Norman Griffiths Oval Flood Assessment

Ku-ring-gai Council

Final Compendium Report

Final

5 October 2018

Norman Griffiths Oval Flood Assessment

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Document history and status

Revision	Date	Description	By	Approved
Final	5/10/2018	Project Director review	A Hossain	L Chong

Contents

Important note about this report

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This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

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1. Introduction

1.1 General

Jacobs has been engaged by Ku-ring-gai Council to undertake a flooding assessment for Norman Griffiths Oval in West Pymble. The Oval currently serves as a flood detention basin on Quarry Creek, which is a part of the Lofberg Quarry Catchment. It was proposed to upgrade the existing turf-pitched sports field on the Oval to a synthetic pitch, with a funding grant for the upgrade to be sought by Northern Suburbs Football Association (NSFA) from the NSW Government. As a part of the upgrade, drainage works are required to achieve flood immunity of the sports field in up to the 2% Annual Exceedance Probability (AEP) flood event.

1.2 Purpose of this Study

Key objectives of this study are to:

- Review the existing DRAINS stormwater model of the catchment and determine if it is necessary to update the assumed pit and pipe levels in the model for the purposes of this study.
- Develop a TUFLOW hydraulic model for the Lofberg Quarry Catchment to assess flood behaviour in the vicinity of the Oval and in the overall catchment. Model calibration is not required in this study.
- Determine existing case flooding conditions in the vicinity of the Oval for a range of flood events including the 0.2 Exceedances per Year ("EY", i.e. 5 year Average Recurrence Interval, "ARI"), the 10%, 5%, 2% and 1% AEP (i.e. 10, 20, 50 and 100 year ARI events, respectively).
- Assess flooding impacts assuming a flow bypass of the Oval and detention basin, in terms of changes to flood levels, velocities and flows.
- Identify and assess mitigation options to retain the detention function of the Oval, in order to maintain existing flooding and flow conditions upstream and downstream of the Oval.
- Prepare preliminary cost estimates for the mitigation works.
- Assist Council with selection of a preferred option and assist with development of a concept design for the preferred option.

1.3 Purpose of this Compendium Report

On 16 August 2018 in the latter part of the stages outlined in Section 1.2, Council had considered the outcomes of the study to date and estimated costs of the project and concluded that the Norman Griffiths Oval upgrade project would be unfeasible, and that it would seek alternative sites which would be more suitable for conversion to synthetic pitch.

Council requested Jacobs to prepare a consolidated report (this report) which compiles all the investigations and study outcomes developed throughout the study. Refer to Section 2 for a chronological summary of the investigations undertaken. Refer to the appendices for each of the study interim reports and other documents.

2. Summary of Investigations

Table 2-1 summarises the investigations delivered to Council over the course of the study.

Table 2-1 Summary of Norman Griffiths Oval Flood Assessment reports and investigations

Item #	Title	Date	Summary of Outcomes	Refer to
1	Memo 1 Review of DRAINS pit/pipe levels versus LiDAR	10 January 2017	• Existing DRAINS model reviewed. Pit/pipe data compared to LiDAR. • Updating DRAINS model with LiDAR for pit/pipe levels would not improve accuracy of model due to variances between different sources of data. • For the purposes of the flood assessment where the main hydraulic controls around the basin have been surveyed, the DRAINS pit/pipe levels are considered adequate to estimate basin inflows/outflows.	Appendix A
2	Norman Griffiths Oval Flood Assessment – Draft Report – Version A	3 March 2017	• Existing DRAINS model reviewed. Catchment inflow hydrographs adopted. ARR 1987 design rainfall adopted. • New TUFLOW flood hydraulic model developed for Lofberg Quarry catchment. Existing flood conditions established for 0.2EY to 1% AEP event • Flow bypass option (no replacement flood detention basin) tested. Increase in 2% AEP flows of 47%. • Underground detention tank options assessed. Approx. 2400m^3 volume. Cost $1.1M - $1.7M • Split detention basin option assessed. Approx 2000m^2 footprint. Cost $282K. subsequently selected as preferred option. • Note: incorporates outcomes discussed in Memo 2 dated 15 January 2017.	Appendix B

3	Memo 3 Flood assessment of basin concept design options	8 November 2017	Two split-basin concept designs were developed by Council (received 20 September 2017) and assessed by Jacobs: • Option 1: total basin volume approx. 1830m^3 and full sized football pitch (100m x 70m) • Option 2: total basin volume approx. 2430m^3 and reduced sized football pitch (96m x 66m). Sub-options were proposed by Jacobs involving adjustment to the lower basin proposed drainage to improve basin time to drain. **Option 1 (010)** with increased lower basin outlet capacity is suggested as the preferred option.	Appendix C
4	Memo 5 Flood assessment of updated concept design and preparation of drainage plans	2 October 2018 (not yet submitted to Council)	• Assessment of updated concept design (received 17 May 2018 from Council) in TUFLOW model, including indicative drainage • Minor modifications to the concept design proposed by Jacobs and tested in TUFLOW. • Updated flood depth and flood impact mapping prepared for 0.2EY to 1% AEP event • Civil design drainage plans prepared and appended. • Council confirmed project is considered unfeasible during preparation of this memo.	Appendix D

3. Conclusions

A flood assessment has been undertaken for the previously proposed Norman Griffiths Oval upgrade project including the development of a new TUFLOW model for existing catchment conditions for Lofberg Quarry catchment. Mitigation options were identified and assessed as a part of the study. Concept designs were developed by Ku-ring-gai Council with assistance from Jacobs for the preferred mitigation option consisting of a split detention basin at the Oval, replacing the existing single basin at the Oval. Council confirmed that the upgrade project was deemed to be unfeasible during the development of the concept design.

This report compiles the assessments undertaken by Jacobs and documents the findings and outcomes throughout the study in the development of the concept designs as a consolidated final deliverable for the study.

Appendix A. Memo 1 – Review of DRAINS pit/pipe levels versus LiDAR

Date	10 January 2017
Attention	Guy Thomas
From	Lih Chong
Subject	**Norman Griffiths Oval Flood Assessment. Review of DRAINS pit/pipe levels versus LiDAR**
Copies to	Anna Milner

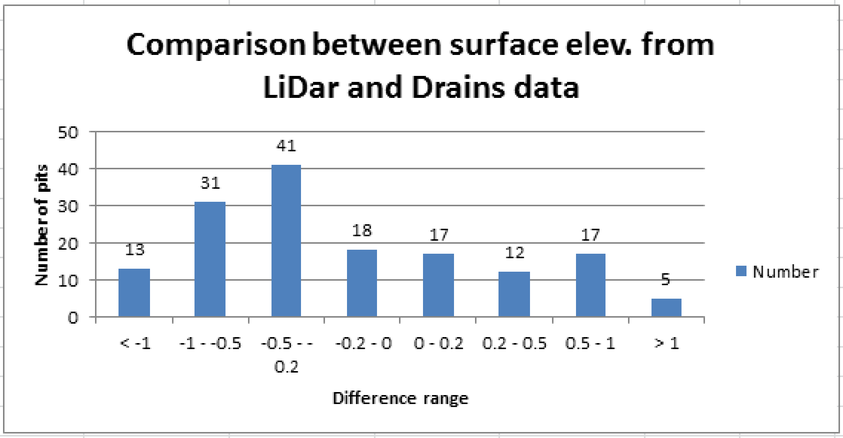
A review of the pit and pipe elevations in the Lofberg – Quarry Catchment DRAINS model, provided by Council, has been undertaken. Findings are summarised below.

Pit Surface Levels

The DRAINS model pit levels (based on 2m contours) have been compared against LiDAR elevations at that pit location. The LiDAR has been provided by Council and is the NSW LPI 2012 Sydney North data set. The statistics are illustrated in Figure 1 below. Negative values in the "Difference Range" indicate that DRAINS levels are lower, and vice versa.

Figure 1 statistics of DRAINS versus LiDAR ground levels at pits

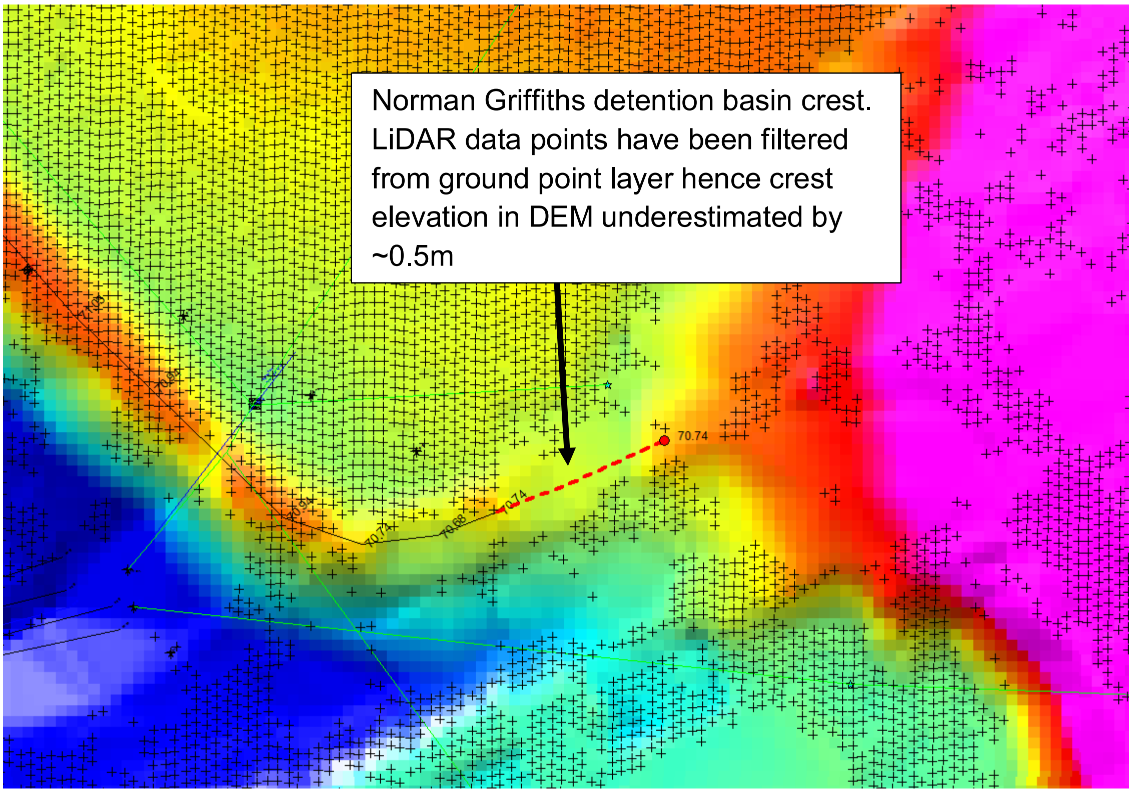
Range	Number	
< -1	13	8%
-1 - -0.5	31	20%
-0.5 - -0.2	41	27%
-0.2 - 0	18	12%
0 - 0.2	17	11%
0.2 - 0.5	12	8%
0.5 - 1	17	11%
> 1	5	3%
sum	154	



In summary:

- 35 pits (23%) are within +/-0.2m variance
- 72 pits (47%) have the LiDAR levels 0.2 – 1m lower than the DRAINS levels
- 29 pits (19%) have the LiDAR levels 0.2 – 1m higher than the DRAINS levels
- 18 pits (11%) are greater than +/-1m difference in level
- There is a bias towards negative variance. This could be due to how the LiDAR complete data points (ground, vegetation etc) are filtered into the different categories. For example, a number of LiDAR points along the crest of the detention basin spillway had been filtered out, perhaps incorrectly, perhaps because it picked up vegetation. Hence the crest level was not picked up in the ground points and the crest level was therefore underestimated in the creation of the DEM. See Figure 2. Jacobs has the raw ground points available for this LiDAR dataset.
- While there are fewer positive variances it is still a substantial number (22% with >0.2m variance). Potentially explained by vegetation data points not being filtered out of the ground point layer.

Figure 2 LiDAR raw data points overlaid on LiDAR DEM



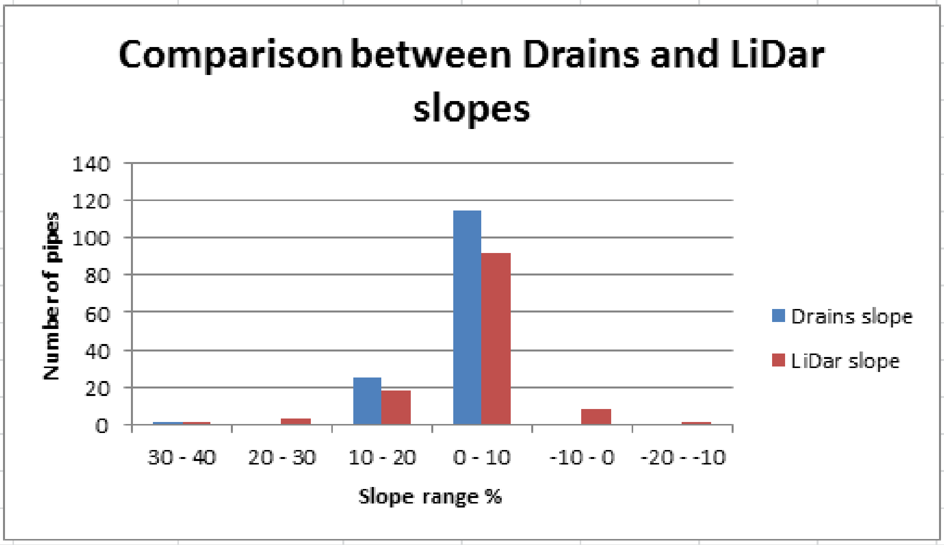
Pipe Grades

The pipe upstream and downstream invert levels were adjusted based on the LiDAR ground levels at the pits and the assumed depth to invert calculated from the DRAINS data. See Figure 3. In summary:

- The large majority of pipes in both the DRAINS and the LiDAR-derived pipe slope data sets have grades of 0-10% which are typical grades
- There are a similar number of pipes with >10% grade
- There are a number of pipes from the LiDAR-derived grades with inverse grades i.e. pipes flowing uphill. This may be due to:
  - Variance between the DRAINS and LiDAR ground levels at pits
  - Inaccurately estimated LiDAR DEM elevations due to filtering and processing of raw points
  - Assumed (rather than measured) depth to invert at pits with not inlet (i.e. blind pits, buried pits, bolted lid pits etc). It is understood from previous discussions with Council staff on other projects that in developing the DRAINS models the depth to invert was measured at the majority of pits with inlet/access.

Figure 3 Comparison of DRAINS and LiDAR-derived pipe grades

Range	Drains slope	LiDar slope
30 - 40	1	1
20 - 30	0	3
10 - 20	25	18
0 - 10	115	92
-10 - 0	0	8
-20 - -10	0	1



Conclusions

The following conclusions are made based on the review:

- Updating the DRAINS model using LiDAR ground elevations may not result in improved accuracy in the pit surface elevations, pipe grades or the routes/directions of overflow paths (if the model is updated with LiDAR levels the overflow routes may need to be redefined so they do not flow uphill) due to the variances in the ground elevations from the different datasets.

- To achieve a DRAINS model with accurate pit levels and relatively reliable pipe levels it is recommended that ground survey be undertaken to collect pit level data, at a minimum. If practical, depth to invert should also be measured/surveyed at the pits.

- For the purposes of the Norman Griffiths Oval flood assessment where the main hydraulic controls around the basin have been surveyed, the DRAINS pit/pipe levels are considered adequate to estimate basin inflows/outflows.

Appendix B. Norman Griffiths Oval Flood Assessment – Draft Report – Version A

Norman Griffiths Oval Flood Assessment

Ku-ring-gai Council

Draft Report

Version A

3 March 2017

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Norman Griffiths Oval Flood Assessment

Project no:	IA133200
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Client name:	Ku-ring-gai Council
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Draft	2/02/2017	Project Director review	A Hossain	L Chong

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1. Introduction

1.1 General

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- Assess flooding impacts assuming a flow bypass of the Oval and detention basin, in terms of changes to flood levels, velocities and flows.
- Identify and assess mitigation options to retain the detention function of the Oval, in order to maintain existing flooding and flow conditions upstream and downstream of the Oval.
- Prepare preliminary cost estimates for the mitigation works for input into the NSFA grant application.

The flooding models developed in this study will be used by Council in a subsequent flood study for the Lofberg Quarry Catchment.

2. Background on Study Area

2.1.1 Catchment Description

The catchment has a total area of 125 hectares and drains parts of the suburbs of West Pymble and Pymble in the Ku-ring-gai Local Government Area. The catchment area is depicted in **Figure 2-1**. Lofberg Oval is part of the overall Bicentennial Park precinct in the mid-section of the catchment. Lofberg Road skirts around the north-eastern side of the Oval and then along the north-western side of Bicentennial Park.

The catchment is drained by Quarry Creek, which consists of two main creek lines which converge upstream of Yanko Road at Bicentennial Park. The main creek line drains through and immediately downstream of Norman Griffiths Oval. The secondary creek line drains the area to the north of Bicentennial Park. Downstream of Yanko Road the creek flows in a forested incised gully before discharging into Lane Cove River. Land use in the catchment is low-density residential, open space and forest, with a small area of light commercial land use.

Watercourses were observed during site inspections to experience some low levels of baseflow but would otherwise be expected to be dry during periods of low rainfall. Overland flow paths through developed areas are a mix of having being filled/piped and developed, or in a few cases have been retained as more natural watercourses.

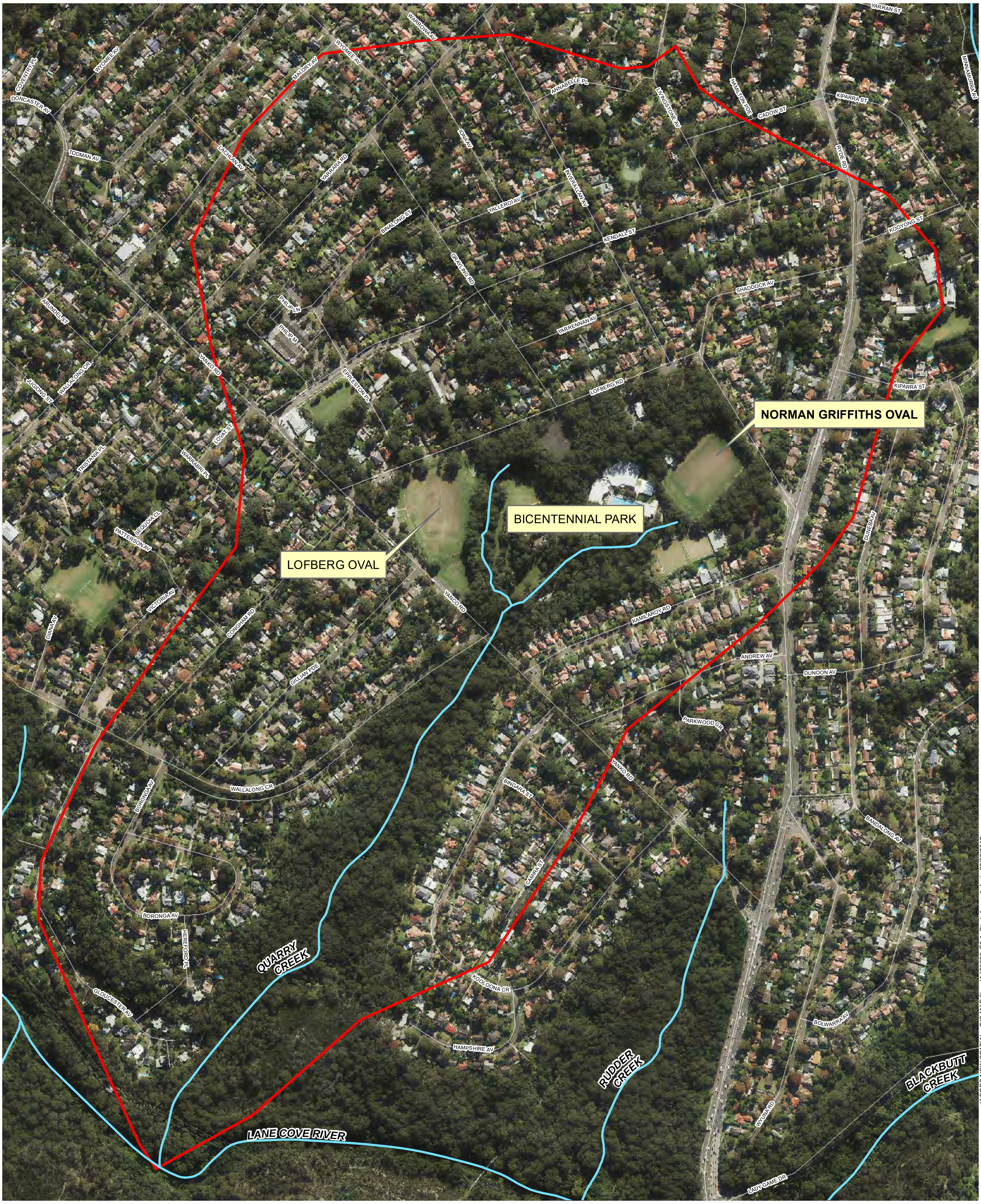
2.2 Drainage Features in the Vicinity of the Oval

Norman Griffiths Oval was constructed as a detention basin in 1987 and during the 1990's and 2000's the stormwater drainage system and open channels at Bicentennial Park between Lofberg Oval and Yanko Road were modified. **Figure 2-2** presents the drainage features in the vicinity of the Oval. The stormwater drainage pipe network discharges into a 60m long concrete lined open channel, which passes between residential properties and then crosses under Lofberg Road via 4x 750mm diameter pipes. It then is joined by additional stormwater pipe lines at a junction pit immediately upstream of the Oval. The pipe line then reduces to a single 1050mm pipe located under the Oval. Flows exceeding this pipe capacity surcharge onto the Oval via a surcharge box culvert.

There are two large grated sump pits located at the upstream and downstream ends of the Oval, connected to each end of the 1050mm pipe. A series of minor sump pits are also connected to the downstream pit. These pits drain the Oval detention basin during flood events when there are floodwaters stored in the basin.

The basin drains, along with two additional stormwater lines draining Ryde Road to the east, into Quarry Creek immediately downstream of the Oval. The creek is generally incised with vegetated banks. The creek channel's base appears to be located on bedrock. A number of footbridges and an access road cross the creek between the Oval and Yanko Road. Quarry Creek is joined by its tributary 50m upstream of Yanko Road. A timber boardwalk traverses the creek immediately upstream of Yanko Road.

The creek drops into a 4m deep drop structure under the boardwalk, and then flows under Yanko Road via an 1800mm diameter pipe. The creek then continues flowing in a south-westerly direction before discharging into Lane Cove River.



Legend

- Lofberg Quarry Catchment
- Watercourse

0 250 500m
1:6,000 @ A3

N

JACOBS NSW SPATIAL - GIS MAP file : IA133200_F2-1_StudyArea_r1v1 | 22/02/2017

Data sources

Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Figure 2-1 | Study Area

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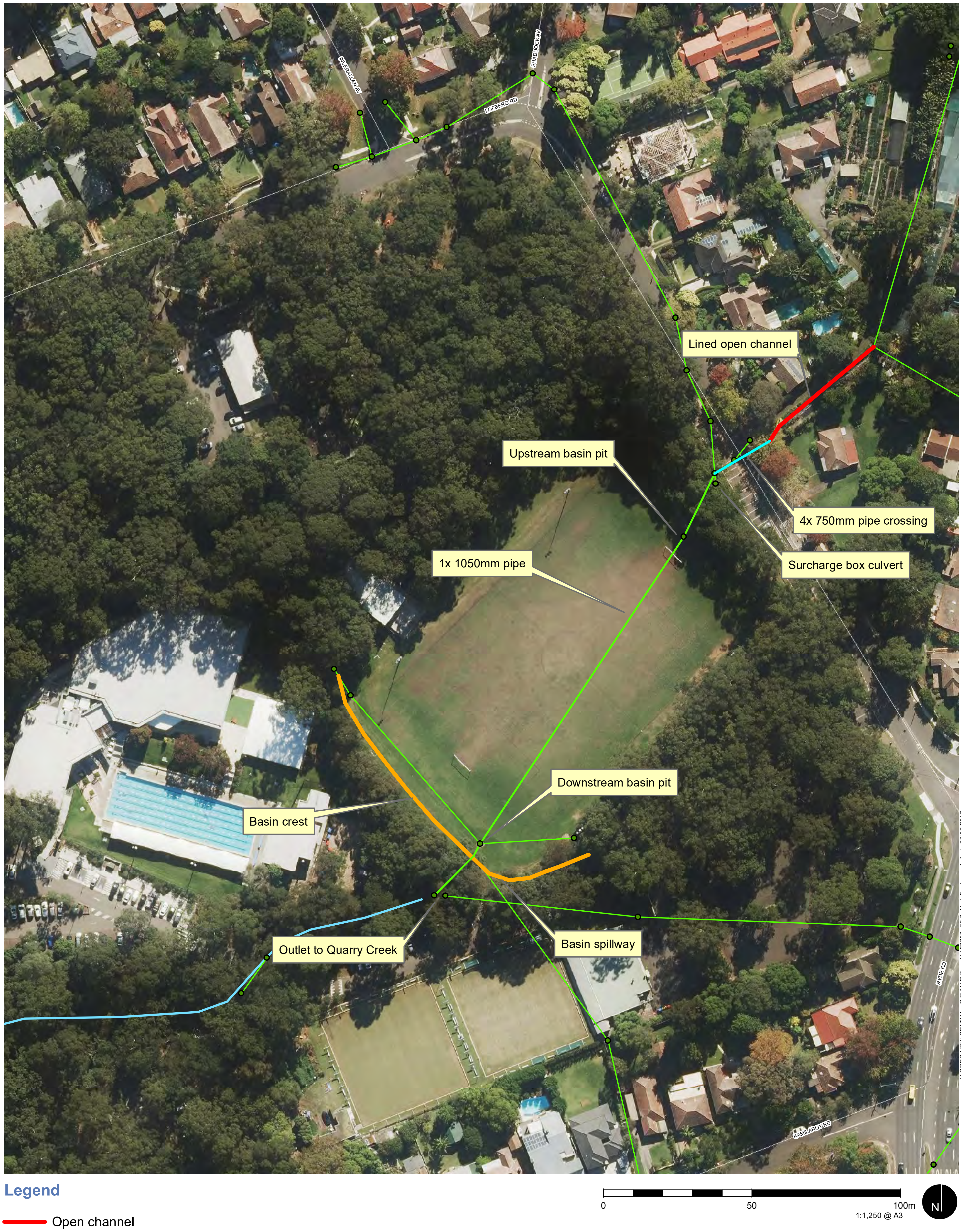

JACOBS NSW SPATIAL - GIS MAP file : IA133200_F2-2_Hyd_Feature_r1v1 | 22/02/2017

Legend

- Open channel
- Stormwater pits
- Stormwater pipes
- Basin crest
- Watercourse

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Figure 2-2 | Hydraulic Features in Vicinity of Oval

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3. Available Data

3.1 Background

Details on the data available to this study are provided in the following sections.

3.2 Previous Studies and Models

In 2006 the Lofberg Quarry catchment was modelled in DRAINS by URS, and in 2012 preliminary flood mapping of the 1% AEP event within the catchment was undertaken by Mott MacDonald, based on HEC-RAS hydraulic modelling. Neither the hydrologic and hydraulic modelling of the Lofberg Quarry catchment incorporated the Norman Griffiths Oval as a detention basin, or included the current culvert inlet design at Yanko Road. As such the detention basin's influence on large flood events within the catchment has not been identified.

The DRAINS model developed by URS in 2005 was provided by Council for this study. The Mott MacDonald HEC-RAS model was not provided. Both previous study reports were not provided for this study, however, they have been reviewed by Jacobs previously for separate flood studies.

3.3 Topographic Data

Council provided the following data for use in this study. Comments on the data set are provided where there are particular findings with respect to the data.

- LiDAR data captured by NSW Government Land and Property Information (LPI) with a vertical accuracy of approximately +/-0.15m (one standard deviation) of the catchment.
- GIS layers
  - Drainage pipes and pits
  - Cadastre.
- Existing topographic survey, which was collected at several different times in the area between Lofberg Road and Yanko Road, including the Oval and detention basin drainage infrastructure. The various survey data sets did not include the creek channel between the Oval and Yanko Road, although the bank areas were surveyed. The dates when the existing survey was captured is not known.

3.4 Design Drawings

A number of design drawing sets were provided by Council for road drainage, trunk drainage and detention basin design for Norman Griffiths Oval, Lofberg Road and Yanko Road. Design plans of the Yanko Road boardwalk were also provided. These design drawings were reviewed and relevant details extracted for input into the hydrologic and hydraulic modelling.

3.5 Aerial Photography

AUSIMAGE aerial photography dated May 2016 was obtained by Jacobs for the study area, and is the latest available imagery for the catchment.

3.6 Rainfall Data

3.6.1 Intensity-Frequency-Duration Data

Design Intensity-Frequency-Duration (IFD) rainfall information is contained in the existing DRAINS model of the catchment. The IFD data is based on Australian Rainfall and Runoff 1987 (Engineers Australia, 1987),as the study and modelling pre-dates the recent ARR 2016 IFD updates. The ARR 1987 IFD parameters adopted in the model are summarised in **Table 3-1**.

Table 3-1 IFD Parameters for Study Area

Parameter	0.5 EY (i.e. 2 year ARI)	2% AEP (i.e 50 year ARI)
1hr Event Intensity (mm/h)	37.5	82.5
12hr Event Intensity (mm/h)	8.3	17
72hr Event Intensity (mm/h)	2.8	5.5
Frequency Factor	4.29	15.8
Skewness	0.00	

3.7 Site Inspections

A site visit was undertaken following project inception on 8 December 2016. The purpose of the site inspection was to gain an appreciation of the existing basin and drainage structures in the vicinity of the Oval in addition to the current condition of the creek. Jacobs' project manager and project engineer was accompanied by officers from Council. **Figure 3-1** to **Figure 3-10** present photographs from the site inspection.

3.8 Ground Survey

Additional ground survey was collected in December 2016 including the open channel upstream of Lofberg Road, the embankment and spillway of the detention basin, the creek channel between the Oval and Yanko Road and details of culverts (including Yanko Road culvert), access road crossing, footbridges and the boardwalk in this section of the creek.

3.9 CCTV Inspection of Drainage Network

Council undertook CCTV inspection of the stormwater network in the vicinity of the basin outlet into Quarry Creek in December 2016 in order to confirm the layout of the network and connectivity of the pipes.

Figure 3-1 Lined open channel looking upstream from Lofberg Road

Figure 3-2 Upstream side of 4x 750mm pipe crossing of Lofberg Road

Figure 3-3 Surcharge box culvert structure at upstream end of Oval

Figure 3-4 Existing downstream basin pit inlet

Figure 3-5 Pipe outlets into Quarry Creek downstream of basin

Figure 3-6 Typical footbridge crossing

Figure 3-7 Access road crossing of Quarry Creek

Figure 3-8 Boardwalk upstream of Yanko Road

Figure 3-9 Boardwalk and screened drop structure inlet into Yanko Road culvert

Figure 3-10 Upstream side of 1800mm diameter Yanko Road culvert

4. Review of DRAINS Modelling

4.1 Overview

The existing DRAINS model (URS, 2005) represents the entire stormwater pit and pipe system in the Lofberg Quarry catchment, which was divided into 253 sub-catchments. The model was reviewed for use in this study for its adequacy to estimate sub-catchment runoff hydrographs for input into the hydraulic model. An assessment of flow capacities and pipe hydraulics using the DRAINS model was not included in the scope of this study.

A review of the pit and pipe surface and invert levels against the LiDAR was undertaken at the request of Council. This review is discussed in this section.

The existing DRAINS model did not include the detention basin in Norman Griffiths Oval. The model was updated in this study to represent the basin, with the elevation versus storage area relationship estimated from the LiDAR. The multiple pits located across the basin were lumped together, in terms of the elevation versus inflow relationship, for representation in the DRAINS model. The DRAINS model has also been updated to reflect surveyed pit and pipe levels in and around the basin.

4.2 Sub-Catchment Data

The sub-catchment boundaries were not provided in spatial form by Council. An overview of the sub-catchment details in the DRAINS model indicated that the sub-catchment total areas and the catchment impervious proportions were consistent with the overall catchment area and with existing development patterns. Council confirmed that there has not been significant development in the catchment since the development of the DRAINS model, meaning that there not been any change in catchment hydrologic behaviour as a result of changing development patterns in the catchment since the previous drainage study.

4.3 Hydrologic Parameters

The following parameter values were adopted in the DRAINS modelling for the design storms:

- Depression storage: Paved areas – 1mm; Grassed areas – 5mm.
- Soil type: Type 3, which represents a not-particularly well drained soil landscape.
- Antecedent Moisture Condition: This represents the degree of soil wetness at the onset of a storm, which affects its infiltration capacity. A value of 3 was adopted for storms up to and including the 1% AEP event, which represents “rather wet” (but not saturated) soil conditions due to total rainfall of between 12.5 and 25mm in the preceding 5 days prior to the modelled storm event (DRAINS User Manual, Watercom, 2012). It was assumed that the ground would be completely saturated during extreme storm events, therefore, a value of 4 was adopted for the PMP event.

4.4 Design Rainfall

The storm events including the 0.2EY and the 10%, 5%, 2% and 1% Annual Exceedance Probability (AEP) events were modelled as Australian Rainfall and Runoff 1987 (ARR 1987) Zone 1 storms in DRAINS.

4.5 Comparison of DRAINS Levels versus LiDAR

A review of the pit and pipe elevations in the Lofberg Quarry Catchment DRAINS model has been undertaken at the request of Council. Findings are summarised below.

4.5.1 Pit Surface Levels

The DRAINS model pit levels (based on 2m contours) have been compared against LiDAR elevations at that pit location. The LiDAR has been provided by Council and is the NSW LPI 2012 Sydney North data set. The statistics are illustrated in **Figure 4-1** below. Negative values in the “Difference Range” indicate that DRAINS levels are lower, and vice versa.

Figure 4-1 statistics of DRAINS versus LiDAR ground levels at pits

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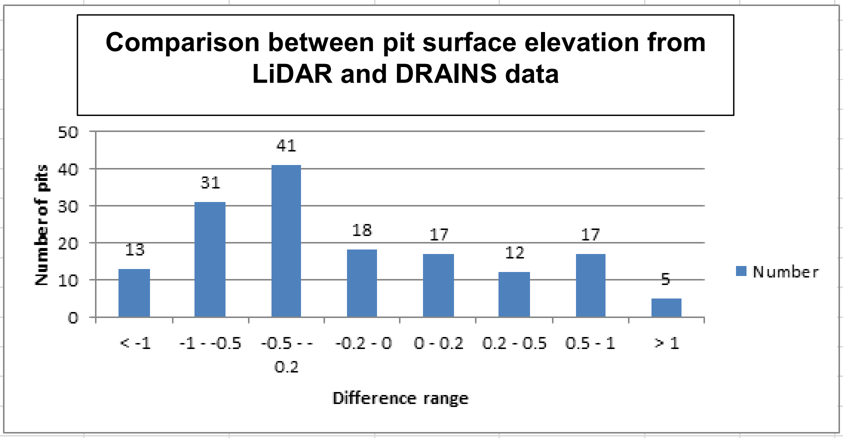

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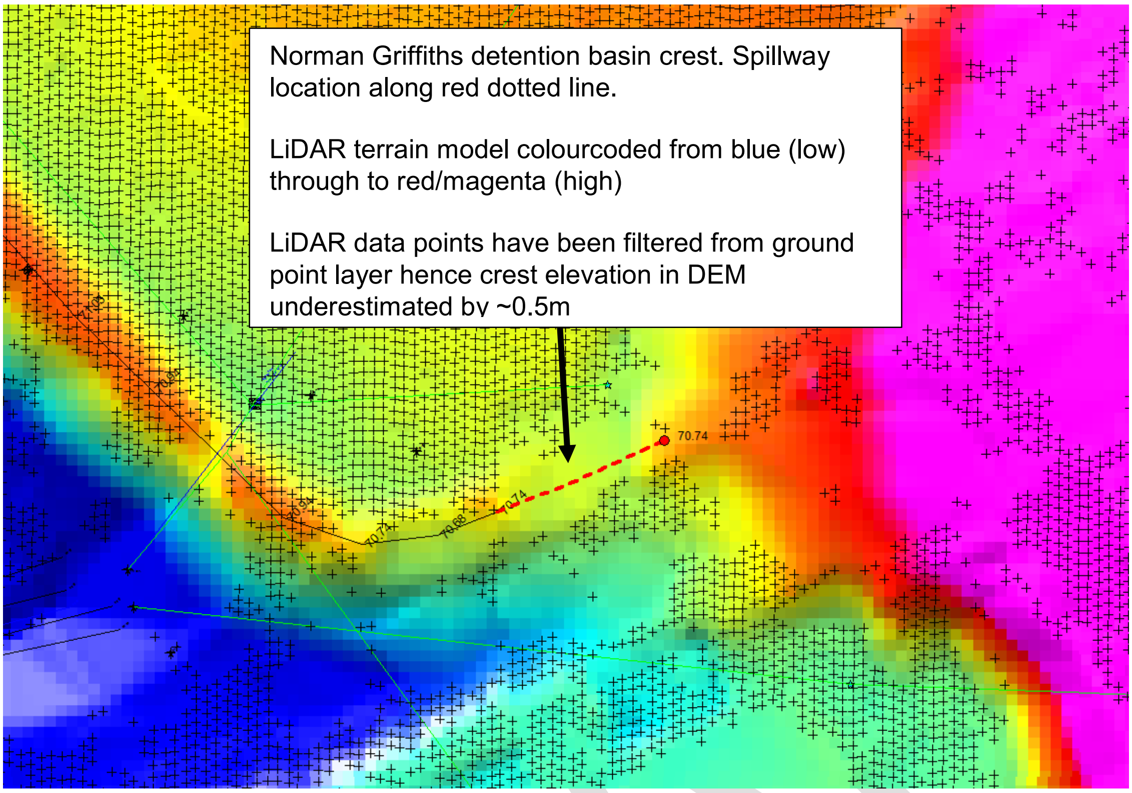
- 29 pits (19%) have the LiDAR levels 0.2 – 1m higher than the DRAINS levels
- 18 pits (11%) are greater than +/-1m difference in level
- There is a bias towards negative variance. This could be due to how the LiDAR complete data points (ground, vegetation etc) are filtered into the different categories. For example, a number of LiDAR points along the crest of the detention basin spillway had been filtered out, perhaps incorrectly, it picked up vegetation. Hence the crest level was not picked up in the ground points and the crest level was therefore underestimated in the creation of the DEM as shown in **Figure 4-2**. Jacobs has the raw ground points available for this LiDAR dataset.
- While there are fewer positive variances it is still a substantial number (22% with >0.2m variance). Potentially explained by vegetation data points not being filtered out of the ground point layer.

Figure 4-2 LiDAR raw data points overlaid on LiDAR DEM



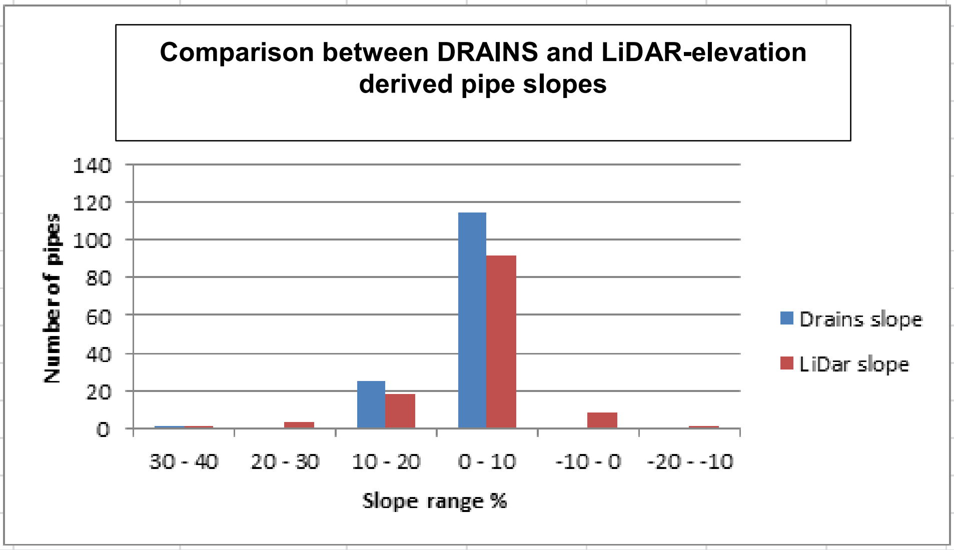
4.5.2 Pipe Grades

The pipe upstream and downstream invert levels were adjusted based on the LiDAR ground levels at the pits and the assumed depth to invert calculated from the DRAINS data. See **Figure 4-3**. In summary:

- The large majority of pipes in both the DRAINS and the LiDAR-derived pipe slope data sets have grades of 0-10% which are typical grades
- There are a similar number of pipes with >10% grade
- There are a number of pipes from the LiDAR-derived grades with inverse grades i.e. pipes flowing uphill. This may be due to:
    - Variance between the DRAINS and LiDAR ground levels at pits
    - Inaccurately estimated LiDAR DEM elevations due to filtering and processing of raw points
    - Assumed (rather than measured) depth to invert at pits with not inlet (i.e. blind pits, buried pits, bolted lid pits etc). It is understood from previous discussions with Council staff on other projects that in developing the DRAINS models the depth to invert was measured at the majority of pits with inlet/access.

Figure 4-3 Comparison of DRAINS and LiDAR-derived pipe grades

Range	Drains slope	LiDar slope
30 - 40	1	1
20 - 30	0	3
10 - 20	25	18
0 - 10	115	92
-10 - 0	0	8
-20 - -10	0	1



4.5.3 Conclusions on DRAINS Model Review

The following conclusions are made based on the review:

- Sub-catchment definition in the existing DRAINS model reflects existing catchment conditions and is suitable for estimation of inflow hydrographs into the subsequent hydraulic modelling.
- The DRAINS model has been updated to reflect surveyed pit and pipe levels in and around the basin. The basin storage has been included in the model, with elevation versus storage area relationship estimated from LiDAR.
- Updating the DRAINS model using LiDAR ground elevations may not result in improved accuracy in the pit surface elevations, pipe grades or the routes/directions of overflow paths (if the model is updated with LiDAR levels the overflow routes may need to be redefined so they do not flow uphill) due to the variances in the ground elevations from the different datasets.
- To achieve a DRAINS model with accurate pit levels and relatively reliable pipe levels it is recommended that ground survey be undertaken to collect pit level data, at a minimum. If practical, depth to invert should also be measured/surveyed at the pits.
- For the purposes of the Norman Griffiths Oval flood assessment where the main hydraulic controls around the basin have been surveyed, the DRAINS pit/pipe levels are considered adequate to estimate basin inflows/outflows.

5. Hydraulic Modelling

5.1 Model Selection

A TUFLOW combined one-dimensional (1D) and two-dimensional (2D) hydrodynamic model has been developed for this study. TUFLOW is an industry-standard flood modelling platform, which was selected for this assessment as it has:

- Capability in representing complex flow patterns on the floodplain, including flows through street networks and around buildings.
- Capability in representing the stormwater drainage network, including pit inlet capacities and interflows between the network and floodplain including system surcharges.
- Capability in accurately modelling flow behaviour in 1D channel, bridge and culvert structures and interflows with adjacent 2D floodplain areas.
- Easy interfacing with GIS and capability to present the flood behaviour in easy-to-understand visual outputs.

The model was developed and run in TUFLOW 2016-03-AB- w64, in double-precision mode.

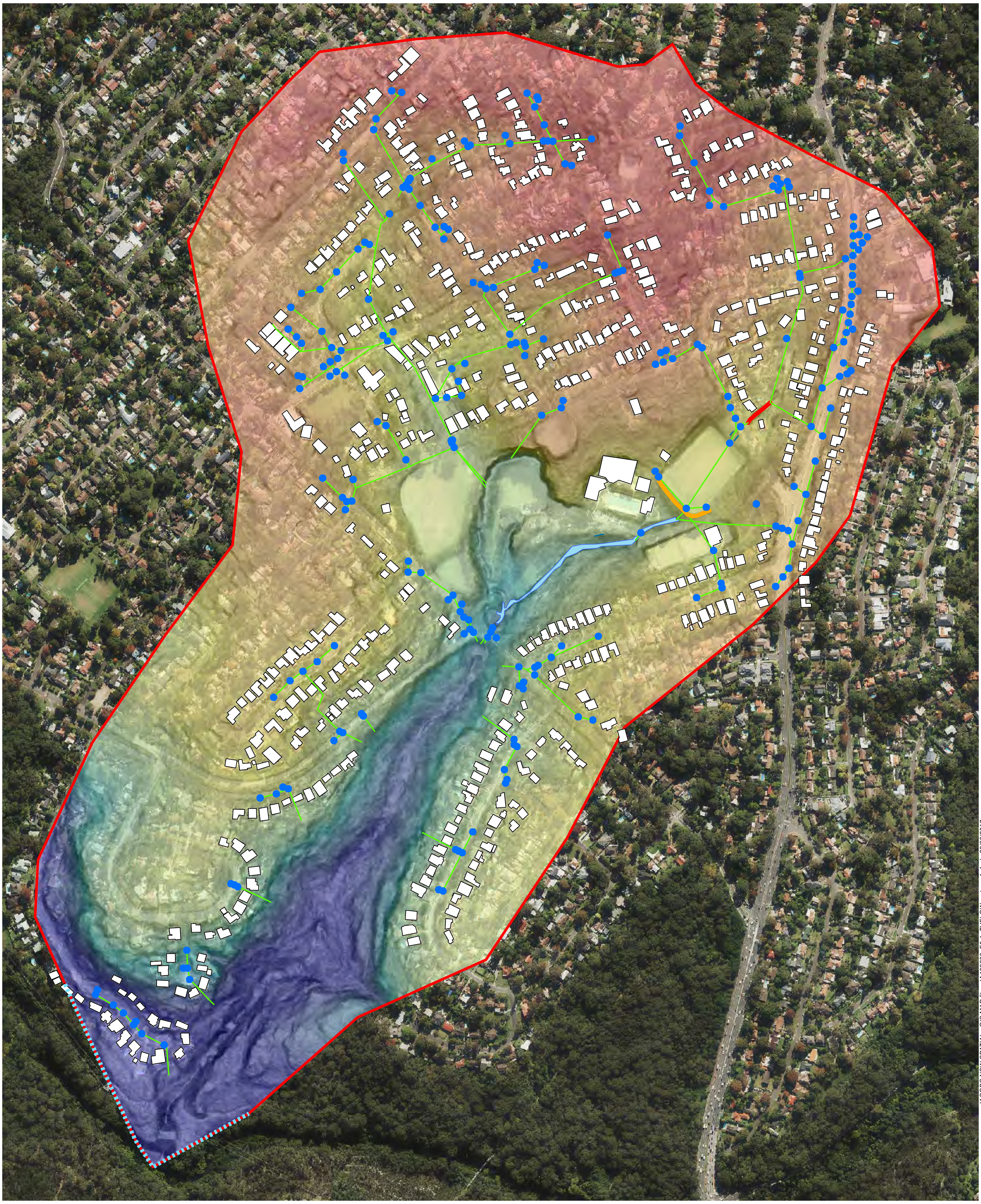
5.2 Configuration of Hydraulic Model

5.2.1 Extent and Structure

The TUFLOW model is comprised of:

- A 2D domain of the catchment surface reflecting the catchment topography, with varying roughness as dictated by land use. The watercourses are in general modelled in 2D.
- A 1D network of pits and pipes representing the stormwater network. The pits have a defined inflow capacity as dictated by their type and size.
- Additional hydraulic structures including culverts (1D) and footbridges (2D).
- Obstructions to flow are represented as 2D objects, including existing buildings identified from aerial photo.

Refer to the following report sections for details on these features. The locations of various features in the TUFLOW model are shown on **Figure 5-1**.



JACOBS NSW SPATIAL - GIS MAP file : IA133200_F5-1_TUFLOW_setup_r1v1 | 23/02/2017

Legend

- Open channel
- Stormwater pipes
- Basin crest
- Downstream boundary
- Surveyed creek channel
- Inflow location
- Modelled buildings
- TUFLOW model domain

Ground Elevation

High : 93m AHD

Low : 33m AHD

0 50 100m
1:6,000 @ A3

N

Data sources

Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Figure 5-1 | TUFLOW Model Configuration

JACOBS

5.2.2 Model Topography

The topography of the catchment is represented in the model using a 2m grid. This level of precision in the grid is considered necessary in order to represent detailed flood behaviour in a fully developed catchment. Finer model grid sizes such as 1m grid are not considered practical given the large size and expected excessively long computing times. The basis of the topographic grid used in the TUFLOW model is the LiDAR data set in addition to ground survey.

5.2.3 Stormwater Network

5.2.3.1 Stormwater Pits

The stormwater pits provide a dynamic linkage between the underground drainage network and the 2D TUFLOW model domain, representing the floodplain. Water is able to flow between the drainage network and floodplain, depending on the hydraulic conditions.

The location of the stormwater pits and associated attributes were available from Council in GIS format. Locations of structures were updated based on survey where available. Pit inflow relationships were defined in terms of flow depths versus pit inflow. The pit types and inflow relationships adopted in the DRAINS model were also used in the TUFLOW model.

TUFLOW automatically calculates hydraulic energy losses in the pits based on the alignment of pipes connected to each pit and the flows in each pipe. The calculations are based on the Engelhund manhole loss approach (*TUFLOW User Manual*, BMT WBM, 2010).

The surface levels of the stormwater pits were derived from the LiDAR levels for consistency with terrain in the TUFLOW model.

5.2.3.2 Stormwater Conduits

Each of the stormwater pipes in the DRAINS models are also modelled in the TUFLOW models. Several pipes down to a diameter of 225mm are represented, but are typically larger than 300mm. The conduits are represented as circular pipes or rectangular culverts with dimensions matching those adopted in the DRAINS models.

Details of additional pipes and culverts which were not in the DRAINS model were collected during ground survey.

5.2.3.3 Pit and Pipe Details in the Vicinity of the Oval

The pit and pipe details for features around the Oval were modelled based on topographic survey. This is critical as these details determine the timing and behaviour of surcharge into the detention basin during flood events.

5.2.4 Blockage of Hydraulic Structures

Stormwater pit inlets were assumed to be 20% blocked for on-grade pits and 50% blocked for sag pits.

A 20% blockage factor was assumed for all culverts in the study area, which is consistent with the guidance in Australian Rainfall and Runoff Revision Project 11 Stage 2 “Blockage of Hydraulic Structures” for culverts with height < 3m or width < 5m. The exception to this rule is for Yanko Road culvert, for which the drop inlet structure is heavily screened by wooden slat panels as a part of the boardwalk structure. A 70% blockage factor was adopted for the screening. Zero blockage was assumed for the culvert itself.

5.2.5 Building Polygons

This study considers buildings as solid objects in the floodplain. This means that buildings form impermeable boundaries within the model, and while water can flow around buildings, it cannot flow across their footprint. The building footprints in the TUFLOW model were digitised based on the 2016 aerial imagery. The building polygons were superimposed on the model grid to make model computational cells under the footprints inactive.

5.2.6 Property Fencelines

Fencelines have typically not been explicitly represented in the model and floodwaters are allowed to flow across them freely. Although fences may obstruct overland flood flows in some parts of the catchment, experience indicates that representing fences in the hydraulic model requires making unvalidated assumptions about depths at which fences overflow or fail.

Hence, the potential obstruction to flow caused by fences was represented in the model by increasing the cell roughness (Manning's n values) for certain land uses, as described in **Section 5.2.7**. The limitation of this approach is that the flood levels may be slightly overestimated and flow velocities slightly underestimated for flooding within properties depending on the actual locations of obstructions and the interaction of flood flows with these obstructions. However, this approach does preserve the likely typical flooding behaviour, in which floodwaters use the road corridor as the preferential flow path.

5.2.7 Surface Roughness

All parts of the study area within the TUFLOW model were assigned hydraulic roughness values according to the LEP zoning and ground cover. These are based on engineering experience and typical values used in previous flood studies undertaken in the Sydney Region by Jacobs and other consultants. The relatively high Manning's n values for the residential land use accounts for expected obstructions such as minor structures (sheds, etc.) and fences.

Note that the road corridor areas were identified from the cadastre layer and represented as a "land use type". This means the road pavement areas are lumped with the road verge areas and an averaged roughness value adopted. This approach was considered satisfactory for the purposes of this study.

Table 5-1 TUFLOW Model Grid Hydraulic Roughness Values

Land Use Type	Manning's n	Comment
Road corridor	0.03	Averaged value for road corridors
Grassed area	0.04	May include landscaped areas, ground cover
Urbanised area	0.06	Residential areas
Watercourse	0.05	Generally uneven bedrock base, no vegetation. Accounts for irregularities in channel
Forest	0.15	
Paved areas	0.025	Concreted areas, parking lots etc

5.2.8 Footbridges and Boardwalk

Details of identified footbridges and the boardwalk at the upstream side of Yanko Road in the study area were obtained from survey, including soffit, deck and hand railing levels. Footbridges were modelled as 2D structures and their locations are indicated on **Figure 5-1**.

5.3 Boundary Conditions and Initial Conditions

5.3.1 Model Inflows

Runoff generated in the sub-catchments from the DRAINS model was input to the TUFLOW model via one of two methods:

- At the pits located at the outlet of each sub-catchment. Sealed pits are not assigned an inflow. The amount of surface flow entering the pit is dictated by the pit inflow relationship. Flows in excess of the pit inlet capacity remain in the 2D model domain as point inflows, subsequently forming overland flow.
- At the outlet to the sub-catchment if there are no pits in that sub-catchment, for example, in forested sub-catchments. Flows are initially input at the lowest point of the sub-catchment and then distributed to wet areas in the catchment as the storm progresses.

Pit surcharge flows are caused when flows in the drainage network exceed network capacity and spill out of the pits and into the 2D domain. Pit surcharges would similarly form overland flow in the model. Depending on the hydraulic conditions in the pipe system, overland flows can re-enter the pipe system via the stormwater pits.

5.3.2 Downstream Boundary Conditions

A normal depth boundary was adopted where Quarry Creek discharges into the Lane Cove River. This location is situated at an elevation of 25m AHD, which is 50m lower than the nearest development and hydraulic structures. Flood behaviour in and around the Oval and in existing developed areas is not expected to be sensitive to the tailwater conditions due to flooding in the Lane Cove River.

5.4 Model Calibration

The DRAINS and TUFLOW models were not required to be calibrated or verified for the purposes of this study.

6. Estimation of Existing Flooding Conditions

6.1 Simulated Design Events

The storm events modelled include the 0.2 EY, 10%, 5%, 2% and1% AEP events. The storm durations initially assessed include the 25 minute, 1, 1.5, 2, 3, 6 and 9 hour duration events for the 2% and 1% AEP events. The 2 hour duration event is observed to be the critical event in and around the Oval.

6.2 Mapping of Existing Case Flood Conditions

Flood mapping for the existing case is presented in **Appendix B**. The flood mapping is focussed on the area in the vicinity of the Oval to immediately downstream of Yanko Road for the purposes of this study.

Flow depths in Quarry Creek are typically 1 – 2m for all events from the 0.2 EY up to the 1% AEP events due to the incised nature of the channel. Maximum depths occur upstream of Yanko Road to depths of approximately 3.5m for all events.

The Oval itself is affected by flooding of up to 0.1m in localised areas in the 0.2 EY, and 0.7m in the 1% AEP event. Depths are 0.2m deeper in the swales (i.e. 0.3m in the 20% AEP, and 0.9m AEP) surrounding the Oval. The detention basin spillway at the south-eastern corner of the Oval begins to spill in the 2% AEP event.

Flow velocities typically exceed 2m/s in the creek channel between the Oval and Yanko Road. Out-of-bank flow velocities are typically 0.5 – 1m/s for all events.

6.3 Summary of Flow Rates

The flow rates for surface, pipe and total flows in the vicinity of the Oval are summarised in **Table A-1** in **Appendix A**.

7. Assessment of Flow Bypass Design Case – No Mitigation

7.1 Description

A design case, with no mitigation, was agreed with Council to include upgrade of drainage capacity to bypass flood flows in pipe under the Oval in up to a 2% AEP (minimum) event. The design case was represented in the TUFLOW model which consisted of:

- An amplification of the existing 1050mm pipe under the Oval to bypass flows in up to a minimum of the 2% AEP flood event. The amplification includes 3x 1050mm pipes (i.e. two additional pipes) between Lofberg Road and the basin outlet pipe to Quarry Creek. A 2x 1050mm pipe arrangement was considered, but provided only minimal freeboard at the basin upstream pit.
- A series of surface inlets to intercept surface flood flows before they inundate the Oval. This has been modelled as an "unlimited capacity" inlet in the TUFLOW model. Actual inlet capacity would need to be approximately $3m^3/s$ in the 2% AEP event. Approximately 4 letterbox-type pits with 1m x 1m opening would be required, directly draining to the storage tank.
- The existing letterbox inlet at the downstream end of the Oval is to be retained to allow drainage of water at this low point.
- Earthworks at the upstream end of the sports field to form a swale at 71.8m AHD, and berm with crest 72.15m AHD (approx.) to intercept surfaces flows approaching the field and allowing ponding to drive flows into the pit inlets.
- Minor earthworks around the sides of the sports field to form a berm or swale, up to 0.2m high/deep to prevent minor surface flows spilling onto the field. The flows would be directed to the low point at the downstream end of the field.

The design option layout is shown on **Figure 7-1**. All flood events from the 20% AEP up to the 1% AEP were assessed. The flooding impacts, in terms of changes in flood levels and in flow velocities, will be mapped and presented in the Draft Report. The Oval is flood-free in the 2% AEP event, therefore the bypass arrangement achieves this design objective.

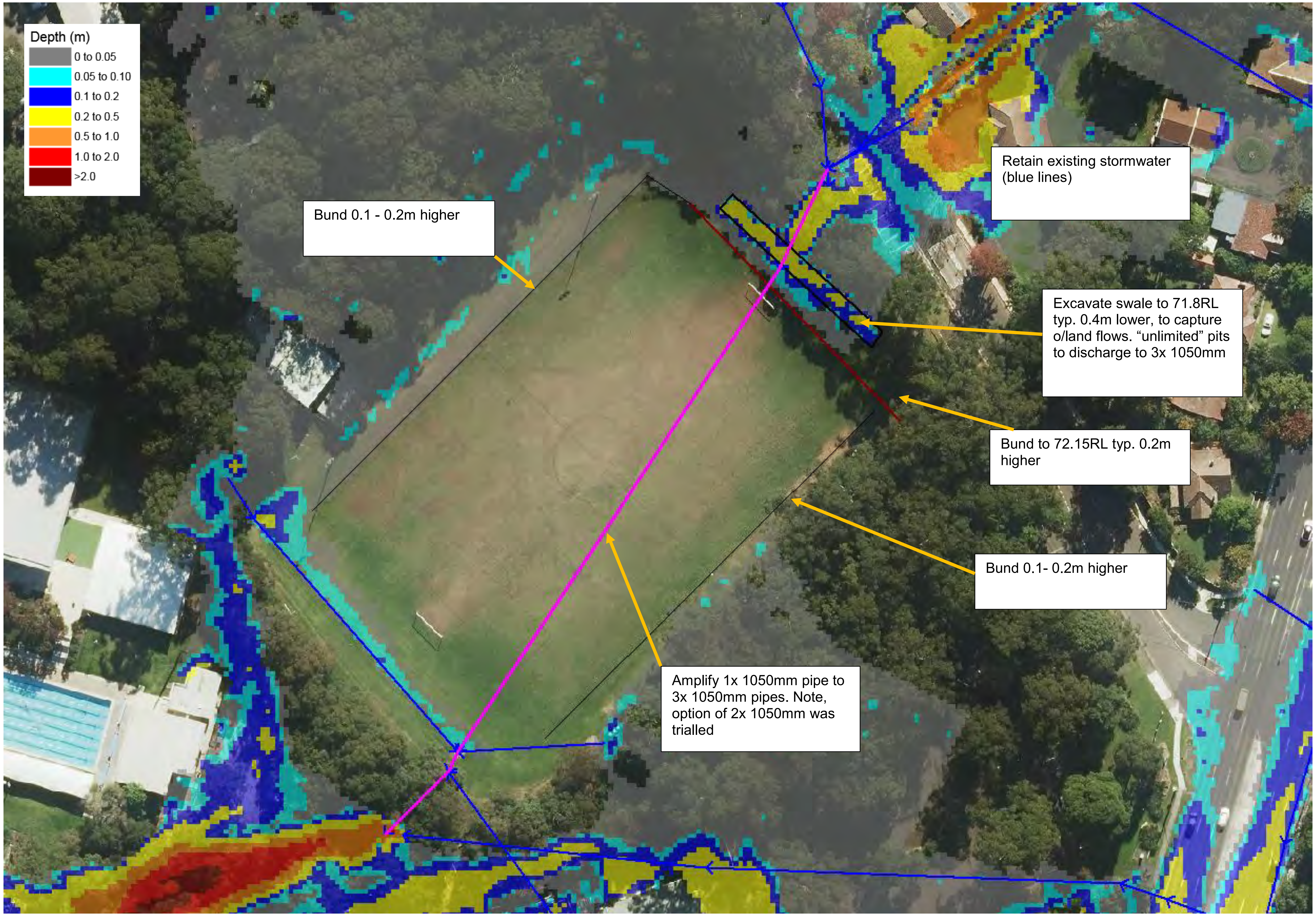
7.2 Mapping of Design Case Flooding Impacts

The flooding impacts, in terms of changes to flood levels, are mapped in **Appendix C**.

Flood levels downstream of the Oval increase by 0.05m in the 0.2 EY event and up to 0.2m in the 1% AEP event, although no existing development is affected by this flood impact. Yanko Road, which is already flooded in the 0.2 EY event, would experience minor increases in flood depths of 0.02m in the 0.2 EY and 10% AEP events, and up to 0.07m in the 1% AEP event. It is expected that durations of inundation would increase only slightly.

Maps indicating the change in flow velocity have not been presented. The modelling results indicate localised, high increases in peak flow velocities which appear to be a result of the calculation techniques in TUFLOW during very shallow flow conditions, and are not representative of flow velocities during the peak of the flood. The summary of flow rates (refer **Appendix A**) indicate increases in peak flows in the design case, which would result in increases in flow velocities during the flood peak.

Figure 7-1 Layout of design case. Upgrade existing 1050mm pipes to convey all 2% AEP event flow with interception of surface flows with "unlimited" capacity pits



7.3 Summary of Flow Rates and Comparison to Existing Case

The increase in channel flows as a result of the bypass are summarised at selected locations in **Table A-1 in Appendix A**, and compared to the existing conditions. The flows are split into pipe and overland flows, and the total flows are also indicated. The comments on trends are summarised for flood events representative of a frequent flood event (i.e. 0.2 EY event) and a large design flood (2% AEP event).

It is observed that total flows increase by up to 13% in the 0.2 EY event at the discharge point into Quarry Creek (location 4), and by up to 47% in the 2% AEP event. These increased flows and flow volumes would be stored within the Oval and basin in the existing case. The bypass allows these flows to be discharged downstream with no detention effects. These increased flows are expected to result in morphologic changes (i.e. increase in channel width) in the creek channel in response to minor floods and larger if the bypass is implemented with no mitigation.

Note that normal storm flows in the drainage system and creek are not expected to increase as a result of the bypass, as these flows would be too small to surcharge and engage the detention basin. Hence, the erosion potential during these very frequent storm events is not expected to increase significantly as a result of the bypass.

8. Assessment of Mitigation Options

8.1 Description of Mitigation Option – Underground Detention

At the request of Council, a mitigation option was identified and modelled, with preliminary sizing and layout determined. The mitigation option is comprised of:

- An underground storage tank with 2400m^3 storage volume, 1.5m high (i.e. 1600m^2 surface area).
- A series of surface inlets to intercept surface flood flows before they inundate the Oval. This has been modelled as an "unlimited capacity" inlet in the TUFLOW model. Actual inlet capacity would need to be approximately 3m^3/s in the 2% AEP event. Approximately 4 letterbox-type pits with 1m x 1m opening would be required, directly draining to the storage tank.
- Single 1050mm (or equivalent) outlet pipe connected to existing downstream basin pit. It is assumed that the downstream pit would need to be demolished and reconstructed to accommodate the additional pipe. The existing letterbox inlet is to be retained to allow drainage of water at this low point.
- Earthworks at the upstream end of the sports field to form a swale at 71.8m AHD, and berm with crest 72.15m AHD (approx.) to intercept approaching surfaces flows and allowing ponding to drive flows into the pit inlets.
- Minor earthworks around the sides of the sports field to form a berm or swale, up to 0.2m high/deep to prevent minor surface flows spilling onto the field. The flows would be directed to the low point at the downstream end of the field.

The mitigation option layout is shown on **Figure 8-1**. This mitigation option was discussed with Council during Meeting #2 held on 19 January 2017 and it was agreed to proceed with this underground tank option in which flows would be allowed to surcharge onto the Oval in events larger than the 2% AEP event.

The underground tank is assumed to be upstream of the field itself so that maintenance/inspection portals are not on the field itself. Additionally, the letterbox pits need to be upstream of the field so that surface flows can be intercepted before they spill onto the field. GPTs are required to capture sediment before it enters the storage tank to minimise the more difficult task of cleaning out the tank, compared to the GPTs.

8.2 Description of Alternative Mitigation Option – Split Detention Basin

An alternative mitigation option was identified as a potential alternative option to the underground detention option. It was agreed with Council to proceed with assessing the alternative option. The option consists of constructing a new detention basin upstream of the sports field in lieu of the proposed underground tank.

The basin would be formed by a 1m high bund along the upstream side of the field, then grading down to an excavated area 0.5m below existing ground level. Depth of the basin from base to top of berm would be 1.5m. The base would then grade up to existing levels on Lofberg Road with 1:3 batters. The basin would capture surfaces flows off Lofberg Road in addition to surcharging flows from the existing stormwater system. The 1m high bund (crest level 73m AHD) is at the same level as Lofberg Road to ensure that flooding upstream of the road is not increased. Refer to **Figure 8-2** for the layout.

The footprint of the basin would be 2000m^2, but with the 1:3 batters a storage volume of only 1300m^3 can be achieved (approx. 50% of the required volume). Therefore, the available storage in the low point of the existing basin would also be utilised to provide the total required storage. Spillways and swales on either side of the upper basin would convey overflows around the field to the bottom storage. The downstream end of the field would need to be lifted by approximately 0.4m to achieve flood immunity in the 2% AEP flood.

The existing stormwater network would largely be retained as is, including the existing surcharge box culvert. A required modification is to relocate the upstream basin pit (construct a new pit and decommission the existing pit) to align with the new upper basin floor. GPTs are assumed not to be required for this option, however, could be considered at detailed design stage if a high risk of leaf/debris blockage is identified.

Figure 8-1 Layout of Mitigation Option. Underground OSD with interception of 2% AEP surface flows with “unlimited” capacity pits

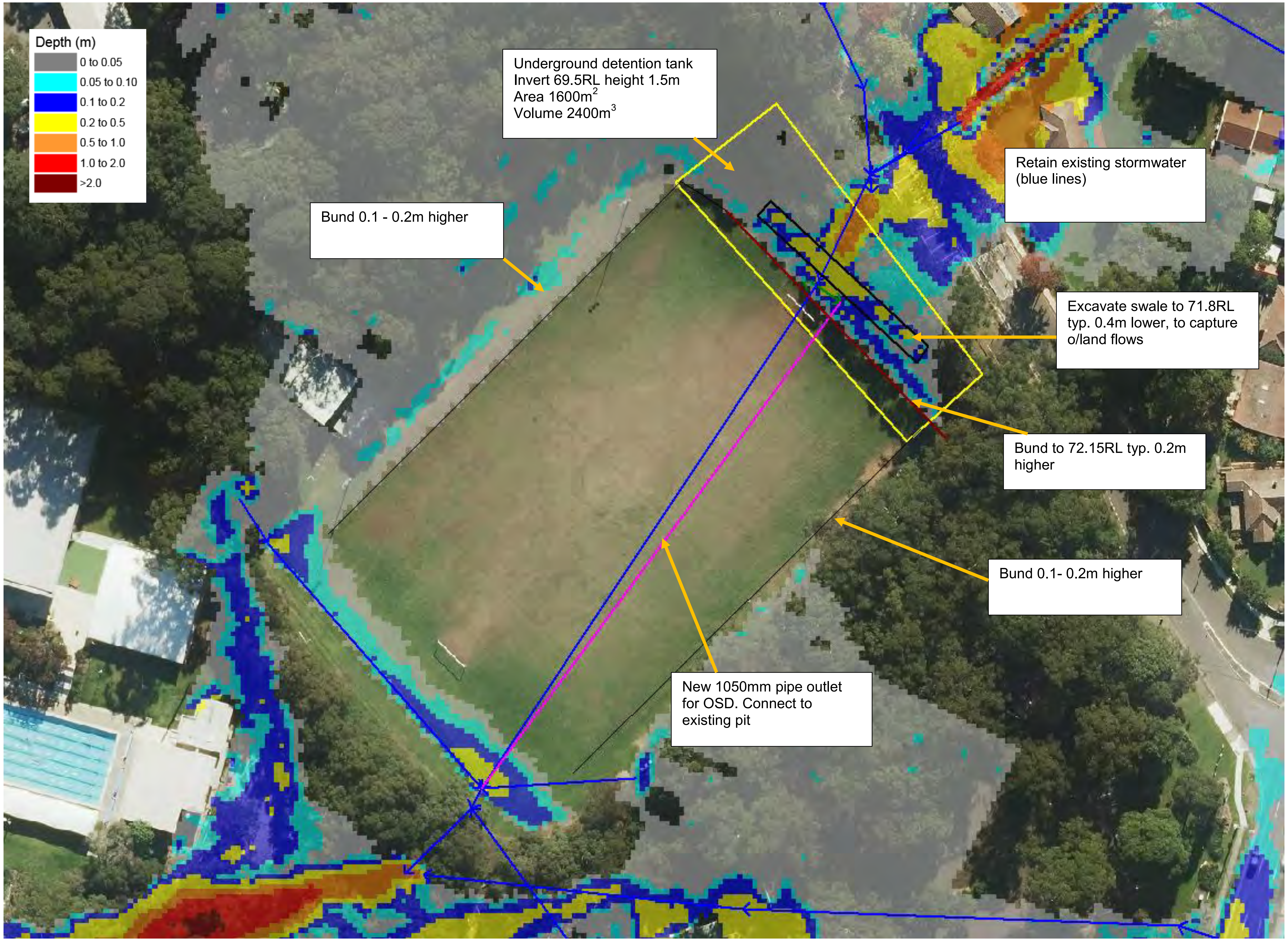
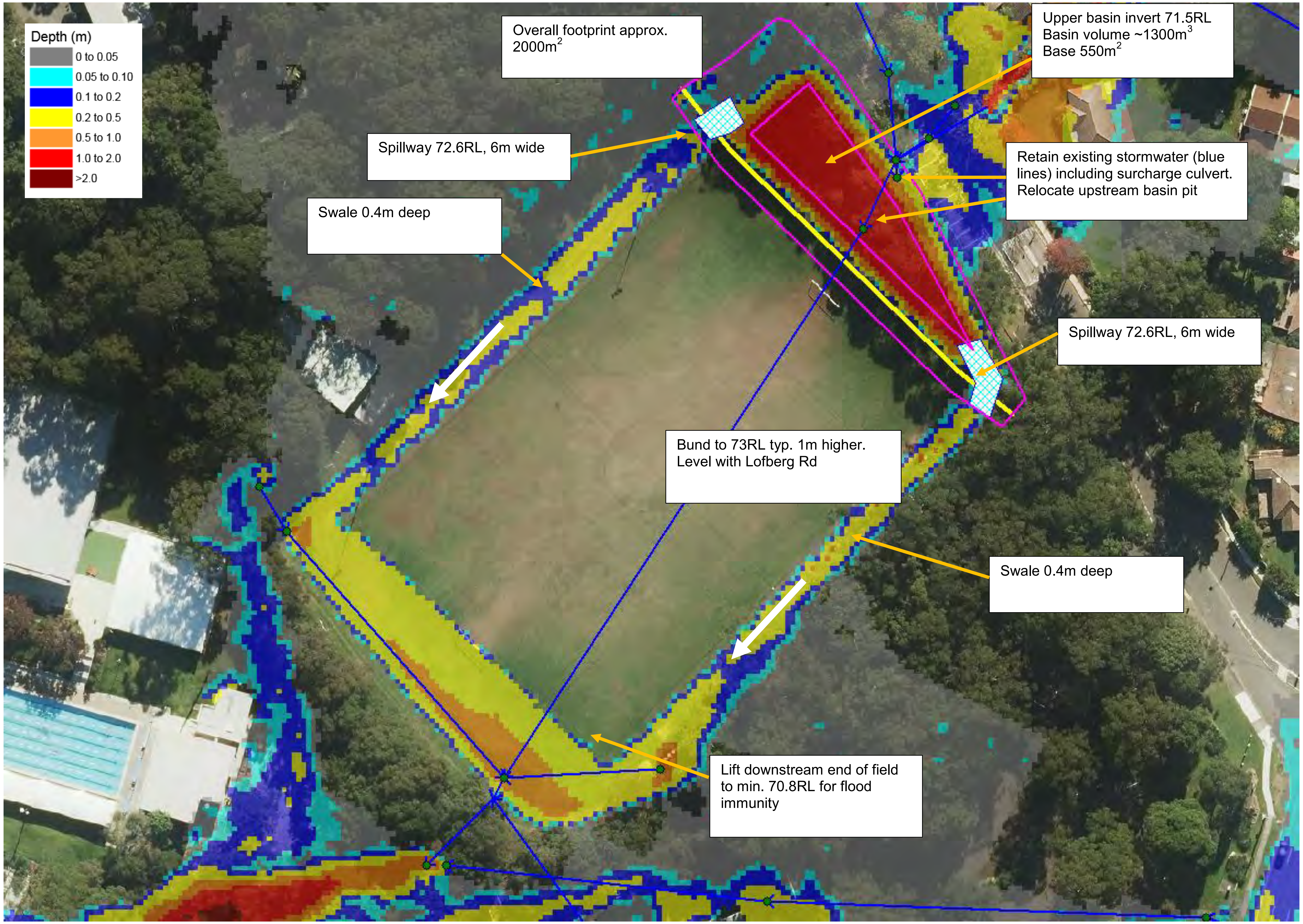


Figure 8-2 Layout of Alternative Mitigation Option



8.3 Modelling of Mitigation Options

8.3.1 Underground Detention Option

All flood events from the 0.2 EY up to the 1% AEP were assessed. The flood depths and changes in flood levels are mapped in **Appendix D**. The Oval is flood-free in the 2% AEP event, similar to the design case, due to the proposed inlet structures and berm/swale system intercepting all surface flows. Flood levels are slightly reduced from the existing case, by up to 0.01m in all events assessed.

In the 1% AEP event, there are minor overflows onto the upstream end of the Oval as the pit inlet capacity is exceeded. The downstream end of the sports field is inundated by floodwaters ponding in the low point of the Oval, noting that this exceeds the design objective of the field being flood free in up to the 2% AEP event. These floodwaters originate from the downstream basin pit surcharging in the 1% AEP event. This pit does not surcharge in the 2% AEP event.

Table A-1 in Appendix A compares the mitigation case peak flows with the existing case flows, indicating that peak flows are reduced by 0.2m^3/s, or up to 3.6%, in the 2% AEP event in Quarry Creek Location 4.

In summary, the modelling of the mitigation case indicates that the underground detention is effective at mitigating the peak outflow to near, or slightly below, existing rates, while achieving the design objective of the Oval being flood free up to the 2% AEP event.

8.3.2 Split Basin Option

All flood events from the 0.2 EY up to the 1% AEP were assessed. The flood depths and changes in flood levels are mapped in **Appendix E**. **Table A-1 in Appendix A** indicates that the alternative mitigation case slightly reduces the outflows into Quarry Creek when compared to existing. As a result, flood levels downstream of the basin are also slightly reduced. Flood levels upstream of the basin are also maintained at existing and there are no flooding impacts to upstream residences.

The sports field is flood free up to the 2% AEP event with floodwaters contained within the basin/s and drainage swales. The upper basin overflows over the crest by a depth of 60mm in the 1% AEP event, causing overflow of floodwaters onto the sports field. The upper basin does not overflow in the 2% AEP event. There is no surcharging of the downstream basin pit in events up to the 1% AEP event

In summary, the split basin mitigation option is effective at maintaining upstream and downstream flooding and hydraulic conditions, in addition to achieving the required flood immunity for the upgraded sports field.

8.4 Preliminary Cost Estimate

8.4.1 Underground detention tank

A preliminary cost estimate has been prepared based on unit costs in Rawlinson 2016 for the underground detention option, including:

- Supply and install underground detention tank including excavation
- Inlet works, including 4x letterbox pits (1m x 1m grate)
- 2x proprietary Gross Pollutant Traps located at the letterbox pits to capture leaf litter and sediment. This will limit the need to clean out the tank itself. Assume two pits can be connected to one GPT. Each GPT is required to have a treatment capacity of 1.5m^3/s (total flow intercepted is 3m^3/s, in the 2% AEP event).
- Outlet works, including trenching, supply and installation of 1x 1050mm pipe, connection to detention tank and connection to existing basin downstream pit. This assumes breaking into and connecting to the existing downstream pit, rather than demolition and reconstruction.

- Earthworks including spreading of excavated material and formation of bunds and swales. No offsite disposal of excavated material assumed.
- Supply and installation of the synthetic sports field is assumed to be additional. Cost estimate to be provided by supplier via Northern Suburbs Football Association (NSFA).
- Relocation of existing services excluded. Location and protection of services is included in the cost estimate. A location of services has not been undertaken to date.
- Management and disposal of contaminated material excluded.
- Removal and replacement of existing trees excluded. The detention tank is assumed to be located to avoid existing trees. It is assumed that the tank could be partially located under the field if required to avoid trees.
- An access road off Lofberg Road would be required for maintenance of the GPTs/pits. This is not included in the cost estimate.

Quotes were obtained for supply and installation of detention tank units from manufacturer Atlantis. Additional quotes have been sought from manufacturer Humes, but were not available in time for this memo.

The units from Atlantis are the Flo-Tank units, which are a modular box unit constructed with plastic matrix sides. These are stacked together to form the overall tank unit. These have been used in car parks and developments in Australia and may be suitable if low traffic and vehicular loads are expected on the Oval.

Quotes were sought from Humes on supply and installation of their Stormtrap units. These would be able to accommodate heavier vehicles, if required. A preliminary cost estimate has been prepared based on unit costs in Rawlinson 2016.

The cost estimate schedule of quantities are provided in **Appendix F.** The costs for the two proprietary products considered are:

- **Atlantis Flo-Tank: $1,720,000** (based on manufacturer quote)
- **Humes Stormtrap: $1,111,000** (based on unit costs in Rawlinson 2016). Note that this estimate is preliminary and pending a budget estimate to be provided by the supplier.

8.4.2 Split detention basin

A preliminary cost estimate has been prepared based on unit costs in Rawlinson 2016 for the split basin option, including:

- Earthworks including cut and fill to form the basin, spreading of excavated material and formation of bunds and swales. No offsite disposal of excavated material assumed.
- Modification of the existing drainage at the upstream end of the existing basin, including sealing the inlet of the existing pit (it will be located under the berm) and construction of new inlet pit in split basin low point and connection to existing pipes (existing 1050mm pipe to be cut to fit the new pit)
- Removal of up to 150 trees has been allowed for.
- Approximately 2600m^3 of clean fill to be imported to lift the sports field to required elevation to provide flood immunity against the 2% AEP event at downstream end.
- Supply and installation of the synthetic sports field is assumed to be additional. Cost estimate to be provided by supplier via Northern Suburbs Football Association (NSFA).
- Relocation of existing services excluded. Location and protection of services is included in the cost estimate. A location of services has not been undertaken to date.
- Management and disposal of contaminated material excluded.

The cost estimate schedule of quantities are provided in **Appendix F.** The cost for this option is estimated to be **$282,000**.

8.5 Selection of Preferred Option

Two feasible options have been identified and assessed in this study to maintain existing flow conditions in Quarry Creek downstream of the Oval. The first, the underground detention tank option, includes three options from two separate suppliers which vary in cost and suitability, depending on the vehicular load expected for the Oval. There is flexibility in the ability to locate an underground tank under the sports field to avoid existing environmental constraints if required.

The second option, the split basin option, is a less expensive option involving earthworks to construct a new detention basin and utilisation of a part of the existing basin storage to achieve flow mitigation. Limitations to this option include:

Limitations of this option include:

- A significant number of trees would need to be removed within the proposed footprint of the upper basin.
- The configuration shown on **Figure 4** assumes that the existing basin low point can be utilised for flood storage. This permits only sufficient space for a full sized soccer field. Older aerial photos on Google Maps indicates that the Oval is sometimes marked out to fit up to eight (approx.) junior/mini soccer pitches, which takes up the entire Oval including the existing basin low point. The split basin option would preclude the use of the Oval in this manner, or at least reduce the number of mini pitches which can be accommodated on the synthetic field surface.
- Public safety measures would need to be in place, such as safety fencing and signage, given that the upper basin would fill up to a depth of 1.5m during flood events.
- The basin is visually conspicuous, while the underground tank option is not visible.

Council, in consultation with NSFA, should consider factors including cost/available funding, space requirements for the sports field/s, space requirements for the mitigation options, likely usage (vehicular traffic) and environmental aspects, among others, in the selection of a preferred option.

The identified options are likely to represent the upper and lower bound costs to provide the required flood immunity to the playing field against the 2% AEP event. Design refinement is recommended at concept design to optimise against the various design requirements and constraints, which may reduce option sizing or introduce different elements, which will affect the final cost of the preferred option.

9. Conclusions and Recommendations

The following conclusions and recommendations are made:

- The existing DRAINS model was reviewed and updated as a part of this study, to reflect surveyed pit and pipe levels in and around the basin. The basin storage has been included in the model, with elevation versus storage area relationship estimated from LiDAR.
- Comparison of the DRAINS pit and pipe levels (derived from 2m contours) and LiDAR indicated inconsistencies between the data sets. To achieve a DRAINS model with accurate pit levels and relatively reliable pipe levels it is recommended that ground survey be undertaken to collect pit level data, at a minimum. If practical, depth to invert should also be measured/surveyed at the pits.
- For the purposes of the Norman Griffiths Oval flood assessment where the main hydraulic controls around the basin have been surveyed, the DRAINS pit/pipe levels are considered adequate to estimate basin inflows/outflows.
- A TUFLOW hydraulic model was developed for Lofberg Quarry catchment to establish existing flooding conditions in the vicinity of Norman Griffiths Oval.
- A flow bypass option which bypasses the existing detention basin on the Oval was assessed to achieve a 2% AEP flood immunity of the Oval, which is proposed to be upgraded to a synthetic pitch. Impacts to flooding downstream of the Oval include a 13% increase in the 0.2 EY flows and a 47% increase in 2% AEP flows. The flood impacts have the potential to cause erosion resulting in geomorphic change in the downstream creek channel. Impacts from flood level increases do not affect existing properties.
- An option consisting of an underground detention tank was assessed and demonstrated to maintain/slightly reduce downstream flows while achieving the required flood immunity for the sports field. Preliminary cost estimates for supply and install for two alternative proprietary products are:
  - **Atlantis Flo-Tank: $1,720,000** (based on manufacturer quote)
  - **Humes Stormtrap: $1,111,000** (based on unit costs in Rawlinson 2016). Note that this estimate is preliminary and pending a budget estimate to be provided by the supplier.

  Both units would accommodate light vehicle load if installed properly. There is some flexibility to place the units to avoid existing trees. GPTs are recommended to capture runoff-borne sediment to reduce the need to flush out the tank itself.
- Another option involving "**split basin**" was identified and assessed, involving construction of a new detention basin upstream of the sports field to partially provide the required detention volume. Part of the existing basin storage would provide the remaining required volume. This option was also demonstrated to maintain/slightly reduce downstream flows in addition to existing upstream and downstream flood levels, while achieving the required flood immunity for the sports field. This option has a lower cost of **$282,000** but limitations of this option include the need to remove a large number of trees, potential reduction of the total available area for sports field/s, additional public safety measures and aesthetic and visual aspects of a new detention basin. A GPT was not assumed to be required, but should be considered in the detailed design if a high risk of blockage due to leaf litter and debris is identified.
- The cost estimates provided in this report are for drainage and flood mitigation works only. The cost for supply and installation of the synthetic pitch for the sports field is additional to the costs for the drainage and flood mitigation works.
- Council, in consultation with NSFA, should consider factors including cost/available funding, space requirements for the sports field/s, space requirements for the mitigation options, likely usage (vehicular traffic) and environmental aspects, among others, in the selection of a preferred option.
- The identified options are likely to represent the upper and lower bounds for cost of flood mitigation works. Design refinement is recommended at concept design to optimise against the various design requirements and constraints, which may reduce option sizing or introduce different elements, which will affect the final cost of the preferred option.

- The flood assessment was undertaken using the 1987 AR&R and it is recommended that the flood immunity requirements for the playing field with the mitigation should be confirmed using the 2016 AR&R at the later stages of the design.

10. References

BMT WBM (2016) TUFLOW User Manual 2016-03-AA.

Engineers Australia (2003). Australian Rainfall and Runoff, a Guide for Flood Estimation. Vol. I and II. The Institution of Engineers, Australia.

Engineers Australia (2013). Australian Rainfall and Runoff Revision Projects – Project 11 Blockage of Hydraulic Structures Stage 2. The Institution of Engineers, Australia.

Mott Macdonald Hughes Trueman (2012) Ku-ring-gai Council Preliminary Flood Mapping Report. Prepared for Ku-ring-gai Council.

NSW Government (2005) Floodplain Development Manual.

URS (2006) Local Catchment Plan – Lane Cove River Southern Region Catchments. Prepared for Ku-ring-gai Council.

Watercom (2012) DRAINS User Manual.

11. Glossary

Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. In this study AEP has been used consistently to define the probability of occurrence of flooding. It is to be noted that design rainfalls used in the estimation of design floods up to and including 100 year ARI (ie. 1% AEP) events was derived from 1987 Australian Rainfall and Runoff. The following relationships between AEP and ARI applies to this study (AR&R, 2016).

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very frequent	**12**			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.50
	1	**63.2**	1.58	1.00
Frequent	0.69	**50.00**	2	1.44
	0.5	39.35	2.54	2.00
	0.22	**20.00**	5	4.48
	0.2	18.13	5.52	5.00
	0.11	**10.00**	10.00	9.49
Infrequent	0.05	**5.00**	20	20.0
	0.02	**2.00**	50	50.0
	0.01	**1.00**	**100**	100
Rare	0.005	0.50	**200**	200
	0.002	0.20	**500**	500
	0.001	0.10	**1000**	1000
	0.0005	0.05	**2000**	2000
Extremely Rare	0.0002	0.02	5000	5000
			↓	
Extreme			PMP	

Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.

Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrences of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Development	Is defined in Part 4 of the EP&A Act <u>In fill development</u>: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. New development: refers to development of a completely different nature to that associated with the former land use. Eg. The urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of exiting urban services, such as roads, water supply, sewerage and electric power. Redevelopment: refers to rebuilding in an area. Eg. As urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.
DRAINS	DRAINS is a computer program which is used to simulate local catchment rainfall-runoff and stormwater system hydraulics and is widely used across Australia.
Effective Warning Time	The time available after receiving advise of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
Exceedances per Year (EY)	The number of times an event is likely to occur or be exceeded within any given year.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.

Flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
Flood liable land	Is synonymous with flood prone land (i.e.) land susceptibility to flooding by the PMF event. Note that the term flooding liable land covers the whole floodplain, not just that part below the FPL (see flood planning area)
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is flood prone land.
Floodplain risk management options	The measures that might be feasible for the management of particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
Floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually include both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defines objectives.
Flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES.
Flood planning levels (FPLs)	Are the combination of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "designated flood" or the “flood standard” used in earlier studies.
Flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings and structures subject to flooding, to reduce or eliminate flood damages.
Flood readiness	Readiness is an ability to react within the effective warning time.
Flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. <u>Existing flood risk</u>: the risk a community is exposed to as a result of its location on the floodplain. <u>Future flood risk</u>: the risk a community may be exposed to as a result of new development on the floodplain. <u>Continuing flood risk</u>: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For

	an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
Flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
Hazard	A source of potential harm or situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community.
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
m AHD	Metres Australian Height Datum (AHD)
m/s	Metres per second. Unit used to describe the velocity of floodwaters.
m^3/s	Cubic metres per second or "cumecs". A unit of measurement of creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
Modification measures	Measures that modify either the flood, the property or the response to flooding.
Overland flow path	The path that floodwaters can follow as they are conveyed towards the main flow channel or if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation couplet with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain.

Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall which actually ends up as a streamflow, also known as rainfall excess.
Stage	Equivalent to water level (both measured with reference to a specified datum)
TUFLOW	TUFLOW is a computer program which is used to simulate free-surface flow for flood and tidal wave propagation. It provides coupled 1D and 2D hydraulic solutions using a powerful and robust computation. The engine has seamless interfacing with GIS and is widely used across Australia.

Appendix A. Tabulated Summary of Flows for each Scenario

Figure A-1 Flow summary locations. 2% AEP existing flood depths shown

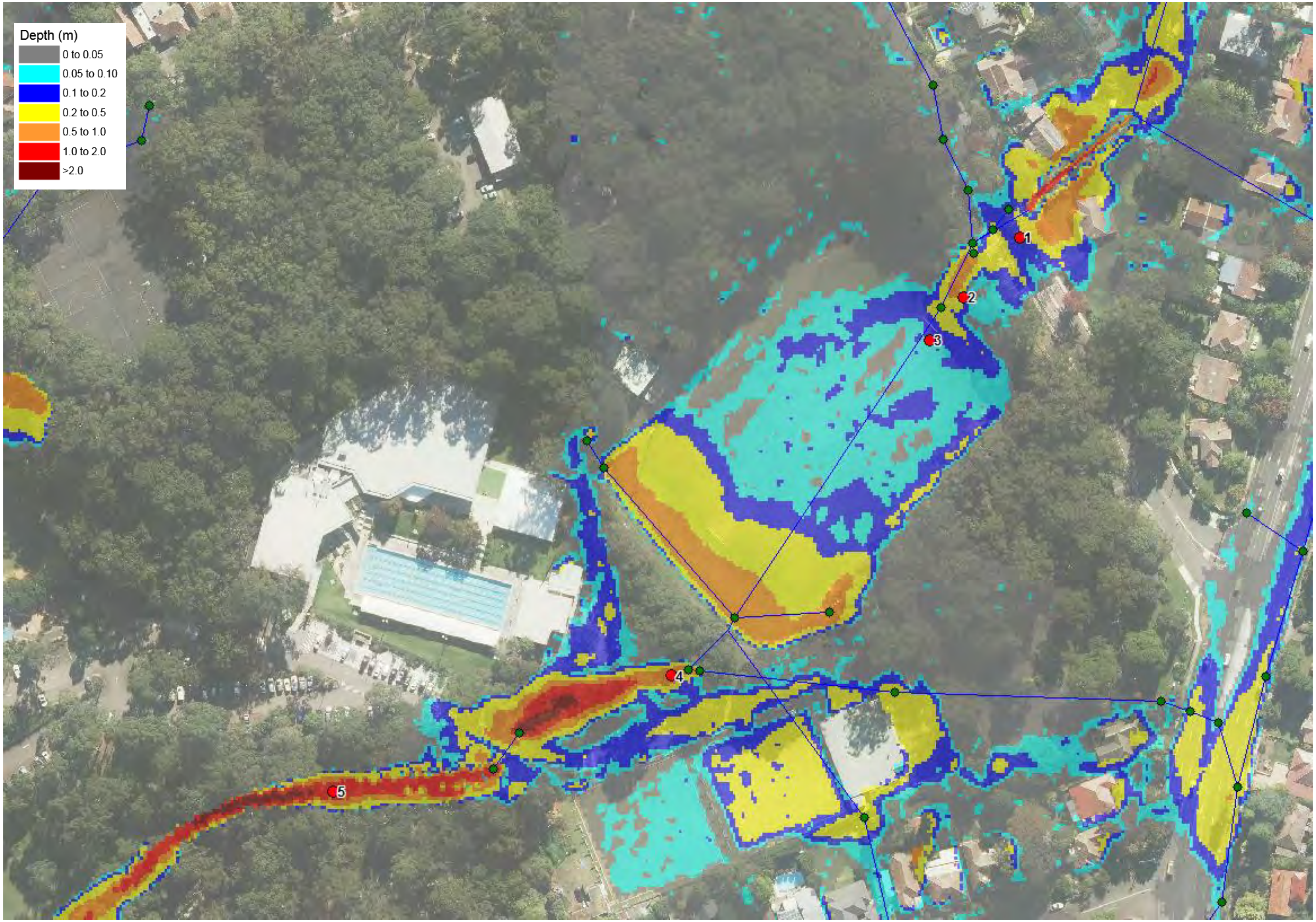


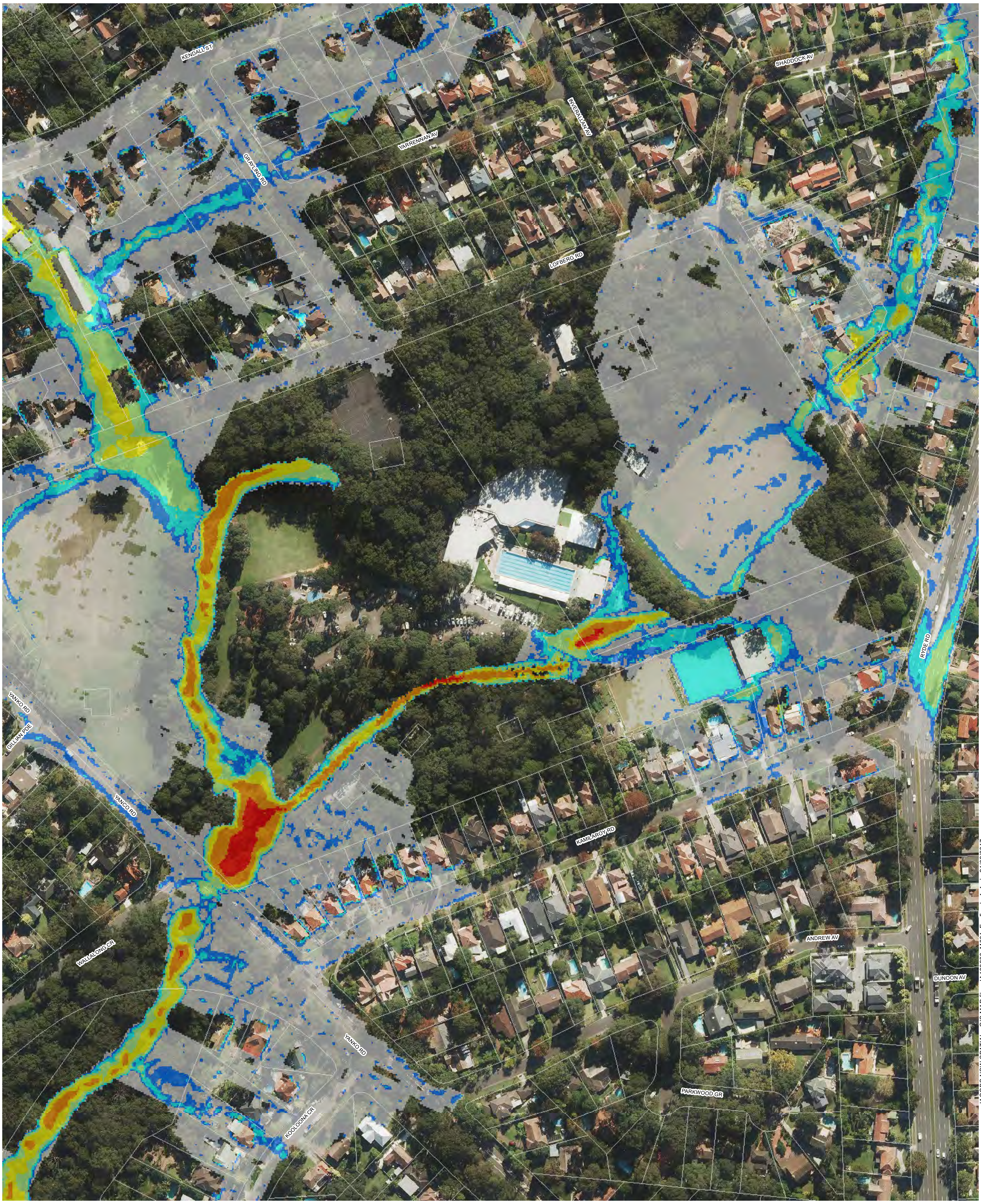
Table 1 Summary of flows for Existing, Design and Mitigation Cases

		Existing			Des_002			Mit_004			Mit_005			
		Existing			Design (no mitigation)			Mitigation (underground detention)			Alternative Mitigation (split basin)			
Location		Overland	Pipe	Total	Overland	Pipe	Total	Overland	Pipe	Total	Overland	Pipe	Total	
0.2 EY (5yr)														
1	Lofberg Road	0.7	2.6	3.3	0.7	3.7	4.4	0.7	2.6	3.3	0.7	2.7	3.4	
2	Between Lofberg Rd and Oval	1.0	2.6	3.6	0.4	3.7	4.2	0.5	2.6	3.1	0.5	2.7	3.2	
3	on Oval	0.7	3.0	3.7	0.0	3.8	3.8	0.0	3.0	3.0	0.0	3.1	3.1	
4	Discharge to Quarry Creek	4.5	0.0	4.5	5.1	0.0	5.1	4.3	0.0	4.3	4.4	0.0	4.4	
5	Quarry Creek	5.5	0.0	5.5	6.0	0.0	6.0	5.3	0.0	5.3	5.4	0.0	5.4	
10% AEP (10yr)														
1	Lofberg Road	0.7	2.6	3.3	0.7	4.1	4.8	0.7	2.7	3.4	0.7	2.8	3.5	
2	Between Lofberg Rd and Oval	1.5	2.6	4.1	0.6	4.1	4.7	1.4	2.7	4.1	0.3	2.8	3.1	
3	on Oval	1.2	3.1	4.3	0.0	4.4	4.4	0.0	3.5	3.5	0.0	3.3	3.3	
4	Discharge to Quarry Creek	5.0	0.0	5.0	6.0	0.0	6.0	4.8	0.0	4.8	4.8	0.0	4.8	
5	Quarry Creek	6.2	0.0	6.2	7.4	0.0	7.4	6.1	0.0	6.1	6.2	0.0	6.2	
5% AEP (20yr)														
1	Lofberg Road	1.5	2.7	4.2	1.0	4.2	5.2	1.5	2.7	4.2	1.3	2.8	4.1	
2	Between Lofberg Rd and Oval	2.4	2.7	5.1	0.8	4.2	5.0	2.4	2.7	5.1	0.6	2.8	3.4	
3	on Oval	2.2	3.2	5.4	0.0	5.2	5.2	0.0	4.3	4.3	0.0	3.4	3.4	Note: 0.7cumec bypassing oval in swales
4	Discharge to Quarry Creek	5.4	0.0	5.4	7.3	0.0	7.3	5.1	0.0	5.1	5.2	0.0	5.2	
5	Quarry Creek	7.2	0.0	7.2	8.9	0.0	8.9	6.9	0.0	6.9	7.2	0.0	7.2	
2% AEP (50yr)														
1	Lofberg Road	2.6	2.7	5.3	1.4	5.0	6.4	2.6	2.7	5.3	2.6	2.7	5.3	
2	Between Lofberg Rd and Oval	2.6	2.7	5.3	1.2	5.0	6.2	2.5	2.7	5.2	2.5	2.7	5.2	
3	on Oval	3.3	3.2	6.5	0.0	6.2	6.2	0.0	4.6	4.6	0.0	3.3	3.3	Note: 2cumec bypassing oval in swales
4	Discharge to Quarry Creek	5.7	0.0	5.7	8.4	0.0	8.4	5.5	0.0	5.5	5.5	0.0	5.5	
5	Quarry Creek	7.9	0.0	7.9	10.7	0.0	10.7	7.7	0.0	7.7	7.8	0.0	7.8	
1% AEP (100yr)														
1	Lofberg Road	3.4	2.7	6.1	1.5	5.5	7.0	3.4	2.7	6.1	3.5	2.7	6.2	
2	Between Lofberg Rd and Oval	4.3	2.7	7.0	1.1	5.5	6.6	4.2	2.7	6.9	1.4	2.7	4.1	
3	on Oval	4.2	3.1	7.3	0.0	6.9	6.9	0.0	5.7	5.7	0.4	3.3	3.7	Note: 2.5cumec bypassing oval in swales
4	Discharge to Quarry Creek	6.1	0.0	6.1	9.5	0.0	9.5	6.0	0.0	6.0	5.8	0.0	5.8	
5	Quarry Creek	8.8	0.0	8.8	12.5	0.0	12.5	8.8	0.0	8.8	8.8	0.0	8.8	

NOTES (refer to colour-coded cells in table)

1. zero overland flows on Oval in Design and Mitigation Cases. Except split basin option in 1% AEP
2. Design case results in 13% increase in 20% AEP flows, and 47% increase in 2% AEP flows in creek downstream of Oval.
3. Mitigation case maintains (slight reduction) existing flows in creek downstream of Oval.

Appendix B. Existing Case Flood Mapping



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M001_Ex_5y_d_r1v1 | 21/02/2017

Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

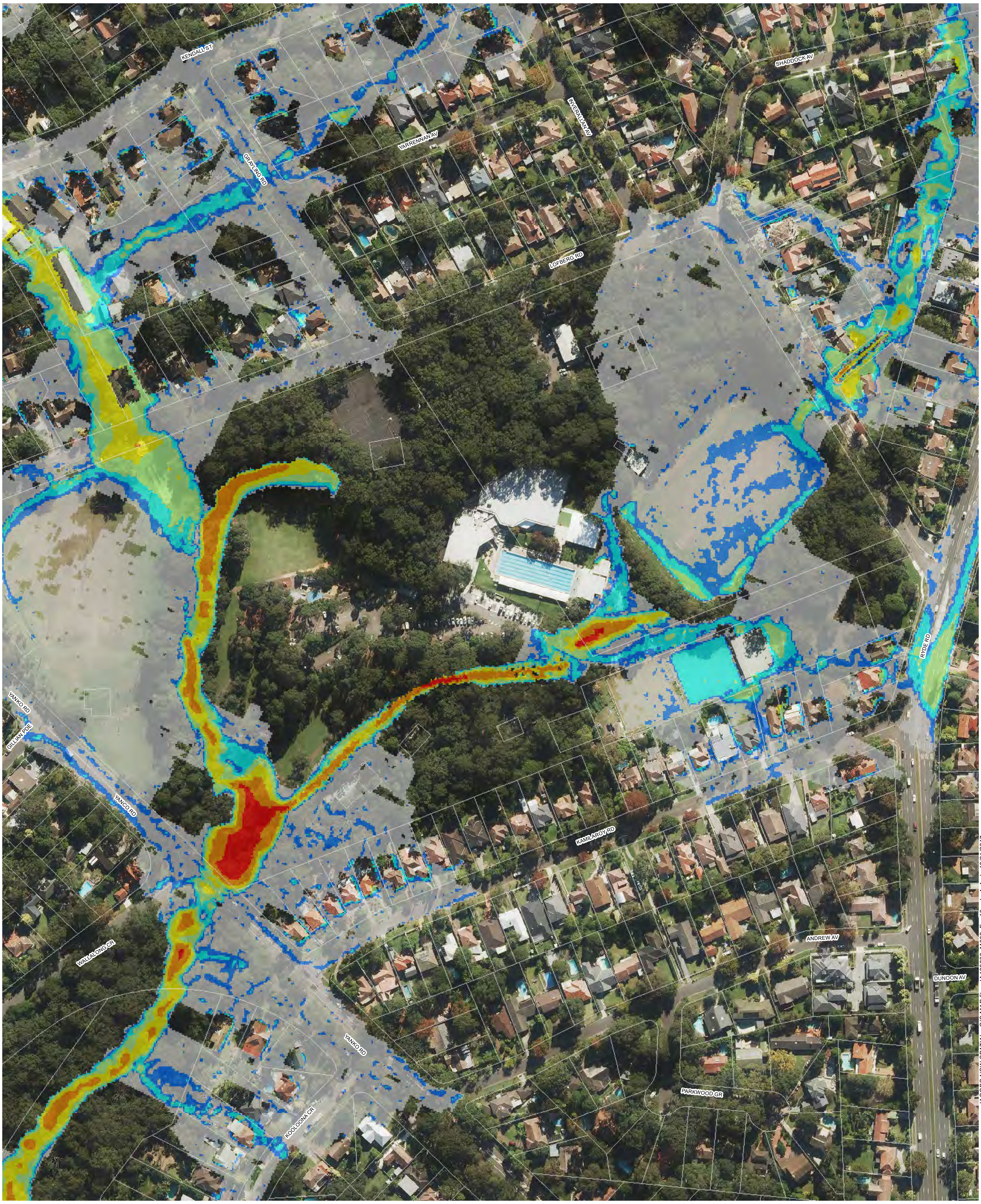
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 1 | 0.2 EY Flood Depth - Existing Case

JACOBS



Legend

0 50 100m
1:2,500 @ A3

N

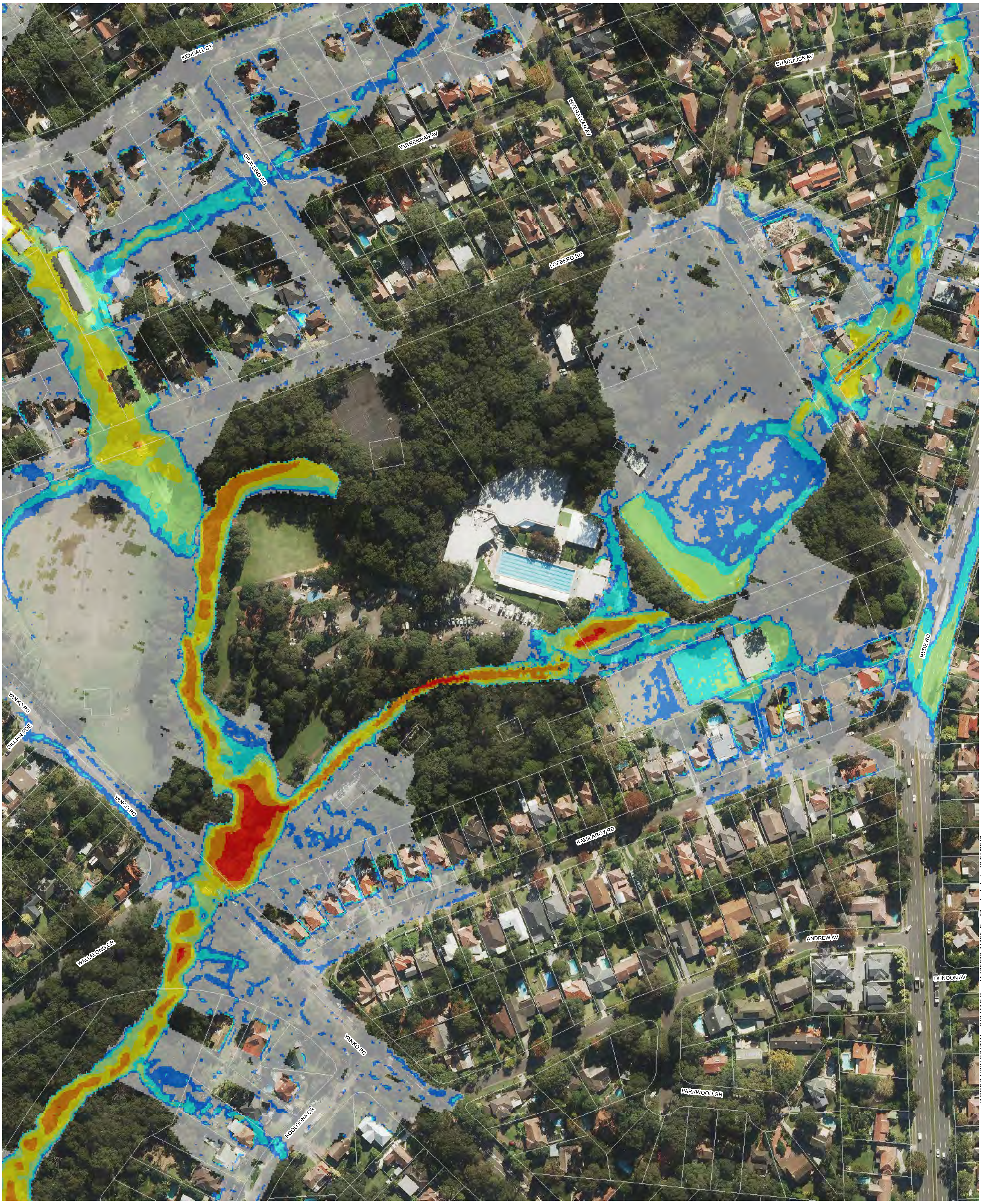
Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 2 | 10% AEP Flood Depth - Existing Case

JACOBS



Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

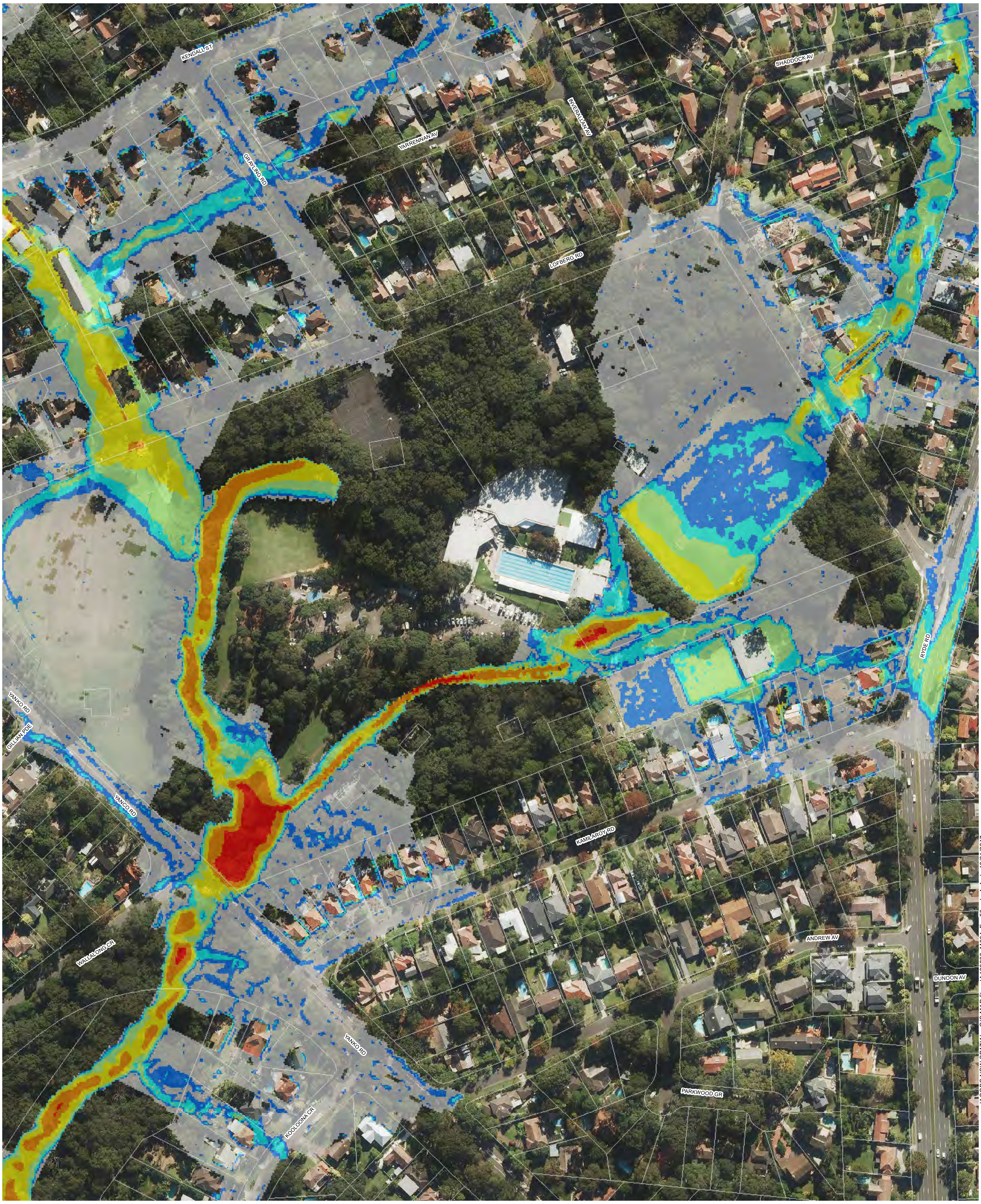
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 3 | 5% AEP Flood Depth - Existing Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M004_Ex_50y_d_r1v1 | 18/01/2017

Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

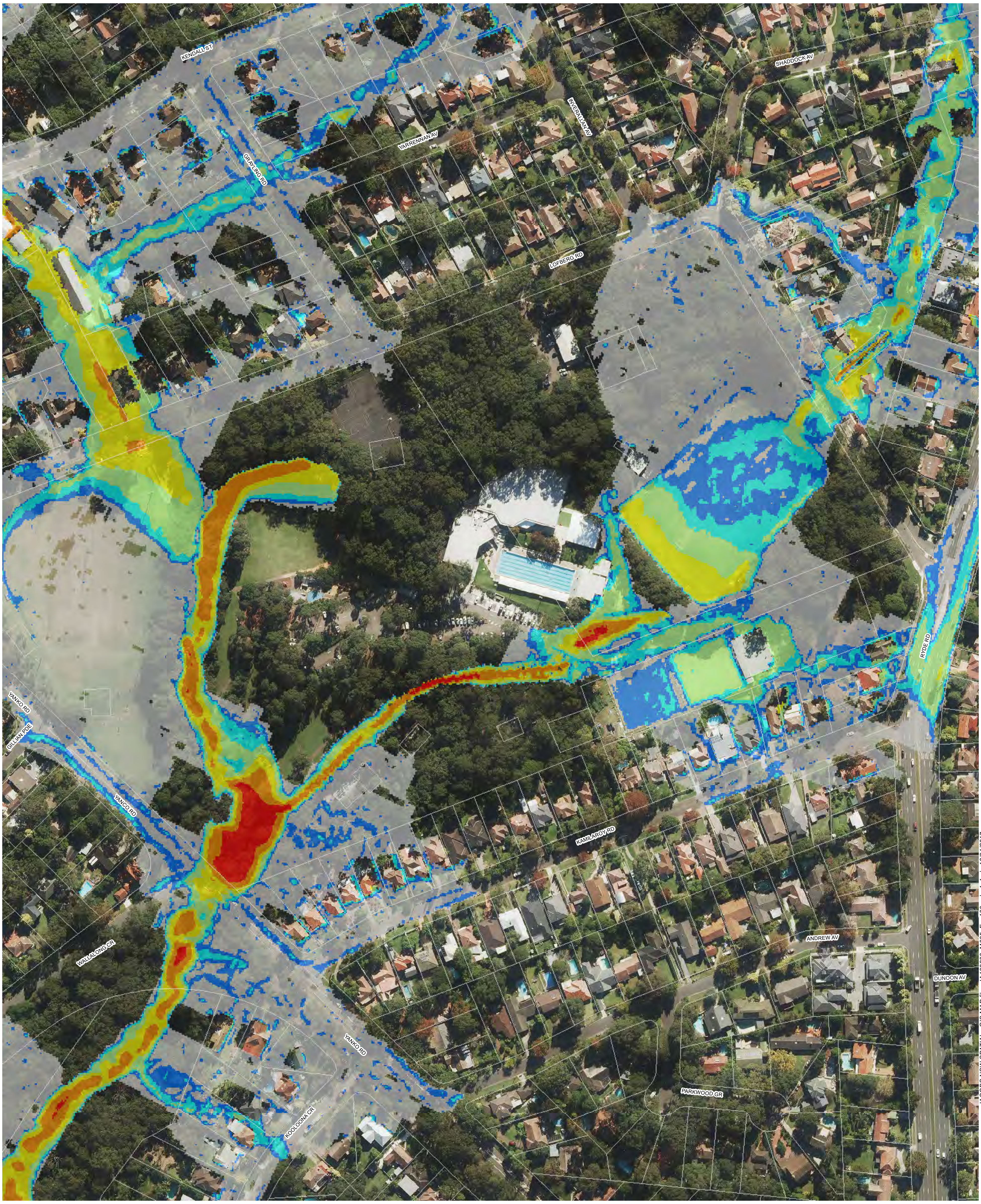
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 4 | 2% AEP Flood Depth - Existing Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M005_Ex_100y_d_r1v1 | 18/01/2017

Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

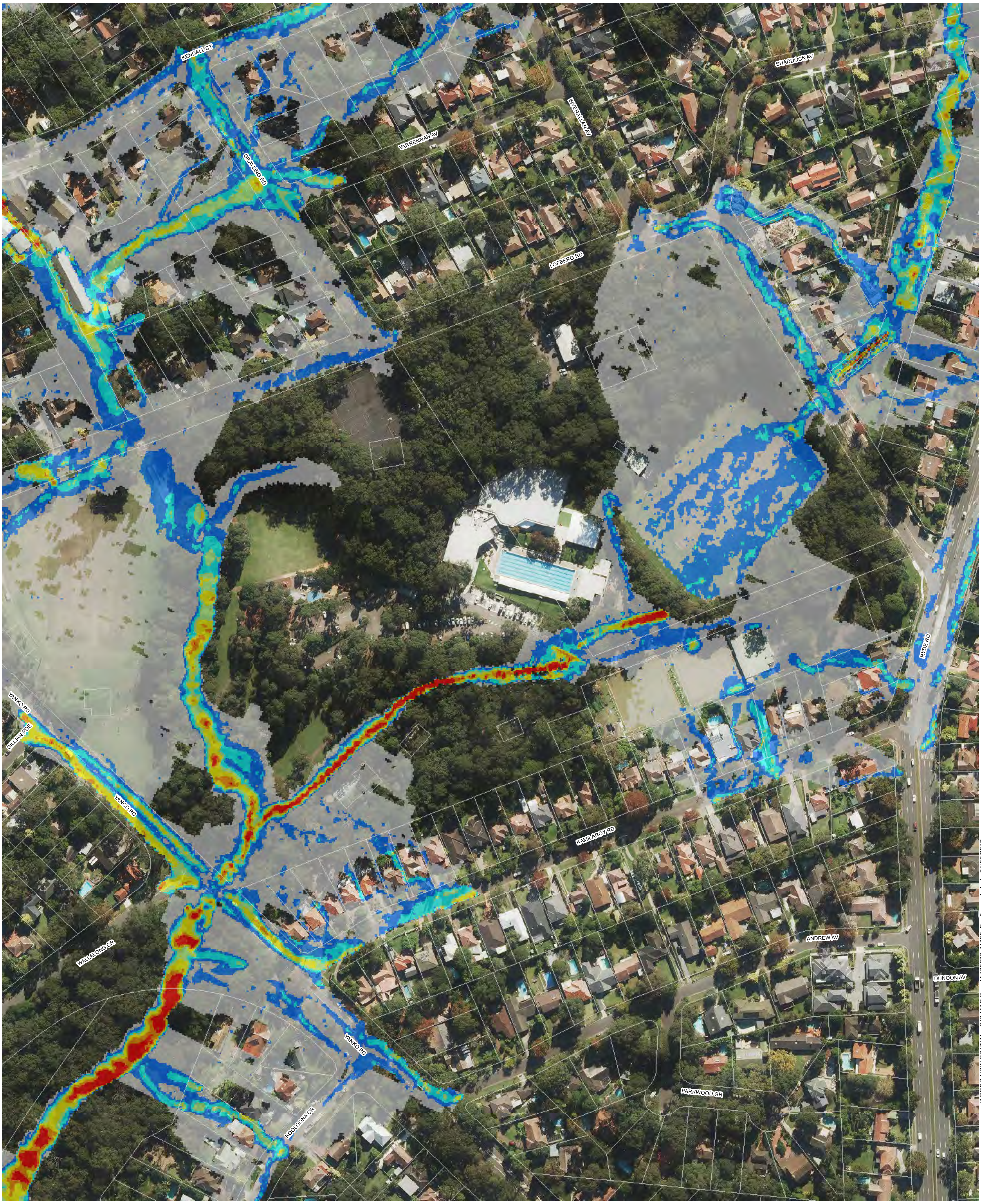
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 5 | 1% AEP Flood Depth - Existing Case

JACOBS



Legend

0 50 100m
1:2,500 @ A3

N

Peak velocity (m/s)

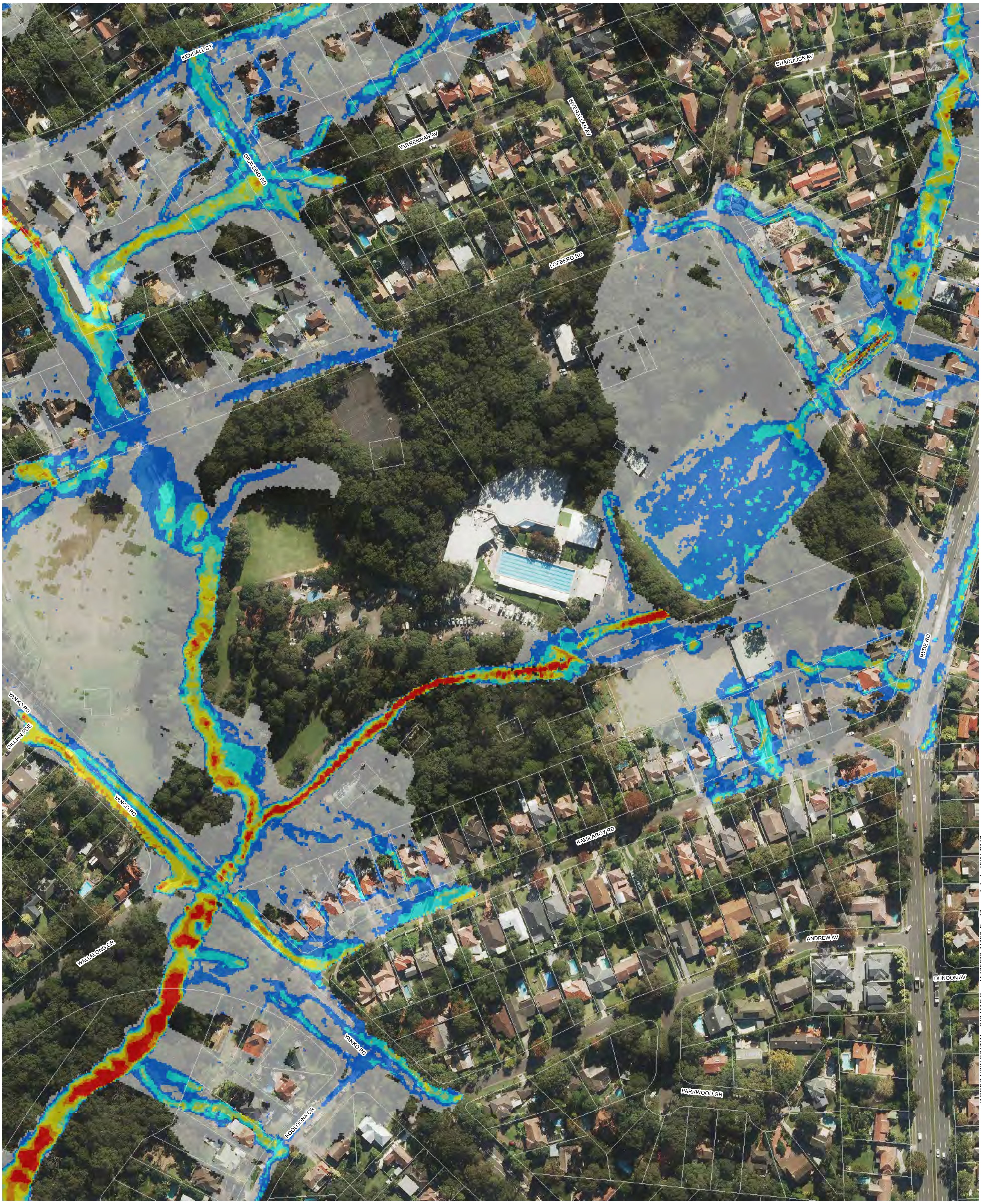
- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

Data sources

Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 6 | 0.2 EY Flow Velocity - Existing Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M007_Ex_10y_v_r1v1 | 18/01/2017

0 50 100m
1:2,500 @ A3

N

Legend

Peak velocity (m/s)

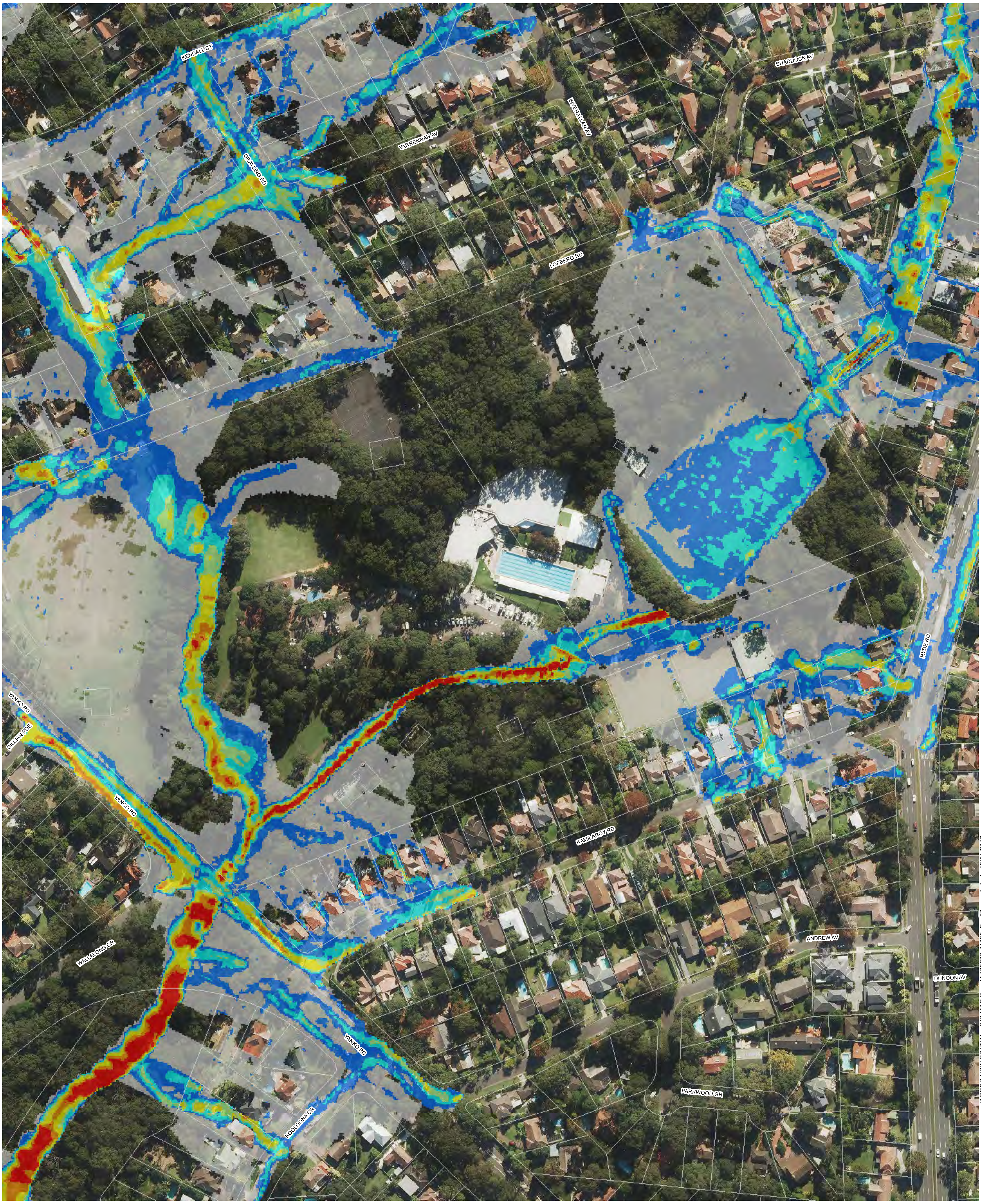
- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

Data sources

Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 7 | 10% AEP Flow Velocity - Existing Case

JACOBS



Legend

Peak velocity (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

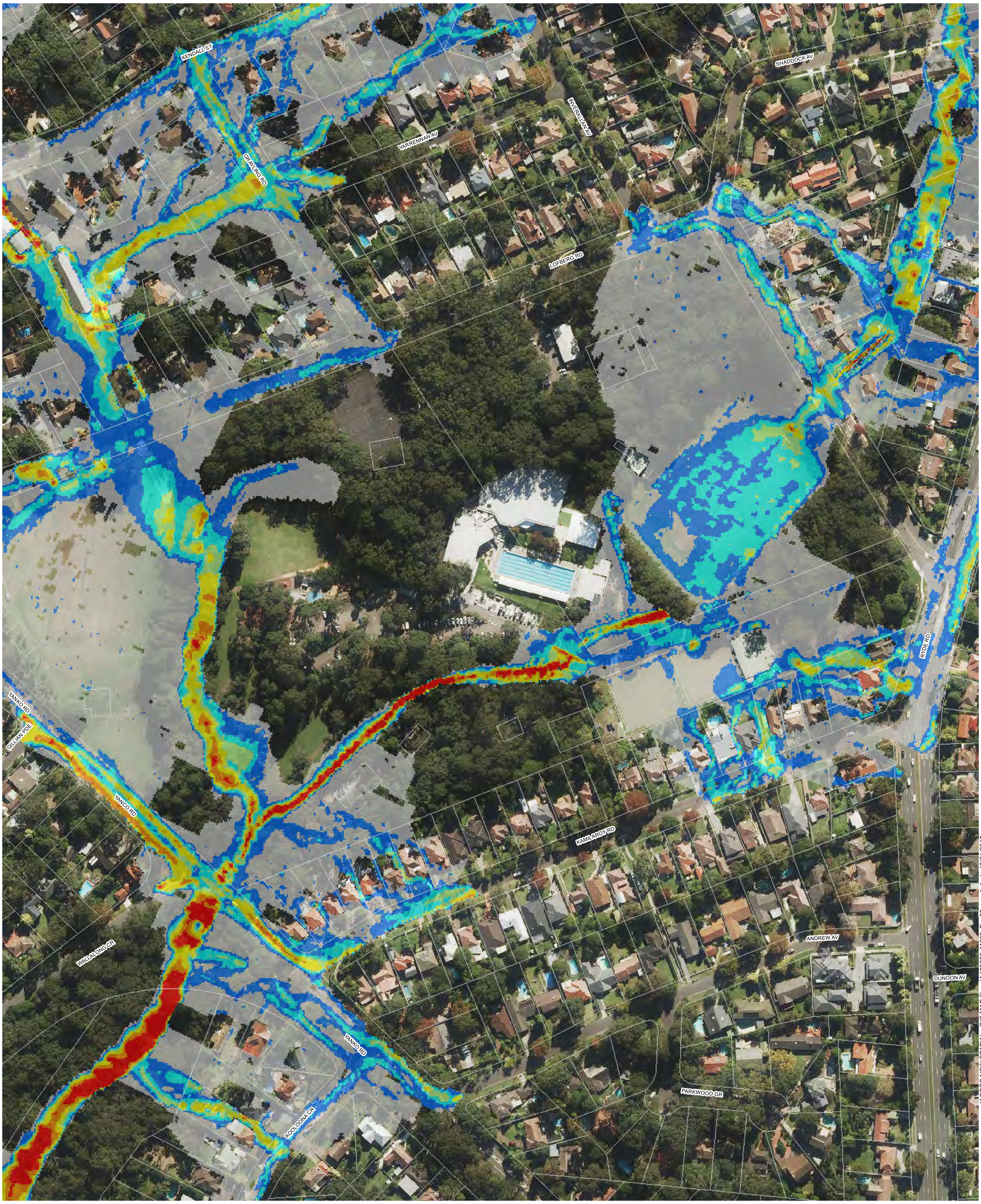
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 8 | 5% AEP Flow Velocity - Existing Case

JACOBS



Legend

Peak velocity (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

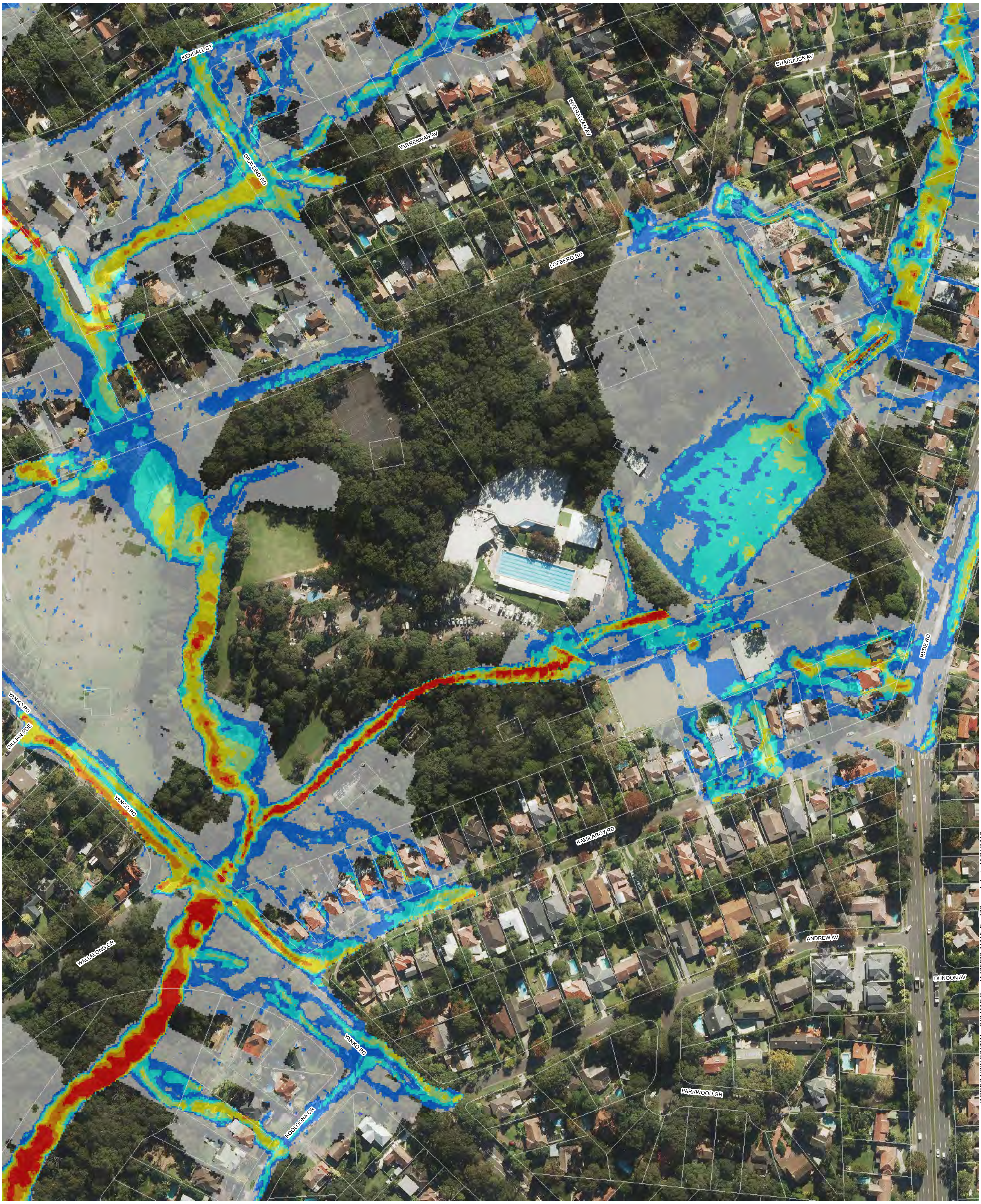
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 9 | 2% AEP Flow Velocity - Existing Case

JACOBS



Legend

Peak velocity (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

0 50 100m
1:2,500 @ A3

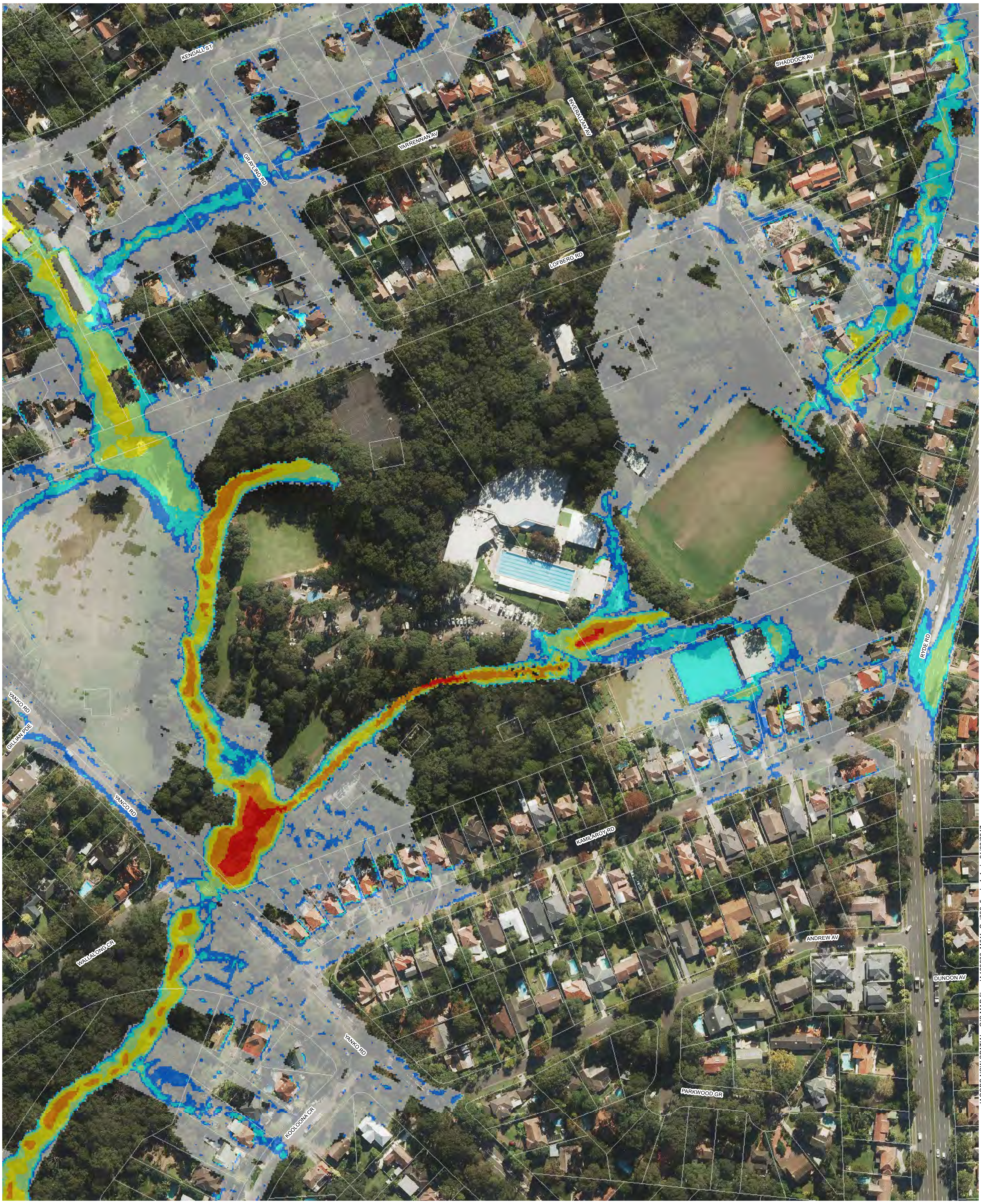
N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 10 | 1% AEP Flow Velocity - Existing Case

JACOBS

Appendix C. Design Case Flood Mapping (No Mitigation)



Legend

0 50 100m
1:2,500 @ A3

N

Peak flood depth (m)

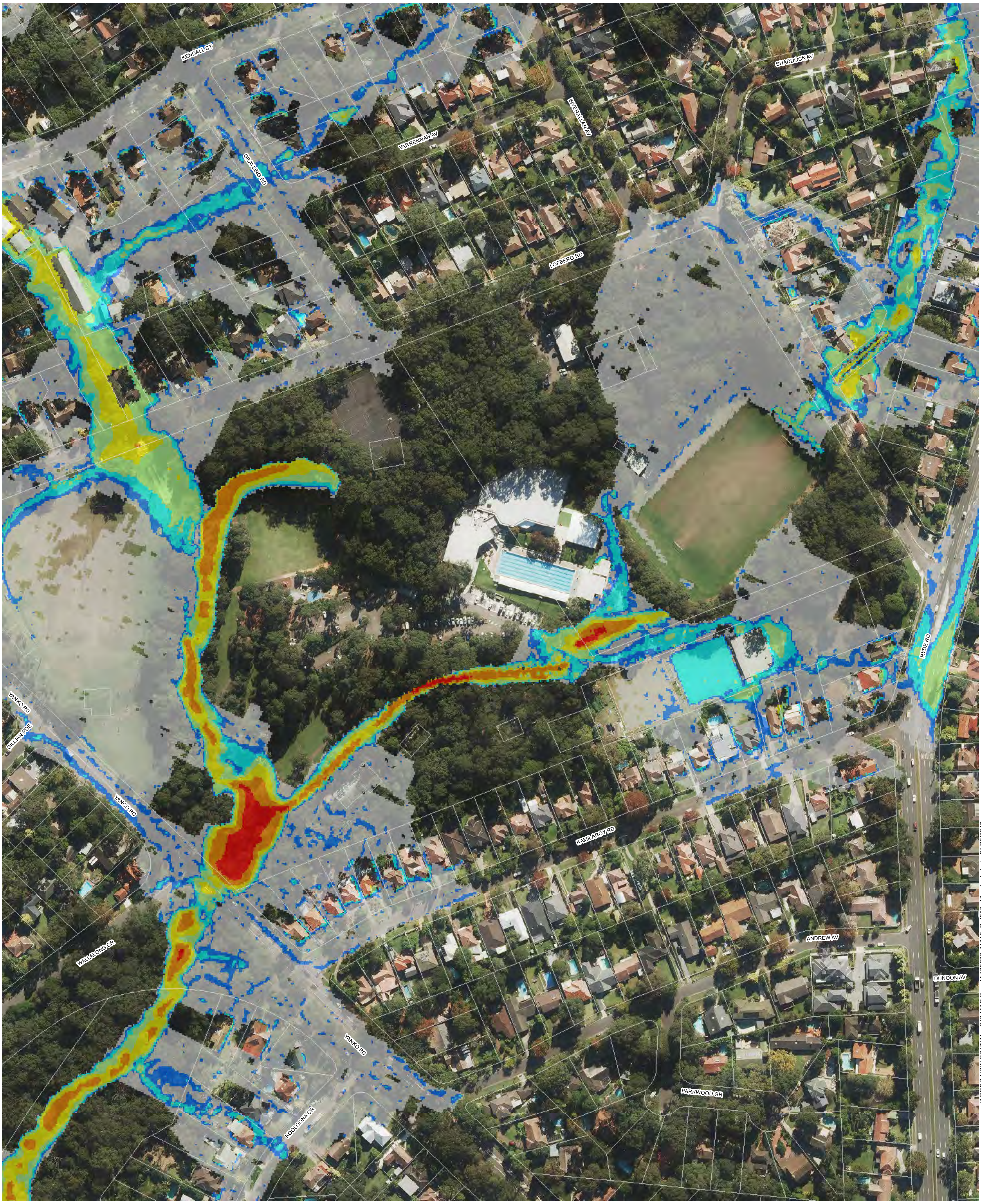
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

NOTE: Design_002 includes upgrade of existing 1 x 1050mm pipe between Lofberg Road and downstream creek, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 11 | 0.2 EY Flood Depth - Design_002 Case

JACOBS



Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

0 50 100m
1:2,500 @ A3

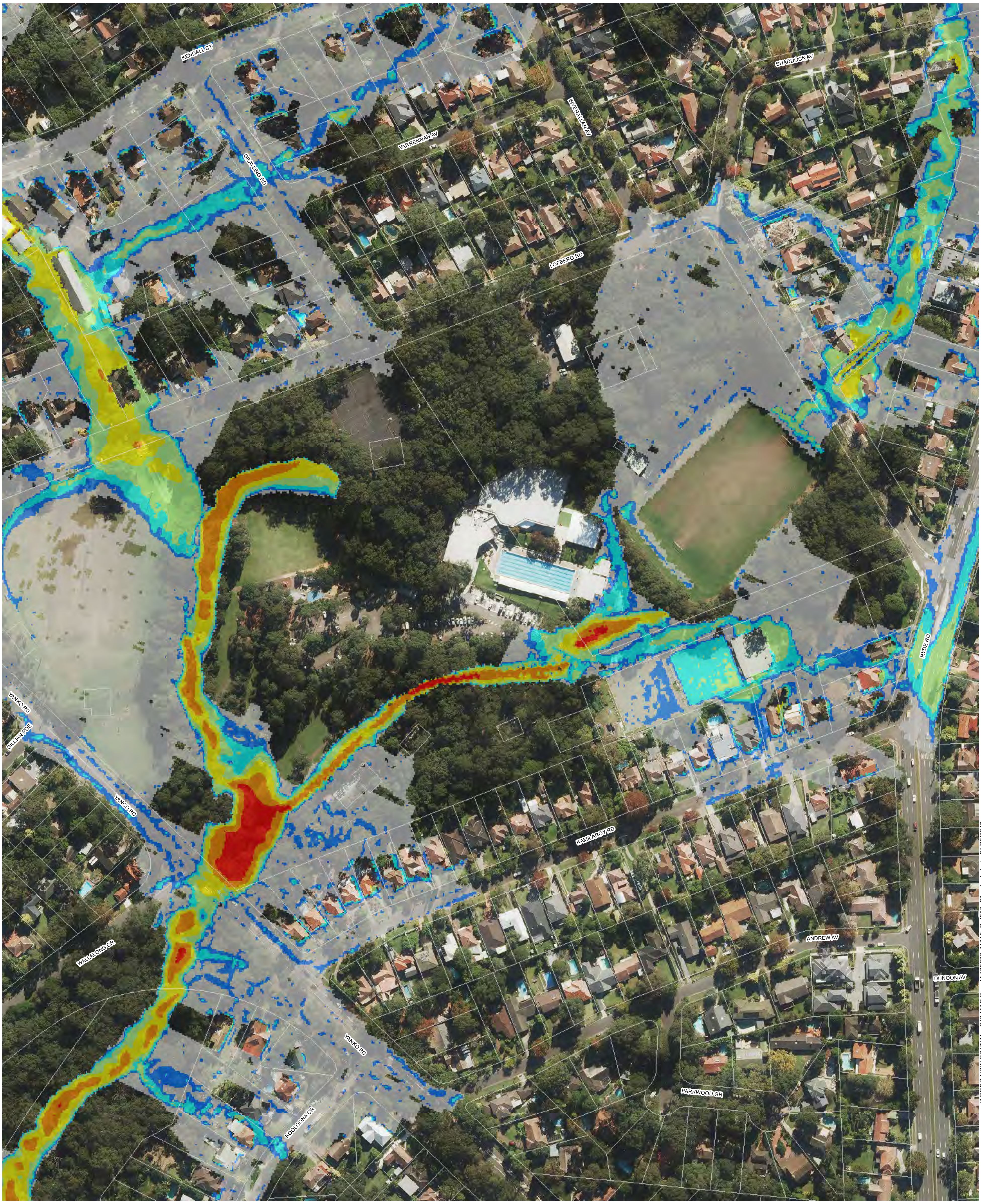
N

NOTE: Design_002 includes upgrade of existing 1 x 1050mm pipe between Lofberg Road and downstream creek, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 12 | 10% AEP Flood Depth - Design_002 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M013_Opt002_20y_d_r1v1 | 21/02/2017

Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

0 50 100m
1:2,500 @ A3

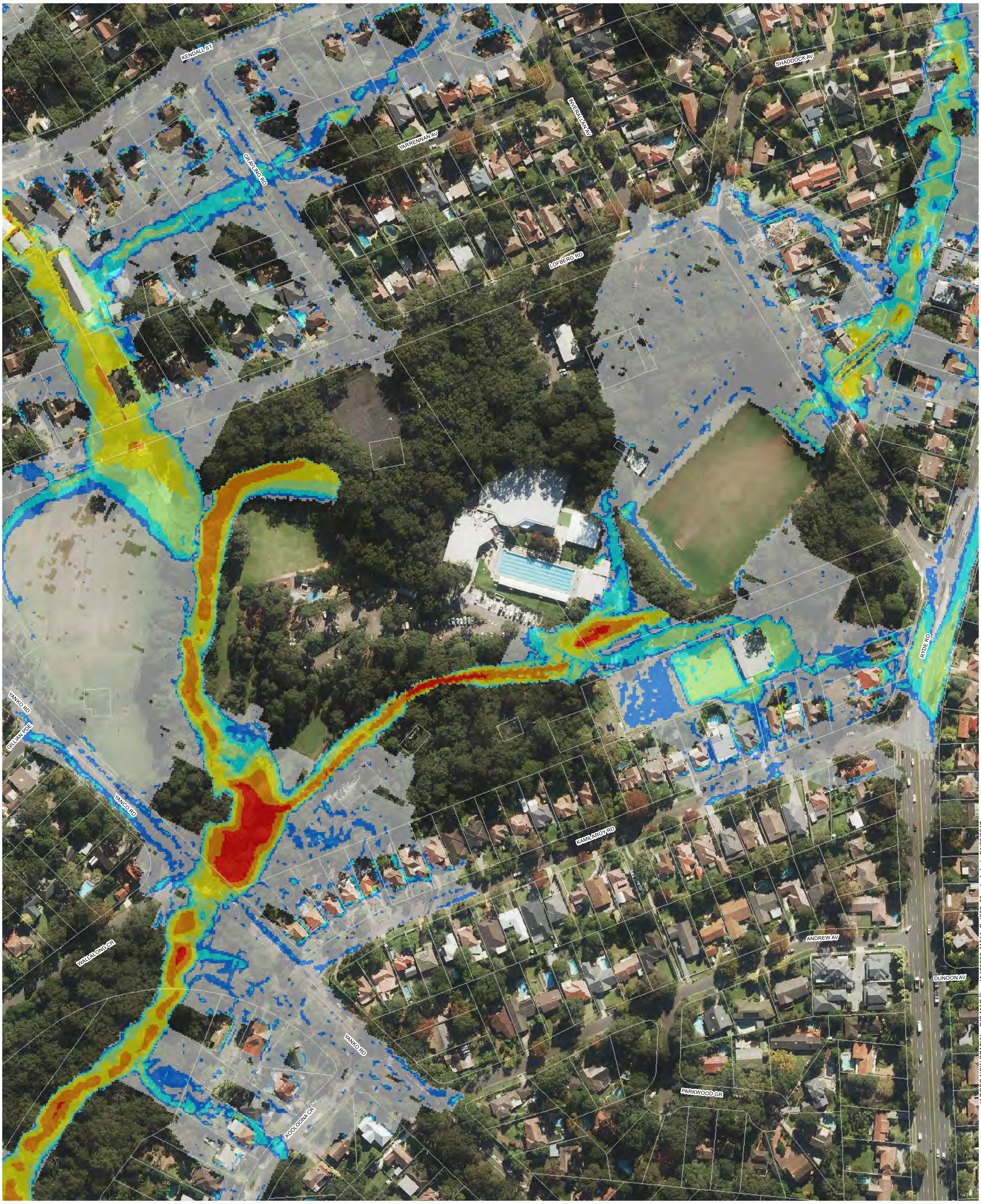
N

NOTE: Design_002 includes upgrade of existing 1 x 1050mm pipe between Lofberg Road and downstream creek, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 13 | 5% AEP Flood Depth - Design_002 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M014_Opt002_50y_d_r1v1 | 21/02/2017

0 50 100m
1:2,500 @ A3

N

Legend

Peak flood depth (m)

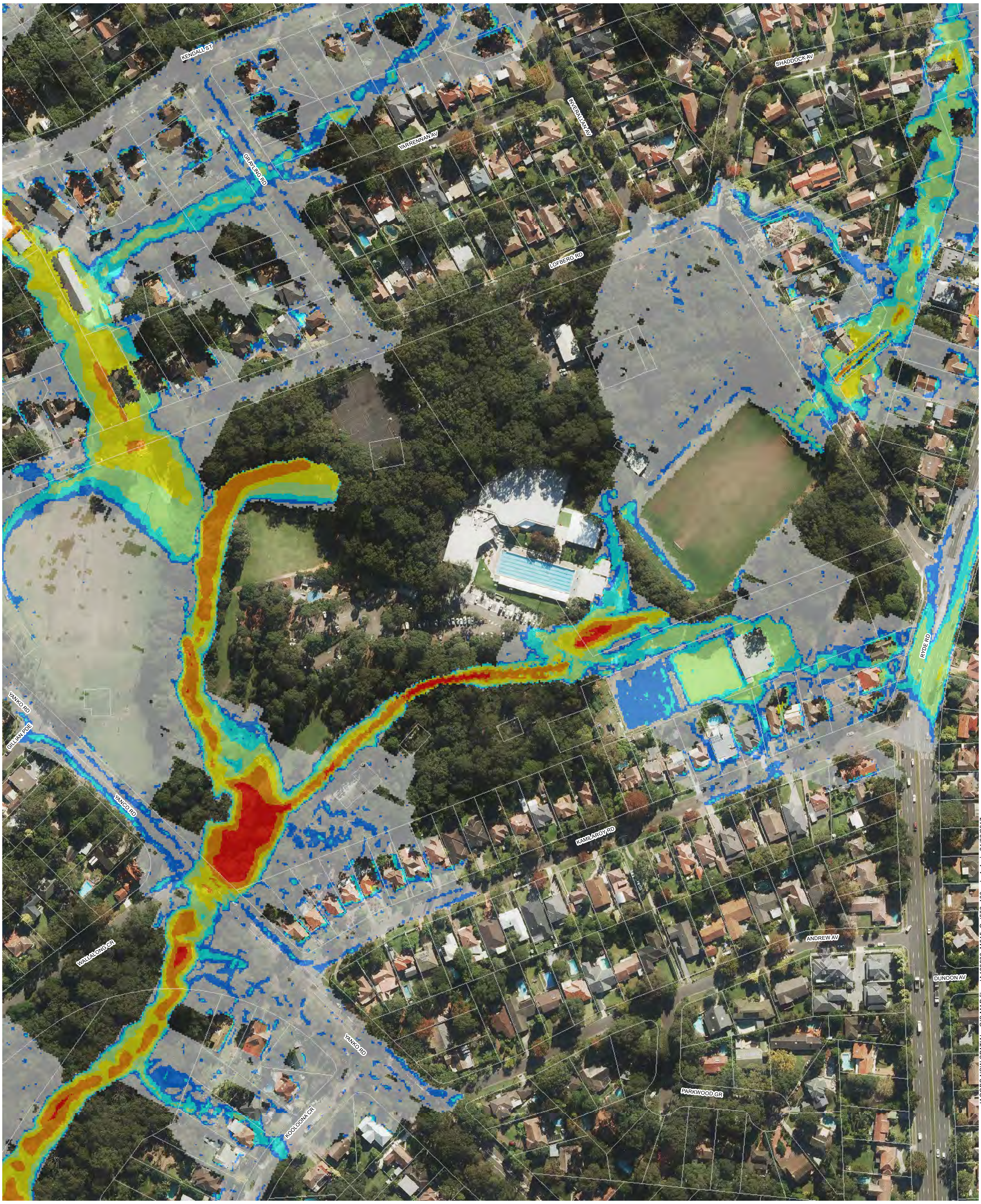
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

NOTE: Design_002 includes upgrade of existing 1 x 1050mm pipe between Lofberg Road and downstream creek, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 14 | 2% AEP Flood Depth - Design_002 Case

JACOBS



Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

0 50 100m
1:2,500 @ A3

N

NOTE: Design_002 includes upgrade of existing 1 x 1050mm pipe between Lofberg Road and downstream creek, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 15 | 1% AEP Flood Depth - Design_002 Case

JACOBS

JACOBS NSW SPATIAL - GIS MAP file : IA133200_M016_Opt002_5y_dh_r1v1 | 21/02/2017

Legend

0 50 100m
1:2,500 @ A3
N

Change in Flood Level (m)

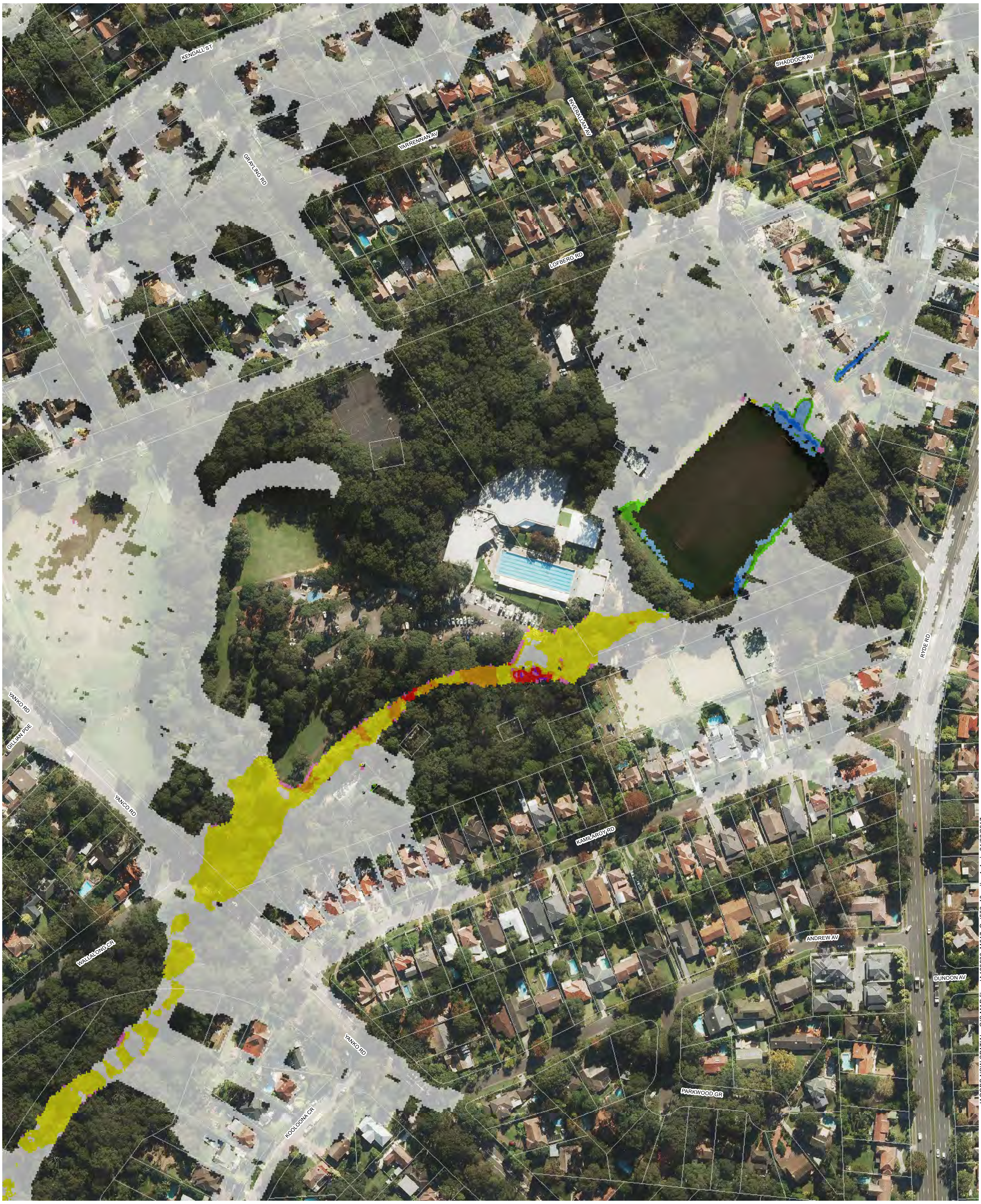
- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

NOTE: Design_002 includes upgrade of existing 1 x 1050mm pipe between Lofberg Road and downstream creek, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 16 | 0.2 EY Change in Flood Level - Design_002 Case

JACOBS



Legend

0 50 100m
1:2,500 @ A3

N

Change in Flood Level (m)

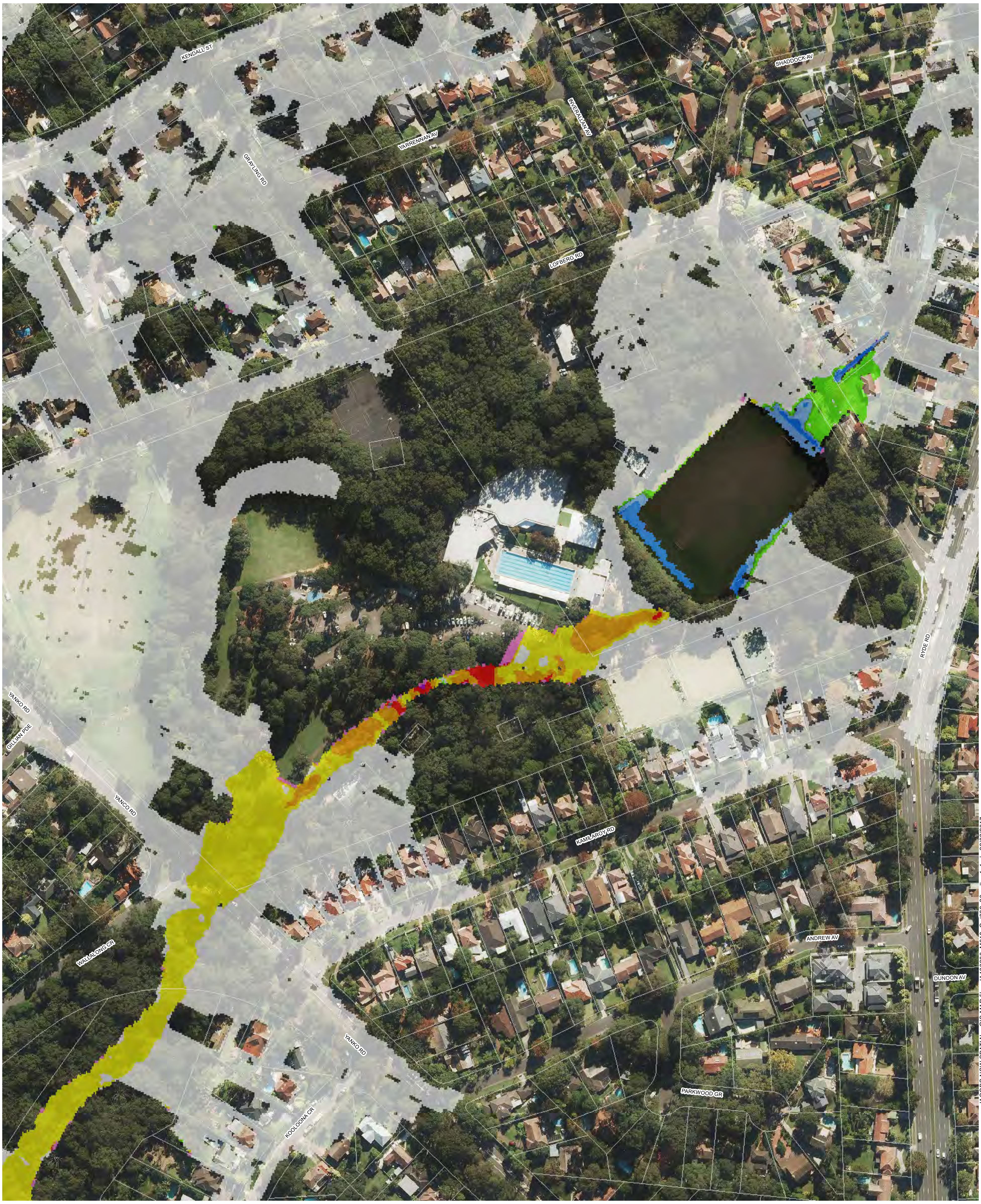
- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

NOTE: Design_002 includes upgrade of existing 1 x 1050mm pipe between Lofberg Road and downstream creek, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 17 | 10% AEP Change in Flood Level - Design_002 Case

JACOBS



Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

0 50 100m
1:2,500 @ A3

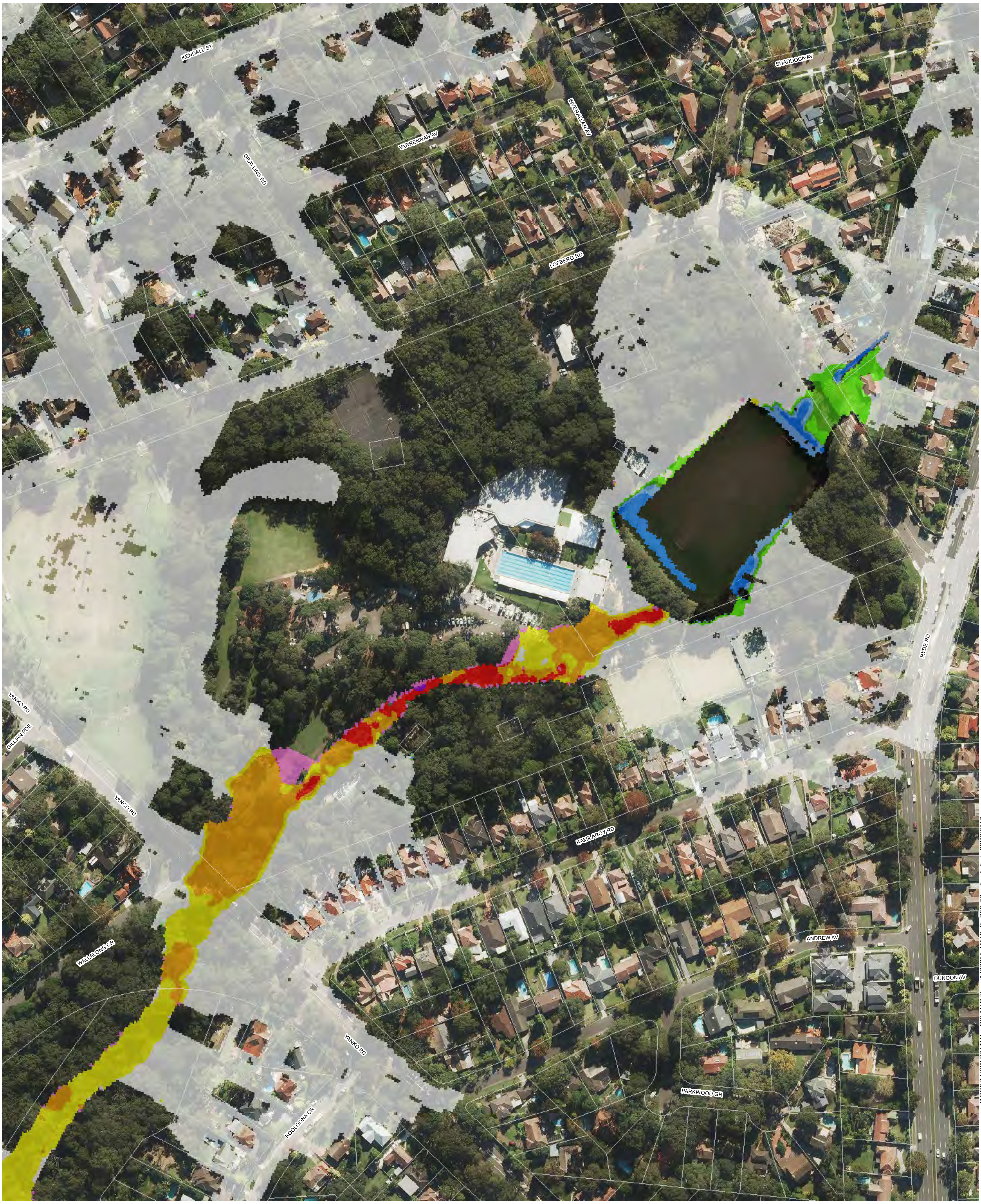
N

NOTE: Design_002 includes upgrade of existing 1 x 1050mm pipe between Lofberg Road and downstream creek, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 18 | 5% AEP Change in Flood Level - Design_002 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M019_Opt002_50y_dh_r1v1 | 22/02/2017

Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

0 50 100m
1:2,500 @ A3

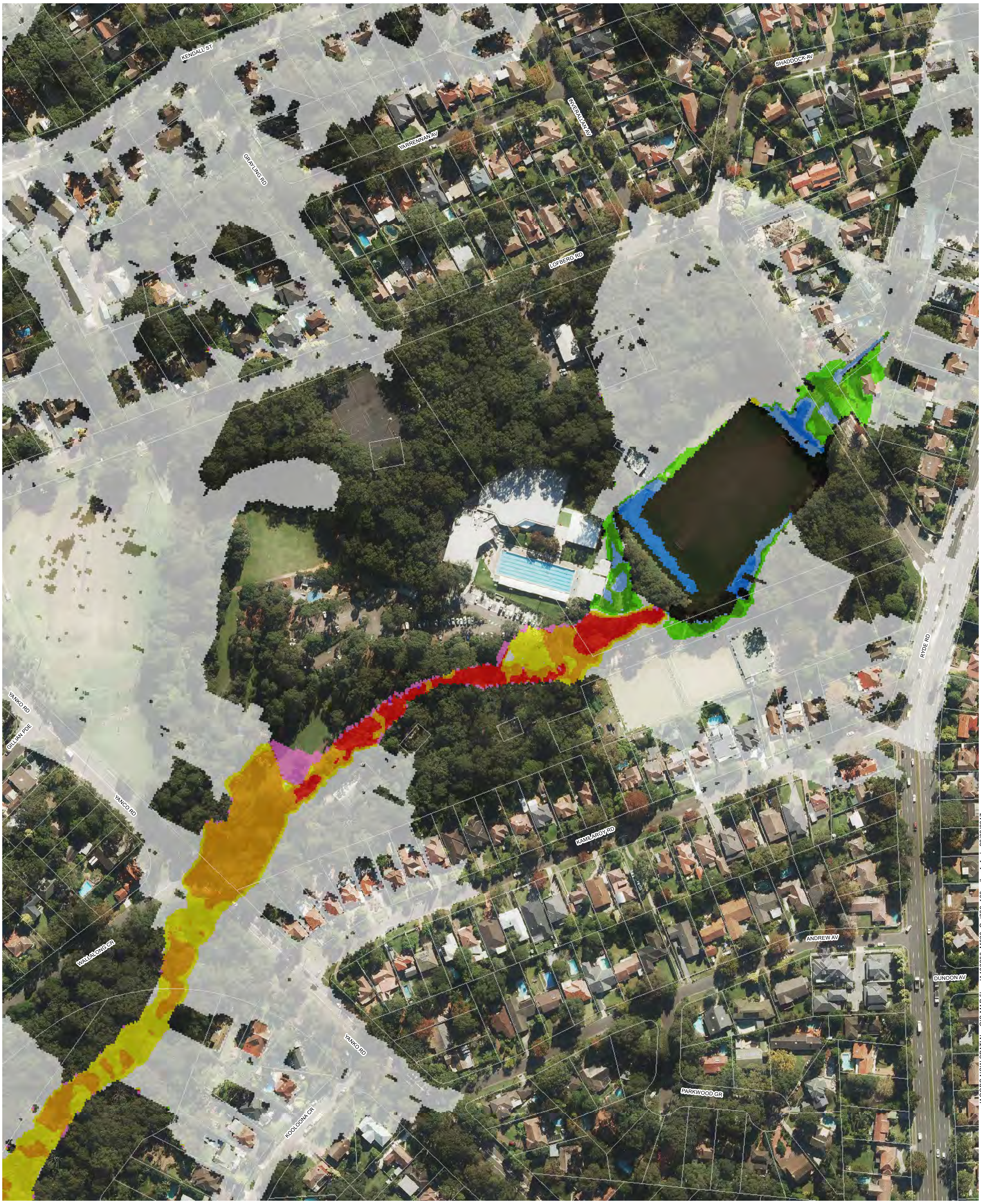
N

NOTE: Design_002 includes upgrade of existing 1 x 1050mm pipe between Lofberg Road and downstream creek, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 19 | 2% AEP Change in Flood Level - Design_002 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M020_Opt002_100y_dh_r1v1 | 22/02/2017

0 50 100m
1:2,500 @ A3

N

Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

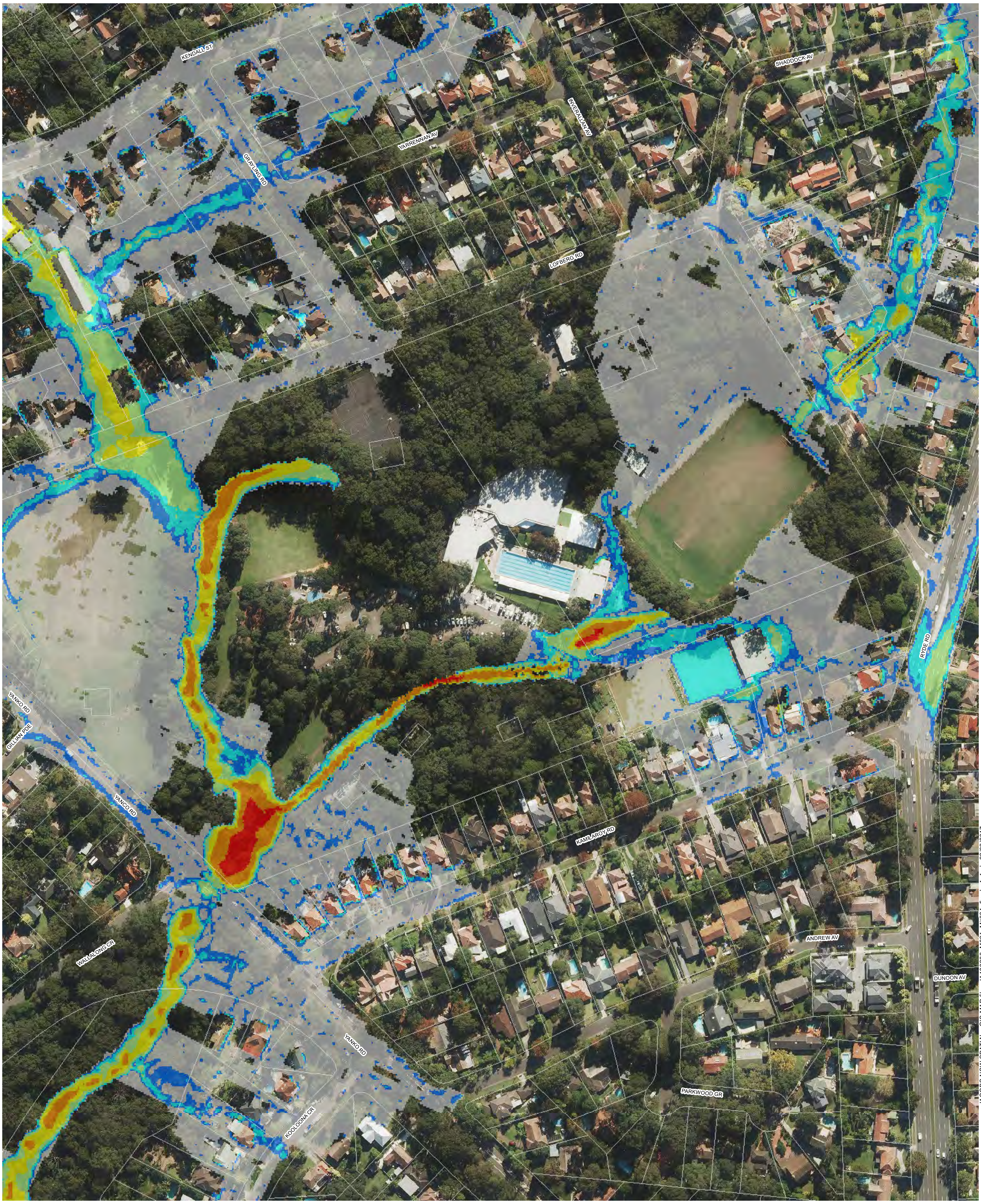
NOTE: Design_002 includes upgrade of existing 1 x 1050mm pipe between Lofberg Road and downstream creek, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 20 | 1% AEP Change in Flood Level - Design_002 Case

JACOBS

Appendix D. Mitigation Case Flood Mapping – Underground Detention



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M021_Mit004_5y_d_r1v1 | 22/02/2017

Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

0 50 100m
1:2,500 @ A3

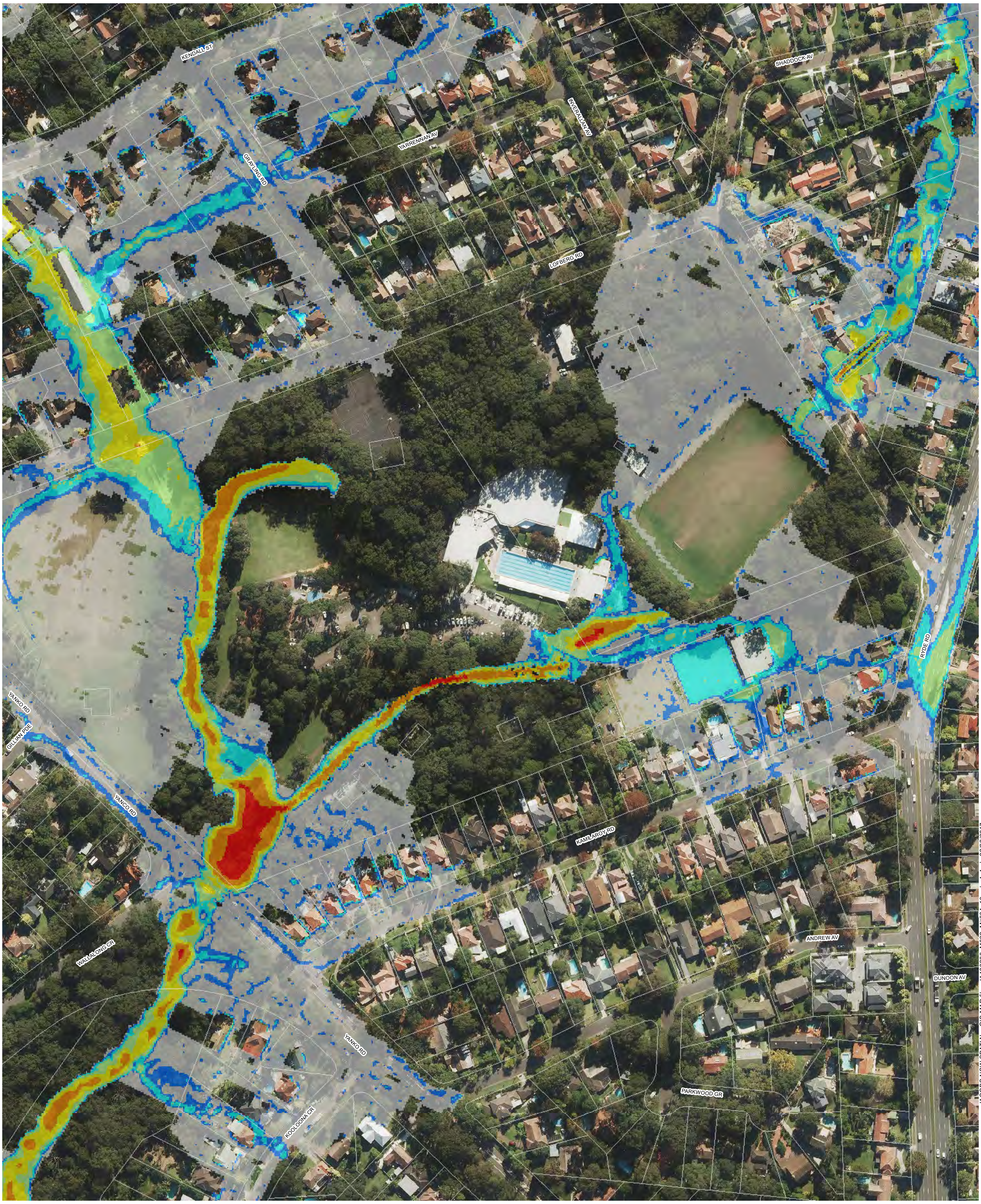
N

NOTE: Mitigation_004 includes 2400cu.m of underground detention with an additional outlet pipe 1 x 1050mm between Lofberg Road and basin downstream pit, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 21 | 0.2 EY Flood Depth - Mitigation_004 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M022_Mit004_10y_d_r1v1 | 22/02/2017

Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

0 50 100m
1:2,500 @ A3

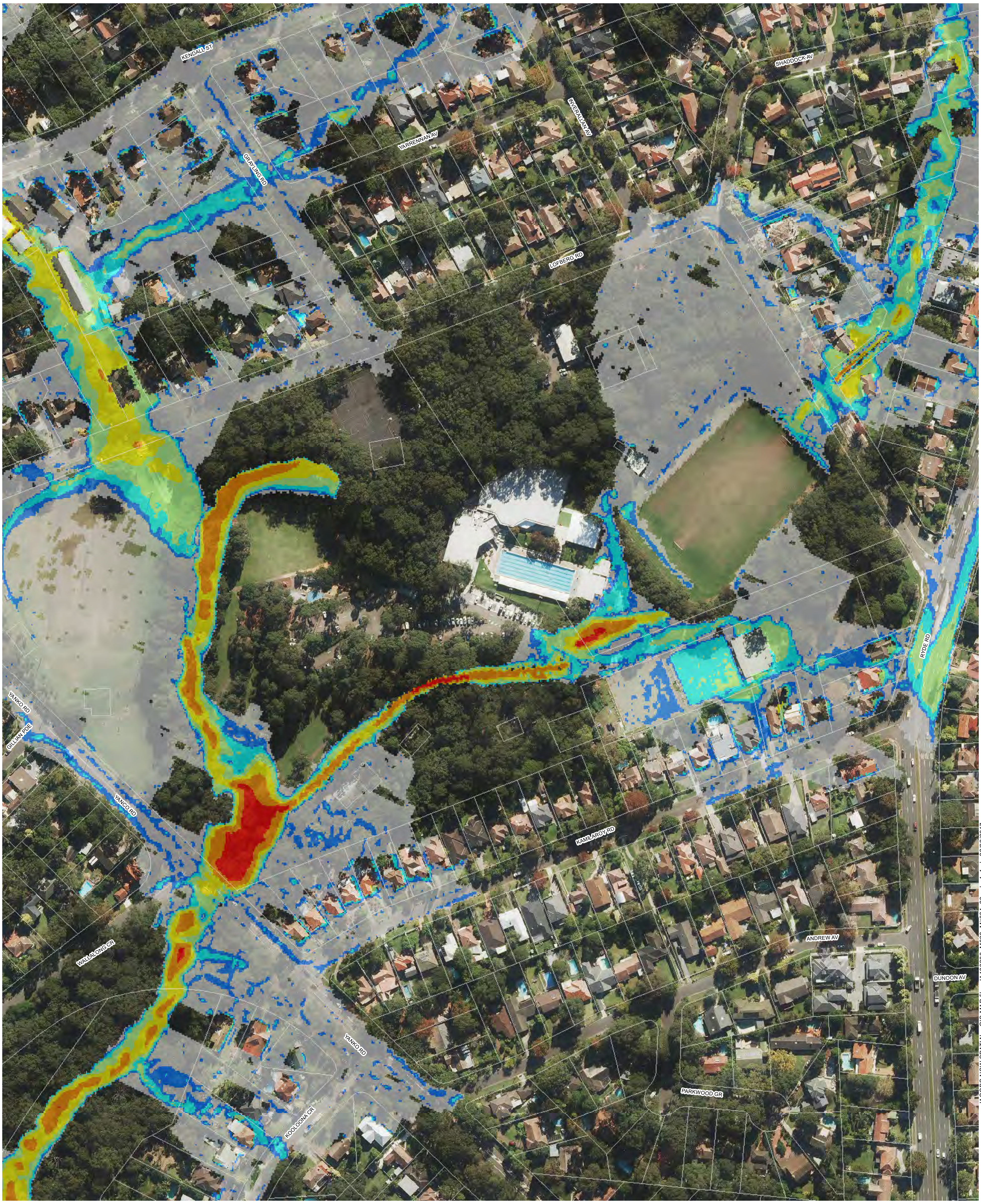
N

NOTE: Mitigation_004 includes 2400cu.m of underground detention with an additional outlet pipe 1 x 1050mm between Lofberg Road and basin downstream pit, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 22 | 10% AEP Flood Depth - Mitigation_004 Case

JACOBS



Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

0 50 100m
1:2,500 @ A3

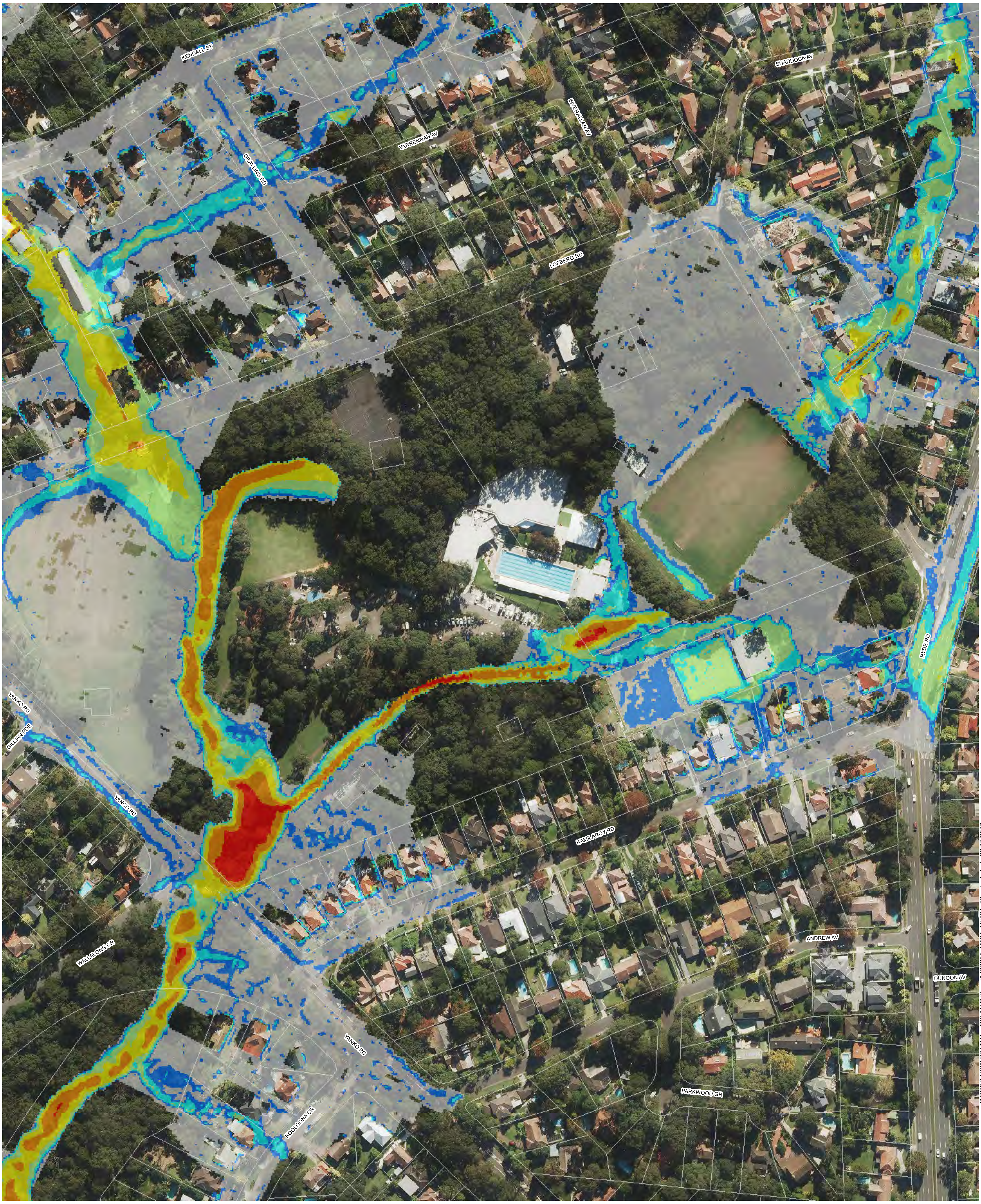
N

NOTE: Mitigation_004 includes 2400cu.m of underground detention with an additional outlet pipe 1 x 1050mm between Lofberg Road and basin downstream pit, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 23 | 5% AEP Flood Depth - Mitigation_004 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M024_Mit004_50y_d_f1v1 | 22/02/2017

Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

0 50 100m
1:2,500 @ A3

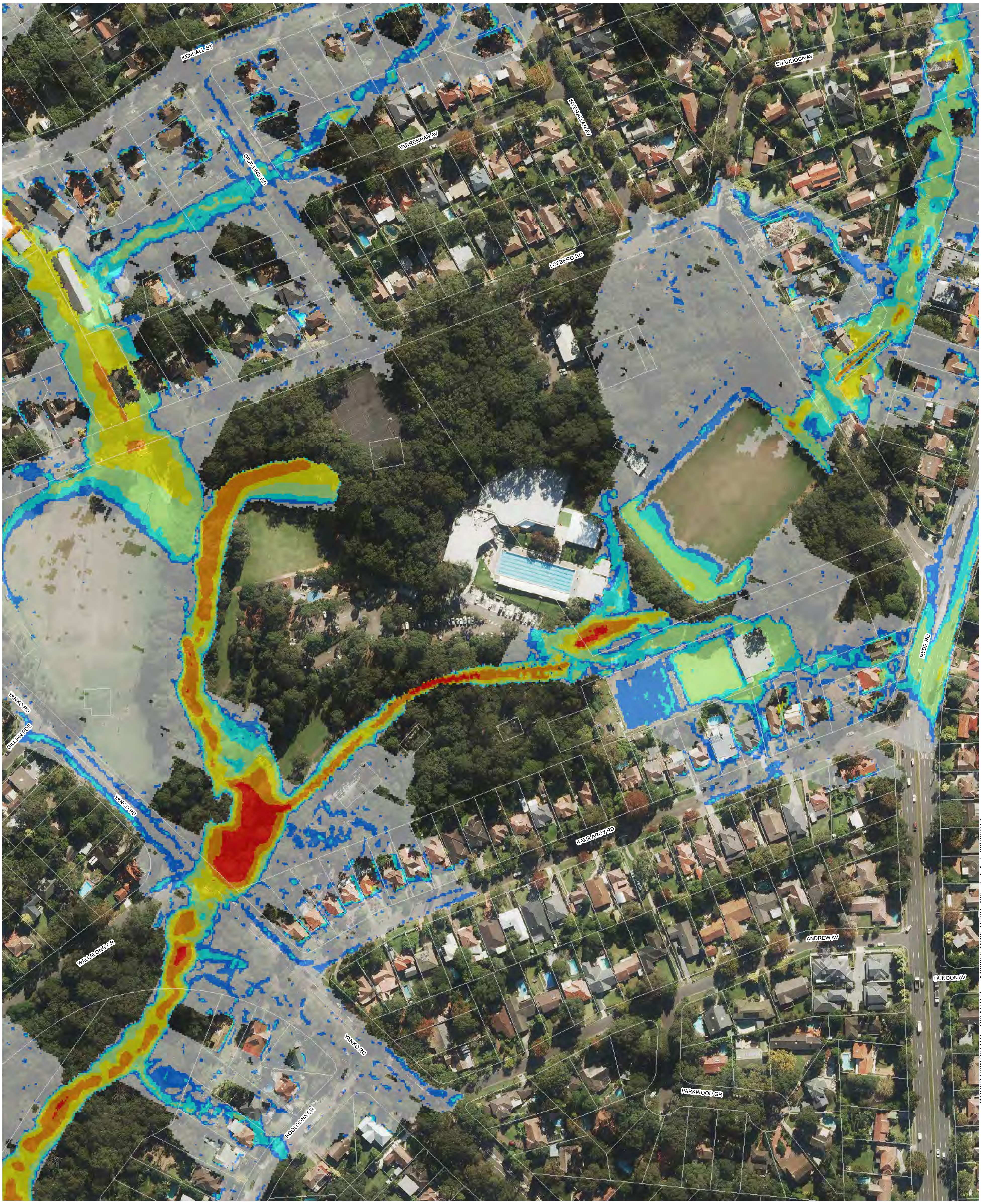
N

NOTE: Mitigation_004 includes 2400cu.m of underground detention with an additional outlet pipe 1 x 1050mm between Lofberg Road and basin downstream pit, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 24 | 2% AEP Flood Depth - Mitigation_004 Case

JACOBS



Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

0 50 100m
1:2,500 @ A3

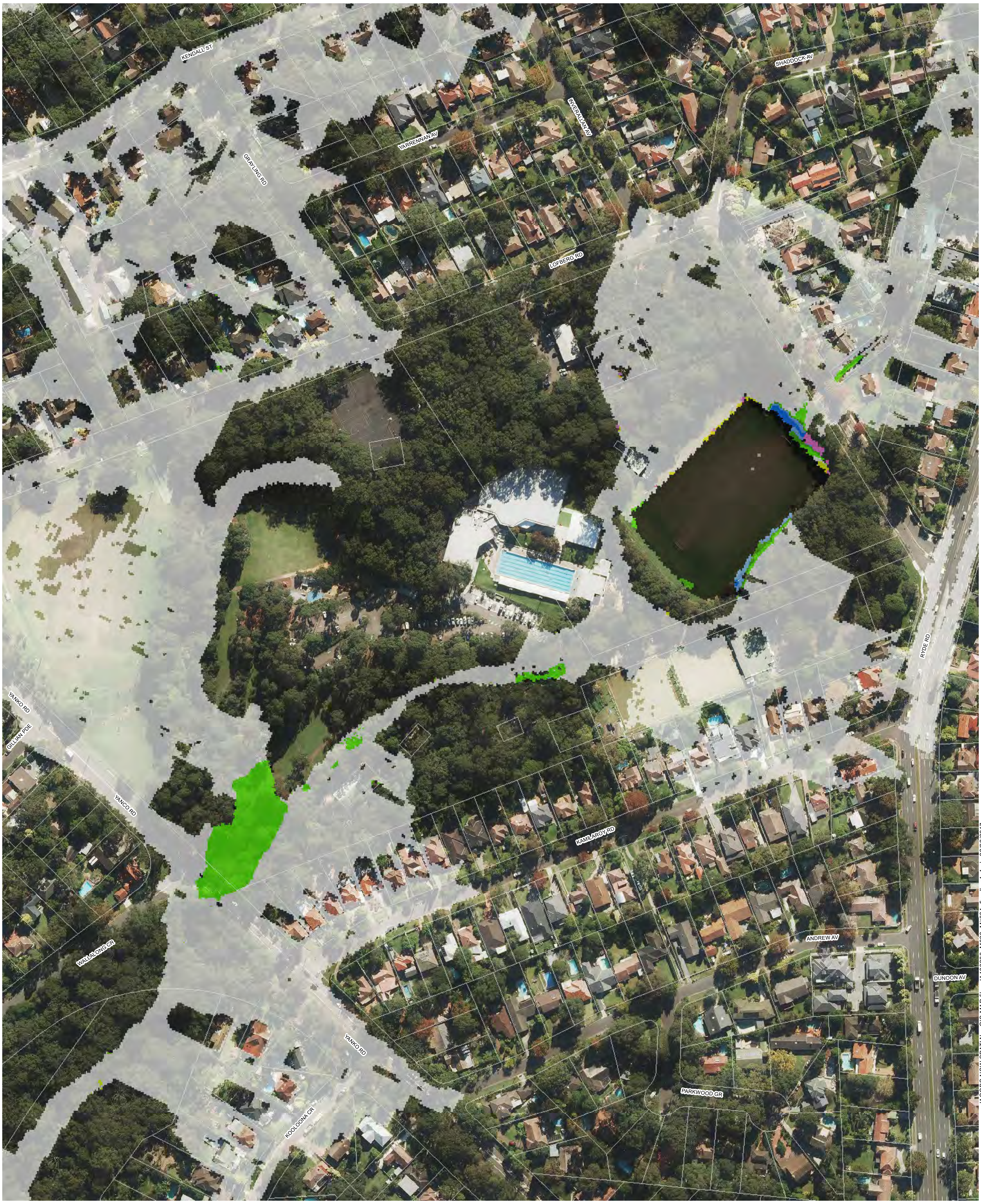
N

NOTE: Mitigation_004 includes 2400cu.m of underground detention with an additional outlet pipe 1 x 1050mm between Lofberg Road and basin downstream pit, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 25 | 1% AEP Flood Depth - Mitigation_004 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M026_Mit004_5y_dh_r1v1 | 22/02/2017

Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

0 50 100m
1:2,500 @ A3

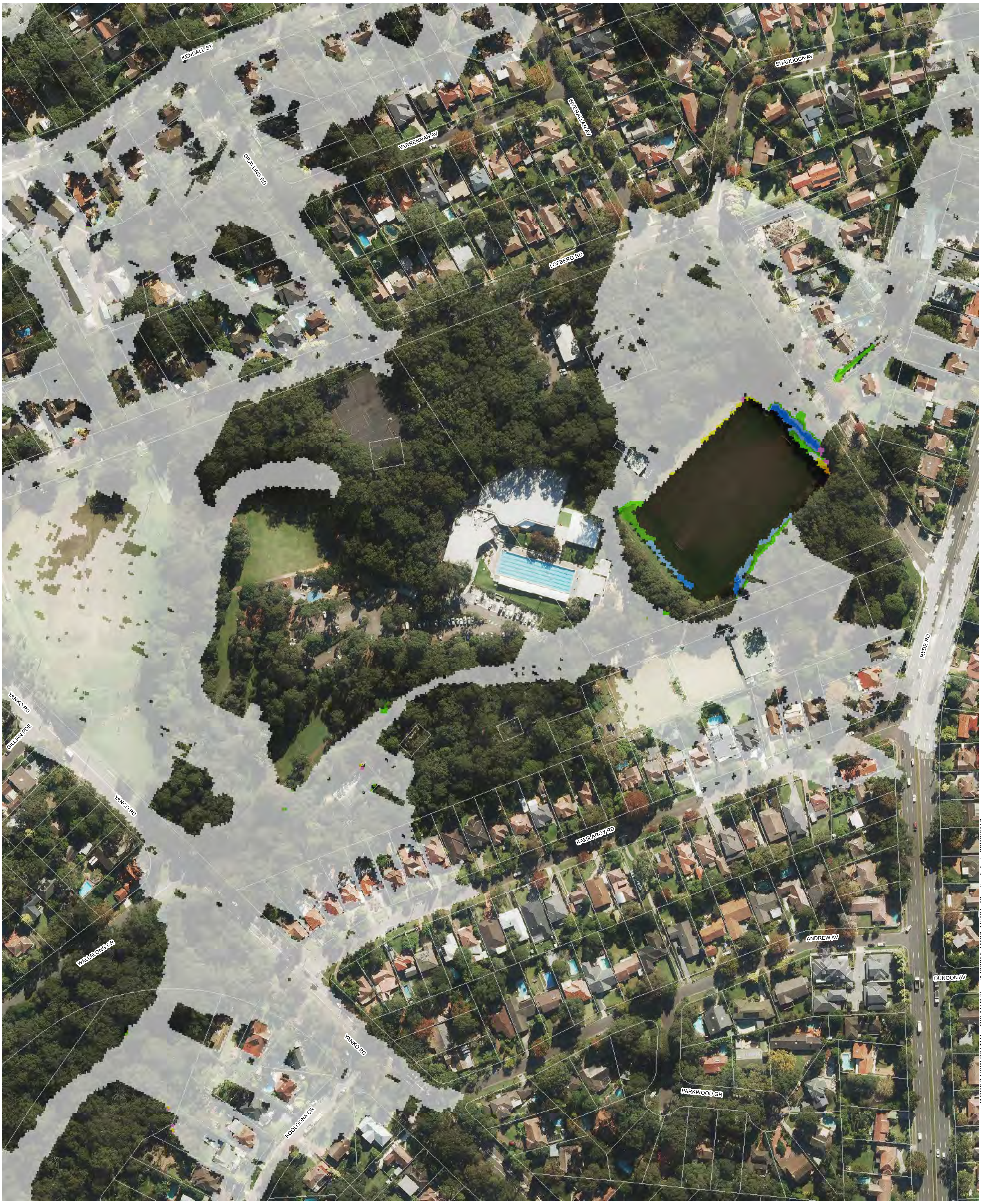
N

NOTE: Mitigation_004 includes 2400cu.m of underground detention with an additional outlet pipe 1 x 1050mm between Lofberg Road and basin downstream pit, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 26 | 0.2 EY Change in Flood Level - Mitigation_004 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M027_Mit004_10y_dh_r1v1 | 22/02/2017

Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- \> 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

NOTE: Mitigation_004 includes 2400cu.m of underground detention with an additional outlet pipe 1 x 1050mm between Lofberg Road and basin downstream pit, and "unlimited" pit inlet capacity at upstream end of soccer field.

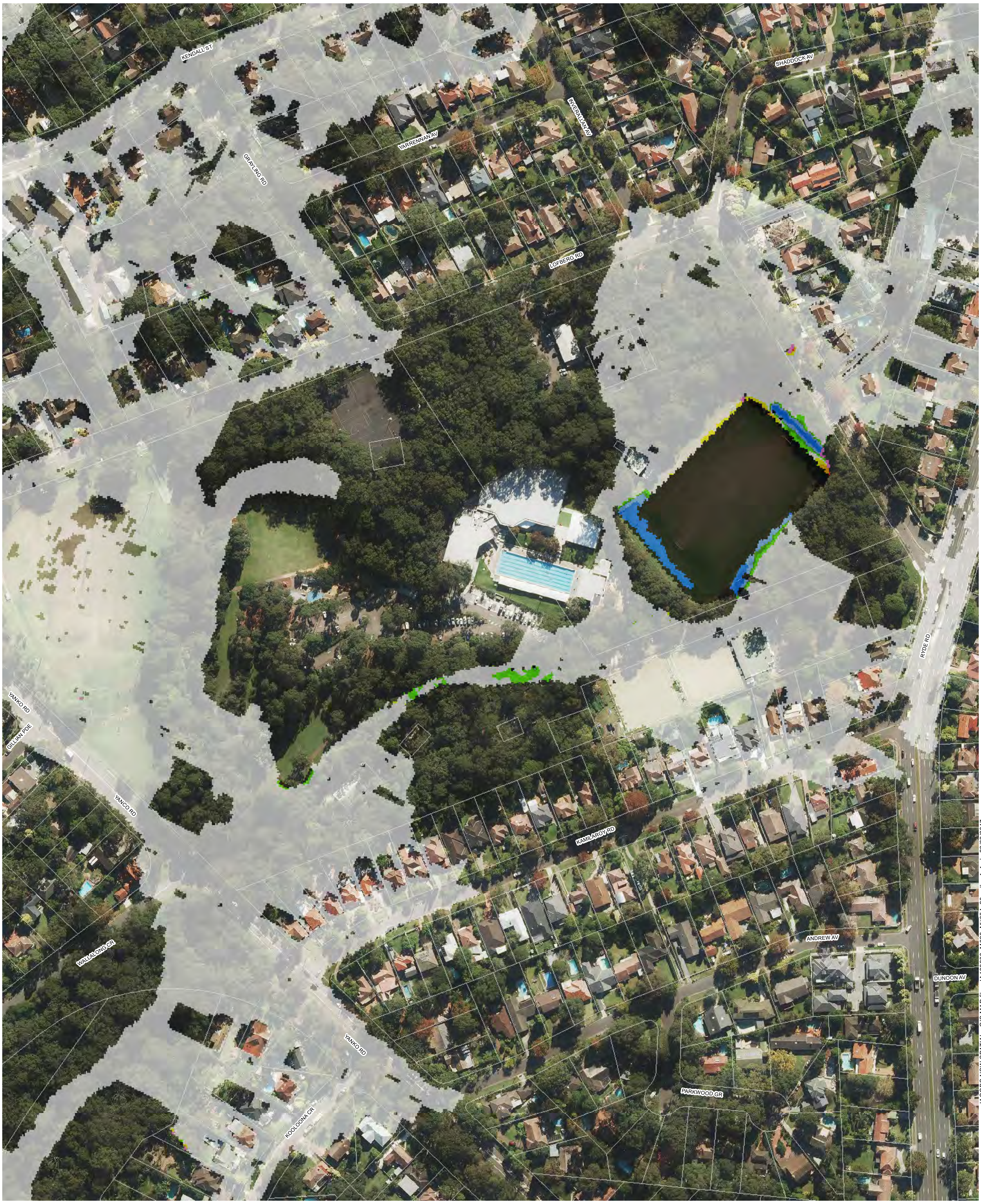
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 27 | 10% AEP Change in Flood Level - Mitigation_004 Case

JACOBS



Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

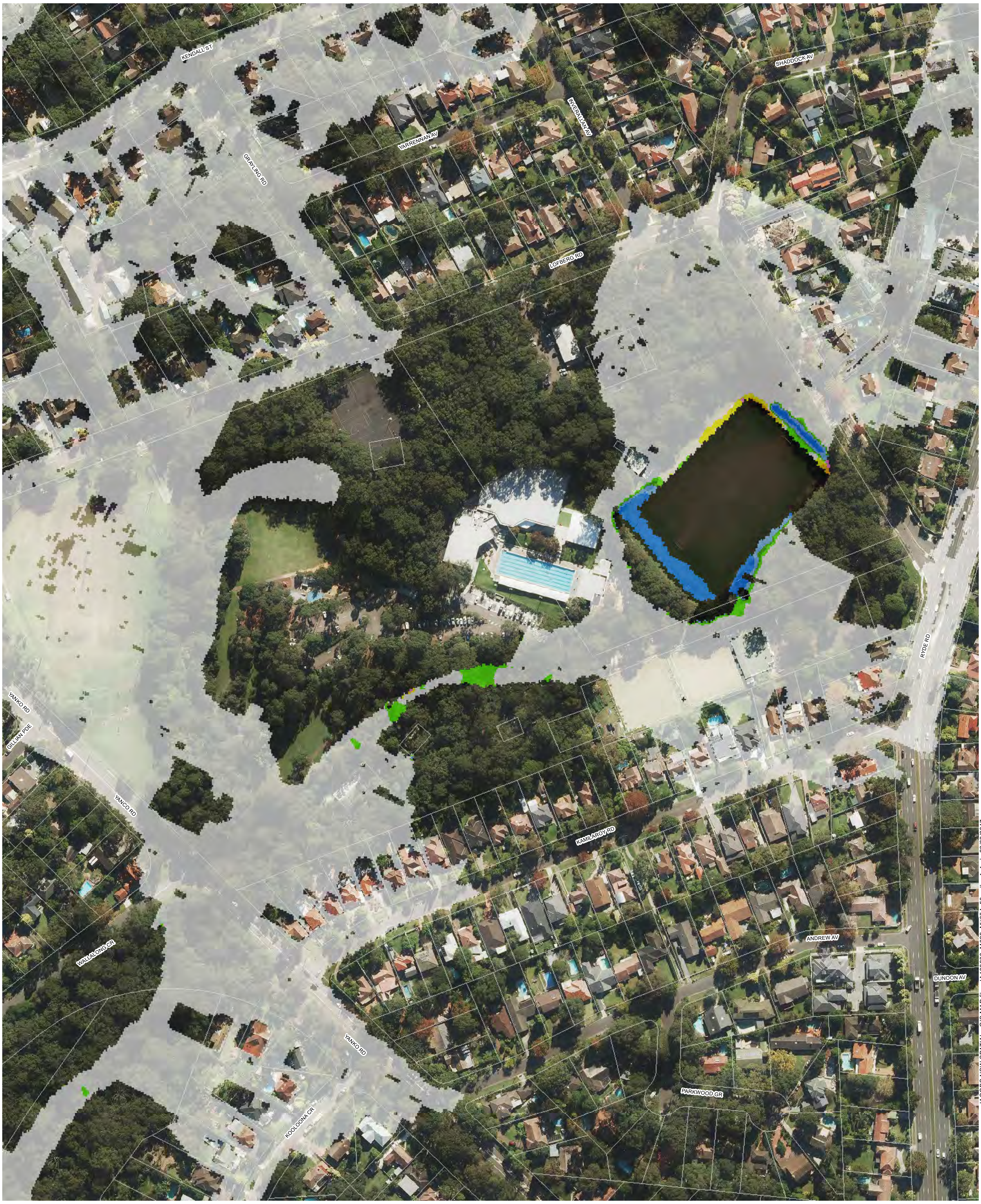
NOTE: Mitigation_004 includes 2400cu.m of underground detention with an additional outlet pipe 1 x 1050mm between Lofberg Road and basin downstream pit, and "unlimited" pit inlet capacity at upstream end of soccer field.

0 50 100m
1:2,500 @ A3
N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 28 | 5% AEP Change in Flood Level - Mitigation_004 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M029_MI004_50y_dh_r1v1 | 22/02/2017

Legend

0 50 100m
1:2,500 @ A3

N

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

NOTE: Mitigation_004 includes 2400cu.m of underground detention with an additional outlet pipe 1 x 1050mm between Lofberg Road and basin downstream pit, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 29 | 2% AEP Change in Flood Level - Mitigation_004 Case

JACOBS

JACOBS NSW SPATIAL - GIS MAP file : IA133200_M030_MI004_100y_dh_r1v1 | 22/02/2017

Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

0 50 100m
1:2,500 @ A3

N

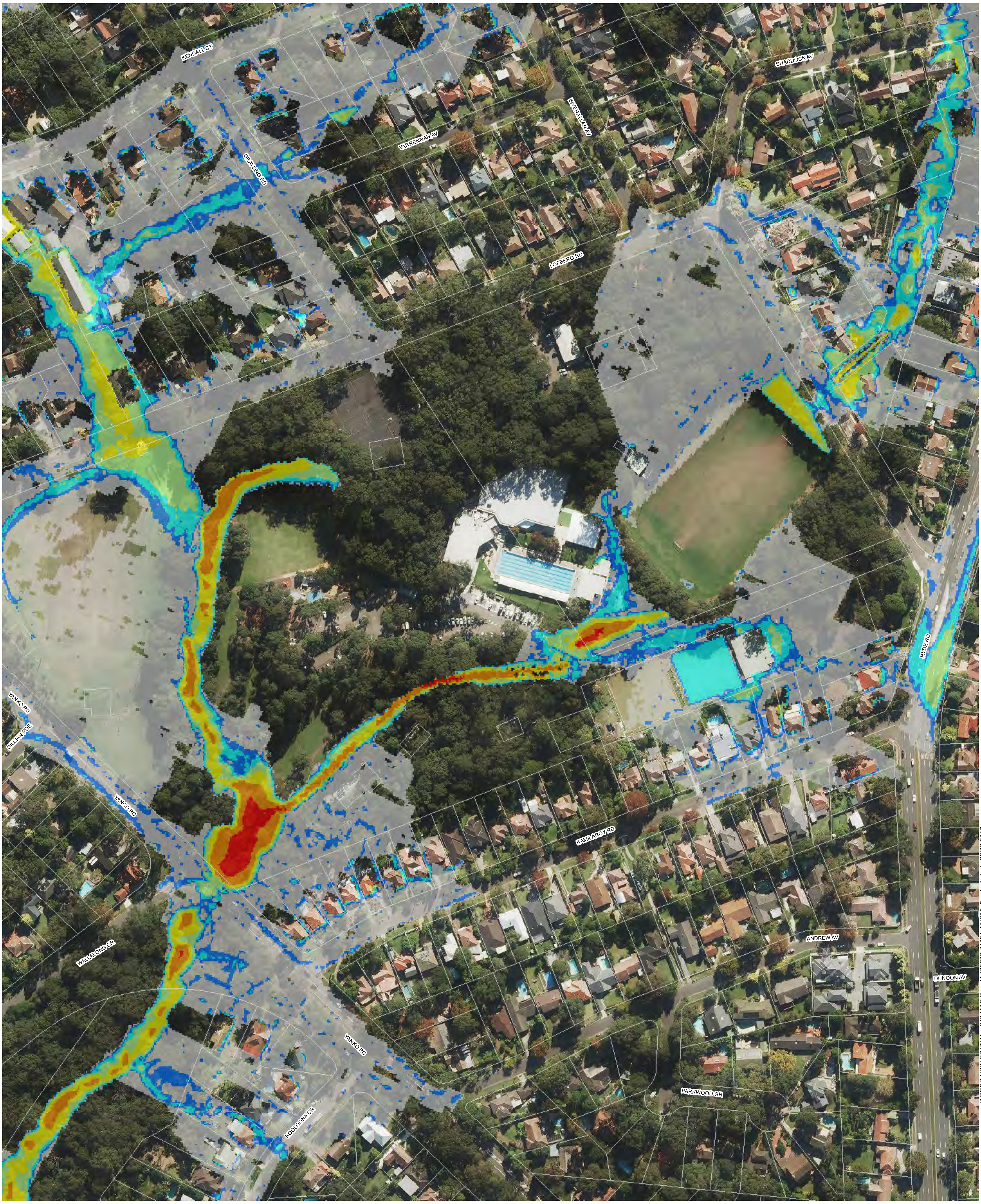
NOTE: Mitigation_004 includes 2400cu.m of underground detention with an additional outlet pipe 1 x 1050mm between Lofberg Road and basin downstream pit, and "unlimited" pit inlet capacity at upstream end of soccer field.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 30 | 1% AEP Change in Flood Level - Mitigation_004 Case

JACOBS

Appendix E. Alternative Mitigation Case Flood Mapping – Split Basin Option



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M031_MI005_5y_d_r1v1 | 22/02/2017

Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

0 50 100m
1:2,500 @ A3

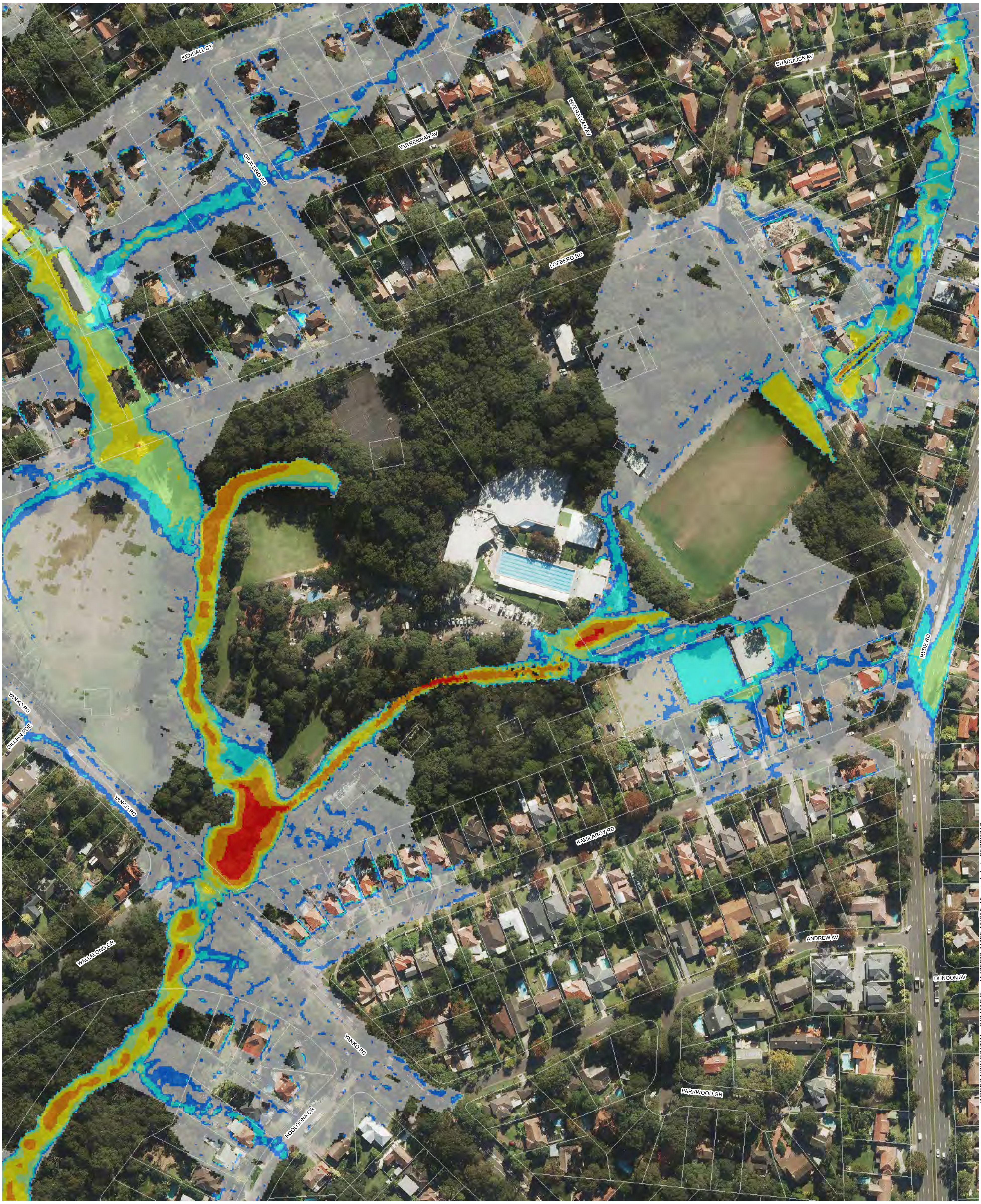
N

NOTE: Mitigation_005 includes construction of 1300cu.m detention basin at upstream end of field, operating in series with storage in low point of existing basin.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 31 | 0.2 EY Flood Depth - Mitigation_005 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M032_Mit005_10y_d_r1v1 | 22/02/2017

Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

0 50 100m
1:2,500 @ A3

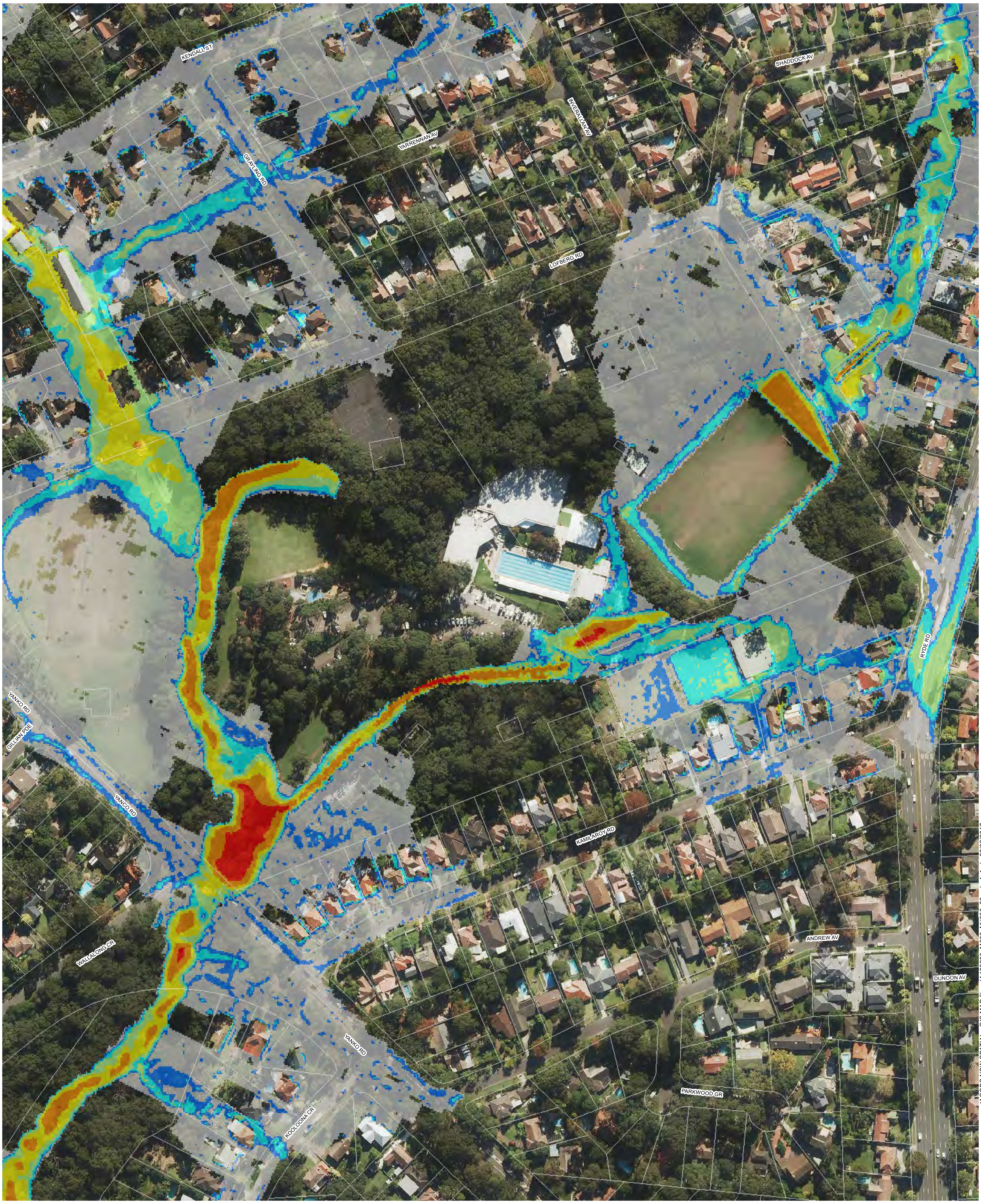
N

NOTE: Mitigation_005 includes construction of 1300cu.m detention basin at upstream end of field, operating in series with storage in low point of existing basin.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 32 | 10% AEP Flood Depth - Mitigation_005 Case

JACOBS



Legend

0 50 100m
1:2,500 @ A3
N

Peak flood depth (m)

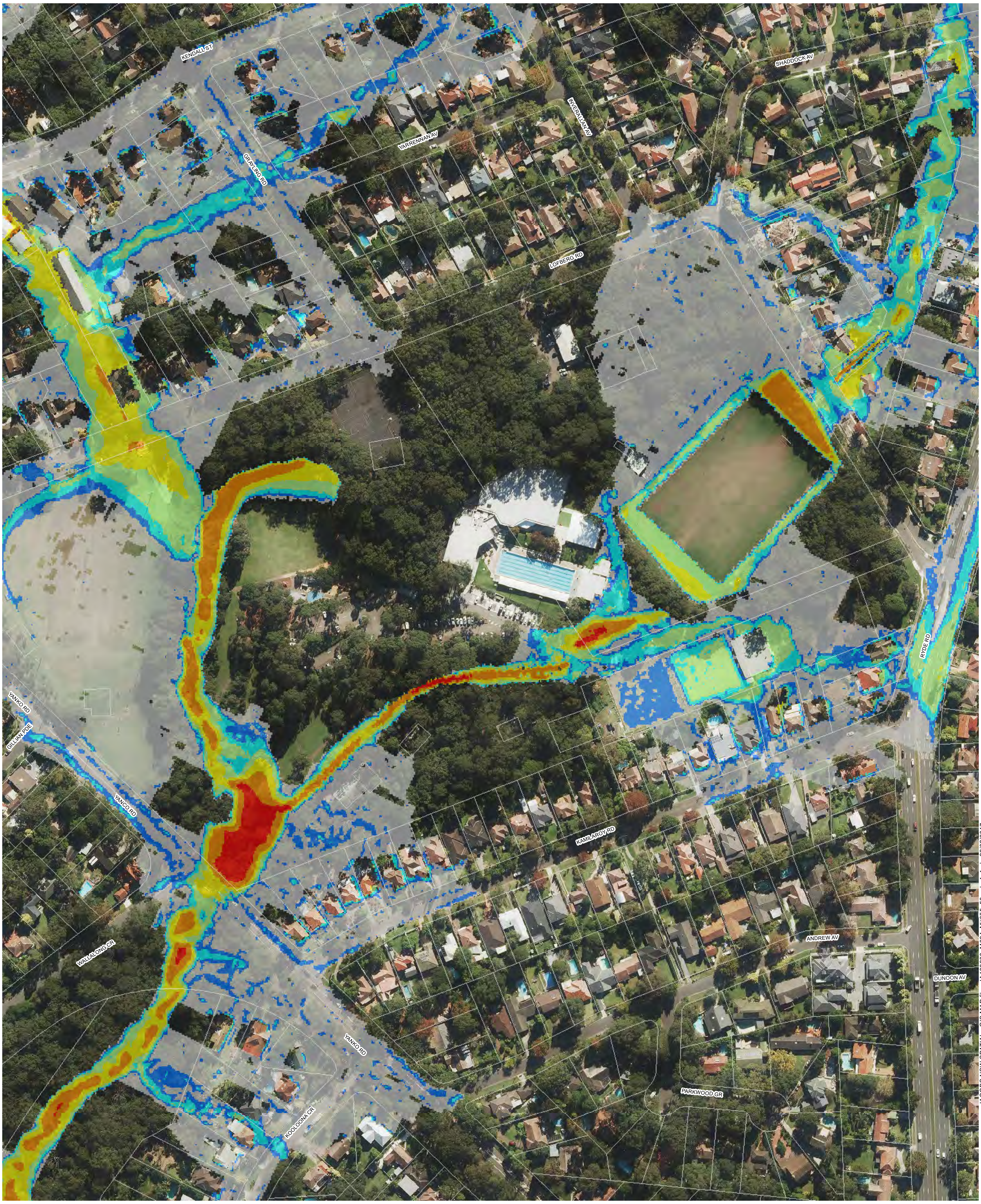
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

NOTE: Mitigation_005 includes construction of 1300cu.m detention basin at upstream end of field, operating in series with storage in low point of existing basin.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 33 | 5% AEP Flood Depth - Mitigation_005 Case

JACOBS



Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

0 50 100m
1:2,500 @ A3

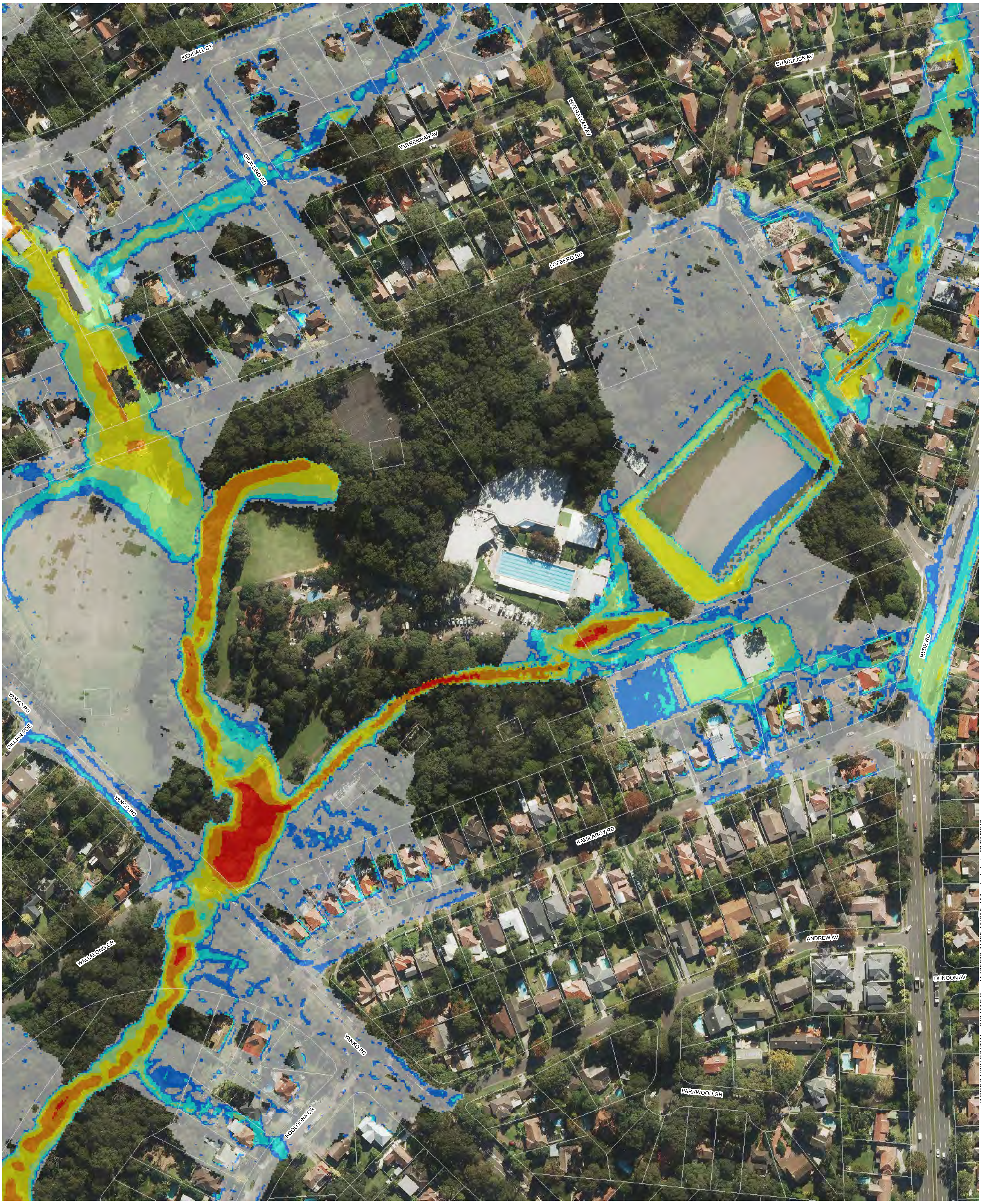
N

NOTE: Mitigation_005 includes construction of 1300cu.m detention basin at upstream end of field, operating in series with storage in low point of existing basin.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 34 | 2% AEP Flood Depth - Mitigation_005 Case

JACOBS



Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

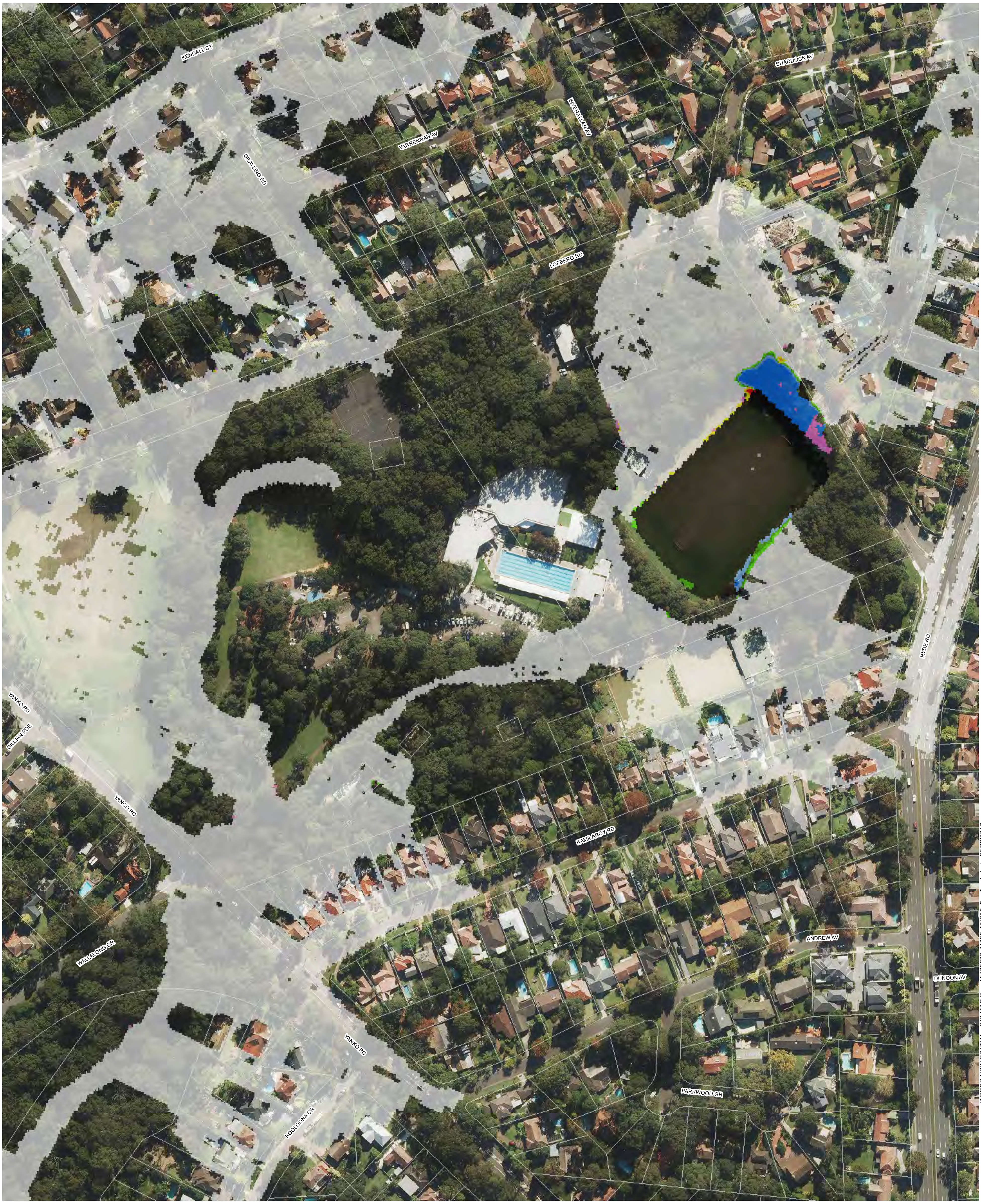
NOTE: Mitigation_005 includes construction of 1300cu.m detention basin at upstream end of field, operating in series with storage in low point of existing basin.

Data sources

Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 35 | 1% AEP Flood Depth - Mitigation_005 Case

JACOBS



Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

0 50 100m
1:2,500 @ A3

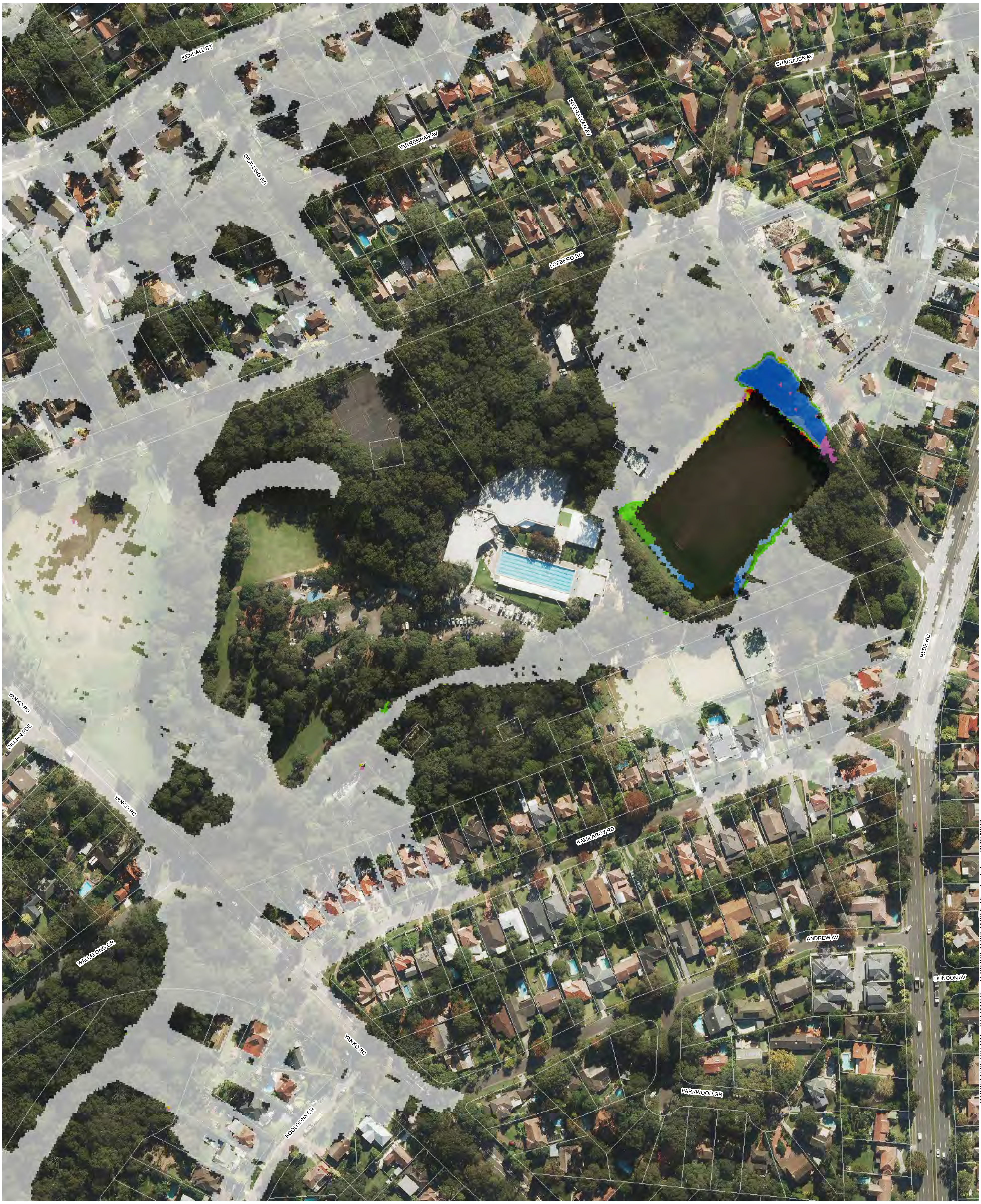
N

NOTE: Mitigation_005 includes construction of 1300cu.m detention basin at upstream end of field, operating in series with storage in low point of existing basin.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 36 | 0.2 EY Change in Flood Level - Mitigation_005 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M037_Mit005_10y_dh_r1v1 | 22/02/2017

Legend

0 50 100m
1:2,500 @ A3

Change in Flood Level (m)

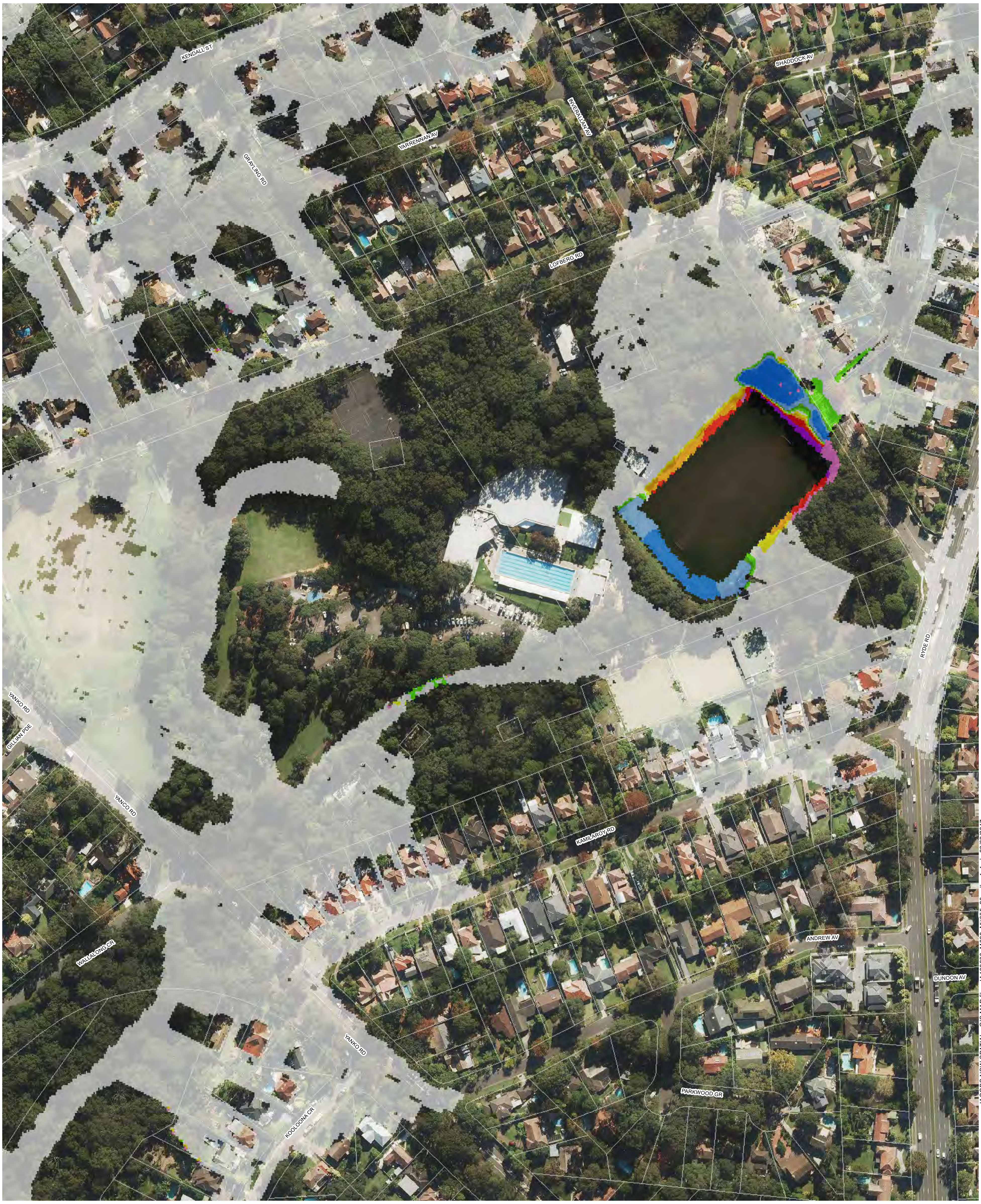
- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

NOTE: Mitigation_005 includes construction of 1300cu.m detention basin at upstream end of field, operating in series with storage in low point of existing basin.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 37 | 10% AEP Change in Flood Level - Mitigation_005 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M038_Mit005_20y_dh_r1v1 | 22/02/2017

Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

NOTE: Mitigation_005 includes construction of 1300cu.m detention basin at upstream end of field, operating in series with storage in low point of existing basin.

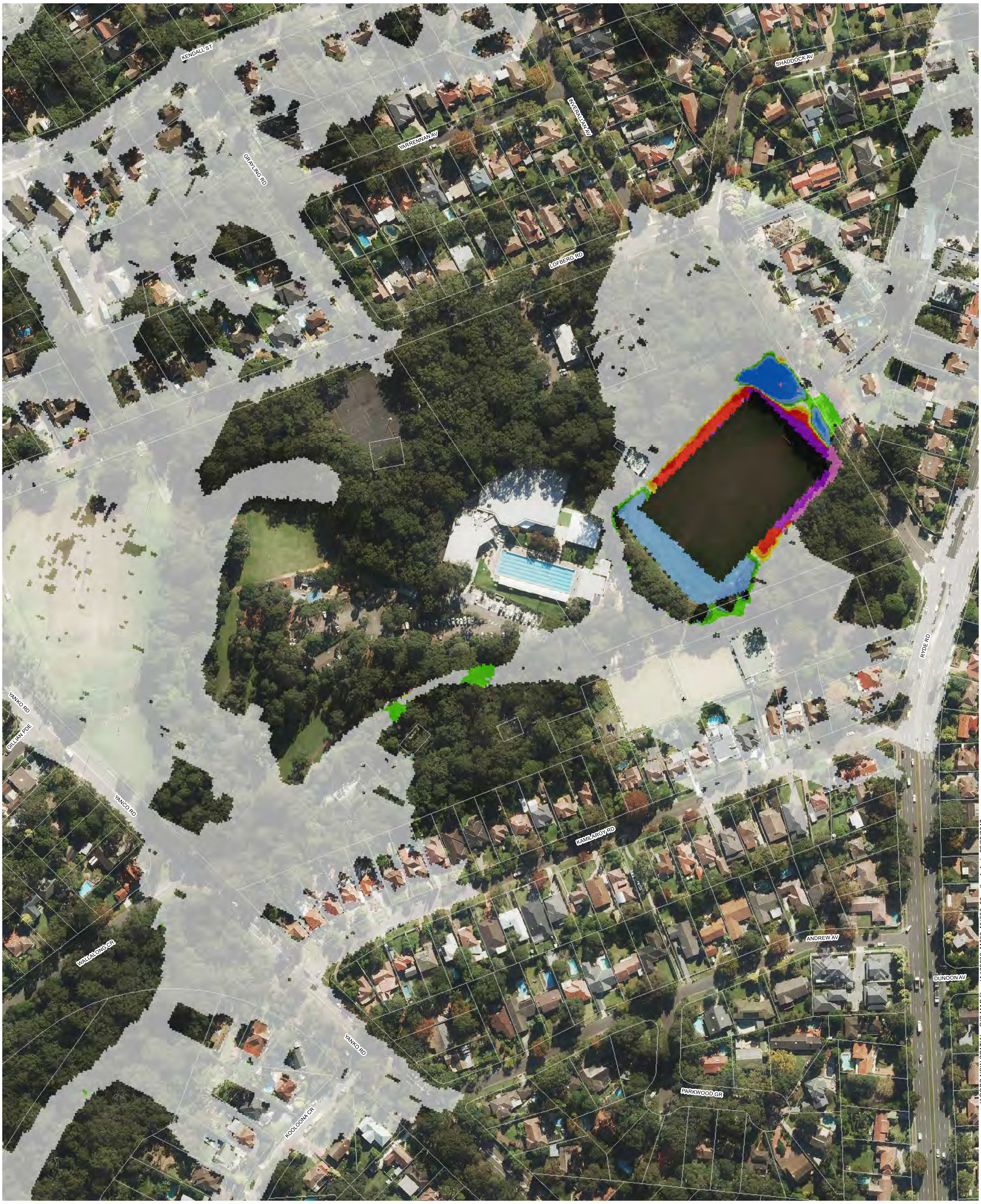
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 38 | 5% AEP Change in Flood Level - Mitigation_005 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M039_Mit005_50y_dh_r1v1 | 22/02/2017

Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

0 50 100m
1:2,500 @ A3

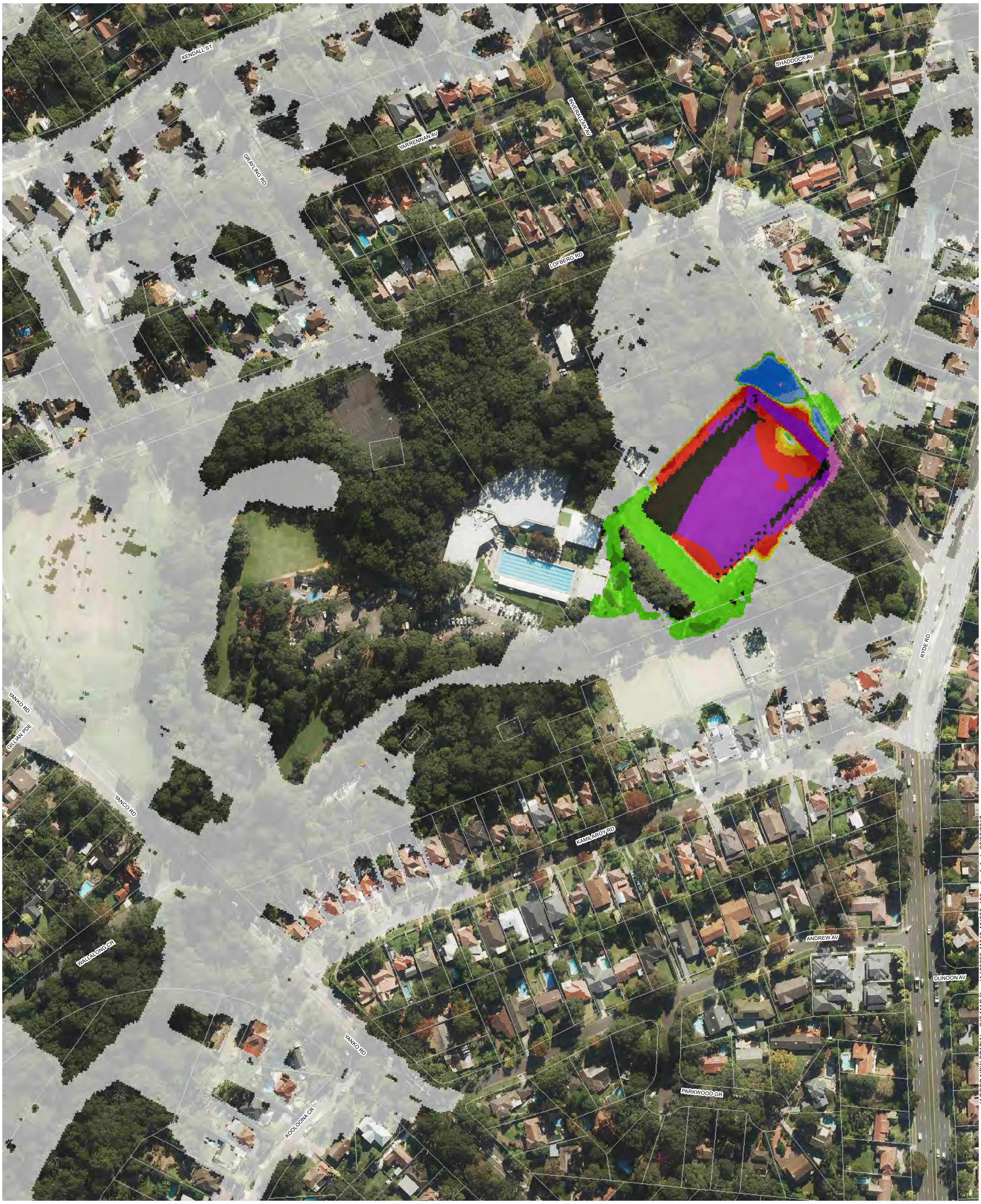
N

NOTE: Mitigation_005 includes construction of 1300cu.m detention basin at upstream end of field, operating in series with storage in low point of existing basin.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 39 | 2% AEP Change in Flood Level - Mitigation_005 Case

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_M040_Mit005_100y_dh_r1v1 | 22/02/2017

Legend

0 50 100m
1:2,500 @ A3

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25
- Was Flooded Now Dry
- Was Dry Now Flooded

NOTE: Mitigation_005 includes construction of 1300cu.m detention basin at upstream end of field, operating in series with storage in low point of existing basin.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 40 | 1% AEP Change in Flood Level - Mitigation_005 Case

JACOBS

Appendix F. Preliminary Cost Estimates

DESCRIPTION: **Atlantis Flo-Tank - based on supplier cost estimate**

										Quantity			Rate			Cost Range		Most likely
Ref	Code	Section	Comment	Unit	Length	Width	Height	Times	Result	Lowest	Highest	Indicative Quantity	Lowest	Highest	Indicative Rate	Lowest	Highest	Indicative Cost
		PROJECT AND PROGRAM ADMINISTRATION																
		Client Project Delivery Management & Administration																
		Tender Costs	*0.5% of Construction Costs; Based on 2008 SWC construction pricing manual*	Item	1				*1.00*			1.00			500.00			1,000
		Planning Costs	*5% of Construction Costs; Based on 2008 SWC construction pricing manual*	Item	1				*1.00*			1.00			5,000.00			5,000
		Project Management Costs	*5% of Construction Costs; Based on 2008 SWC construction pricing manual*	Item	1				*1.00*			1.00			5,000.00			5,000
		Project Insurances	*0.6% of Construction Costs; Based on 2008 SWC construction pricing manual*	Item	1				*1.00*			1.00			600.00			1,000
		Direct Cost Sub-Total																12,000
		CONSTRUCTION PRELIMINARIES																
		Pre-construction Activities																
		Project Signage		No					-			1.00			1,000.00			1,000
		Advertising/Community liaison		Item					-			1.00			2,000.00			2,000
		Services investigations	*Water; Power*	Item					-			1.00			3,000.00			3,000
		Preliminaries, O/H & Margin																
		Site Establishment & Demobilisation	*Say ~1% of Construction Total approx~ $200,000*	Item					-			1.00			2,000.00			2,000
		Investigations & Monitoring																
		Geotechnical Investigation	*Assume no challenging geotechnical conditions*	Item														-
		Direct Cost Sub-Total																8,000
		PREPARARTION																
		Demolition																
		Remove trees	*Assume location of OSD will accomodate all trees being retained*	*No.*														-
		Divert services	*Assume no diversion of services required*	*Item*														-
		Excavation - OSD																
		Excavation for OSD	*Excavation included in cost of install*	*m3*								-						-
		Direct Cost Sub-Total																-
		DRAINAGE WORK																
		Atlantis - OSD																
		Supply and install Atlantis OSD	*Includes cost of geotextile fabric, impermeable liner, excavation and backfill*	m3	65.76	29.38	1.31		*2,530.96*			2,530,957.73	0.45	0.65	0.55			1,393,000
		Trenching																
		Excavate trenches and stockpile onsite	*Assume clay; No contamination assumed, Assumed 2m deep excavation (For US need to excavate 2.83m for DS need to excavate 1.96m), Rawlinsons 2015 pg 212*	m3	122.80	1.05	2.00	1.00	*257.88*			257.88			65.50			17,000
		Planking, strutting and shoring of sides of trench excavation	*Assume clay, Rawlinsons 2015 pg 215*	m2	122.80		2.00		*245.60*			245.60			11.30			3,000
		Imported Bedding incl. compaction	*Assume 200mm bedding required; Sand*	m3	122.80	1.05			*128.94*			128.94	45.00	60.00	49.90			7,000
		Backfill excavated material and assume that excess site spoil to be spread and levelled on oval	*Assume 1m of backfill required, Rawlinsons 2015 pg 233*	m3	122.80	1.05	1.00	1.00	*128.94*			128.94			14.80			2,000
		Pipes and pits																
		4 x 1m x 1m SI pits	*Assume precast concrete 900 x 900 x 900mm deep with 150mm concrete baseand wall, Rawlinsons 2015 pg 488*	No.				4.00	*4.00*			4.00			975.00			4,000
		Add extra for each additional 100mm in depth	*RL of Swale = 71.8, IL of underground OSD = 69.5 therefore pit depth is 2.3m, therefore need an additional 1.4m depth*	No.				14.00	*14.00*			14.00			59.00			1,000
		4 x Galvanised floor plate - Sump	*Assume 6mm thich galvanised floor plate cover o sump, cost is for 600 x 600, therefore assume times by 4 to get 1m x 1m, Rawlinsons 2015 pg 300*	No.				4.00	*4.00*			4.00			141.50			1,000
		2 x GPTS HG35A	*Assume 2 pit connected to 1 GPT, Rawlinsons 2015 pg 488*	No.					*2.00*			2.00			65,000.00			130,000
		1 x 1050 Dia. supply and installation	*Assumed Class 3 strength to allow for maintenance vehicles, Concrete, 1200mm D, Rawlinsons 2015 pg 478*	m	122.80			1.00	*122.80*			122.80			975.00			120,000
		Break into and connect exisitng downstream basin pit	*Assume excavation required to break into existing pit is included in cost of trenching*	No								1.00	2,000.00	5,000.00	3,325.00			4,000
		Minor Earthworks - Swales and Berms																
		Excavated material as filling for berms	*Berms on either side of field approximately 100m, Rawlinsons 2015 pg 214*	m3	100.00		0.15	2.00	*30.00*	20.00	40.00	30.00			7.90			1,000
		Excavated material as filling for berms	*Berm parralel to swale approximately 70m, Rawlinsons 2015 pg 214*	m3	70.00		0.20	1.00	*14.00*			14.00			7.90			1,000
		Trim surfaces of cuttings and embankments in other than rock to slope	*Rawlinsons 2015 pg 214*	m2	170.00			1.00	*170.00*			170.00			3.35			1,000
		Excavated material as filling over OSD up to swale	*Assume 400mm cover over OSD area of 1600m2*	m3					-			640.00			7.90			6,000
		Excavated material as filling over OSD around swale	*Assume additional 400mm cover around swale, Assume swale is 30m x 5m*	m3					-			580.00			7.90			5,000
		Landscaping																
		Planting - Park turf	*Assume landscaping includes rehab of site after works, Rawlinsons 2015 pg 228*	m2	1,600.00				*1,600.00*			1,600.00			8.60			14,000
		Direct Cost Sub-Total																1,710,000
															TOTAL			$ 1,730,000

DESCRIPTION: Humes Stormtrap - based on Rawlinson 2015 unit costs

										Quantity			Rate			Cost Range		Most likely
Ref	Code	Section	Comment	Unit	Length	Width	Height	Times	Result	Lowest	Highest	Indicative Quantity	Lowest	Highest	Indicative Rate	Lowest	Highest	Indicative Cost
		PROJECT AND PROGRAM ADMINISTRATION																
		Client Project Delivery Management & Administration																
		Tender Costs	*0.5% of Construction Costs; Based on 2008 SWC construction pricing manual*	Item	1				1.00			1.00			500.00			1,000
		Planning Costs	*5% of Construction Costs; Based on 2008 SWC construction pricing manual*	Item	1				1.00			1.00			5,000.00			5,000
		Project Management Costs	*5% of Construction Costs; Based on 2008 SWC construction pricing manual*	Item	1				1.00			1.00			5,000.00			5,000
		Project Insurances	*0.6% of Construction Costs; Based on 2008 SWC construction pricing manual*	Item	1				1.00			1.00			600.00			1,000
		Direct Cost Sub-Total																12,000
		CONSTRUCTION PRELIMINARIES																
		Pre-construction Activities																
		Project Signage		No					-			1.00			1,000.00			1,000
		Advertising/Community liaison		Item					-			1.00			2,000.00			2,000
		Services investigations	*Water; Power*	Item					-			1.00			3,000.00			3,000
		Preliminaries, O/H & Margin																
		Site Establishment & Demobilisation	*Say ~1% of Construction Total approx~ $200,000*	Item					-			1.00			2,000.00			2,000
		Investigations & Monitoring																
		Geotechnical Investigation	*Assume no challenging geotechnical conditions*	Item														-
		Direct Cost Sub-Total																8,000
		PREPARARTION																
		Demolition																
		Remove trees	*Assume location of OSD will accomodate all trees being retained*	No.														-
		Divert services	*Assume no diversion of services required*	Item														-
		Excavation - OSD																
		Excavation for OSD	*Assume excavation over site to reduce levels in clay, 2400m3 for OSD and and 0.5m for cover = 800m3 , Rawlinsons pg 212*	m3					3,200.00			3,200.00			28.50			92,000
		Direct Cost Sub-Total																92,000
		DRAINAGE WORK																
		OSD																
		Supply and install OSD	*Waiting on Humes cost therefore assume single trap large volume trafficable stormwater systems, 1500mm high, per 1000 m3, Rawlinsons pg 489*	m3				2.40	2.40			2.40			340,000.00			816,000
		Backfill excavated material and assume that excess site spoil to be spread and levelled on oval	*Assume 0.5m of backfill required, Rawlinsons 2015 pg 233*	m3					800.00			800.00			14.80			12,000
		Trenching																
		Excavate trenches and stockpile onsite	*Assume clay; No contamination assumed, Assumed 2m deep excavation (For US need to excavate 2.83m for DS need to excavate 1.96m), Rawlinsons 2015 pg 212*	m3	122.80	1.05	2.00	1.00	257.88			257.88			65.50			17,000
		Planking, strutting and shoring of sides of trench excavation	*Assume clay, Rawlinsons 2015 pg 215*	m2	122.80		2.00		245.60			245.60			11.30			3,000
		Imported Bedding incl. compaction	*Assume 200mm bedding required; Sand*	m3	122.80	1.05			128.94			128.94	45.00	60.00	49.90			7,000
		Backfill excavated material and assume that excess site spoil to be spread and levelled on oval	*Assume 1m of backfill required, Rawlinsons 2015 pg 233*	m3	122.80	1.05	1.00	1.00	128.94			128.94			14.80			2,000
		Pipes and pits																
		4 x 1m x 1m SI pits	*Assume precast concrete 900 x 900 x 900mm deep with 150mm concrete baseand wall, Rawlinsons 2015 pg 488*	No.				4.00	4.00			4.00			975.00			4,000
		4 x Galvanised floor plate - Sump	*Assume 6mm thich galvanised floor plate cover o sump, cost is for 600 x 600, therefore assume times by 4 to get 1m x 1m, Rawlinsons 2015 pg 300*	No.				4.00	4.00			4.00			141.50			1,000
		1 x 1050 Dia. supply and installation	*Assumed Class 3 strength to allow for maintenance vehicles, Concrete, 1200mm D, Rawlinsons 2015 pg 478*	m	122.80			1.00	122.80			122.80			975.00			120,000
		Break into and connect exisitng downstream basin pit	*Assume excavation required to break into existing pit is included in cost of trenching*	No								1.00	2,000.00	5,000.00	3,325.00			4,000
		Minor Earthworks - Swales and Berms																
		Excavated material as filling for berms	*Berms on either side of field approximately 100m, Rawlinsons 2015 pg 214*	m3	100.00		0.15	2.00	30.00	20.00	40.00	30.00			7.90			1,000
		Excavated material as filling for berms	*Berm parralel to swale approximately 70m, Rawlinsons 2015 pg 214*	m3	70.00		0.20	1.00	14.00			14.00			7.90			1,000
		Trim surfaces of cuttings and embankments in other than rock to slope	*Rawlinsons 2015 pg 214*	m2	170.00			1.00	170.00			170.00			3.35			1,000
		Excavated material as filling over OSD up to swale	*Assume 400mm cover over OSD area of 1600m2*	m3					-			640.00			7.90			6,000
		Excavated material as filling over OSD around swale	*Assume additional 400mm cover around swale, Assume swale is 30m x 5m*	m3					-			580.00			7.90			5,000
		Landscaping																
		Planting - Park turf	*Assume landscaping includes rehab of site after works, Rawlinsons 2015 pg 228*	m2	1,600.00				1,600.00			1,600.00			8.60			14,000
		Direct Cost Sub-Total																1,014,000
															TOTAL			$ 1,126,000

DESCRIPTION: **Split detention basin option - based on Rawlinson 2016**

										Quantity			Rate			Cost Range		Most likely
Ref	Code	Section	Comment	Unit	Length	Width	Height	Times	Result	Lowest	Highest	Indicative Quantity	Lowest	Highest	Indicative Rate	Lowest	Highest	Indicative Cost
		PROJECT AND PROGRAM ADMINISTRATION																
		Client Project Delivery Management & Administration																
		Tender Costs	*0.5% of Construction Costs; Based on 2008 SWC construction pricing manual*	Item	1				***1.00***			**1.00**			**500.00**			**1,000**
		Planning Costs	*5% of Construction Costs; Based on 2008 SWC construction pricing manual*	Item	1				***1.00***			**1.00**			**5,000.00**			**5,000**
		Project Management Costs	*5% of Construction Costs; Based on 2008 SWC construction pricing manual*	Item	1				***1.00***			**1.00**			**5,000.00**			**5,000**
		Project Insurances	*0.6% of Construction Costs; Based on 2008 SWC construction pricing manual*	Item	1				***1.00***			**1.00**			**600.00**			**1,000**
		Direct Cost Sub-Total																**12,000**
		CONSTRUCTION PRELIMINARIES																
		Pre-construction Activities																
		Project Signage		No					-			**1.00**			**1,000.00**			**1,000**
		Advertising/Community liaison		Item					-			**1.00**			**2,000.00**			**2,000**
		Services investigations	*Water; Power*	Item					-			**1.00**			**3,000.00**			**3,000**
		Preliminaries, O/H & Margin																
		Site Establishment & Demobilisation	*Say ~1% of Construction Total approx~ $200,000*	Item					-			**1.00**			**2,000.00**			**2,000**
		Investigations & Monitoring																
		Geotechnical Investigation	*Assume no challenging geotechnical conditions*	Item														-
		Direct Cost Sub-Total																**8,000**
		PREPARARTION																
		Demolition																
		Remove trees	*Assume trees have 500mm girth, cost per 10 trees, assumed removal of 150 trees, Rawlinsons 2015 pg 211*	*No.*				150.00	***150.00***			**150.00**			**150.00**			**23,000**
		Divert services	*Assume no diversion of services required*	*Item*														-
		Excavation - OSD																
		Excavation for OSD	*Rawlinsons pg 212*	*m3*					-			**1,562.49**			**28.50**			**45,000**
		Direct Cost Sub-Total																**68,000**
		DRAINAGE WORK																
		Pipes and pits																
		1 x Precast concrete cover	*Assume standard not trafficable 900 x 900mm to cover pit that will now be buried by bund, Rawlinsons 2015 pg 488*	No.				4.00	***4.00***			**4.00**			**196.00**			**1,000**
		Excavation for new upstream basin pit	*Excavate pit 1m deep in clay, assume 1m of excavation around pit, Rawlinsons pg 213*	m3	1.00	1.00	1.00	1.00	***1.00***			**1.00**			**60.10**			**1,000**
		1 x 1m x 1m SI pit	*Assume precast concrete 900 x 900 x 900mm deep with 150mm concrete base and wall, Rawlinsons 2015 pg 488*	No.				1.00	***1.00***			**1.00**			**975.00**			**1,000**
		Add an additional 0.7m of depth to pit	*Assume in situ concrete cost for adding each additional 100mm depth to 900 x 900 x 900mm deep pit with 150mm concrete base, Rawlinsons pg 488*	No			0.70		***0.70***			**0.70**			**146.00**			**1,000**
		Break into and connect new upstream basin pit		No								**1.00**	2,000.00	5,000.00	**3,325.00**			**4,000**
		Minor Earthworks - Swales and Berms																
		Excavated material as filling to create bund and lift downstream end of field	*Rawlinsons 2015 pg 214*	m3				1,562.49	***1,562.49***			**1,562.49**			**7.90**			**13,000**
		Filling to lift surface of field	*Assume clean sand filling, Rawlinsons 2015 pg 214*	m3				2,624.46	***2,624.46***			**2,624.46**			**47.00**			**124,000**
		Trim surfaces of cuttings and embankments in other than rock to slope	*Trim surface of playing field, Rawlinsons 2015 pg 214*	m2	70.00	100.00			***7,000.00***			**7,000.00**			**3.35**			**24,000**
		Trim surfaces of cuttings and embankments in other than rock to slope	*Trim surface of detention basin, Rawlinsons 2015 pg 214*	m2					-			**2,000.00**			**3.35**			**7,000**
		Landscaping																
		Planting - Park turf	*Assume landscaping includes rehab of site after works, assume only need landscaping of detention basin, Rawlinsons 2015 pg 228*	m2					-			**2,000.00**			**8.60**			**18,000**
		Direct Cost Sub-Total																**194,000**
															TOTAL			**$ 282,000**

Appendix C. Memo 3 - Flood assessment of basin concept design options

JACOBS

Memorandum

Flood assessment of basin concept design options

Subject	**Flood assessment of basin concept design options**	**Project Name**	Norman Griffiths Oval Flood Study
Attention	Guy Thomas	**Project No.**	IA133200
From	Lih Chong		
Date	8 November 2017		
Copies to	Anna Milner		

This memo provides the results and assessments from the flood modelling undertaken of the two split detention basin concept designs provided by Ku-ring-gai Council and two variant options which increase the capacity of the pit and pipe network in the South-Eastern basin of the oval.

1. Existing conditions

The existing Norman Griffiths Oval, located on Lofberg Road in West Pymble, includes an earthen embankment on its downstream side to form a flood detention basin. The stormwater network upstream of the Oval includes a lined open channel and underground pipes. The network passes under the Oval via a 1050mm pipe, which has a reduced capacity compared to the system upstream. Excess flows surcharge into the detention basin, and in addition to flood flows in excess of the open channel and the 4x 750mm pipe cross drainage under Lofberg Road, form the flows into the detention basin. Several grated letterbox-type pits drain the basin, transferring the floodwaters back into the stormwater network and discharging them into the downstream natural channel (i.e. Lofberg Creek). Lofberg Creek then flows westward and joins another creek, Quarry Creek, before flowing via culvert under Yanko Road and then further westward down the valley to discharge into the Lane Cove River.

2. Concept Designs

Two concept designs were developed by Council following preliminary assessment and options identification by Jacobs, and are summarised below:

- Option 1: total basin volume approx. 1830m^3 and full sized football pitch (100m x 70m)
- Option 2: total basin volume approx. 2430m^3 and reduced sized football pitch (96m x 66m).

The designs of the ovals as provided by Council can be found in Appendix C.

Following test runs and Council consultation of these initial designs, new drainage systems were designed and included to prevent increased flooding. These changes within the model included:

- Swale/channel as a footpath with a cross-fall of 1:40 constructed on the north-western side of the oval to mitigate sheet flow coming from the north-western side of the oval.
- New drainage points along the swale. This included three new pits and pipes along the length of the swale.
- Moving the two existing pits in the south side of the oval to the new lowest topographic points in the basins. The existing pipes were moved to connect to the new position of the pits.

The two concept designs as provided by Council have been assessed in the TUFLOW hydraulic model and are denoted by the model run number 009 (i.e. Option 1 (009) and Option 2 (009)).

Along with these changes, an alternate option was run by Jacobs. The only changes were increasing the capacity of the pit and pipe in the south-eastern side of the oval, (i.e. draining the lower basin), increasing the diameter of the pipe from 200mm to 600mm and having 2 pits. This was to allow water to drain from the basins more efficiently. This design is detailed in Appendix C. For this alternate option, it was run for both Option 1 and Option 2. This set up is denoted by the model run number 010 (i.e. Option 1 (010) and Option 2 (010).

3. Assessment objectives

- Update an existing hydraulic model of the catchment and define existing flooding conditions. Flood events to be assessed include the 0.2 Exceedances per Year ("EY", i.e. 5 year Average Recurrence Interval, "ARI") 10%, 5%, 2% and 1% Annual Exceedance Probability (AEP) events.
- It is proposed to upgrade the Oval to a synthetic pitch, which requires flood immunity, at least, in the 2% AEP event. A flow bypass system is to be modelled and flood impacts quantified.
- Identify and assess a feasible mitigation scheme to manage the flooding impacts.

4. Results and assessment

All flood events including the 0.2 EY, 10%, 5%, 2% and 1% AEP events for durations from 25 minute to 6 hours have been modelled for the existing case and various options. Table B.1 details the peak flows and changes in flow magnitudes for all flood AEPs in areas of interest including upstream of the oval, flows over the oval and downstream of the oval. As it can be seen in this table, there is generally a reduction in flows across the network when modelling all of the design options.

Flood depth and change in flood level mapping has been prepared for the 2% AEP and 0.2 EY flood events only, for simplicity in evaluating the flooding in a frequent and rarer/the design flood events. The results of the for the existing oval configuration are presented in Figure A1 and Figure A2. Flood depths of up to approximately 1.0m occur for the 2% AEP at the low point of the existing oval and basin.

All floods events from the 1% AEP to 0.2 EY were tested for the new options. The results of the modelling indicate that the options provided by council significantly reduce flooding on the oval. The basins along the edges of the oval reducing the amount of pooling on the oval.

In the Afflux maps, there appears to be a large change in flood depths in the project area but this is due to the increased elevations of the fields. This happens because the afflux map is the difference of the heights of the water. This means the Afflux maps should be used to assess changes in water levels outside of the project area.

4.1 Option 1 (009)

Please refer to Figures A3 and A4 for the peak flood depths and to Figures A11 and A12 for the change in flood levels (afflux) for the 2% AEP and 0.2 EY storm events.

There is significantly less flooding on the oval for this scenario than for the existing conditions. On the oval, there are generally peak flood depths of less than 0.01m. These flows are due to the swale in the north-western side of the oval overflowing onto the oval.

For the 2% AEP, the upper basin fills to a level of 72.8mAHD, flows over the eastern spillway and does not overtop the basin embankment. The lower basin fills to a level of 71.1m AHD, with increased overflow over the existing basin spillway.

Outside of the project area, there is a slight increase in flood depths due to water spilling from the western and the southern corners of the design compared to the existing conditions. This causes an increase in flood levels in the access road and car park to the eastern side of the Ku-ring-gai Fitness and Aquatic Centre. Besides this increase, there are either no other changes in flood levels or a slight decrease in flood levels as seen in the Afflux maps.

As seen in Table B.1, there is an increase from the existing case in the peak flows spilling from the lower basin (Location 4) for the 2% AEP and the 1% AEP of 0.2m^3/s and 0.9m^3/s, respectively. Flows at the basin pipe outlet discharging into Quarry Creek (Location 5) increase by 0.5m^3/s in the flows for the 1% AEP due to the increased basin overflows. Flows at Location 5 are reduced for events up to and including the 2% AEP.

During the 1% AEP there is a slight increase in discharge downstream in Quarry Creek (Location 6) of 0.1m^3/s. Flows at Location 6 are reduced for events up to and including the 2% AEP.

4.2 Option 2 (009)

Please refer to Figures A4 and A5 for the peak flood depths and to Figures A13 and A14 for the change in flood levels (afflux) for the 2% AEP and 0.2 EY storm events.

There is significantly less flooding on the oval for this scenario than for the existing conditions. On the oval, there are generally peak flood depths of less than 0.01m. These flows are due to the swale in the north-western side of the oval overflowing onto the oval.

For the 2% AEP, the upper basin fills to a level of 72.7m AHD, flows over the eastern spillway and does not overtop the basin embankment. The lower basin fills to a level of 70.96m AHD, with increased overflow over the existing basin spillway in the 1% AEP only.

Outside of the project area, there is a slight increase in flood depths due to water spilling from the western corner of the design compared to the existing conditions. This causes an increase in flood levels in the access road and car park to the eastern side of the Ku-ring-gai Fitness and Aquatic Centre. Besides this increase, there are either no other changes in flood levels or a slight decrease in flood levels as seen in the Afflux maps.

As seen in Table B.1, there is an increase from the existing case in the peak flows spilling from the lower basin (Location 4) for the 1% AEP of 0.3m^3/s. Overflows are reduced in the 2% AEP.

Flows at the basin pipe outlet discharging into Quarry Creek (Location 5) increase by 0.1m^3/s in the flows for the 1% AEP due to the increased basin overflows. Flows at Location 5 are reduced for events up to and including the 2% AEP.

During the 1% AEP there is a slight decrease in discharge downstream in Quarry Creek (Location 6) of 0.1m^3/s. Flows at Location 6 are similar or reduced for events up to and including the 2% AEP.

4.3 Option 1 (010)

Please refer to Figures A7 and A8 for the peak flood depths and to Figures A15 and A16 for the change in flood levels (afflux) for the 2% AEP and 0.2 EY storm events.

There is significantly less flooding on the oval for this scenario than for the existing conditions. On the oval, there are generally peak flood depths of less than 0.01m. These flows are due to the swale in the north-western side of the oval overflowing onto the oval.

For the 2% AEP, the upper basin fills to a level of 72.81m AHD, flows over the eastern spillway and does not overtop the basin embankment. The lower basin fills to a level of 71.06m AHD, with increased overflow over the existing basin spillway in the 1% AEP only.

Outside of the project area, there is a slight increase in flood depths due to water spilling from the western corner of the design compared to the existing conditions. This causes an increase in flood levels in the access road and car park to the eastern side of the Ku-ring-gai Fitness and Aquatic Centre. Besides this increase, there are either no other changes in flood levels or a slight decrease in flood levels as seen in the Afflux maps.

As seen in Table B.1, there is an increase from the existing case in the peak flows spilling from the lower basin (Location 4) for the 1% AEP of 0.8m^3/s. Overflows are reduced in the 2% AEP.

Flows at the basin pipe outlet discharging into Quarry Creek (Location 5) increase by 0.1m^3/s in the flows for the 1% AEP due to the increased basin overflows. Flows at Location 5 are reduced for events up to and including the 2% AEP.

During the 1% AEP there is a slight increase in discharge downstream in Quarry Creek (Location 6) of 0.1m^3/s. Flows at Location 6 are similar or reduced for events up to and including the 2% AEP.

4.4 Option 2 (010)

Please refer to Figures A4 and A5 for the peak flood depths and to Figures A13 and A14 for the change in flood levels (afflux) for the 2% AEP and 0.2 EY storm events.

There is significantly less flooding on the oval for this scenario than for the existing conditions. On the oval, there are generally peak flood depths of less than 0.01m. These flows are due to the swale overtopping in the north-western section of the oval.

For the 2% AEP, the upper basin fills to a level of 72.7m AHD, flows over the eastern spillway and does not overtop the basin embankment. The lower basin fills to a level of 70.84m AHD, with slightly decreased overflow over the existing basin spillway.

Outside of the project area, there is a slight increase in flood depths due to water spilling from the western corner of the design compared to the existing conditions. This causes an increase in flood levels in the access road and car park to the eastern side of the Ku-ring-gai Fitness and Aquatic Centre. Besides this increase, there are either no other changes in flood levels or a slight decrease in flood levels as seen in the Afflux maps.

As seen in Table B.1, there is an increase from the existing case in the peak flows spilling from the lower basin (Location 4) for the 1% AEP of 0.1m^3/s. Overflows are reduced in the 2% AEP.

Flows at the basin pipe outlet discharging into Quarry Creek (Location 5) increase by 0.1m^3/s in the flows for the 1% AEP due to the increased basin overflows. There is no change, or a reduction in flows in Quarry Creek at Location 5 and Location 6 for all flood events

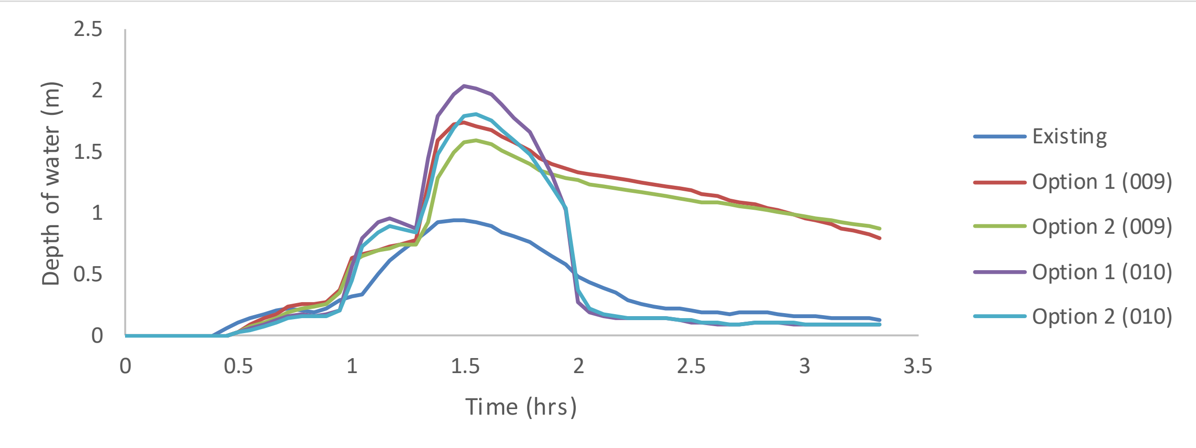
5. Basin low point time to drain

The time to drain the upper and lower basins is likely to be a factor in selection of the concept design option. The pipe sizes for the network connecting the upper basin has not changed between the existing model and the concept designs and generally has a high inlet (i.e. outflow) capacity. The outlet for the lower basin is significantly reduced in the run 009 options provided by Council (200mm pipe as the main outlet), with an alternatively higher outlet capacity trialled by Jacobs (600mm pipe as the lower basin main outlet). As such, the time to drain the lower basin is analysed and the results are presented in Figure 5.1.

For the existing case, the time to drain the basin from the peak flood depths is approximately 45 minutes. For Option 1 (009) and Option 2 (009) the time it takes to drain the basin is greater than 3 hours (potentially greater than 6 hours). For Option 1 (010) and Option 2 (010) the time it takes to drain the basin is approximately 40 minutes.

We conclude from this that the scenario 010 with the increased network capacity is the better option, as it significantly reduces the time to drain the lower basin.

Figure 5.1 : Depth of water with time - 2% AEP 2 hour event, at lower basin low point – 2% AEP 2-hour event, at lower basin low point



6. Flow conditions in Quarry Creek

The influence of the designs on the flows within Quarry Creek are an important factor in determining the best design. The hydrograph for Quarry Creek at monitoring locations 5 and 6 (refer to Figure 6.5) for the 2% AEP 2 hour storm are presented in Figure 6.1 and Figure 6.2.

There is a decrease in flows in Quarry Creek up until the 2% AEP as can be seen in Figure 6.1 and Figure 6.2. Before the peak of all of the scenarios, the hydrographs are very similar as expected. After the peak there are slight differences between the existing scenario and the modelled options. This causes sections of the hydrographs where the flows are greater and less for approximately 20 minutes in the modelled flows. At the end of the hydrographs the hydrographs converge.

There is a slight increase in peak flows for the 1% AEP in Quarry Creek at both monitoring points 5 and 6 for Option 1 (009) and Option 1 (010). This increase in maximum flow is due to a second peak that is not observed in the existing hydrographs. The second peak in the modelled hydrographs occur when the lower basin reaches maximum capacity and spills (refer to Figure 5.1). After the peak (at the 2 hour mark) there are differences between the existing scenario and the modelled options. This causes sections of the hydrographs where the options flows remain greater than the existing case for approximately 30 minutes. Hence, the duration of mid- to high flows (above say 3m^3/s) are approximately 20 – 30 minutes longer for all concept design options, compared to the existing case, for the 1 and 2% AEP events. This may be tolerable for these larger flood events, noting that these are less than the peak 0.2 EY flow of approximately 4.5m^3/s. At the end of the hydrographs the hydrographs converge.

Flows in Quarry Creek at Yanko Road are observed to maintained at or slightly below existing for all concept design scenarios and all flood events up to the 1% AEP.

Figure 6.1 : 2% AEP 2 hour event, flow in Quarry Creek at monitoring location 5

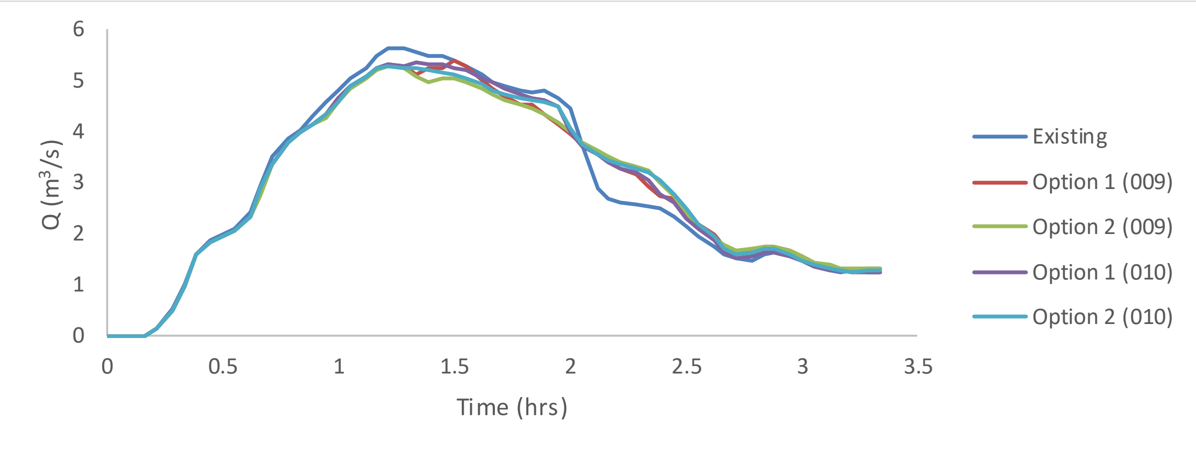


Figure 6.2 : 2% AEP 2 hour event, flow in Quarry Creek at monitoring location 6

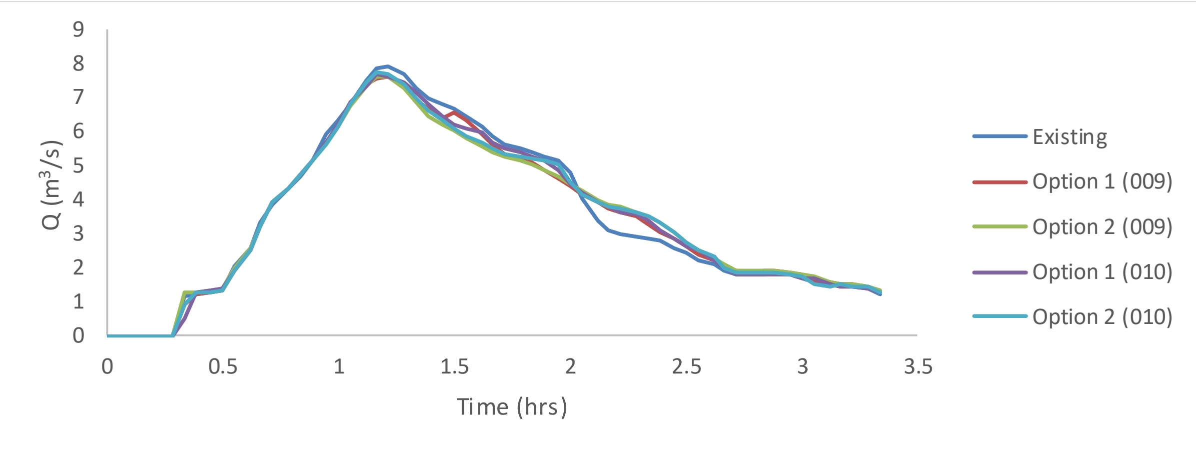


Figure 6.3 : 1% AEP 2 hour event, flow in Quarry Creek at monitoring location 5

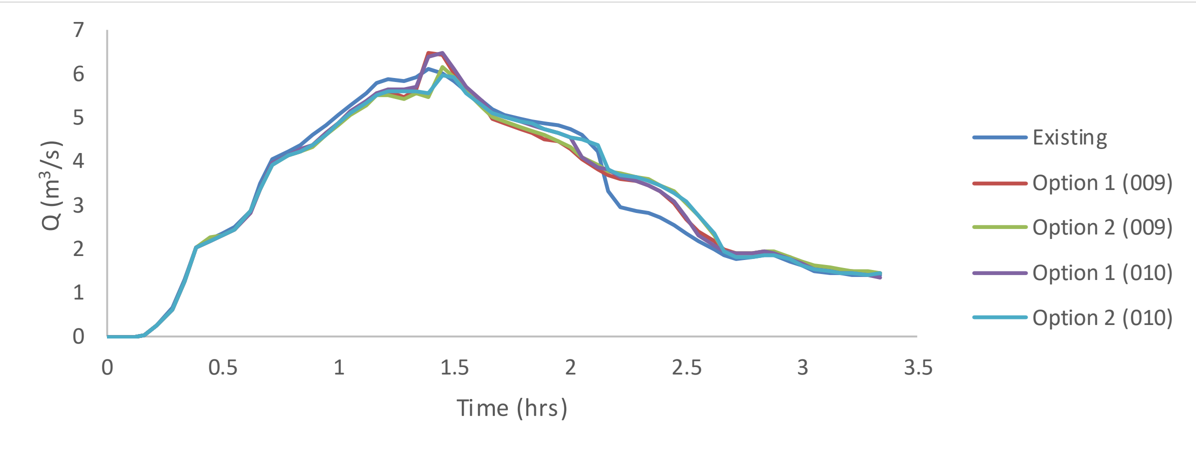
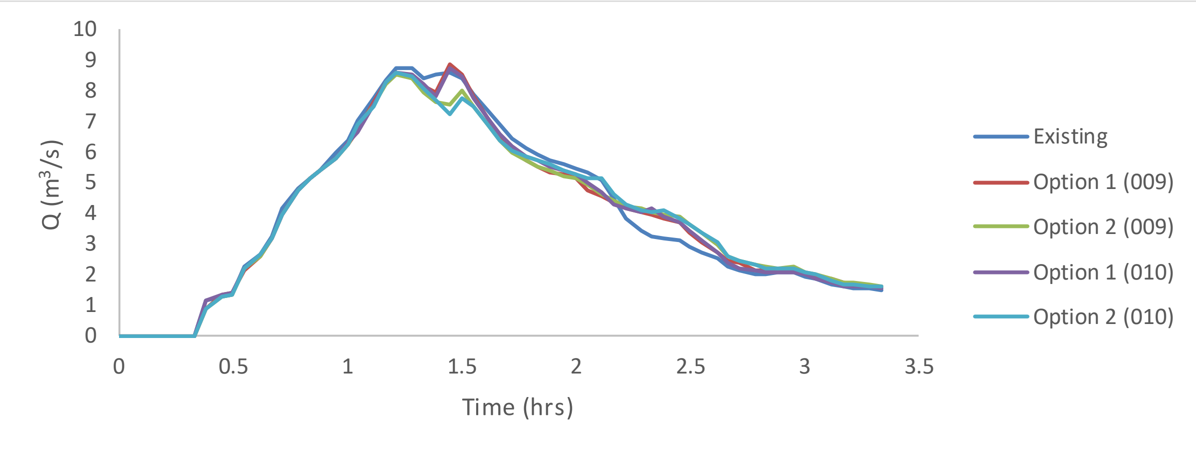
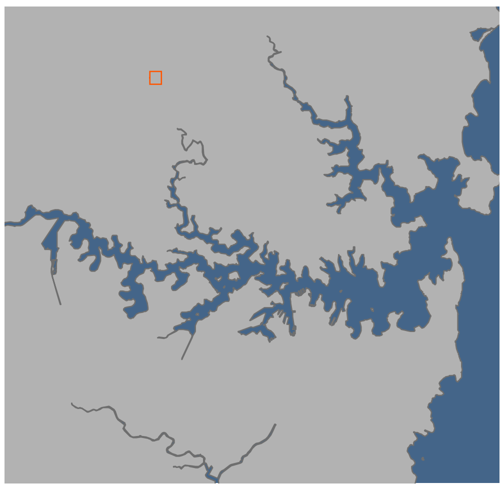


Figure 6.4 : 1% AEP 2 hour event, flow in Quarry Creek at monitoring location 6



Legend

- Reporting Locations - Pipe flow
- Reporting Locations - Overland flow



A3

1:2,000

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

Figure 6-5 | Flow reporting locations

7. Further Design Validation and Refinement

The current modelling of the concept designs suggests that overland sheet flow approaching the oval from the north-west would overflow the footpath and swale on that side of the oval and flow across the field. The modelling may not be sufficiently fine in resolution (2m grid) to accurately represent this drainage feature. It is recommended that separate drainage hydraulic calculations be prepared to validate and update the design of the swale, if required, to cater for the 2% AEP overland sheet flow of 120L/s. A low “lip” or kerb on the field-side of the footpath of 50mm height is likely to be sufficient to contain the flows in the footpath. For the grassed swale section, a v-section drain profile with a 1:4 side slope and 1m width would be sufficient to contain the flows.

Overflows over the existing basin spillway (i.e. from the lower basin) are increased in all concept design option scenarios in the 1% AEP event, with a maximum increase of 0.8 – 0.9m^3/s for Option 1 (009) and Option 1 (010), respectively. Only Option 1 (009) results in an increase in the overflows of 0.3m^3/s in the 2% AEP event. The increased overflows result in higher flows in the creek as well as in the access road and car park to the eastern side of the aquatic centre.

The proposed lower basin spillway could potentially be lifted by approximately 0.2 – 0.3m to provide an increased flood storage volume, which may limit the increase in basin overflows and downstream creek flows. This raising of the proposed spillway level is expected to maintain the soccer field as flood-free in up to the 2% AEP event. These proposed modifications would need to be modelled to assess whether these outcomes can be achieved.

Flows in Quarry Creek (monitoring locations 5 and 6) are generally higher in the 1% AEP. The only scenario which maintained the flows within the creek was Option 2 (010). Flows at these locations are not increased in all events up to and including the 2% AEP.

8. Conclusions and Recommendations

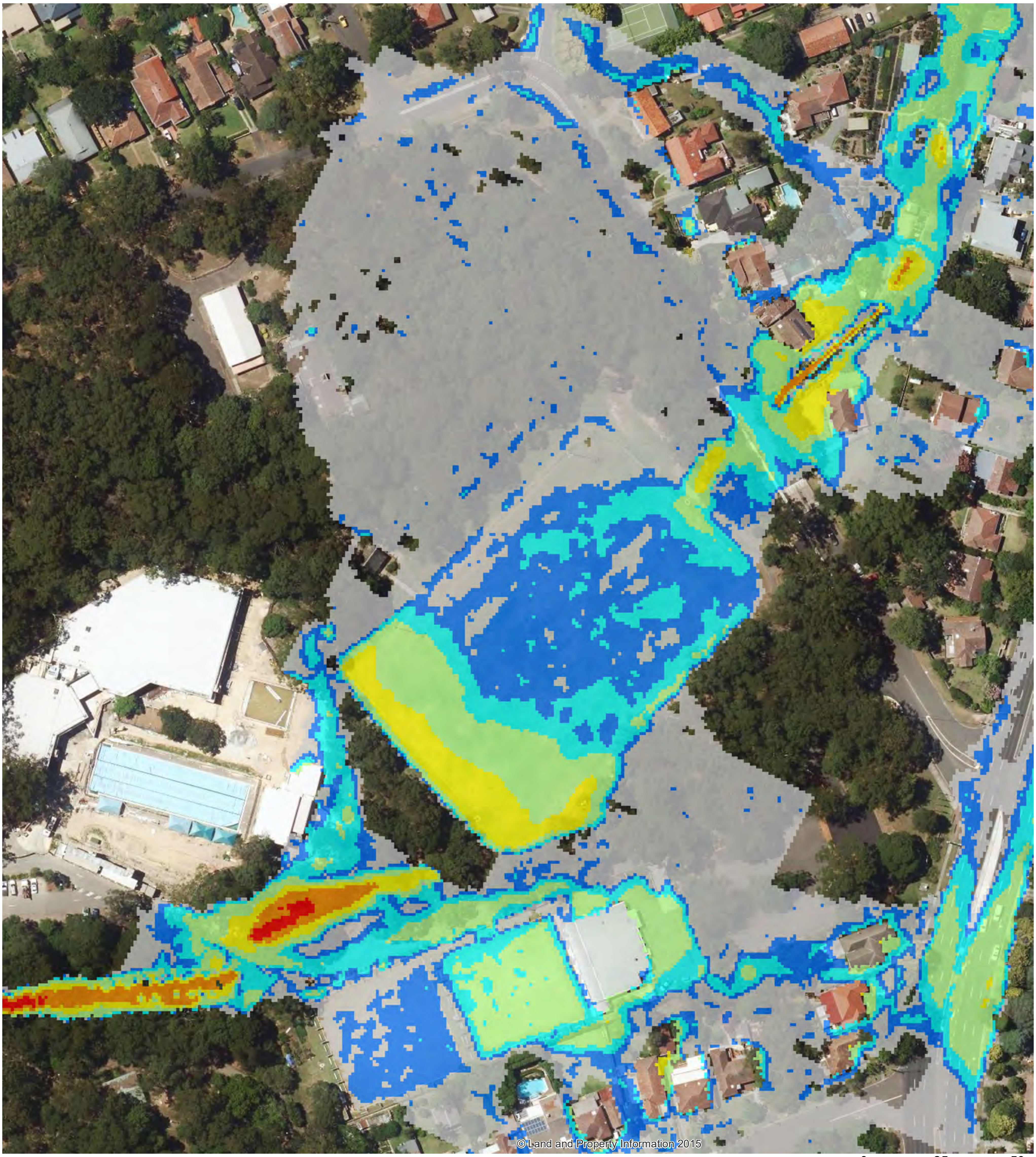
The following conclusions and recommendations are made:

- Two options provided by council were tested to determine the impacts this had on flooding including 2 more options selected by Jacobs to improve the drainage time of the lower basin.
- None of the options assessed achieved flood immunity for the oval for 2% AEP, let alone 0.2 EY. This was due to the swale being an insufficient flow path for intercepted sheet flow occurring from the north-western side of the oval. Refinements in the swale design are recommended to prevent overflows onto the oval of up to 0.01m depth.
- The Option 1 oval and basin configuration is highly preferred as it allows for a full-sized soccer field, with reduced flood storage volume. The alternative Option 2 oval and basin configuration requires a reduced-size soccer field to achieve a larger flood storage volume.
- The increased lower basin outlet capacity (010) is suggested as being preferred over the original outlet capacity as per Council’s concept design as it allows for significantly shorter time to drain for the lower basin, and also results in reduced basin overflows.
- Considering the above outcomes and the downstream creek flows, **Option 1 (010)** with increased lower basin outlet capacity is suggested as the preferred option, as basin overflows and downstream creek flows are not increased in up to the 2% AEP event. Overflows from the basin are significantly increased from existing in the 1% AEP event, however this may be tolerable and managed with scour protection on the spillway downstream side. Peak flows would be increased by 8% in the 1% AEP at the basin discharge point to Quarry Creek only, with minor increases in flow further downstream. The duration of mid- to high flows (above say 3m^3/s) are approximately 20 – 30 minutes longer for all concept design options, compared to the existing case, for the 1

and 2% AEP events. This may be tolerable for these larger flood events, noting that these are less than the peak 0.2 EY flow of approximately 4.5m^3/s. This occurs for all options tested.

- The proposed lower basin spillway could potentially be lifted by approximately 0.2 – 0.3m to provide an increased flood storage volume, which may limit the increase in basin overflows for Option 1 (010) and downstream creek flows. This raising of the proposed spillway level is expected to maintain the soccer field as flood-free in up to the 2% AEP event. These proposed modifications would need to be modelled to assess whether these outcomes can be achieved.
- If a reduced soccer field is acceptable then Option 2 (010) is suggested as an appropriate option as the basin overflows and downstream creek flows are not significantly increased and modification to the proposed spillway level is not required.
- Council, in conjunction with NSFA, should consider the advice above along with factors including cost/available funding, desired space for the sports field/s, likely usage (vehicular traffic) and environmental aspects, among other, in selection of a preferred concept.
- Flows in Quarry Creek at Yanko Road are observed to maintained at or slightly below existing for all concept design scenarios and all flood events up to the 1% AEP.

Appendix A – Flood depth and afflux maps



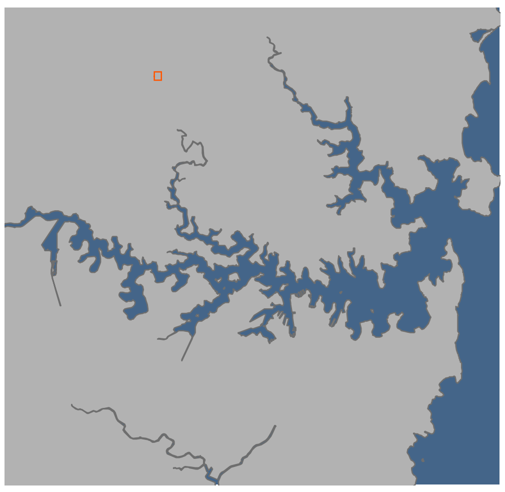
0 25 50 m

Legend

Peak Depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

N

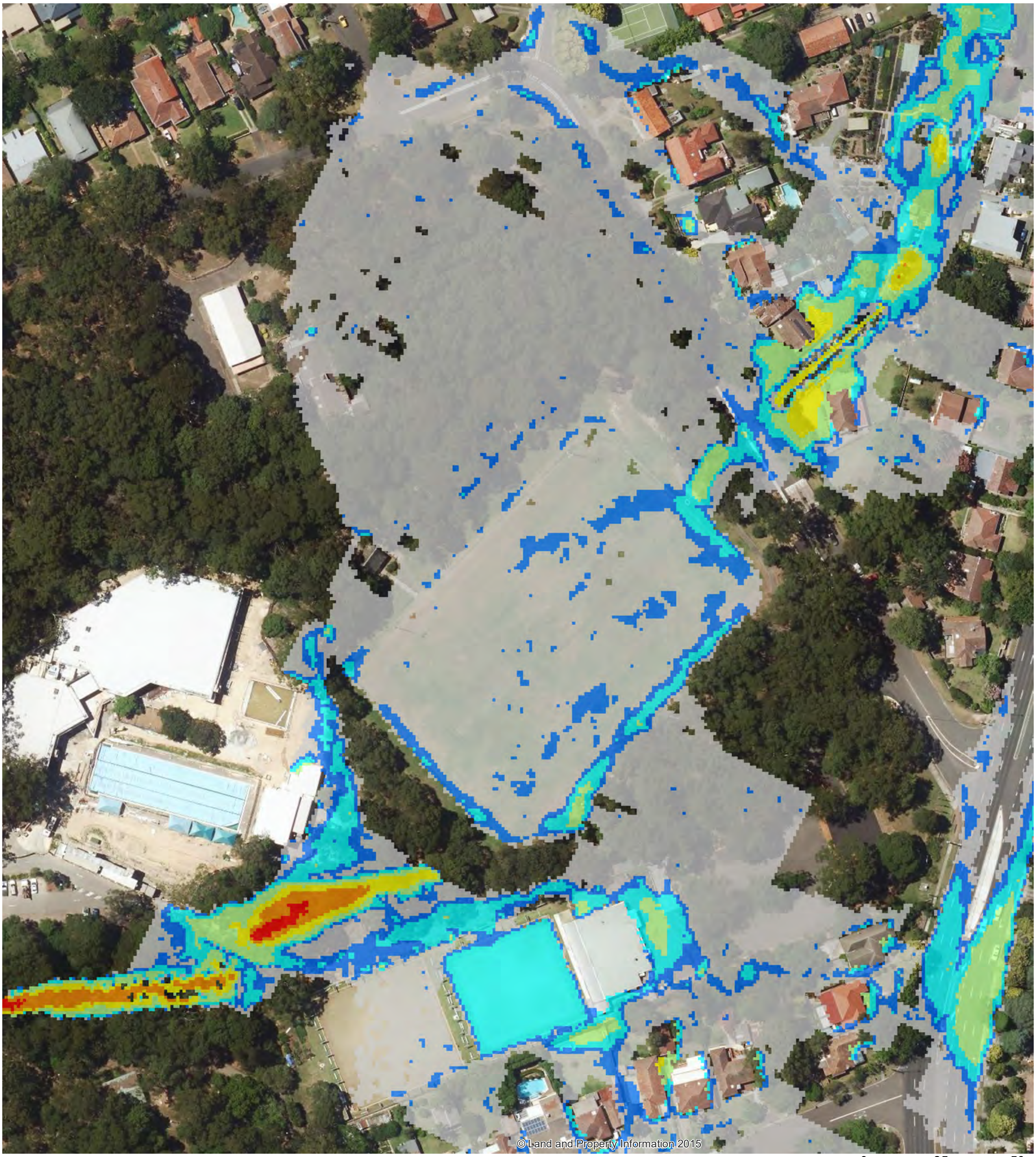


A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A1: NGO EXG - 2% AEP Existing Case Peak Depth



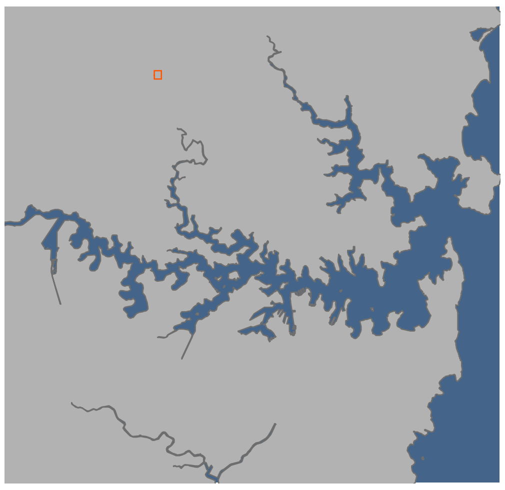
0 25 50 m

Legend

Peak Depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

N

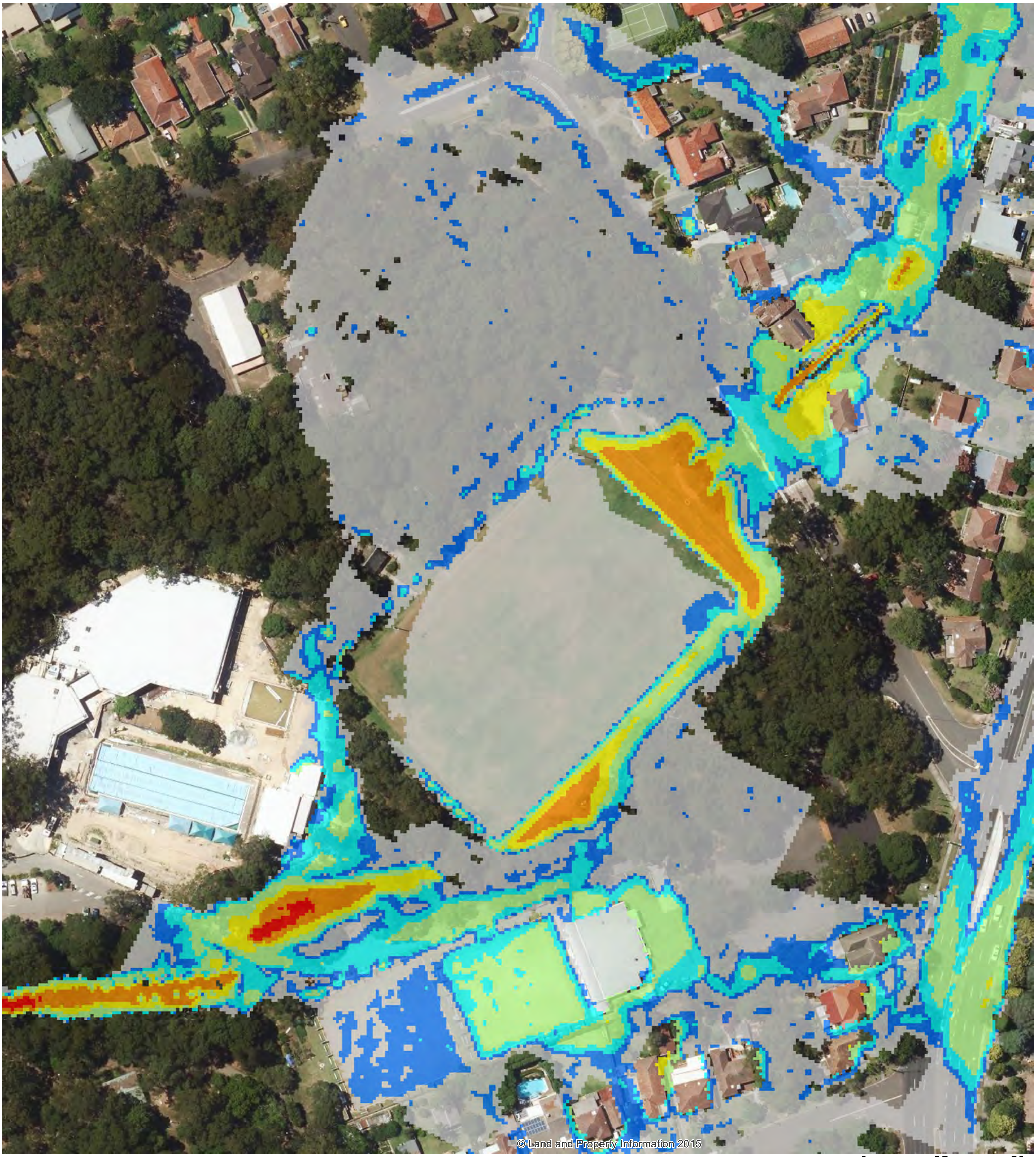


A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A2: NGO EXG - 0.2 EY Existing Case Peak Depth

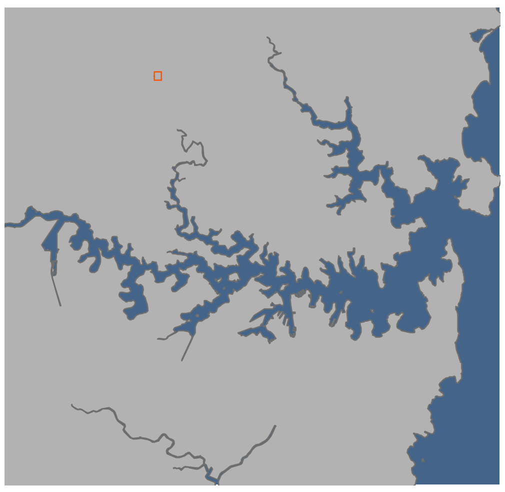


Legend

Peak Depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

N

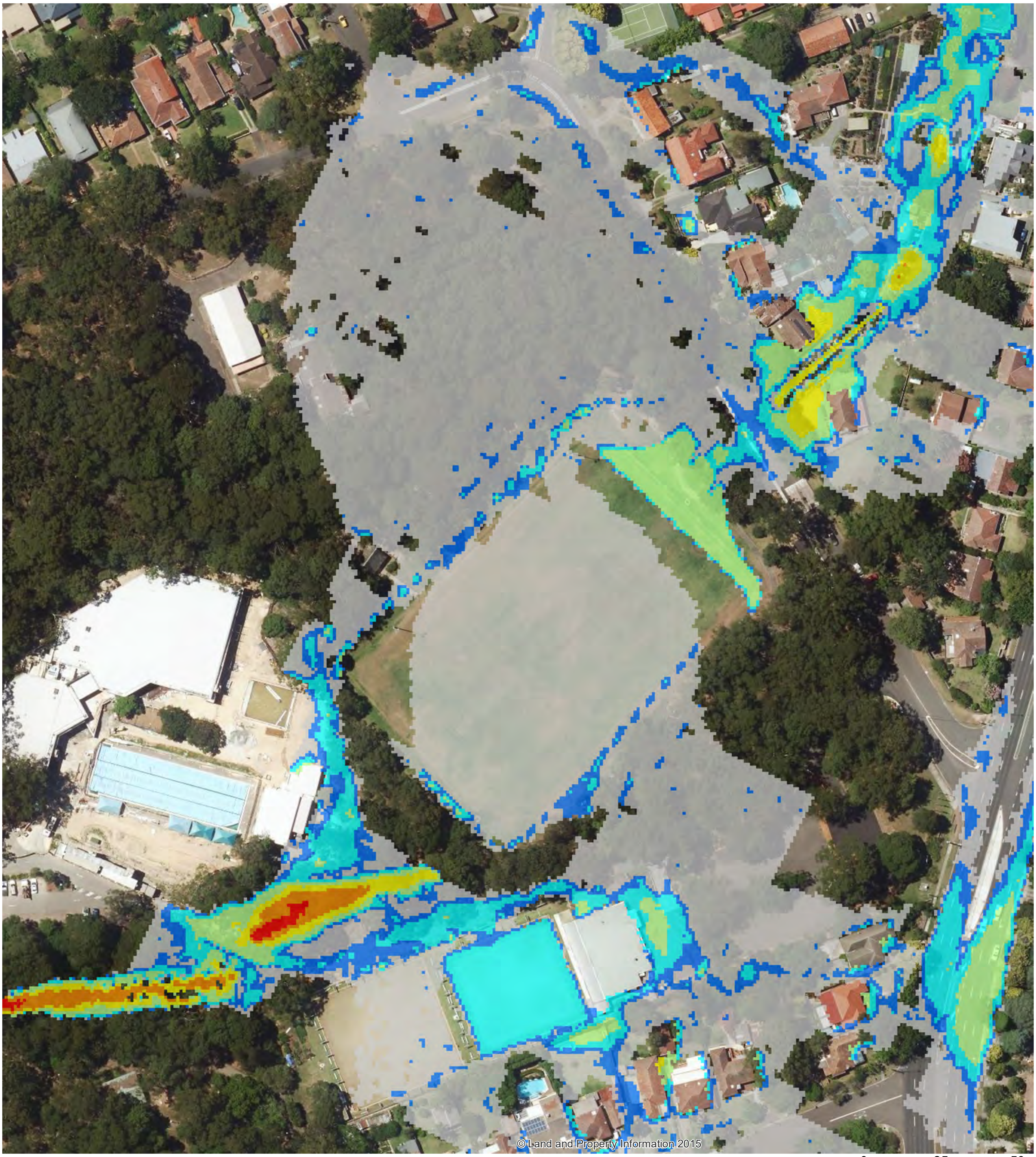


A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A3: NGO Design 009 - 2% AEP Design Case Option 1 Peak Depth

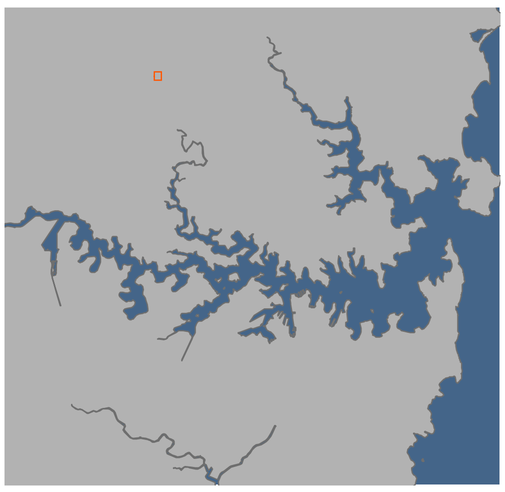


Legend

Peak Depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

N

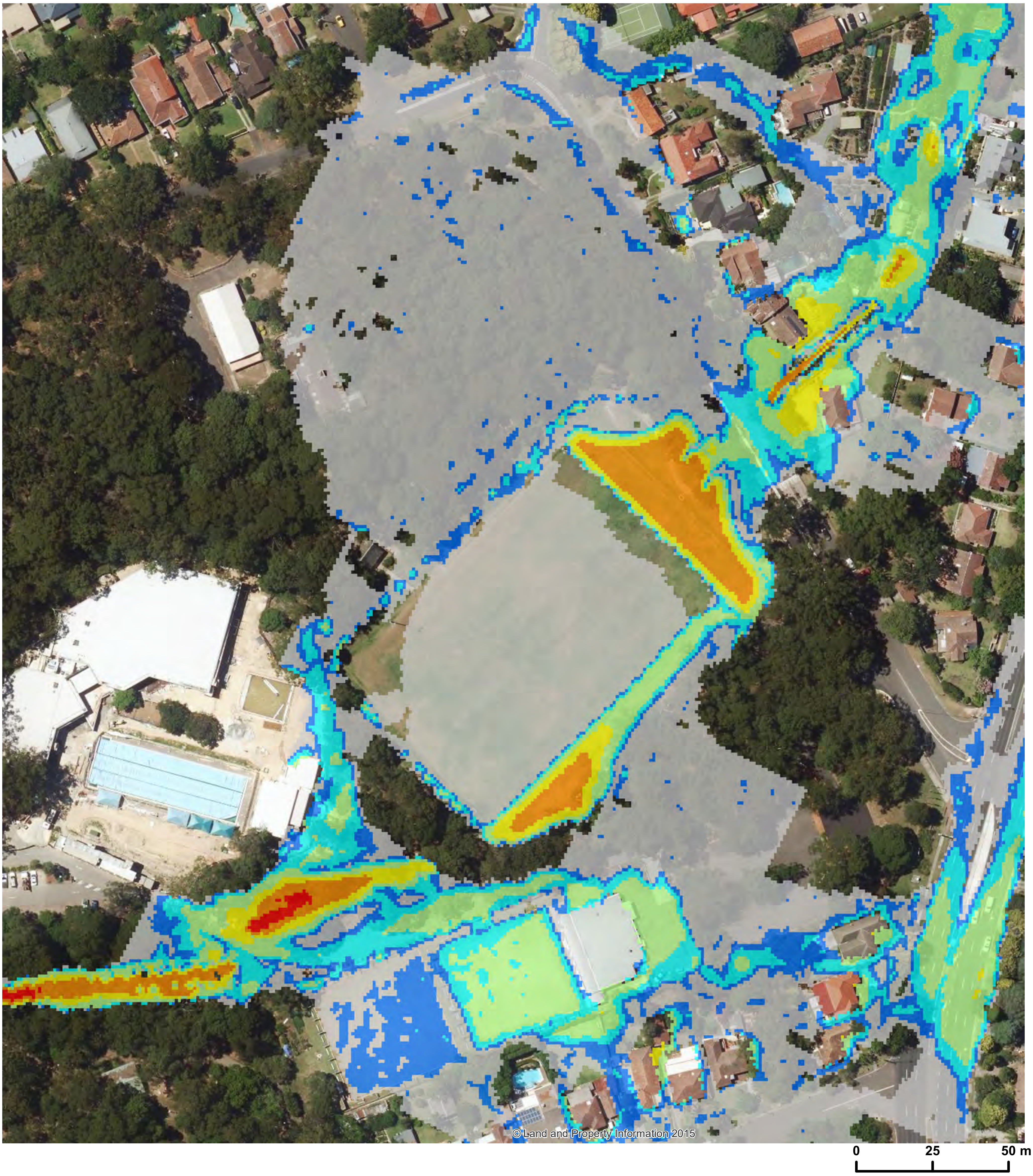


A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

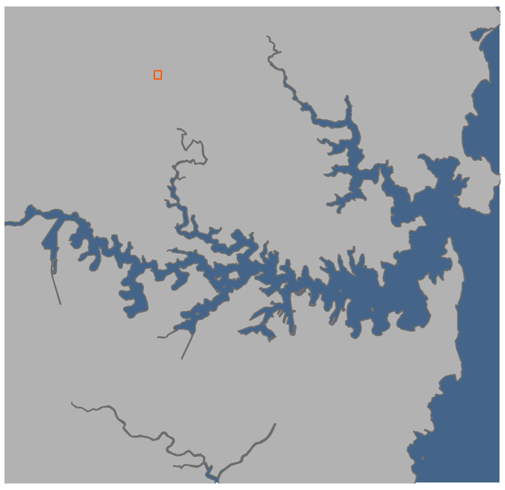
FIGURE A4: NGO Design 009 - 0.2 EY Design Case Option 1 Peak Depth



Legend

Peak Depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

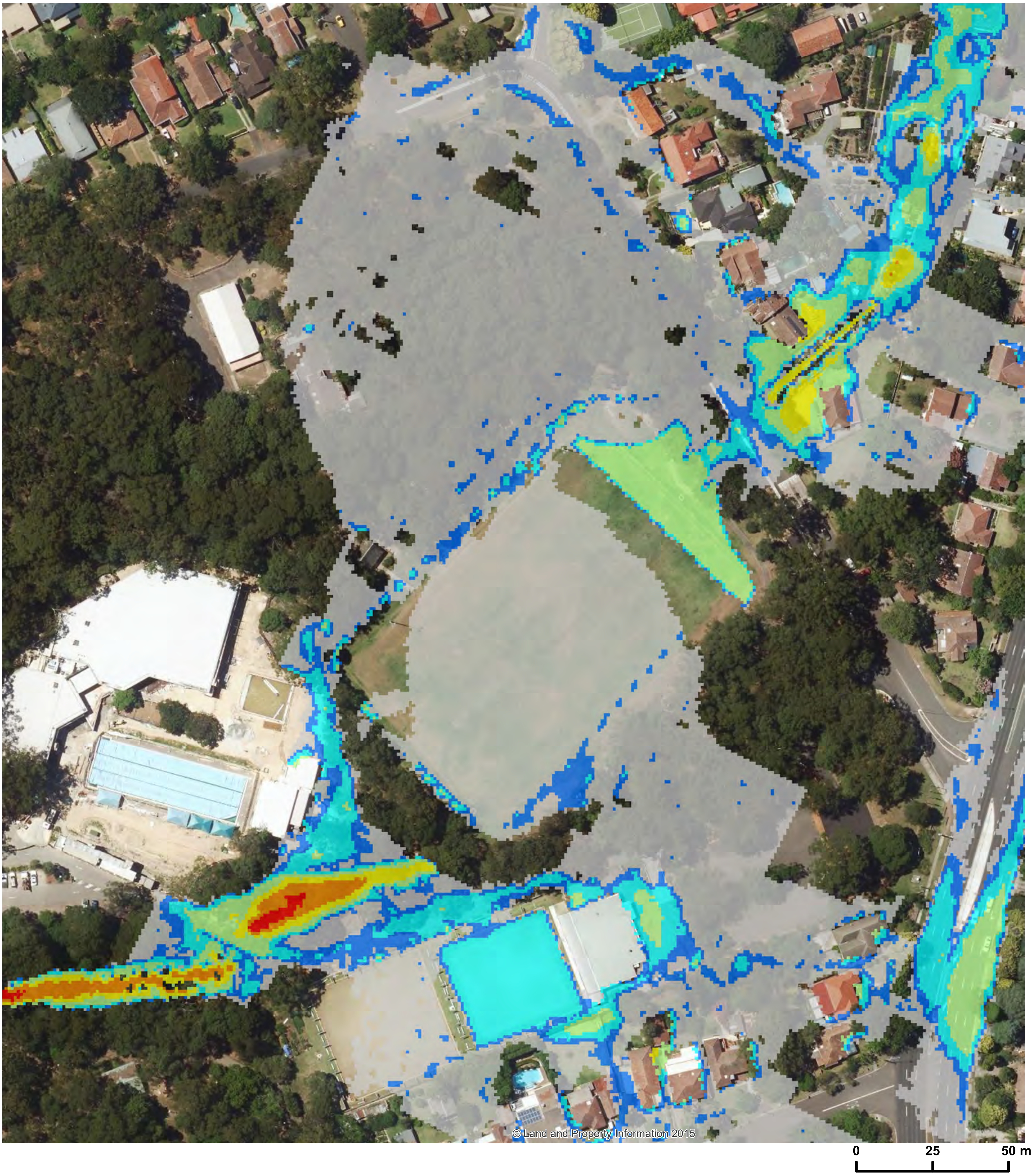


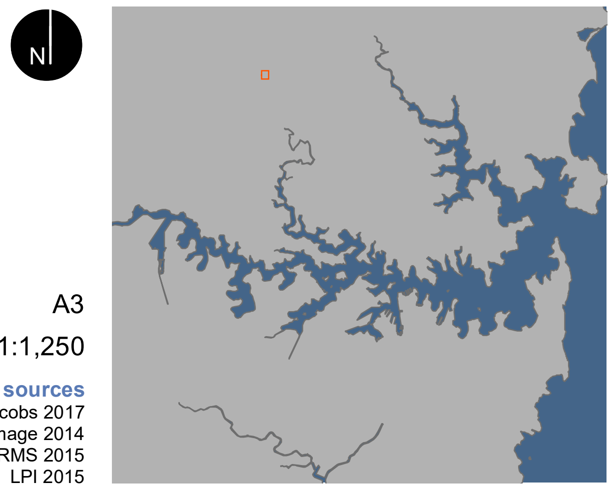
A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A5: NGO Design 009 - 2% AEP Design Case Option 2 Peak Depth





Legend

Peak Depth (m)

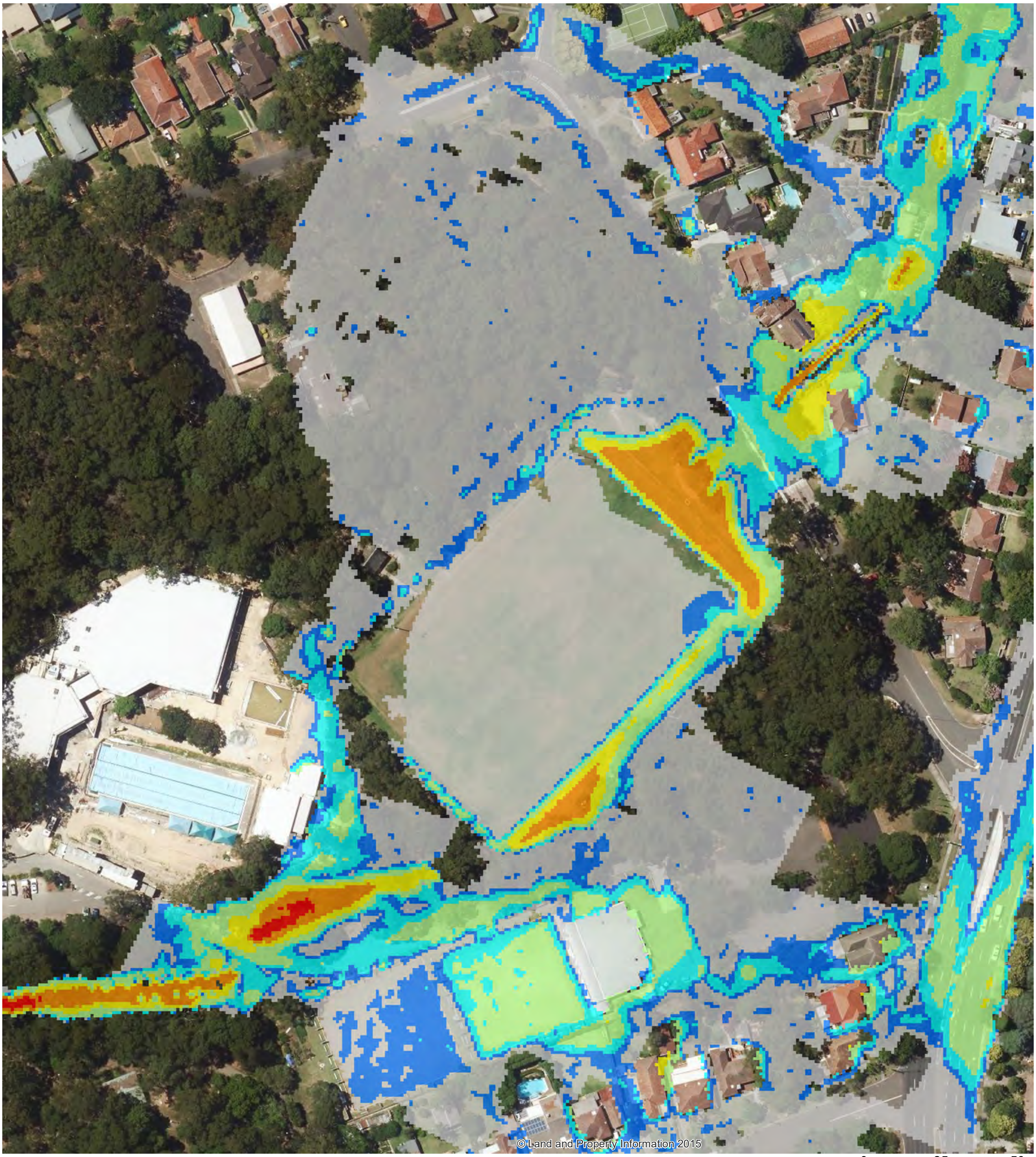
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

A3

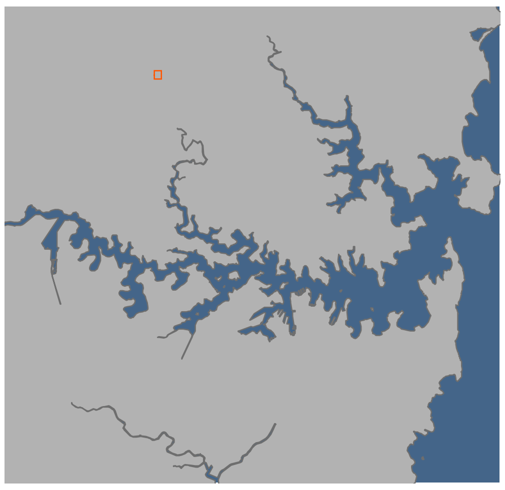
1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A6: NGO Design 009 - 0.2 EY Design Case Option 2 Peak Depth



0 25 50 m



Legend

Peak Depth (m)

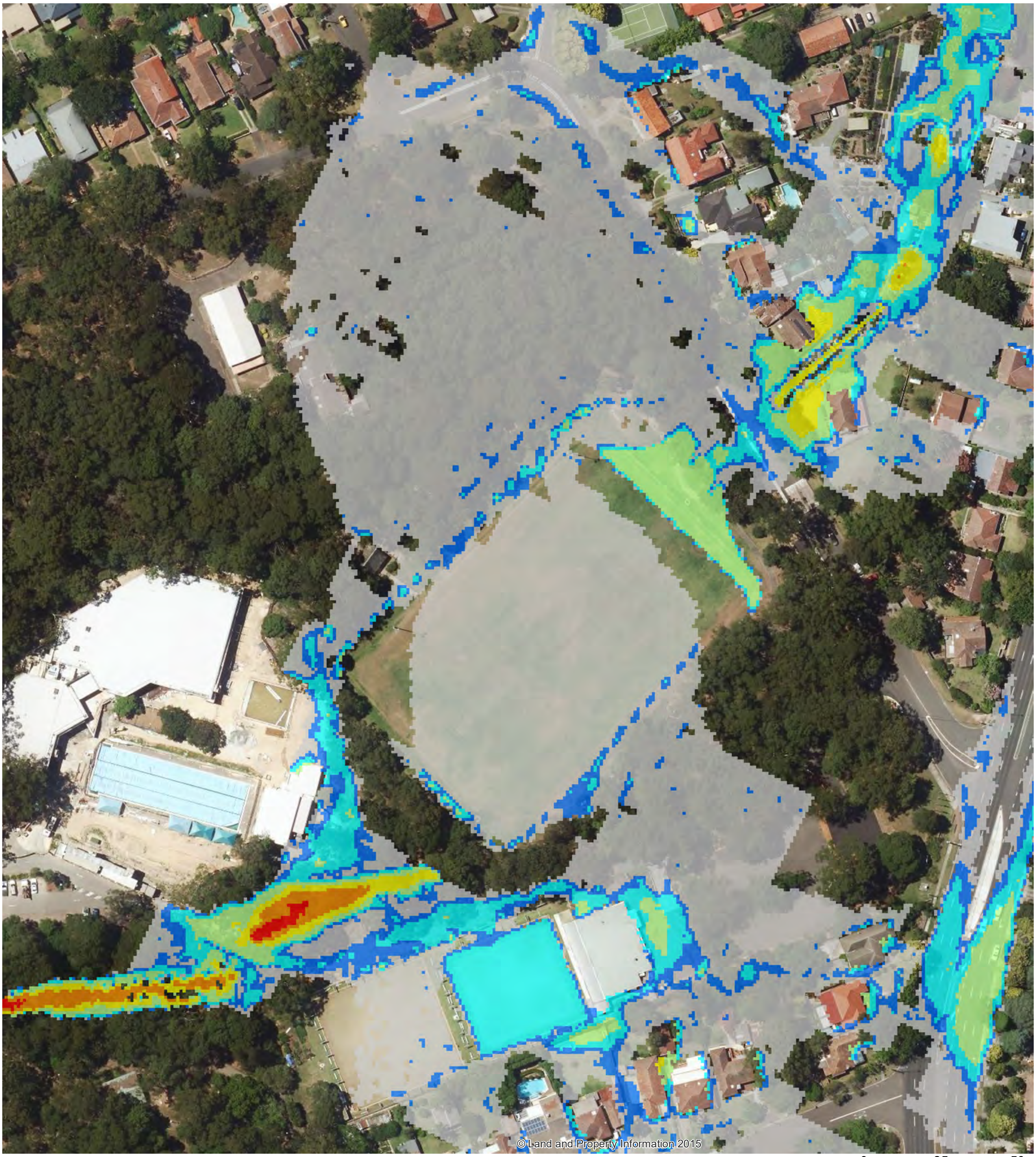
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A7: NGO Design 010 - 2% AEP Design Case Option 1 Peak Depth



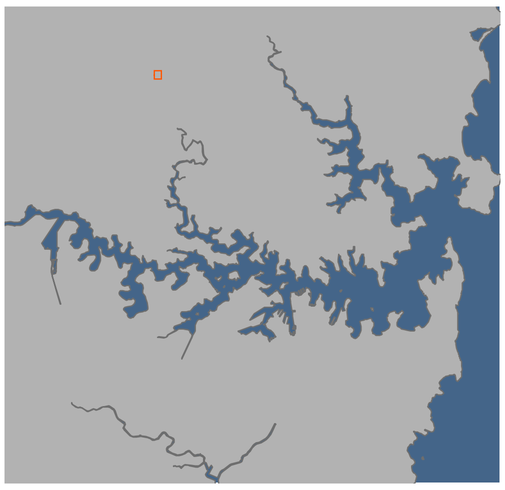
0 25 50 m

Legend

Peak Depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

N

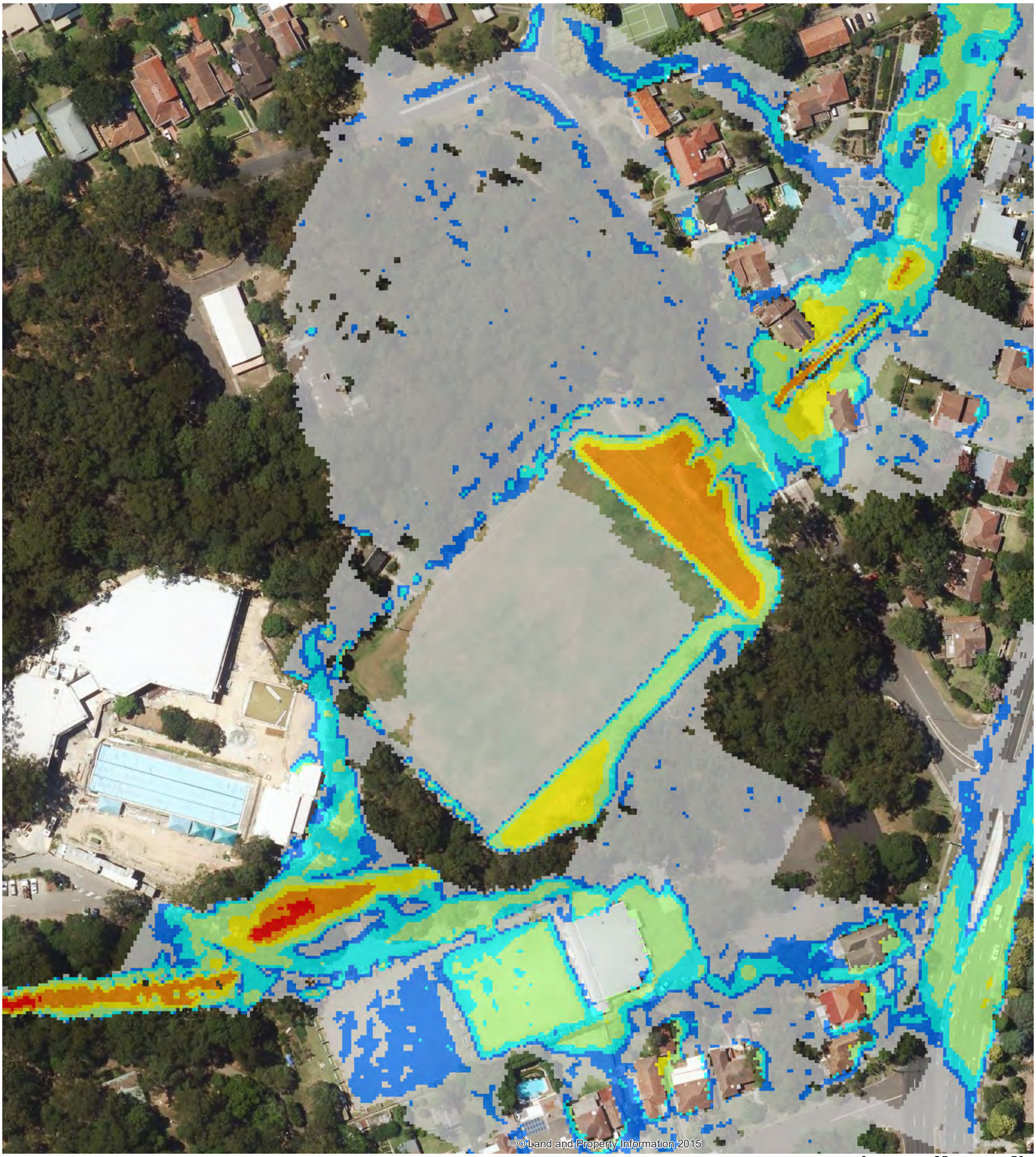


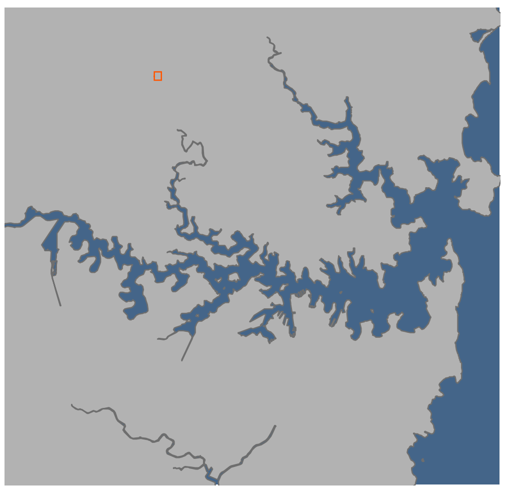
A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A8: NGO Design 010 - 0.2 EY Design Case Option 1 Peak Depth

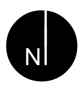




Legend

Peak Depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

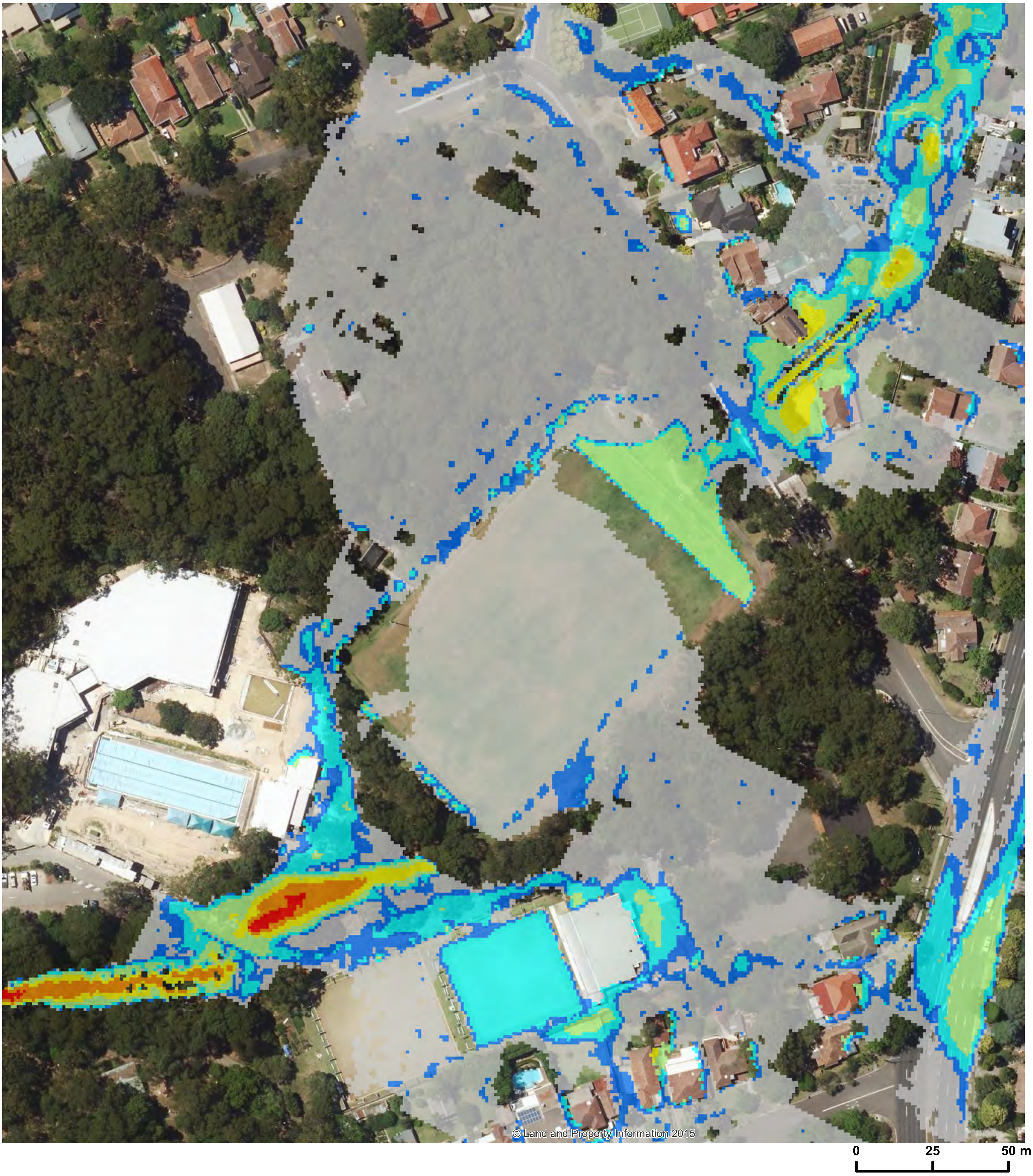


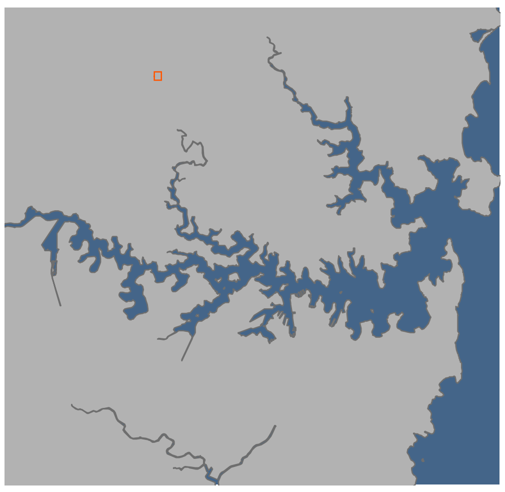
A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A9: NGO Design 010 - 2% AEP Design Case Option 2 Peak Depth





Legend

Peak Depth (m)

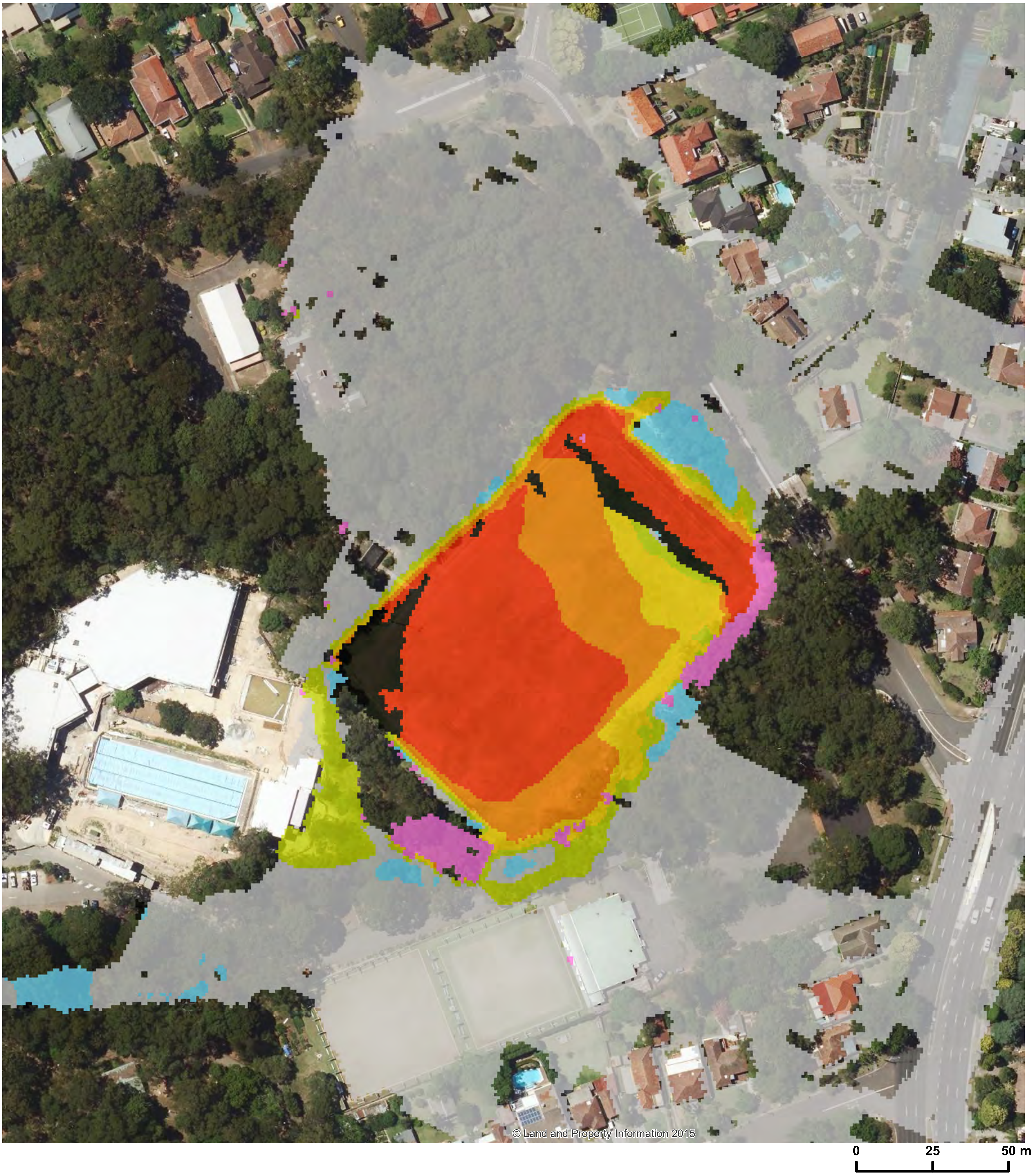
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

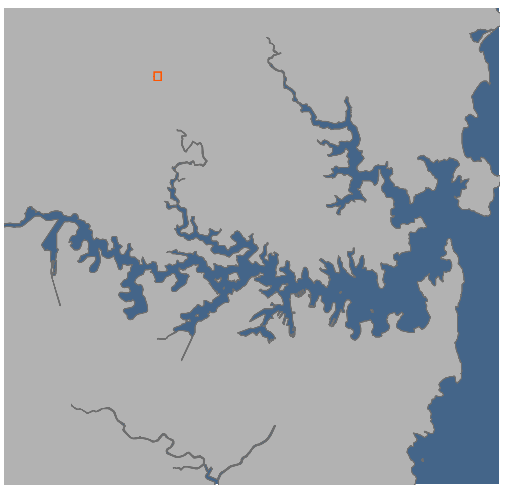
A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A10: NGO Design 010 - 0.2 EY Design Case Option 2 Peak Depth





Legend

Afflux (m)

- < -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- > 0.5
- Was Flooded Now Dry
- Was Dry Now Flooded

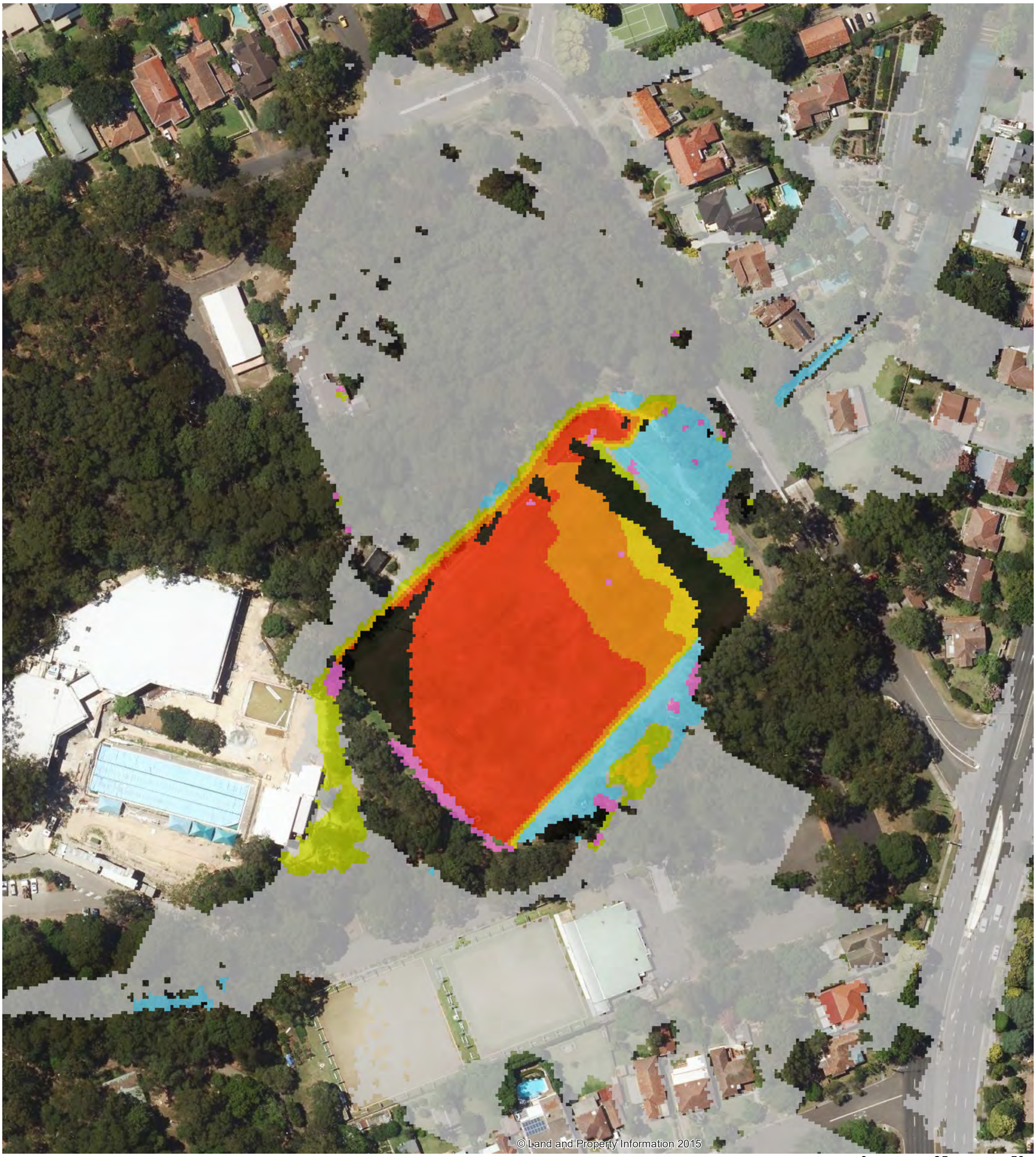
N

A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A11: NGO Design 009 - 2% AEP Design Case Option 1 Afflux



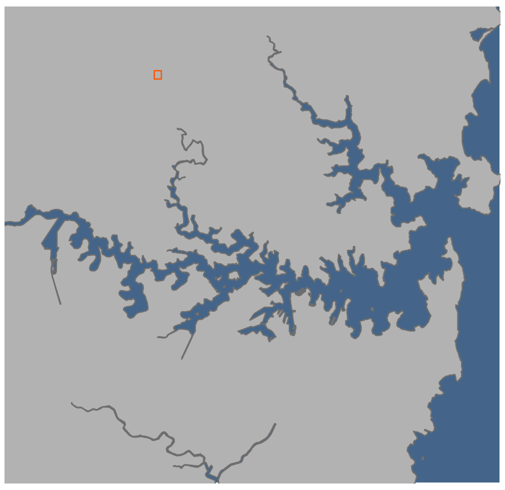
0 25 50 m

Legend

Afflux (m)

- < -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- > 0.5
- Was Flooded Now Dry
- Was Dry Now Flooded

N

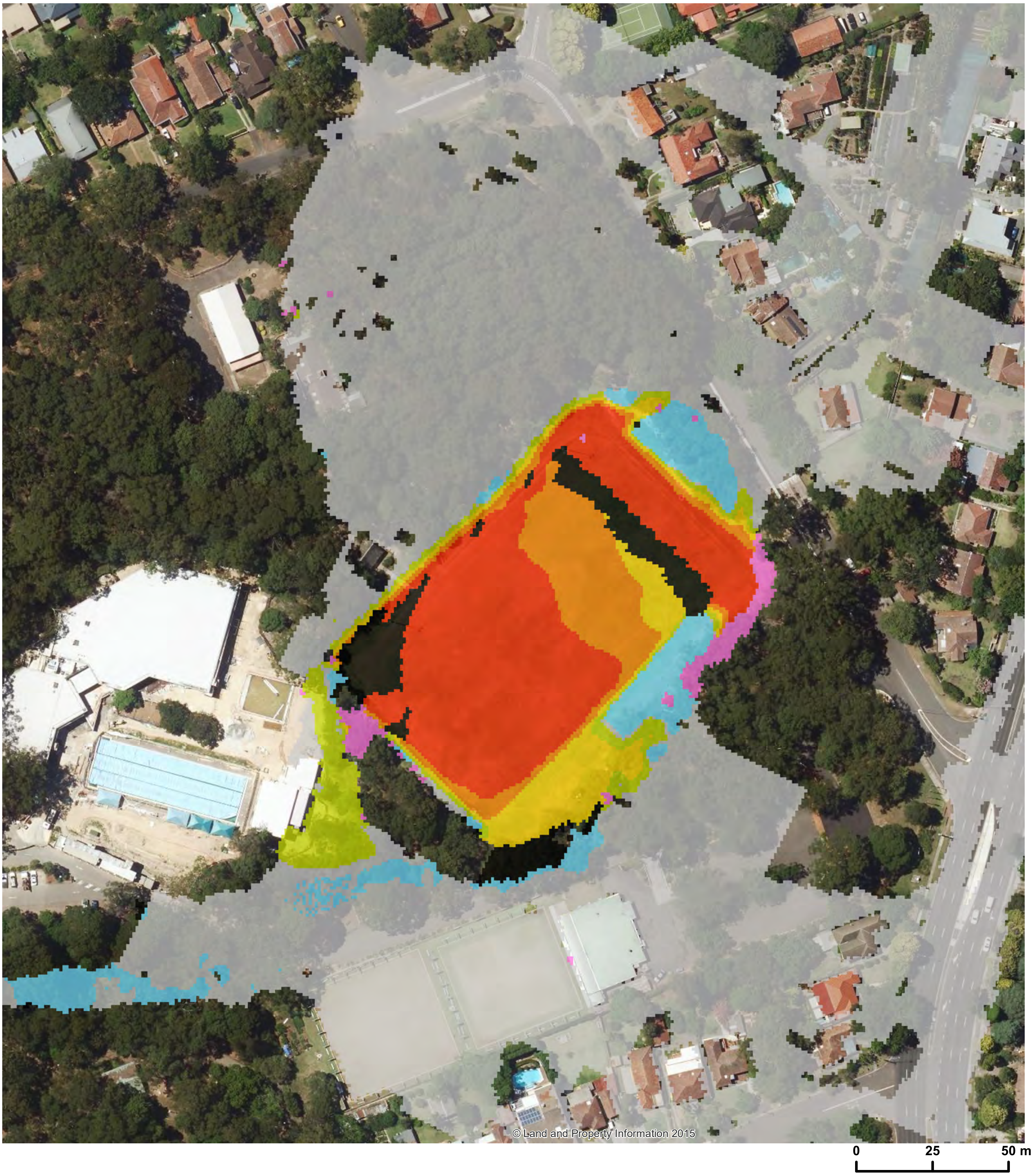


A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A12: NGO Design 009 - 0.2 EY Design Case Option 1 Afflux



Legend

Afflux (m)

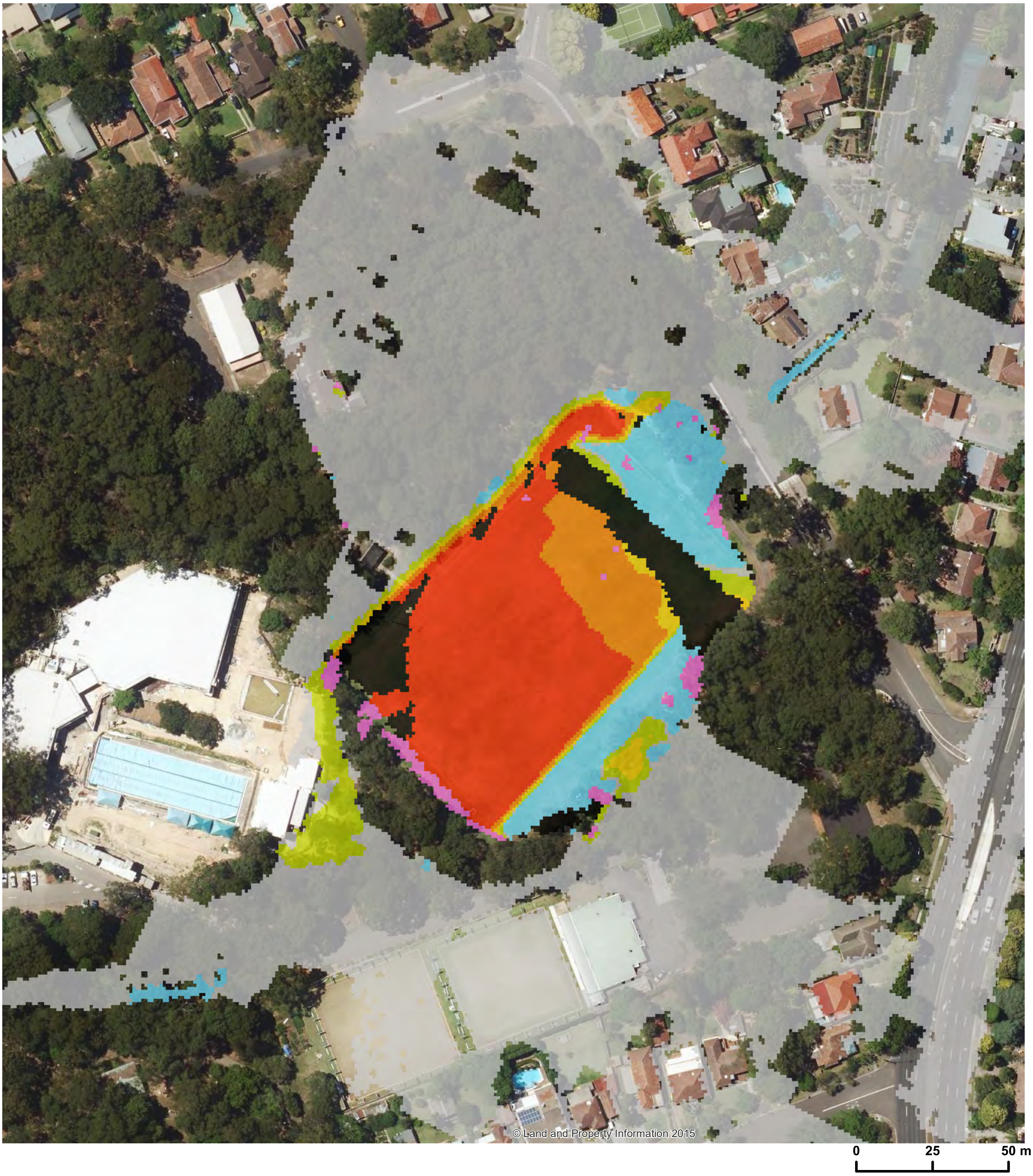
- < -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- > 0.5
- Was Flooded Now Dry
- Was Dry Now Flooded

A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A13: NGO Design 009 - 2% AEP Design Case Option 2 Afflux

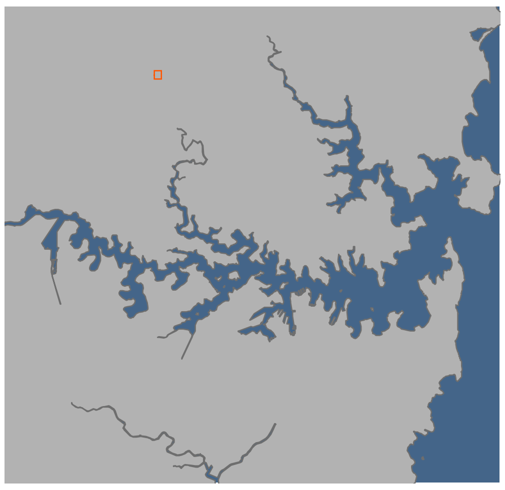


Legend

Afflux (m)

- < -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- > 0.5
- Was Flooded Now Dry
- Was Dry Now Flooded

N

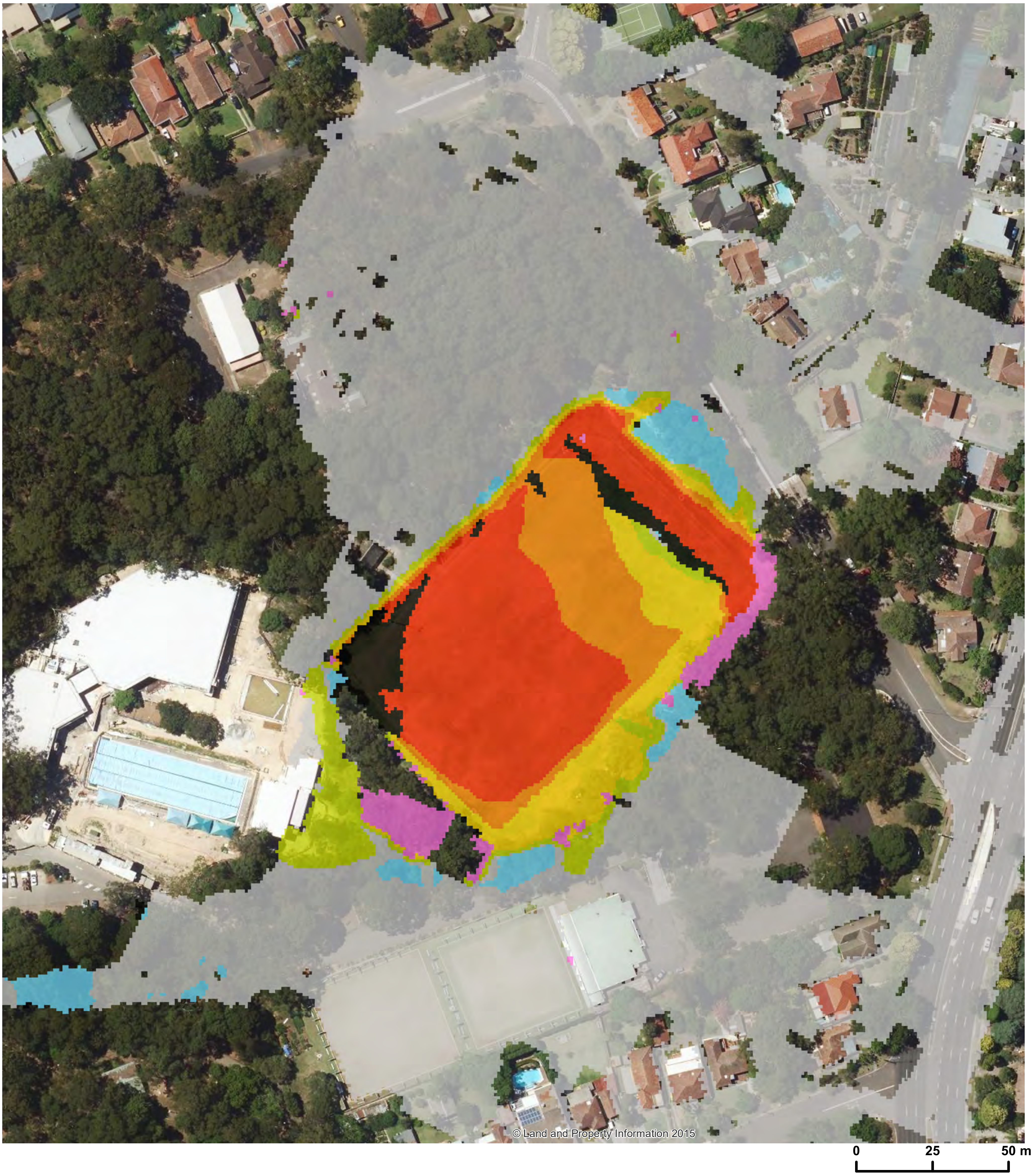


A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A14: NGO Design 009 - 0.2 EY Design Case Option 2 Afflux

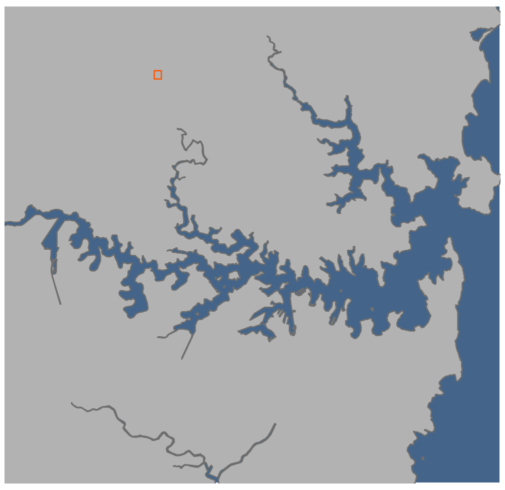


Legend

Afflux (m)

- < -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- > 0.5
- Was Flooded Now Dry
- Was Dry Now Flooded

N

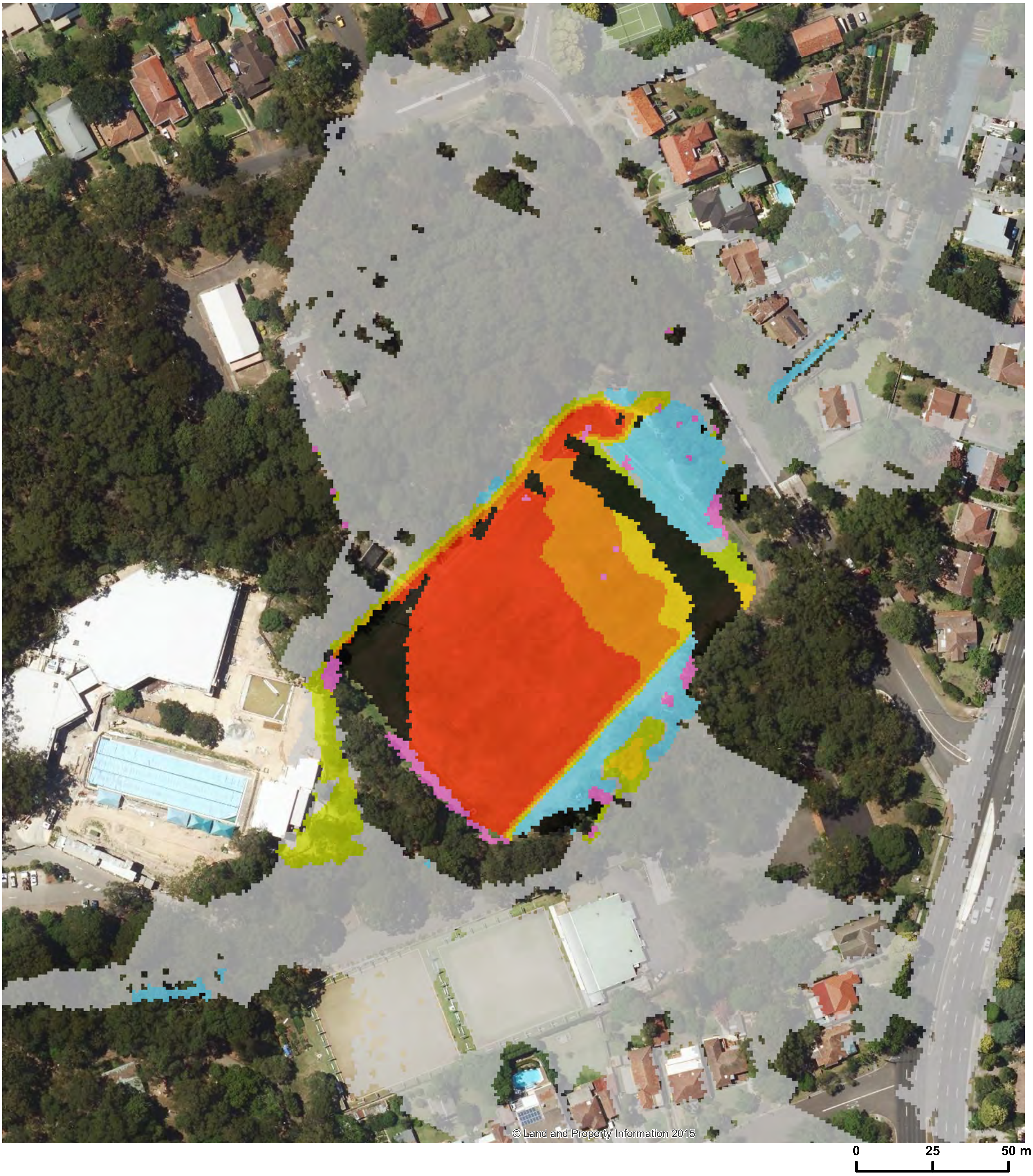


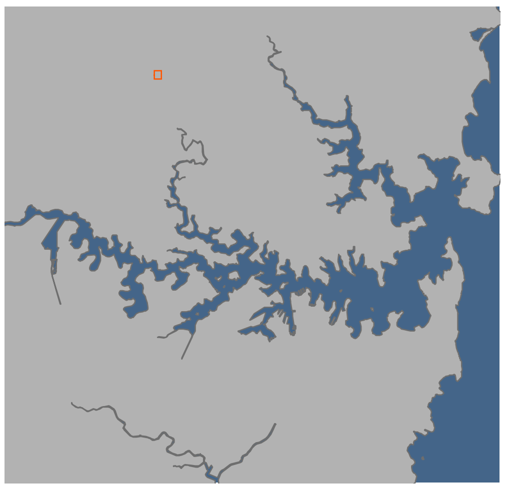
A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A15: NGO Design 010 - 2% AEP Design Case Option 1 Afflux





Legend

Afflux (m)

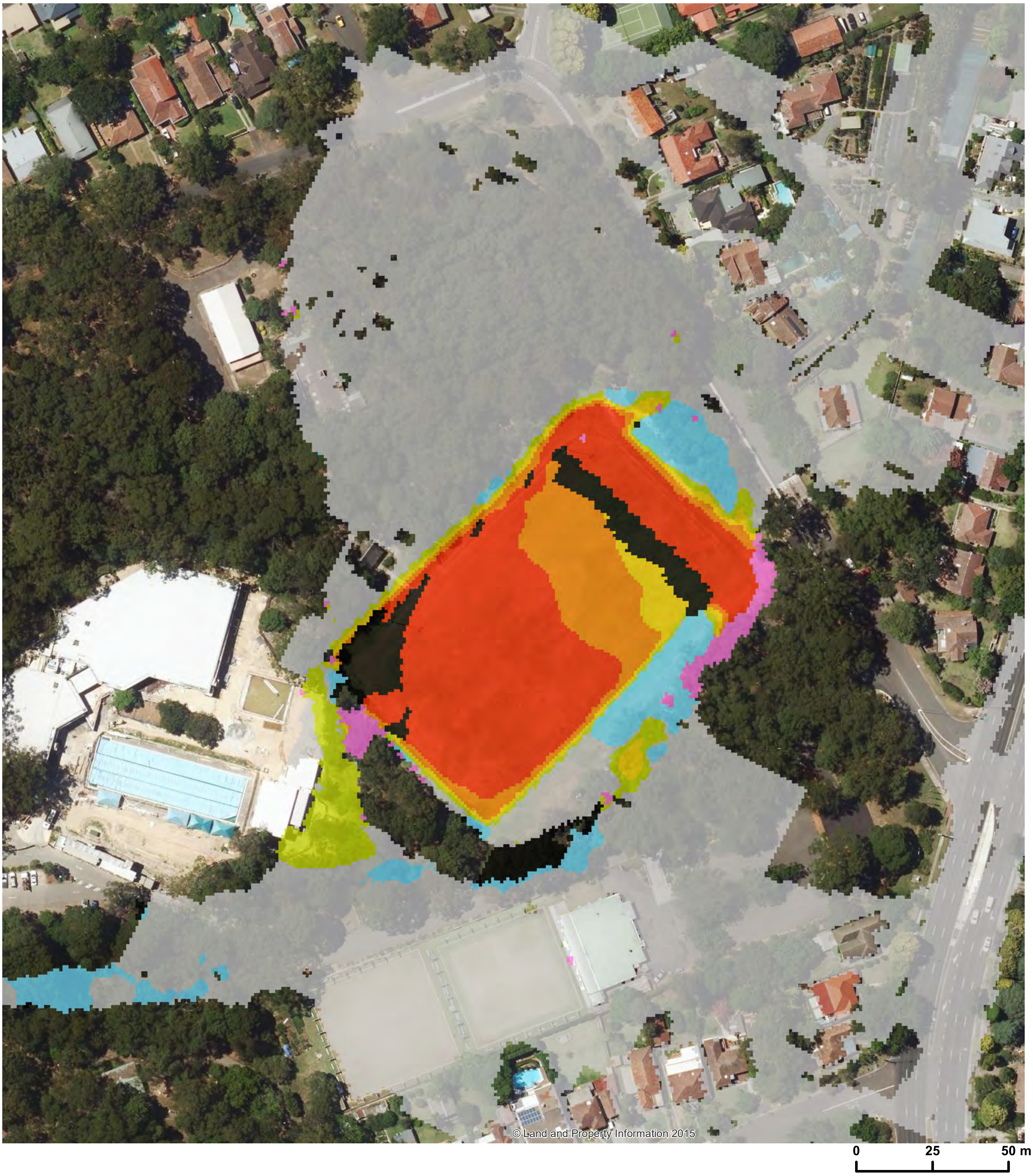
- < -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- > 0.5
- Was Flooded Now Dry
- Was Dry Now Flooded

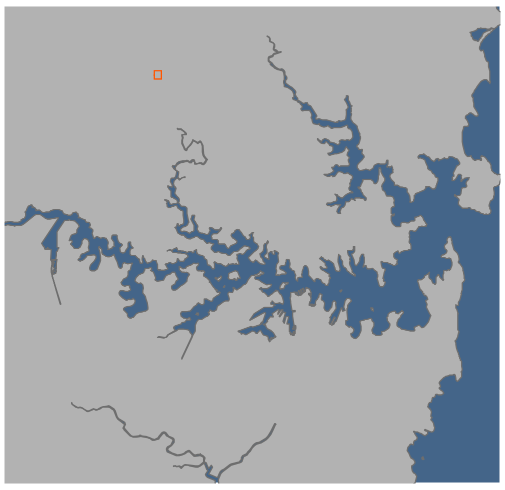
A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A16: NGO Design 010 - 0.2 EY Design Case Option 1 Afflux





Legend

Afflux (m)

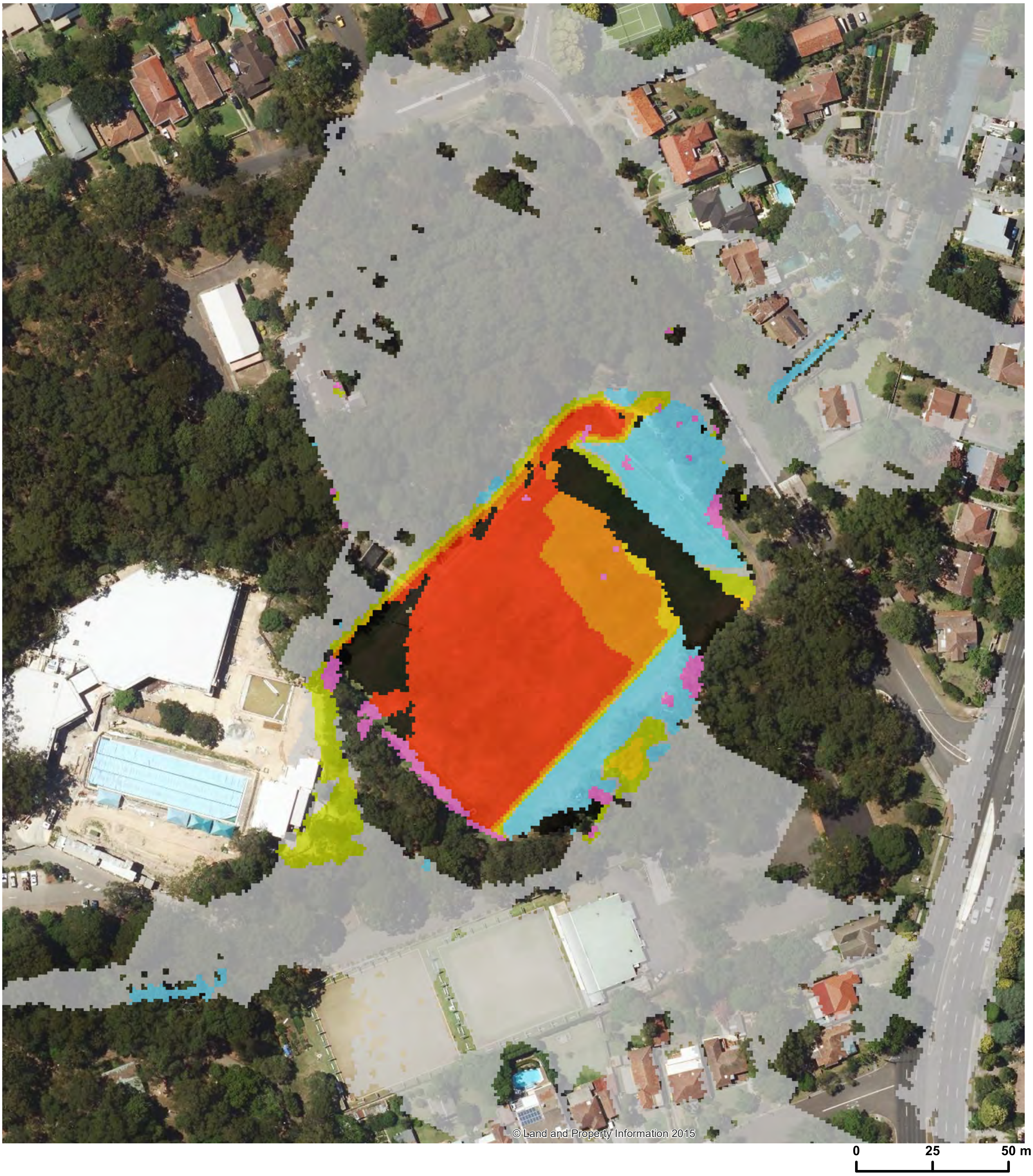
- < -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- > 0.5
- Was Flooded Now Dry
- Was Dry Now Flooded

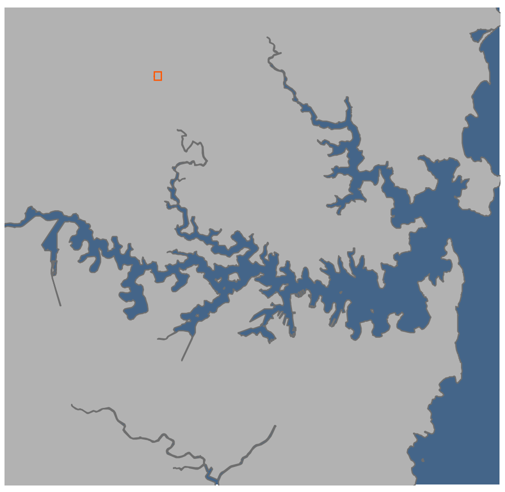
A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A17: NGO Design 010 - 2% AEP Design Case Option 2 Afflux





Legend

Afflux (m)

- < -0.01
- -0.01 - 0.01
- 0.01 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- > 0.5
- Was Flooded Now Dry
- Was Dry Now Flooded

A3

1:1,250

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

FIGURE A18: NGO Design 010 - 0.2 EY Design Case Option 2 Afflux

Appendix B – Tables of flow results

Table B.1 - Summary of flows for Existing, Design and Mitigation Cases

		Existing			Option 1 (009)			Option 2 (009)			Option 1 (010)			Option 2 (010)		
		Existing			Design from council - Option 1			Design from council - Option 2			Alternative Mitigation (increased pipe capacity) - Option 1			Alternative Mitigation (increased pipe capacity) - Option 2		
Location		Overland	Pipe	Total	Overland	Pipe	Total	Overland	Pipe	Total	Overland	Pipe	Total	Overland	Pipe	Total
20% AEP (5yr)																
1	Lofberg Road	0.7	2.7	3.4	0.7	2.7	3.4	0.7	2.7	3.4	0.7	2.7	3.4	0.7	2.7	3.4
2	Between Lofberg Rd and Oval	1.0	3.0	4.0	0.5	2.7	3.2	0.5	2.7	3.2	0.5	2.7	3.2	0.5	2.7	3.2
3	on Oval	0.7	3.0	3.7	0.0	3.0	3.0	0.0	2.9	2.9	0.0	3.0	3.0	0.0	2.9	2.9
4	Overflow from basin	0.0	3.7	3.7	0.0	3.5	3.5	0.0	3.5	3.5	0.0	3.5	3.5	0.0	3.5	3.5
5	Discharge to Quarry Creek	4.5	0.0	4.5	4.3	0.0	4.3	4.3	0.0	4.3	4.3	0.0	4.3	4.3	0.0	4.3
6	Quarry Creek	5.5	0.0	5.5	5.4	0.0	5.4	5.4	0.0	5.4	5.4	0.0	5.4	5.4	0.0	5.4
7	Upstream of Yanko Road	12.5	0.0	12.5	12.5	0.0	12.5	12.4	0.0	12.4	12.5	0.0	12.5	12.4	0.0	12.4
10% AEP (10yr)																
1	Lofberg Road	0.9	2.7	3.6	0.9	2.7	3.6	0.9	2.7	3.6	0.9	2.7	3.6	0.9	2.7	3.6
2	Between Lofberg Rd and Oval	1.5	2.6	4.1	0.7	2.7	3.4	0.8	2.8	3.6	0.7	2.7	3.4	0.8	2.8	3.6
3	on Oval	1.2	3.1	4.3	0.0	3.2	3.2	0.0	3.1	3.1	0.0	3.2	3.2	0.0	3.1	3.1
4	Overflow from basin	0.0	4.2	4.2	0.0	3.8	3.8	0.0	3.8	3.8	0.0	3.8	3.8	0.0	3.8	3.8
5	Discharge to Quarry Creek	5.0	0.0	5.0	4.7	0.0	4.7	4.6	0.0	4.6	4.7	0.0	4.7	4.6	0.0	4.6
6	Quarry Creek	6.2	0.0	6.2	6.1	0.0	6.1	6.1	0.0	6.1	6.1	0.0	6.1	6.1	0.0	6.1
7	Upstream of Yanko Road	15.7	0.0	15.7	15.3	0.0	15.3	15.2	0.0	15.2	15.3	0.0	15.3	15.2	0.0	15.2
5% AEP (20yr)																
1	Lofberg Road	1.6	2.9	4.5	1.6	2.9	4.5	1.5	3.0	4.5	1.6	2.9	4.5	1.6	3.0	4.6
2	Between Lofberg Rd and Oval	2.4	2.7	5.1	1.4	2.7	4.1	1.4	2.8	4.2	1.4	2.7	4.1	1.4	2.8	4.2
3	on Oval	2.2	3.2	5.4	0.5	3.3	3.8	0.1	3.3	3.4	0.5	3.3	3.8	0.1	3.3	3.4
4	Overflow from basin	0.0	4.3	4.3	0.0	4.0	4.0	0.0	3.9	3.9	0.0	4.0	4.0	0.0	3.9	3.9
5	Discharge to Quarry Creek	5.4	0.0	5.4	5.0	0.0	5.0	5.0	0.0	5.0	5.0	0.0	5.0	5.0	0.0	5.0
6	Quarry Creek	7.2	0.0	7.2	7.2	0.0	7.2	7.2	0.0	7.2	7.2	0.0	7.2	7.2	0.0	7.2
7	Upstream of Yanko Road	19.4	0.0	19.4	19.1	0.0	19.1	19.1	0.0	19.1	19.1	0.0	19.1	19.1	0.0	19.1
2% AEP (50yr)																
1	Lofberg Road	2.6	2.9	5.5	2.6	2.9	5.5	2.6	2.9	5.5	2.7	2.9	5.6	2.6	2.9	5.5
2	Between Lofberg Rd and Oval	3.4	2.7	6.1	2.3	2.7	5.0	2.3	2.8	5.1	2.3	2.7	5.0	2.3	2.7	5.0
3	on Oval	3.3	3.2	6.5	2.1	3.3	5.4	1.8	3.2	5.0	2.2	3.2	5.4	2.0	3.3	5.3
4	Overflow from basin	0.4	4.4	4.8	0.7	4.3	5.0	0.0	4.3	4.3	0.2	4.4	4.6	0.0	4.3	4.3
5	Discharge to Quarry Creek	5.6	0.0	5.6	5.4	0.0	5.4	5.3	0.0	5.3	5.4	0.0	5.4	5.3	0.0	5.3
6	Quarry Creek	7.9	0.0	7.9	7.7	0.0	7.7	7.7	0.0	7.7	7.7	0.0	7.7	7.8	0.0	7.8
7	Upstream of Yanko Road	23.0	0.0	23.0	22.6	0.0	22.6	22.6	0.0	22.6	22.7	0.0	22.7	22.6	0.0	22.6
1% AEP (100yr)																
1	Lofberg Road	3.5	2.8	6.3	3.5	2.9	6.4	3.4	2.9	6.3	3.5	2.9	6.4	3.5	2.9	6.4
2	Between Lofberg Rd and Oval	4.3	2.7	7.0	3.3	2.7	6.0	3.1	2.7	5.8	3.3	2.7	6.0	3.1	2.7	5.8
3	on Oval	4.2	3.1	7.3	3.3	3.3	6.6	3.1	3.3	6.4	3.4	3.2	6.6	3.3	3.2	6.5
4	Overflow from basin	1.2	4.4	5.6	2.1	4.4	6.5	1.5	4.4	5.9	2.0	4.5	6.5	1.3	4.5	5.8
5	Discharge to Quarry Creek	6.1	0.0	6.1	6.6	0.0	6.6	6.2	0.0	6.2	6.6	0.0	6.6	6.1	0.0	6.1
6	Quarry Creek	8.8	0.0	8.8	8.9	0.0	8.9	8.7	0.0	8.7	8.9	0.0	8.9	8.8	0.0	8.8
7	Upstream of Yanko Road	26.3	0.0	26.3	26.1	0.0	26.1	26.0	0.0	26.0	26.2	0.0	26.2	26.1	0.0	26.1

Appendix C – Designs provided by council

NORMAN GRIFFITHS OVAL: SYNTHETIC FIELD - CONCEPT PLAN: OPTION 01

1:400 @ A3

REV B

OCT 2017

Ku-ring-gai Council

NORMAN GRIFFITHS OVAL: SYNTHETIC FIELD - CONCEPT PLAN: OPTION 02 (REDUCED FIELD SIZE)

1:400 @ A3 0 10m

REV B
OCT 2017

Ku-ring-gai Council

Appendix D. Memo 5 – Flood assessment of updated concept design and preparation of drainage plans

JACOBS

Memorandum

Flood assessment of updated concept design and preparation of drainage plans

Subject	**Flood assessment of updated concept design and preparation of drainage plans**	**Project Name**	Norman Griffiths Oval Flood Study
Attention	Guy Thomas	**Project No.**	IA133200
From	Lih Chong		
Date	2 October 2018		
Copies to	Anna Milner		

This memo provides the results and assessments from the flood modelling undertaken of the updated concept design for the Norman Griffiths Oval upgrade and flood detention basins provided by Ku-ring-gai Council in May 2018. The design received from Council has been assessed in a TUFLOW flood model and design modifications are proposed to achieve design objectives. Drainage plans detailing the proposed drainage design have also been prepared.

1. Existing conditions

The existing Norman Griffiths Oval, located on Lofberg Road in West Pymble, includes an earthen embankment on its downstream side to form a flood detention basin. The stormwater network upstream of the Oval includes a lined open channel and underground pipes. The network passes under the Oval via a 1050mm pipe, which has a reduced capacity compared to the system upstream. Excess flows surcharge into the detention basin, and in addition to flood flows in excess of the open channel and the 4x 750mm pipe cross drainage under Lofberg Road, form the flows into the detention basin. Several grated letterbox-type pits drain the basin, transferring the floodwaters back into the stormwater network and discharging them into the downstream natural channel (i.e. Lofberg Creek). Lofberg Creek then flows westward and joins another creek, Quarry Creek, before flowing via culvert under Yanko Road and then further westward down the valley to discharge into the Lane Cove River.

2. Description of Received Concept Design

Previous flood modelling undertaken in 2017 have informed the concept design development of the Oval upgrade and proposed flood detention basins and drainage works. Design objectives include maintain a flood detention function of the Oval including maintaining downstream creek flows at existing conditions, mitigating against flood impacts to adjacent properties as a result of the design, and ensuring a flood immunity level of 2% AEP for the upgraded synthetic soccer pitch on the Oval.

The updated concept design dated 10 April 2018 was assessed in the TUFLOW flood model for the Lofberg – Quarry Creek catchment. The concept design includes the following aspects:

- Full-sized synthetic soccer pitch on the Oval (100m x 70m)
- Upper detention basin between soccer pitch and Lofberg Road with bed level 71.3m AHD, storage volume (to spillway level 72.6m AHD) 1185m^3. Freestanding sandstone block wall forming basin crest at 72.7m AHD. Retain existing trunk drainage pipes and pit location, adjust pit grate level to suit basin bed level.
- Upper basin spillway drains to channel leading to lower detention basin at south-eastern corner of Oval at existing drainage low point, bed level 69.8m AHD. Storage volume to spillway level 515m^3. Existing Oval basin spillway acts as the spillway for the lower basin, draining to Quarry Creek downstream of the Oval. Two new pits connected via 600mm pipe for low flow drainage to existing trunk drainage pit at southern corner of Oval.

- Concrete footpath with a cross-fall of 2.5% along north-western side of the oval draining away from the soccer pitch.
- 2x sandstone block retaining walls stepping down from adjoining hillside to the concrete footpath.
- Proposed drainage along north-western side includes a number of drainage pits along footpath and the top sandstone wall connected via 200mm diameter pipe to existing trunk drainage pit at southern corner of Oval.

The designs of the oval as provided by Council can be found in Appendix A. Notable changes from the previous concept design include more gentle basin side slopes, reduced from 1:4 to approximately 1:6 (i.e. 15%) which eliminates the need for safety fencing along the top of the basin slopes. This reduces the total nominal basin storage volume from 1830m^3 to 1700m^3.

3. Flood modelling assessment and proposed design modifications

The previous versions of the TUFLOW models were updated to improve the estimates of overland flows on the north-western hillside approaching the Oval and hence a better understanding of drainage requirements in that area. Model inflows, which were previously concentrated to one existing pit on the north-western corner of the Oval, were redistributed along the hillside in both the existing and design cases.

The received design was modelled in the TUFLOW hydraulic model and the following flood impacts were observed:

- Floodwaters in the 2% AEP event overflowed from the upper basin over the sandstone block wall onto the soccer pitch.
- Overland flows in the 2% AEP event flowed from the north-western hillside onto the soccer pitch.
- There were flood impacts on residential properties on the upstream side of Lofberg Road exceeding 100mm due to apparent raised footpath levels along the top of the upper basin next to the Lofberg Road car parking bays. Council since indicated that the proposed footpath levels in the design are to match existing levels, and the apparent raising of surface levels were due to inconsistency with the older LiDAR data (dated 2011-2013) in the TUFLOW model. The existing car parking bays and footpath in that location were regraded and raised following capture of the LiDAR.

Proposed design modifications have been identified and tested in the TUFLOW model and include:

- Raise the upper basin crest (Wall 5 and north-eastern end Wall 6 – refer to concept design drawings in Appendix A) by one additional sandstone block level (500mm) to 73.2m AHD to prevent overflows in up to the 2% AEP event. Structural assessment to be done by Council relating to elevated basin water levels and hydrostatic forces. Structural treatments to be done by Council designers.
- Install a concrete catch drain along the top sandstone block retaining wall on the north-western side of the Oval (Wall 2) to intercept overland flows from the hillside, with capacity to capture 400L/s in the 2% AEP event. Drain dimensions approx. 1.2m wide, 0.3m deep, 1:2 side slopes.
- 2x of grated inlet pits draining the catch drain and 2x grated pits for drainage of adjacent footpath. Upsize the previously proposed 200mm pipe to maximum 600mm pipe, draining to existing trunk drainage pit at southern corner of Oval.
- Ensure the proposed footpath along top side of upper basin maintains existing surface levels, to avoid flood impacts to adjacent properties.

- Raise the spillway level of lower basin to 71m AHD, which may require an additional sandstone block wall to form the spillway crest. The existing spillway level varies from 70.68m AHD to 71m AHD. Note that the spillway overflows in the 2% AEP event in both existing and design cases.

Council has been consulted on the items discussed above and have indicated that these modifications are likely to be feasible. The modifications are assumed to be incorporated into the concept design, and the design case scenario in the TUFLOW modelling includes these modifications,

4. Results and assessment

The TUFLOW model was run for the 20%, 10%, 5%, 2% and 1% AEP events for the existing case and design case (with proposed modifications) for the critical storm durations. The 2 hour event is critical for the 20%, 10% and 5% AEP events while the 1 hour and 2 hour are both critical for the 2% and 1% AEP events. Flood depth mapping for the existing and design cases are shown in Appendix B. Flood impact mapping (change in flood level as a result of the design) is also shown in Appendix B.

Key results from the modelling include:

- The synthetic pitch is not flood-affected in events up to the 2% AEP event, with the exception of the southern corner of the Oval where approximately 200m^2 of the pitch is affected to a depth of 100mm. Sandstone retaining block wall (Wall 6) could be raised to sit proud of the pitch surface (currently sits flush) to contain the floodwaters within the lower basin (2% AEP flood level 71.09m AHD).
- Flood impacts are 0.01m or less on upstream properties on Lofberg Road
- Flood levels in Quarry Creek downstream are not increased in up to the 2% AEP event. Localised increases of up to 0.08m occur in the 1% AEP event (typically less than 0.02m)
- Peak flood levels in the upper basin are 72.89m AHD in the 2% AEP and 72.99m AHD in the 1% AEP event
- Peak flood levels in the lower basin are 71.09m AHD in the 2% AEP and 71.17m AHD in the 1% AEP event.

5. Flow conditions in Quarry Creek

Peak flows in the vicinity of the Oval and downstream in Quarry Creek are summarised in Appendix C for the existing and design (with modifications) cases. Refer to Figure 1 for flow locations. The following observations are made:

- Peak flows are maintained at existing or are slightly higher (10% AEP only) for locations upstream of the Oval (locations 1 and 2) for all events.
- Peak flows are maintained at existing or are lower in Quarry Creek downstream of the Oval (locations 5 to 7) for events up to the 2% AEP.
- Peak flows downstream of the Oval (at locations 4 to 6) including Quarry Creek are increased in the 1% AEP by as a result of reduced flood storage available in the Oval detention basins, which mainly due to space constraints have been sized for mitigating floods up to and including the 2% AEP. Overflows from the lower basin are increased by 1m^3/s, or 55%, from existing. Impacts of increased basin overflows are discussed in Section 6. Peak flows are increased by 10% in the creek itself at the trunk drainage outlet. This may be acceptable as the increment in flow velocities would be less than 10% and also considering the magnitude and rarity of the 1% AEP flood.

- Peak flows in Quarry Creek upstream of Yanko Road are slightly reduced from existing for all flood events.

6. Impacts of increased basin overflows

The flood hazard and flow vector patterns were analysed for existing and concept design (with modifications) cases to investigate the potential impacts of the increased basin overflows in the design case 1% AEP event. The access road to the West Pymble Aquatic Centre and adjacent facilities runs immediately adjacent to the basin spillway and there may be concerns with the impacts to trafficability of the access road due to the increased basin overflows.

Figures 2 and 3 show the high flood hazard areas (in red) and flow vectors for baseline and concept design cases, respectively. Comparison of the flood hazard extents and flow vectors indicates there is minimal change in flow conditions in the access road. The flood impact mapping in Appendix B also indicates minimal change in flood depths on the access road. Hence, the trafficability of the access road is not expected to be impacted. Note that the access road crossing of Quarry Creek is affected by high hazard flooding in both existing and concept design cases in the 1% AEP event, and likely other more frequent flood events.

7. Preparation of drainage design plans

Design plans of the proposed drainage are provided in Appendix D. RMS standard drawings are referenced for pit and drainage details where denoted.

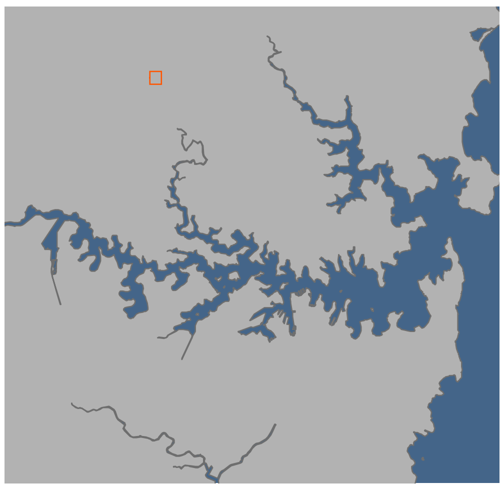
Sub-soil drainage for retaining walls, as indicated on the Council concept design plans, is not shown. Proposed sub-soil drainage for the synthetic soccer pitch, to be prepared by others, is not shown. The sub-soil drainage for the retaining walls and the soccer pitch can be connected to the proposed stormwater pits on the sides of the soccer pitch.

Legend

Reporting Locations - Pipe flow

Reporting Locations - Overland flow

N



A3

1:2,000

Data sources
Jacobs 2017
Ausimage 2014
RMS 2015
LPI 2015

Figure 1 | Flow reporting locations

Figure 2 Flood hazard and flow vectors 1% AEP event – Existing. High hazard in Red

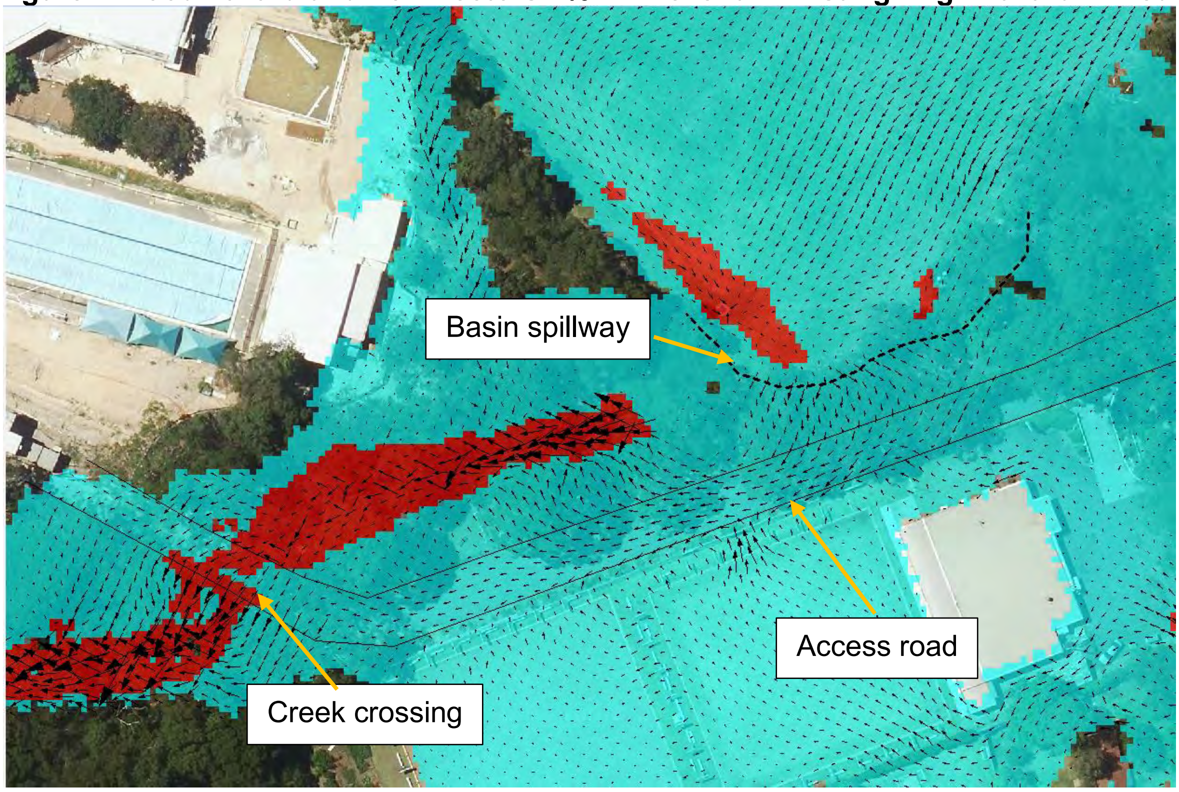
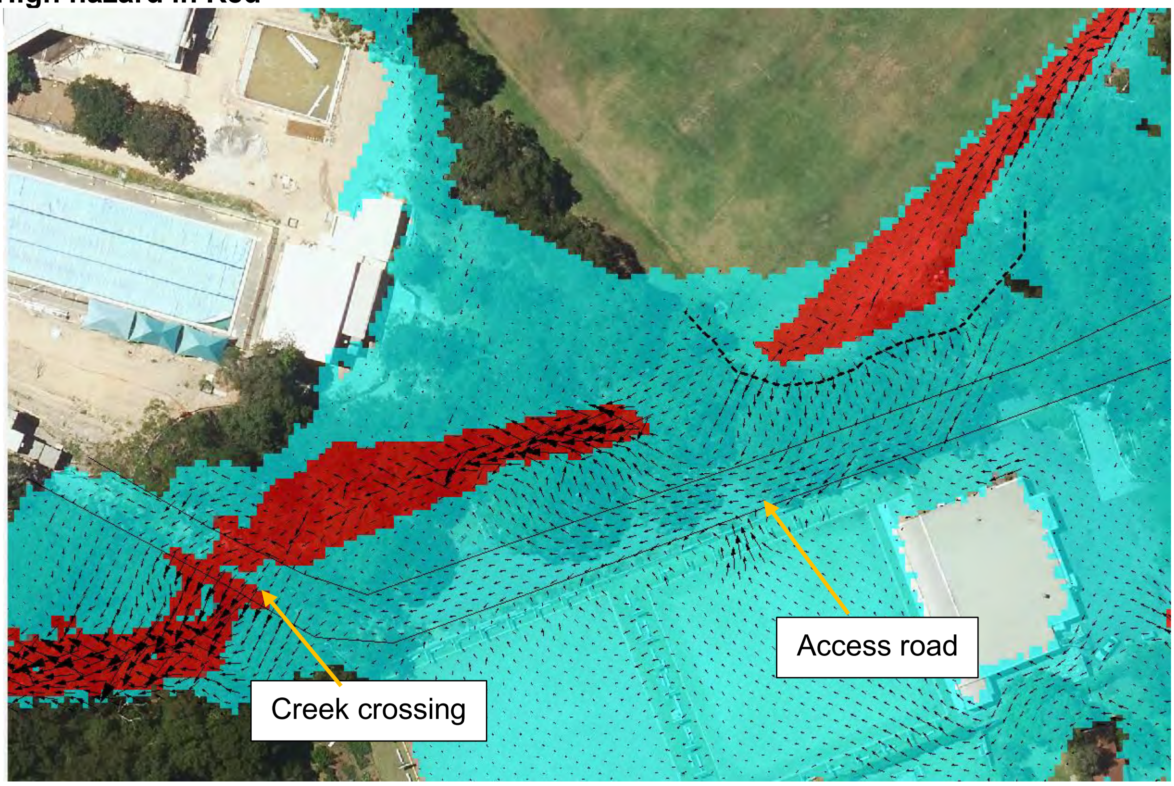


Figure 3 Flood hazard and flow vectors 1% AEP event – Concept Design with Mods. High hazard in Red



8. Conclusions and Recommendations

A number of modifications to the concept design provided by Council in May 2018 have been identified and tested in the TUFLOW flood model for hydraulic performance, and include:

1. Raise the upper basin crest (Wall 5 and north-eastern end Wall 6) by one additional sandstone block level (500mm) to 73.2m AHD to prevent overflows in up to the 2% AEP event, minimum. Structural assessment to be done by Council relating to elevated basin water levels and hydrostatic forces. Structural treatments to be done by Council designers.
2. Install a concrete catch drain along the top sandstone block retaining wall on the north-western side of the Oval (Wall 2) to intercept overland flows from the hillside, with capacity to capture 400L/s in the 2% AEP event.
3. 2x of grated inlet pits draining the catch drain and 2x grated pits for drainage of adjacent footpath. Upsize the previously proposed 200mm pipe to maximum 600mm pipe, draining to existing trunk drainage pit at southern corner of Oval.
4. Ensure the proposed footpath along top side of upper basin maintains existing surface levels, to avoid flood impacts to adjacent properties.
5. Raise the spillway level of lower basin to 71m AHD, which may require an additional sandstone block wall to form the spillway crest. The existing spillway level varies from 70.68m AHD to 71m AHD.
6. Additionally, Wall 6 could be raised to sit proud of the pitch surface (currently sits flush) to contain the floodwaters within the lower basin (2% AEP flood level 71.06m AHD).

The proposed modifications have been discussed with Council who have indicated that they appear to be feasible. It is recommended that Council update the concept design to incorporate these modifications. If the recommended modifications are not feasible or require substantial changes then these may need to be reassessed in the TUFLOW model.

The TUFLOW modelling confirms the following on the hydraulic performance of the concept design with proposed modifications:

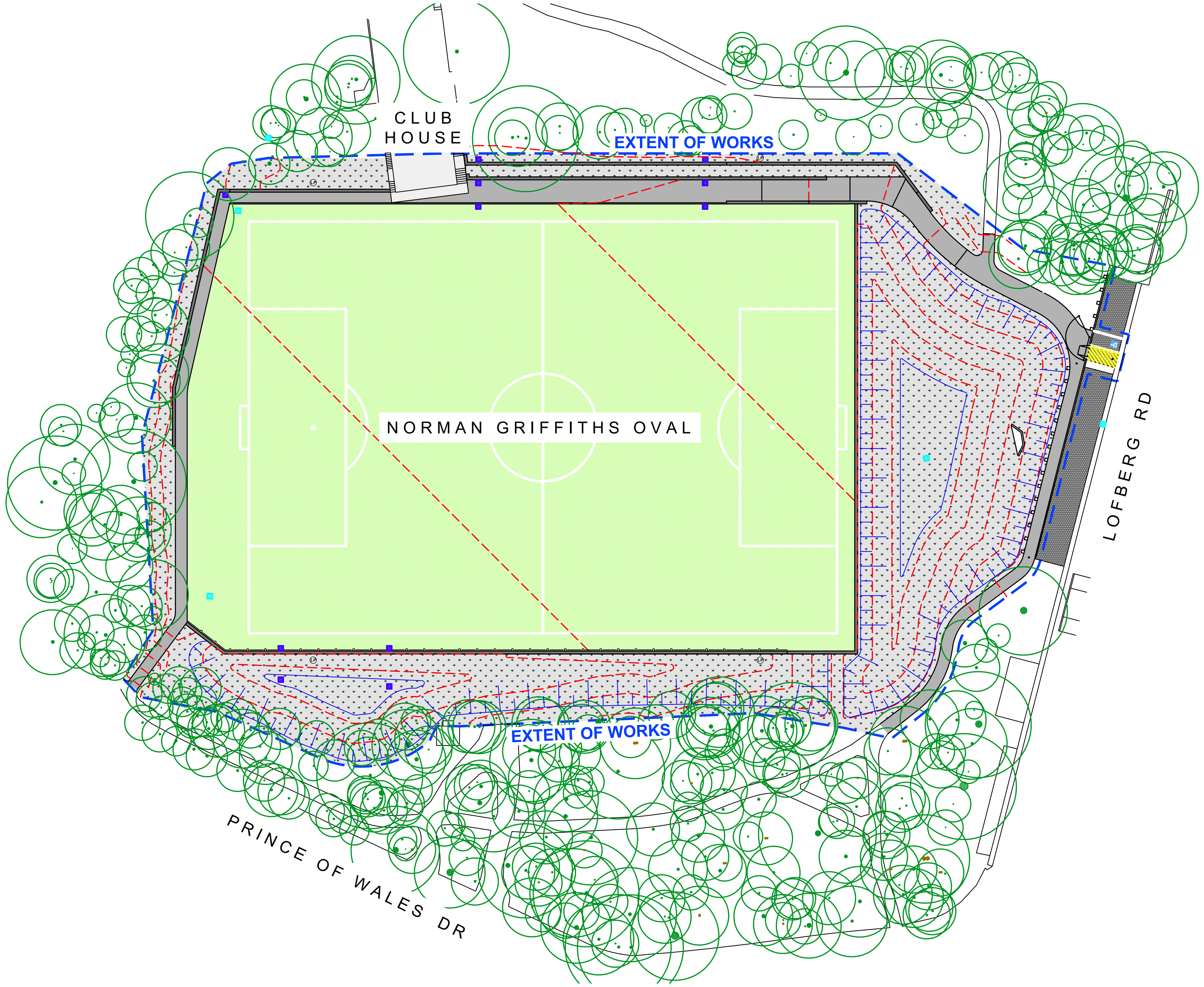
- Peak flows are generally maintained at existing conditions in Quarry Creek downstream of the Oval in up to and including the 2% AEP event.
- There are increased peak flows in Quarry Creek, including increased overflows from the lower basin, in the 1% AEP. Peak flows are increased by 10% in the creek itself at the trunk drainage outlet. This may be acceptable as the increment in flow velocities would be less than 10% and also considering the magnitude and rarity of the 1% AEP flood.
- Flood impacts on the access road to the West Pymble Aquatic Centre is not expected to affect the trafficability of the road in up to the 1% AEP event.

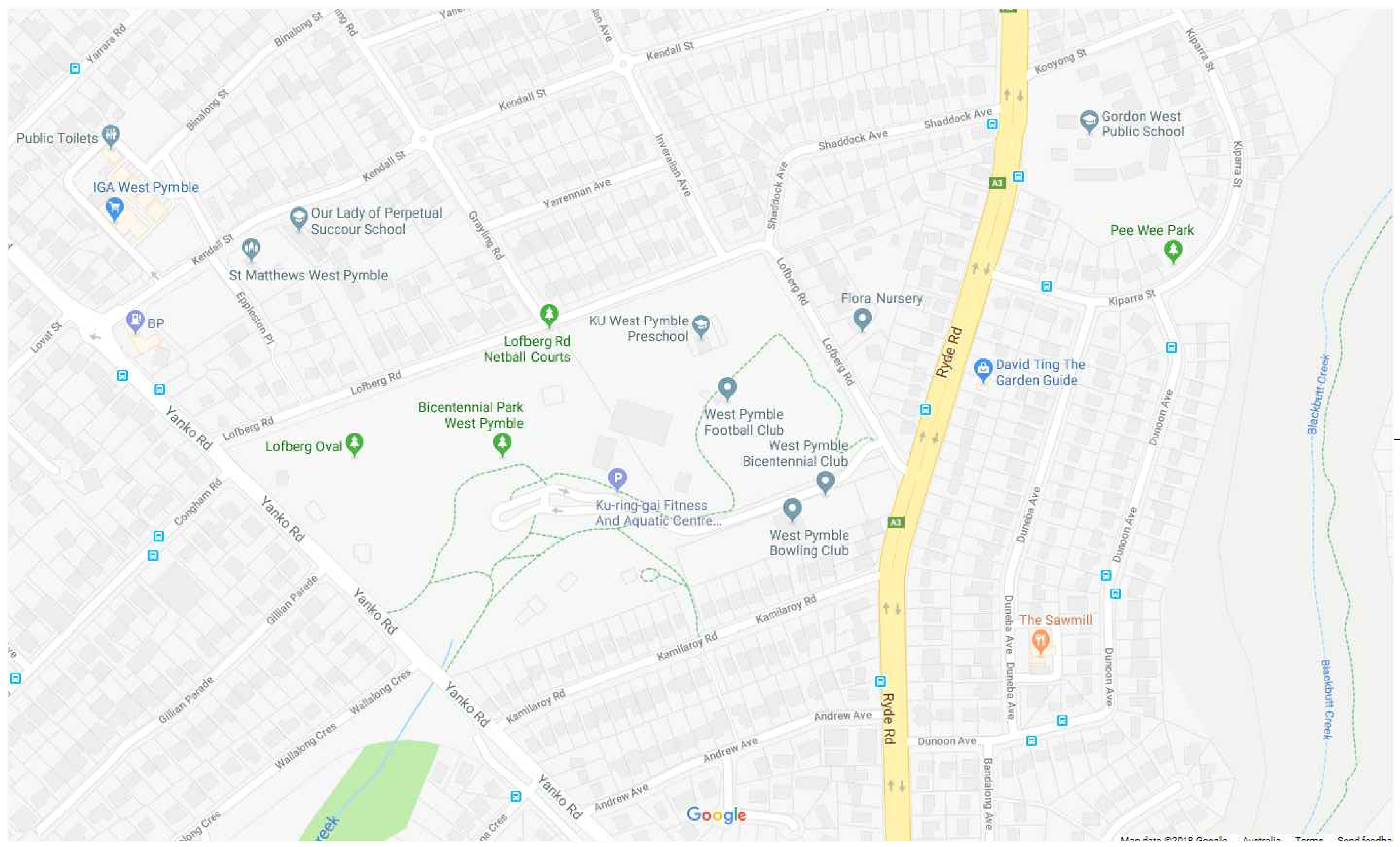
Appendix A – Concept Design provided by council

NORMAN GRIFFITHS OVAL UPGRADE
BICENTENNIAL PARK
LOFBERG ROAD, WEST PYMBLE

DRAWING LIST

DRAWING TITLE	DRAWING NO.	SCALE
COVER SHEET	L-000	1:500 @ A1
SURVEY PLAN	L-101	1:250 @ A1
DEMOLITION PLAN	L-102	1:250 @ A1
DRAINAGE PLAN	L-103	1:250 @ A1
FINISHES / LEVELS PLAN	L-104	1:250 @ A1
PLANTING PLAN	L-105	1:250 @ A1
SITE SECTIONS 01 - 05	L-201	1:250 @ A1
SITE SECTIONS 06 - 10	L-202	1:250 @ A1
CONSTRUCTION DETAILS 01: WALL 01 - 03	L-301	AS SHOWN
CONSTRUCTION DETAILS 02: WALL 04 - 06	L-302	AS SHOWN
CONSTRUCTION DETAILS 03	L-303	AS SHOWN





— NORMAN GRIFFITHS OVAL

LOCATION PLAN

GENERAL NOTES

- FINAL SETOUT WILL BE PROVIDED AS .DWG CAD FILE AT CONSTRUCTION STAGE
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B	10.04.18	CONSULTANT REVIEW	NB

DATE: NOV 2017

DRAWN BY: NBROWN

APPROVAL BY: Director of Operations

APPROVAL BY: Director of Strategy & Environment

SCALE: 1:500 @ A1

Ku-ring-gai Council

KU-RING-GAI COUNCIL

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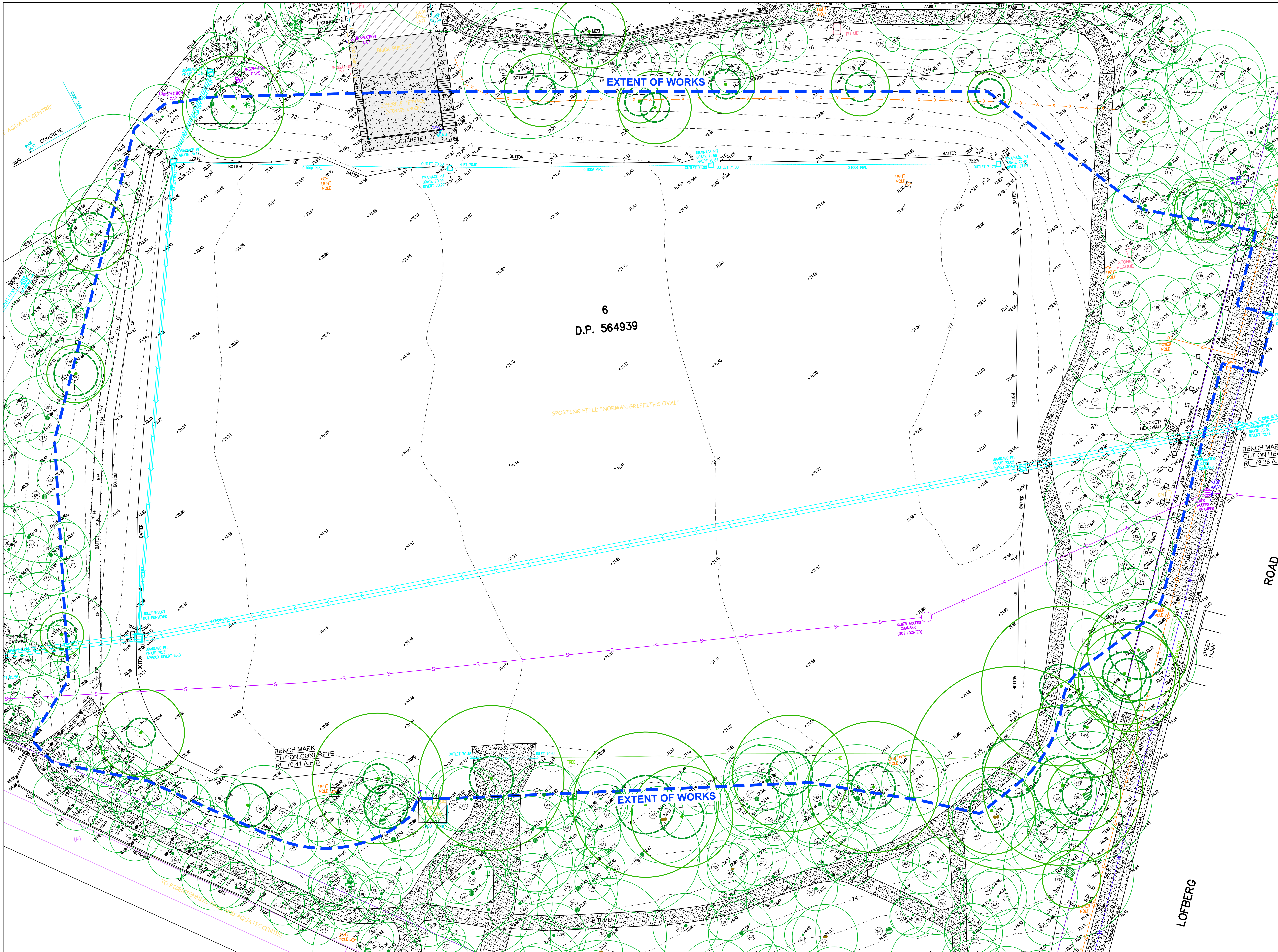
PROJECT: **NORMAN GRIFFITHS OVAL**
FIELD UPGRADE

PRELIMINARY ONLY - **NOT FOR CONSTRUCTION**

SHEET: **COVER SHEET**

LMU NO.:	PLAN NO.:	SHEET:	OF:	REV:
287	L-001	01	11	B



SURVEY NOTES

- ALL AREAS AND DIMENSIONS HAVE BEEN COMPILED FROM PLANS MADE AVAILABLE AT THE LAND TITLES OFFICE
- ORIGIN OF LEVELS ON A.H.D. IS TAKEN FROM P.M. 48947 RL 73.334 A.H.D
- CONTOUR INTERVAL 0.5 METRES
- CONTOURS ARE INDICATIVE OF GROUND ONLY. ONLY SPOT LEVELS SHOULD BE USED FOR CALCULATIONS OF QUANTITIES WITH CAUTION
- TREE SPREADS ARE DIAGRAMMATIC ONLY AND ARE NOT SYMMETRICAL
- UNDERGROUND (NON-VISIBLE) SERVICE LINES HAVE BEEN SHOWN FROM 'DIAL BEFORE YOU DIG' SERVICE AUTHORITY RECORDS AND ARE DIAGRAMMATIC ONLY IN REGARD TO THEIR POSITION AND WIDTH UNLESS STATED OTHERWISE
- SPOT LEVELS ARE ACCURATE
- BEARINGS SHOWN ARE ON M.G.A.

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DRAWN BY: NBROWN

APPROVAL BY: Director of Operations

APPROVAL BY: Director of Strategy & Environment

SCALE: 1:250 @ A1

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NORMAN GRIFFITHS OVAL FIELD UPGRADE

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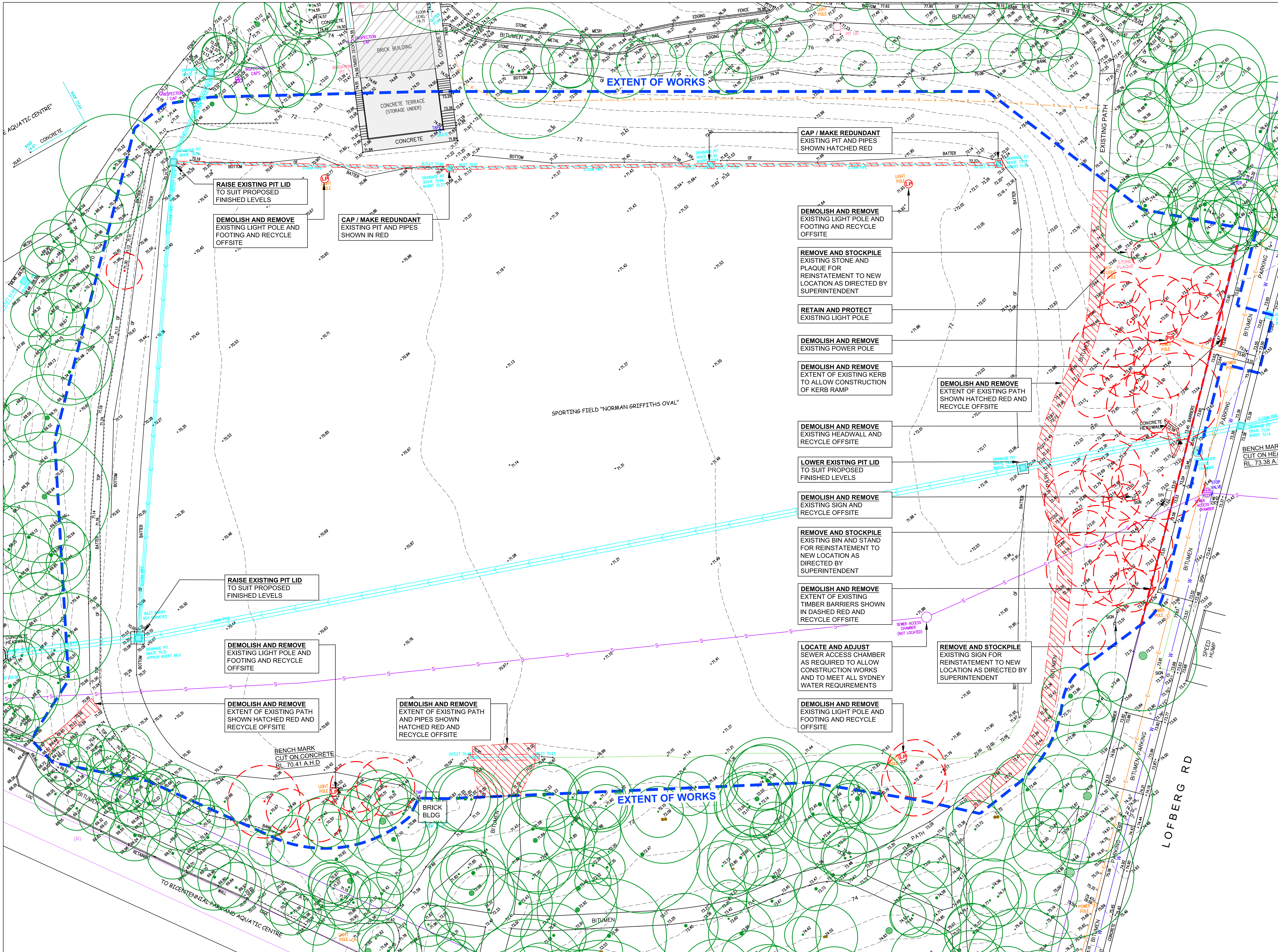
SHEET:

SURVEY PLAN

LMU NO.:	PLAN NO.:	SHEET:	OF:	REV:
287	L-101	02	11	B



LEGEND: DEMOLITION

- EXTENT OF WORKS
- EXISTING CONTOUR — 0.5m INTERVAL
- EXISTING LEVEL
- EXISTING STORMWATER LINE / PIT — SHOWN NOTIONALLY. CONTRACTOR TO CONFIRM LOCATION
- EXISTING WATER LINE — SHOWN NOTIONALLY. CONTRACTOR TO CONFIRM LOCATION
- EXISTING SEWER LINE — SHOWN NOTIONALLY. CONTRACTOR TO CONFIRM LOCATION
- EXISTING OVERHEAD POWER LINE — SHOWN NOTIONALLY. CONTRACTOR TO CONFIRM LOCATION
- EXISTING UNDERGROUND POWER LINE — SHOWN NOTIONALLY. CONTRACTOR TO CONFIRM LOCATION
- EXISTING TREE TO BE RETAINED
- EXISTING TREE TO BE REMOVED
- ITEM TO BE DEMOLISHED

DEMOLITION NOTES

- SERVICE LOCATIONS SHOWN INDICATIVELY. CONFIRM LOCATION OF ALL SERVICES AND EASEMENTS PRIOR TO ANY WORKS COMMENCING ON SITE AND PROTECT THROUGHOUT WORKS
- INSTALL EROSION CONTROL AND SEDIMENT CONTROL MEASURES ON SITE PRIOR TO ANY DEMOLITION OR SITE ESTABLISHMENT AND MAINTAIN REGULARLY IN ACCORDANCE WITH POEO ACT UNTIL REMOVAL IS APPROVED BY THE SUPERINTENDENT
- LOCATION OF SITE ACCESS / STOCKPILES / TEMPORARY SECURITY FENCING ETC TO BE CONFIRMED ON SITE WITH THE SUPERINTENDENT PRIOR TO WORKS COMMENCING
- ALL EXISTING TREES ARE TO BE RETAINED AND TEMPORARY TREE PROTECTION FENCE TO BE INSTALLED TO MEET AS4970.2009 THROUGHOUT WORKS UNLESS OTHERWISE NOTED
- DO NOT UNDERPRUNE OR CROWN LIFT CANOPIES UNLESS OTHERWISE NOTED ON THE PLAN OR DIRECTED BY THE SUPERINTENDENT

GENERAL NOTES

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APPROVAL BY: Director of Operations
APPROVAL BY: Director of Strategy & Environment
SCALE: 1:250 @ A1

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NORMAN GRIFFITHS OVAL FIELD UPGRADE

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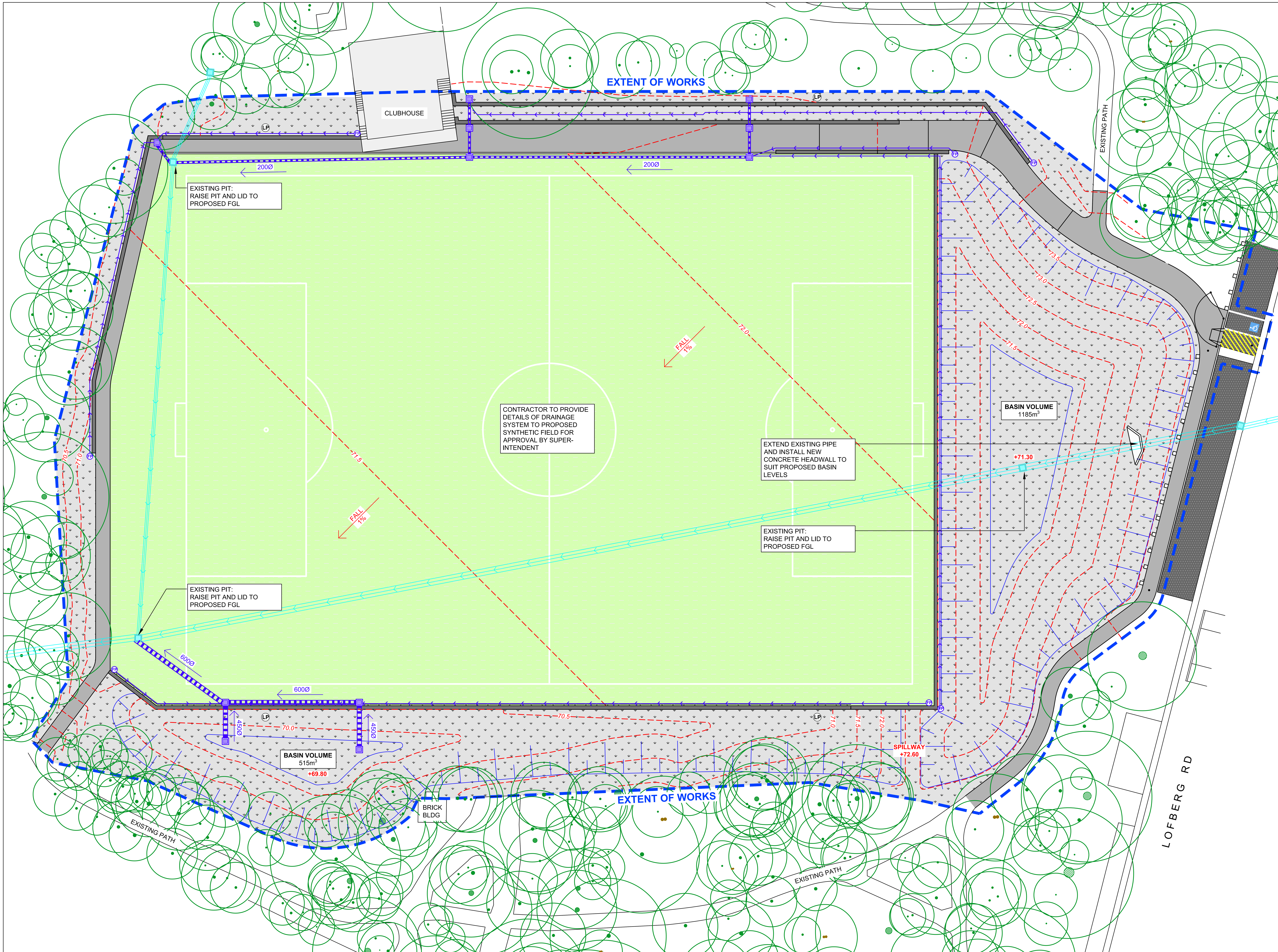
SHEET:

DEMOLITION PLAN

LMU NO.:	PLAN NO.:	SHEET:	OF:	REV:
287	L-102	03	11	B



LEGEND: DRAINAGE

- EXTENT OF WORKS
- EXISTING TREE TO BE RETAINED
- EXISTING STORMWATER LINE / PIT — SHOWN NOTIONALLY. CONTRACTOR TO CONFIRM LOCATION
- PROPOSED CONTOUR — 0.5m INTERVAL
- PROPOSED STORMWATER LINE — AS SPECIFIED
- PROPOSED STORMWATER PIT — AS SPECIFIED
- PROPOSED SUBSOIL DRAINAGE LINE — AS SPECIFIED
- PROPOSED SUBSOIL FLUSH POINT — AS SPECIFIED

GENERAL NOTES

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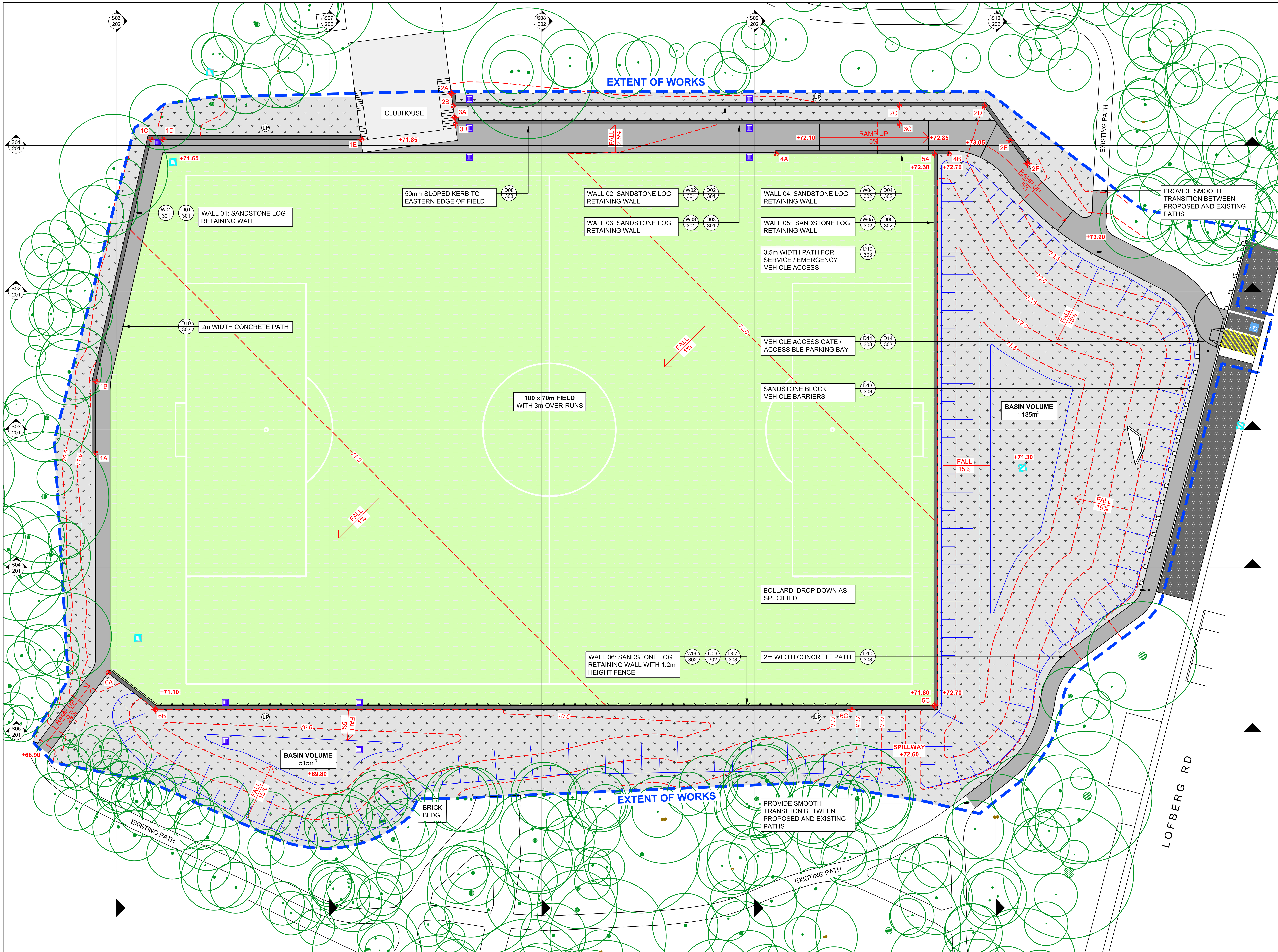
SHEET: **INDICATIVE DRAINAGE PLAN**

LMU NO.	PLAN NO.	SHEET	OF	REV
287	L-103	04	11	B



LEGEND: FINISHES / LEVELS

- EXTENT OF WORKS
- EXISTING TREE TO BE RETAINED
- EXISTING ASPHALT PAVEMENT
- EXISTING STORMWATER PIT
- PROPOSED CONTOUR 0.5m INTERVAL
- +73.05 PROPOSED FINISHED LEVEL
- PROPOSED STORMWATER PIT AS SPECIFIED
- PROPOSED WALL: SANDSTONE AS SPECIFIED
- 1A PROPOSED WALL: SETOUT POINT REFER WALL ELEVATIONS
- D07/303 PROPOSED FENCE AS SPECIFIED
- D08/303 PROPOSED CONCRETE KERB AS SPECIFIED
- D10/303 PROPOSED CONCRETE PAVEMENT AS SPECIFIED
- D13/303 PROPOSED SANDSTONE BARRIER AS SPECIFIED
- PROPOSED TURF AS SPECIFIED
- PROPOSED SYNTHETIC TURF TO CONTRACTOR SUPPLIED AND APPROVED SPECIFICATIONS
- LP PROPOSED LIGHT POLE LOCATION SHOWN NOTIONALLY TO CONTRACTOR SUPPLIED AND APPROVED SPECIFICATIONS

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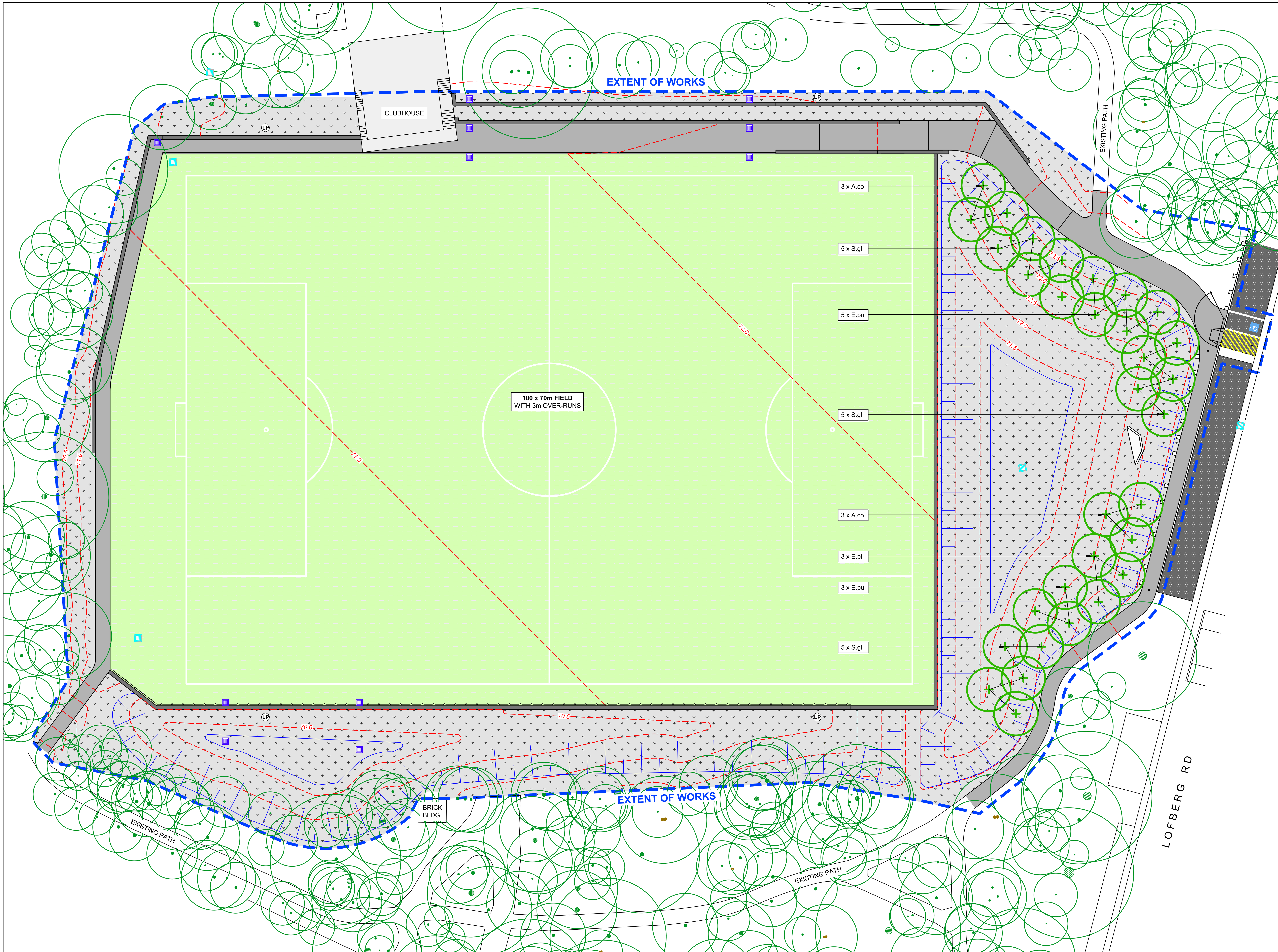

LEGEND: PLANTING

- EXTENT OF WORKS
- EXISTING TREE TO BE RETAINED
- PROPOSED TREE PLANTING (REFER PLANT SCHEDULE)
- PROPOSED TURF (AS SPECIFIED)

PLANT SCHEDULE

	NAME	POT	SPACING	QTY
TREES				
A.co	Angophora costata	75L	as shown	6
E.pi	Eucalyptus pilularis	75L	as shown	3
E.pu	Eucalyptus punctata	75L	as shown	8
S.gl	Syncarpia glomulifera	75L	as shown	15

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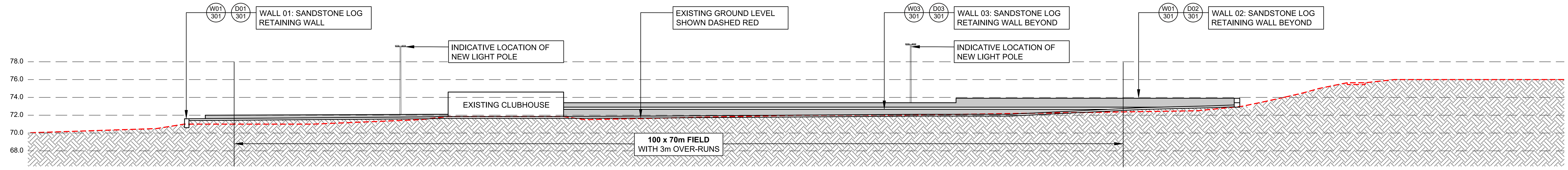
SHEET:
PLANTING PLAN

LMU NO.:	PLAN NO.:	SHEET:	OF:	REV:
287	L-105	06	11	B



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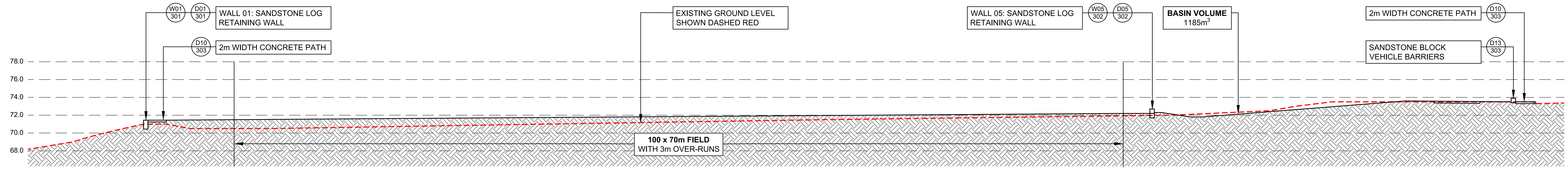

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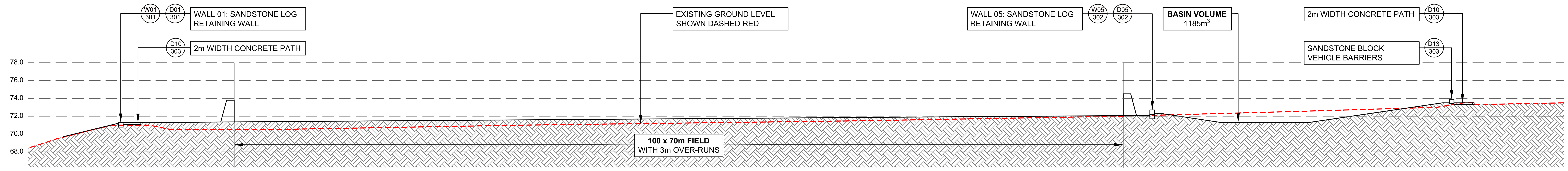

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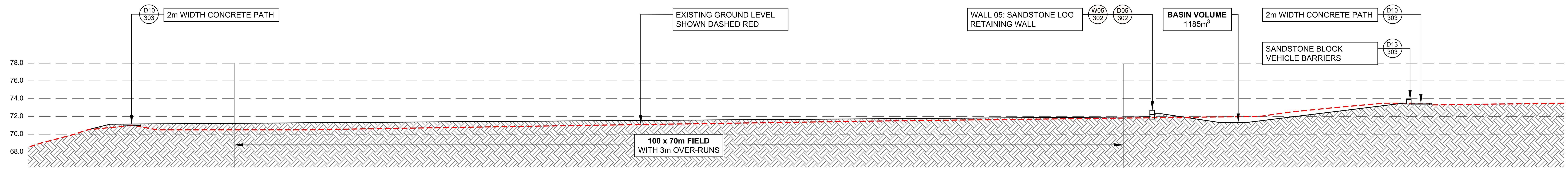

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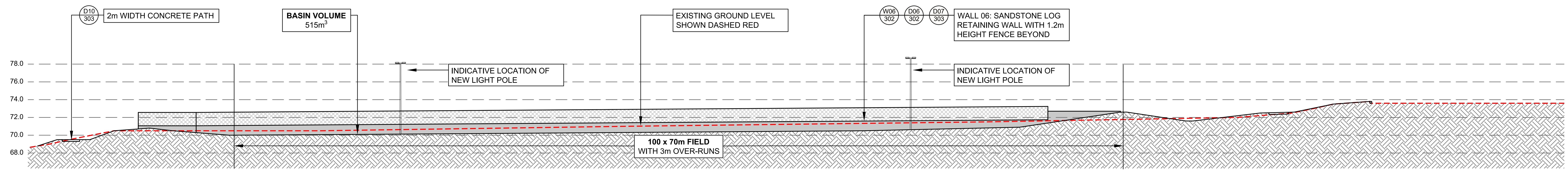

S05 SECTION 05
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APPROVAL BY: Director of Strategy & Environment
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PROJECT:
NORMAN GRIFFITHS OVAL
FIELD UPGRADE

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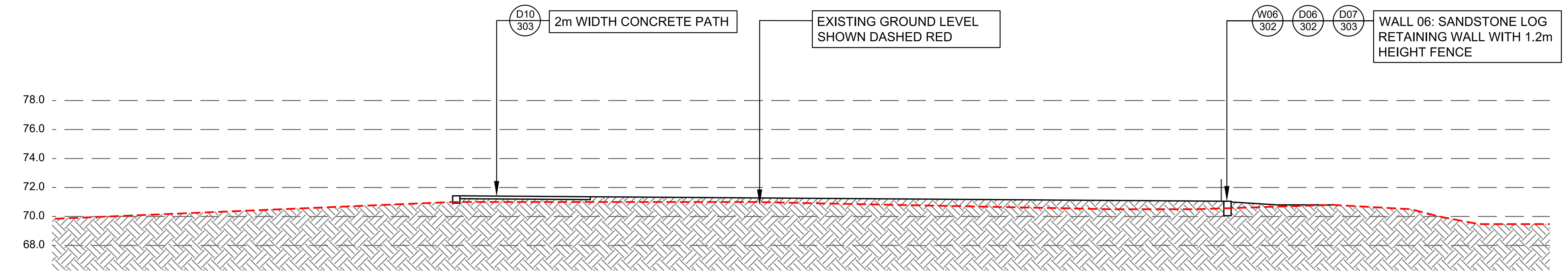
SHEET:
SITE SECTIONS 01

LMU NO.:	PLAN NO.:	SHEET:	OF:	REV:
287	L-201	07	11	B



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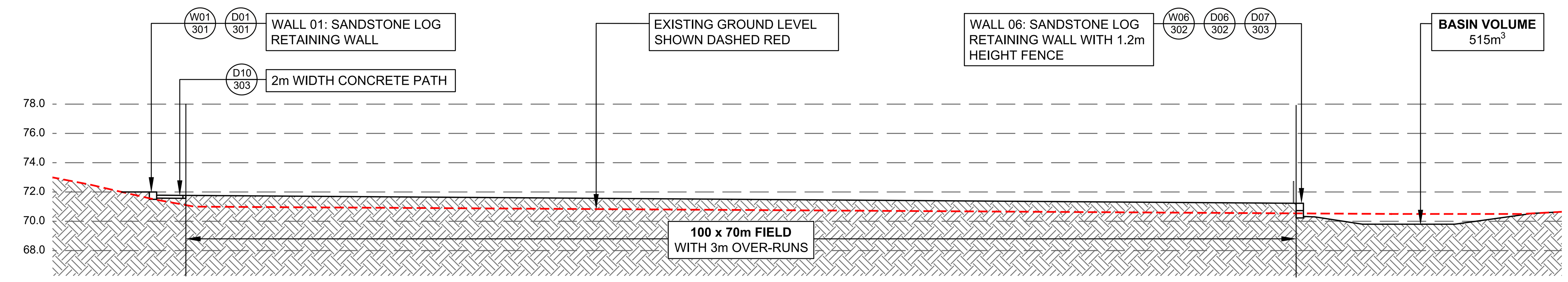

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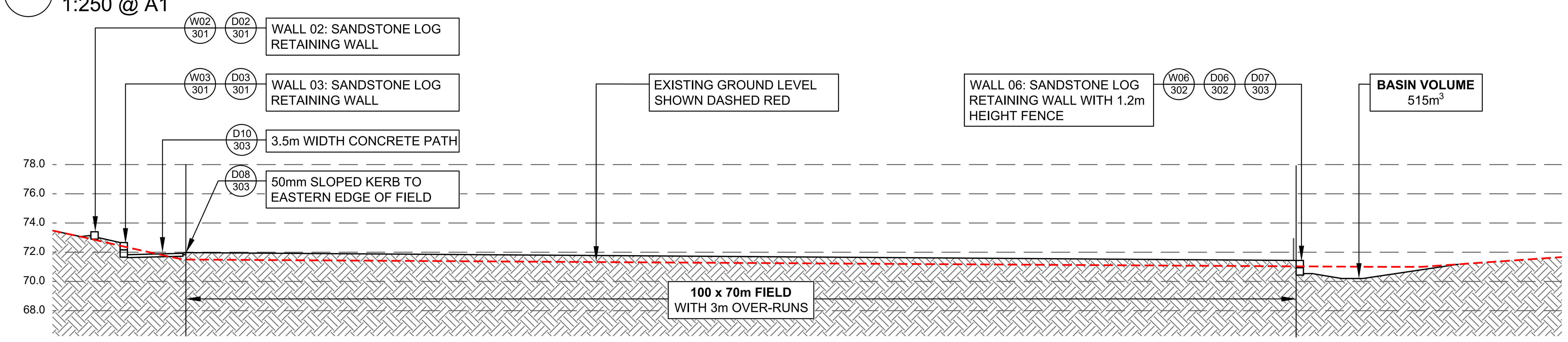

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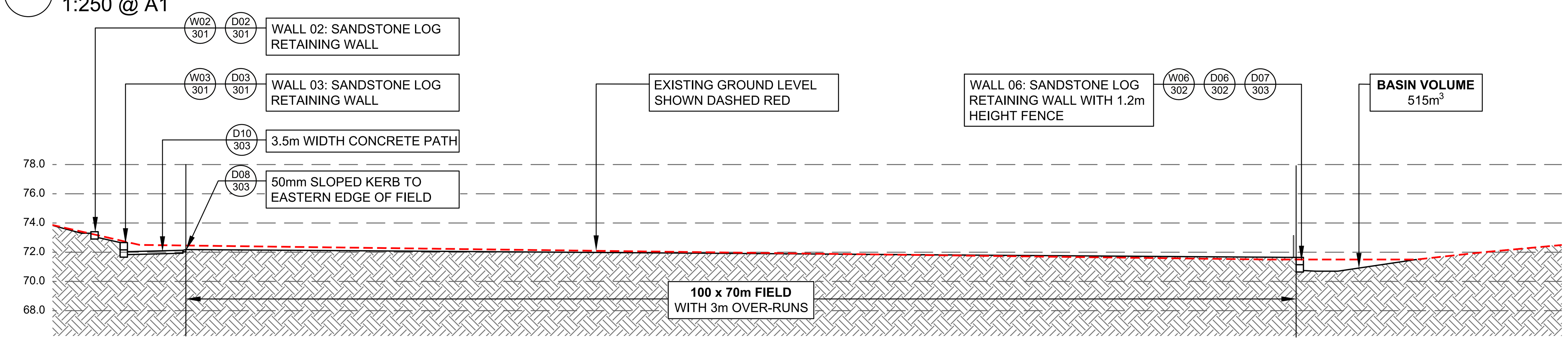

S09 SECTION 09
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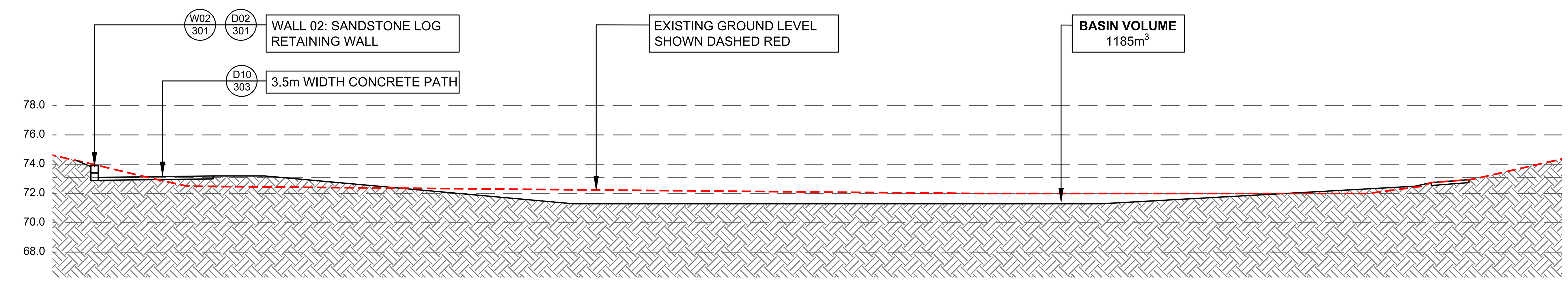

S10 SECTION 10
1:250 @ A1

GENERAL NOTES

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REV	DATE	AMENDMENTS	INITIALS
A	28.03.18	FOR COMMENT	NB
B	10.04.18	CONSULTANT REVIEW	NB

DATE: NOV 2017
DRAWN BY: NBROWN
APPROVAL BY: Director of Operations
APPROVAL BY: Director of Strategy & Environment
SCALE: 1:250 @ A1

Ku-ring-gai Council

KU-RING-GAI COUNCIL

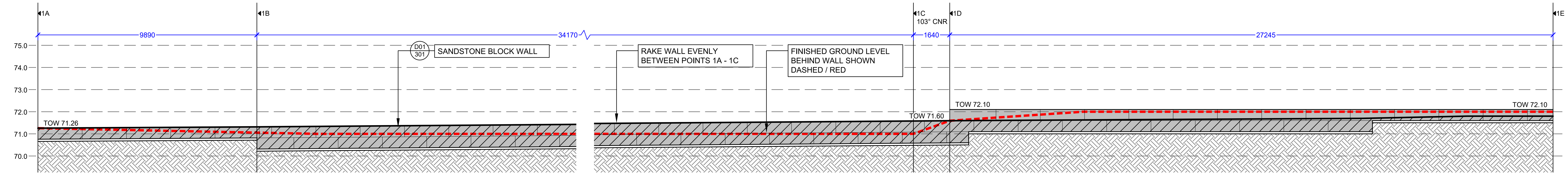
Mail: Locked bag 1056, Pymble NSW 2073
Street: 818 Pacific Hwy, Gordon NSW 2072
Contact: T: 02 9424 0000 W: www.kmc.nsw.gov.au

PROJECT:
NORMAN GRIFFITHS OVAL FIELD UPGRADE

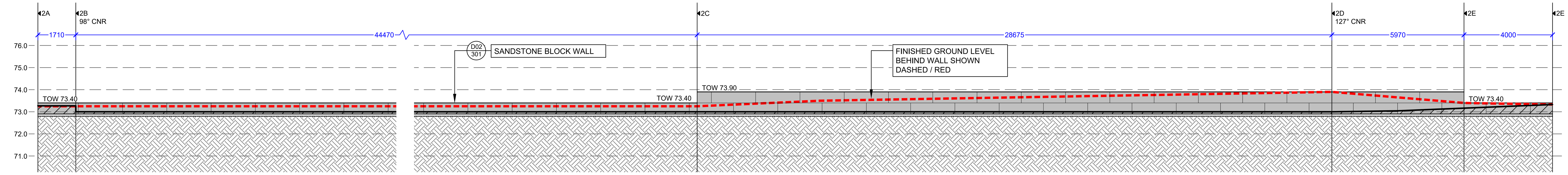
PRELIMINARY ONLY - NOT FOR CONSTRUCTION

SHEET:
SITE SECTIONS 02

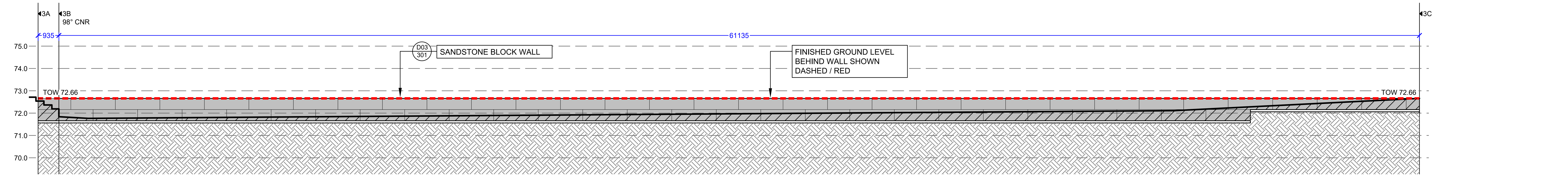
LMU NO.:	PLAN NO.:	SHEET:	OF:	REV:
287	L-202	08	11	B



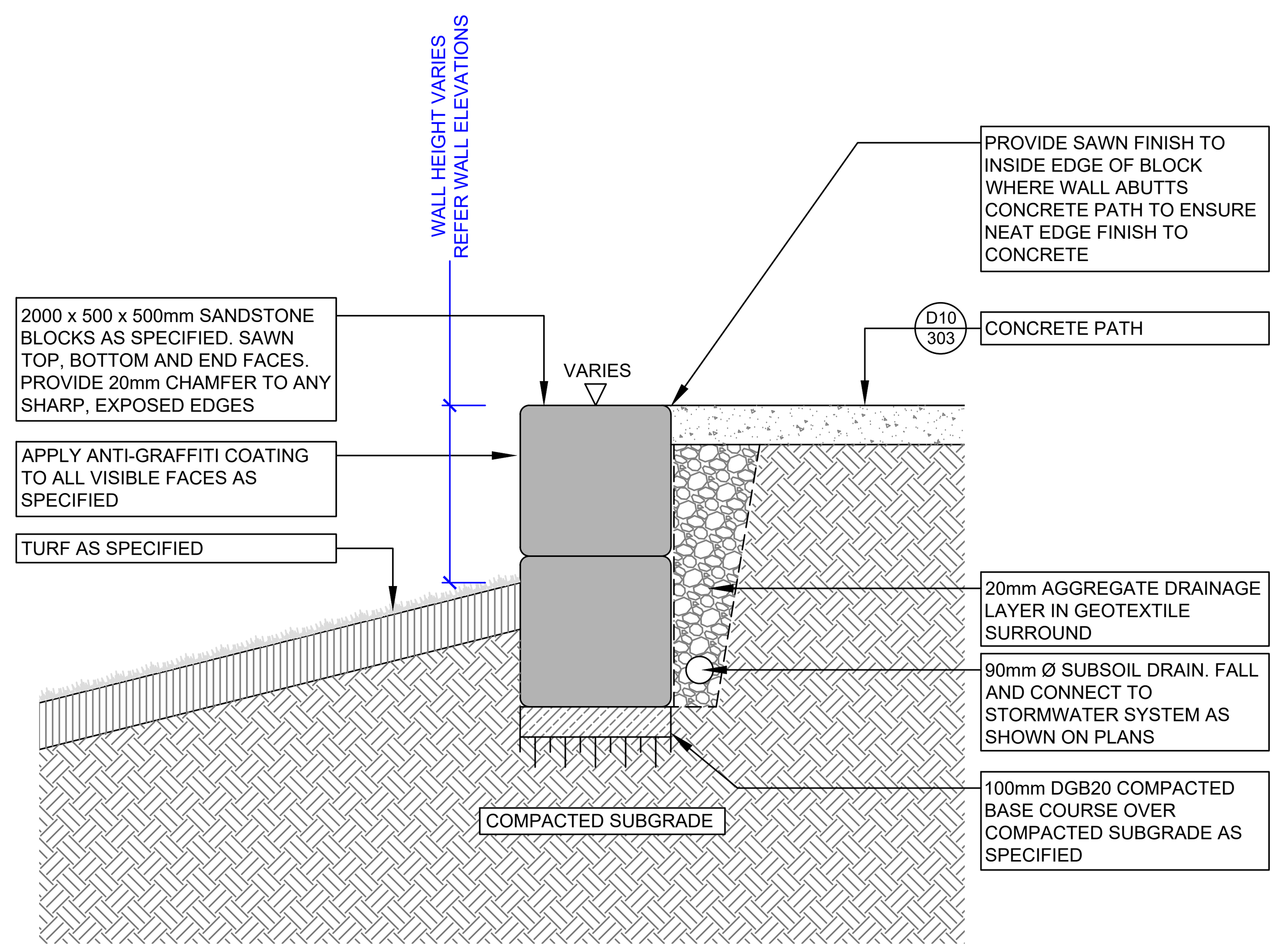
W01 WALL 01
ELEVATION 1:100 @ A1



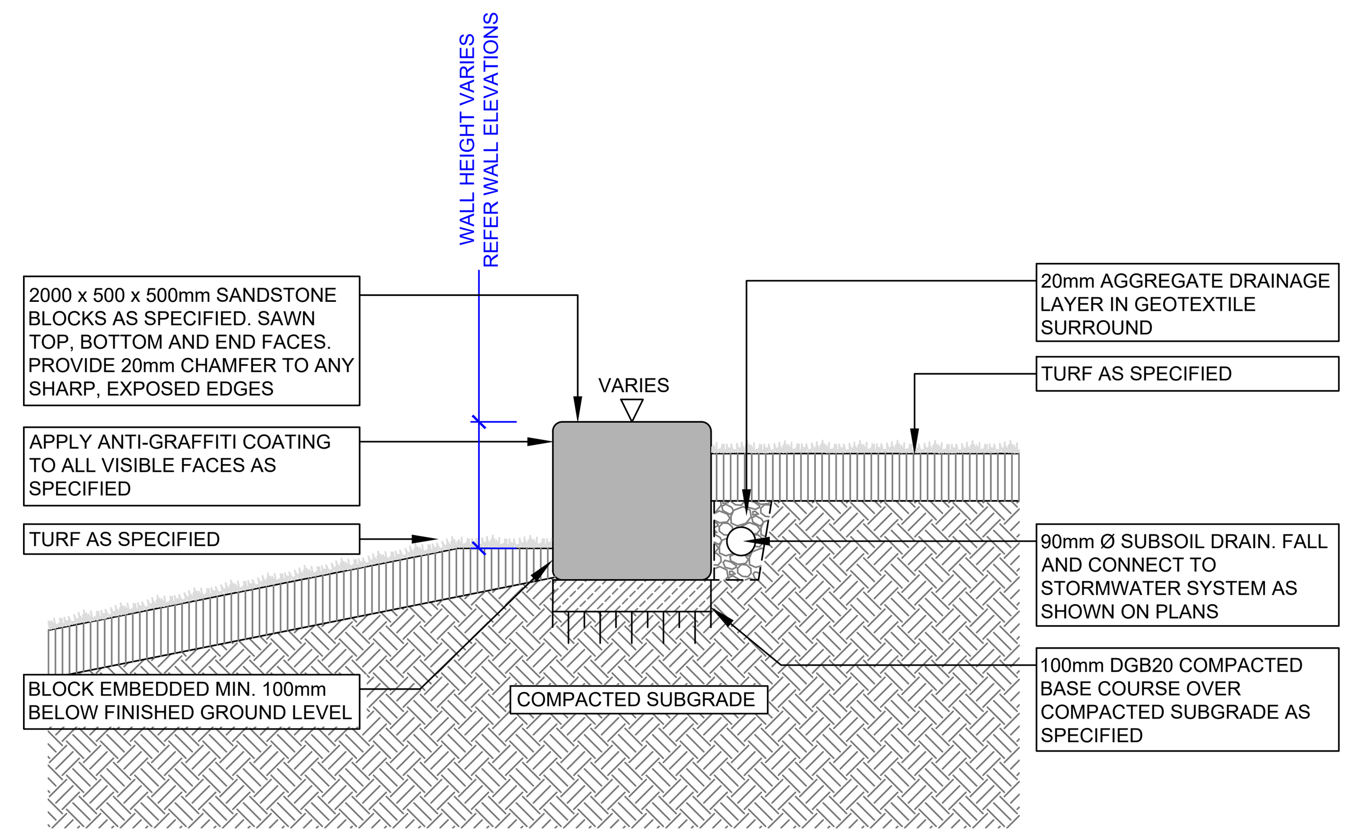
W02 WALL 02
ELEVATION 1:100 @ A1



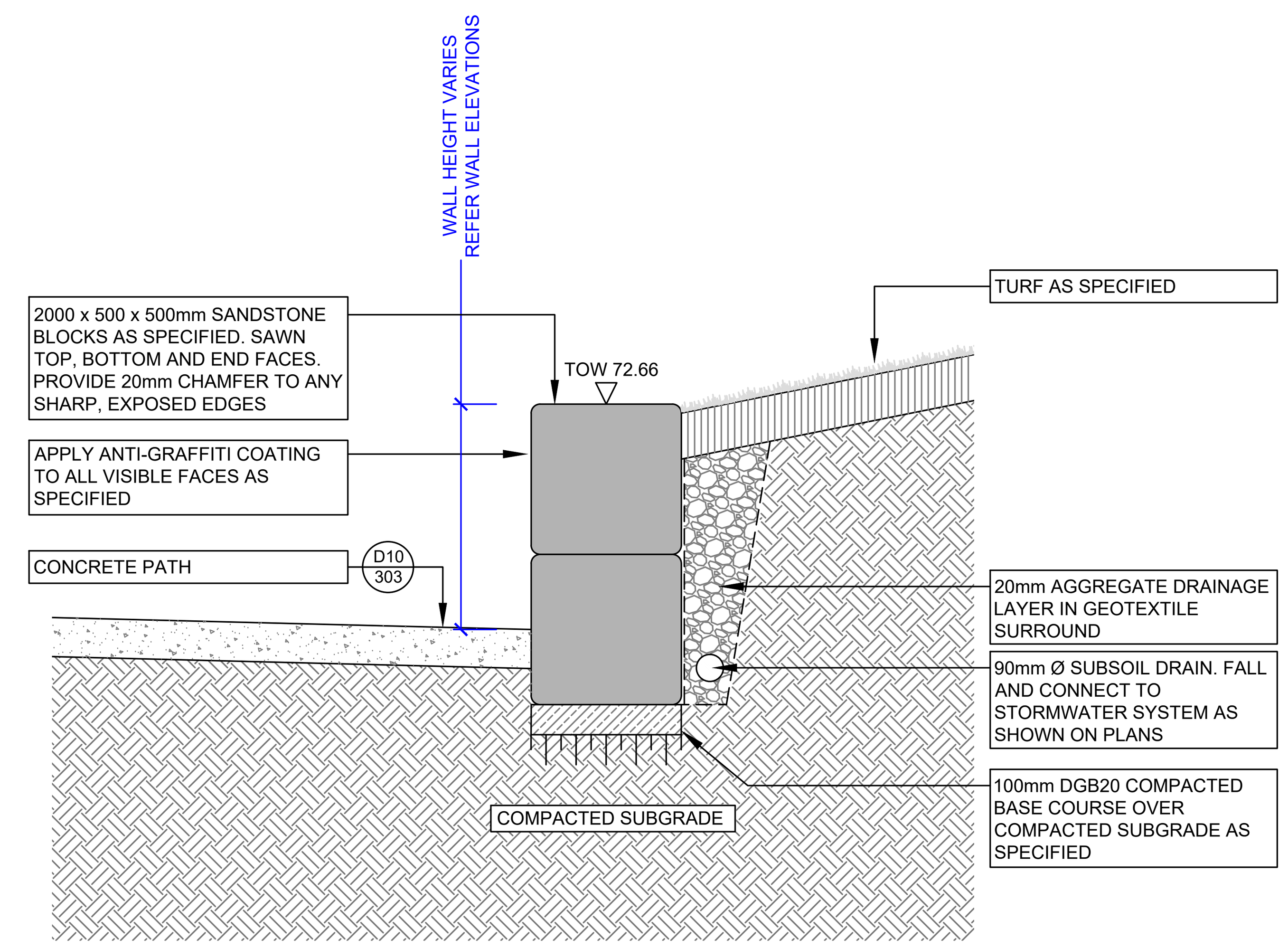
W03 WALL 03
ELEVATION 1:100 @ A1



D01 SANDSTONE WALL 01
SECTION 1:20 @ A1



D02 SANDSTONE WALL 02
SECTION 1:20 @ A1



D03 SANDSTONE WALL 03
SECTION 1:20 @ A1

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DATE: NOV 2017	DRAWN BY: NBROWN
APPROVAL BY: Director of Operations	
APPROVAL BY: Director of Strategy & Environment	SCALE: AS SHOWN @ A1

Ku-ring-gai Council

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PROJECT:
NORMAN GRIFFITHS OVAL
FIELD UPGRADE

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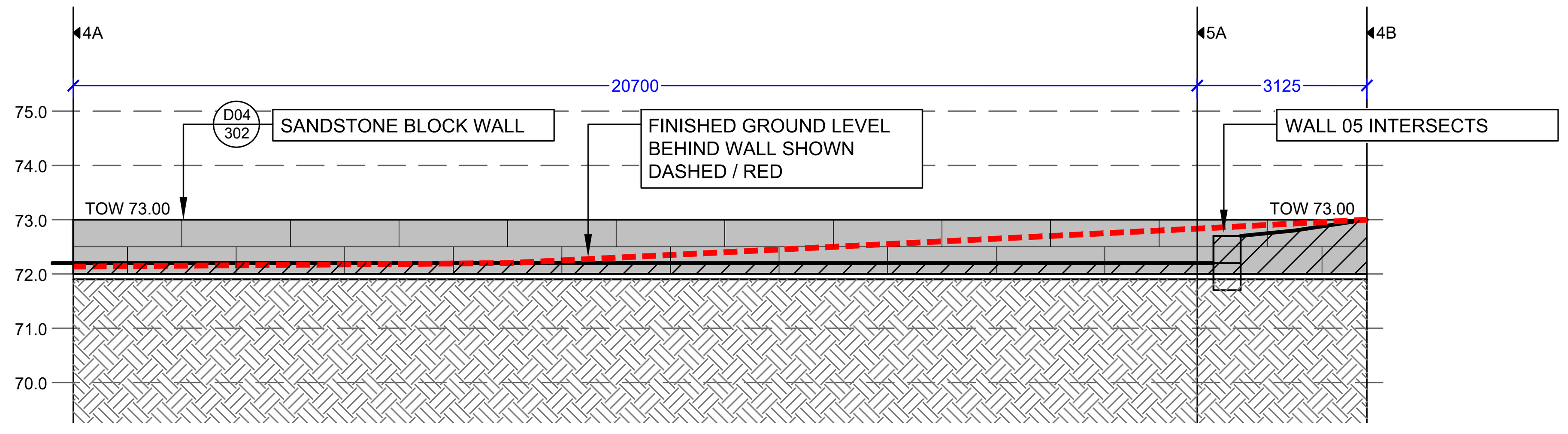
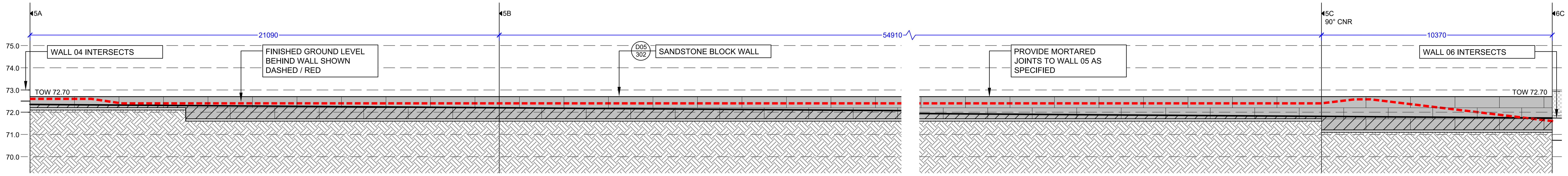
SHEET:
CONSTRUCTION DETAILS 01 WALLS 01 - 03

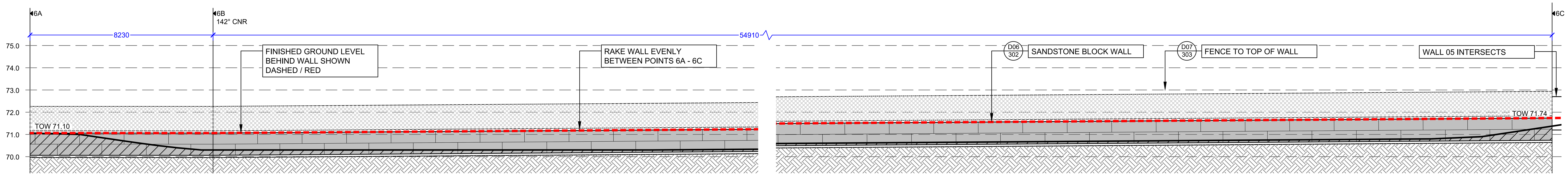
LMU NO.:	PLAN NO.:	SHEET:	OF:	REV:
287	L-301	09	11	B



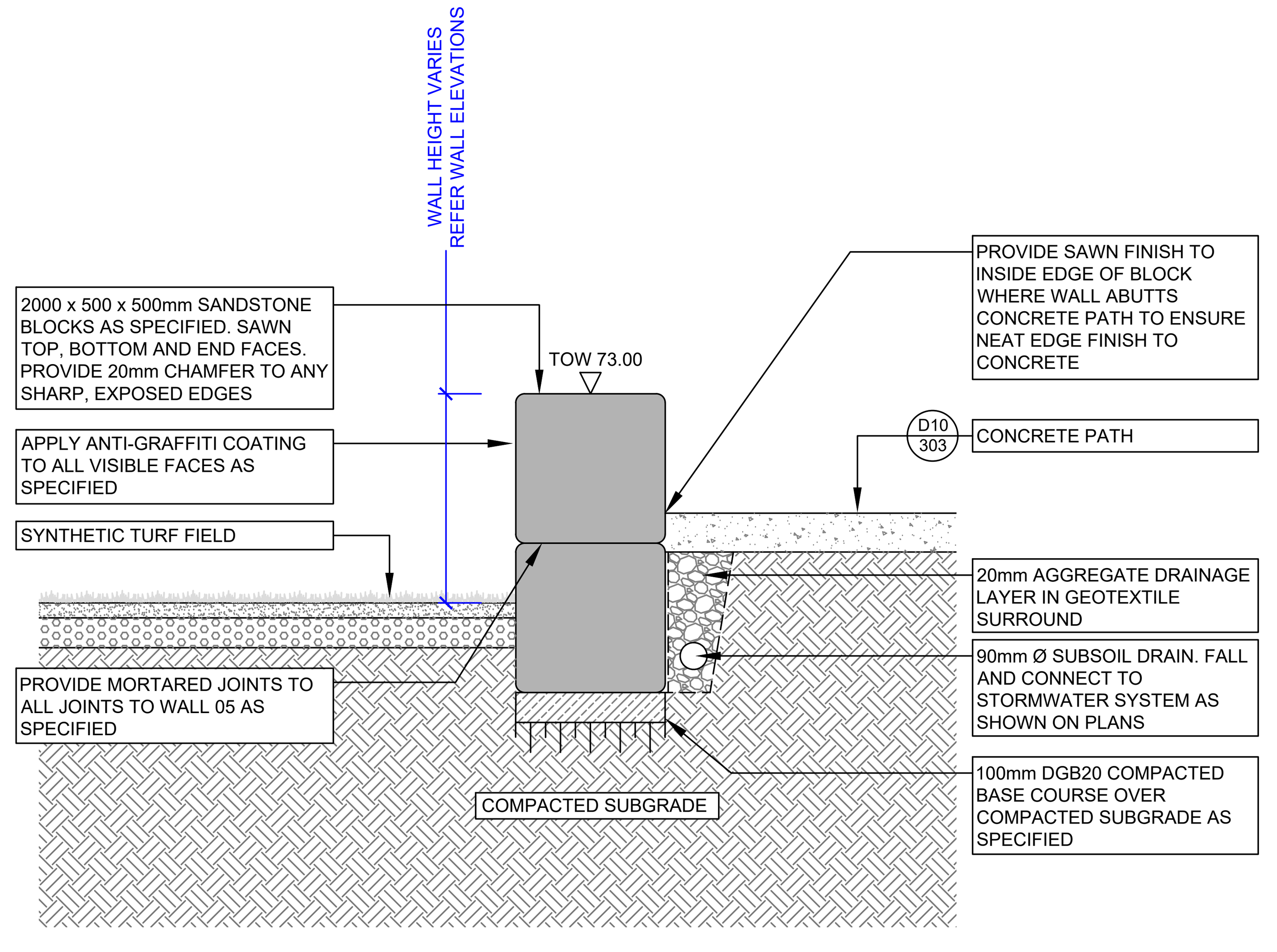
W04 WALL 04
ELEVATION 1:100 @ A1



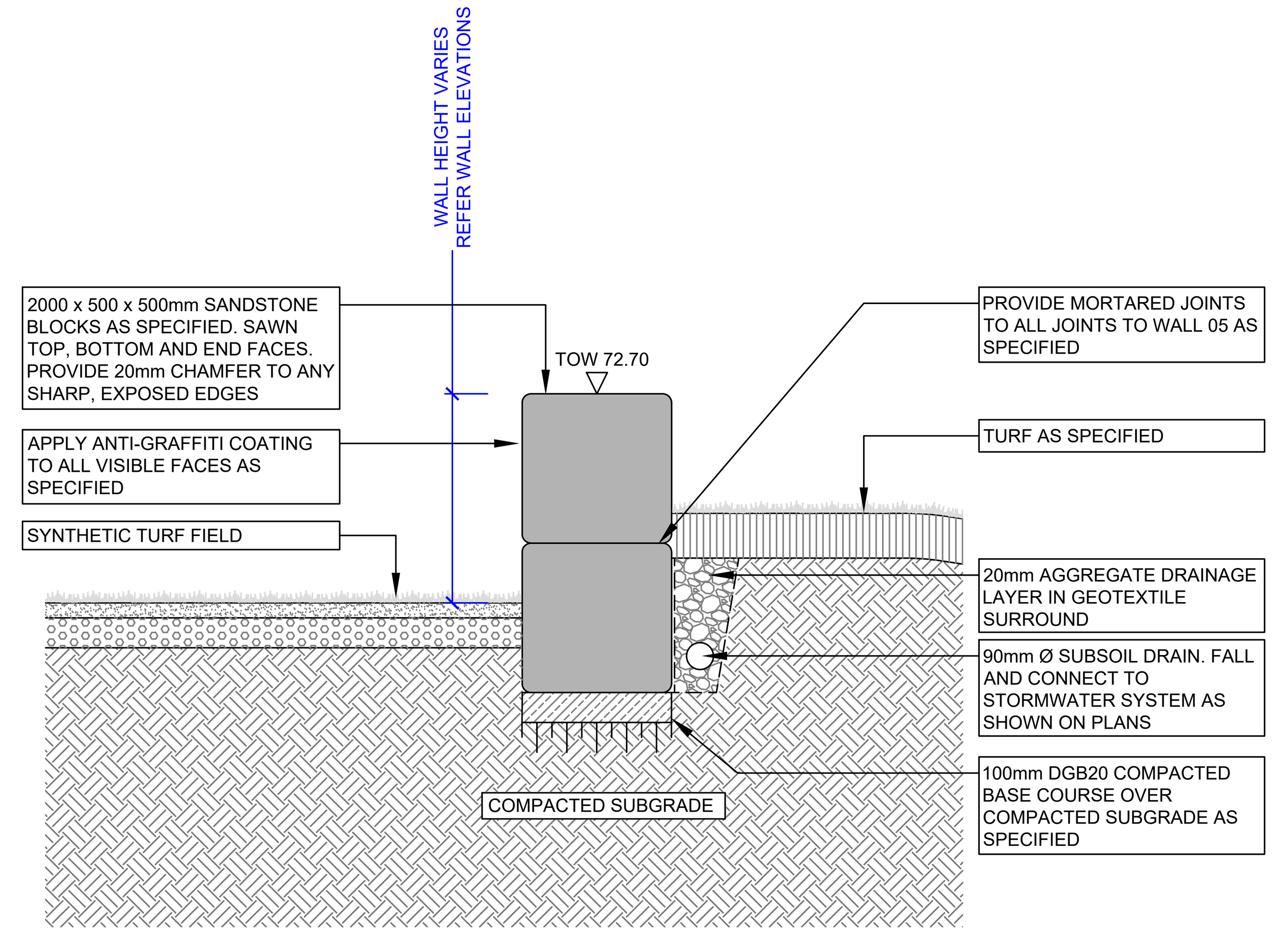
W05 WALL 05
ELEVATION 1:100 @ A1



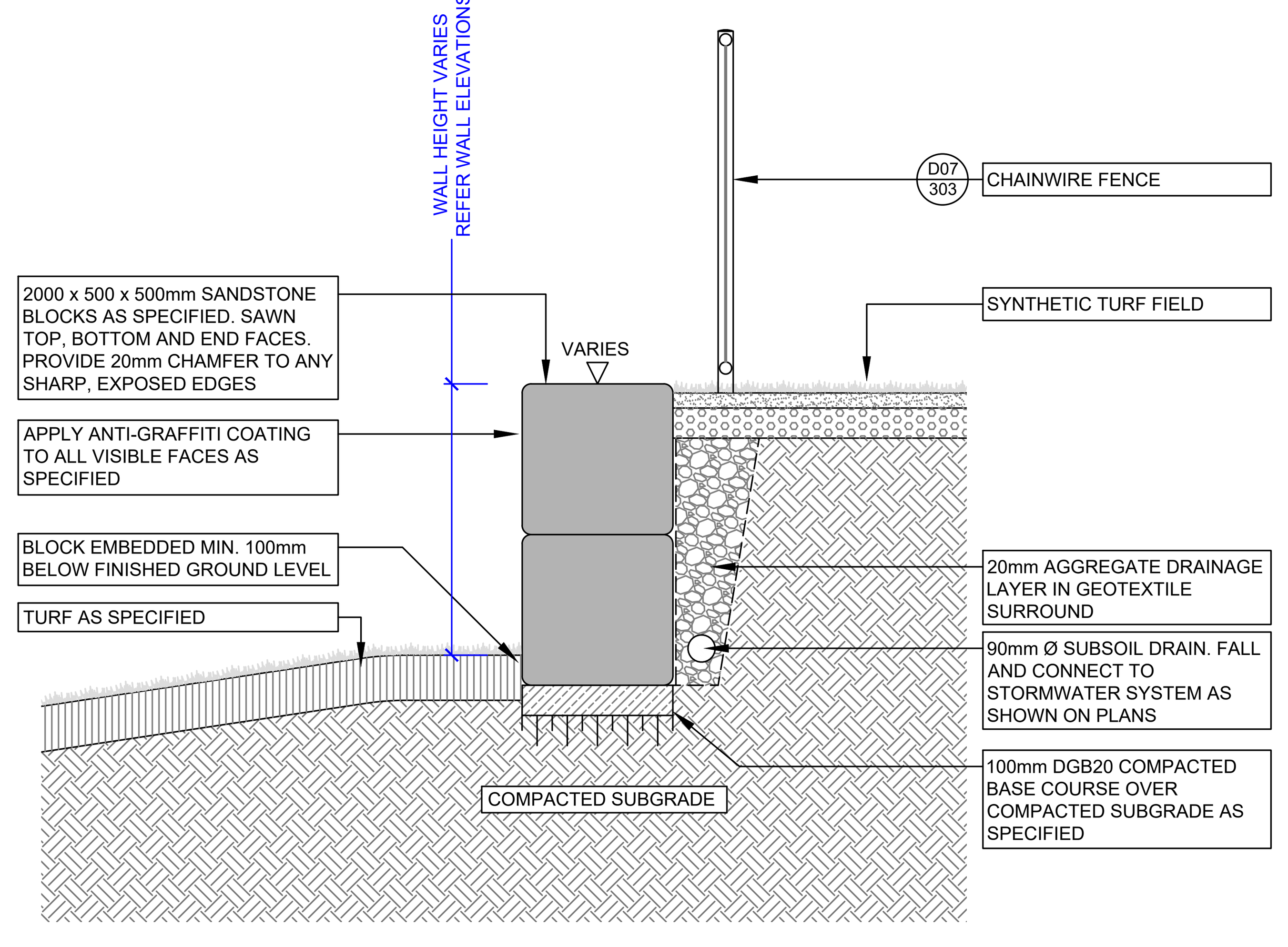
W06 WALL 06
ELEVATION 1:100 @ A1



D04 SANDSTONE WALL 04 WITH MORTARED JOINTS
SECTION 1:20 @ A1



D05 SANDSTONE WALL 05 WITH MORTARED JOINTS
SECTION 1:20 @ A1



D06 SANDSTONE WALL 06
SECTION 1:20 @ A1

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APPROVAL BY: Director of Strategy & Environment
SCALE: AS SHOWN @ A1

Ku-ring-gai Council

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PROJECT:
NORMAN GRIFFITHS OVAL
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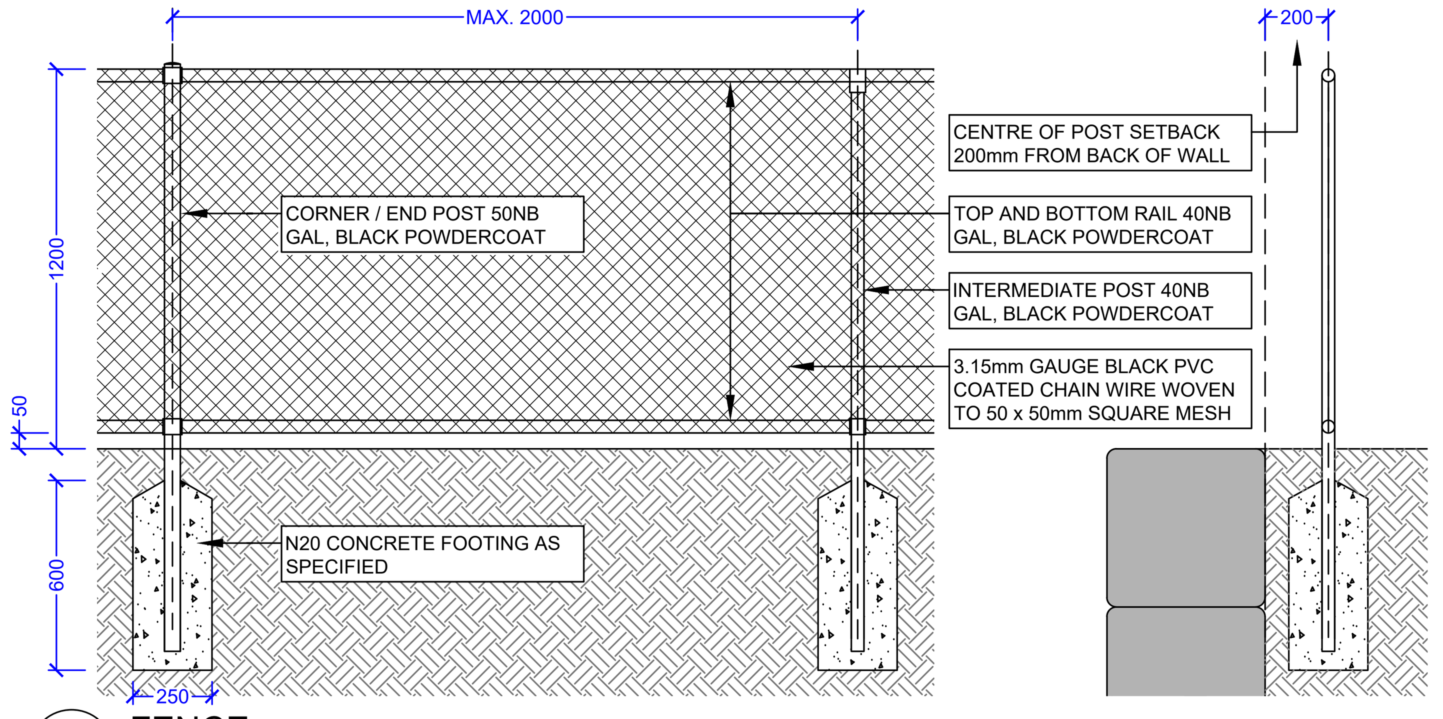
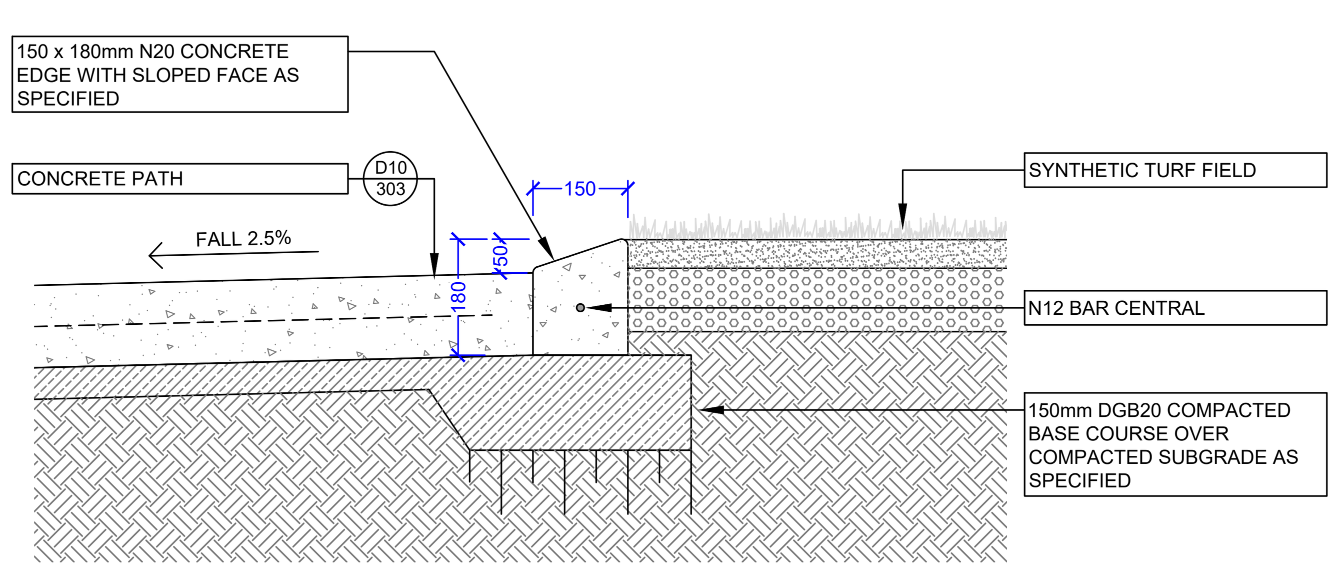
SHEET:
CONSTRUCTION DETAILS 04 WALLS 04 - 06

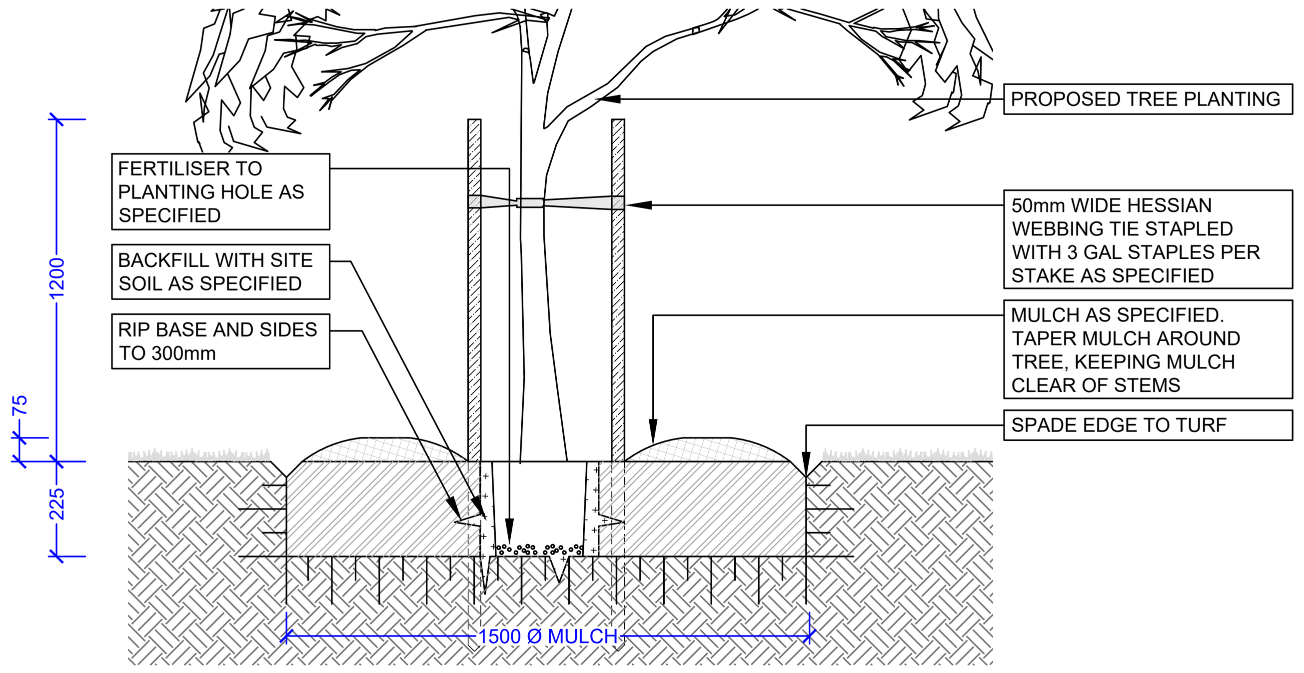
LMU NO.:	PLAN NO.:	SHEET:	OF:	REV:
287	L-302	10	11	B



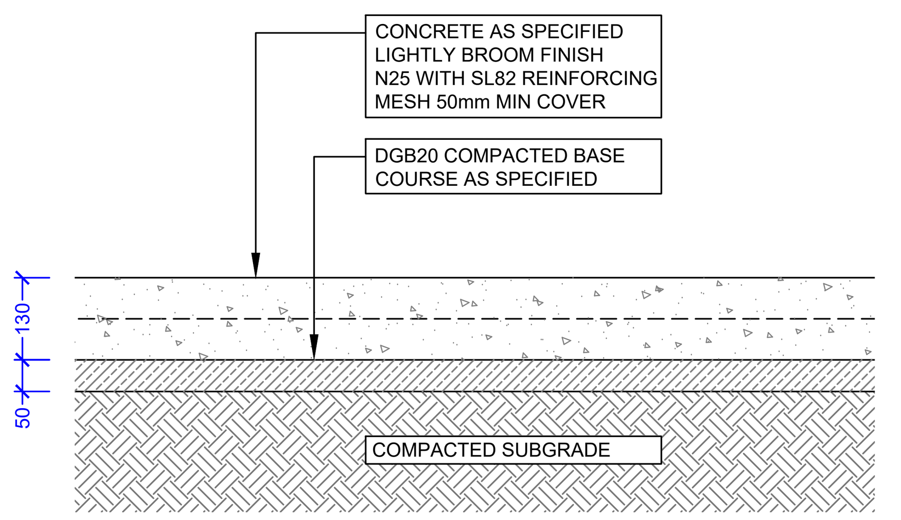
D07 FENCE
ELEVATION 1:20 @ A1 SECTION 1:20 @ A1



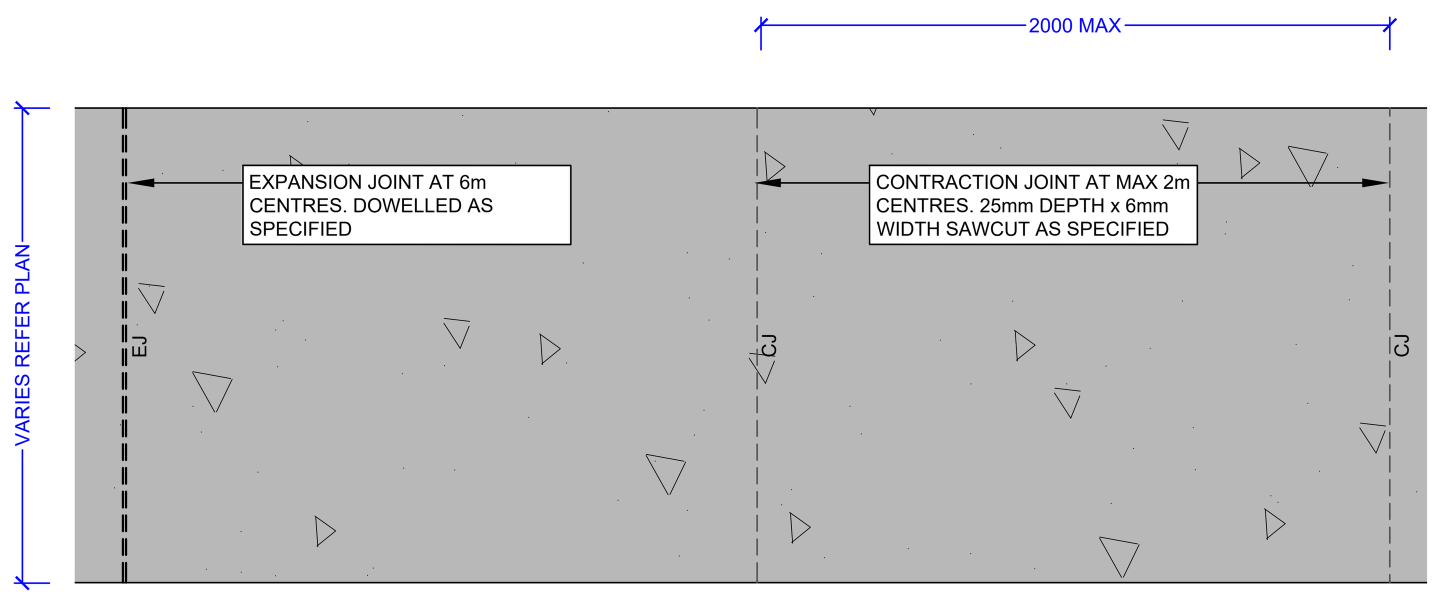
D08 CONCRETE KERB TO FIELD
SECTION 1:20 @ A1



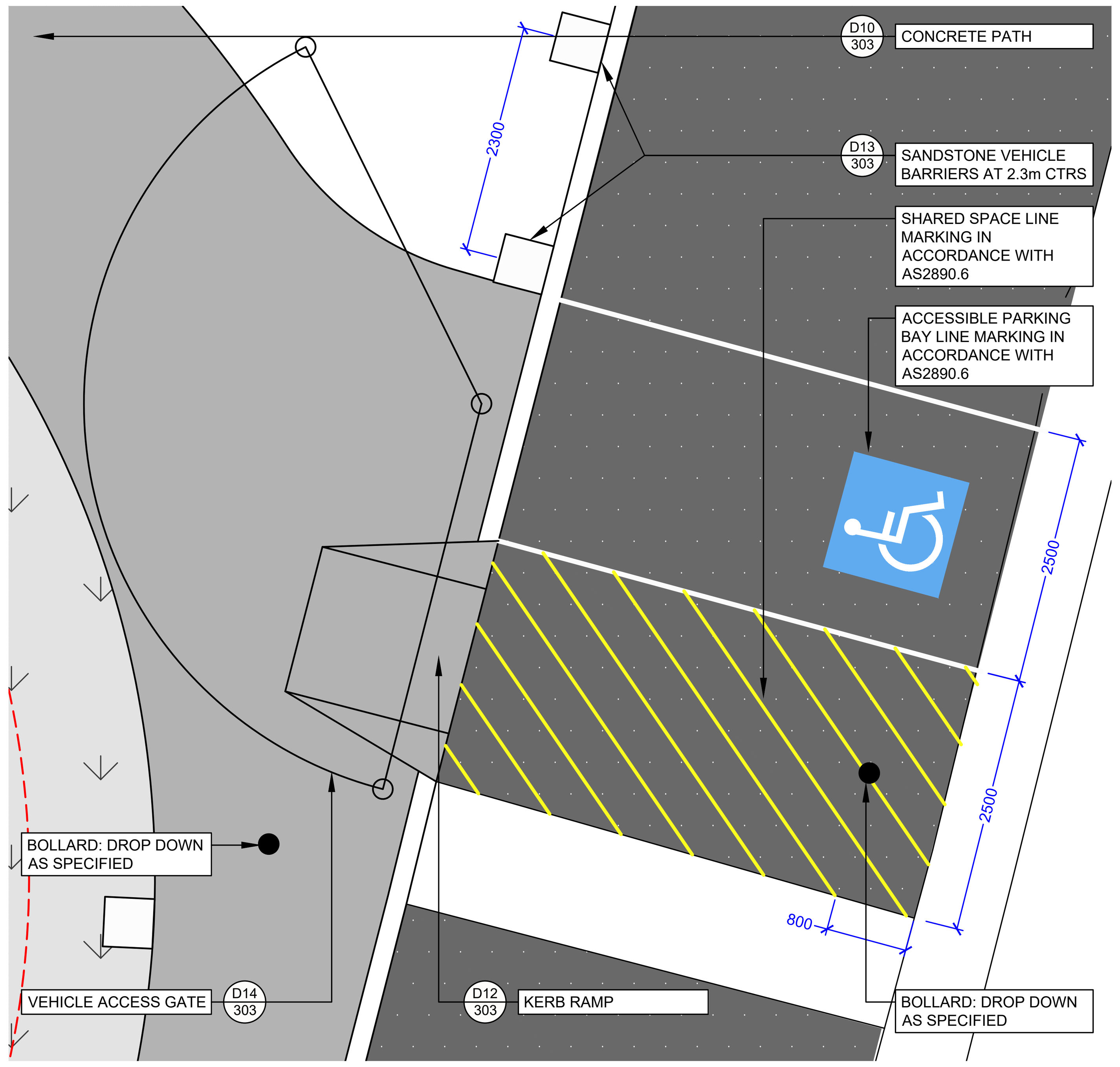
D09 TREE PLANTING
SECTION 1:20 @ A1



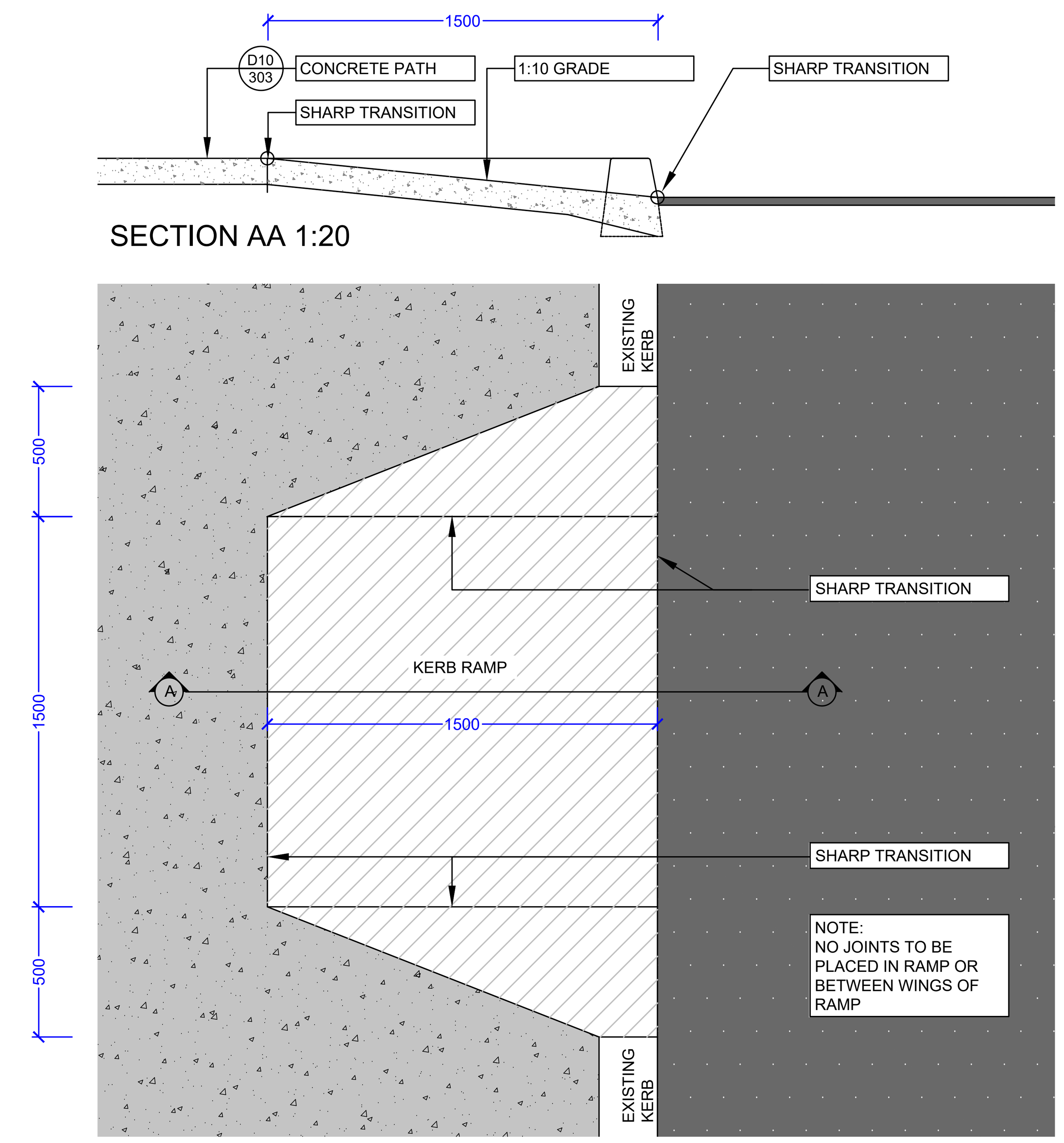
SECTION 1:10 @ A1



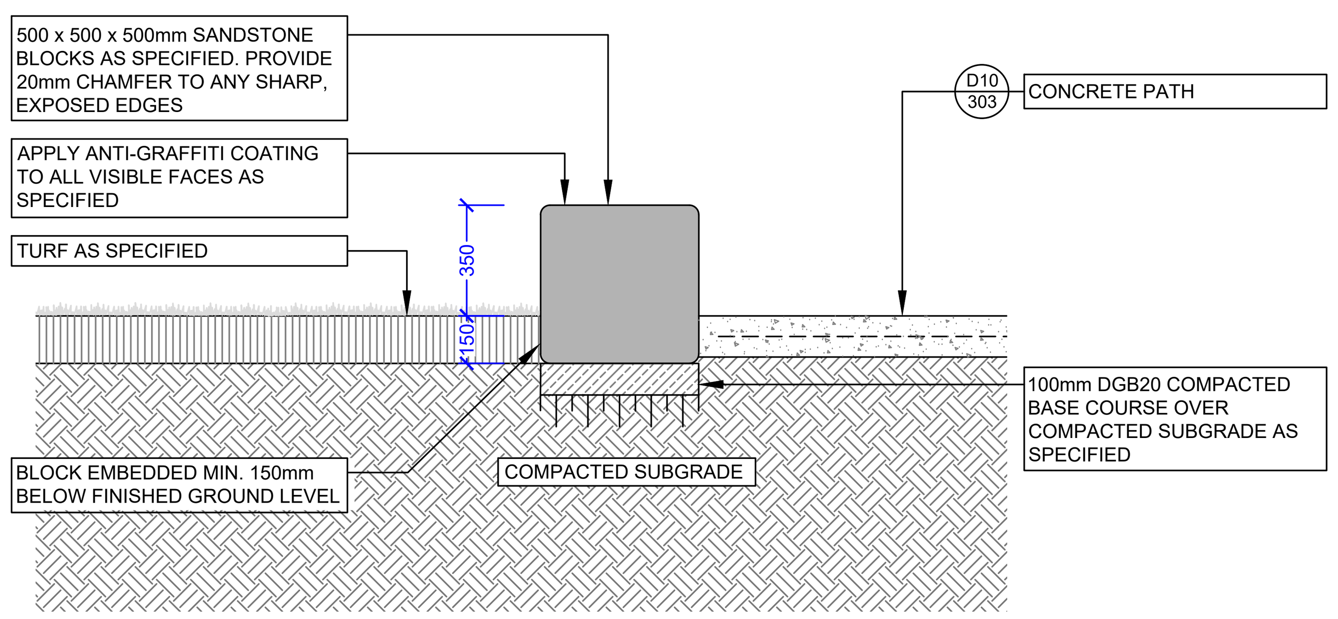
D10 CONCRETE FOOTPATH
PLAN 1:20 @ A1



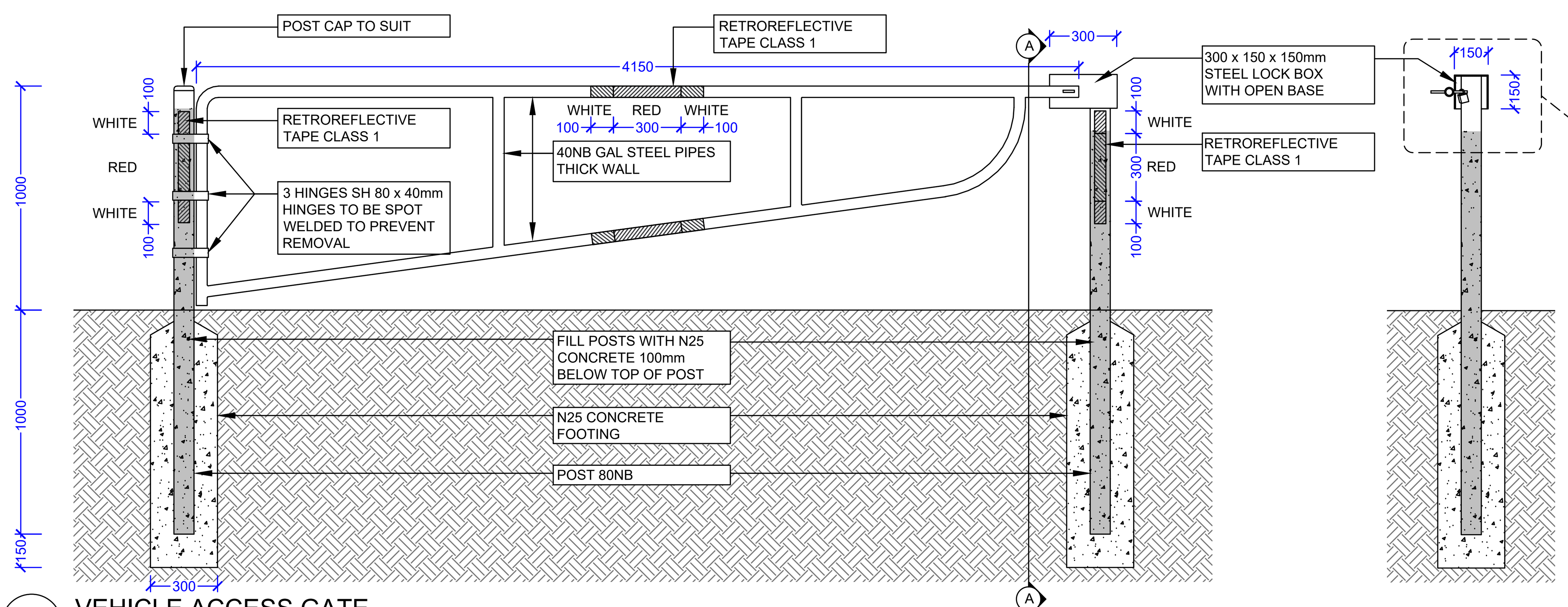
D11 ACCESSIBLE PARKING BAY / GATE / VEHICLE BARRIERS
PLAN 1:50 @ A1

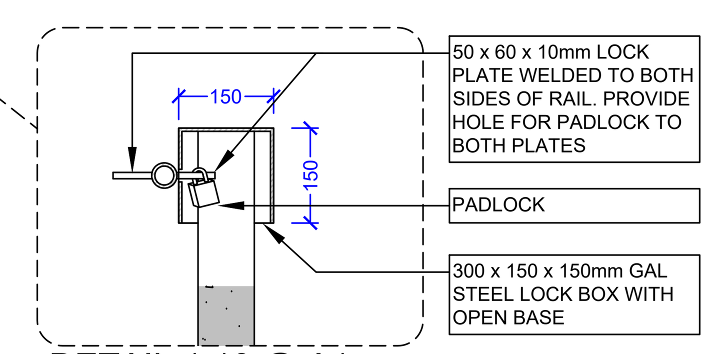


D12 CONCRETE KERB RAMP
PLAN 1:20 @ A1



D13 SANDSTONE VEHICLE BARRIER
SECTION 1:20 @ A1





DETAIL 1:10 @ A1

NOTE:
ALL STEEL TO BE HOT DIPPED GALVANISED
ALL WELDS TO BE CONTINUOUS MINIMUM 6mm GP WELDS

D14 VEHICLE ACCESS GATE
SECTION 1:20 @ A1 SECTION AA 1:20 @ A1

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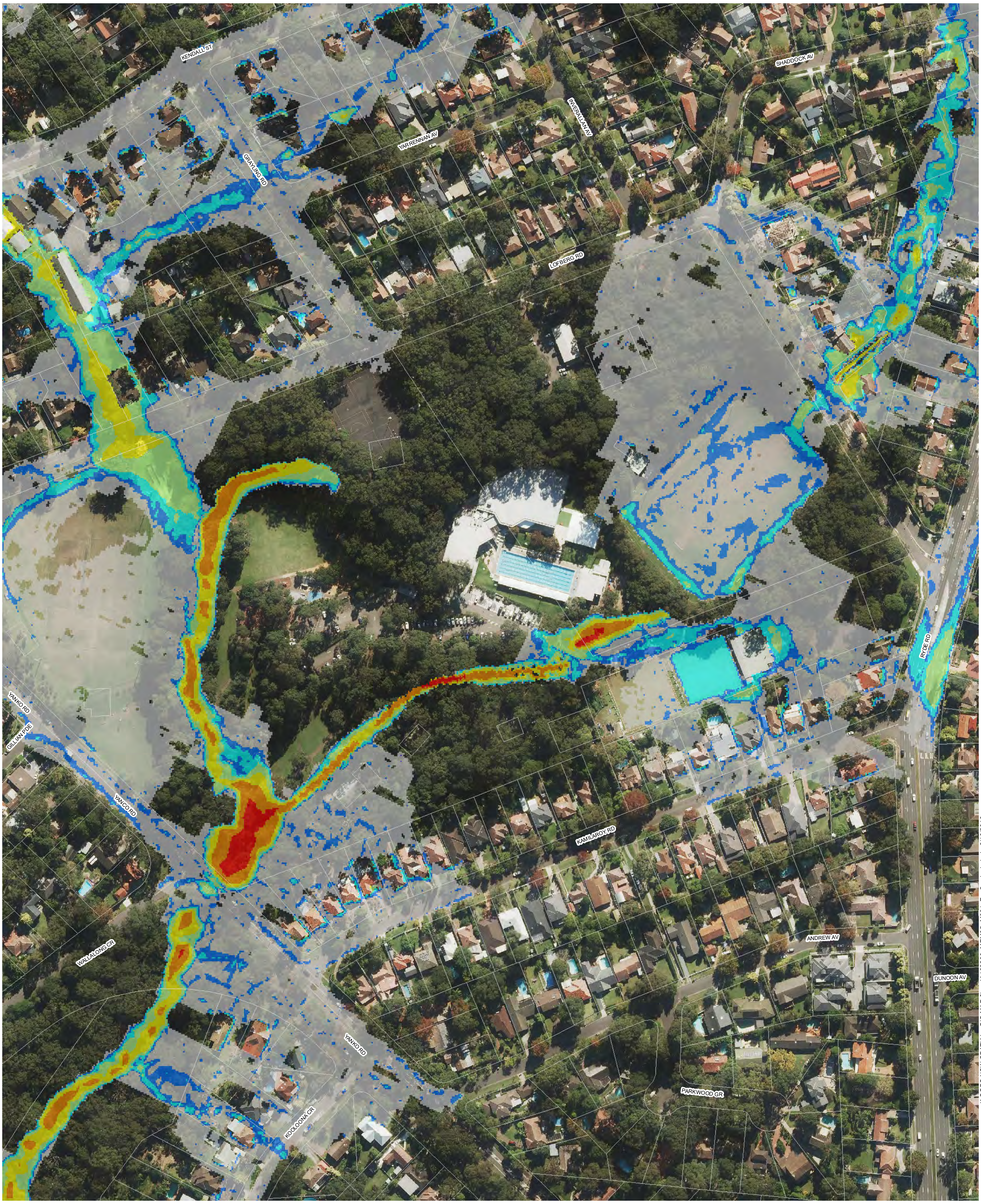
SHEET:
CONSTRUCTION DETAILS 03

LMU NO.:	PLAN NO.:	SHEET:	OF:	REV:
287	L-303	11	11	B

Appendix B – Flood depth and impact maps



Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

NOTE: Refined existing case flood depths. Overland inflows on north-west side of Oval have been redistributed.

0 50 100m
1:2,500 @ A3

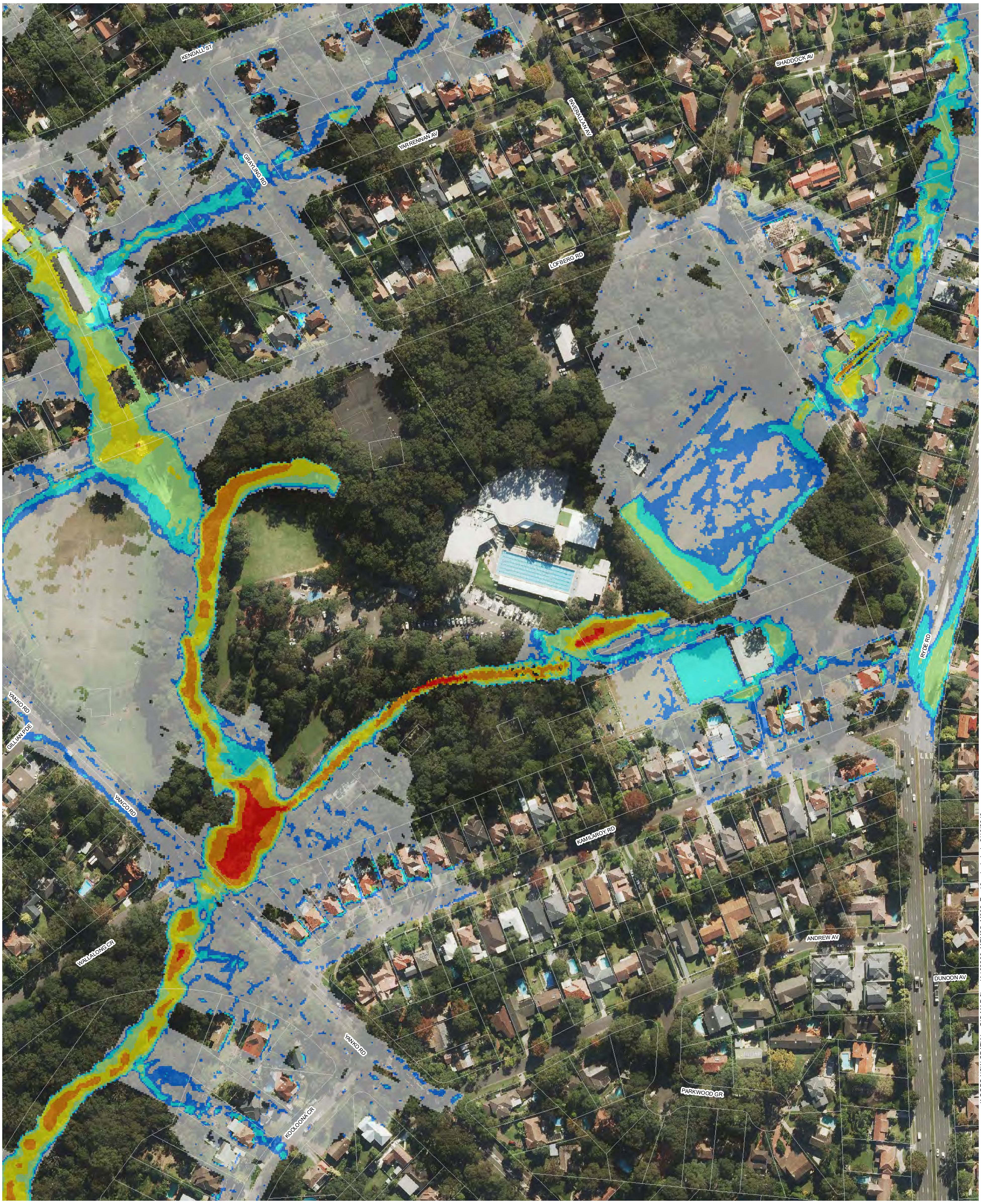
N

Data sources

Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 1 | 0.2 EY Flood Depth - Existing Case

JACOBS



Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

NOTE: Refined existing case flood depths. Overland inflows on north-west side of Oval have been redistributed.

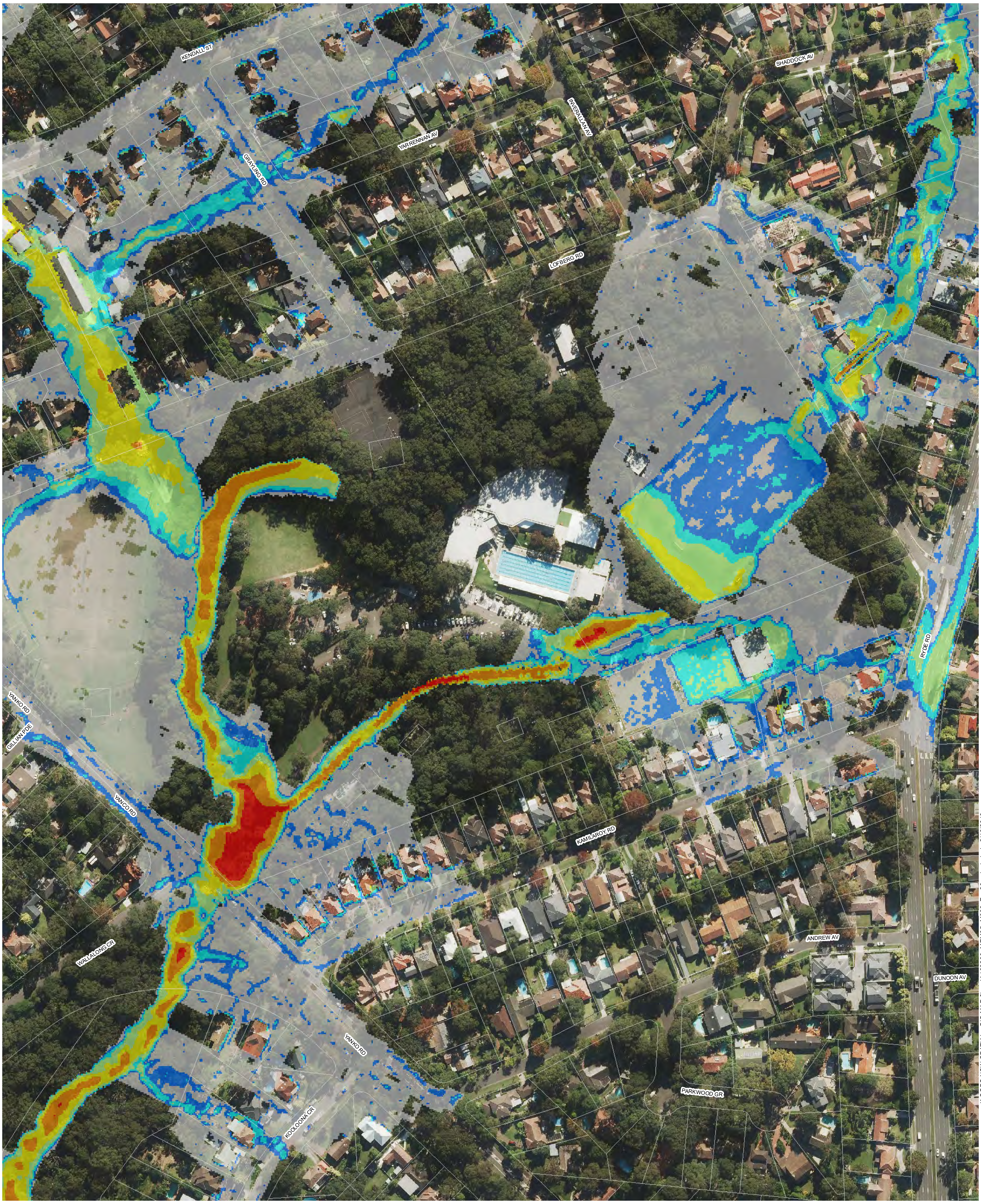
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 2 | 10% AEP Flood Depth - Existing Case

JACOBS



Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

NOTE: Refined existing case flood depths. Overland inflows on north-west side of Oval have been redistributed.

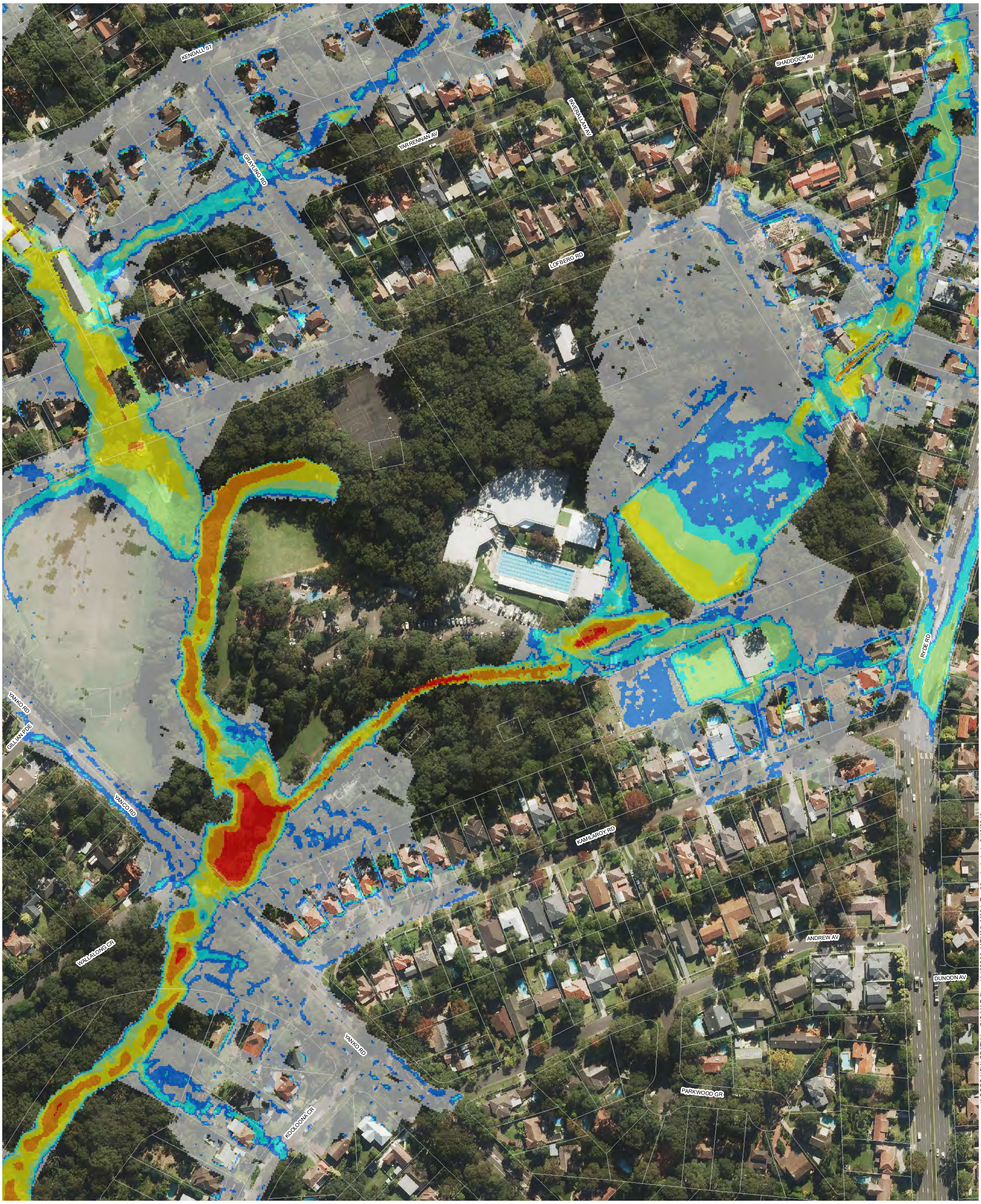
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 3 | 5% AEP Flood Depth - Existing Case

JACOBS



Legend

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

NOTE: Refined existing case flood depths. Overland inflows on north-west side of Oval have been redistributed.

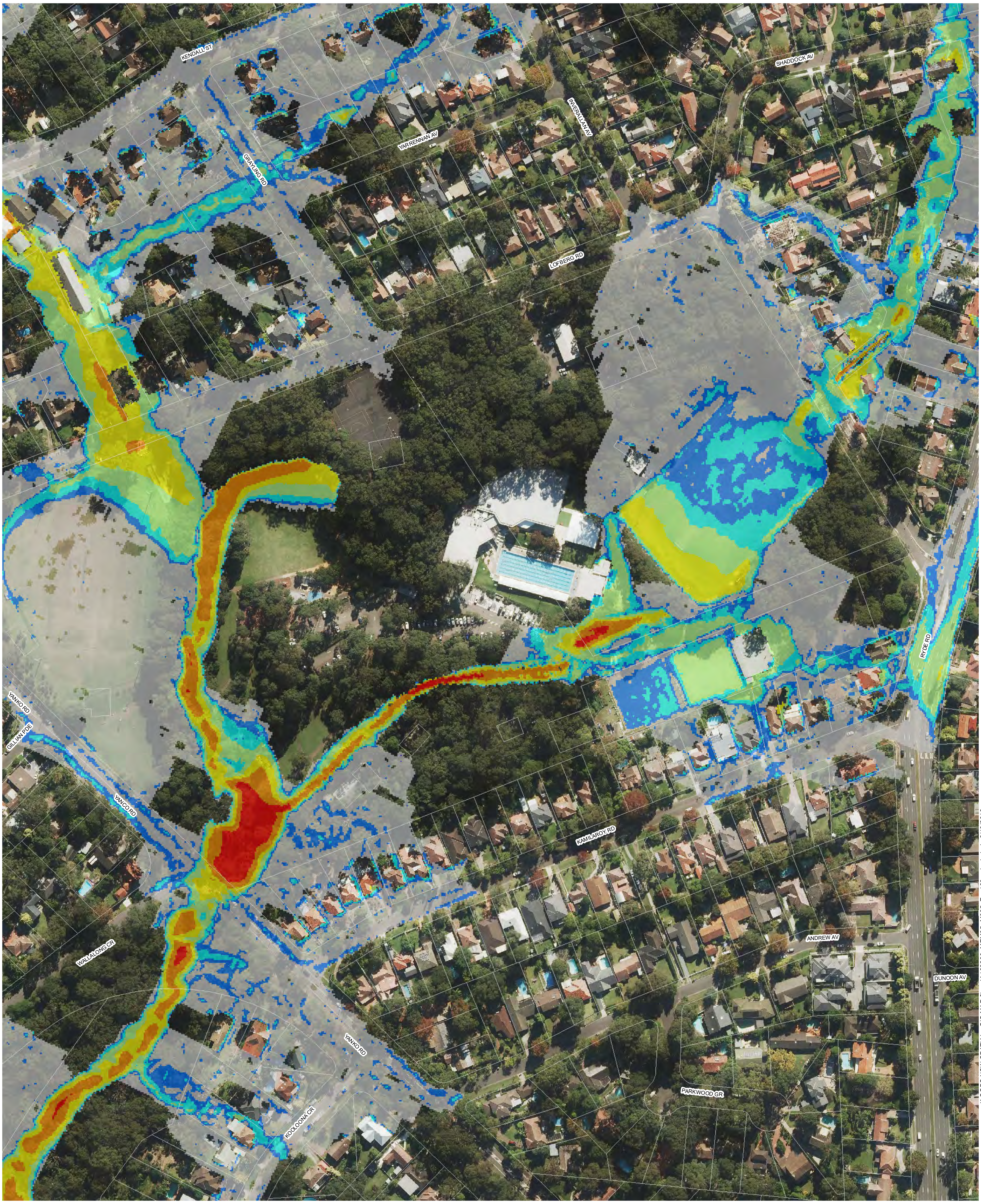
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 4 | 2% AEP Flood Depth - Existing Case

JACOBS



Legend

0 50 100 m
1:2,500 @ A3

N

Peak flood depth (m)

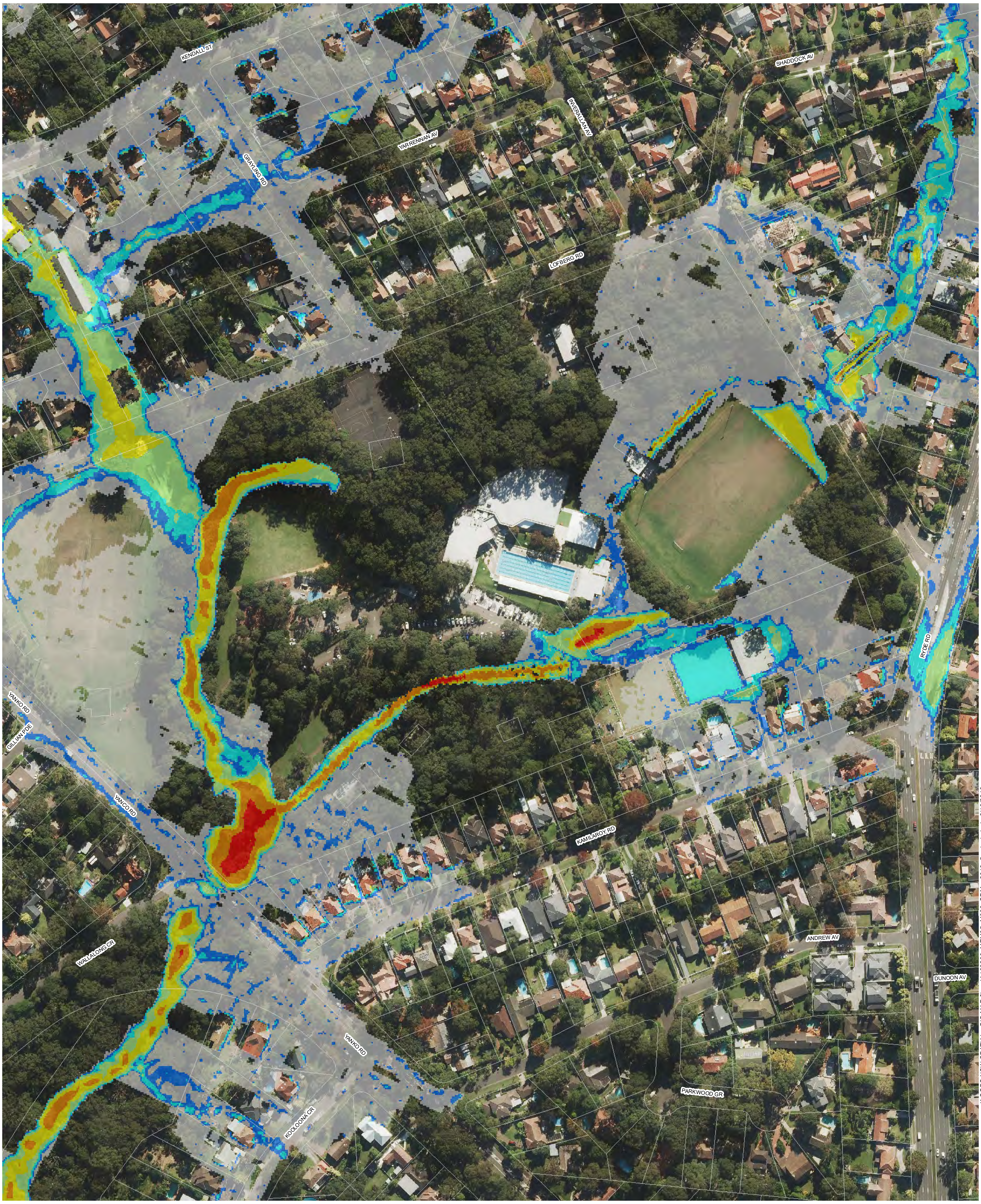
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

NOTE: Refined existing case flood depths. Overland inflows on north-west side of Oval have been redistributed.

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 5 | 1% AEP Flood Depth - Existing Case

JACOBS



Legend

0 50 100m
1:2,500 @ A3

N

Peak flood depth (m)

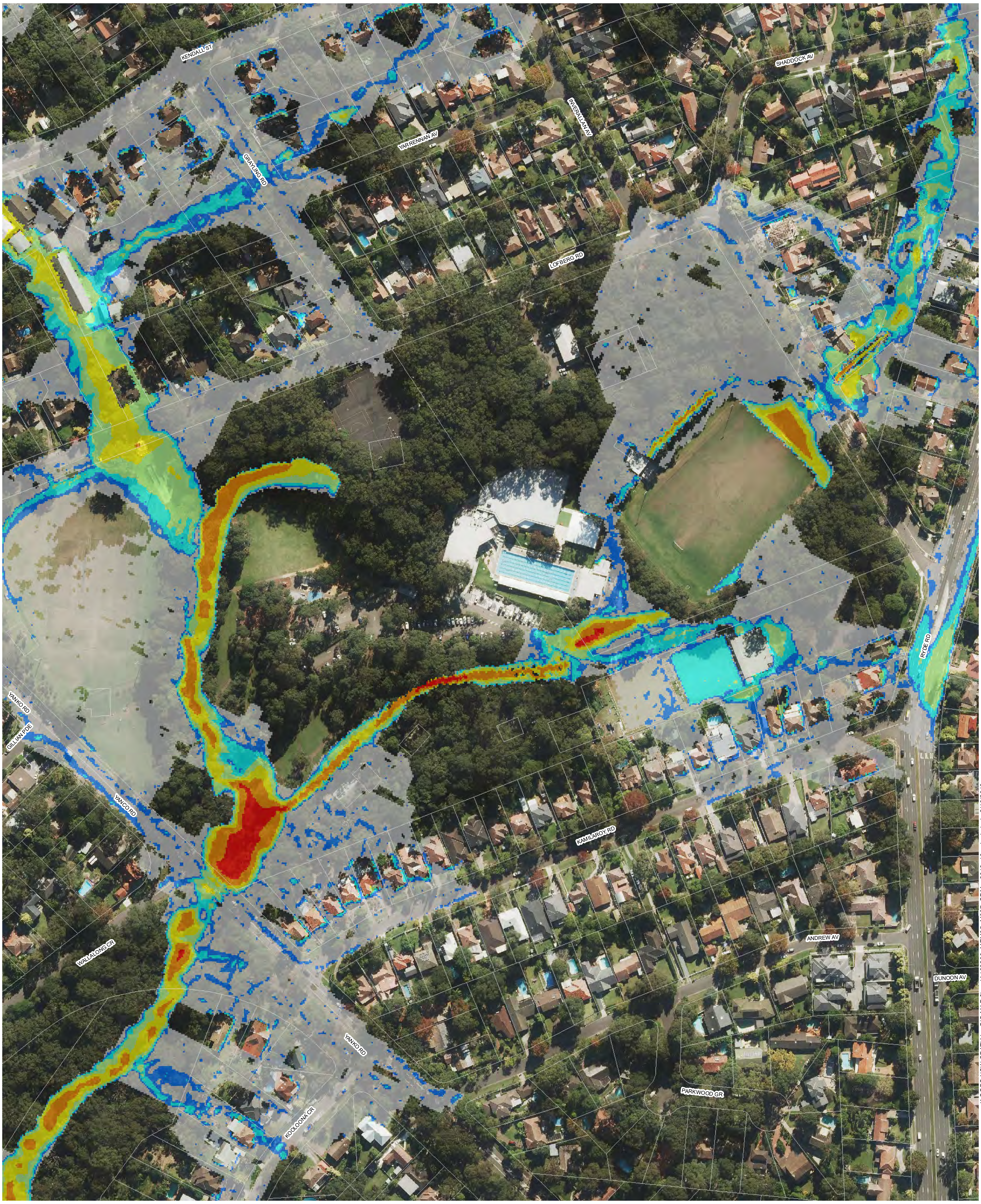
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

Data sources

Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 6 | 0.2 EY Flood Depth - Concept Design May 2018

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_MEM05_M007_CDMay2018_10y_d_r1v1 | 2/10/2018

0 50 100m
1:2,500 @ A3

N

Legend

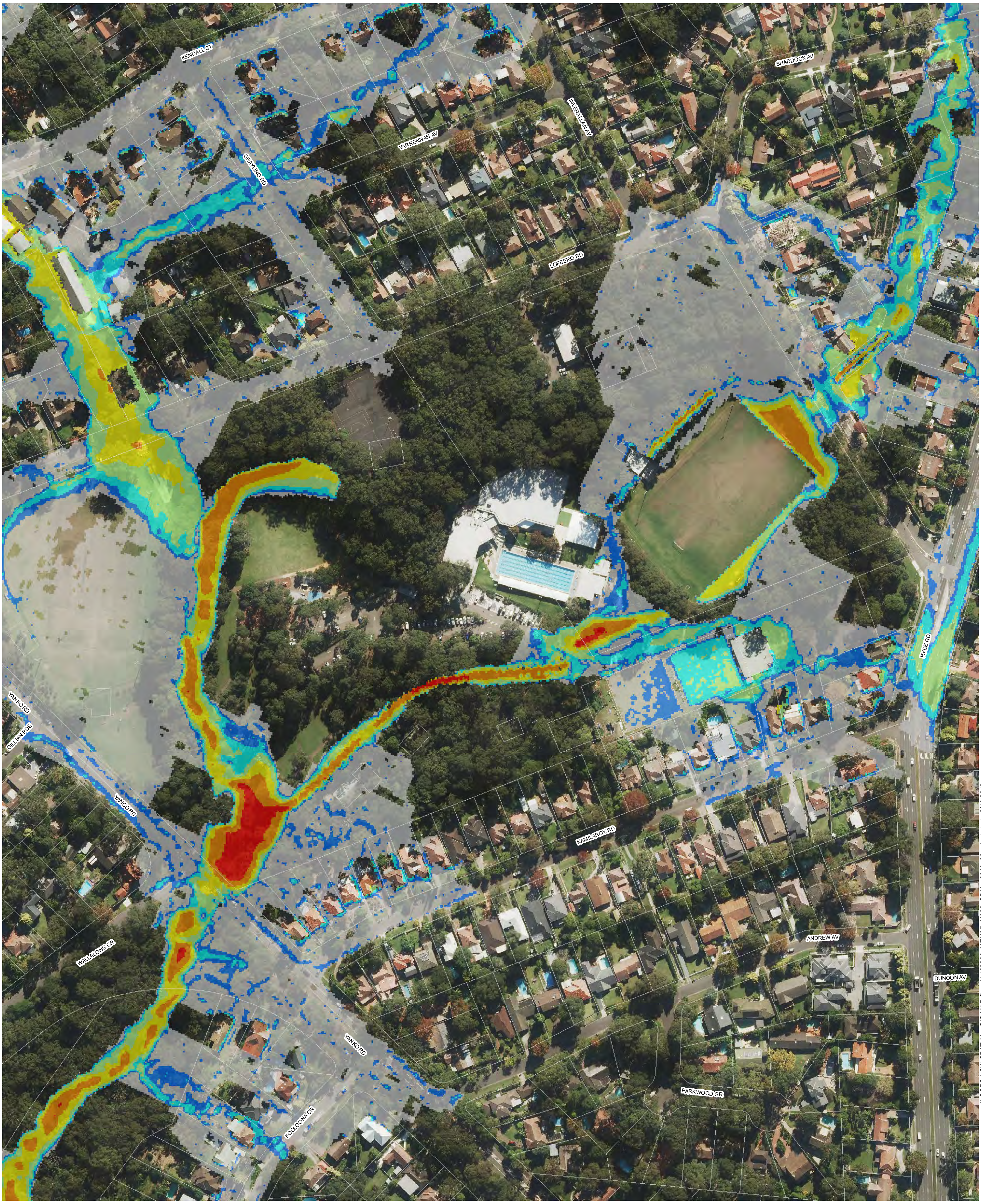
Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 7 | 10% AEP Flood Depth - Concept Design May 2018

JACOBS



Legend

Peak flood depth (m)

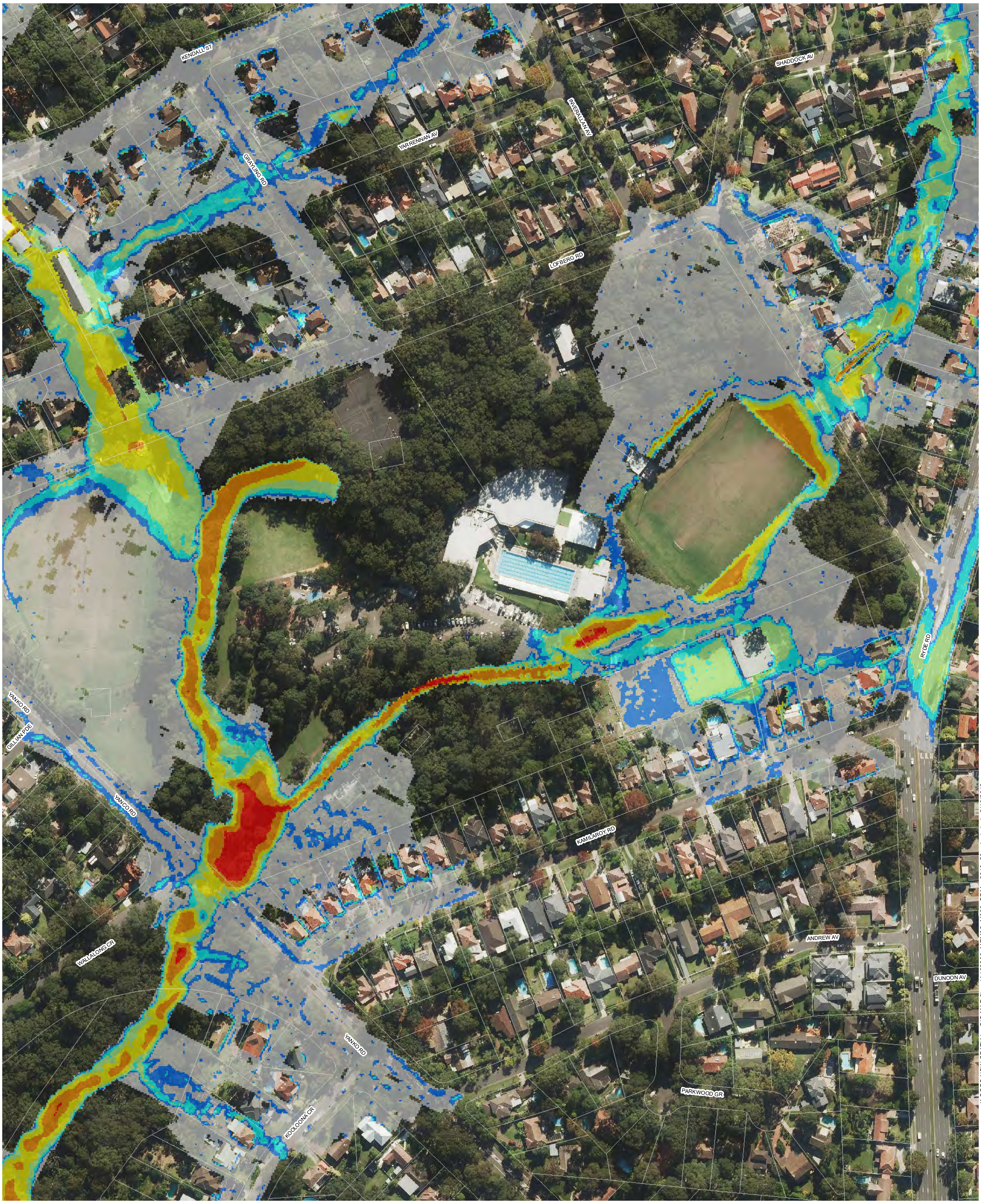
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

0 50 100m
1:2,500 @ A3
N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 8 | 5% AEP Flood Depth - Concept Design May 2018

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_MEM05_M009_CDMay2018_50y_d_r1v1 | 2/10/2018

0 50 100m
1:2,500 @ A3

N

Legend

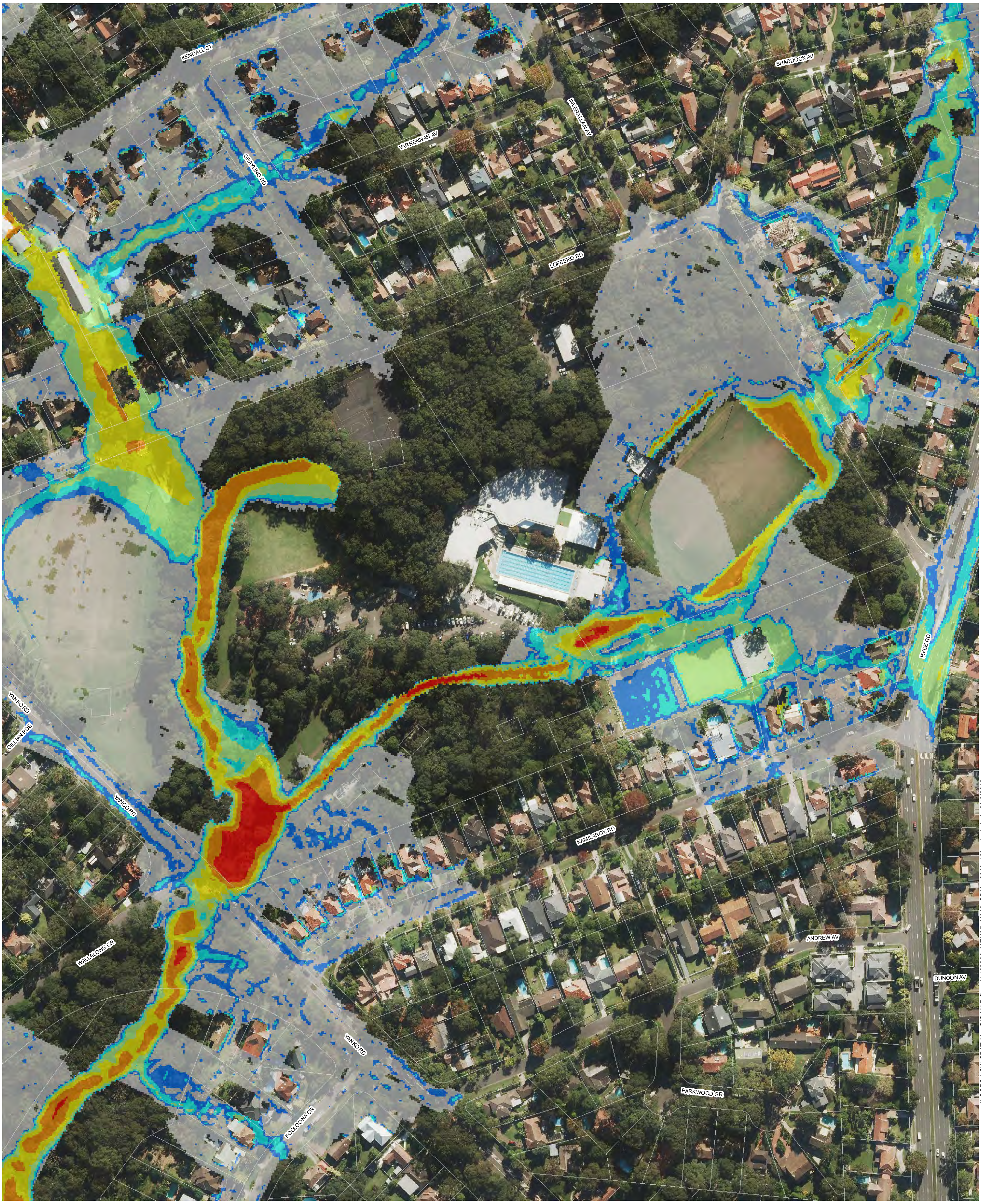
Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 9 | 2% AEP Flood Depth - Concept Design May 2018

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_MEM05_M010_CDMay2018_100y_d_r1v1 | 2/10/2018

Legend

0 50 100m
1:2,500 @ A3

N

Peak flood depth (m)

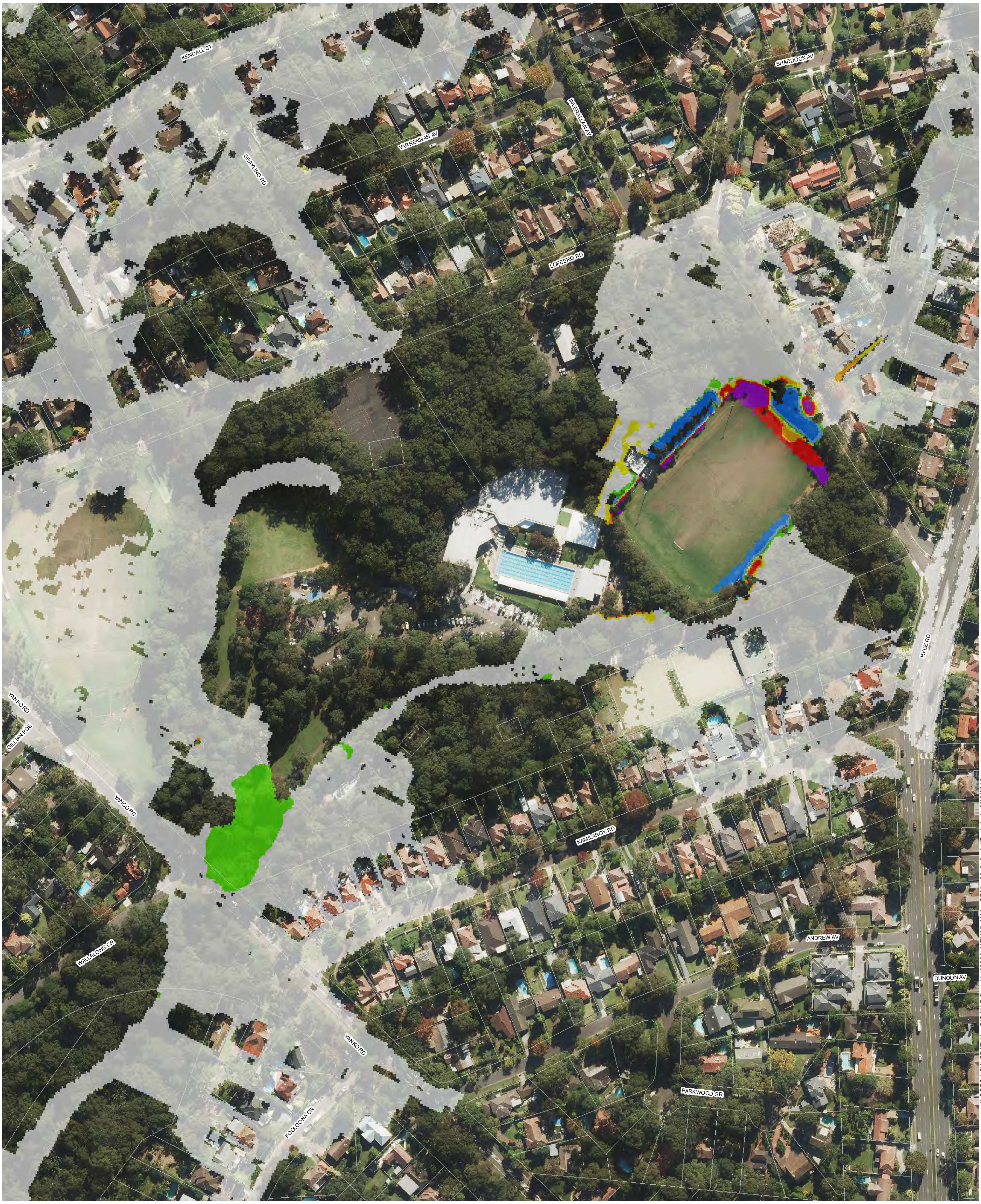
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

Data sources

Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 10 | 1% AEP Flood Depth - Concept Design May 2018

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_MEM05_M011_CDMay2018_5y_hdiff_r1v1 | 2/10/2018

0 50 100m
1:2,500 @ A3

N

Legend

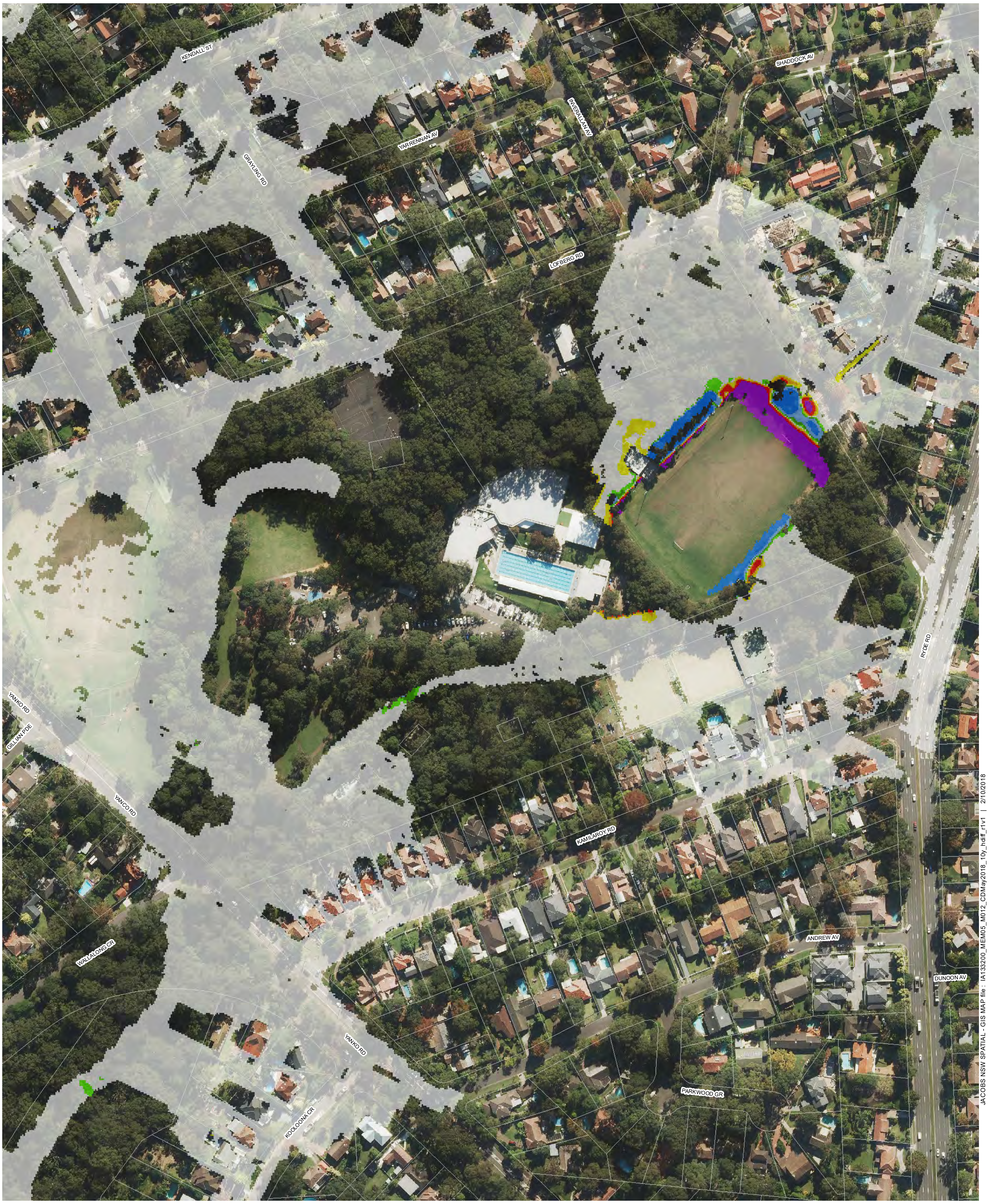
Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 11 | 0.2 EY Change in Flood Level - Concept Design May 2018

JACOBS



Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25

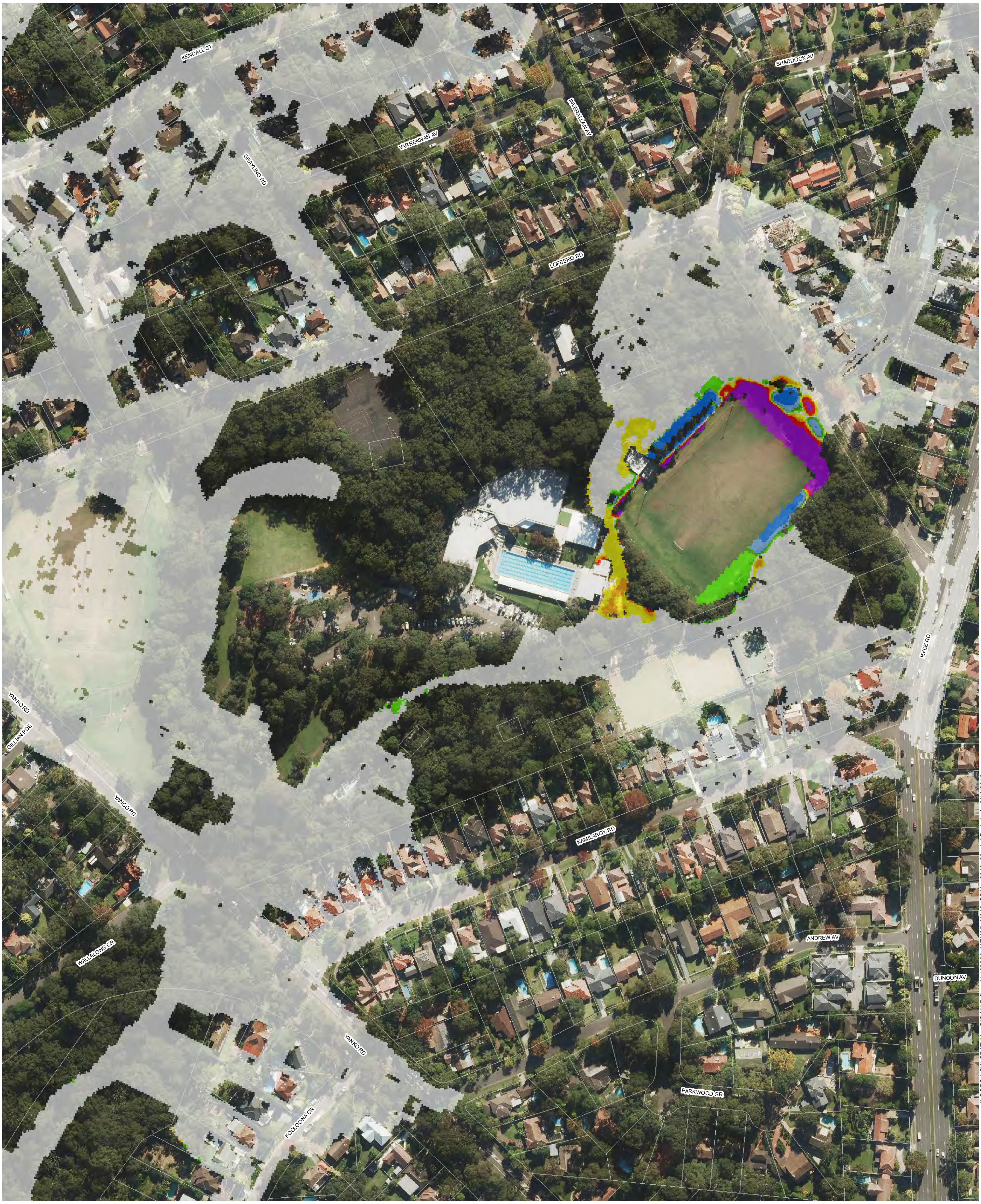
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 12 | 10% AEP Change in Flood Level - Concept Design May 2018

JACOBS



Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25

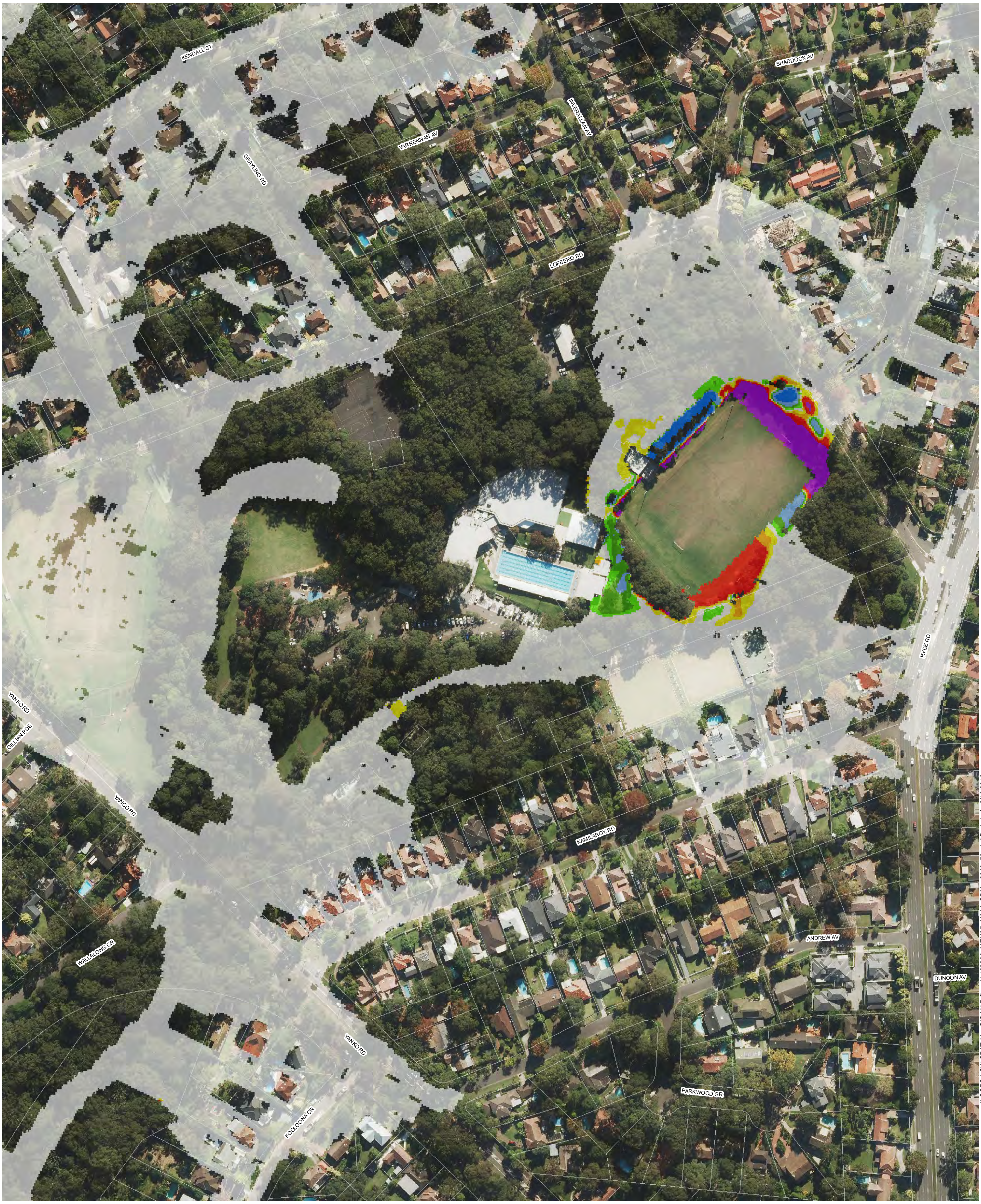
0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 13 | 5% AEP Change in Flood Level - Concept Design May 2018

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_MEM05_M014_CDMay2018_50y_hdiff_r1v1 | 2/10/2018

0 50 100m
1:2,500 @ A3

N

Legend

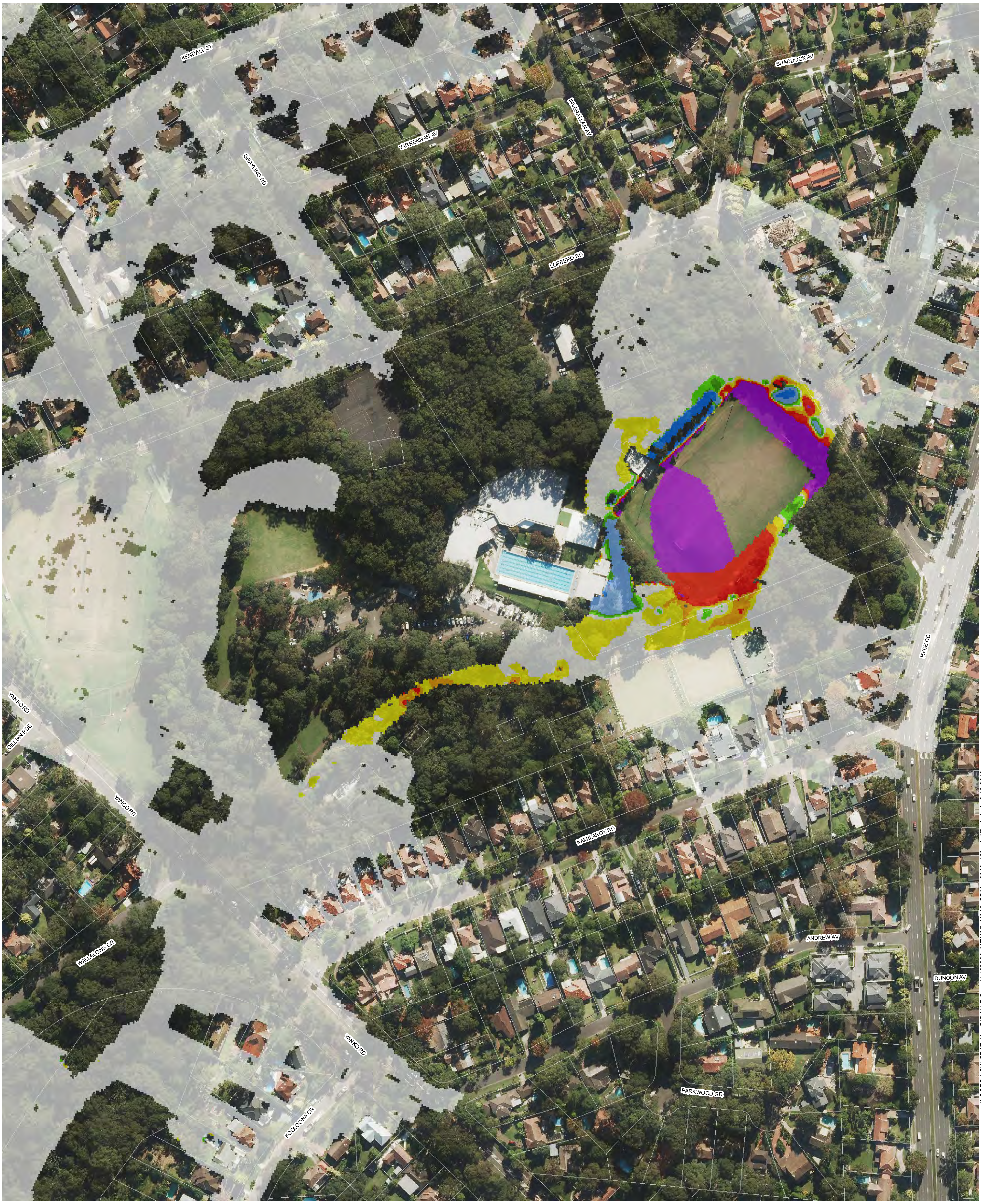
Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 14 | 2% AEP Change in Flood Level - Concept Design May 2018

JACOBS



JACOBS NSW SPATIAL - GIS MAP file : IA133200_MEM05_M015_CDMay2018_100y_hdiff_r1v1 | 2/10/2018

Legend

Change in Flood Level (m)

- < -0.25
- -0.25 - -0.11
- -0.1 - -0.06
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.06 - 0.11
- 0.11 - 0.25
- > 0.25

0 50 100m
1:2,500 @ A3

N

Data sources
Jacobs 2017
Ausimage 2016
Ku-ring-gai Council 2016
LPI 2013

Map 15 | 1% AEP Change in Flood Level - Concept Design May 2018

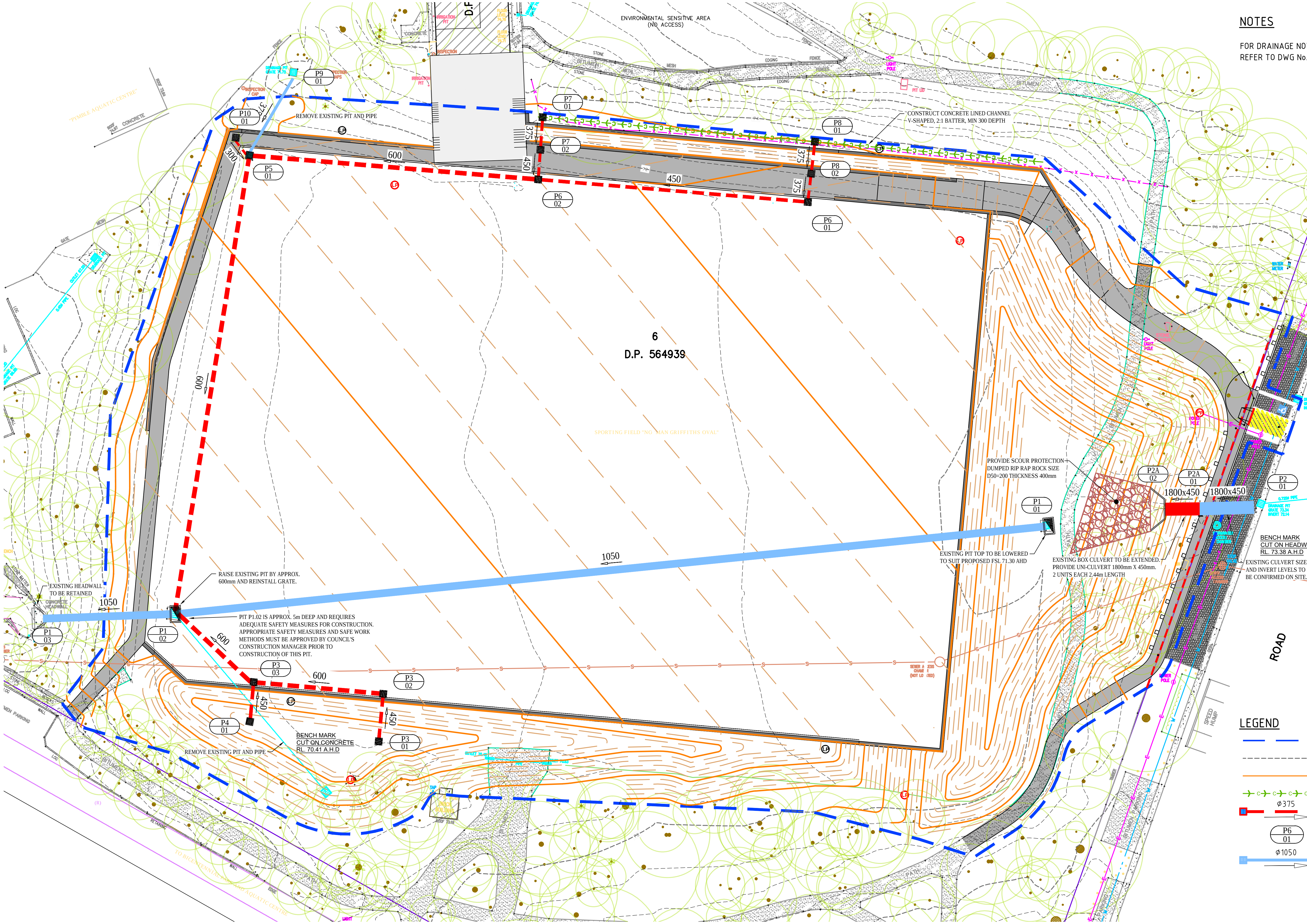
JACOBS

Appendix C – Tables of flow results

Table B.1 - Summary of flows for Existing and Updated Concept Design Cases

		Existing			Updated Concept Design Includes Proposed Design Modifications		
	Location	Overland	Pipe	Total	Overland	Pipe	Total
20% AEP (5yr)							
1	Lofberg Road	0.7	3.0	3.7	0.7	3.0	3.7
2	Between Lofberg Rd and Oval	0.6	3.1	3.7	0.6	3.1	3.7
3	on Oval (incl. side swales)	1.0	3.0	4.0	0.1	3.1	3.2
4	Overflow from basin	0.0	4.1	4.1	0.0	3.8	3.8
5	Discharge to Quarry Creek	4.9	0.0	4.9	4.6	0.0	4.6
6	Quarry Creek	5.7	0.0	5.7	5.6	0.0	5.6
7	Upstream of Yanko Road	13.6	0.0	13.6	13.2	0.0	13.2
10% AEP (10yr)							
1	Lofberg Road	0.9	3.4	4.3	1.0	3.5	4.5
2	Between Lofberg Rd and Oval	0.8	3.4	4.2	0.8	3.5	4.3
3	on Oval (incl. side swales)	1.6	3.1	4.7	0.1	3.3	3.4
4	Overflow from basin	0.0	4.3	4.3	0.0	4.1	4.1
5	Discharge to Quarry Creek	5.2	0.0	5.2	5.0	0.0	5.0
6	Quarry Creek	6.3	0.0	6.3	6.3	0.0	6.3
7	Upstream of Yanko Road	16.6	0.0	16.6	16.4	0.0	16.4
5% AEP (20yr)							
1	Lofberg Road	1.8	3.4	5.2	1.7	3.5	5.2
2	Between Lofberg Rd and Oval	1.7	3.4	5.1	1.6	3.5	5.1
3	on Oval (incl. side swales)	2.7	3.1	5.8	1.3	3.4	4.7
4	Overflow from basin	0.1	4.4	4.5	0.1	4.3	4.4
5	Discharge to Quarry Creek	5.4	0.0	5.4	5.3	0.0	5.3
6	Quarry Creek	7.2	0.0	7.2	7.2	0.0	7.2
7	Upstream of Yanko Road	20.2	0.0	20.2	20.2	0.0	20.2
2% AEP (50yr)							
1	Lofberg Road	2.6	3.4	6.0	2.6	3.5	6.1
2	Between Lofberg Rd and Oval	2.6	3.4	6.0	2.6	3.5	6.1
3	on Oval (incl. side swales)	3.6	3.1	6.7	2.2	3.3	5.5
4	Overflow from basin	0.7	4.4	5.1	0.9	4.4	5.3
5	Discharge to Quarry Creek	5.7	0.0	5.7	5.5	0.0	5.5
6	Quarry Creek	7.7	0.0	7.7	7.7	0.0	7.7
7	Upstream of Yanko Road	22.8	0.0	22.8	22.7	0.0	22.7
1% AEP (100yr)							
1	Lofberg Road	3.5	3.4	6.9	3.6	3.5	7.1
2	Between Lofberg Rd and Oval	3.5	3.4	6.9	3.6	3.5	7.1
3	on Oval (incl. side swales)	4.8	3.1	7.9	3.5	3.3	6.8
4	Overflow from basin	1.8	4.5	6.3	2.8	4.5	7.3
5	Discharge to Quarry Creek	6.7	0.0	6.7	7.4	0.0	7.4
6	Quarry Creek	9.9	0.0	9.9	10.2	0.0	10.2
7	Upstream of Yanko Road	27.1	0.0	27.1	26.8	0.0	26.8

Appendix D – Drainage Design Plans



NOTES

FOR DRAINAGE NOTES, DETAILS AND PIT SCHEDULE REFER TO DWG No.002.

LEGEND

- EXTENT OF WORKS
- EXISTING CONTOUR
- DESIGN CONTOUR
- CONCRETE LINED CHANNEL
- Φ375 DRAINAGE PIPE/PIT/SIZE
- P6 01 DRAINAGE PIT NUMBER
- Φ1050 EXISTING DRAINAGE PIPE

REV	DATE	AMENDMENTS	INITIALS

DATE: ########## DRAWN BY: ----

APPROVAL BY: Director of Operations

APPROVAL BY: Director of Strategy & Environment

SCALE: 1:250 @ A1

KU-RING-GAI COUNCIL

Mail: Locked bag 1056, Pymble NSW 2073
Street: 818 Pacific Hwy, Gordon NSW 2072
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PROJECT: NORMAN GRIFFITHS OVAL FIELD UPGRADE

PRELIMINARY ONLY - NOT FOR CONSTRUCTION

SHEET: STORMWATER DESIGN PLAN

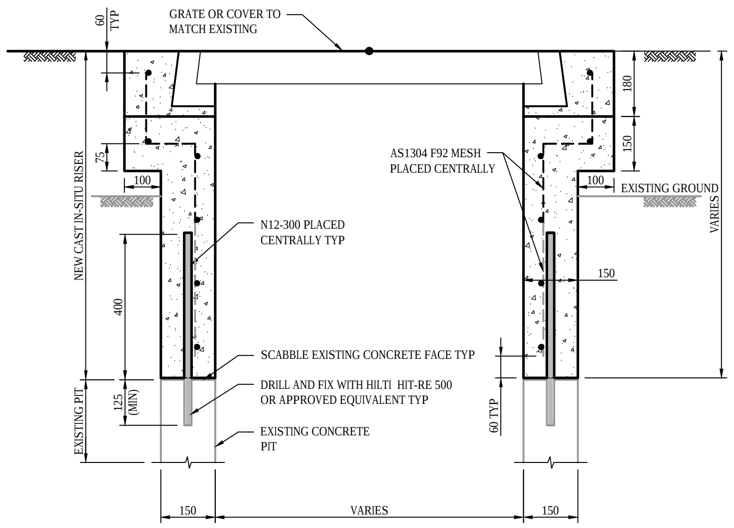
LMU NO.: ## | PLAN NO.: 001 | SHEET: 1 | OF: ### | REV: #

PIT SCHEDULE

STRUCTURE NO	STRUCTURE TYPE	STRUCTURE RL	EASTING	NORTHING	DRAWING REFERENCE	STRUCTURE DEPTH M
P1-01	EXISTING PIT TO BE MODIFIED	71.3000	327371.2990	6262613.2110	LOWER PIT SURFACE BY APPROX 1000MM TO FSL 71.30 AND REINSTALL RAISED CLASS D STEEL GRATE IN ACCORDANCE WITH RMS STANDARD DWG R0220-36	1.3000
P1-02	EXISTING PIT TO BE MODIFIED	71.1110	327302.5900	6262509.6100	RAISE EXISTING PIT WALLS BY 600MM TO FSL 71.11 AND INSTALL CLASS D STEEL GRATE	5.1700
P1-03	EXISTING HEADWALL TO REMAIN	66.7260	327291.2050	6262494.6710	EXISTING HEADWALL TO REMAIN	1.0500
P2A-01	PTP	73.5810	327382.9240	6262631.2610	EXTEND EXISTING CULVERT WITH A BUTT JOINT TO NEW CULVERT	0.4500
P2A-02	HW	72.4820	327379.8750	6262627.4780	PRECAST HEADWALL TO SUIT 1800X450 UNI-CULVERT-CONTACT MANUFACTURES FOR DETAILS	0.4500
P3-01	IS	69.8000	327334.7840	6262520.4680	R0220 - 36	0.8500
P3-02	GRATED PIT	71.2640	327329.9840	6262525.2220	PRECAST PIT (900X900) WITH CLASS D STEEL GRATE	2.3800
P3-03	GRATED PIT	71.1340	327317.0810	6262512.0760	PRECAST PIT (900X900) WITH CLASS D STEEL GRATE	2.4800
P4-01	IS	69.8000	327321.0500	6262508.1210	R0220 - 36	0.9500
P5-01	GRATED PIT	71.6000	327258.9600	6262558.8830	PRECAST PIT (900X900) WITH CLASS D STEEL GRATE	2.4000
P6-01	GRATED PIT	72.1430	327314.1760	6262615.8740	PRECAST PIT (900X900) WITH CLASS D STEEL GRATE	1.1600
P6-02	GRATED PIT	71.9000	327287.5180	6262588.3490	PRECAST PIT (900X900) WITH CLASS D STEEL GRATE	1.3200
P7-01	IS	72.5940	327281.0970	6262594.4150	R0220 - 36	1.1900
P7-02	GRATED PIT	71.9000	327284.4650	6262591.2590	PRECAST PIT (900X900) WITH CLASS D STEEL GRATE	0.9600
P8-01	IS	73.0990	327308.1970	6262622.0630	R0220 - 36	1.5000
P8-02	GRATED PIT	72.0550	327311.3620	6262618.7880	PRECAST PIT (900X900) WITH CLASS D STEEL GRATE	1.0200
P9-01	EXISTING PIT TO REMAIN	72.1170	327254.3030	6262570.9530	-	2.2600
P10-01	GRATED PIT	71.5500	327255.8110	6262558.9690	PRECAST PIT (900X900) WITH CLASS D STEEL GRATE	0.7700

NOTES

1. EASTING AND NORTHING CO-ORDINATES REFER TO SETOUT POINT.
2. SETOUT POINT FOR STANDARD RMS PITS TO BE AS PER RMS REFERENCE DRAWINGS.
3. SETOUT FOR ANY OTHER PIT IS PIT CENTRE.
4. SETOUT POINT FOR EXISTING PITS WHERE SHOWN REFER TO PIT CENTRE, AND IS APPROXIMATE ONLY.



MODIFICATION DETAILS FOR PIT P1-02

SCALE 1:20

DRAINAGE NOTES

GENERAL

1. DURING CONSTRUCTION, THE CONTRACTOR SHALL ENSURE THAT ALL DRAINAGE STRUCTURES SUCH AS PIPES AND PITS ARE PROTECTED AGAINST EXCESSIVE CONSTRUCTION LOADING.
2. THE CONTRACTOR IS RESPONSIBLE FOR EROSION AND SEDIMENTATION CONTROL MEASURES.
3. THE DRAINAGE DRAWINGS INCLUDE DETAILS OF THE PERMANENT STORMWATER DRAINAGE SYSTEM ONLY, UNLESS NOTED OTHERWISE. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ANY TEMPORARY STORMWATER DRAINAGE WORKS.
4. WHERE CONNECTION IS TO BE MADE TO AN EXISTING DRAINAGE STRUCTURE OR OPEN DRAIN THE POSITION AND LEVEL OF THE EXISTING DRAINAGE STRUCTURE SHALL BE CONFIRMED PRIOR TO CONSTRUCTION.
5. EXISTING STORMWATER PIPES OR CULVERTS THAT ARE IDENTIFIED TO BE DECOMMISSIONED OR ABANDONED SHALL BE REFERRED TO SUPERINTENDANT FOR ASSESSMENT OF THE APPROPRIATE TREATMENT WHICH INCLUDES:
   i) REMOVE AND BACKFILL - EXISTING PIPES / PITS TO BE REMOVED WITH TRENCH BACKFILLED AND COMPACTED IN ACCORDANCE WITH RMS STANDARD SPECIFICATIONS.
   ii) SEAL AND GROUT - PIPE ENDS TO BE CAPPED AND PIPES INFILLED WITH GROUT.
   iii) SEAL ONLY - PIPE ENDS TO BE CAPPED AND PIPES MAY REMAIN IN-SITU.
6. ANY MODIFICATION TO THE DRAINAGE DESIGN THAT MAY IMPACT ON THE PIT TYPE, LOCATION AND LEVEL, AND ANY MODIFICATION TO PIPE TYPE, SIZE, LEVEL, GRADING, AND INSTALLATION CONDITIONS MUST BE GIVEN TO THE PRINCIPAL REPRESENTATIVE FOR CONSIDERATION AND APPROVAL PRIOR TO ANY ALTERATION BEING CARRIED OUT IN THE FIELD

DRAINAGE PIPES

1. ALL DRAINAGE PIPES SHALL BE REINFORCED CONCRETE PIPES (RCP) OR FIBRE REINFORCED PIPE (FRCP). PIPE CLASS ARE SHOWN IN DRAINAGE LONG SECTIONS.
2. USE OF HUMES 'UNITCULVERT' MODULES OR SIMILAR FROM OTHER MANUFACTURERS/SUPPLIERS FOR BOX CULVERTS IS ACCEPTABLE.
3. PIPE LENGTHS SHOWN ARE CALCULATED BETWEEN SETOUT POINTS OF STRUCTURES (WITH NO ALLOWANCE FOR PIT).
4. PRECAST REINFORCED CONCRETE PIPES ARE TO BE MANUFACTURED IN ACCORDANCE WITH AUSTRALIAN STANDARD 4058. FIBRE REINFORCED CONCRETE (FRC) PIPES ARE TO BE MANUFACTURED IN ACCORDANCE WITH AUSTRALIAN STANDARD 4139.

DRAINAGE PITS

1. EQUIVALENT PRECAST HEADWALLS / PITS MAY BE USED WHICH SATISFY RMS SPECIFICATIONS.
2. PROVIDE STEP IRONS TO PITS DEEPER THAN 600mm.
3. ALL PIT GRATES AND COVER SHALL BE HEAVY DUTY CLASS D TO AS3996-2006.

DRAINAGE INSTALLATION

1. DRAINAGE PIPES AND CULVERTS SHALL BE INSTALLED TO TYPE HS3 SUPPORT AS PER AUSTRALIAN STANDARD AS3725 AND RMS SPECIFICATION D&C R11. COMPACTION TO THE BACKFILL SHALL BE IDENTIFIED, VALIDATED AND APPROVED BY A QUALIFIED GEOTECHNICAL ENGINEER.
2. DRAINAGE TRENCH SIZE AND DEPTHS OF MATERIAL ZONES SHALL CONFORM TO RMS STANDARD DRAWING R0240-01.
3. THE BED, HAUNCH, SIDE AND OVERLAY SELECTED FILL MATERIAL ZONES ARE TO BE IN ACCORDANCE WITH SPECIFICATION R11
4. PROVIDE 100 DIAMETER SUBSOIL DRAINAGE PIPE 3000 LONG WRAPPED IN FABRICK SOCK ADJACENT TO THE INLET PIPES.
5. FOUNDATION MATERIAL AND CONDITION BENEATH DRAINAGE PITS, PIPES, HEADWALLS AND CULVERTS MUST BE INSPECTED AND APPROVED BY A QUALIFIED GEOTECHNICAL ENGINEER BASED ON RELEVANT GEOTECHNICAL TESTS. UNSUITABLE MATERIALS SHALL BE REMOVED AND REPLACED BY SUITABLE MATERIAL CONFORMING TO RMS SPECIFICATION D&C R11.

CHANNEL

1. FOR CHANNEL SETOUT DETAILS REFER TO THE RELEVANT ELECTRONIC MODEL. THE LOCATIONS ARE INDICATIVE AND THE ACTUAL ALIGNMENT AND LOCATION IS TO BE DETERMINED ON SITE TO SUIT PURPOSE.
2. FOR CONCRETE LINED CHANNEL THE CONCRETE SHALL BE 150mm THICK UNREINFORCED 20MPa (UNO). PROVIDE CONTRACTION JOINTS AT 4m INTERVALS.

SERVICES

1. THE LOCATION OF ALL SERVICES/UTILITIES SHALL BE CONFIRMED PRIOR TO CONSTRUCTION AND CHECKED FOR CONFLICT WITH THE STORMWATER DRAINAGE SYSTEM.
2. ALL NECESSARY MEASURES SHALL BE PROVIDED TO PROTECT PUBLIC UTILITY SERVICES DURING THE COURSE OF THE WORK.

SUPPLEMENTARY RMS DRAWINGS

- R0240-01- TYPE HS3 CONDITIONS.
- R0220-45- INDIVIDUAL RUNG LADDER (STEP IRONS) FOR DRAINAGE.
- R0220-36-INLET SUMP WITH RAISED STEEL GRATE.

REV	DATE	AMENDMENTS	INITIALS

DATE: ########## DRAWN BY: ----

APPROVAL BY: Director of Operations

APPROVAL BY: Director of Strategy & Environment

SCALE: NTS @ A1

Ku-ring-gai Council

KU-RING-GAI COUNCIL

Mail: Locked bag 1056, Pymble NSW 2073
Street: 818 Pacific Hwy, Gordon NSW 2072
Contact: T: 02 9424 0000 W: www.kmc.nsw.gov.au

PROJECT: NORMAN GRIFFITHS OVAL FIELD UPGRADE

PRELIMINARY ONLY - **NOT FOR CONSTRUCTION**

SHEET: **STORMWATER** DRAINAGE DETAILS, NOTES & SCHEDULE

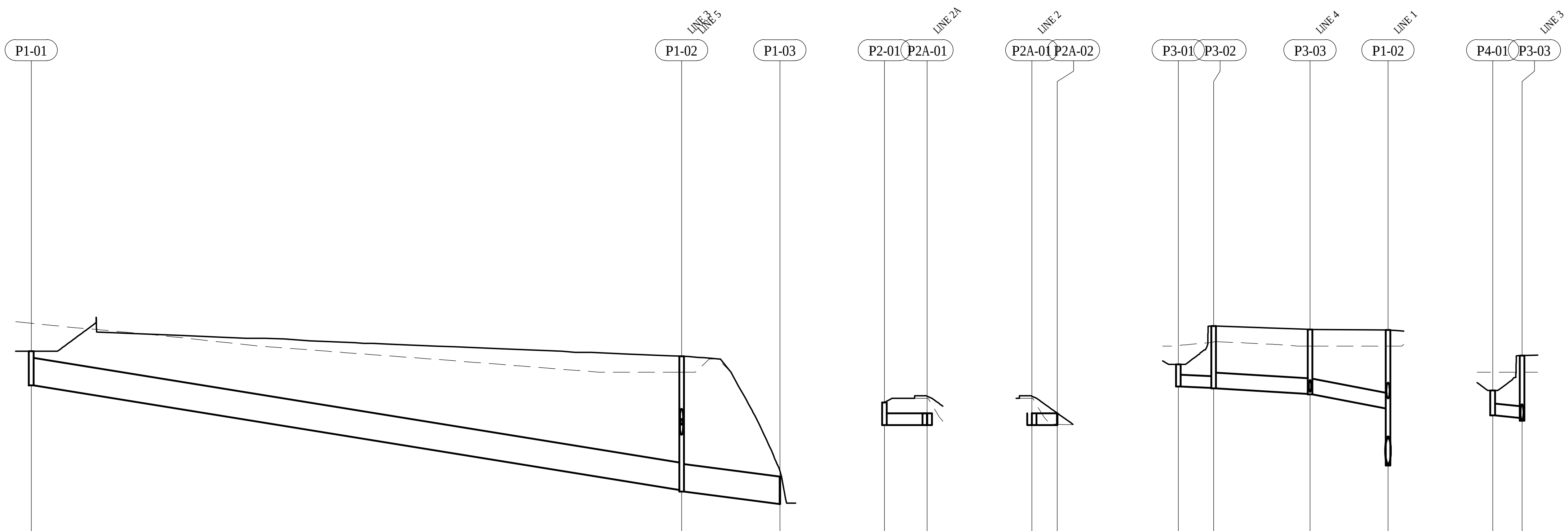
LMU NO.:	PLAN NO.:	SHEET:	OF:	REV:
##	002		###	#

NOTES

1. FOR HGLS, FLOWS AND VELOCITIES IN LINES 1, 2, 2A, 3 & 4 REFER TO TUFLOW FLOOD MODEL.

LEGEND

- EXISTING SURFACE
- DESIGN SURFACE
- 100 YR ARI HGL LINE



LINE 1

	P1-01	P1-02	P1-03
PIPE DIAMETER (mm)	1050	1050	
PIPE CLASS	EXISTING	EXISTING	
PIPE VELOCITY (m/s)	0.000	1.240	
PIPE FLOW (m3/s)	0.000	4.220	
PIPE GRADE (%)	3.22	2.53	
DATUM R.L.	53.000		
HYDRAULIC GRADE LINE (100 YR ARI)	0.000	77.400 / 77.400	77.300 / 77.300
EXISTING SURFACE LEVELS	72.371	70.500	66.726
DESIGN SURFACE LEVELS	71.300	71.111	66.515
DEPTH TO INVERT	1.300	5.111 / 5.171	1.050 / 1.050
PIPE INVERT LEVELS	70.000	66.000 / 65.940	65.465 / 65.465
PIPE CHAINAGE	0.000	124.316	143.098

LINE 2

	P2-01	P2A-01
PIPE DIAMETER (mm)	1800x450	
PIPE CLASS	EXISTING	
PIPE VELOCITY (m/s)	0.000	
PIPE FLOW (m3/s)	0.000	
PIPE GRADE (%)	-0.01	
DATUM R.L.	57.000	
HYDRAULIC GRADE LINE (100 YR ARI)	0.000	0.000 / 0.000
EXISTING SURFACE LEVELS	73.340	73.500
DESIGN SURFACE LEVELS	73.340	72.933
DEPTH TO INVERT	0.857	0.450 / 0.451
PIPE INVERT LEVELS	72.483	72.483 / 72.482
PIPE CHAINAGE	0.000	8.164

LINE 2A

	P2A-01	P2A-02
PIPE DIAMETER (mm)	1800x450	
PIPE CLASS	RCBC	
PIPE VELOCITY (m/s)	0.000	
PIPE FLOW (m3/s)	0.000	
PIPE GRADE (%)	-0.01	
DATUM R.L.	57.000	
HYDRAULIC GRADE LINE (100 YR ARI)	0.000	0.000 / 0.000
EXISTING SURFACE LEVELS	73.500	72.513
DESIGN SURFACE LEVELS	72.933	72.932
DEPTH TO INVERT	0.451	0.450 / 0.450
PIPE INVERT LEVELS	72.482	72.482 / 72.482
PIPE CHAINAGE	0.000	4.859

LINE 3

	P3-01	P3-02	P3-03	P1-02
PIPE DIAMETER (mm)	450	600	600	
PIPE CLASS	3	2	2	
PIPE VELOCITY (m/s)	0.000	0.000	0.000	
PIPE FLOW (m3/s)	0.000	0.000	0.000	
PIPE GRADE (%)	0.74	1.14	3.60	
DATUM R.L.	52.000			
HYDRAULIC GRADE LINE (100 YR ARI)	0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 77.400
EXISTING SURFACE LEVELS	70.515	70.658	70.500	70.500
DESIGN SURFACE LEVELS	69.800	71.264	71.134	71.111
DEPTH TO INVERT	0.850	2.364 / 2.384	2.464 / 2.484	2.998 / 5.171
PIPE INVERT LEVELS	68.950	68.900 / 68.880	68.670 / 68.650	68.113 / 65.940
PIPE CHAINAGE	0.000	6.756	25.176	40.091

LINE 4

	P4-01	P3-03
PIPE DIAMETER (mm)	450	
PIPE CLASS	3	
PIPE VELOCITY (m/s)	0.000	
PIPE FLOW (m3/s)	0.000	
PIPE GRADE (%)	1.78	
DATUM R.L.	53.000	
HYDRAULIC GRADE LINE (100 YR ARI)	77.300 / 0.000	0.000 / 0.000
EXISTING SURFACE LEVELS	70.500	70.500
DESIGN SURFACE LEVELS	69.800	71.134
DEPTH TO INVERT	0.950	2.384 / 2.484
PIPE INVERT LEVELS	68.850	68.750 / 68.650
PIPE CHAINAGE	0.000	5.604

REV	DATE	AMENDMENTS	INITIALS

DATE: ##########
DRAWN BY: ----
APPROVAL BY: Director of Operations
APPROVAL BY: Director of Strategy & Environment
SCALE: 1:250 @ A1

KU-RING-GAI COUNCIL

Mail: Locked bag 1056, Pymble NSW 2073
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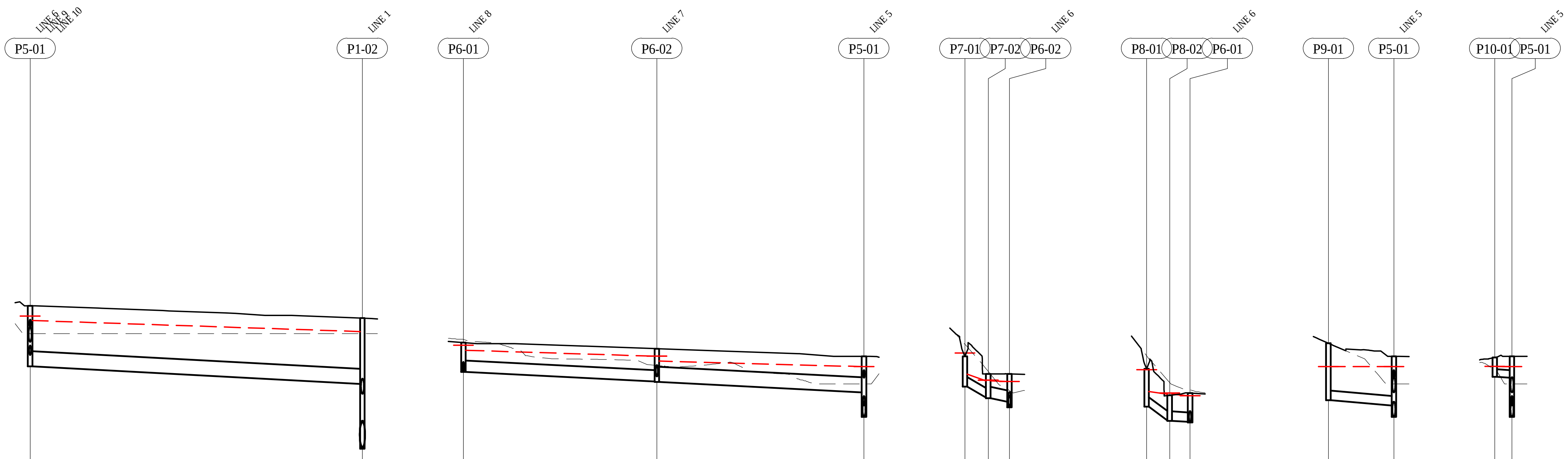
PROJECT:
NORMAN GRIFFITHS OVAL FIELD UPGRADE

PRELIMINARY ONLY - **NOT FOR CONSTRUCTION**

SHEET:
STORMWATER
DRAINAGE LONGITUDINAL SECTIONS

LMU NO.:	PLAN NO.:	SHEET:	OF:	REV:
##	003	3	###	#



LINE 5

	P5-01		P1-02
PIPE DIAMETER (mm)		600	
PIPE CLASS		2	
PIPE VELOCITY (m/s)		1.640	
PIPE FLOW (m3/s)		0.462	
PIPE GRADE (%)		1.06	
DATUM R.L.	52.000		
HYDRAULIC GRADE LINE (100 YR ARI)	71.190, 71.017		70.578, 77.400
EXISTING SURFACE LEVELS	70.500		70.500
DESIGN SURFACE LEVELS	71.600		71.111
DEPTH TO INVERT	2.400		2.611, 5.171
PIPE INVERT LEVELS	69.200		68.500, 65.940
PIPE CHAINAGE	0.000		65.822

LINE 6

	P6-01		P6-02		P5-01
PIPE DIAMETER (mm)		450		600	
PIPE CLASS		2		2	
PIPE VELOCITY (m/s)		1.510		1.590	
PIPE FLOW (m3/s)		0.240		0.450	
PIPE GRADE (%)		0.99		1.00	
DATUM R.L.	54.000				
HYDRAULIC GRADE LINE (100 YR ARI)	72.038, 71.837		71.603, 71.603, 71.409		71.190, 71.190, 71.017
EXISTING SURFACE LEVELS	72.266		71.236		70.500
DESIGN SURFACE LEVELS	72.143		71.900		71.600
DEPTH TO INVERT	1.163		1.300, 1.320		1.430, 2.400
PIPE INVERT LEVELS	70.980		70.600, 70.580		70.170, 69.200
PIPE CHAINAGE	0.000		38.318		79.353

LINE 7

	P7-01		P7-02		P6-02
PIPE DIAMETER (mm)		375		450	
PIPE CLASS		3		2	
PIPE VELOCITY (m/s)		5.760		1.420	
PIPE FLOW (m3/s)		0.200		0.227	
PIPE GRADE (%)		9.34		3.32	
DATUM R.L.	55.000				
HYDRAULIC GRADE LINE (100 YR ARI)	72.726, 71.891		71.628, 71.649		71.628, 71.603, 71.603, 71.409
EXISTING SURFACE LEVELS	73.075		72.000		71.236
DESIGN SURFACE LEVELS	72.594		71.900		71.900
DEPTH TO INVERT	1.194		0.931, 0.961		1.101, 1.320
PIPE INVERT LEVELS	71.400		70.969, 70.939		70.799, 70.580
PIPE CHAINAGE	0.000		4.615		8.833

LINE 8

	P8-01		P8-02		P6-01
PIPE DIAMETER (mm)		375		375	
PIPE CLASS		3		2	
PIPE VELOCITY (m/s)		3.500		2.200	
PIPE FLOW (m3/s)		0.203		0.243	
PIPE GRADE (%)		11.86		0.99	
DATUM R.L.	56.000				
HYDRAULIC GRADE LINE (100 YR ARI)	73.070, 72.203		72.100, 72.142		72.100, 72.038, 72.038, 71.837
EXISTING SURFACE LEVELS	73.617		72.559		72.266
DESIGN SURFACE LEVELS	73.099		72.055		72.143
DEPTH TO INVERT	1.499		0.995, 1.015		1.143, 1.163
PIPE INVERT LEVELS	71.600		71.060, 71.040		71.000, 70.980
PIPE CHAINAGE	0.000		4.554		8.606

LINE 9

	P9-01		P5-01
PIPE DIAMETER (mm)		375	
PIPE CLASS		EXISTING	
PIPE VELOCITY (m/s)		0.030	
PIPE FLOW (m3/s)		0.004	
PIPE GRADE (%)		1.62	
DATUM R.L.	54.000		
HYDRAULIC GRADE LINE (100 YR ARI)	71.191, 71.191		71.190, 71.190, 71.017
EXISTING SURFACE LEVELS	72.117		70.500
DESIGN SURFACE LEVELS	72.117		71.600
DEPTH TO INVERT	2.257		1.950, 2.400
PIPE INVERT LEVELS	69.860		69.650, 69.200
PIPE CHAINAGE	0.000		12.967

LINE 10

	P10-01		P5-01
PIPE DIAMETER (mm)		300	
PIPE CLASS		2	
PIPE VELOCITY (m/s)		0.160	
PIPE FLOW (m3/s)		0.012	
PIPE GRADE (%)		1.03	
DATUM R.L.	54.000		
HYDRAULIC GRADE LINE (100 YR ARI)	71.196, 71.191		71.190, 71.190, 71.017
EXISTING SURFACE LEVELS	71.061		70.500
DESIGN SURFACE LEVELS	71.550		71.600
DEPTH TO INVERT	0.766		0.851, 2.400
PIPE INVERT LEVELS	70.784		70.749, 69.200
PIPE CHAINAGE	0.000		3.394

REV	DATE	AMENDMENTS	INITIALS

DATE: ##########
DRAWN BY: ----
APPROVAL BY: Director of Operations
APPROVAL BY: Director of Strategy & Environment
SCALE: 1:250 @ A1

KU-RING-GAI COUNCIL

Mail: Locked bag 1056, Pymble NSW 2073
Street: 818 Pacific Hwy, Gordon NSW 2072
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PROJECT:
NORMAN GRIFFITHS OVAL FIELD UPGRADE

PRELIMINARY ONLY - **NOT FOR CONSTRUCTION**

SHEET:
STORMWATER
DRAINAGE LONGITUDINAL SECTIONS

LMU NO.:	PLAN NO.:	SHEET:	OF:	REV:
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