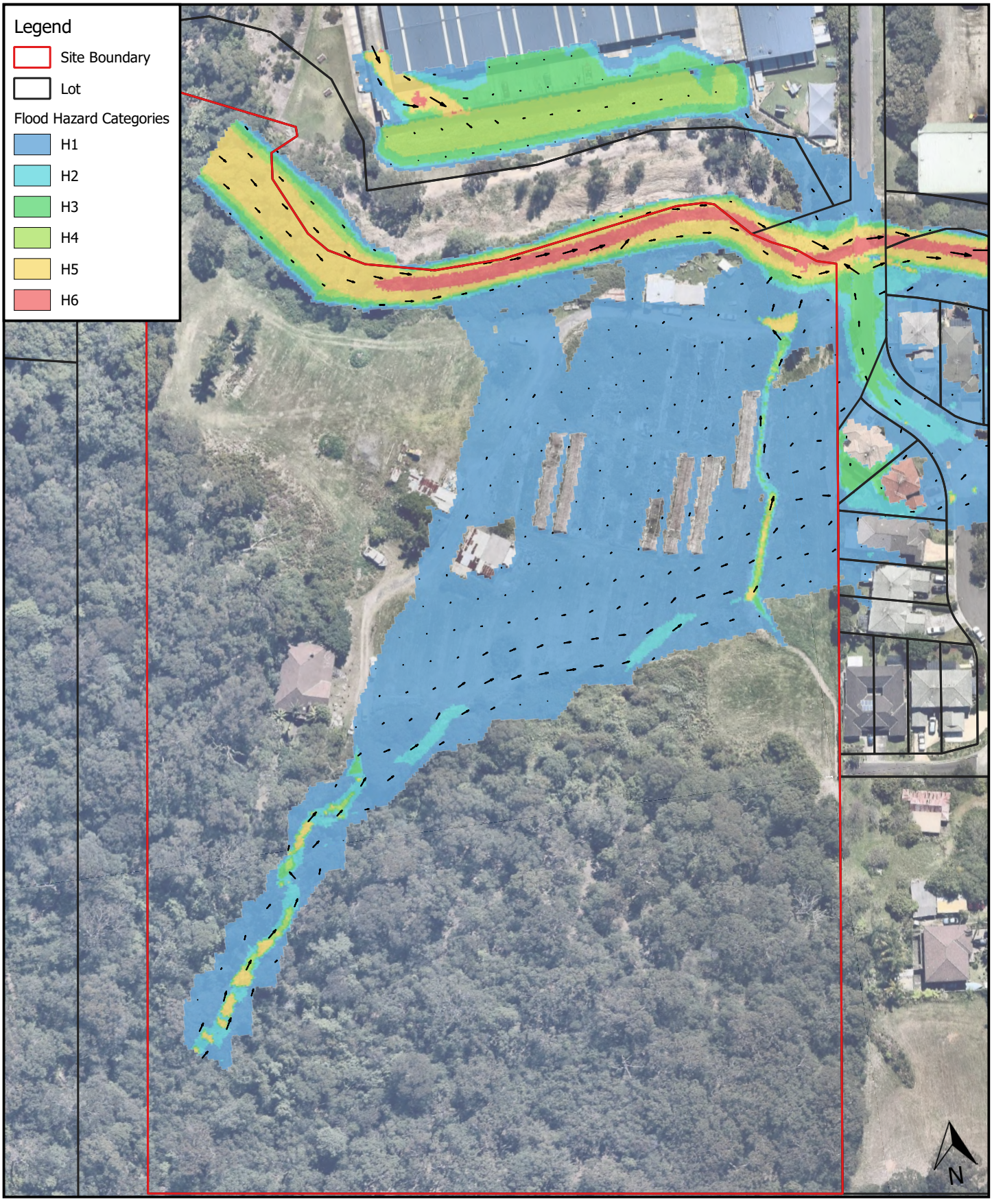

0 10 20 30 40 50 m

1:1500 @ A4

Note: Flood Hazard Categories based on Australian Rainfall and Runoff (2019 definitions):
H1 - Generally safe for people, vehicles and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for people and vehicles, children and the elderly.
H4 - Unsafe for people and vehicles

Map Title / Figure:

1% AEP Critical Storm Duration Existing Condition ARR Flood Hazard Categories

Map 05	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

1% AEP Critical Storm Duration Existing Condition Hydraulic Categorisation

Note:
Adopted hydraulic categories are:
- Floodway is defined as areas where the peak value of velocity multiplied by depth (VD product) > 0.25 m2/s AND peak velocity > 0.25 m/s OR
  Peak velocity > 1.0 m/s AND peak depth > 0.15 m.
- Flood Storage is defined as areas outside the Floodway where peak depth > 0.5 m;

Map 06	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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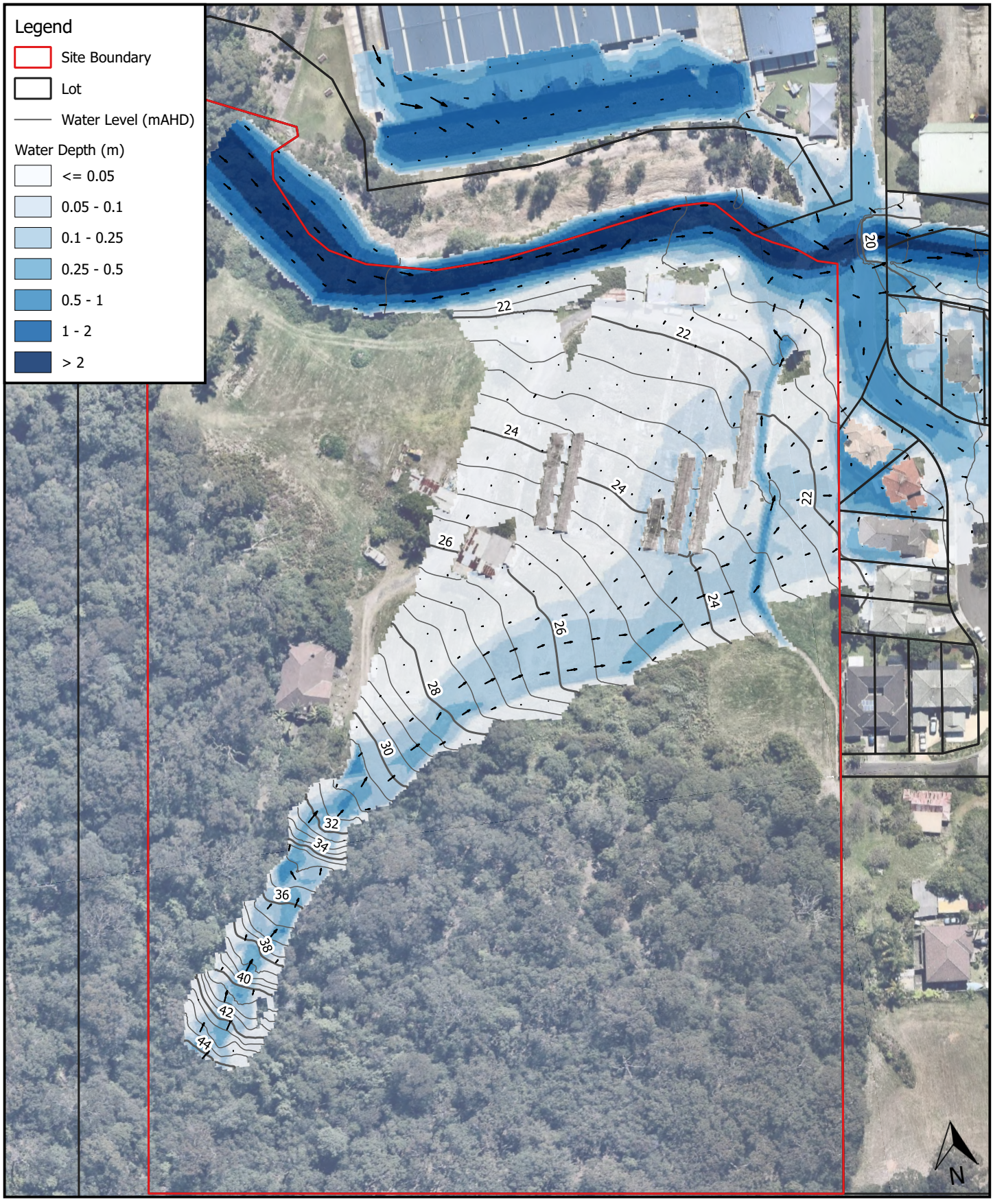

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1:1500 @ A4

Map Title / Figure:

1% AEP + CC Critical Storm Duration Existing Condition Water Level (mAHD) & Water Depth (m)

Map 07	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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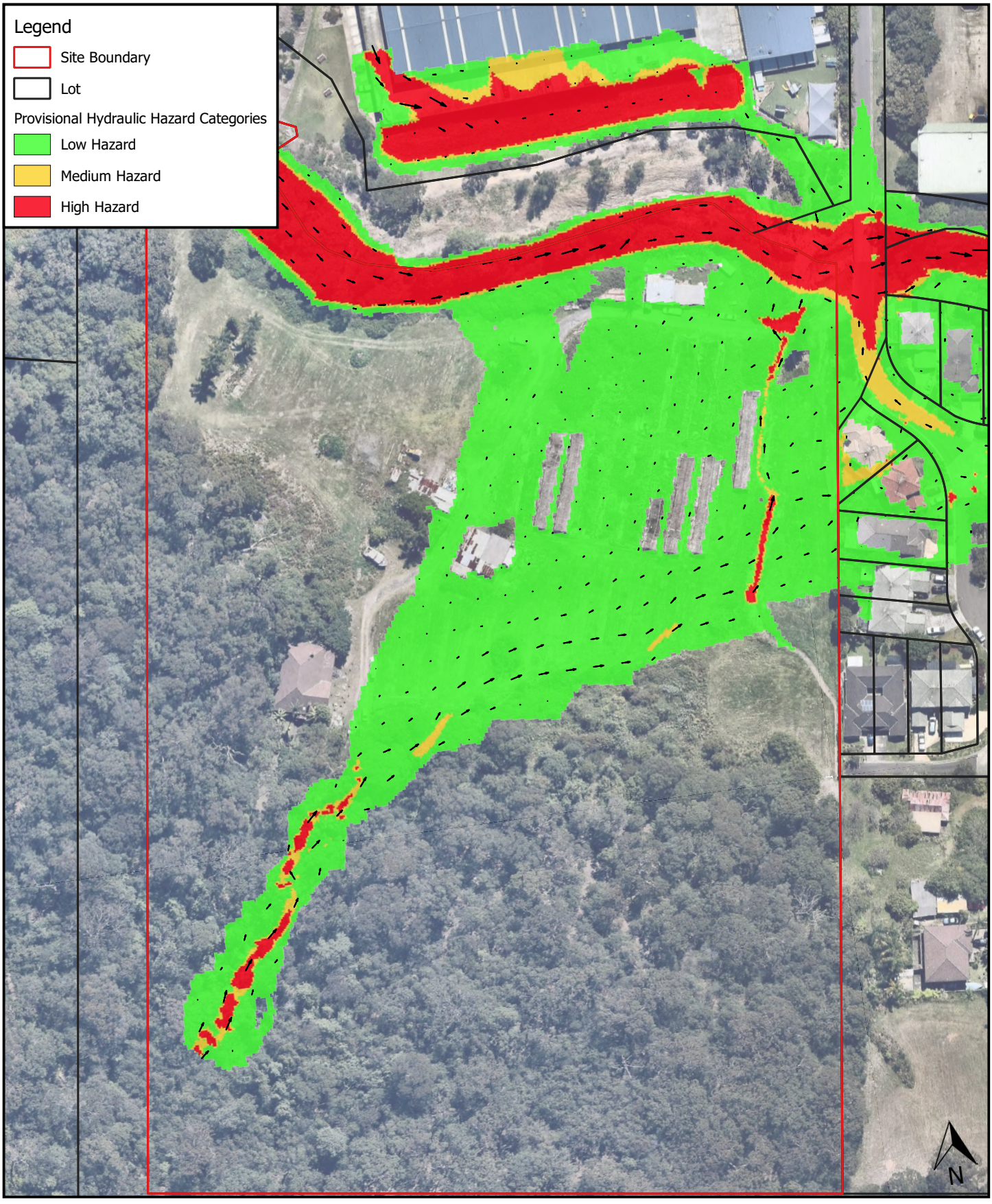

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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

1% AEP + CC Critical Storm Duration Existing Condition Provisional Hydraulic Hazard Categories

Note:
Hydraulic hazard based on NSW Government (2005) Floodplain Development Manual
Provisional Hydraulic Hazard Categories

Map 08	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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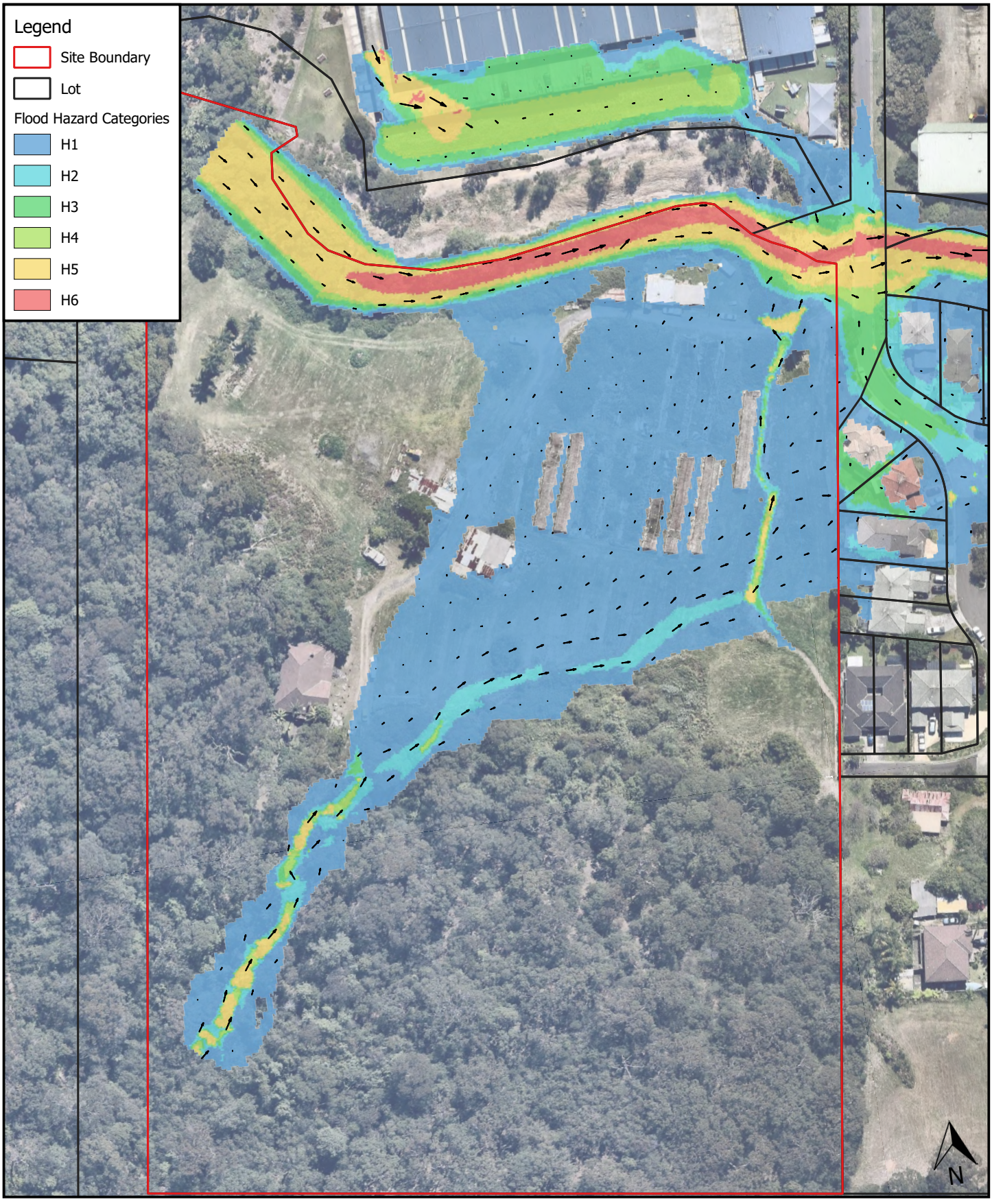

0 10 20 30 40 50 m

1:1500 @ A4

Note: Flood Hazard Categories based on Australian Rainfall and Runoff (2019 definitions):
H1 - Generally safe for people, vehicles and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for people and vehicles, children and the elderly.
H4 - Unsafe for people and vehicles

Map Title / Figure:

1% AEP + CC Critical Storm Duration Existing Condition ARR Flood Hazard Categories

Map 09	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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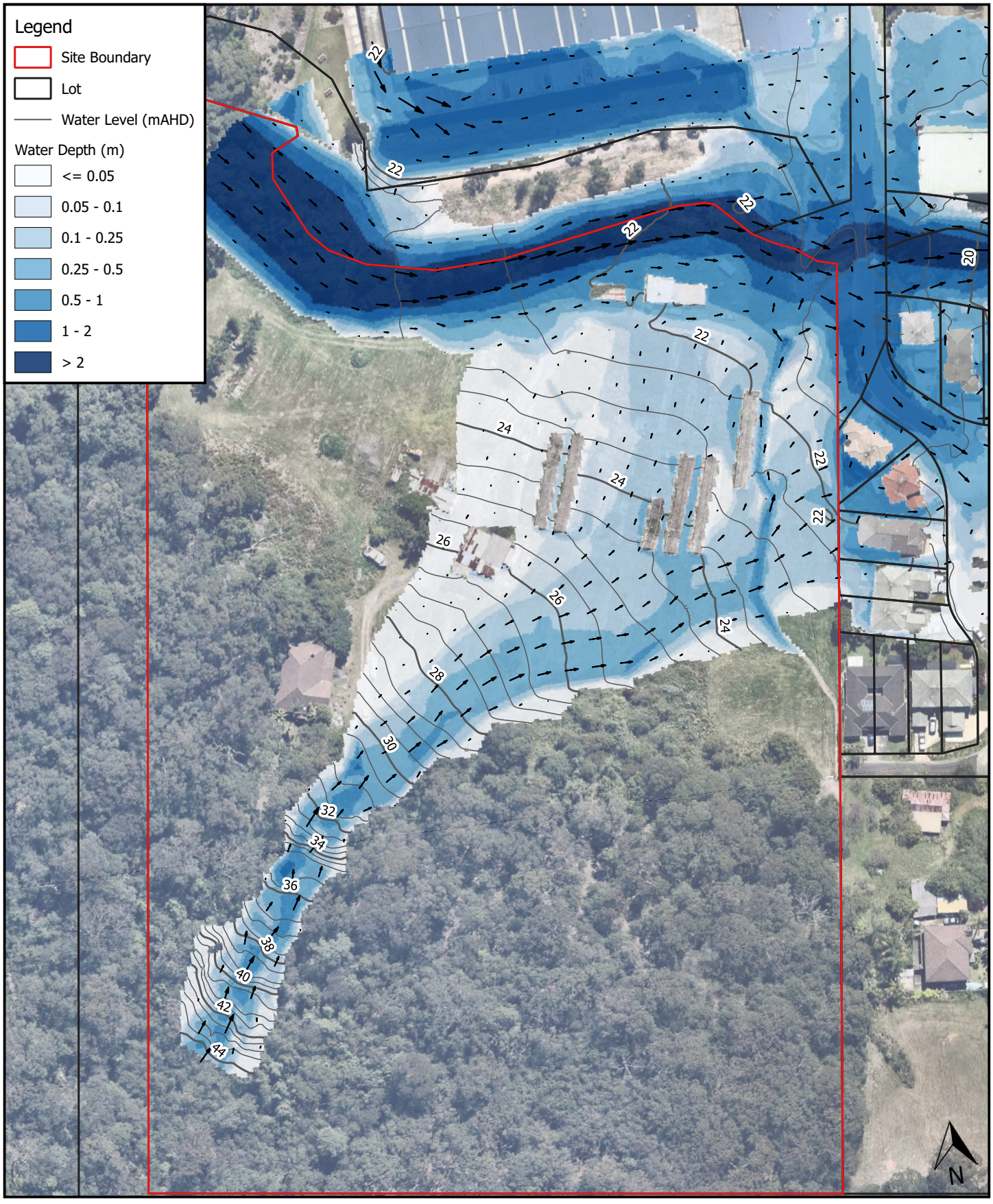

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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

PMF Critical Storm Duration Existing Condition Water Level (mAHD) & Water Depth (m)

Map 10	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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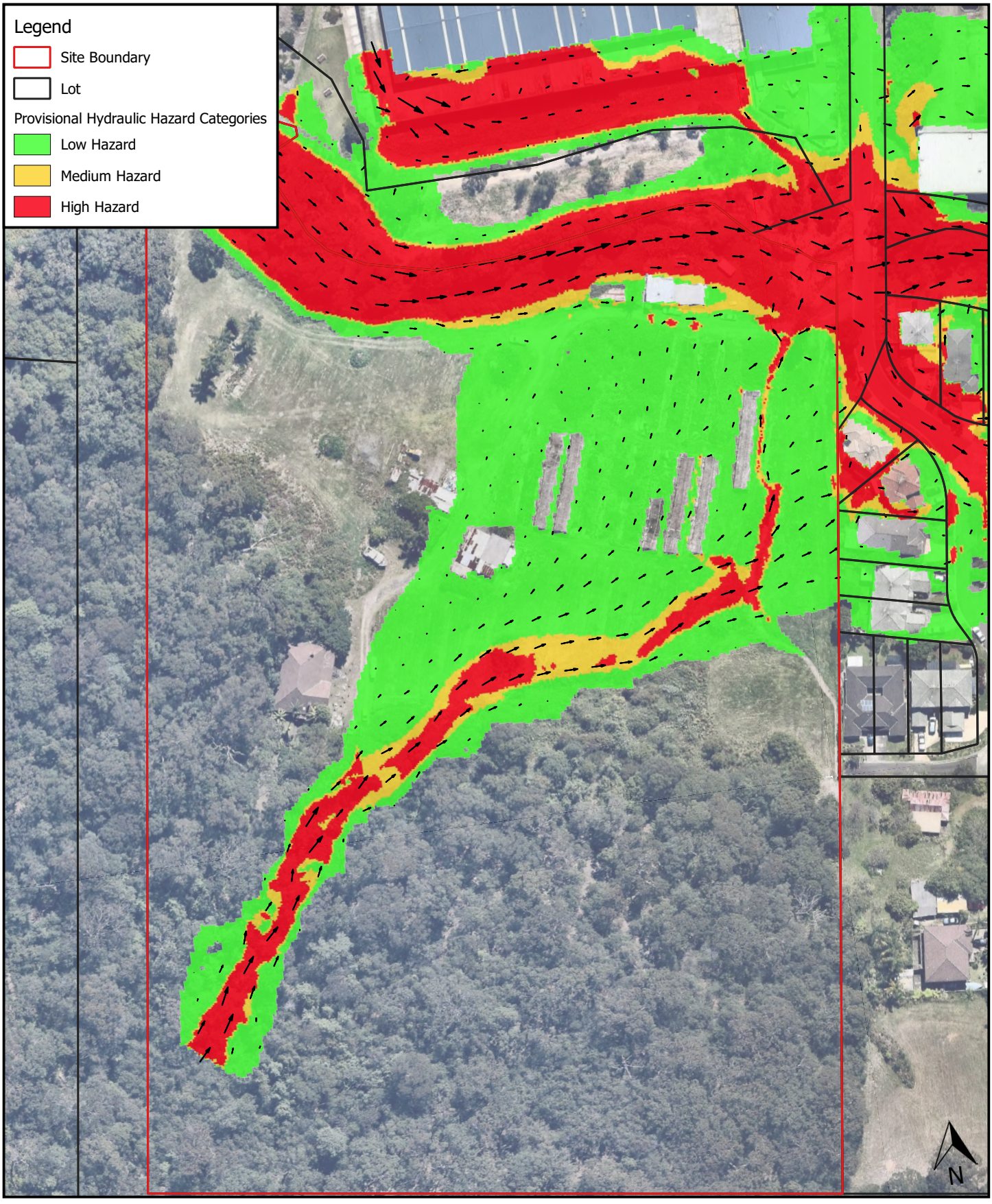

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1:1500 @ A4

Map Title / Figure:

PMF Critical Storm Duration Existing Condition Provisional Hydraulic Hazard Categories

Note:
Hydraulic hazard based on NSW Government (2005) Floodplain Development Manual
Provisional Hydraulic Hazard Categories

Map 11	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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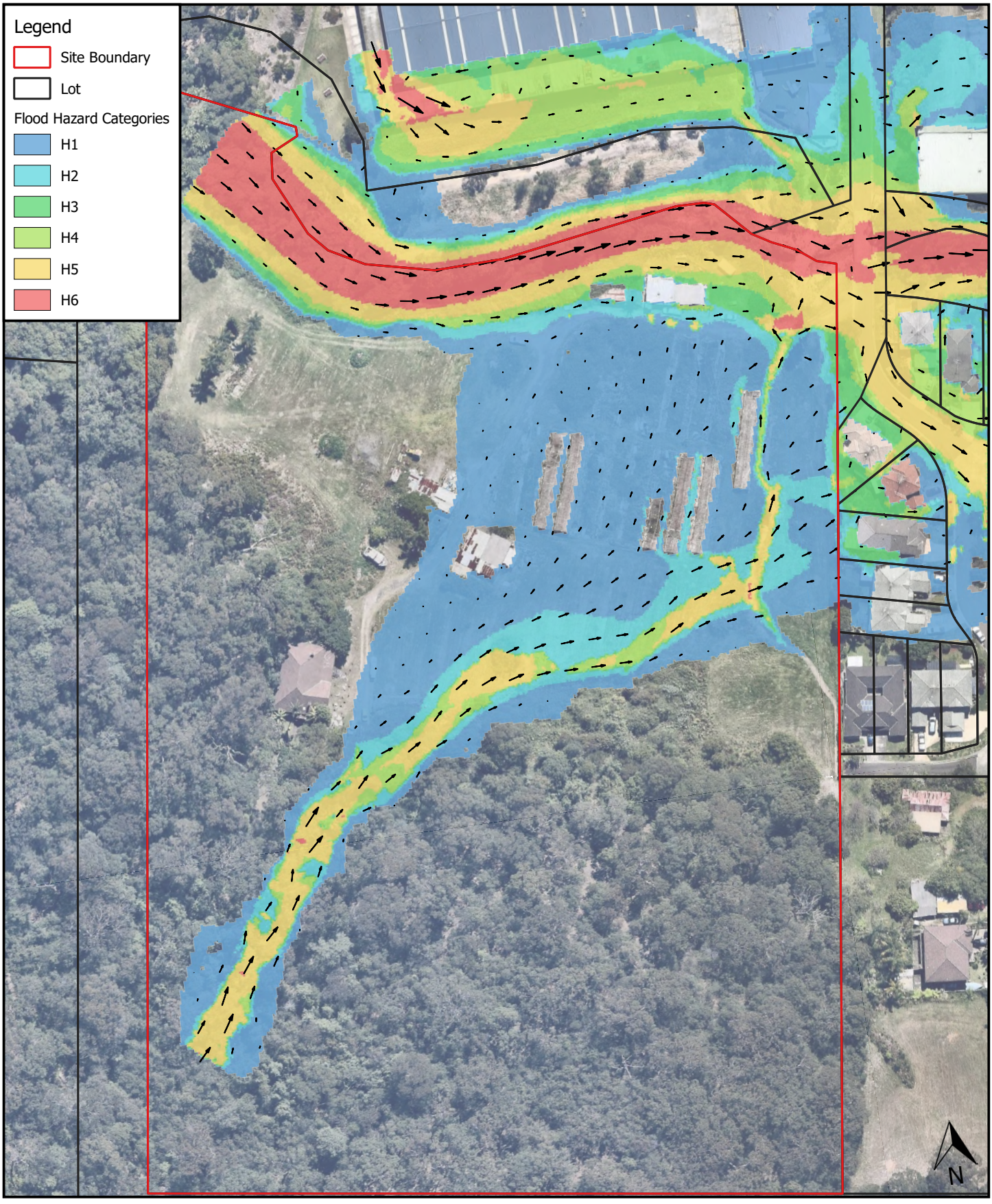

0 10 20 30 40 50 m

1:1500 @ A4

Note: Flood Hazard Categories based on Australian Rainfall and Runoff (2019 definitions):
H1 - Generally safe for people, vehicles and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for people and vehicles, children and the elderly.
H4 - Unsafe for people and vehicles

Map Title / Figure:

PMF Critical Storm Duration Existing Condition ARR Flood Hazard Categories

Map 12	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
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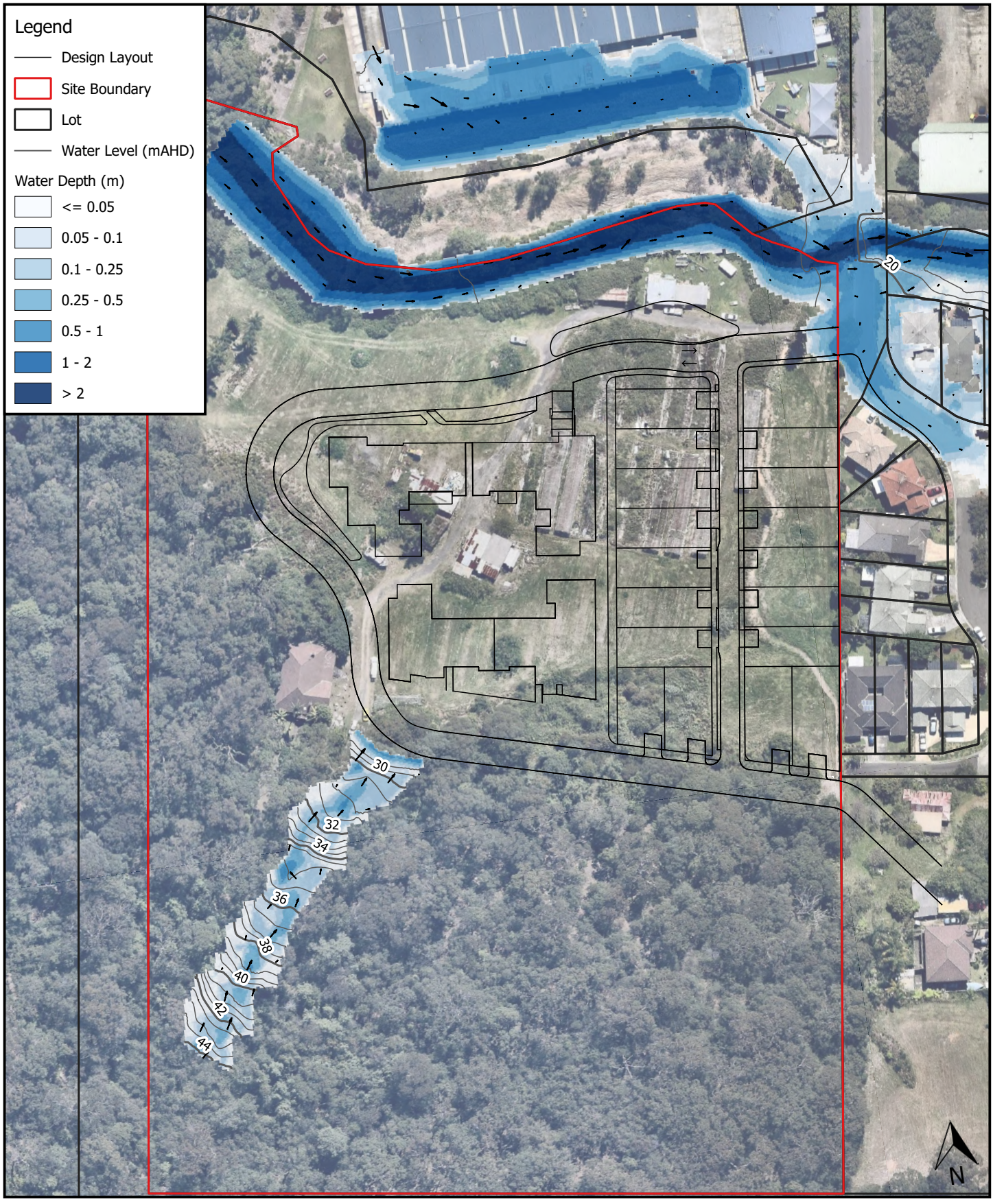

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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

1% AEP Critical Storm Duration Developed Condition (Stage 2) Water Level (mAHD) & Water Depth (m)

Map 13	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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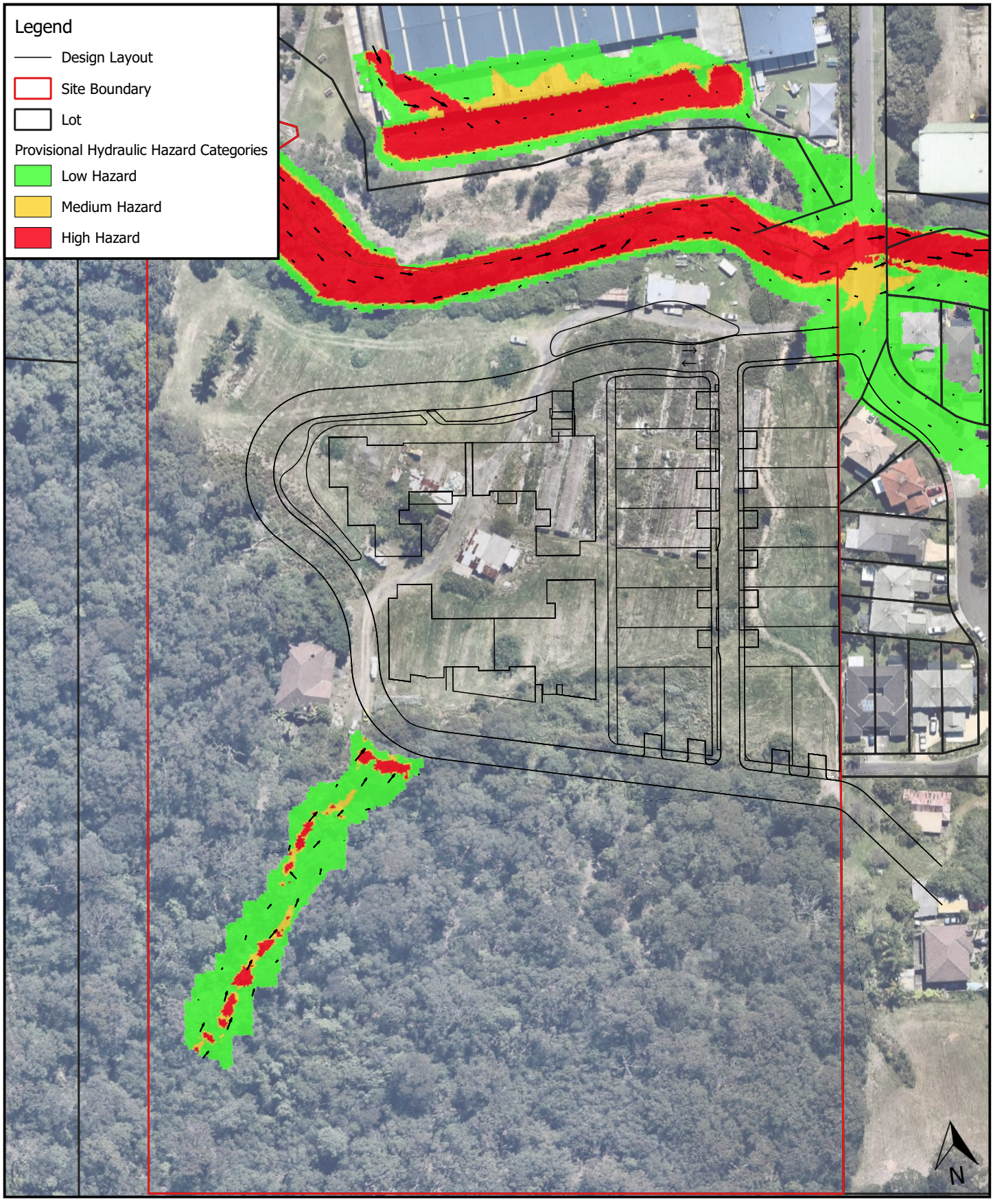

0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

1% AEP Critical Storm Duration Developed Condition (Stage 2) Provisional Hydraulic Hazard Categories

Note:
Hydraulic hazard based on NSW Government (2005) Floodplain Development Manual
Provisional Hydraulic Hazard Categories

Map 14	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
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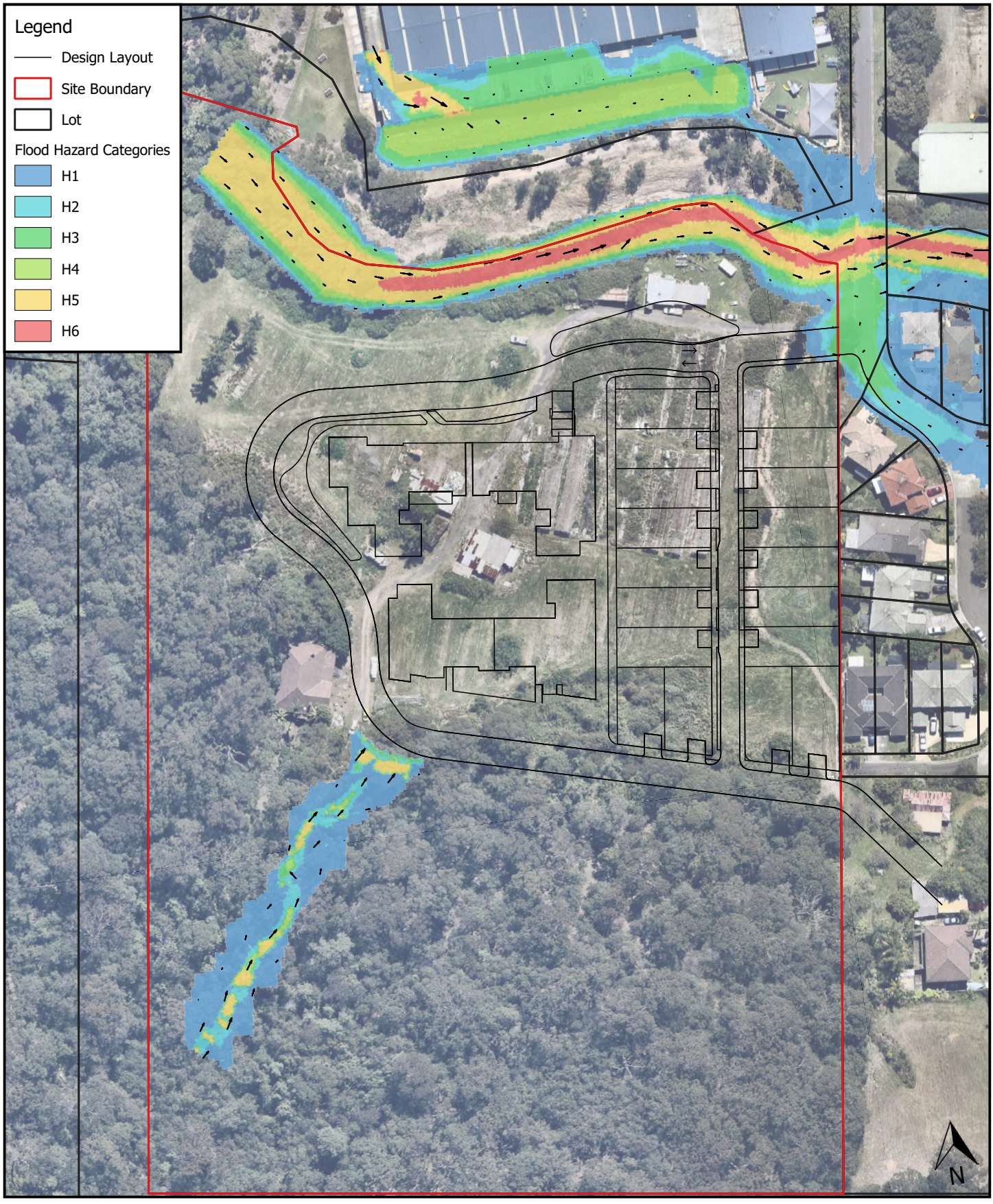

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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

1% AEP Critical Storm Duration Developed Condition (Stage 2) ARR Flood Hazard Categories

Note: Flood Hazard Categories based on Australian Rainfall and Runoff (2019 definitions):
H1 - Generally safe for people, vehicles and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for people and vehicles, children and the elderly.
H4 - Unsafe for people and vehicles

Map 15	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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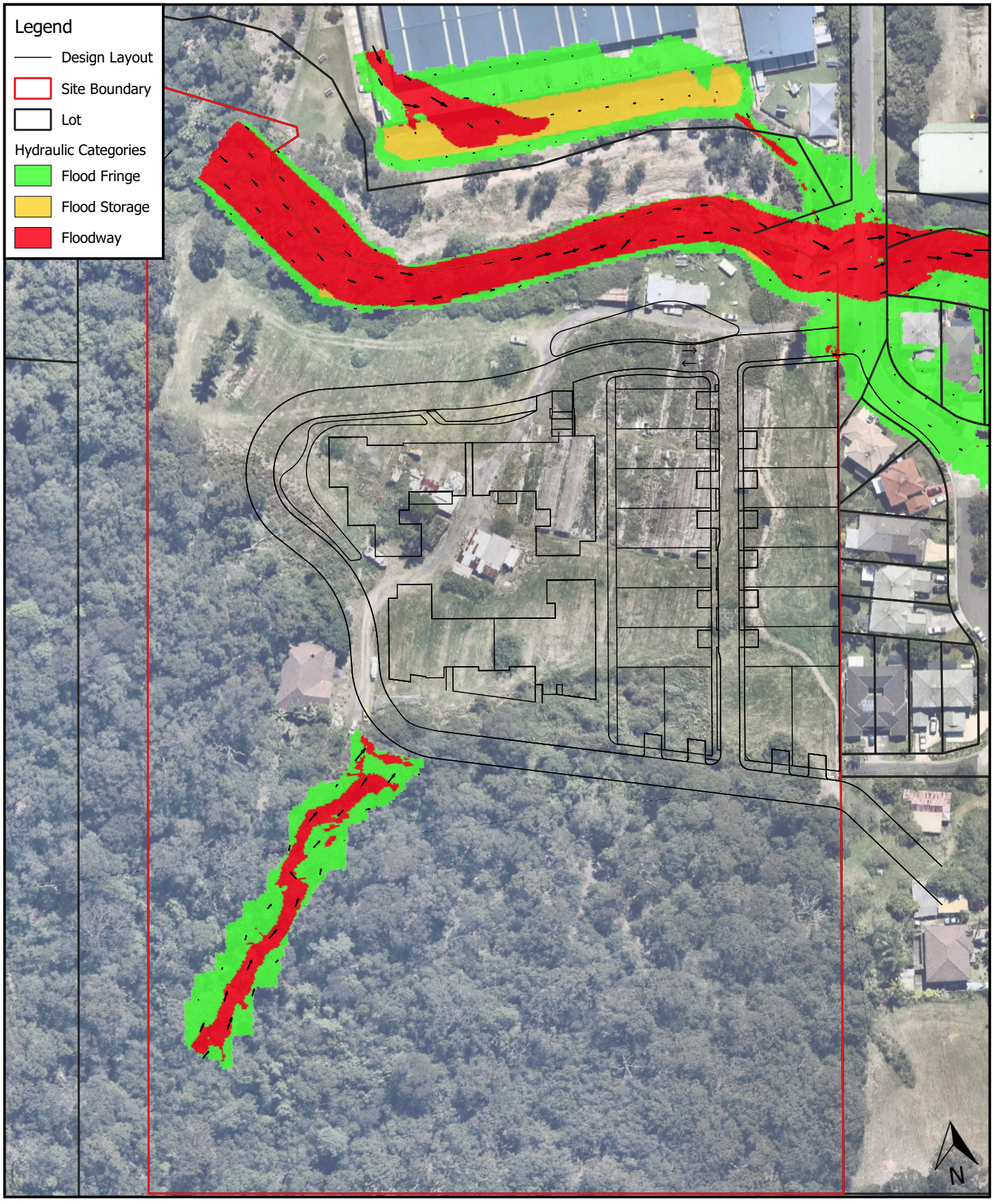

0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

1% AEP Critical Storm Duration Developed Condition (Stage 2) Hydraulic Categorisation

Note:
Adopted hydraulic categories are:
- Floodway is defined as areas where the peak value of velocity multiplied by depth (VD product) > 0.25 m2/s AND peak velocity > 0.25 m/s OR
  Peak velocity > 1.0 m/s AND peak depth > 0.15 m.
- Flood Storage is defined as areas outside the Floodway where peak depth > 0.5 m;

Map 16	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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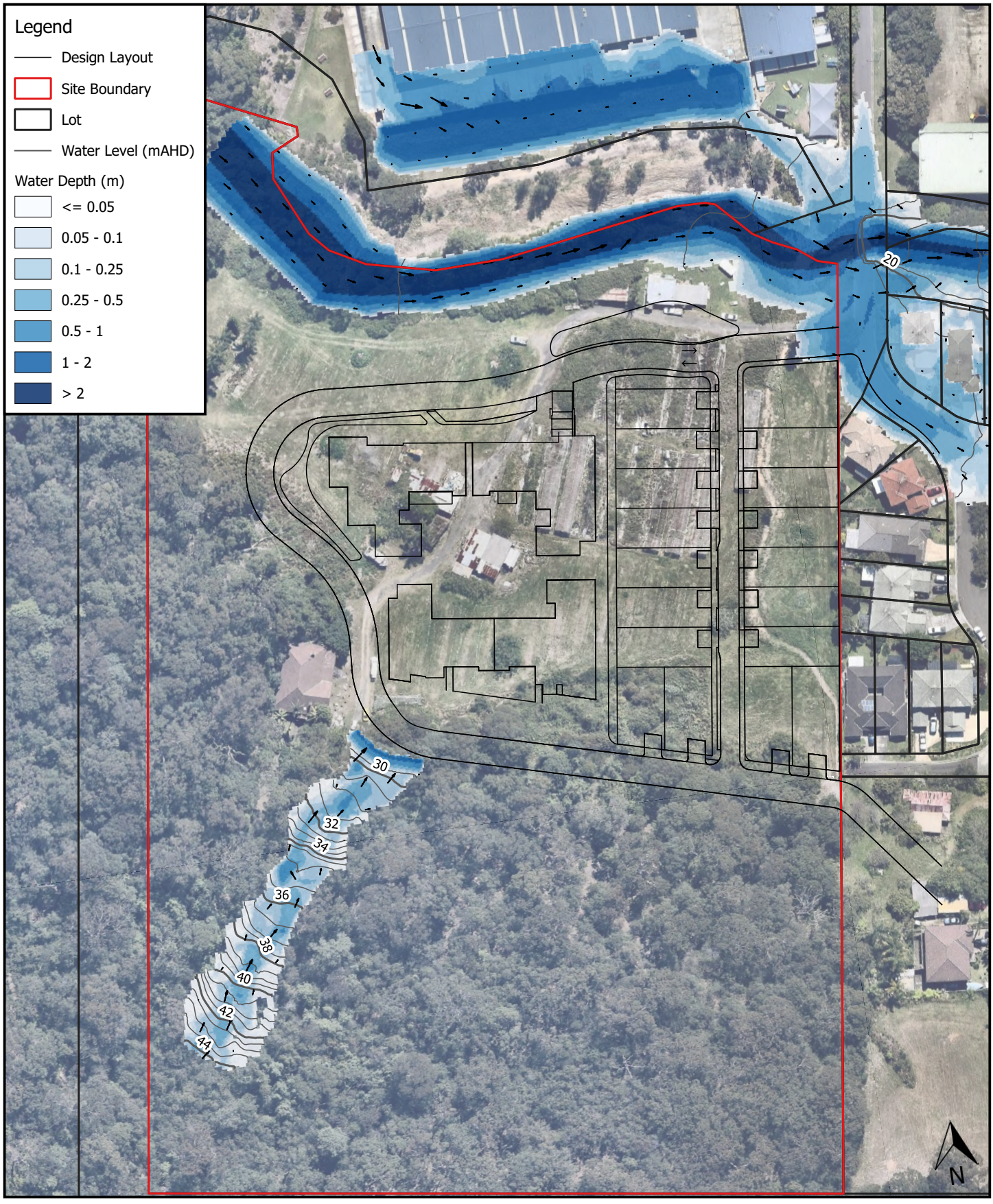

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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

1% AEP + CC Critical Storm Duration Developed Condition (Stage 2)

Map 17	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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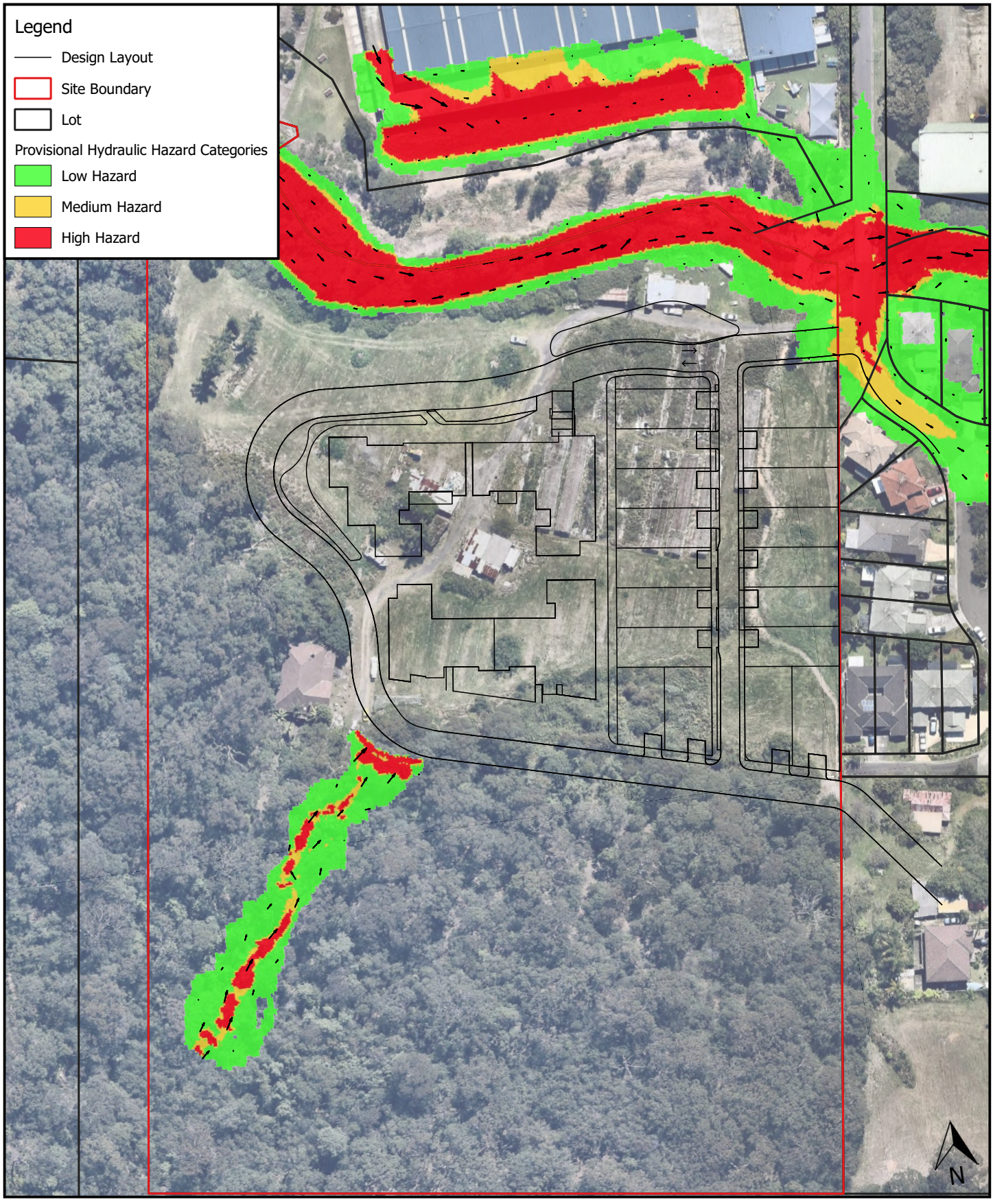

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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

1% AEP + CC Critical Storm Duration Developed Condition (Stage 2)

Note:
Hydraulic hazard based on NSW Government (2005) Floodplain Development Manual
Provisional Hydraulic Hazard Categories

Map 18	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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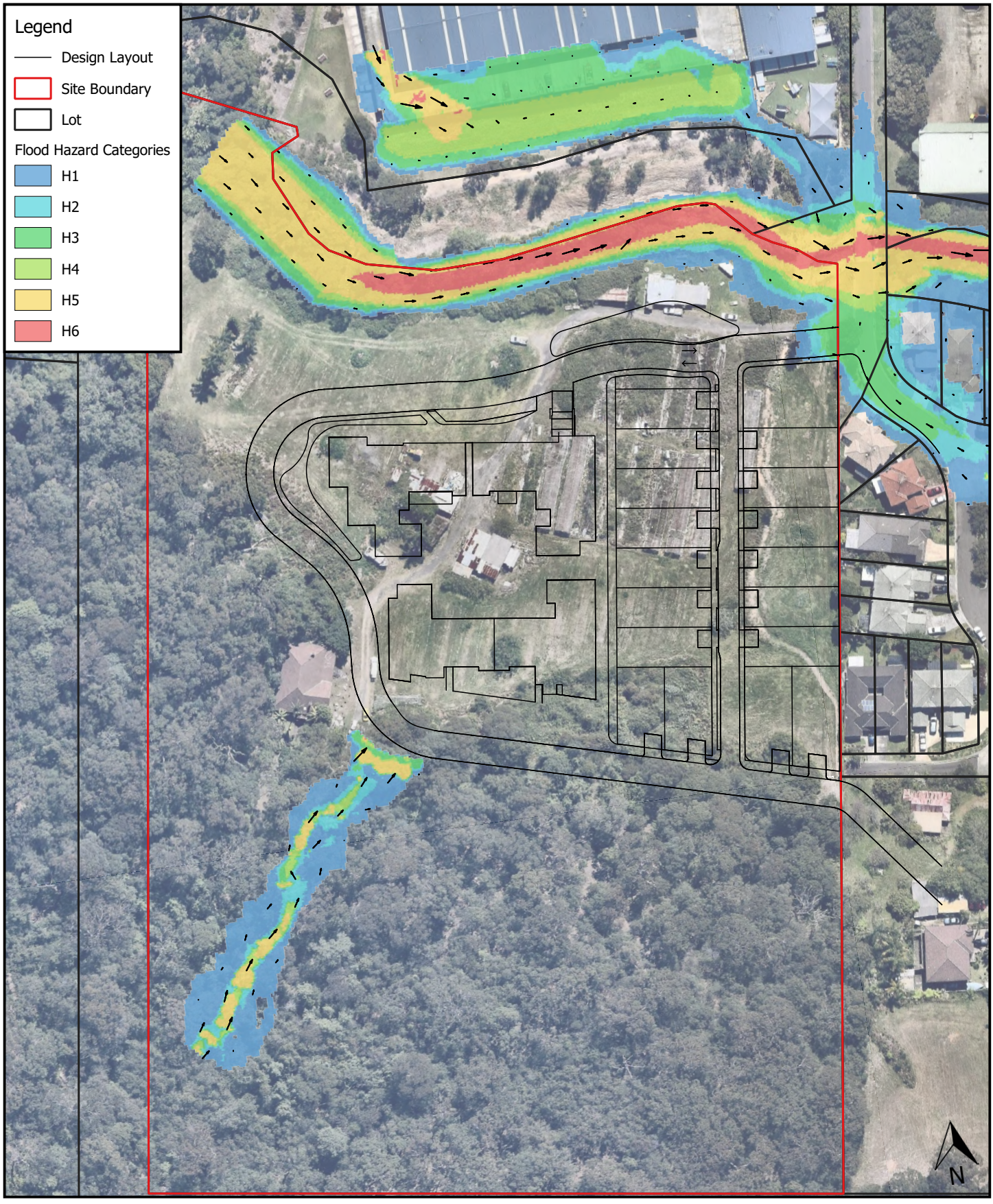

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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

1% AEP + CC Critical Storm Duration Developed Condition (Stage 2)

Note: Flood Hazard Categories based on Australian Rainfall and Runoff (2019 definitions):
H1 - Generally safe for people, vehicles and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for people and vehicles, children and the elderly.
H4 - Unsafe for people and vehicles

Map 19	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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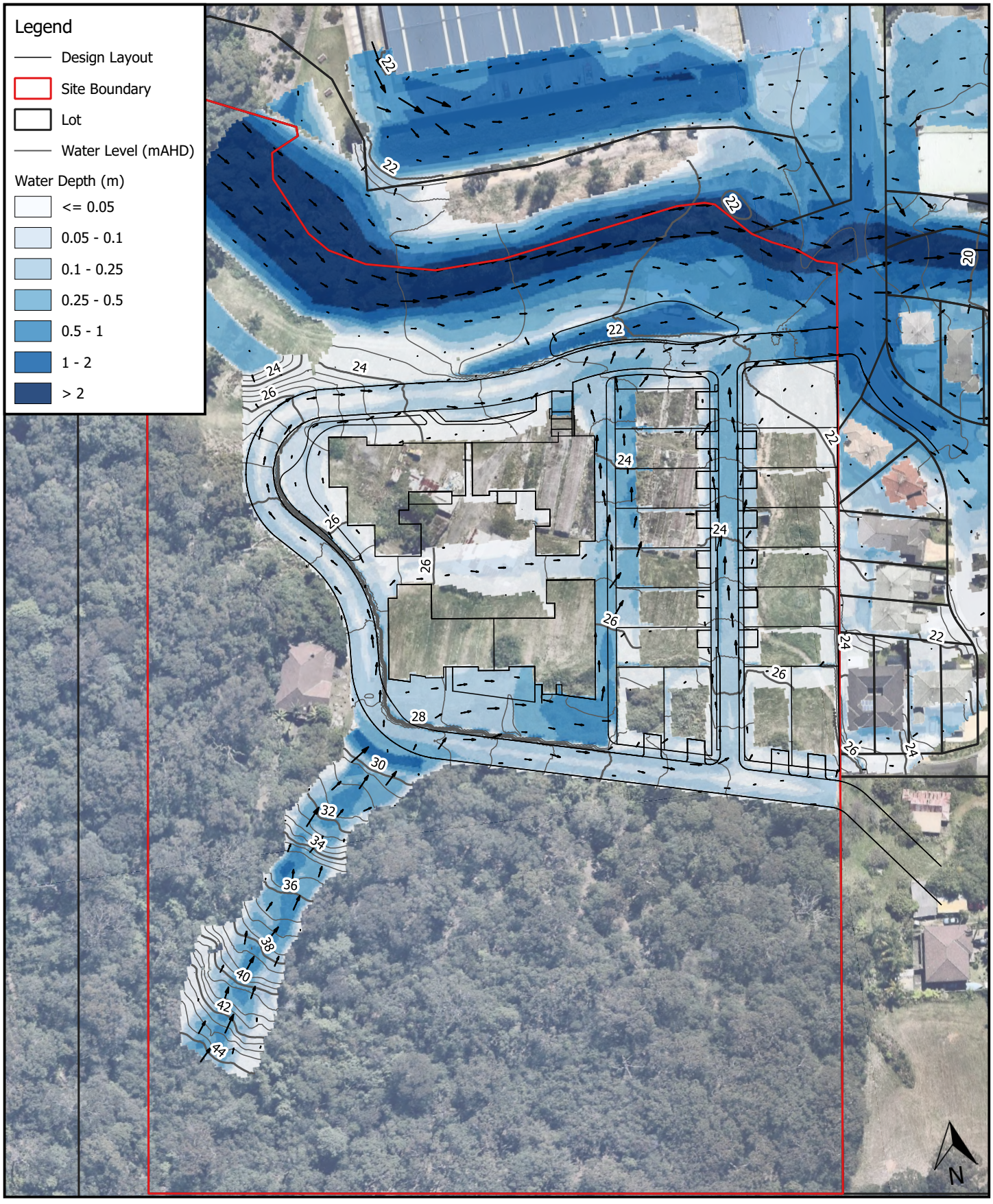

0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

PMF Critical Storm Duration Developed Condition (Stage 2)
Water Level (mAHD) & Water Depth (m)

Map 20	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
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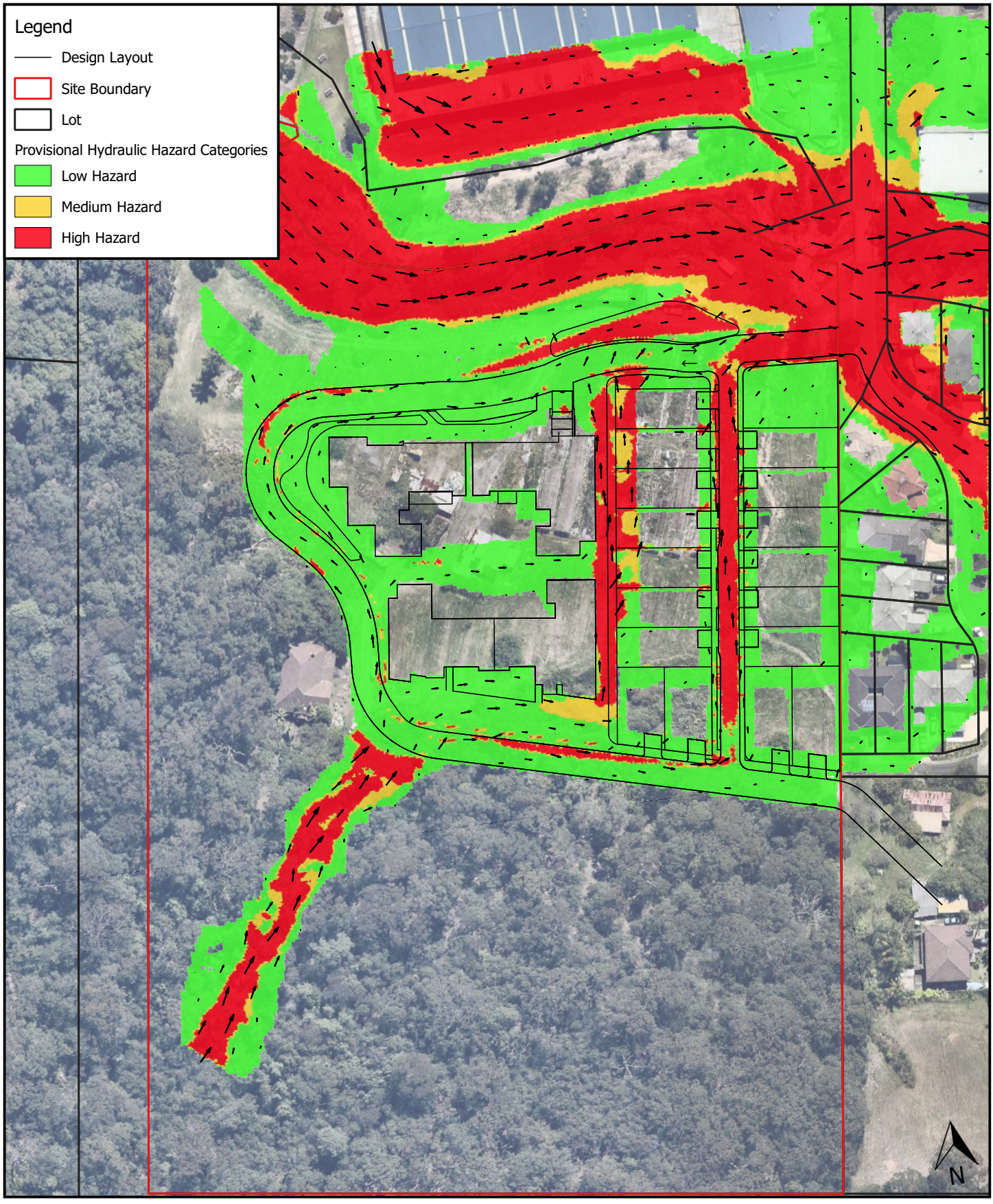

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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

PMF Critical Storm Duration Developed Condition (Stage 2)
Provisional Hydraulic Hazard Categories

Note:
Hydraulic hazard based on NSW Government (2005) Floodplain Development Manual
Provisional Hydraulic Hazard Categories

Map 21	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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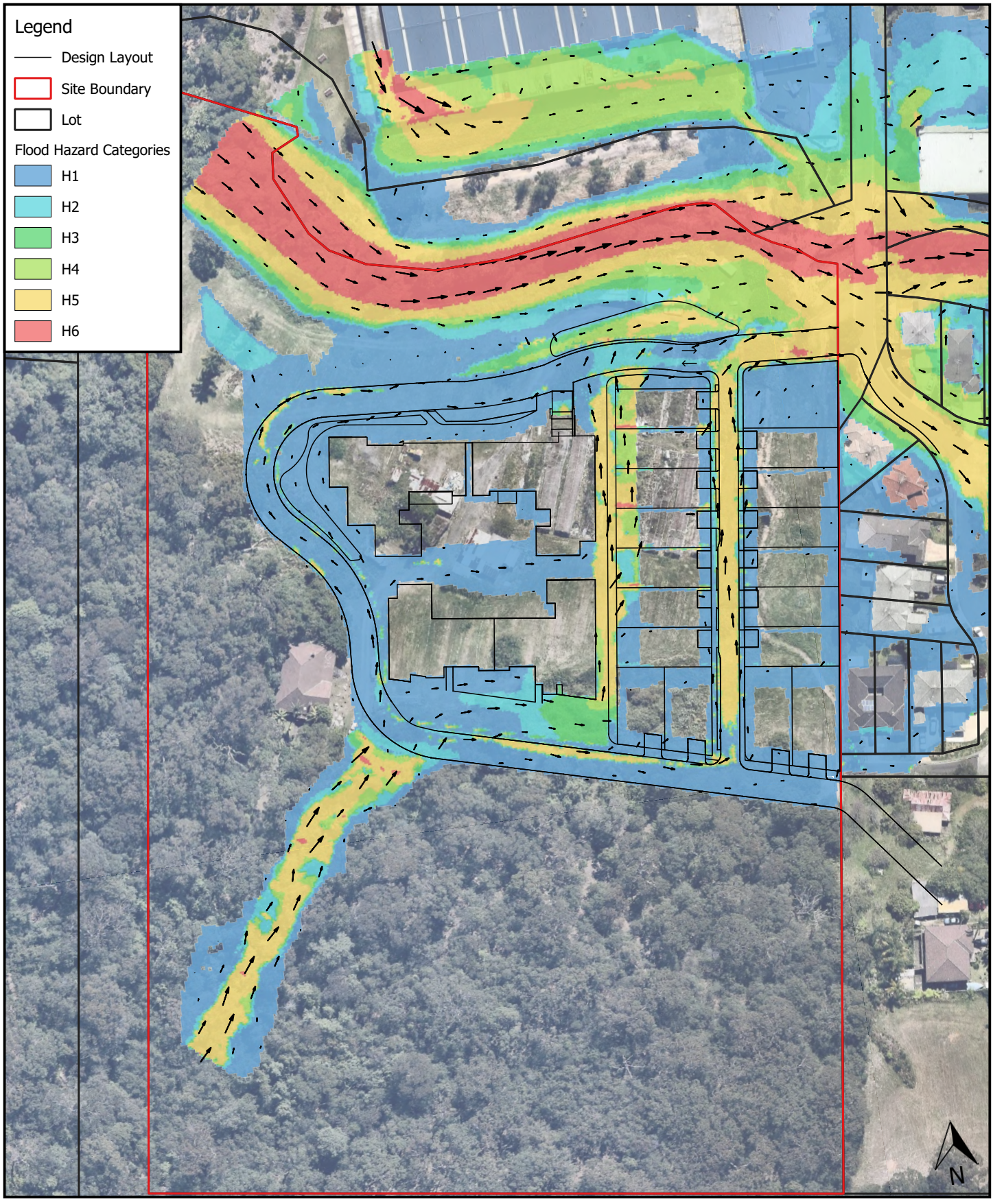

0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

PMF Critical Storm Duration Developed Condition (Stage 2)
ARR Flood Hazard Categories

Note: Flood Hazard Categories based on Australian Rainfall and Runoff (2019 definitions):
H1 - Generally safe for people, vehicles and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for people and vehicles, children and the elderly.
H4 - Unsafe for people and vehicles

Map 22	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
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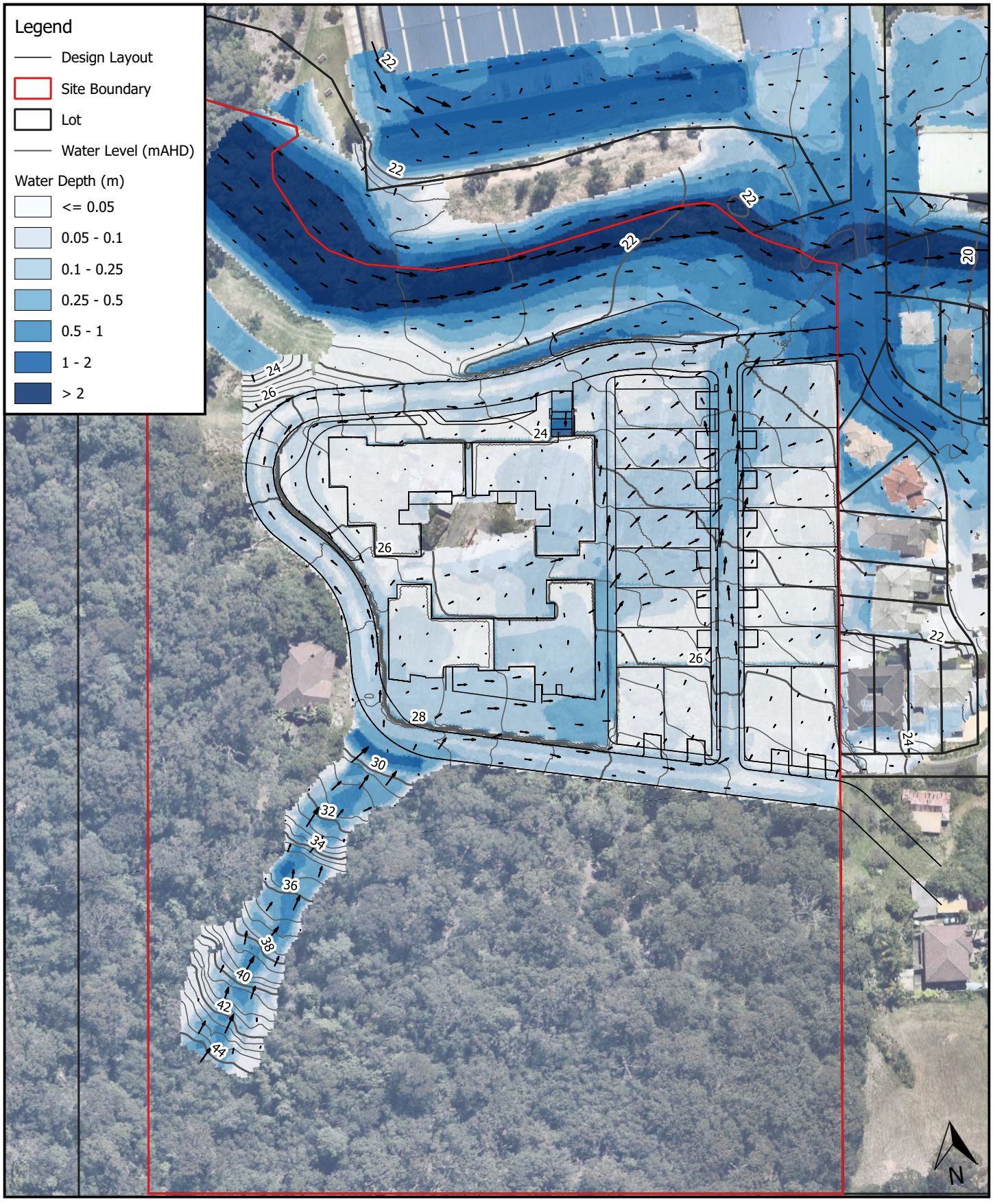

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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

PMF Critical Storm Duration Developed Condition (Stage 1) Water Level (mAHD) & Water Depth (m)

Map 23	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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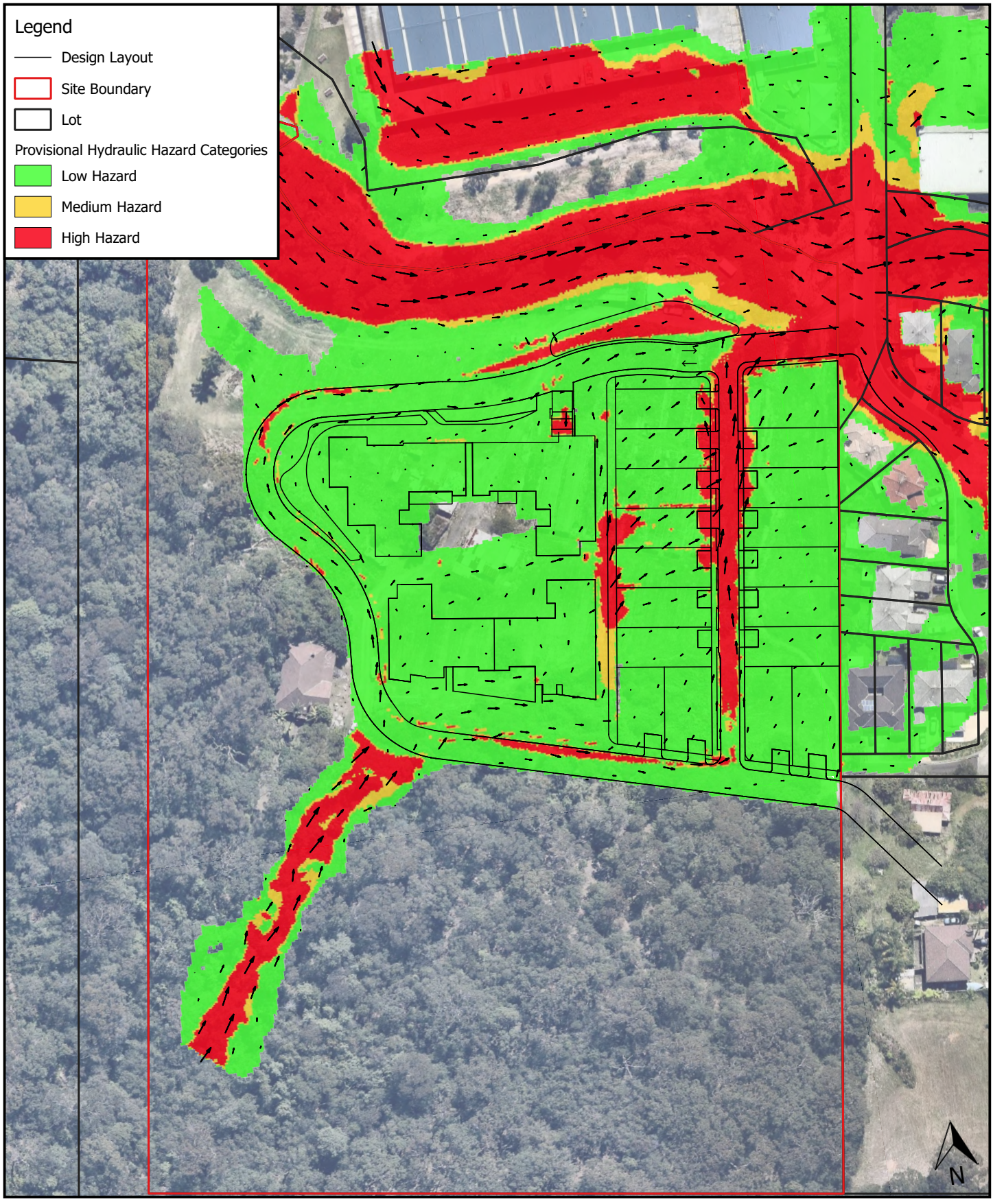

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0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

PMF Critical Storm Duration Developed Condition (Stage 1)
Provisional Hydraulic Hazard Categories

Note:
Hydraulic hazard based on NSW Government (2005) Floodplain Development Manual
Provisional Hydraulic Hazard Categories

Map 24	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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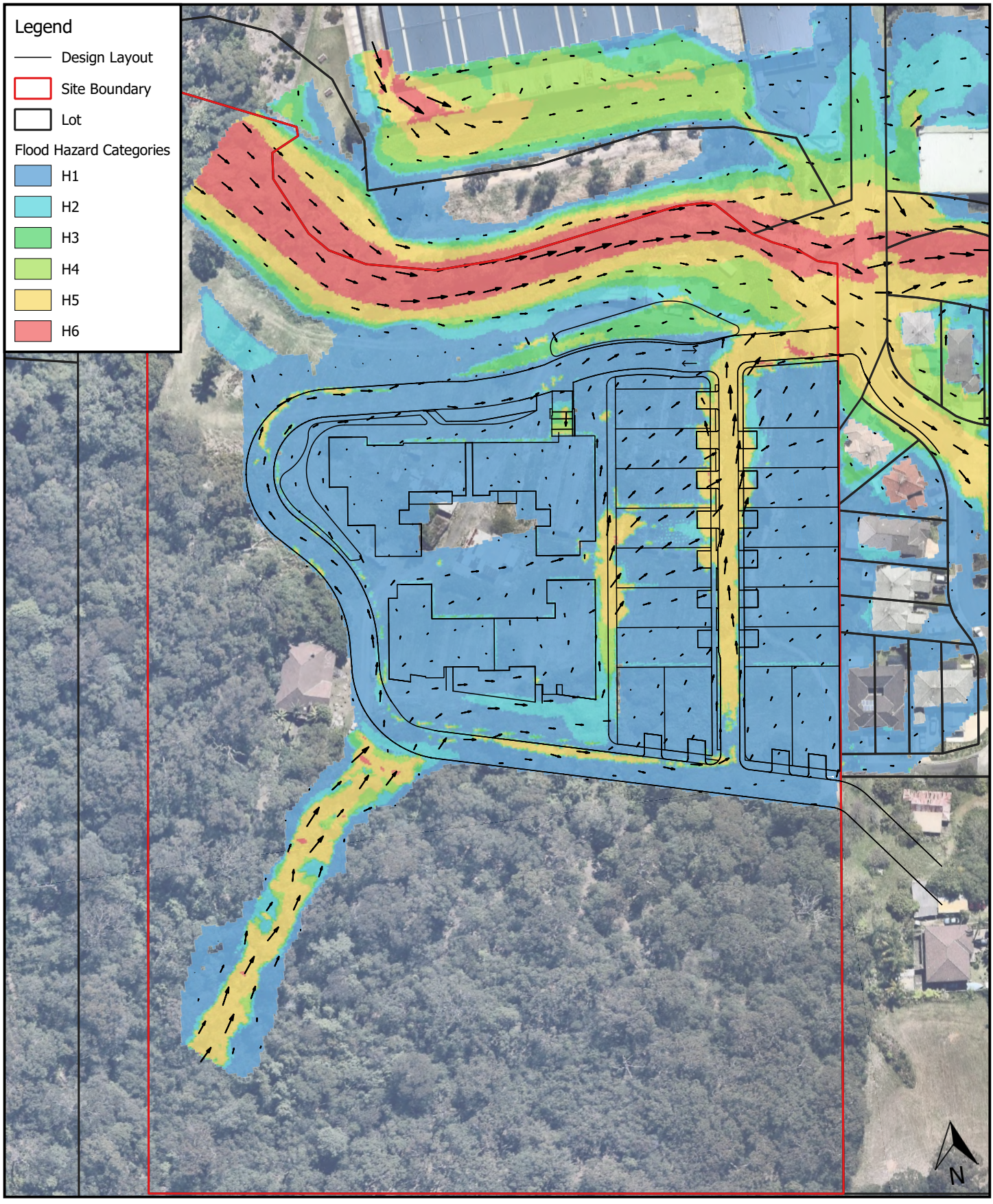

0 10 20 30 40 50 m

1:1500 @ A4

Map Title / Figure:

PMF Critical Storm Duration Developed Condition (Stage 1)
ARR Flood Hazard Categories

Note: Flood Hazard Categories based on Australian Rainfall and Runoff (2019 definitions):
H1 - Generally safe for people, vehicles and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for people and vehicles, children and the elderly.
H4 - Unsafe for people and vehicles

Map 25	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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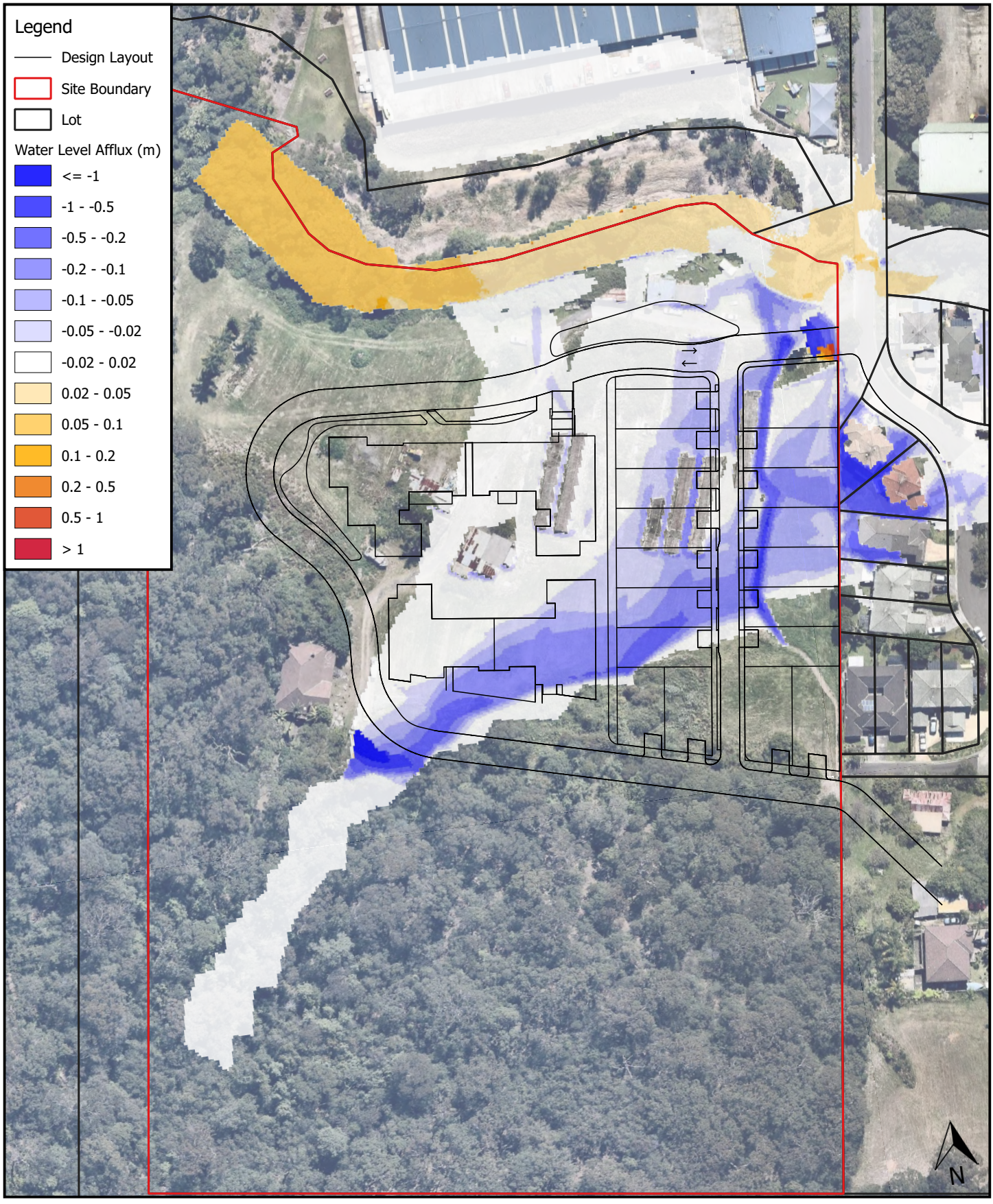

0 10 20 30 40 50 m

1:1500 @ A4

Note:
Areas coloured white represent negligible change.
Areas coloured blue represent water level reduction.
Areas coloured yellow/red represent water level increase.

Map Title / Figure:

1% AEP Critical Storm Duration Design Condition Water Level Afflux (m)

Map 26	Map
8 Forest Road, Warriewood, NSW	Site
Concept Engineering Works for DA	Project
Flood Assessment	Sub-Project
WarriewoodVale Pty Ltd	Client
23/09/2020	Date

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