Flood Impact Report

Hammond Care Cardiff

Prepared for Hammond Care / 16 December 2016

141125

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Structural
Civil
Traffic
Facade
Consulting
Engineers

Contents

1.0 Introduction

This flood study has been prepared by TTW to determine the flood planning level and flood impact for the proposed development at 158 Macquarie Road, Cardiff.

1.1 The Site

The site is located in Cardiff, approximately 1km south of the centre of Cardiff. The site is currently being used as a golfing green with the surrounding area being predominantly residential with free standing houses.

Figure 1 Air Photo (source: NearMap)

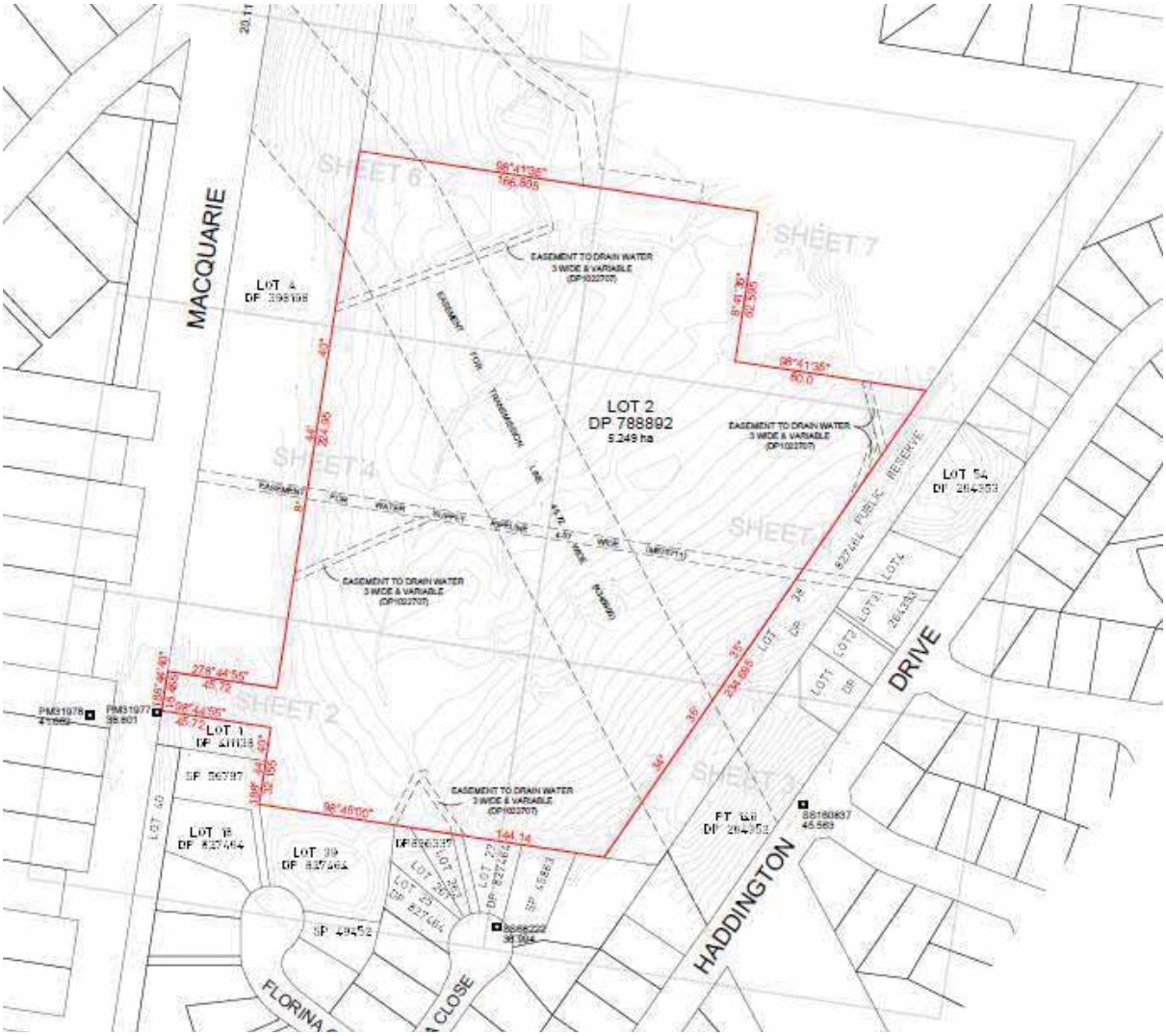

Figure 2 Site Survey

Figure 3 Proposed site plan

2.0 Available Information

2.1 Existing Documents

The following documents have been reviewed as part of this flood study

- Architectural drawings issued by Allen Jack + Cottier (AJ+C) dated 30/04/2016;
- Survey by Carman Surveyors dated 16/03/2015;
- GHD Flood Report dated June 2015;
- Tuflow Model provided by GHD (received 31/10/2016);
- Lake Macquarie City Council Development Control Plan (LMDCP) 2014;
- LiDAR data provided by Land and Property Information;

2.2 Council Requirements

The DCP sets out the following flood controls for the developments relevant to the subject site:

- Habitable floor levels shall be equal to or greater than the Flood Planning Level (FPL) (Probable Maximum Flood (PMF) level plus 500mm freeboard);
- The impact of the development on flooding elsewhere shall be considered.

3.0 Flood Modelling

Two-dimensional flood modelling was undertaken using TUFLOW software. The modelled area extends from the southern end of Haddington Drive, Blaxand Rd and Maud St to the west and east and May St to the north.

A digital terrain model was created using the LiDAR data provided by Land and Property Information NSW. This data provides surface elevations on a 1m grid. This data has an accuracy of 0.3m (95% confidence). The LiDAR was compared to the field survey data and showed good agreement.

A one metre grid size and 0.25 second time step were used for the flood modelling. Buildings were removed from the code, such that there was no flood water conveyance through buildings. Manning's roughness values were adopted form the Ourimbah Creek Catchment Study and therefore was set at 0.015 for roads and footpaths, and 0.035 in grass areas and 0.05 in light vegetation areas.

Two (2) scenarios were considered in the flood modelling:

- Existing conditions; and
- Developed conditions including mitigation measures were incorporated with a view of reducing the impact of the development on surrounding properties.

The hydrology and hydraulic modelling was undertaken for a previous design scheme by GHD (as shown in Appendix A) using software modelling program TUFLOW. All results and flows were calibrated to the Winding Creek and Lower Cockle Creek Flood Study and therefore considered appropriate to use for this further developed layout. Whilst it is recognised that the GHD report in Appendix A is for a previous layout the hydrology and hydraulic modelling is still relevant and this report allows for the updated layout with revised earthworks tin and model runs.

Council requested that the 1 in 100 year storm event be conveyed within the channel and the difference between the PMF and the 1 in 100 year storm event to be conveyed within a below ground culvert system. Therefore inlet structures have been proposed within the northern portion of the site and a box culvert system to convey these flows. Please refer to Appendix C for the civil drawings.

3.1 Hydrology

The hydrology modelling was undertaken by GHD using software modelling program WBNM. As part of their original analysis the flows were calibrated to the Winding Creek and Lower Cockle Creek Flood Study. Refer to Appendix A for more details.

3.2 Boundary Conditions

The hydrology modelling was undertaken by GHD using software modelling program WBNM. As part of their original analysis the flows were calibrated to the Winding Creek and Lower Cockle Creek Flood Study. Refer to Appendix A for more details.

Catchment hydrographs output from GHD modelling were input to the flood model as SA polygons. This method distributes the inflows over each sub-catchment area.

The downstream condition for the flood analysis was taken as a normal depth at May Street.

3.3 100-year ARI Flood Results

3.4 Existing conditions

The existing flood levels on the site are shown in Appendix B. The maximum flood depth across the site is approximately 1.2m.

It is noted that the above results calibrate well with the existing flood levels given by Council and therefore are considered appropriate to use for further modelling purposes.

3.5 Proposed Development

The proposed development was added to the model to determine the flood impact of the development. The flood extent and flood impact is shown within Appendix A.

3.6 Flood mitigation

The proposed flood mitigation for the site aims to reduce the flood impact on neighboring properties. The proposal includes the construction of a minimum 10m wide channel that runs through the middle of the site. This conveys the flood water for the 1 in 100 year storm event through the site. During the higher storm events (up to PMF) the flood water is conveyed through an underground box culvert system. This includes 3 x 1200x900mm RCBCs. The civil design tin and box culvert system has been design modelled within TUFLOW modeling. Results are shown in Appendix A.

The flood afflux for the site and surrounding area for the 1 in 100 year storm event as shown in Appendix A demonstrates that there is afflux within the site which is expected due to the proposed earthworks. There is no afflux within private property.
The afflux shown adjacent to the left boundary is due to a proposed fence which detains flood water within the Council road reserve area.

3.7 Additional Flood mapping

The flood velocities for the existing and design scenarios for the 1 in 100 year storm events are shown in Appendix A. As can be seen the maximum velocities for the site are expected to be between 2-3m/s. Within the channel the velocities are a maximum of approximately 3m/s. It is recommended that erosion protection be put in place to ensure the channel does not scour out.

3.8 Flood Planning Levels

Given the use of the proposed development is considered to be ‘sensitive’, the finished flood levels of all of the proposed aged care buildings have been set at or above the PMF in accordance with Lake Macquarie’s City Council flood requirements.

Key locations across the development with available freeboard are shown in Table 1.

Table 1 Flood Planning Levels

Location	Proposed FFL	PMF flood level	Freeboard	Compliant with DCP?
Buildings 1, 2, 7, 8 & 9	33.00 mAHD	32.90 mAHD	100mm	YES
Building 3 & 4	32.00 mAHD	32.00 mAHD	000mm	YES
Building 5	32.00 mAHD	31.90 mAHD	100mm	YES
Building 6B	32.80 mAHD	32.60 mAHD	200mm	YES
Building 6A	32.50 mAHD	32.40 mAHD	100mm	YES
Building 10A	33.00 mAHD	32.90 mAHD	100mm	YES
Building 10B	36.50 mAHD	36.50 mAHD	000mm	YES

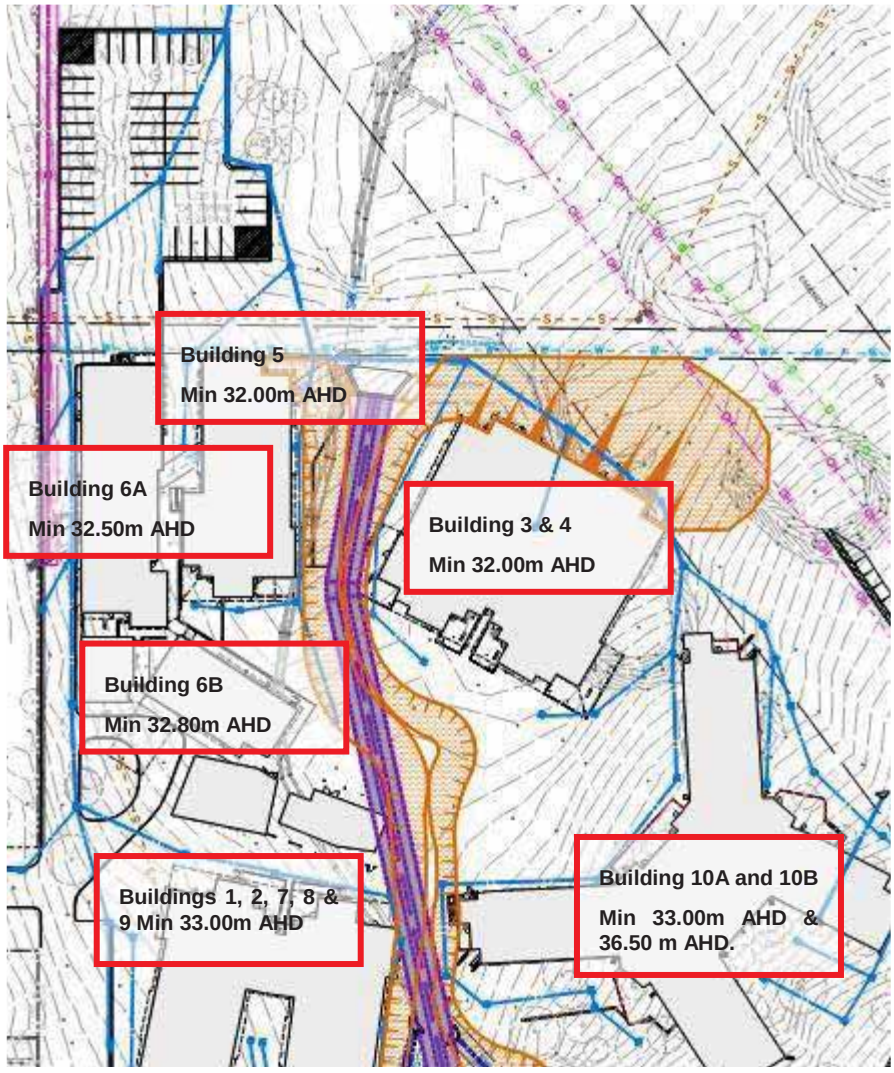

Figure 4 Recommended Flood Planning Levels

4.0 Other Requirements

As per the DCP, All structures are to have flood compatible building components at or below the flood planning level (100-year level plus 500mm freeboard).

The structural engineering design must certify that any structure can withstand the forces of flood water including buoyancy, and debris impact loads.

Based on our assessment of the site, the development does not have a detrimental impact with respect to flooding on local amenity or on ecology of the local area or waterways.

In accordance with clause 7.15 of Lake Macquarie's City Council Local Environmental Plan it is required to balance flood storage for the proposed development. The existing and design flood tins were extrapolated and compared to the detailed survey and design tin to obtain flood storage volumes. The existing and design flood storage volumes were found to be 1,238m^3 and 1361m^3 respectively. Both of the calculations and figures showing the flood storage for each are included within Appendix C. Also it is noted that the storage within the culverts has not been included which would further increase the flood storage. In addition whilst not direct storage volume there is a total of 120m3 of volume capturing roof runoff within the proposed rainwater tank. It is considered that the flood storage volume has been maintained.

5.0 Recommendations

- For the proposed development we recommend that the following flood planning levels shown in Figure 4 be adopted.
- It is recommended that if during the detailed design stage that any changes are required to the earthworks the flood modelling be updated and results verified to ensure the development remains in accordance with Lake Macquarie's City Councils requirements.

The proposed development at 158 Macquarie Road, Cardiff has been designed to reduce the flood impact on neighbouring properties. The finished floor levels are set at or above the PMF storm event in accordance with Council's requirements.

6.0 Conclusions

The proposed development can be designed without causing any actionable nuisance to neighbouring properties. The finished floor levels provide adequate freeboard to the PMF flood levels in accordance with Council's DCP.

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Technical Director

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Appendix A

GHD Flood Report

Hammondcare

Macquarie Road, Cardiff

Flood Impact Assessment

June 2015

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EXECUTIVE SUMMARY

GHD was commissioned by the client to provide a Flood Impact Assessment to support Development Applications (DA) at a proposed Age Care site on Macquarie Road, Cardiff located in the upper reaches of a north draining Winding Creek tributary. The proposal is for the development of an age care facility at the site comprising a residential Age Care and a number of ancillary buildings. All residential age care will be located with ground floor above the Probable Maximum Flood (PMF) level.

Purpose-compiled WBNM and TUFLOW hydrology/hydraulics models were compiled for the site and adjacent areas which better simulated the flooding at the site, since the *Winding Creek and Lower Cockle Creek Flood Study* did not simulate this part of the catchment at the required detail. Council advised in the Flood Certificate that flood planning levels for Sensitive Uses (Residential age care, hospitals etc.) are to have internal floor height at the Probable Maximum Flood (PMF) and unsealed electrical installations at the PMF level.

Findings of the simulations were that the site would be expected to be of a 'flash flood' nature, with flood levels rising and receding within 1 to 2 hours. In a 20-year event, a number of distributed shallow sheet flow (less than 50mm) overflows occur onto the site from Macquarie Road and the residential areas to the west of the site. In a 100-year event overflows to the site are increased as are the sheet flows across the flows which now are at depths of 150 mm in places. Deeper flows are encountered along Drainage Line 1. In a PMF the adjoining residential areas and Macquarie Road provide significant overflows onto the site, however still distributed along the length of the Golf Driving Range.

The results of the impact assessment showed that flood depth for all events remains shallow in the area of the proposed development. Even in a PMF event, flood depths across the site entry road are not expected to exceed 150mm, making it trafficable if required. In a 20 year and 100 year event the impact of the development on flooding is contained within the lot boundary. Building floor levels are above flood levels, and increases in flood levels are noted in areas of proposed fill platforms, where onsite flood waters are redistributed around proposed buildings. Minor affectation is noted in Councils land along Macquarie Road, however this is zoned E3, and thus these minor impacts are assumed to be acceptable. In a PMF the impacts are still contained on the site, with minor impacts beyond the southern site boundary at the outlet of Councils basin. Notably the building floor levels will be above the PMF flood levels, and flood levels are raised in areas where fill is proposed. The flood response for the site will be shelter in place, given the nature of the facility and that floor levels will be at the PMF. Notwithstanding, should flood evacuation be required, this could occur along Macquarie Road in a southerly direction to The Warner Bay private hospital.

On the basis of the above, it is considered that flooding matters at the site would be managed to meet Councils requirements and flood impacts on account of the proposed development are likely to be contained within the lot boundary.

1. Introduction

1.1 Background

GHD was commissioned by the client to provide a Flood Impact Assessment to support Development Applications (DA) at a proposed Age Care site on Macquarie Road, Cardiff (hereafter called 'site').

The site is located east of Macquarie Road at the location of the current Lymington Park Golf Driving Range. It is located in the upper reaches of a north draining Winding Creek tributary as shown in Figure 1-1.

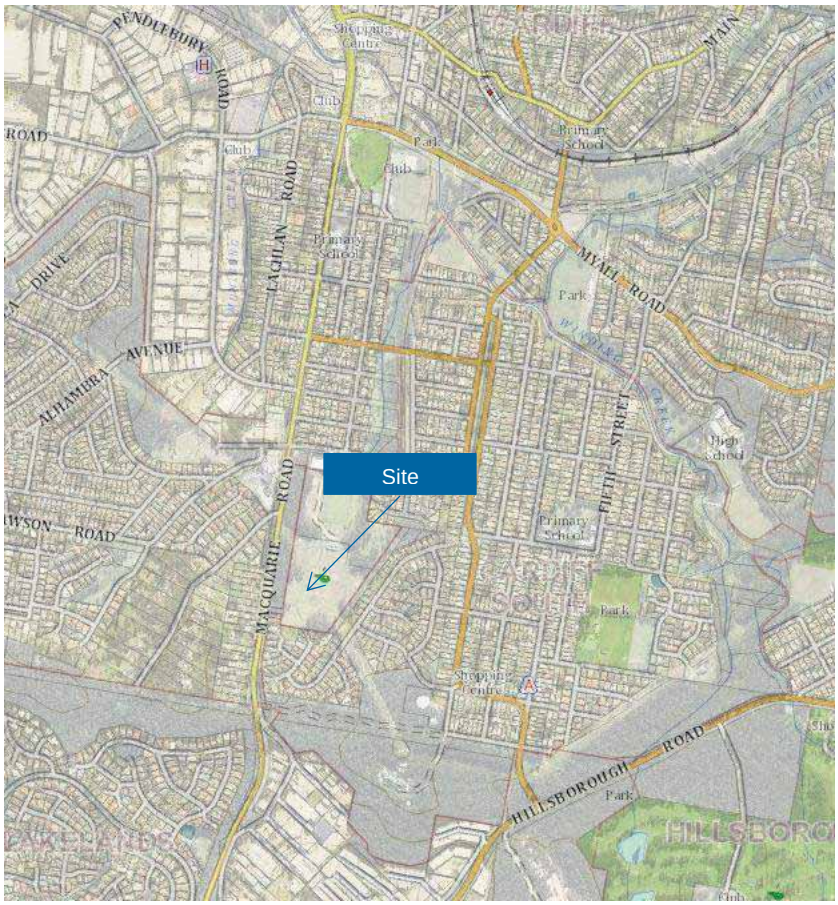


Figure 1-1 Site (ref Six Viewer, LPI)

1.2 Methodology

The *Winding Creek and Lower Cockle Creek Flood Study*, Lake Macquarie City Council (August 2013) compiled WBNM and TUFLOW models to simulate flooding in these creek systems. For the catchment draining to the site, the upstream limit of the *Winding Creek and Lower Cockle Creek Flood Study* was the Lymington Park Sports Fields, which is approximately 450m downstream of the site. In addition, the representation of the catchment draining to the site was only represented as a single catchment in the overall model, which was considered too 'coarse' for the assessment of flooding at the site.

In order to assess the site, purpose compiled WBNM and TUFLOW models developed to better represent the study area and were used to simulate the flooding at the site. These models subdivided the upstream catchment of the site into a number of sub-catchments to represent inflow locations to the TUFLOW model and used the *Winding Creek and Lower Cockle Creek Flood Study* flood levels as downstream controls. Using these purpose-compiled flood models, this assessment is based on the simulated results considering:

- Flood levels/depths, velocities, hazards and time to/duration of inundation
- Flood readiness, flood warning and evacuation
- Structural stability with respect to flooding

In addition the following information documents and Local/State Government policies were relevant:

- *NSW Floodplain Development Manual, April 2005*
- *Lake Macquarie City Council, Development Control Plan 2013, Part 3 – Development within Residential Zones, Adopted by Council – 2 December 2013.*
- *Lake Macquarie City Council, Flood Management Guidelines, February 2012 – Exhibition Draft.*
- Council advice on flooding at the site noted in the Flood Certificate (Council ref 1065, Appendix A)

1.3 Council Flood Certificate

Council advice in the Flood Certificate (Council ref 1065, Appendix A) notes the following key matters:

- Flood levels were derived from rudimentary rezoning flood assessments in 2008, which have been revised through the detailed assessments presented in this report
- Flood planning levels for Sensitive Uses (Residential age care, hospitals etc.) are to have:
  - Internal floor height at the Probable Maximum Flood (PMF)
  - Unsealed electrical installations at the PMF level

1.4 Limitations

This report has been prepared by GHD for Hammondcare and may only be used and relied on by Hammondcare for the purpose agreed between GHD and Hammondcare. GHD otherwise disclaims responsibility to any person other than Hammondcare arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible. The services undertaken by GHD in connection with preparing this report were limited to those

specifically detailed in this report and are subject to the scope limitations set out in the report. The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared. The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD. GHD disclaims liability arising from any of the assumptions being incorrect.

2. Development

2.1 Existing

The site is currently in the Lymington Park Golf Driving Range area and is located in the headwaters of the Winding Creek (Brush Creek) catchment. This catchment drains northward, separated from the south draining North Creek catchment (and Warners Bay) by the elevated Munibung Hill Reserve. Two drainage lines traverse the site, both draining in a south to north direction:

- Drainage Line 1 essentially bisects the site. This creek receives runoff from the elevated Munibung Hill Reserve catchment and upstream residential areas. Along its length, stormwater from the elevated western residential areas would be expected to discharge to the watercourse.
- Drainage Line 2 drains partly along the eastern boundary of the site, discharging runoff from the eastern residential areas.

The creeks do not confluence on the site under low flow conditions, but may well confluence under flooding conditions. Under low flow conditions the creeks receive discharges from subdivision stormwater pipes, while under flood conditions both pipe and overland flows would be expected to discharge to the site from surrounding catchments and the site. Both drainage lines discharge via upstream basins located in the adjoining residential areas before discharging to the site.

Figure 2-1 General Catchments

2.2 Proposal

With reference to Appendix B, the proposal is for the development of an age care facility at the site comprising:

- A Residential Age Care
- Three separate buildings housing Age Care Parlours
- A stores/staff/training building
- A chaple building
- A general office building
- Parking areas and internal access roads
- Covered walkways and common garden areas
- Landscaped areas.

All residential age care will be located with ground floor above the Probable Maximum Flood (PMF) level.

3. Flood Assessment

3.1 Flood Data

In compiling the purpose-compiled WBNM and TUFLOW models for the site, the following approach was used.

- The catchments draining to the site were discretised into sub catchments to represent inflows from west of Macquarie Road, residential areas upstream (south), residential areas east of the site and catchment representing the site itself. This information was input to a new WBNM model which was simulated with the same hydrological parameters suggested in the *Winding Creek and Lower Cockle Creek Flood Study.* Simulations were undertaken for the 20-year, 100-year and PMF events, and flood levels were validated against flood levels documented in the *Winding Creek and Lower Cockle Creek Flood Study* for the Lymington Park Sports field.
- To assess the impact of the proposed development, a standalone TUFLOW 2D flood model was compiled for the site and simulations were undertaken to compare the existing (pre-development) and post-development conditions. This model was also used to assess hydraulic categories, flood velocities, provisional flood hazard and provide shear stress data. The model:
  - Was based on photogrammetry derived Digital Elevation Data (DEM) supported by survey data and stormwater infrastructure data provided by Council.
  - Represented the culverts under Lake Macquarie Road and basins in the adjacent residential sub-divisions.
  - Was configured with a 1x1m cell size.
  - Was configured with material roughness, delineated using aerial imagery.
  - Was configured with hydrograph inflows at the upstream boundaries of the model and with downstream flood level boundary controls extracted from the *Winding Creek and Lower Cockle Creek Flood Study*.
  - Was simulated for the 20-year, 100-year and PMF events storm events.

3.1.1 Flood Levels and Depths

Existing conditions flood level and depth figures are provided in Appendix C. Referring to Figures 1, 4 and 7 the following is noted:

- Flooding at the site would be expected to be of a ‘flash flood’ nature, with flood levels rising and receding within 1 to 2 hours.
- In a 20-year event, a number of overflows occur onto the site from Macquarie Road and the residential areas to the west of the site. The overflows are distributed along the length of the Golf Driving Range. Shallow sheet flow (less than 50mm) occurs on the site towards Drainage Line 1. Residential areas to the south and to the east overflow to the site via basins and again enter the site as shallow sheet flows. Some discharges are routed down Macquarie Street and do not overflow to the site
- In a 100-year event overflows to the site are increased as are the sheet flows across the flows which now are at depths of 150 mm in places. Deeper flows are encountered along Drainage Line 1 with depths in the order of 1 m at the location of the creek invert.
- In a PMF the adjoining residential areas and Macquarie Road provide significant overflows onto the site, however still distributed along the length of the Golf Driving

Range. In some areas sheet flows are at depths of up to 500 mm, however flows across the site are largely up to depths of 150mm.

3.1.2 Flood Velocities

Existing condition flood velocities are provided in Appendix C. Referring to Figures 2, 5 and 8 it is noted that velocities across most of the site are less than 0.5m/s in the 20-year and 100-year events, with exception of the creek channel where velocities up to 2 m/s are expected. In a PMF some overflows areas from Macquarie Road across the site would be expected to have elevated velocities due to the increased inflows.

3.1.3 Existing Provisional Hydraulic Hazard

Existing Provisional Hydraulic Hazard is provided in Appendix C, Figures 3, 6 and 9. The hazard has been defined into Hazard Vulnerability Classification in accordance with the Australian Emergency Management Handbook Series, Technical flood risk management guideline, Flood Hazard (Attorney-General's Department, 2014):

- H1 - Generally Safe for vehicles, people and buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for Vehicles, Children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust buildings vulnerable to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

In the 20-year and 100-year events under the existing provisional hydraulic hazard, much of the site is generally safe for vehicles, people and buildings, with exception of the tributary drainage channels. In a PMF some areas are unsafe for small vehicle and the drainage line channel areas are unsafe for vehicles and people.

It is noted, that the intention will be to mitigate the provisional flood hazard at the site through landform adjustments (such as filling), drainage adjustments and stormwater management.

3.1.4 Flood Impact Assessment

A flood impact assessment has been undertaken to assess the impact of the proposed site layout and buildings as provided in Appendix B. This was achieved by using the self-standing TUFLOW flood model developed for the site. This flood impact assessment was undertaken for a design iteration and landform, which will be refined through detailed design in ensuing stages of development. In compiling the landform for the proposed development, a 900mm diameter stormwater pipe has been provided through the centre of the site, to provide continuity for Drainage Line 1 and drain the residential properties located to the south of the site.

The results of the impact assessment are provided in Appendix D, which show:

- Flood depth for all events remains shallow in the area of the proposed development. Even in a PMF event, flood depths across the site entry road are not expected to exceed 150mm, making it trafficable if required.
- In a 20 year and 100 year event the impact of the development on flooding is contained within the lot boundary. Building floor levels are above flood levels, and increases in flood levels are noted in areas of proposed fill platforms, where onsite flood waters are redistributed around proposed buildings. Minor affectation is noted in Councils land

along Macquarie Road, however this is zoned E3, and thus these minor impacts are assumed to be acceptable.

- In a PMF the impacts are still contained on the site, with minor impacts beyond the southern site boundary at the outlet of Councils basin. Notably the building floor levels will be above the PMF flood levels, and flood levels are raised in areas where fill is proposed.

3.1.5 Climate Change

Future climate change impacts at the site could be associated with an increase in the rainfall intensity (DECC, 2007). This impact has not been simulated at present and will be considered during ensuing stages of the project.

3.1.6 Flood response

Flood information including flood forecasts, road closures, and advice on evacuation are broadcast over local radio and TV stations, which is disseminated by the Bureau of Meteorology (BOM). If the owner is unsure of the risk of a flood, the SES should be contacted immediately and flood precautions taken (tel. 132 500). BOM disseminates flood warnings from various sources.

The flood response for the site will be a shelter in place, given the nature of the facility, the fact that floor levels will be at the PMF. Notwithstanding, should flood evacuation be required, this could occur along Macquarie Road in a southerly direction to The Warner Bay private hospital.

Further information on flood readiness can be found on the SES website www.ses.nsw.gov.au.

4. Summary and Conclusions

- GHD was commissioned by the client to provide a Flood Impact Assessment to support Development Applications (DA) at a proposed Age Care site on Macquarie Road, Cardiff located in the upper reaches of a north draining Winding Creek tributary.
- Two drainage lines traverse the site, both draining in a south to north direction. Drainage line 1 essentially bisects the site. This creek receives runoff from the elevated Munibung Hill Reserve catchment and upstream residential areas. Drainage line 2 drains partly along the eastern boundary of the site, discharging runoff from the eastern residential areas.
- A purpose-compiled WBNM and TUFLOW models were developed for the site and adjacent areas which better simulated the flooding at the site, since the *Winding Creek and Lower Cockle Creek Flood Study* did not simulate this part of the catchment at the required level of detail.
- Council advice in the Flood Certificate that flood planning levels for Sensitive Uses (Residential age care, hospitals etc.) are to have internal floor height at the Probable Maximum Flood (PMF) and unsealed electrical installations at the PMF level.
- The proposal is for the development of an age care facility at the site comprising a residential Age Care and a number of ancillary buildings. All residential age care will be located with ground floor above the Probable Maximum Flood (PMF) level.
- The findings of the existing flood simulations are:
  - Flooding at the site would be expected to be of a 'flash flood' nature, with flood levels rising and receding within 1 to 2 hours. In a 20-year event, a number of distributed shallow sheet flow (less than 50mm) overflows occur onto the site from Macquarie Road and the residential areas to the west of the site. In a 100-year event overflows to the site are increased as are the sheet flows across the flows which now are at depths of 150 mm in places. Deeper flows are encountered along Drainage Line 1. In a PMF the adjoining residential areas and Macquarie Road provide significant overflows onto the site, however still distributed along the length of the Golf Driving Range.
  - Existing conditions flood velocities across most of the site are less than 0.5m/s in the 20-year and 100-year events, with exception of the creek channel where velocities up to 2 m/s are expected.
  - In the 20-year and 100-year events under the existing conditions, the provisional hydraulic hazard mapping indicates that much of the site is generally safe for vehicles, people and buildings, with exception of the tributary drainage channels. In a PMF some areas are unsafe for small vehicle and the drainage line channel areas are unsafe for vehicles and people. It is noted, that the intention will be to mitigate the provisional flood hazard at the site through landform adjustments (such as filling), drainage adjustments and stormwater management.
- The results of the impact assessment showed that flood depth for all events remains shallow in the area of the proposed development. Even in a PMF event, flood depths across the site entry road are not expected to exceed 150mm, making it trafficable if required. In a 20 year and 100 year event the impact of the development on flooding is contained within the lot boundary. Building floor levels are above flood levels, and increases in flood levels are noted in areas of proposed fill platforms, where onsite flood waters are redistributed around proposed buildings. Minor affectation is noted in Councils land along Macquarie Road, however this is zoned E3, and thus these minor impacts are

assumed to be acceptable. In a PMF the impacts are still contained on the site, with minor impacts beyond the southern site boundary at the outlet of Councils basin. Notably the building floor levels will be above the PMF flood levels, and flood levels are raised in areas where fill is proposed.

- The flood response for the site will be a shelter in place, given the nature of the facility, the fact that floor levels will be at the PMF. Notwithstanding, should flood evacuation be required, this could occur along Macquarie Road in a southerly direction to The Warner Bay private hospital.
- On the basis of the above, it is considered that flooding matters at the site could be managed to meet Councils requirements and flood impacts on account of the development are likely to be contained within the lot boundary.

5. References

- NSW, 2005, Floodplain Development Manual, NSW Government, 2005,
- AR&R, 2001, Australian Rainfall and Runoff, 2001
- AG D, 2014, Australian Emergency Management Handbook Series, Technical flood risk management guideline, Flood Hazard (Attorney-General's Department, 2014)
- DECC, 2007, Practical Consideration of Climate Change
- LMCC, 2013, Lake Macquarie City Council, Development Control Plan 2013, Part 3 – Development within Residential Zones, Adopted by Council – 2 December 2013.
- LMCC, 2012 Lake Macquarie City Council, Flood Management Guidelines, February 2012 – Exhibition Draft.
- LMCC, 2014 Council advice on flooding at the site noted in the Flood Certificate (Council ref 1065, Appendix A)

Appendices

Appendix A - Council Flood Certificate

24 February 2015

Smyth Planning
Suite 67
330 Wattle St
ULTIMO NSW 2007

Our Ref: 1065
Your Ref: Hammond
Care Cardiff
ABN 81 065 027 868

Attention: Meg Levy

FLOOD CERTIFICATE

Fee Paid: 110.00

Receipt No: 8157191

DESCRIPTION OF LAND

Address: 158 Macquarie Road, CARDIFF NSW 2285

Lot Details: Lot 2 DP 788892

County: Northumberland

G D Jones
Senior Sustainability Officer (Natural Disaster Management)

For: BRIAN BELL
GENERAL MANAGER

126-138 Main Road Speers Point NSW 2284 Box 1906, Hunter Region Mail Centre NSW 2310
Phone: 02 4921 0333 **Fax:** 02 4958 7257 **Email:** council@lakemac.nsw.gov.au **Website:** www.lakemac.com.au
www.facebook.com/lakemaccity www.twitter.com/lakemac
ABN: 81 065 027 868

The following information is provided from the records of the Council pursuant to the Local Government Act 1993 in response to your request for details relating to affectation of the above land by flooding.

Levels shown are in metres on Australian Height Datum (AHD). Refer to attached Flood Information Sheet attached for information on the AHD.

Likelihood of land being flooded

The likelihood of the land and buildings thereon being flooded can be assessed from the following information:-

1. **Highest observed flood over or adjacent to the land:**

   Not Available

NOTE: Applicants are advised that where highest observed historic flood levels are stated, this data may not have been observed by Council, but may be the result of local information and, therefore applicants may consider it advisable to carry out their own investigations.

2. **Information derived from *Hydrology Assessment for Rezoning Land at Cardiff* report by BMT WBM dated August 2008:-**

1 in 100 year probable flood level ...	Refer to Figure 5.4 on page 8 below and Table 5-1 on page 9
1 in 20 year probable flood level ...	Refer to Figure 5.3 on page 7 below and Table 5-1 on page 9
Probable Maximum Flood level (PMF)	Refer to Table 5-1 on page 9 below

3. **Existing ground levels at site:**

   Refer to 9-page Survey Overview report, Reference 3267, by Carman Surveyors dated 08/11/2013.

4. **Existing Dwelling floor level:** ... Not applicable

5. **Existing Garage floor level:** ... Not applicable

Flood Planning Levels

Flood Planning Levels and floor height requirements in areas affected by flooding (Council resolution dated 20 August, 1984) excluding those properties shown affected in the *Lake Macquarie Waterway Flood Study* and *Flood Risk Management Study and Plan (June 2012).*

Development Type (including extensions)	Minimum Height Requirements
Dwellings	
Habitable rooms	1 in 100 year probable flood level plus 500mm freeboard **or** 500mm above the highest observed flood level if no probable flood level is available.
Non-habitable rooms and garages	1 in 20 year probable flood level **or** at the highest observed flood level if no probable flood level is available.
Carports, boat sheds, garden sheds, and other ancillary structures (excluding garages)	No requirement.
Unsealed electrical installations	1 in 100 year probable flood level plus 500mm freeboard **or** 500mm above the highest observed flood level if no probable flood level is available.
Medium and High Density residential development	
Habitable rooms	1 in 100 year probable flood level plus 500mm freeboard **or** 500mm above the highest observed flood level if no probable flood level is available.
Non-habitable rooms and garages	1 in 20 year probable flood level **or** at the highest observed flood level if no probable flood level is available.
Carports, boat sheds, garden sheds, and other ancillary structures (excluding garages)	No requirement.
Basement car parking	Constructed to preclude entry of floodwater at levels up to the 1 in 100 year probable flood level plus 500mm freeboard. Additional requirement for basement levels to implement a failsafe means of evacuation, and a pump-out system to remove floodwaters.
Unsealed electrical installations	1 in 100 year probable flood level plus 500mm freeboard **or** 500mm above the highest observed flood level if no probable flood level is available.

Development Type (including extensions)	Minimum Height Requirements
Commercial and Retail -	
* NOTE: Flood Planning Levels for "Commercial and Retail" also apply to places of public worship, restaurants, clubs, entertainment facilities, warehouses, and bulky goods showrooms, etc.	
Internal floor height	1 in 100 year probable flood level plus 500mm freeboard **or** 500mm above the highest observed flood level if no probable flood level is available.
Basement car parking.	Constructed to preclude entry of floodwater at levels up to the 1 in 100 year probable flood level plus 500mm freeboard. Additional requirement for basement levels to implement a failsafe means of evacuation, and a pump-out system to remove flood waters.
Unsealed electrical installations	1 in 100 year probable flood level plus 500mm freeboard **or** 500mm above the highest observed flood level if no probable flood level is available.
Mixed Use development	
Internal floor height	1 in 100 year probable flood level plus 500mm freeboard **or** 500mm above the highest observed flood level if no probable flood level is available.
Basement car parking	Constructed to preclude entry of floodwater at levels up to the 1 in 100 year probable flood level plus 500mm freeboard. Additional requirement for basement levels to implement a failsafe means of evacuation, and a pump-out system to remove flood waters.
Unsealed electrical installations	1 in 100 year probable flood level plus 500mm freeboard **or** 500mm above the highest observed flood level if no probable flood level is available.
Industrial	
Internal floor height	At or above the 1 in 100 year probable flood level **or** at the highest observed flood level if no probable flood level is available.
Unsealed electrical installations	1 in 100 year probable flood level plus 500mm freeboard **or** 500mm above the highest observed flood level if no probable flood level is available.

Development Type (including extensions)	Minimum Height Requirements
Sensitive Uses (Residential care facilities, hospitals, etc.)	
Internal floor height	Probable maximum flood level.
Unsealed electrical installations	Probable maximum flood level.

6. Applications for approval of/consent to major additions, or relocation of existing buildings, will be required to observe the relevant floor height (Flood Planning Level) adopted by Council at the time the development proposal is considered by Council.

   Applications for minor additions or alterations to existing development will be assessed on the merits of the situation, having regard to meeting an acceptable level of risk of flood damage.

7. **Filling**

   Filling the subject land would require Council's consent.

   Filling of flood affected land may have an impact on the nature and extent of flooding downstream or on neighbouring land and generally is not favoured as a planning response on flood prone land.

   Any use of fill associated with development must not substantially impede flow of floodwaters and must not contribute to flooding or ponding of water on any other property.

8. **Exempt and complying development in the Flood Planning Area**

   Development on a flood control lot would need to comply with conditions as defined in SEPP (Exempt and Complying Development) 2008.

9. **Other development conditions and approvals**

   Development approval/consent for this property is dependent on a range of issues, including compliance with all relevant provisions of Lake Macquarie Local Environmental Plan 2014 (LMLEP 2014) and Lake Macquarie Development Control Plan (LMDCP) 2014.

   Copies of these documents and further information in regard to development on this property can be obtained from Council's website. Compliance with these flood requirements does not guarantee Council will approve development on this property.

10. Development where 100 year probable ARI levels are not available, and which could be flood liable, must be designed to meet an acceptable level of risk from flood damage. This may require the preparation of a Local Flood Study that considers cumulative impact issues, and demonstrates negligible impacts on other lands.

Further Information

11. This certificate considers the relevant flood and flood planning levels for the specific property. There may be other issues to do with flooding, sea level rise, filling, and emergency access and egress that are not addressed in this document.

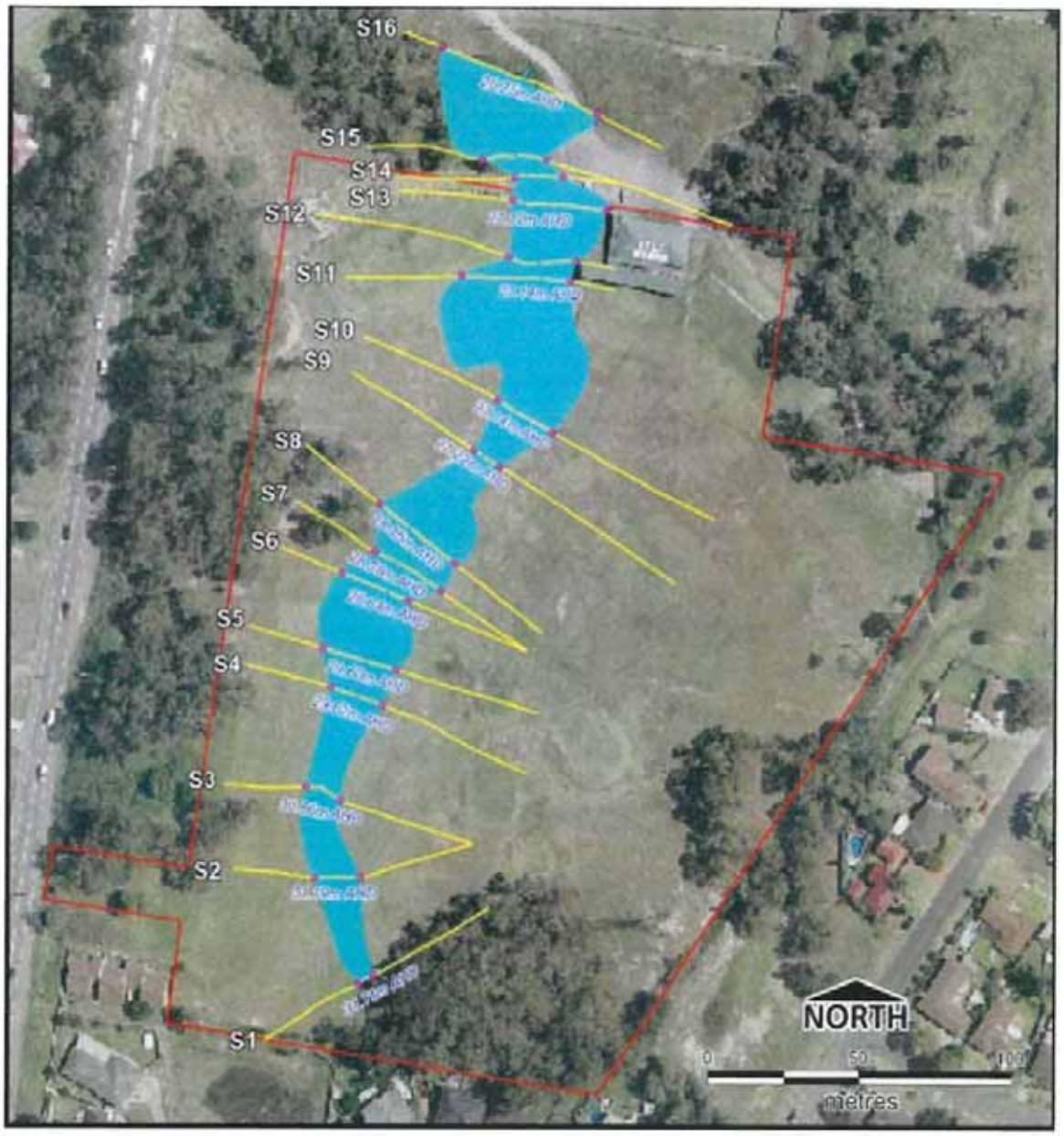


Figure 5-3 20-year ARI peak flood levels and extents (Cardiff study site)

Figure 5-3 20-year ARI peak flood levels and extents (Cardiff study site)

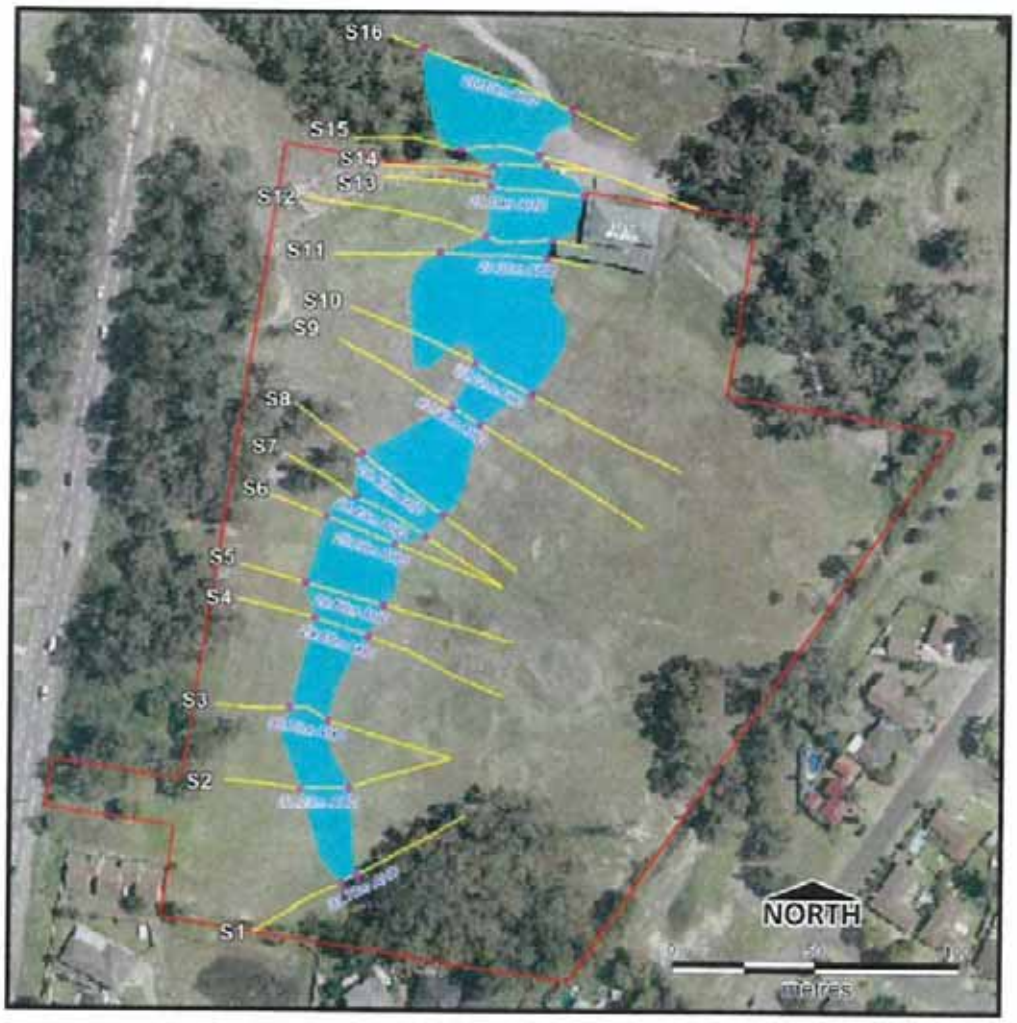


Figure 5-4 100-year ARI peak flood levels and extents (Cardiff study site)

Figure 5-4 100-year ARI peak flood levels and extents (Cardiff study site)

Table 5-1 Estimated flood levels for Cardiff study site (m, AHD)

Cross Section	1yr ARI	5yr ARI	10yr ARI	20yr ARI	100yr ARI	PMF
S1	31.49	31.62	31.66	31.71	31.77	32.18
S2	31.07	31.15	31.17	31.19	31.23	31.34
S3	30.49	30.59	30.62	30.66	30.70	30.93
S4	29.36	29.54	29.57	29.62	29.68	30.15
S5	29.36	29.52	29.56	29.60	29.66	30.09
S6	28.46	28.58	28.61	28.64	28.68	29.10
S7	28.07	28.30	28.34	28.38	28.43	28.59
S8	27.99	28.27	28.32	28.35	28.40	28.84
S9	26.91	27.11	27.16	27.22	27.30	28.03
S10	26.78	27.04	27.09	27.14	27.22	27.93
S11	26.77	27.04	27.09	27.14	27.21	27.92
S12	26.77	27.04	27.08	27.13	27.20	27.87
S13	26.77	27.03	27.07	27.12	27.19	27.82
S14	26.08	26.18	26.23	26.28	26.35	26.95
S15	25.96	26.19	26.23	26.25	26.29	26.49
S16	25.96	26.20	26.23	26.25	26.30	26.82

Table 5-2 Estimated flood extents for Cardiff study site (m, from centreline of channel)

Cross Section	1yr ARI		5yr ARI		10yr ARI		20yr ARI		100yr ARI		PMF	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
S1	-1.5	1.7	-2.2	2.3	-2.3	2.5	-2.6	2.8	-2.9	3.1	-10.3	13.1
S2	-1.9	7.3	-2.6	10.3	-2.9	11.3	-3.0	11.9	-3.4	13.4	-4.5	43.6
S3	-2.1	4.2	-3.0	6.0	-3.9	6.6	-5.0	7.3	-6.3	8.1	-12.3	36.0
S4	-5.0	4.8	-7.7	7.4	-8.3	8.0	-9.0	8.7	-10.0	9.6	-17.4	16.7
S5	-8.4	6.2	-12.4	8.8	-13.5	9.4	-14.8	10.3	-16.5	11.5	-24.5	36.0
S6	-6.9	3.6	-14.0	5.7	-15.0	6.3	-15.9	7.2	-17.0	8.6	-23.3	30.9
S7	-3.6	7.7	-5.7	14.9	-6.8	16.2	-7.8	17.3	-9.2	18.9	-13.4	23.8
S8	-4.0	5.0	-9.9	13.9	-11.4	16.5	-12.3	18.4	-13.4	21.7	-21.5	35.1
S9	-1.8	3.5	-2.8	5.4	-3.1	5.9	-3.3	6.5	-3.8	7.3	-7.6	23.1
S10	-4.0	8.3	-5.9	12.3	-6.2	13.0	-6.6	13.8	-7.1	14.9	-39.6	25.8
S11	-21.6	8.3	-25.2	9.1	-25.8	9.3	-26.5	9.4	-27.4	9.6	-35.6	11.8
S12	-8.0	11.7	-9.6	12.4	-9.9	12.5	-10.2	12.6	-10.6	12.8	-26.2	19.2
S13	-3.4	18.7	-3.9	24.7	-4.0	25.7	-4.1	26.9	-4.2	28.4	-19.1	30.8
S14	-2.9	5.8	-3.4	8.8	-3.7	10.5	-3.9	12.1	-4.2	14.2	-7.2	57.0
S15	-7.2	7.8	-10.5	9.6	-11.0	9.8	-11.3	10.0	-11.9	15.7	-16.6	23.4
S16	-21.2	11.2	-27.3	26.1	-28.2	26.2	-28.7	26.3	-29.7	26.4	-34.7	50.4

Attachment to Certificate - Flood Explanation Sheet

1 in 100 year Probable Flood Level

The 1 in 100 year flood is one that has a 1% chance of occurring in any year, or has the chance of occurring once every 100 years. The term "100-year flood" is a statistical probability designation stating there is a 1-in-100 chance that a flood this size will happen during any year. Another interpretation could be the "1-in-100 chance flood". The I in 100 year flood does not mean that if a location floods one year, it will definitely not flood for the next 99 years. Nor, if it has not flooded for 99 years, will it necessarily flood this year. Some parts of Australia have received more than one 1 in 100 year flood in one decade. Lake Macquarie waterway (the Lake) has not experienced a 1 in 100 year flood since written records began 150 years ago.

The 1 in 100 year flood is a serious but infrequent event, and is used widely as the risk threshold for flood planning.

1 in 20 year Probable Flood Level

The 1 in 20 year flood is one that has a 5% chance of occurring in any year, or has the chance of occurring once every 20 years. This is a statistical probability, and does not mean that if a location floods one year, it will definitely not flood for the next 19 years.

The 1 in 20 year flood is less serious but more frequent than the 1 in 100 year flood.

Flood Planning Level (FPL)

The Flood Planning Level is the risk threshold set for new buildings in flood-affected areas, and is usually applied as a minimum floor level. It is commonly based on the 1% (1-in-100 year) flood level plus 'freeboard' (see below).

Freeboard

Freeboard is included in the Flood Planning Level to allow a safety margin for unpredictable factors such as waves, localised hydraulic effects, blockages, flood debris, and uncertainties in the computer flood modelling. A freeboard of 500mm is typically applied to the 1-in-100 year flood for residential / commercial developments (see page 3 – Flood Planning Levels).

Probable Maximum Flood (PMF)

The Probable Maximum Flood is the largest flood that could feasibly occur. However, it is an extremely rare event. Despite this, some floods in Australia have approached the PMF. Council provides the PMF level on this Flood Certificate, if it is available, to indicate the full extent of risk, even if the chance is very small. Essential services (such as hospitals) and retirement housing, are required to locate above the PMF to avoid any risk from flooding.

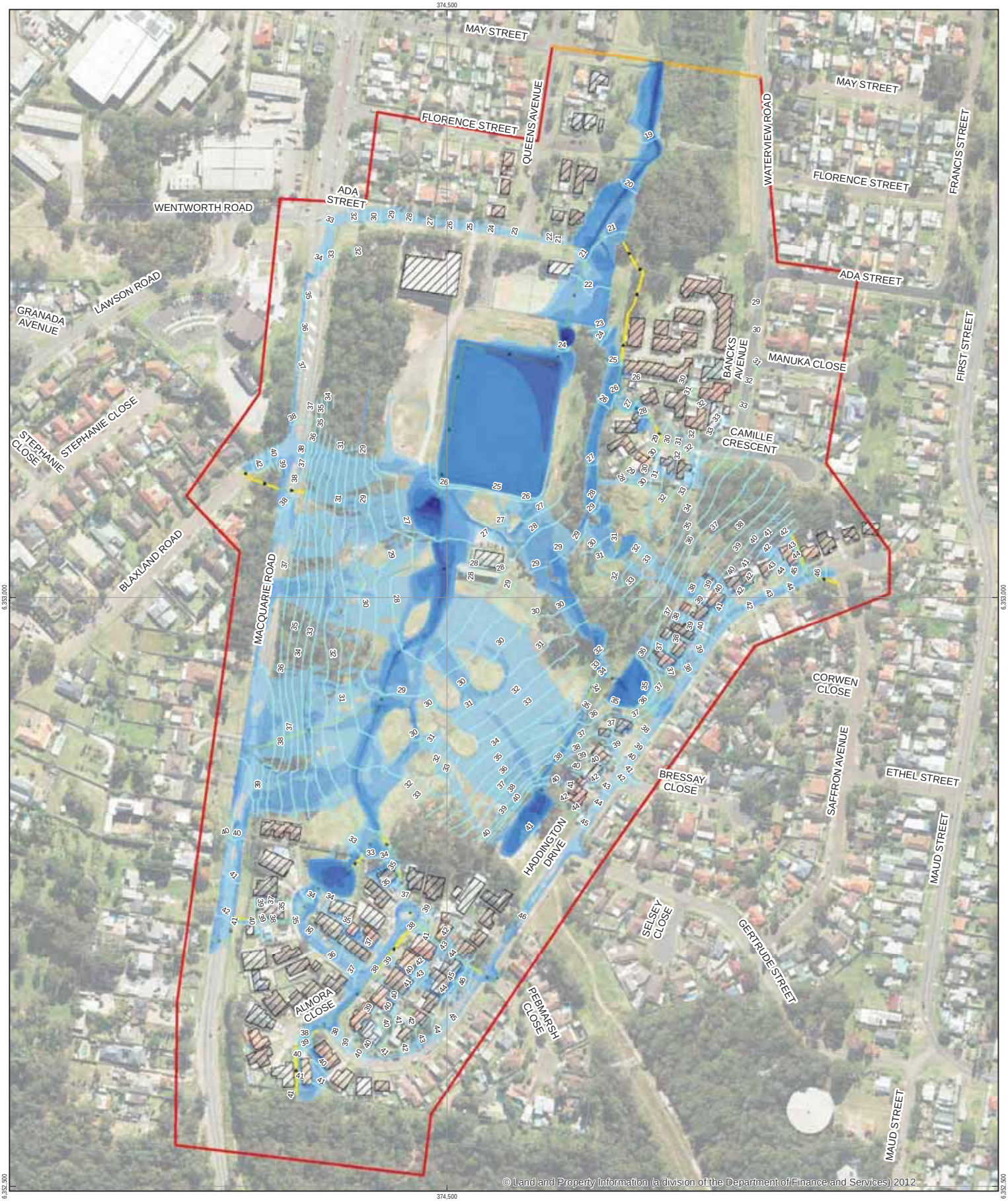
Australian Height Datum (AHD)

Australian Height Datum refers to the elevation relative to a reference point. In Australia this reference point approximates mean sea level, which is taken as 0.00metres AHD. Flood levels, ground levels, floor levels, and flood planning levels are shown in metres AHD.

Appendix B – Proposed Development


STAGE 2
STAGE 1

Appendix C Existing Flood Mapping



LEGEND

Flood Extent and Depth (m)

- 0.00 - 0.01
- 0.01 - 0.05
- 0.05 - 0.15
- 0.15 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- >2.00

- Flood Level Contours (mAHD)
- Downstream Model Boundary
- Drainage Network
- Buildings
- Hydraulic Model Extent
- Cadastre

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

RJA Projects
Cardiff Aged Care Development

Job Number	22-17163
Revision	A
Date	16 Jun 2015

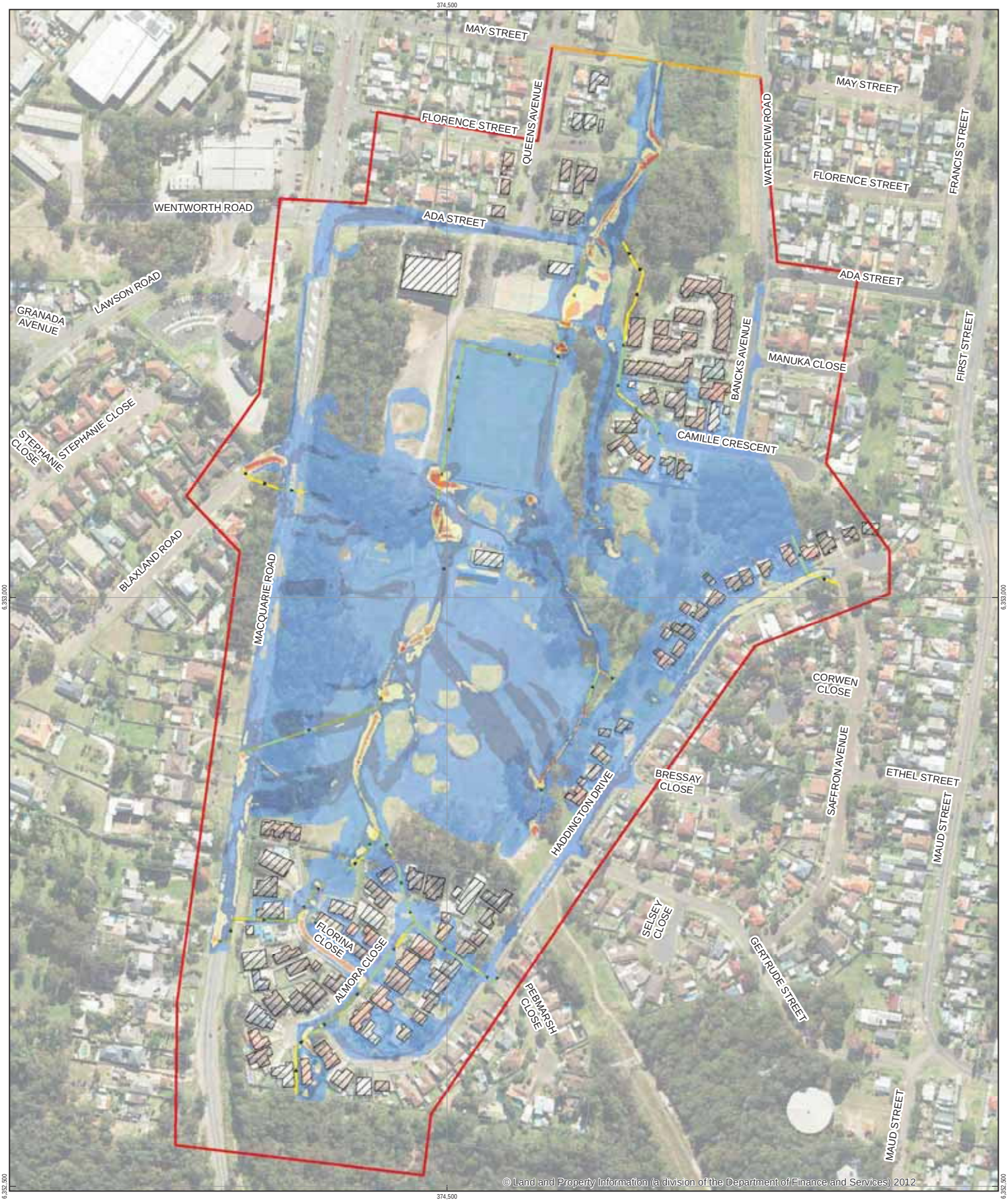
Existing Conditions - 20 Year Flood Event Flood Extent and Depth

Figure 1

N:\AU\Coffs Harbour\Projects\22\17163\GIS\Maps\Deliverables\22_17163_Cardiff_Fig_01_020yr_Existing_Extent_and_Depth_Rev_A.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: LPI, DCBD/DTDB, 2012. Created by:rberg



LEGEND

Peak Flood velocity (m/s)

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- Greater than 2

- Downstream Model Boundary
- Drainage Network
- Buildings
- Hydraulic Model Extent
- Cadastre

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

RJA Projects
Cardiff Aged Care Development

Job Number 22-17163
Revision A
Date 16 Jun 2015

Existing Conditions - 20 Year Flood Event Peak Flood Velocity

Figure 2

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Hazard Vulnerability Classification	Description
H1	Generally Safe for vehicles, people and buildings
H2	Unsafe for small vehicles
H3	Unsafe for Vehicles, Children and the elderly
H4	Unsafe for vehicles and people
H5	Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust buildings vulnerable to failure.
H6	Unsafe for vehicles and people. All building Ttypes considered vulnerable to failure.

LEGEND

Hydraulic Hazard

H1 H2 H3 H4 H5 H6

Downstream Model Boundary

Drainage Network

Buildings

Hydraulic Model Extent

Cadastre

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

O

RJA Projects
Cardiff Aged Care Development

Job Number 22-17163
Revision A
Date 16 Jun 2015

Existing Conditions - 20 Year Flood Event Peak Hydraulic Hazard

Figure 3

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Data source: LPI, DCBD/DTDB, 2012. Created by:rberg

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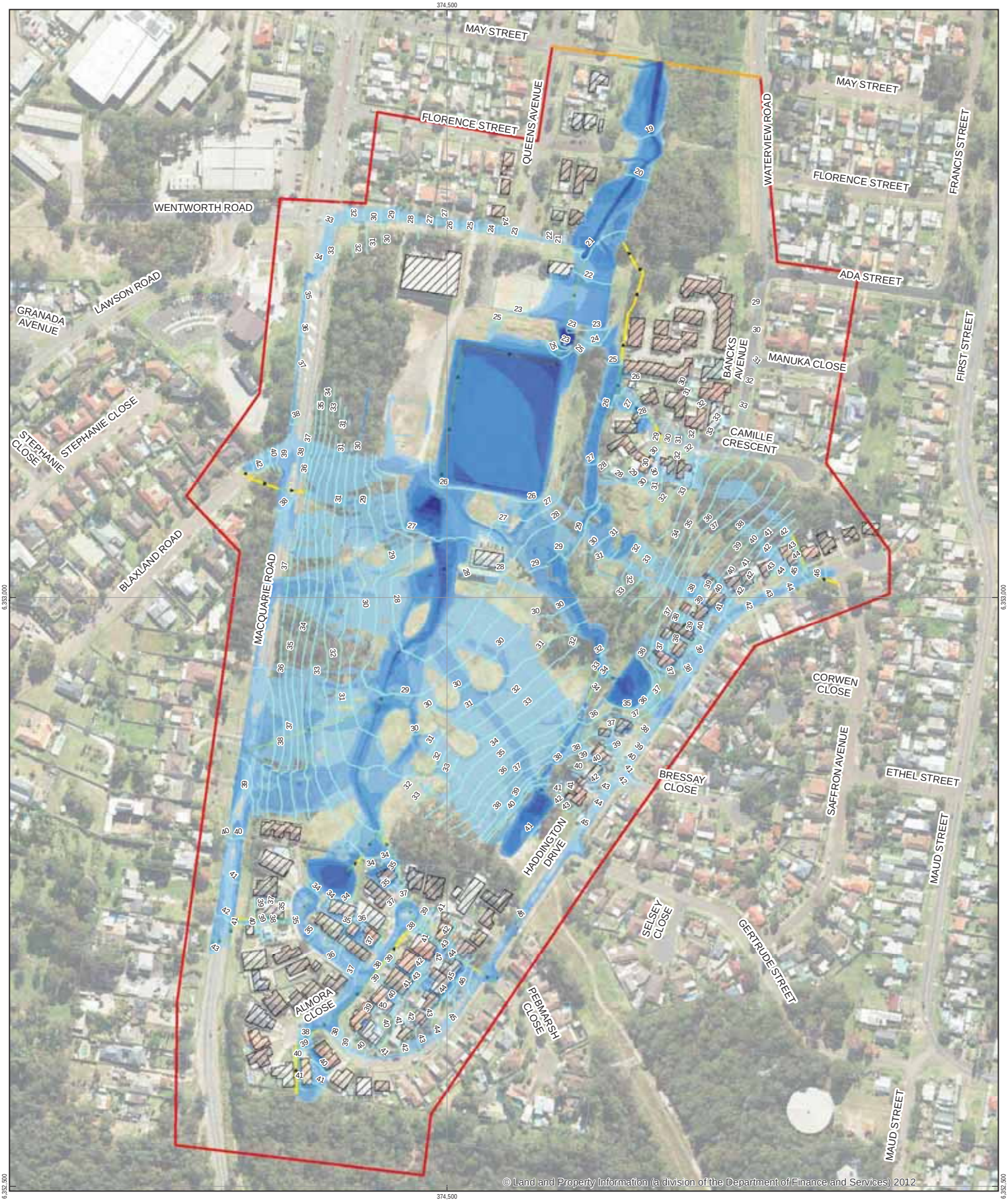

LEGEND

Flood Extent and Depth (m)

- 0.00 - 0.01
- 0.01 - 0.05
- 0.05 - 0.15
- 0.15 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- >2.00

- Flood Level Contours (mAHD)
- Downstream Model Boundary
- Drainage Network
- Buildings
- Hydraulic Model Extent
- Cadastre

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

RJA Projects
Cardiff Aged Care Development

Job Number	22-17163
Revision	A
Date	16 Jun 2015

Existing Conditions - 100 Year Flood Event Flood Extent and Depth

Figure 4

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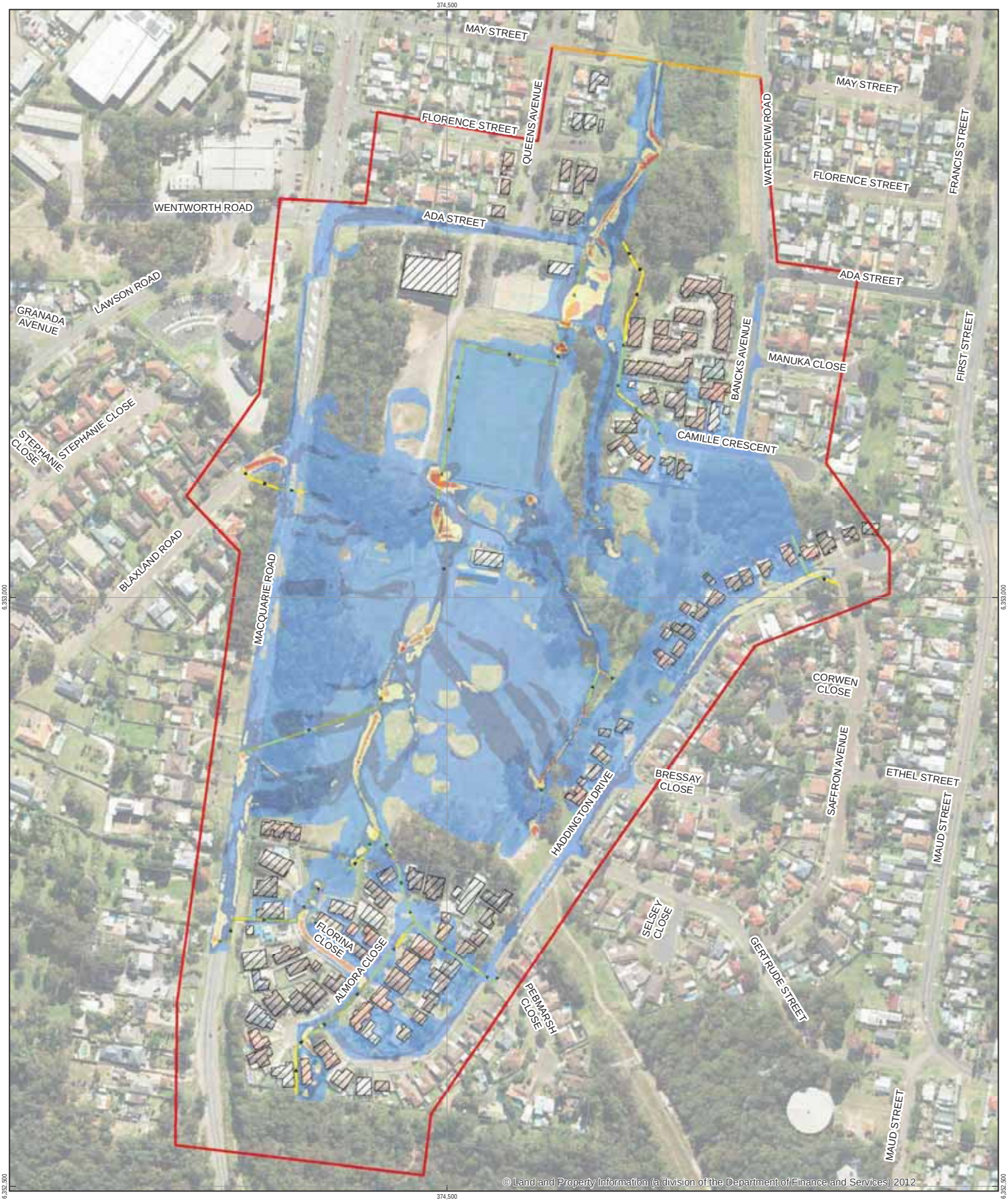
230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: LPI, DCBD/DTDB, 2012. Created by:rberg



LEGEND

Peak Flood velocity (m/s)

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- Greater than 2

- Downstream Model Boundary
- Drainage Network
- Buildings
- Hydraulic Model Extent
- Cadastre

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

RJA Projects
Cardiff Aged Care Development

Job Number 22-17163
Revision A
Date 16 Jun 2015

Existing Conditions - 100 Year Flood Event Peak Flood Velocity

Figure 5

N:\AU\Coffs Harbour\Projects\22\17163\GIS\Maps\Deliverables\22_17163_Cardiff_Fig_05_100yr_Existing_Velocity_Rev_A.mxd

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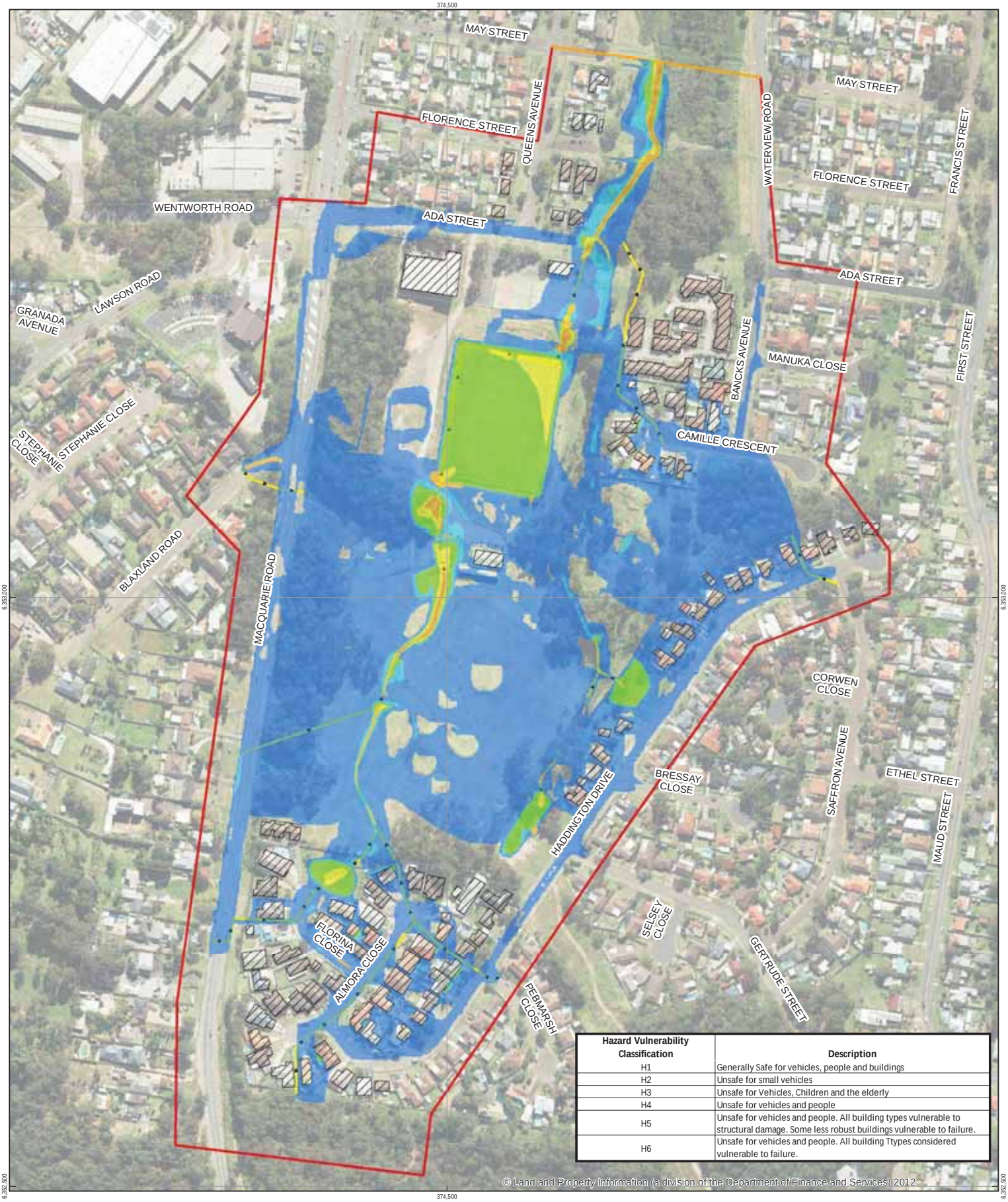


Hazard Vulnerability Classification	Description
H1	Generally Safe for vehicles, people and buildings
H2	Unsafe for small vehicles
H3	Unsafe for Vehicles, Children and the elderly
H4	Unsafe for vehicles and people
H5	Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust buildings vulnerable to failure.
H6	Unsafe for vehicles and people. All building Ttypes considered vulnerable to failure.

LEGEND

Hydraulic Hazard

H1
H2
H3
H4
H5
H6

Downstream Model Boundary
Drainage Network

Buildings
Hydraulic Model Extent
Cadastre

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

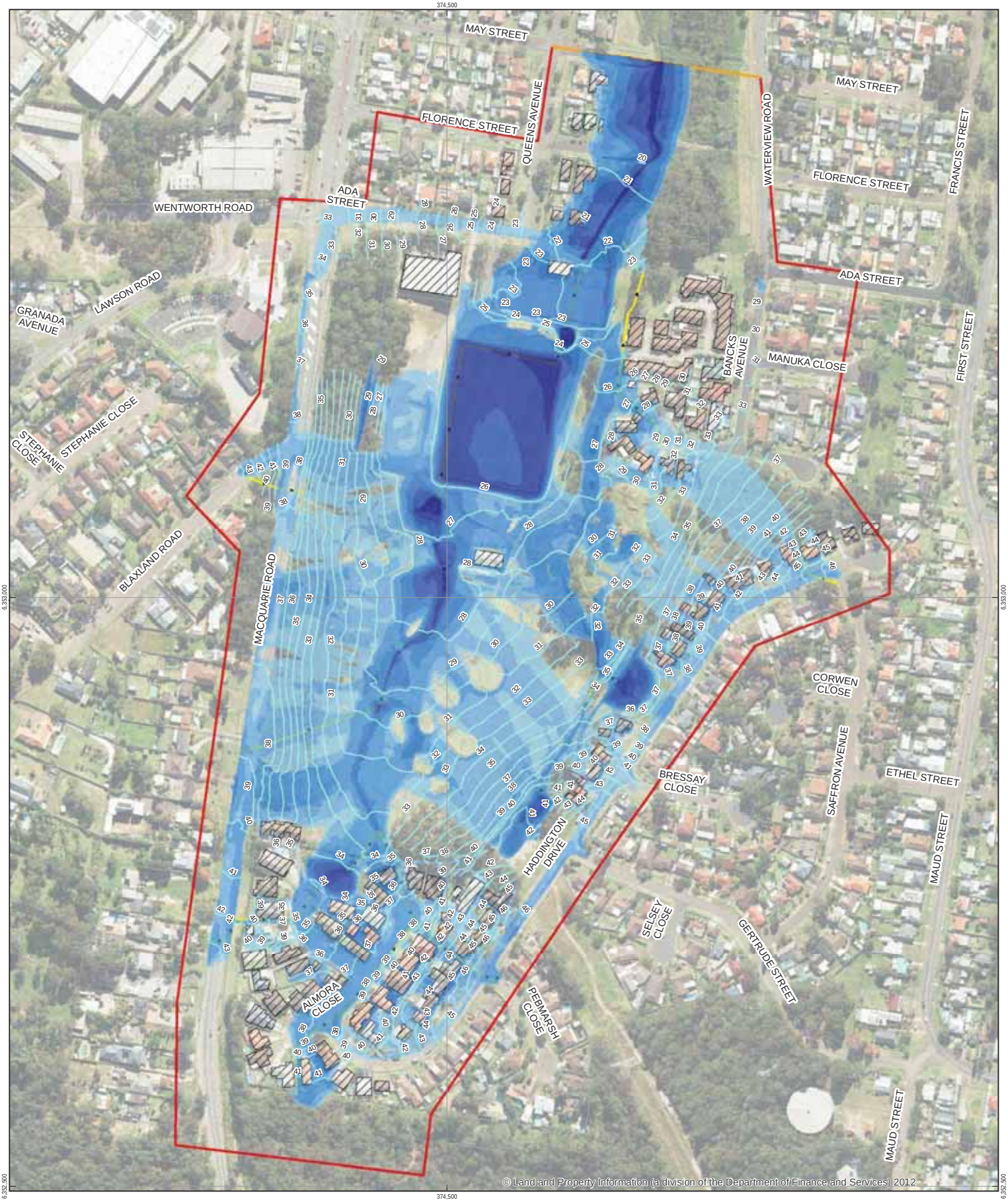
RJA Projects
Cardiff Aged Care Development

Job Number 22-17163
Revision A
Date 16 Jun 2015

Existing Conditions - 100 Year Flood Event Peak Hydraulic Hazard

Figure 06

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com



LEGEND

Flood Extent and Depth (m)

- 0.00 - 0.01
- 0.01 - 0.05
- 0.05 - 0.15
- 0.15 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- >2.00

- Flood Level Contours (mAHD)
- Downstream Model Boundary
- Drainage Network
- Buildings
- Hydraulic Model Extent
- Cadastre

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

RJA Projects
Cardiff Aged Care Development

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Revision A
Date 16 Jun 2015

Existing Conditions - PMF Flood Event Flood Extent and Depth

Figure 7

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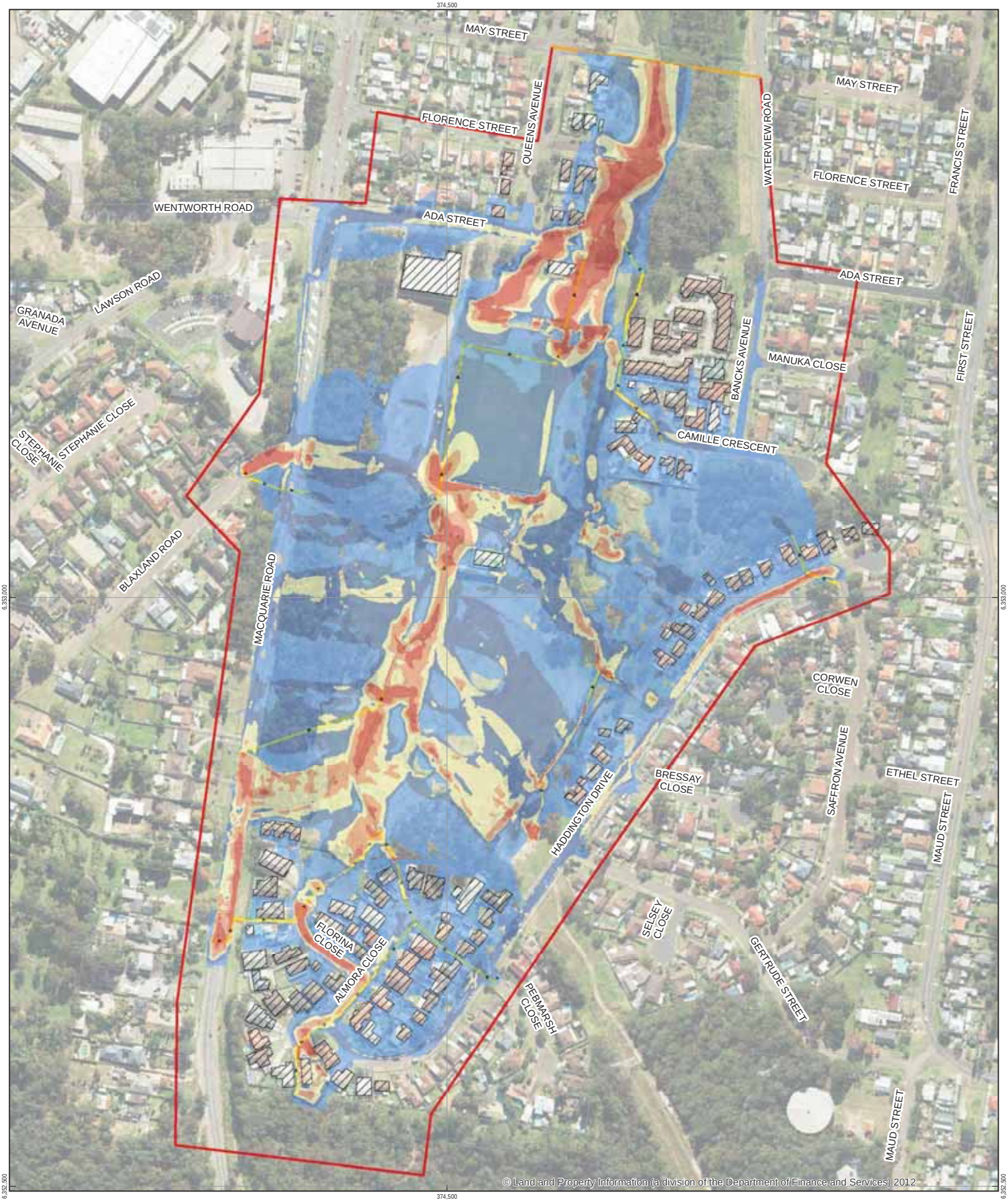
230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com



LEGEND

Peak Flood velocity (m/s)

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- Greater than 2

- Downstream Model Boundary
- Drainage Network
- Buildings
- Hydraulic Model Extent
- Cadastre

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

RJA Projects
Cardiff Aged Care Development

Job Number 22-17163
Revision A
Date 16 Jun 2015

Existing Conditions - PMF Flood Event Peak Flood Velocity

Figure 8

N:\AU\Coffs Harbour\Projects\22\17163\GIS\Maps\Deliverables\22_17163_Cardiff_Fig_08_PMF_Existing_Velocity_Rev_A.mxd

Data source: LPI, DCBD/DTDB, 2012. Created by:rberg

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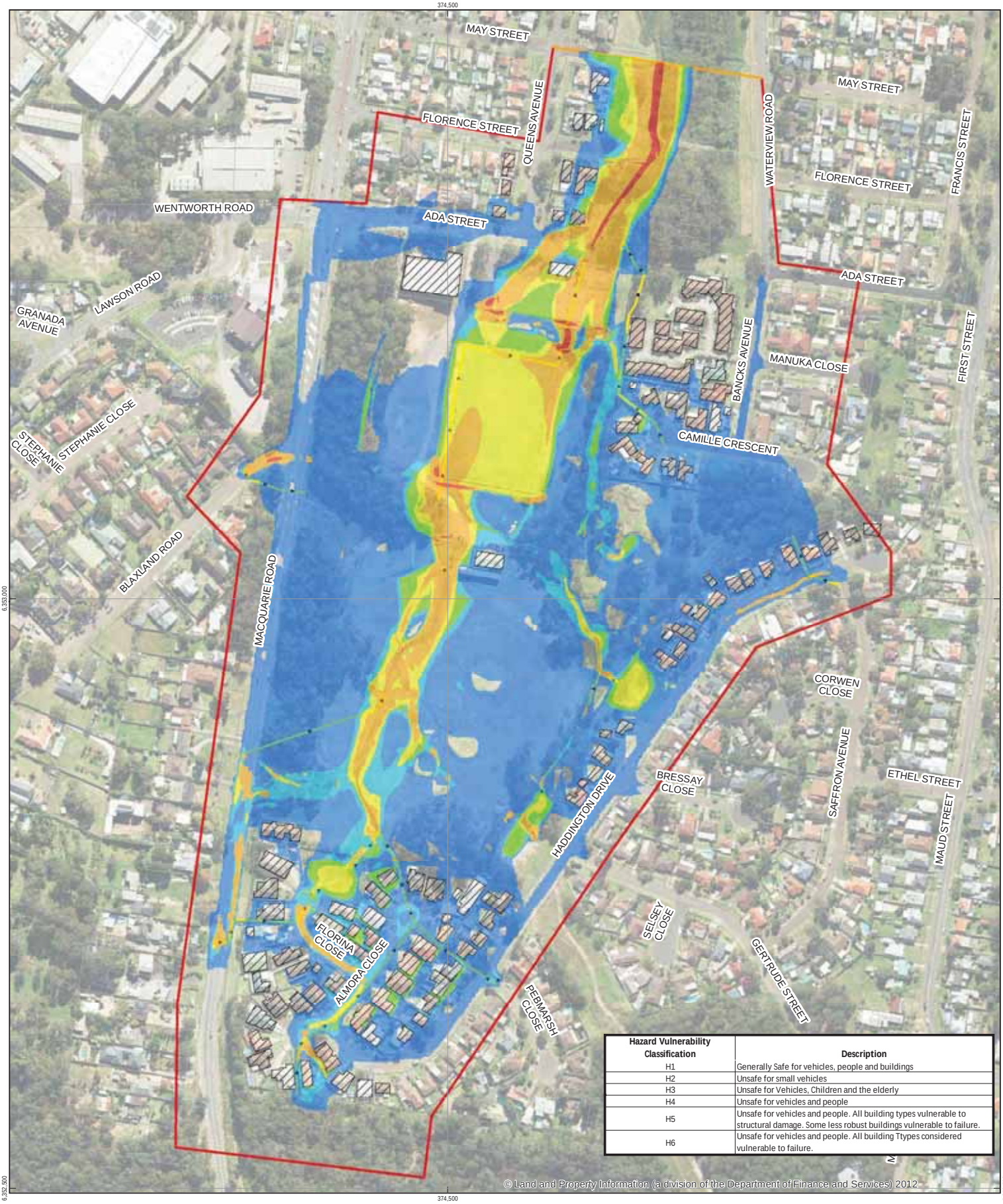

Hazard Vulnerability Classification	Description
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H5	Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust buildings vulnerable to failure.
H6	Unsafe for vehicles and people. All building Ttypes considered vulnerable to failure.

LEGEND

Hydraulic Hazard

H1 H2 H3 H4 H5 H6

Downstream Model Boundary

Drainage Network

Buildings

Hydraulic Model Extent

Cadastre

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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RJA Projects
Cardiff Aged Care Development

Job Number 22-17163
Revision A
Date 16 Jun 2015

Existing Conditions - PMF Flood Event Peak Hydraulic Hazard

Figure 9

N:\AU\Coffs Harbour\Projects\22\17163\GIS\Maps\Deliverables\22_17163_Cardiff_Fig_09_PMF_Existing_Hazard_Rev_A.mxd

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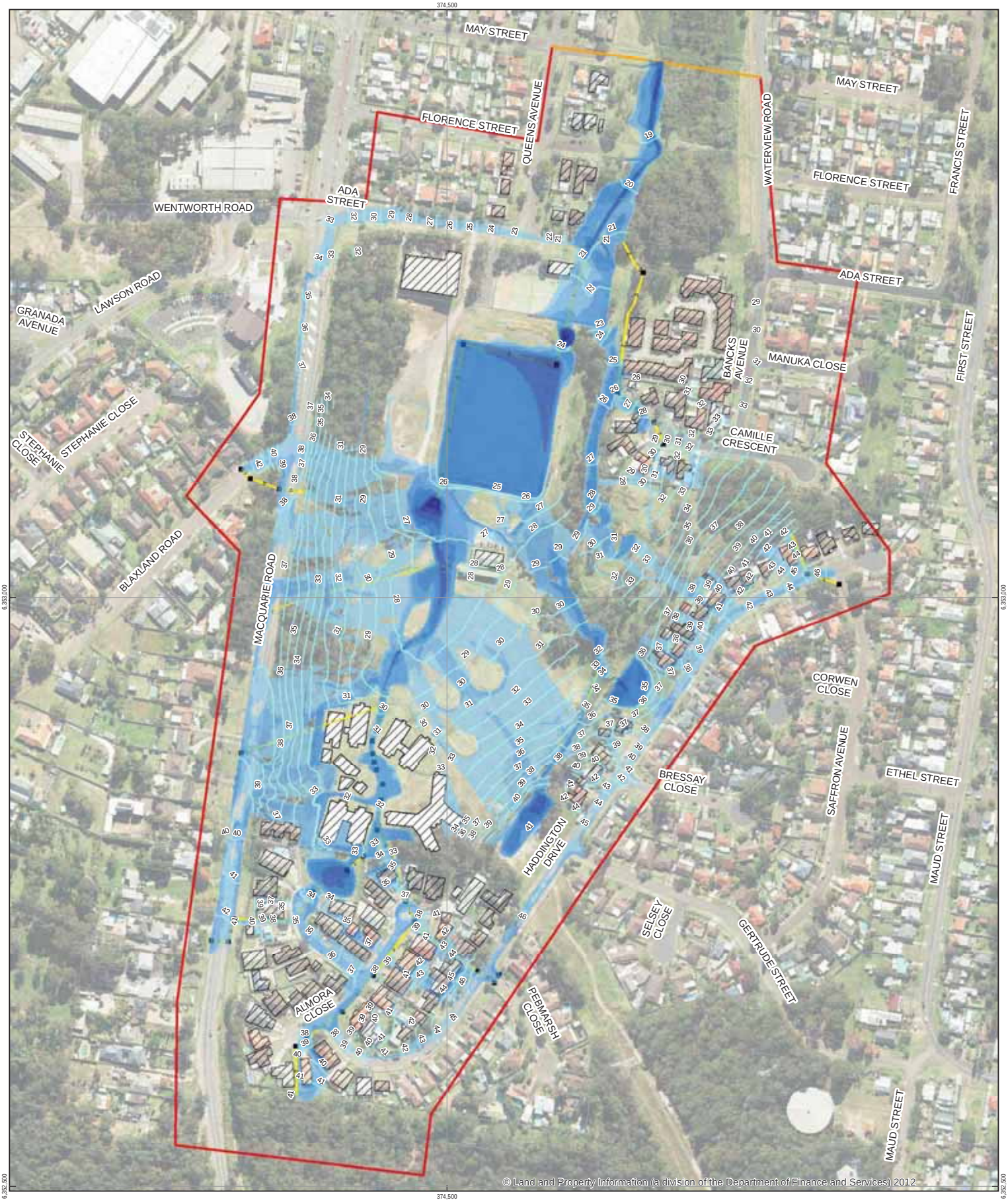
Appendix D Flood Impact Maps



LEGEND

Flood Extent and Depth (m)

- 0.00 - 0.01
- 0.01 - 0.05
- 0.05 - 0.15
- 0.15 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- >2.00

- Flood Level Contours (mAHD)
- Downstream Model Boundary
- Drainage Network
- Buildings
- Hydraulic Model Extent
- Cadastre

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

RJA Projects
Cardiff Aged Care Development

Job Number	22-17163
Revision	A
Date	16 Jun 2015

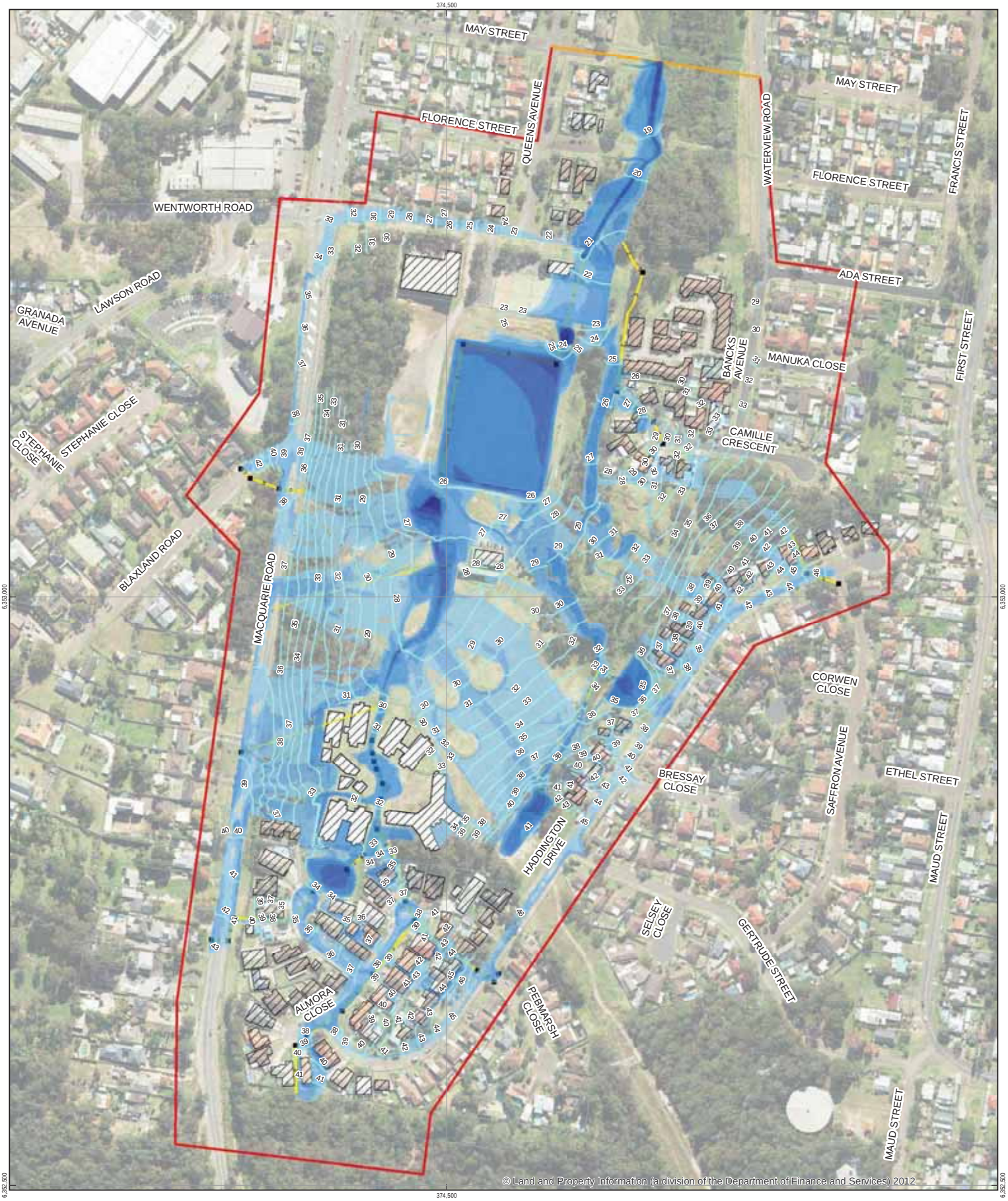
Design Conditions - 20 Year Flood Event Flood Extent and Depth

Figure 10

N:\AU\Coffs Harbour\Projects\22\17163\GIS\Maps\Deliverables\22_17163_Cardiff_Fig_10_020yr_Design_Extent_and_Depth_Rev_A.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: LPI, DCBD/DTDB, 2012. Created by:rberg



LEGEND

Flood Extent and Depth (m)

- 0.00 - 0.01
- 0.01 - 0.05
- 0.05 - 0.15
- 0.15 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- >2.00

- Flood Level Contours (mAHD)
- Downstream Model Boundary
- Drainage Network
- Buildings
- Hydraulic Model Extent
- Cadastre

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

RJA Projects
Cardiff Aged Care Development

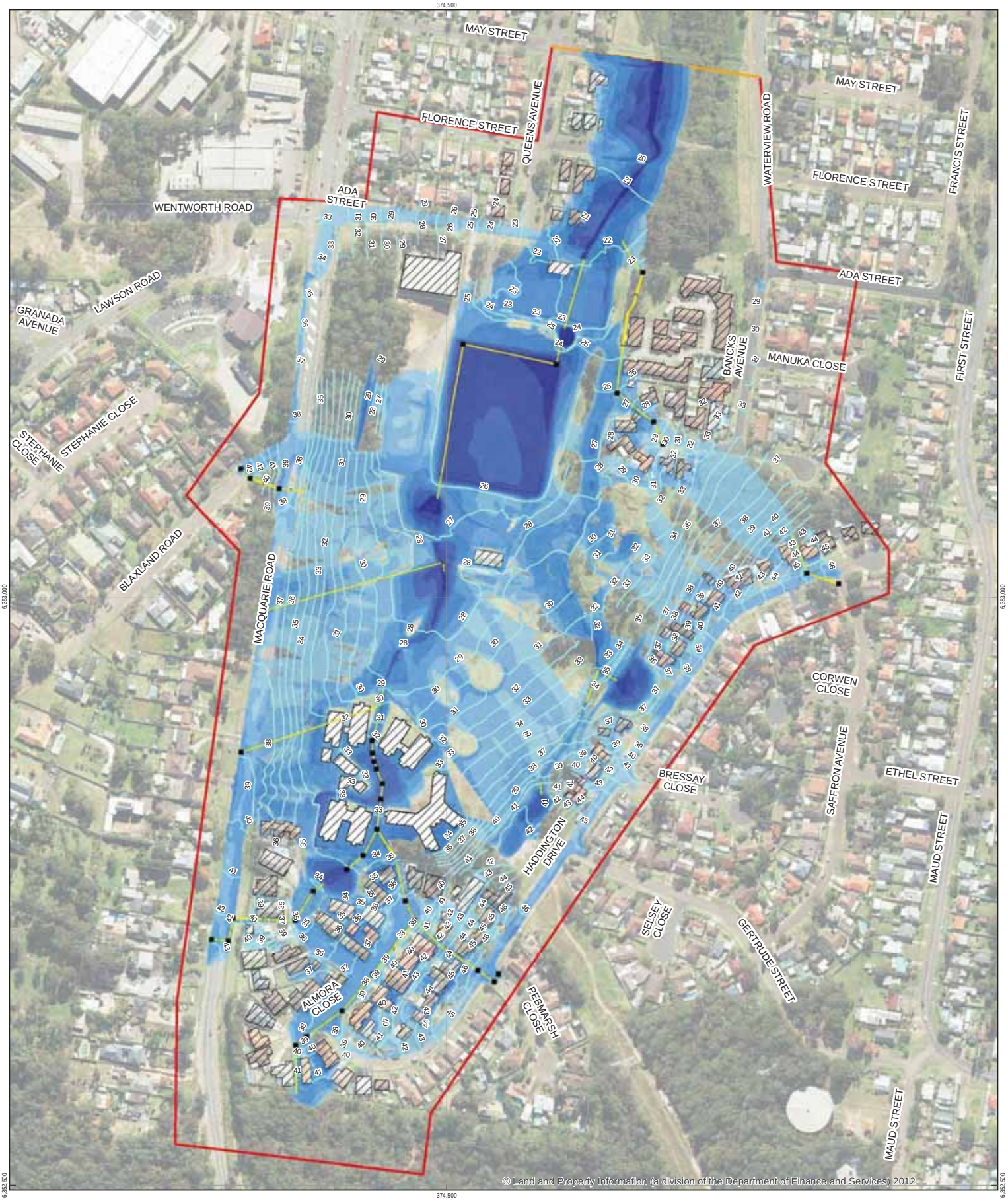
Job Number	22-17163
Revision	A
Date	16 Jun 2015

Design Conditions - 100 Year Flood Event Flood Extent and Depth

Figure 13

N:\AU\Coffs Harbour\Projects\22\17163\GIS\Maps\Deliverables\22_17163_Cardiff_Fig_13_100yr_Design_Extent_and_Depth_Rev_A.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com



LEGEND

Flood Extent and Depth (m)

- 0.00 - 0.01
- 0.01 - 0.05
- 0.05 - 0.15
- 0.15 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- >2.00

Flood Level Contours (mAHD)

Downstream Model Boundary

Drainage Network

Buildings

Hydraulic Model Extent

Cadastre

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

RJA Projects
Cardiff Aged Care Development

Job Number 22-17163
Revision A
Date 16 Jun 2015

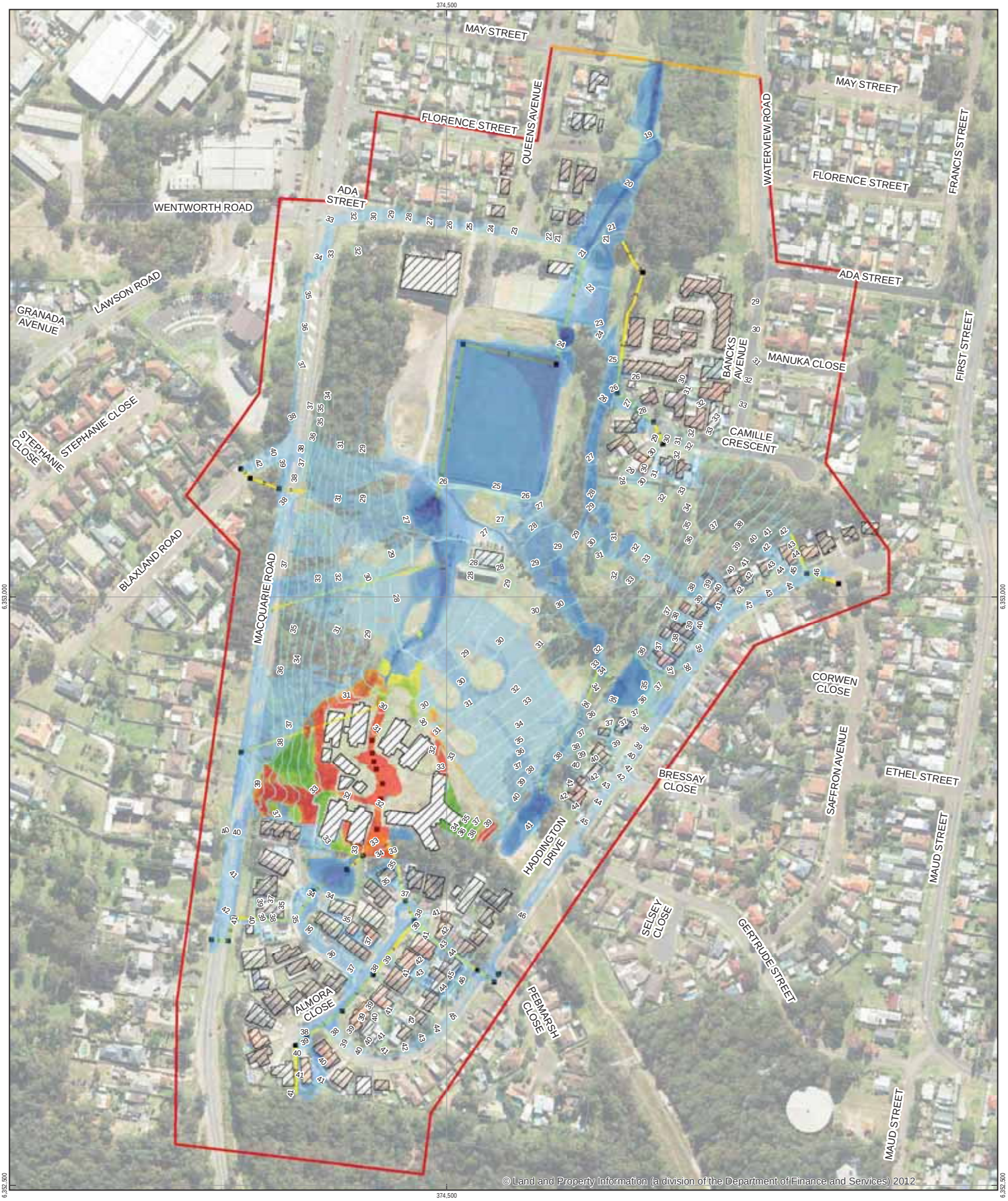
Design Conditions - PMF Flood Event Flood Extent and Depth

Figure 16

N:\AU\Coffs Harbour\Projects\22\17163\GIS\Maps\Deliverables\22_17163_Cardiff_Fig_16_PMF_Design_Extent_and_Depth_Rev_A.mxd

Data source: LPI, DCBD/DTDB, 2012. Created by:rberg

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com



LEGEND

Change In Flood Level (mAHD)

- > -500mm
- -500mm - -250mm
- -250mm - -100mm
- -100mm - -50mm
- -50mm - -30mm
- -30mm - -15mm
- -15mm - +15mm
- +15mm - +30mm
- +30mm - +50mm
- +50mm - +100mm
- +100mm - +250mm
- +250mm - +500mm
- Flood Level Contours (mAHD)

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

RJA Projects
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Job Number 22-17163
Revision A
Date 16 Jun 2015

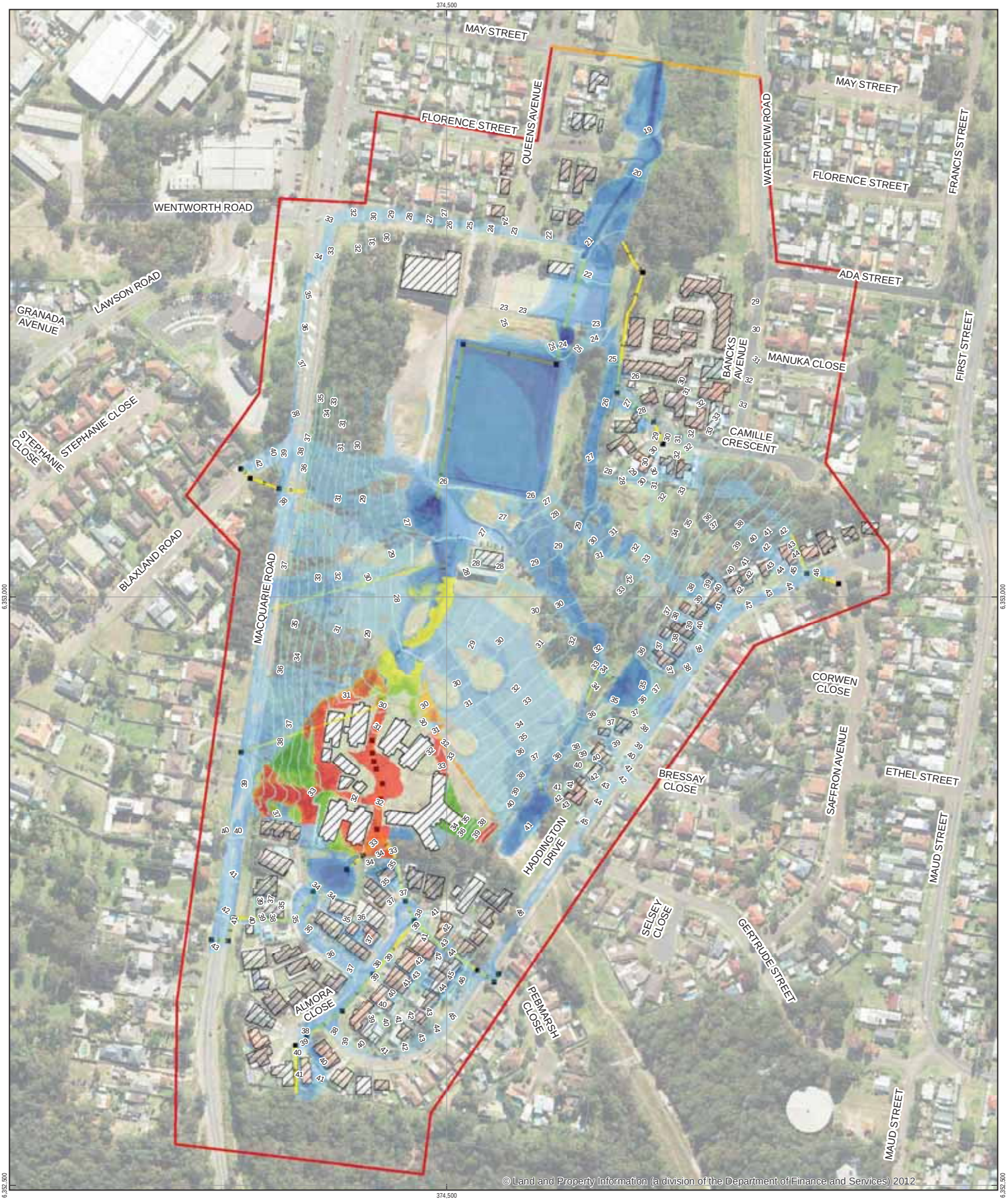
Flood Impact Assessment - 20 Year ARI Change In Flood Level (mAHD)

Figure 19

N:\AU\Coffs Harbour\Projects\22\17163\GIS\Maps\Deliverables\22_17163_Cardiff_Fig_19_020yr_Change_In_Level_Rev_A.mxd

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com

Data source: LPI, DCBD/DTDB, 2012. Created by:rberg



LEGEND

Change In Flood Level (mAHD)

- > -500mm
- -500mm - -250mm
- -250mm - -100mm
- -100mm - -50mm
- -50mm - -30mm
- -30mm - -15mm
- -15mm - +15mm
- +15mm - +30mm
- +30mm - +50mm
- +50mm - +100mm
- +100mm - +250mm
- +250mm - +500mm
- Flood Level Contours (mAHD)

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

RJA Projects
Cardiff Aged Care Development

Job Number	22-17163
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Date	16 Jun 2015

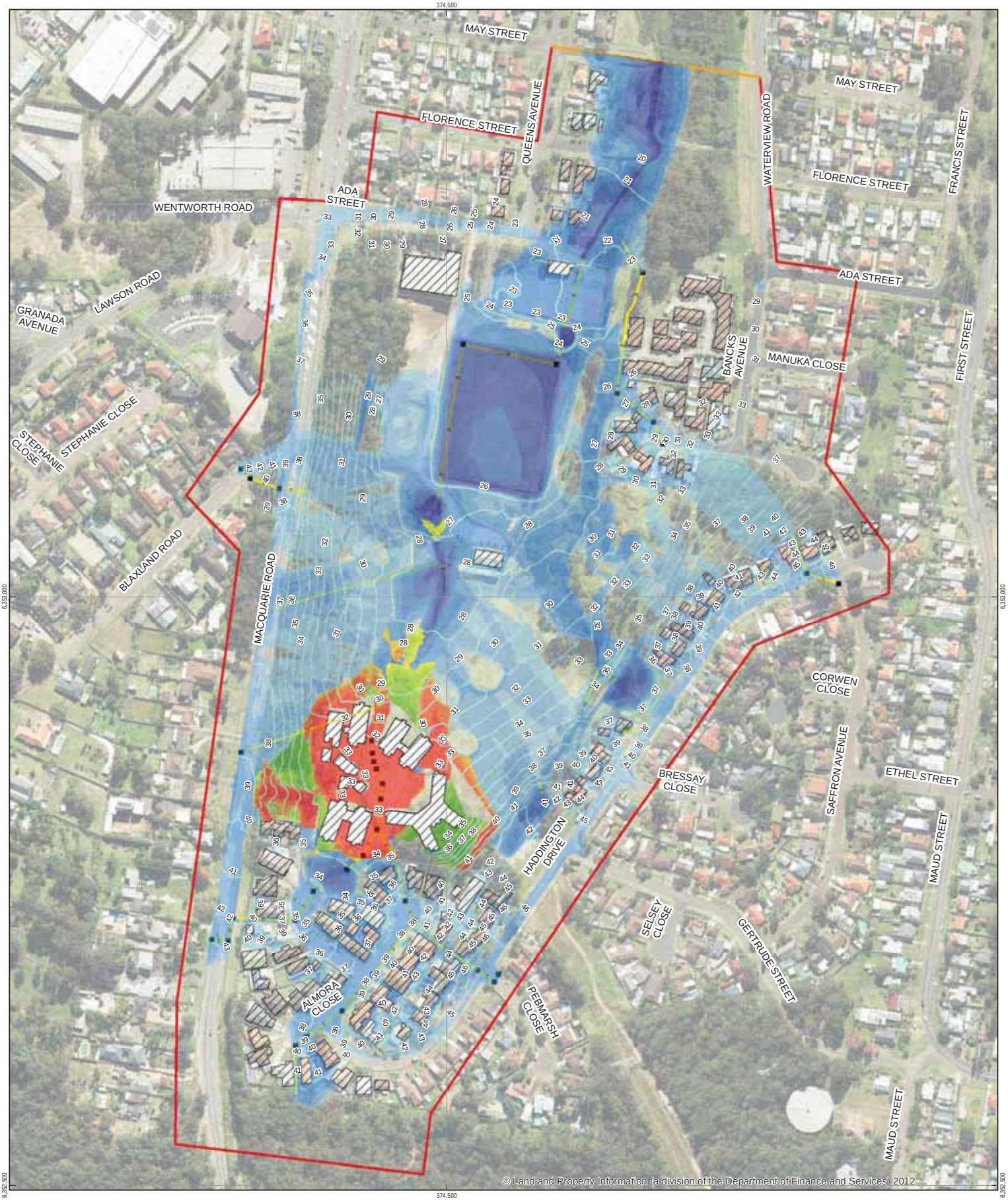
Flood Impact Assessment - 100 Year ARI Change In Flood Level (mAHD)

Figure 20

N:\AU\Coffs Harbour\Projects\22\17163\GIS\Maps\Deliverables\22_17163_Cardiff_Fig_20_100yr_Change_In_Level_Rev_A.mxd

Data source: LPI, DCBD/DTDB, 2012. Created by:rberg

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6650 5600 F 61 2 6650 5601 E cfsmail@ghd.com W www.ghd.com



LEGEND

Change In Flood Level (mAHD)

- > -500mm
- -500mm - -250mm
- -250mm - -100mm
- -100mm - -50mm
- -50mm - -30mm
- -30mm - -15mm
- -15mm - +15mm
- +15mm - +30mm
- +30mm - +50mm
- +50mm - +100mm
- +100mm - +250mm
- +250mm - +500mm
- Flood Level Contours (mAHD)

Paper Size A3

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Flood Impact Assessment - PMF Event
Change In Flood Level (mAHD)

Figure 21

N:\AU\Coffs Harbour\Projects\22\17163\GIS\Maps\Deliverables\22_17163_Cardiff_Fig_21_PMF_Change_In_Level_Rev_A.mxd

Data source: LPI, DCBD/DTDB, 2012. Created by:rberg

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
DRAFT	R Berg	S Douglas		R Berg		5/06/2015
FINAL	R Berg	S Douglas		R Berg		16/06/2015