Flood Impact Assessment

for

Newcastle Airport, Williamtown

for Newcastle Airport Pty Limited

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Contents

Acronyms

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ALS	Airborne Laser Survey (LiDAR)
AR&R 2019	Australian Rainfall and Runoff 2019
BoM	Bureau of Meteorology
DTM	Digital Elevation Model
GPU	Graphics Processing Unit
HPC	Heavy Parallelised Computation
LiDAR	Light Detection and Ranging (also see ALS)
m	Measure of length / height / distance (metres)
m AHD	Meters above Australian High Datum
m/s	Measure of velocity (metres per second)
m^3/s	Measure of flow rate (cubic metres per second)
OEH	Office of Environment and Heritage
RAFTS	Hydrologic modelling software
TUFLOW	A 1D and 2D hydraulic modelling software

Introduction

Northrop Consulting Engineers have been engaged by Newcastle Airport Pty Limited (NAPL) to prepare a Flood Impact Assessment for the proposed development of the existing Apron and Taxiway areas.

This flood impact assessment aims to review the impact the proposed modifications have on flood behaviour and develop measures to mitigate the potential impact within the vicinity of the proposed works and downstream areas, specifically this report only assesses the impacts and associated flood mitigation opportunities on the western and southern sides of the apron and downstream through the Domestic Airport Terminal precinct. We understand impacts to the north and east of the new apron works have been separately assessed by others.

This assessment has been prepared with the consideration of the following guidelines, reports and documents:

- Australian Rainfall and Runoff 2019 (AR&R 2019).
- Flood Risk Management Manual (NSW Government 2023).
- Williamtown/ Salt Ash Flood Study Review (BMT WBM 2012).
- Civil Drawings provided by NAPL.

This report has been prepared to support a Development Application for submission to Port Stephens Council.

Methodology

This flood impact assessment has been undertaken using the following procedure:

- Desktop review of all available information including design plans and latest survey data.
- Site visit to ground truth conditions of existing drainage network.
- Setup a two-dimensional TUFLOW hydraulic model to quantify flood behaviour in Base Case scenario (existing conditions + approved developments) and Developed Case for 1% AEP, 1% AEP Climate Change, 5% AEP and 10% AEP flood events.
- Comparison of the Base and Developed Case results to review the flood impact due to the proposed modifications.
- Develop flood mitigation measures to eliminate or minimise the flood impact.
- Comparison of the Base and Developed Case with flood mitigation measures to review the impact.

Proposed Development

The extent of the proposed development is presented in **Figure 1** below. The proposed works include partial re-grading of the existing apron surface and an increase of paved surface adjacent to the existing apron and taxiway.

The civil design surface including proposed open drains (swales) and below ground pipe is presented in **Figure 2** overleaf.

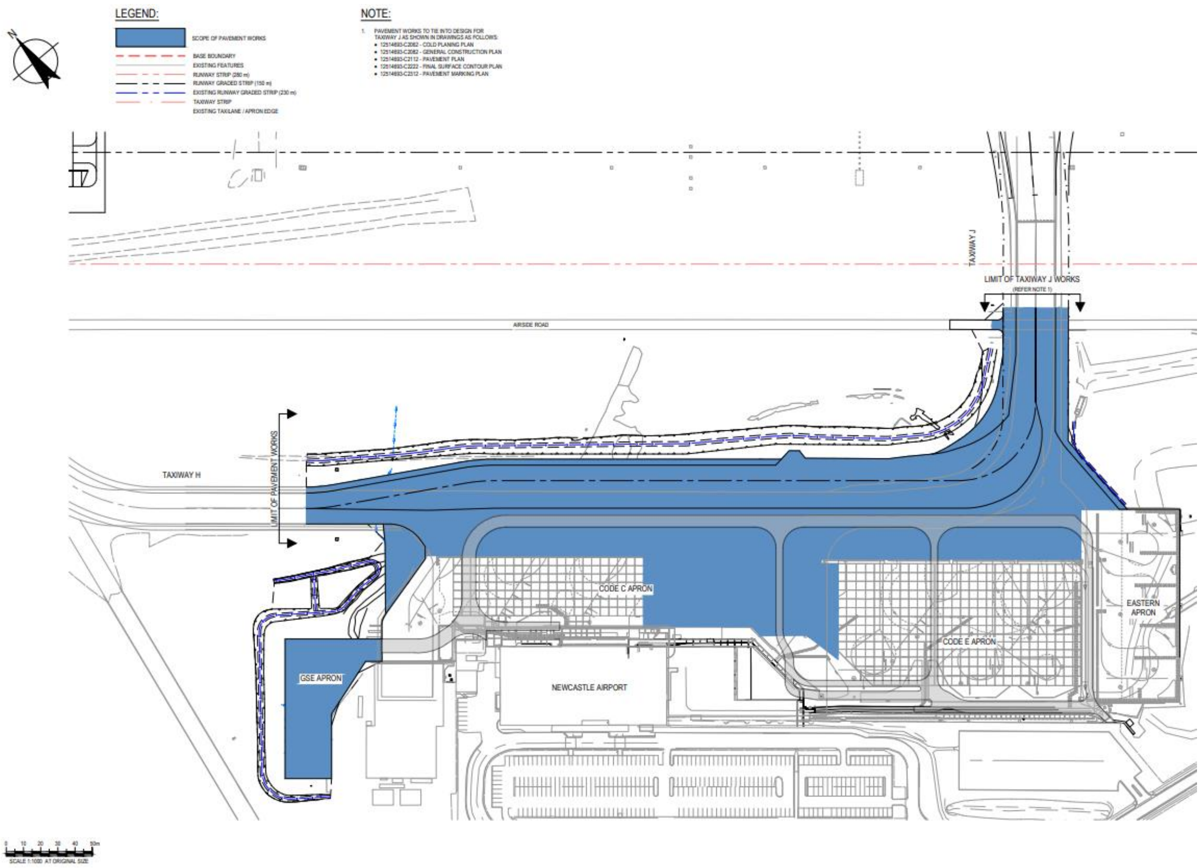
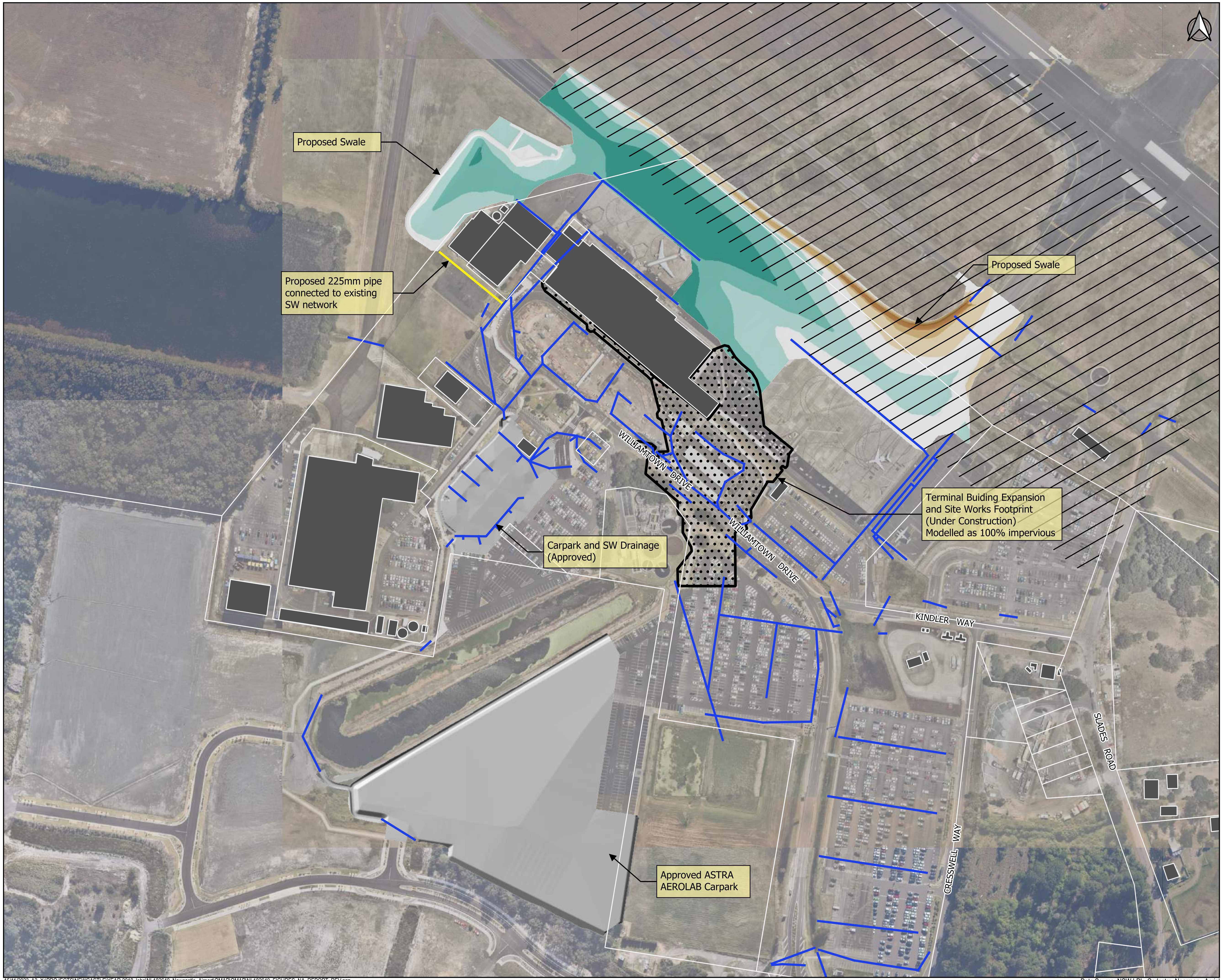


Figure 1 - Proposed Modifications Extent



Legend

- Cadastre
- Modelled Existing and Approved SW Network
- Impact assessed by others
- Proposed SW Pipes
- Proposed Terminal Expansion Boundary

Apron Design Surface(mAHD)

- <= 3.5
- 3.5 - 3.7
- 3.7 - 4.0
- 4.0 - 4.2
- 4.2 - 4.4
- 4.4 - 4.7
- > 4.7

0 50 100 Metres

1:3,000

Figure 2
Proposed Development

Newcastle Airport
Williamtown

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Data Source: NSW LPI - Cadastre, Nearmap - Aerial

Flood Model Setup

Modelling has been undertaken using RAFTS hydrological and two-dimensional TUFLOW hydraulic software packages. **Figure 3** below presents the setup of the hydrological and hydraulic models that have been prepared for Newcastle Airport and contributing upstream catchments.

Hydrology

The RAFTS Laurenson hydrological model, coupled with the Initial and Continuing Loss model has been used for this assessment. As per the AR&R 2019 guidelines, initial loss, continuing loss, storm pre-burst and design burst rainfall have been considered in this assessment. The input data for the RAFTS model used in this assessment includes sub-catchment data, design rainfall, catchment (hydrologic) roughness and the initial and continuing losses. These are summarised below.

The RAFTS model extends into the Tilligery State Conservation Area and Galloping Swamp and has been constructed using a series of links and nodes. A total of 12 sub-catchments were delineated using LiDAR terrain survey. The modelled sub-catchments are shown in the **Figure 3**, and the sub-catchments characteristics are outlined in the **Table 1** below.

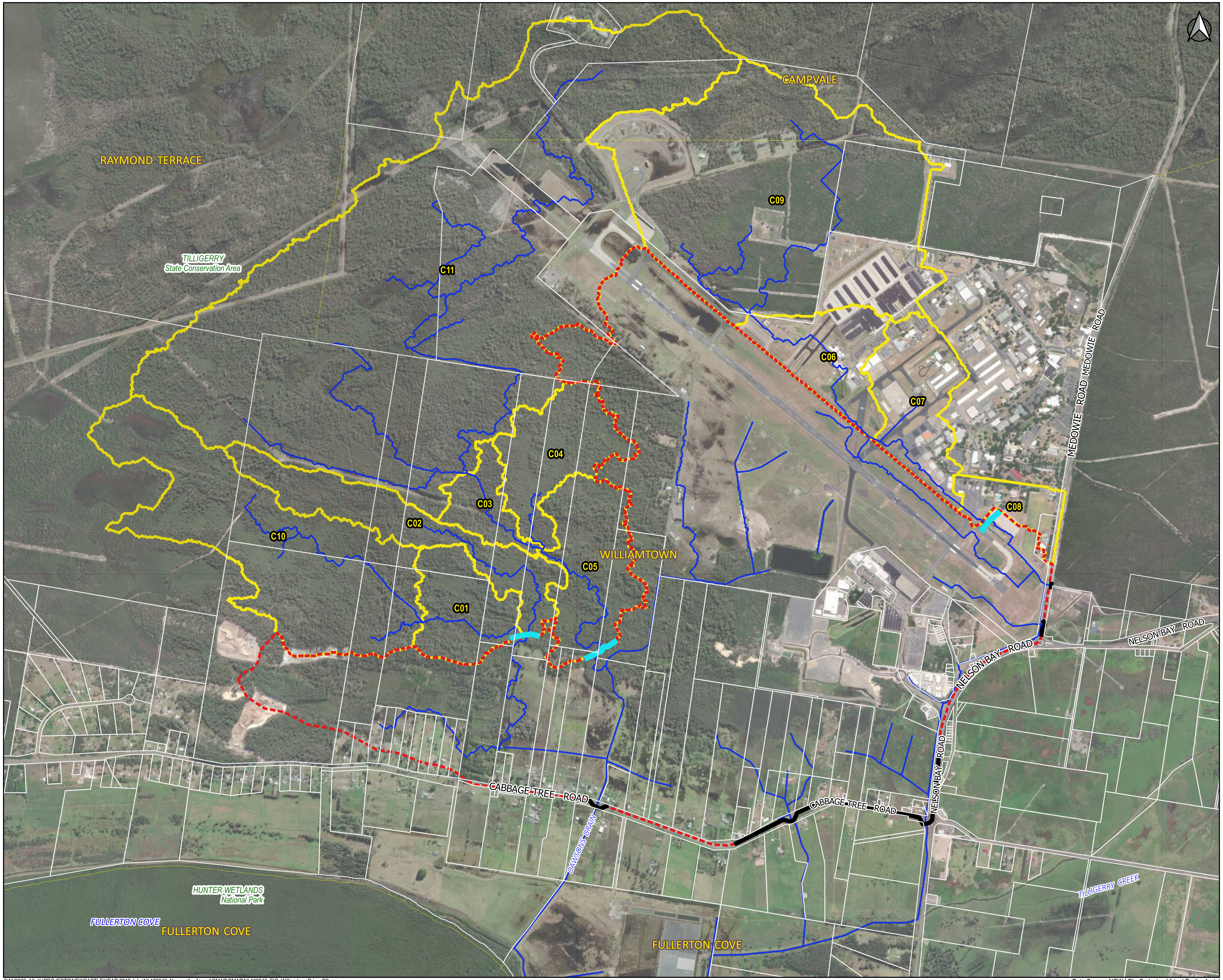
Table 1 – RAFTS Sub-Catchments

Catchment Reference	Area (ha)	Effective Impervious (%)	Slope (%)	Catchment Reference	Area (ha)	Effective Impervious (%)	Slope (%)
C01	691	10	1	**C07**	40	42	1
C02	452	0	2	**C08**	39	0	1
C03	205	10	2	**C09**	35	40	1
C04	120	0	2	**C10**	30	0	2
C05	46	0	1	**C11**	17	0	1
C06	45	0	1	**C12**	16	30	1

Burst and Pre-Burst Rainfall

The latest AR&R 2019 rainfall has been obtained from the Bureau of Meteorology while the accompanying rainfall temporal patterns have been obtained from the AR&R Data Hub for a location over the study area. AR&R 2019 recommends the use of the storm ensemble method using 10 temporal patterns for each storm duration. For this investigation, standard storm durations from 10 minutes to 48 hours were assessed in the hydrological model. Modelled burst rainfall input data are listed in Table G1 of **Appendix G**.

The latest NSW Specific Transformational Pre-Burst depths has also been used as part of the investigation. As recommended by the latest AR&R 2019 guidelines, the 60min pre-burst depths have been used for storm durations less than 60 minutes. Modelled pre-burst rainfall depths are outlined in Table G2 of **Appendix G**.



Legend

- Cadastre
- RAFTS sub-catchments
- Major Drainage
- 2D Model Extent
- U/S Inflow
- D/S Outflow

0 300 600 Metres

1:20,000

Figure 3

Model Setup

Newcastle Airport
Williamtown

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2/11/2023 A3 X:\PROJECTS\NEWCASTLE\YEAR 2018 Jobs\NL182640_Newcastle_Airport\QMAP\QMAP\NL182640_FIG_WilliamtownDrive_D2.qgz

Data Source: NSW LPI - Cadastre, Virtual Earth - Aerial

Infiltration Losses and Roughness

The Initial and Continuing Loss model has been used for this study, and the latest AR&R 2019 storm losses were obtained from the AR&R Data Hub for a location over the study area. The below **Table 2** presents the Initial and Continuing losses obtained from the ARR Data Hub and the corresponding modelled loss rates. The latest OEH guidelines recommend reducing the continuing loss values provided by the ARR Data Hub by a factor 0.4 for un-calibrated models within NSW. Modelled continuing losses have been reduced accordingly.

Table 2 – Infiltration Loss Rates

Land Use	Initial Loss (mm)	Continuous Loss (mm/hr)
ARR Data Hub Losses	13.0	2.7
Modelled Pervious Losses	13.0	1.1
Modelled Impervious Losses	1.5	0.0

The following catchment (hydrological) roughness values have been adopted in the modelling:

- Pervious – from 0.060 to 0.190 (grass, bushland, dense vegetation).
- Impervious – 0.015 (sealed roads, concrete surfaces).

Hydraulics

The two-dimensional model boundary is presented in the **Figure 3** with the model extending from the upstream reaches of Newcastle Airport to the culverts beneath Cabbage Tree Road, Nelson Bay Road and Medowie Road.

The Digital Terrain Model used for the two-dimensional model has been prepared using a combination of one-metre resolution LiDAR elevation data captured over the Williamtown area in 2013, detailed surveys of Newcastle Airport, the Astra Aerolab development and the general vicinity, and project design surfaces. Some additional minor surface modifications were also entered into the TUFLOW model manually to update the LiDAR elevation data to include observations made from aerial imagery and during site visits.

A model grid size of 1.5 metres x 1.5 metres was adopted for the two-dimensional model and run using the latest version of TUFLOW's (2020-10-AD) Heavily Parallelised Compute (HPC), Graphics Processing Unit (GPU) module.

The pit and pipe network has been included in the TUFLOW model with the below ground network for Newcastle Airport and the Cabbage Tree Road, Nelsons Bay Road and Medowie Road culvert crossings represented.

Upstream runoff, modelled in the RAFTS hydrologic model, enters the 2D hydraulic area in the three specified inflow locations (refer to **Figure 3**).

Direct Rainfall (rainfall-on-grid) model has been applied for the 2D model extent. The direct rainfall includes burst and pre-burst rainfall data.

Adopted Manning's hydraulic roughness are presented below in **Tables 3**.

Table 3 – TUFLOW Manning's n Roughness

Land Use	Manning's n
Low grass, cultivated land	0.045
Bushland, dense shrubs	0.100
Minor drainage channel	0.040
Sealed roads and concrete surface	0.014
High grass, swamps	0.065
Open water	0.025
Major drainage channel	0.030
Development Area (Astra Aero Lab Stage 1)	0.023

Downstream boundary conditions were sourced from the Williamtown/ Salt Ash Flood Study (BMT WBM 2012). Fixed water levels of 1.1mAHD, 0.9mAHD and 0.6mAHD were applied for 1%, 5% and 10% AEP flood events, respectively.

Buildings were incorporated into the model based on building footprints and were delineated using aerial imagery and site observations. All buildings within the model were "blocked out" (i.e., impermeable). Rainfall on buildings has been accounted for in the TUFLOW model by using boundary features to calculate the runoff from each building, allocating the calculated flow around the perimeter of each building. This method has ensured that all rain falling on the building roofs has been accounted for and represented as contributing to overland flow.

The following three scenarios have been considered in the TUFLOW modelling:

- Base Case scenario is a combination of existing conditions and approved Newcastle Airport developments. The approved carpark/pond filling was included in the model as a design surface with proposed pit and pipe network. The approved (currently under construction) Terminal Building Expansion and Site Works footprint was modelled as 100% impervious surface (refer to **Figure 2**).
- Developed Case scenario is a combination of the Base Case and the proposed apron modifications.
- Developed Case with Flood Mitigation Measures scenario includes the Developed Case plus proposed flood mitigation works.

Climate Change 2100 sensitivity was considered in this assessment. Rainfall depth increase of 20% was modelled for the 1% AEP for all cases.

Flood Behaviour

Critical Duration

To determine the critical storm duration the guidance provided in the latest AR&R 2019 guidelines was considered as summarised below:

- Classification of the median value of the ten temporal patterns for each storm duration.
- Selection of the duration that produces the maximum median value for each return interval.

A water elevation parameter was used in this investigation to define the highest median value.

All ten rainfall patterns from 10-minute to 48-hour standard storm durations were used to determine the critical storm duration for each of the 1%, 5% and 10% AEP flood events base case conditions.

The two-dimensional TUFLOW modelling indicates that typically the 20-minute, 1, 2, 3 and 6-hour durations were critical for 1% AEP while the 15, 20-minute, 1.5 and 6-hour durations were critical for the 5% AEP across the proposed development and general vicinity. The 15-minute, 1, 1.5 and 6-hour durations was determined to be critical for the 10% AEP.

The 1%. 5% and 10% AEP critical duration maps are presented in **Figure A1, A2** and **A3** of **Appendix A**, respectively.

Base Case

Modelled maximum envelope flood depth and elevation are presented in **Figure B1-B4** of **Appendix B** for the Base Case conditions for the 1%, 5%, 10% AEP and 1% AEP Climate Change flood events.

Developed Case and Impact

Modelled maximum envelope flood depth and elevation are presented in **Figure C1-C4** of **Appendix C** for the Developed Case for the 1%, 5%, 10% AEP and 1% AEP Climate Change flood events.

Flood elevation differences for the Developed versus Base Cases are presented in **Figures D1-D4** of **Appendix D** for the 1%, 5%, 10% AEP and 1% AEP Climate Change flood events.

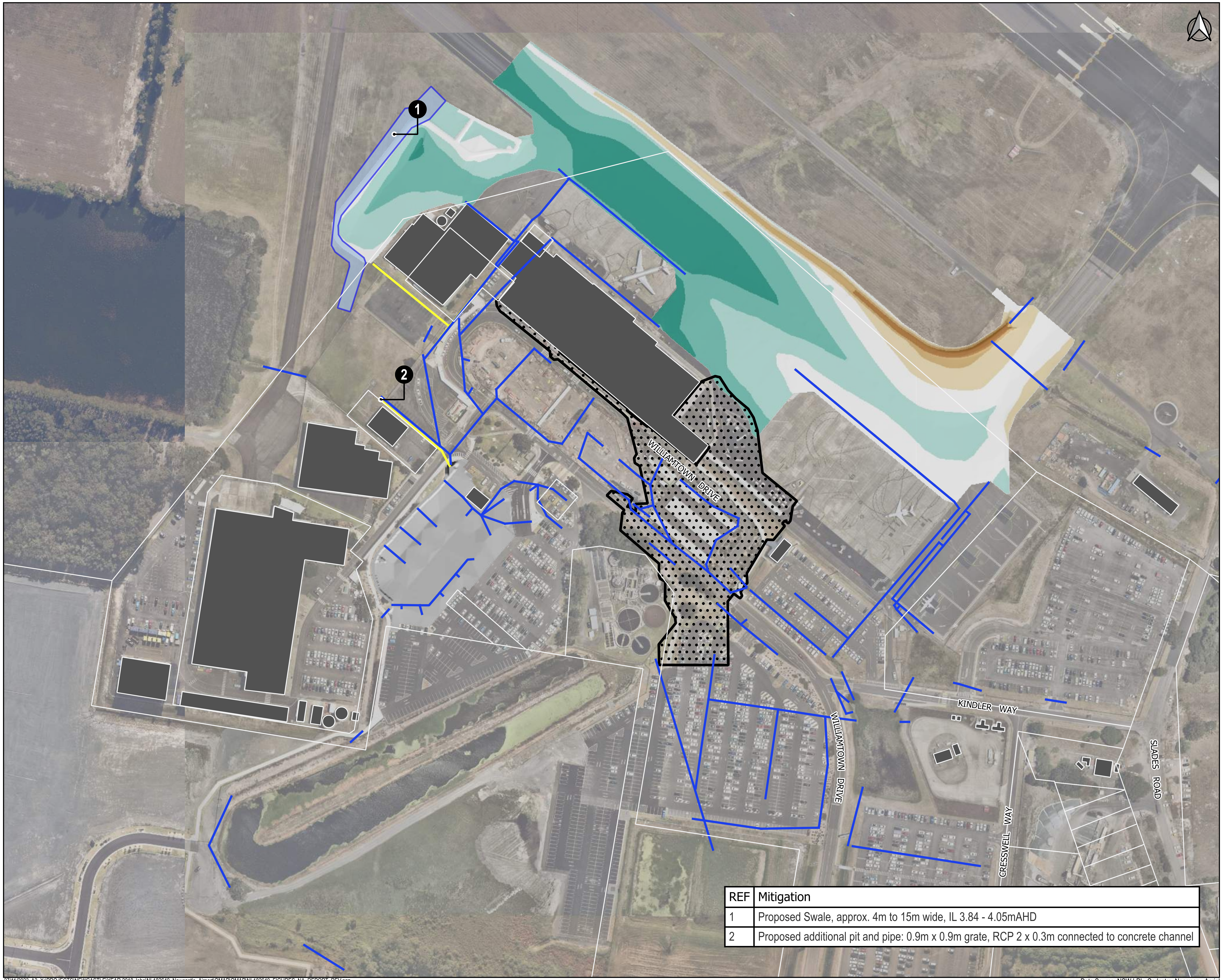
Pre-to-post development 1% AEP flood elevation comparison demonstrates an increase in flood elevation approximately up to 49 millimetres in the area adjacent to the western boundary of the proposed apron (refer to **Figure D1**). An increase approximately up to 26 millimetres is observed downstream of the western end of the proposed apron. Insignificant increases up to 13mm are also observed in the approved pond filling/carpark and along existing downstream channels.

Similarly, increases approximately up to 58mm, 63mm and 35mm are observed in the vicinity of the western end of the development for the 5%, 10%, and 1% AEP Climate Change, respectively.

These increases are expected to be typically due to a loss of flood storage as result of the apron development.

Flood Mitigation Measures

Proposed flood mitigation measures and locations are presented in **Figure 4** below and in **Appendix J (Civil Drawings)** and include the following set of works:



REF	Mitigation
1	Proposed Swale, approx. 4m to 15m wide, IL 3.84 - 4.05mAHD
2	Proposed additional pit and pipe: 0.9m x 0.9m grate, RCP 2 x 0.3m connected to concrete channel

Legend

- Cadastre
- Modelled Base Case SW Network
- Proposed SW Pipes
- Proposed Terminal Expansion Boundary
- Proposed Comp Cut

Apron Design Surface(mAHD)

- <= 3.5
- 3.5 - 3.7
- 3.7 - 4.0
- 4.0 - 4.2
- 4.2 - 4.4
- 4.4 - 4.7
- > 4.7
- Flood Mitigation Locations

0 40 80 Metres

1:2,500

Figure 4

Proposed Development Flood Mitigation Measures

Newcastle Airport
Williamtown

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27/11/2023 A3 X:\PROJECTS\NEWCASTLE\YEAR 2018 Jobs\NL182640_Newcastle_Airport\QMAP\QMAP\NL182640_FIGURES_NA_REPORT_REV.qgz

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

- Widening (approximately 8m to 15m wide) the proposed western swale and extending it approximately 16m upstream and downstream. This will increase flood storage capacity in the area adjacent to the western apron fill.
- Installing an additional pit (0.9m x 0.9m grated) and 2 x 0.3m pipes directly connected to the approved rectangular concrete channel. This will increase discharge from the flood storage zone adjacent to the western apron fill to the downstream channels and detention basin.

Developed Case with Flood Mitigation Measures and Impact

Modelled maximum envelope flood depth and elevation are presented in **Figure C1-M1B to C4-M1B** of **Appendix E** for the Developed Case with Flood Mitigation measures for the 1%, 5%, 10% AEP and 1% AEP Climate Change flood events.

Flood elevation differences for the Mitigated Developed versus Base Cases are presented in **Figures D1-M1B to D4-M1B** of **Appendix F** for the 1%, 5%, 10% AEP and 1% AEP Climate Change flood events.

A comparison of the Base Case and Developed Case with Flood Mitigation flood elevation indicates an insignificant localised increase approximately up to 15mm observed in the area adjacent to the apron western boundary during the 1% AEP flood event (refer to **Figure D1-M1B**). Same magnitude increases are observed in the downstream areas in the approved carpark and channels. This increase is not expected to create a significant adverse impact as it is low in magnitude and typically does not change flow velocity regime and flood hazard conditions in the area.

Similarly, during the 1% AEP Climate Change scenario, insignificant localised increases approximately up to 13mm are observed in the area adjacent to the apron western boundary and up to 25mm in the approved Astra Aero Lab carpark downstream of the existing evaporation ponds. This increase is minor in nature with flood velocity and hazard conditions also remain unchanged. As such, it is not expected to create a significant adverse impact.

During the 5% and 10% AEP, flood elevation decreases are typically observed in the vicinity of the apron western boundary and downstream areas.

Further analysis of the flood elevation differences also indicates increases in flood elevation in the existing detention basin upstream of Kinder Way for the 10% and 5% AEP modelled events. The increase is minor in magnitude with flood depths in the basin generally ranging from approximately 0.9m to 1.0m during the base case. The 10% AEP 48mm increase observed in the basin is equivalent to an increase of less than a 6% when compared to the base case flood depth in the basin. A freeboard of approximately 300mm is maintained with the downstream Kinder Way road surface. As such, this increase is not considered to create a significant adverse impact on the detention basin functionality.

Conclusion

A Flood Impact Assessment Report has been prepared for the proposed development at Newcastle Airport, Williamtown NSW.

Based on the assessment undertaken, Northrop's position is that the proposed modifications with implemented flood mitigations measures will not create any significant adverse impacts to flood behaviour in the vicinity of the proposed works and the downstream areas during modelled flood events.

Limitation Statement

Northrop Consulting Engineers Pty Ltd (Northrop) has been retained to prepare this report based on specific instructions, scope of work and purpose pursuant to a contract with its client. It has been prepared in accordance with the usual care and thoroughness of the consulting profession for the use by Newcastle Airport Pty Limited. The report is based on generally accepted practices and standards applicable to the scope of work at the time it was prepared. No other warranty, express or implied, is made as to the professional advice included in this report.

Except where expressly permitted in writing or required by law, no third party may use or rely on this report unless otherwise agreed in writing by Northrop.

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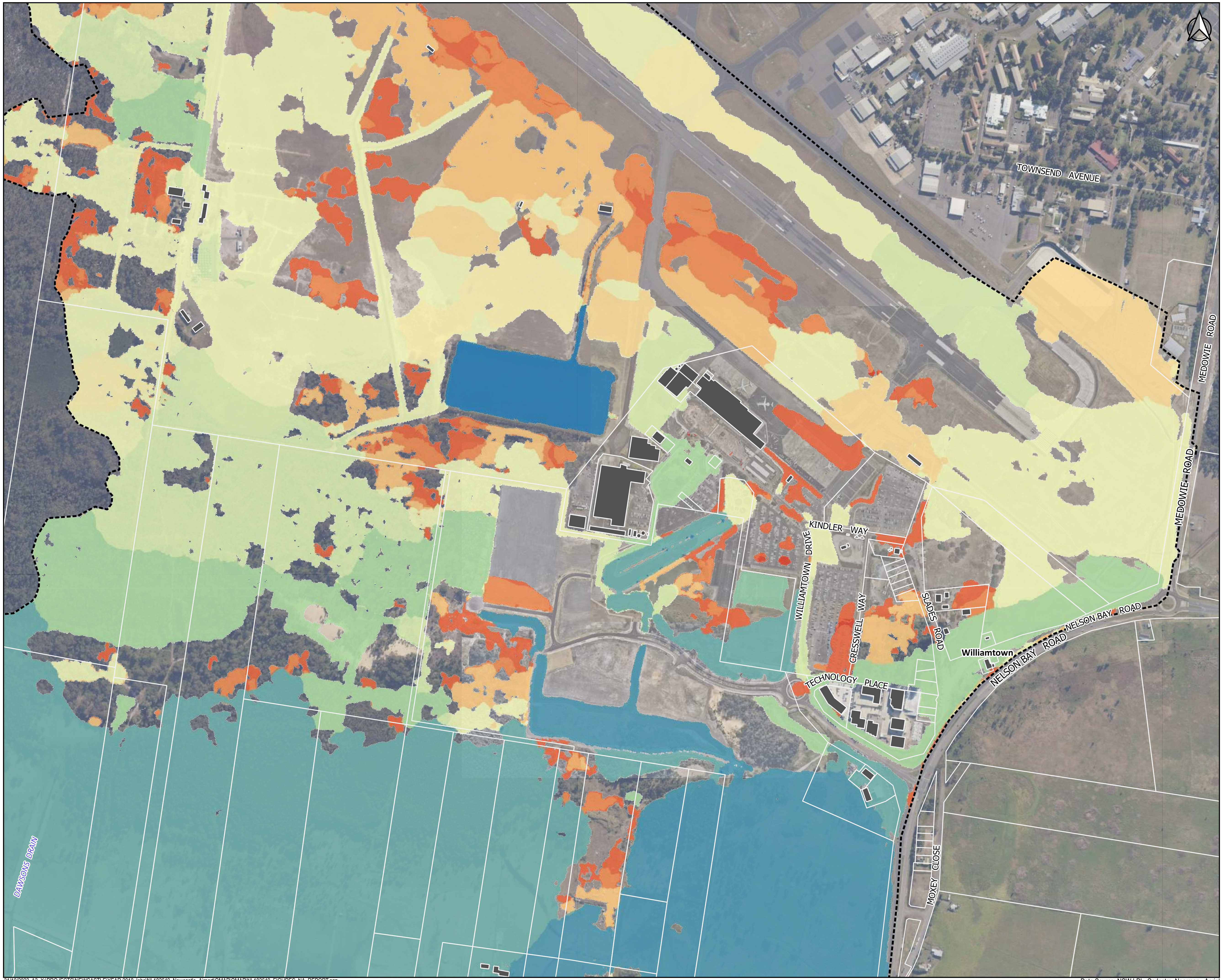
Document Register

Rev	Status	Prepared	Approved	Date
A	Draft for Client Review	RB	GB	3 November 2023
B	For Submission	RB	GB	8 November 2023
C	For Submission	RB	GB	27 November 2023

Appendix A – Critical Duration Maps



Legend

- Cadastre
- 2D Model Extent
- Buildings

Storm Duration

- 10min
- 15min
- 20min
- 25min
- 30min
- 45min
- 1hr
- 1.5hr
- 2hr
- 3hr
- 4.5hr
- 6hr
- 9hr
- 12hr
- 18hr
- 24hr

0 100 200 Metres

1:7,500

Figure A1

1% AEP Critical Storm Durations

Newcastle Airport
Williamtown

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31/10/2023 A3 X:\PROJECTS\NEWCASTLE\YEAR 2018 Jobs\NL182640_Newcastle_Airport\QMAP\QMAP\NL182640_FIGURES_NA_REPORT.qgz

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

Legend

- Cadastre
- 2D Model Extent
- Buildings

Storm Duration

- 10min
- 15min
- 20min
- 25min
- 30min
- 45min
- 1hr
- 1.5hr
- 2hr
- 3hr
- 4.5hr
- 6hr
- 9hr
- 12hr
- 18hr
- 24hr

0 100 200 Metres

1:7,500

Figure A2

5% AEP Critical Storm Durations

Newcastle Airport
Williamtown

NORTHROP

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

Legend

- Cadastre
- 2D Model Extent
- Buildings

Storm Duration

- 10min
- 15min
- 20min
- 25min
- 30min
- 45min
- 1hr
- 1.5hr
- 2hr
- 3hr
- 4.5hr
- 6hr
- 9hr
- 12hr
- 18hr
- 24hr

0 100 200 Metres

1:7,500

Figure A3

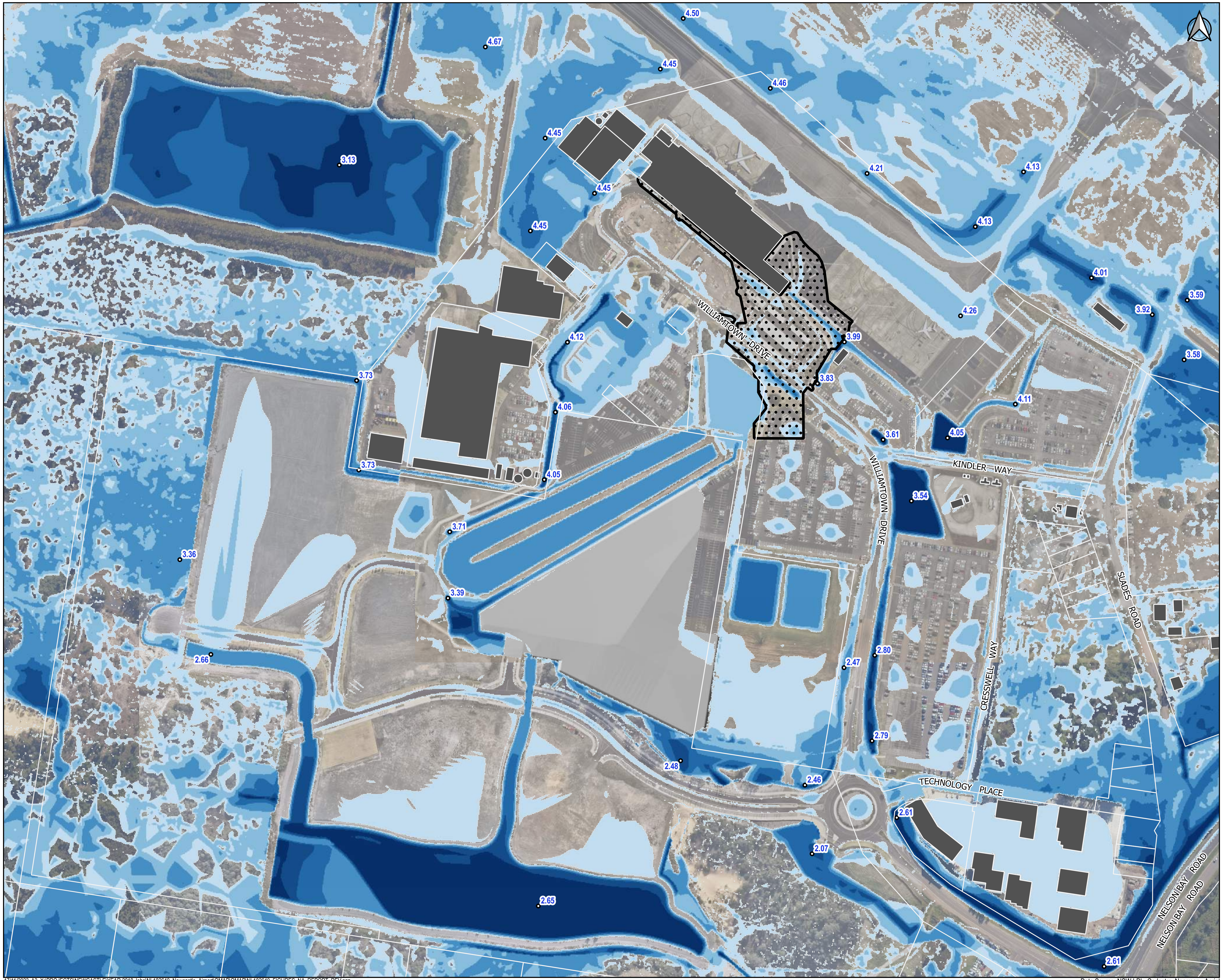
10% AEP Critical Storm Durations

Newcastle Airport
Williamtown

NORTHROP

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

Appendix B – Base Case Flood Maps



Legend

- Cadastre
- Buildings
- Proposed Terminal Expansion
- Water Level (mAHD)

Depth(m)

- <= 0.02
- 0.02 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 60 120 Metres

1:3,500

Figure B1

1% AEP Flood Depth and Elevation Base Case

Newcastle Airport Williamtown

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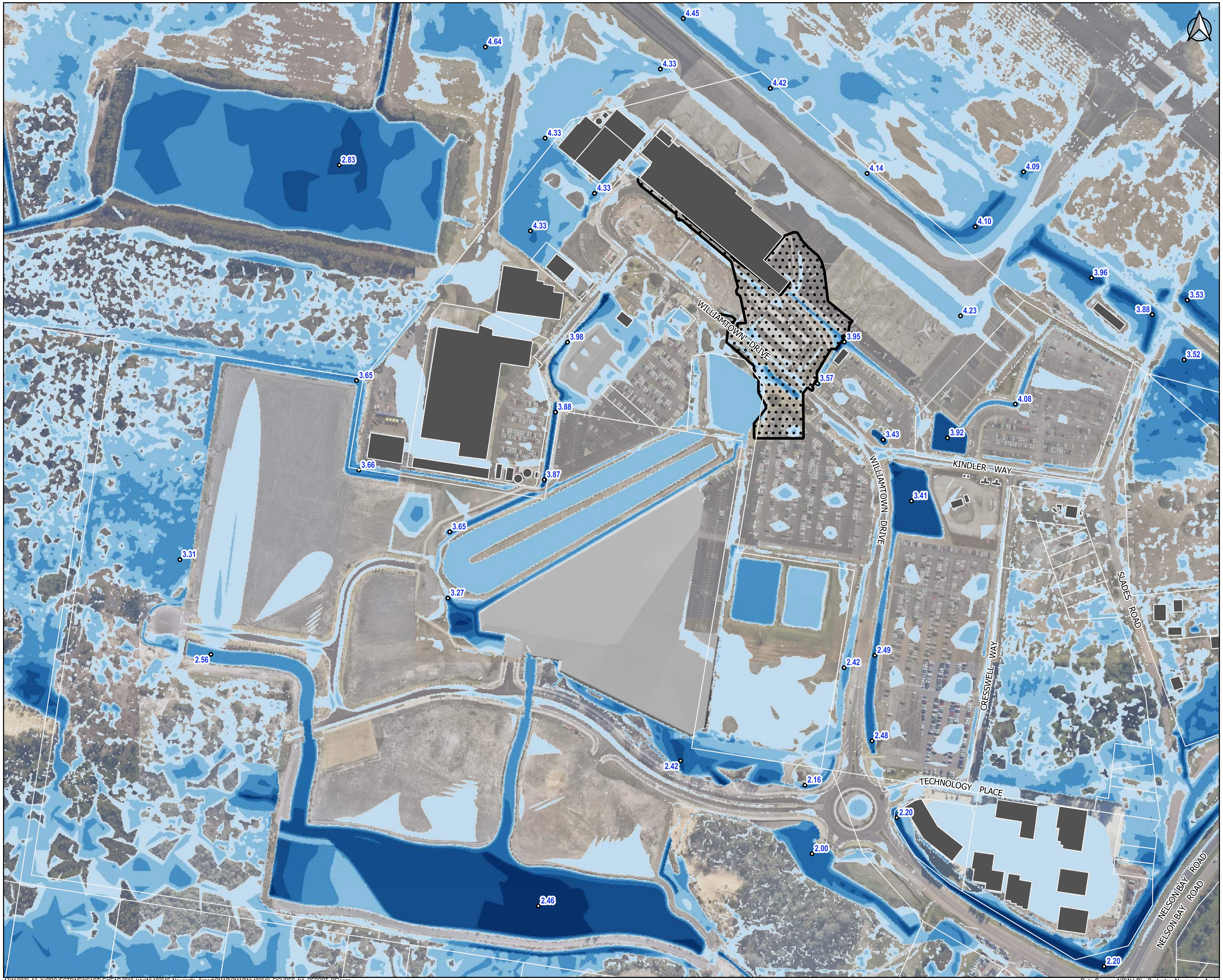
17/11/2023 A3 X:\PROJECTS\NEWCASTLE\YEAR 2018 Jobs\NL182640_Newcastle_Airport\QMAP\QMAP\NL182640_FIGURES_NA_REPORT_REV.qgz

Data Source: NSW LPI - Cadastre, Nearmap - Aerial



Legend

Cadastre
Buildings
Proposed Terminal Expansion
Water Level (mAHD)

Depth(m)
- <= 0.02
- 0.02 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 60 120 Metres

1:3,500

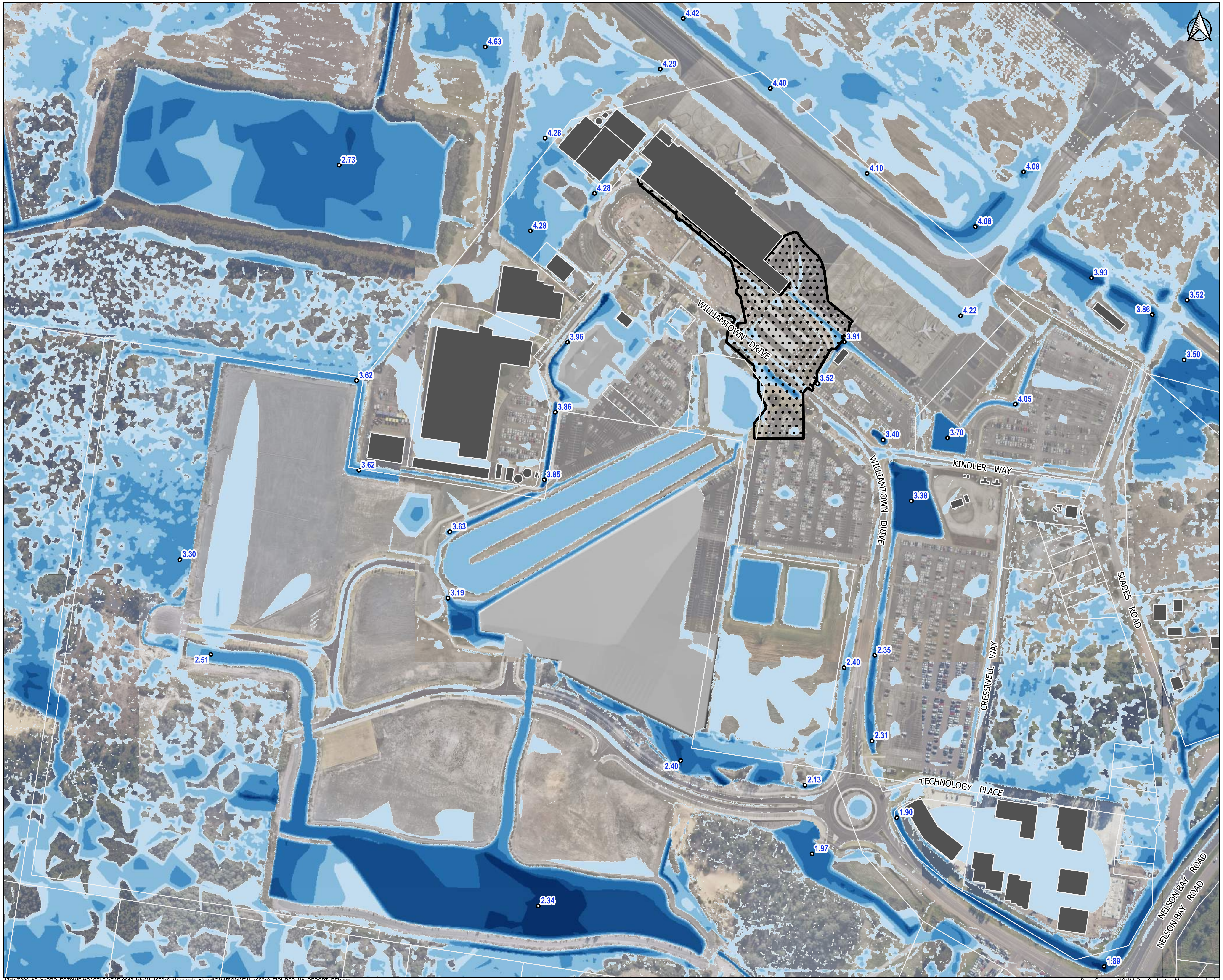
Figure B2

5% AEP Flood Depth and Elevation Base Case

Newcastle Airport
Williamtown

NORTHROP

Data Source: NSW LPI - Cadastre, Nearmap - Aerial



Legend

- Cadastre
- Buildings
- Proposed Terminal Expansion
- Water Level (mAHD)

Depth(m)

- <= 0.02
- 0.02 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 60 120 Metres

1:3,500

Figure B3

10% AEP Flood Depth and Elevation Base Case

Newcastle Airport
Williamtown

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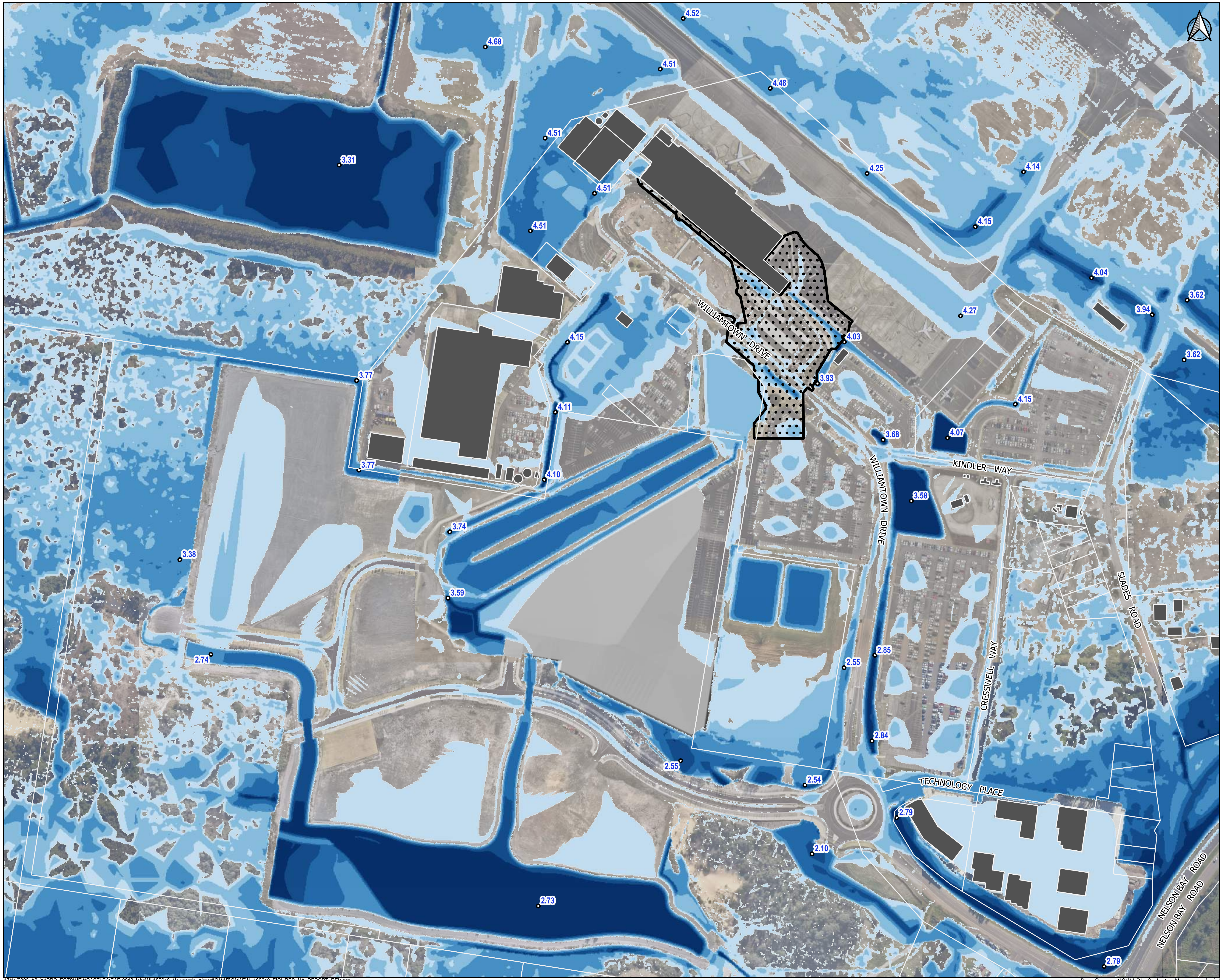
Data Source: NSW LPI - Cadastre, Nearmap - Aerial



Legend

Cadastre
Buildings
Proposed Terminal Expansion
Water Level (mAHD)

Depth(m)

<= 0.02
0.02 - 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
> 1.00

0 60 120 Metres

1:3,500

Figure B4

1% AEP Flood Depth and Elevation Climate Change 2100 Base Case

Newcastle Airport
Williamtown

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Appendix C – Developed Case Flood Maps

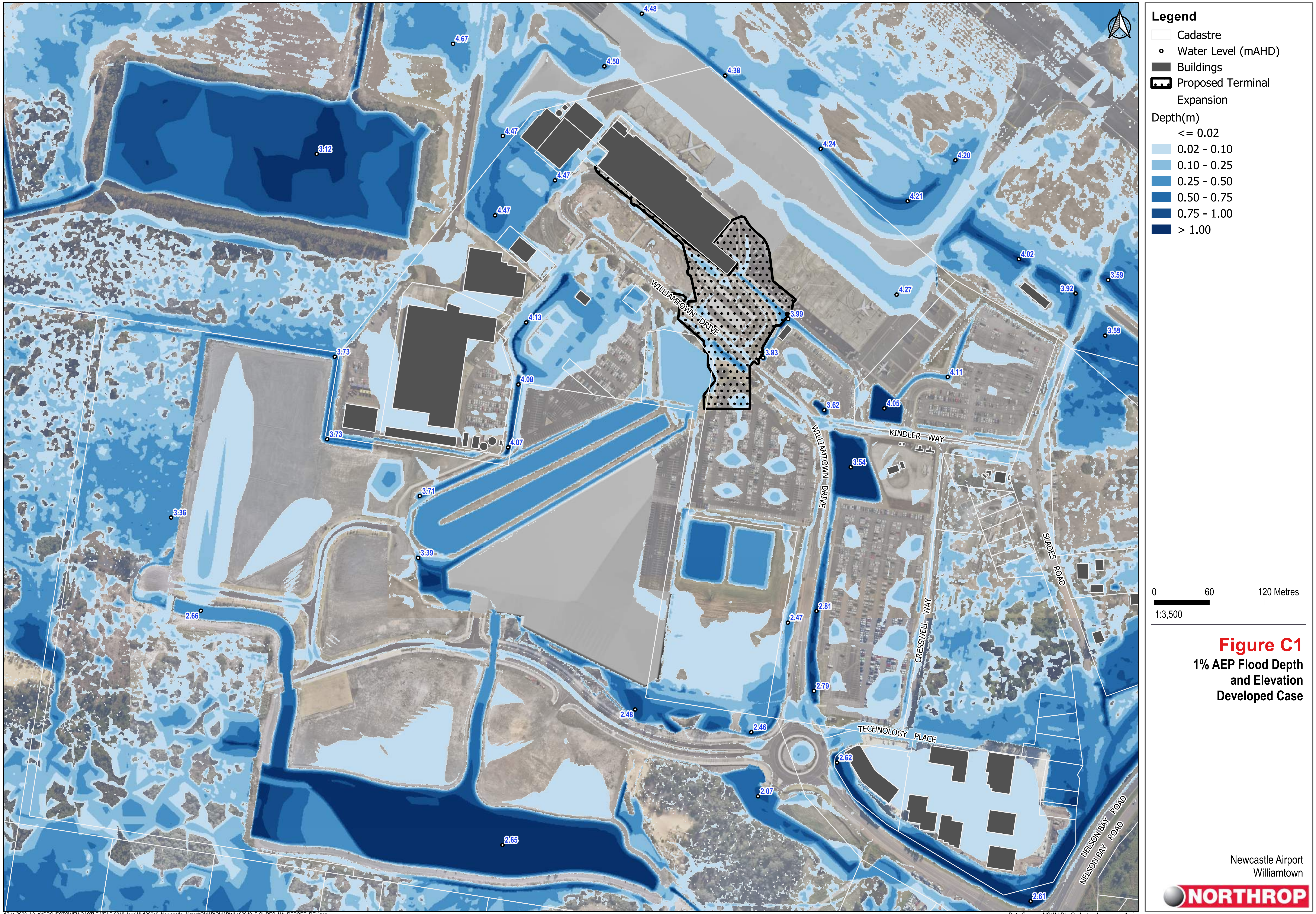

Figure C1
1% AEP Flood Depth and Elevation Developed Case

Newcastle Airport
Williamtown

NORTHROP

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

Legend

Cadastre

Water Level (mAHD)

Buildings

Proposed Terminal Expansion

Depth(m)

<= 0.02

0.02 - 0.10

0.10 - 0.25

0.25 - 0.50

0.50 - 0.75

0.75 - 1.00

> 1.00

0 60 120 Metres

1:3,500

Figure C2

5% AEP Flood Depth and Elevation Developed Case

Newcastle Airport
Williamtown

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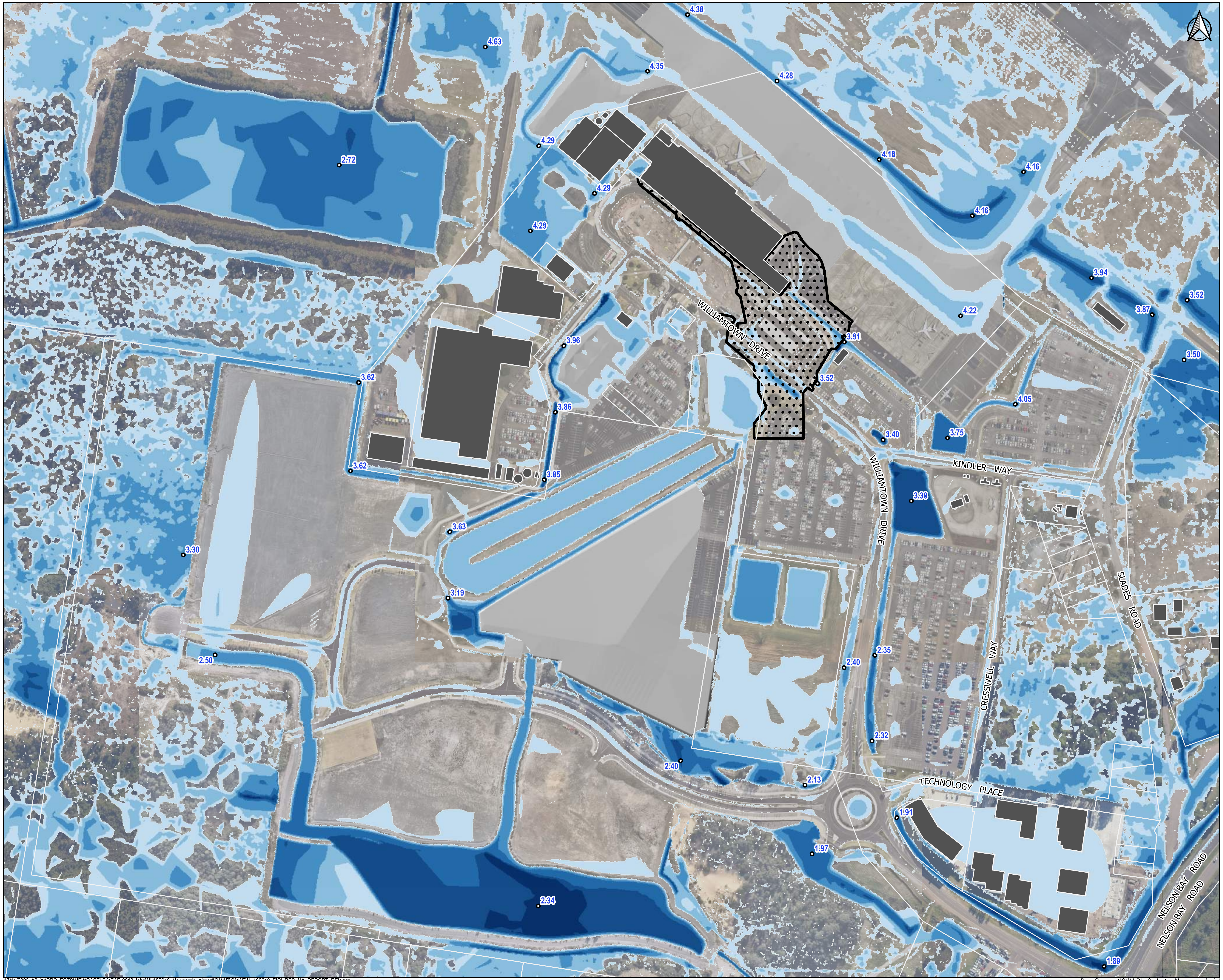
Data Source: NSW LPI - Cadastre, Nearmap - Aerial



Legend

- Cadastre
- Water Level (mAHD)
- Buildings
- Proposed Terminal Expansion

Depth(m)

- <= 0.02
- 0.02 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 60 120 Metres

1:3,500

Figure C3

10% AEP Flood Depth and Elevation Developed Case

Newcastle Airport
Williamtown

NORTHROP

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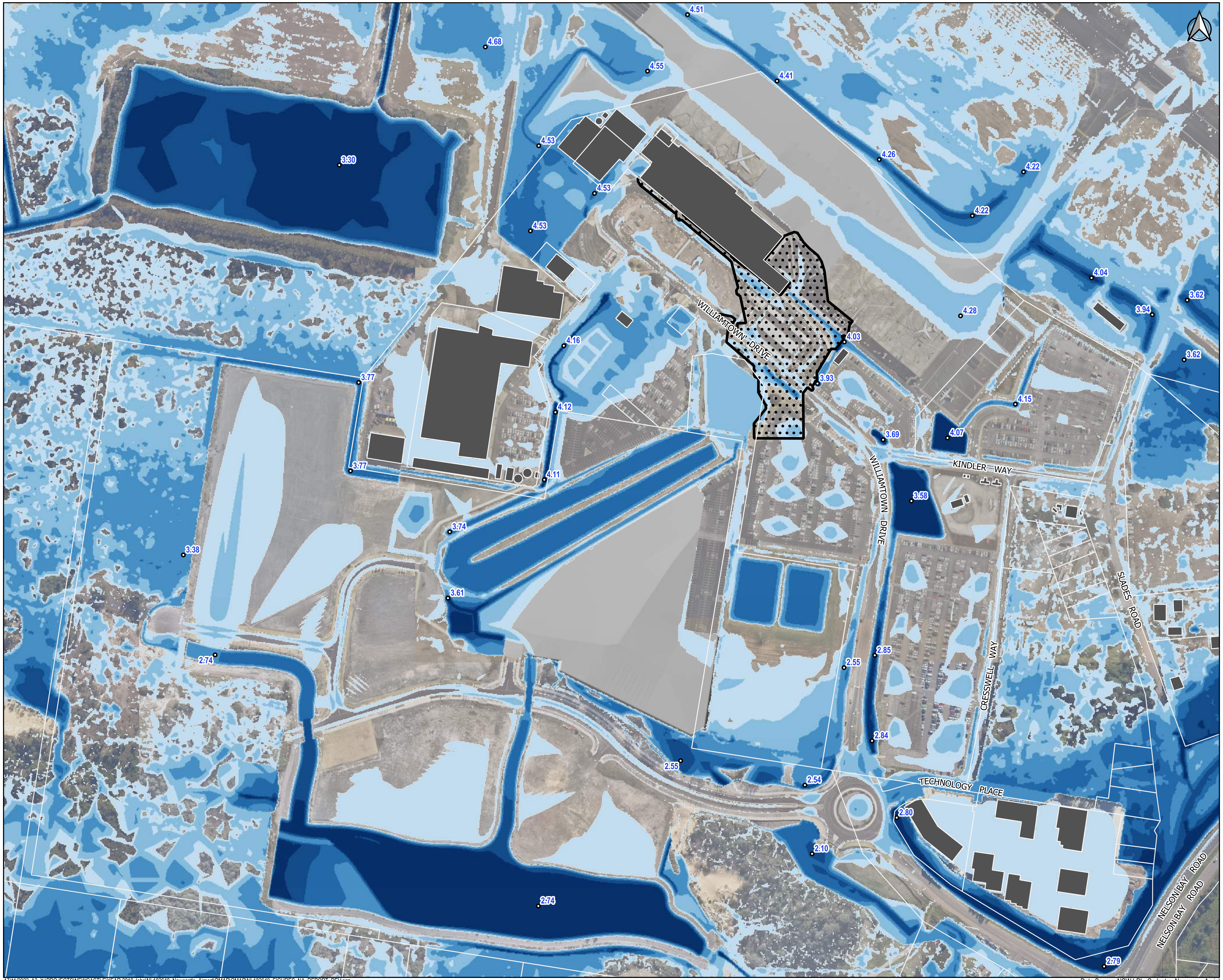
Data Source: NSW LPI - Cadastre, Nearmap - Aerial



Legend

- Cadastre
- Buildings
- Proposed Termina Expansion
- Water Level (mAHD)

Depth(m)

- <= 0.02
- 0.02 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 60 120 Metres

1:3,500

Figure C4

1% AEP Flood Depth and Elevation Climate Change 2100 Developed Case

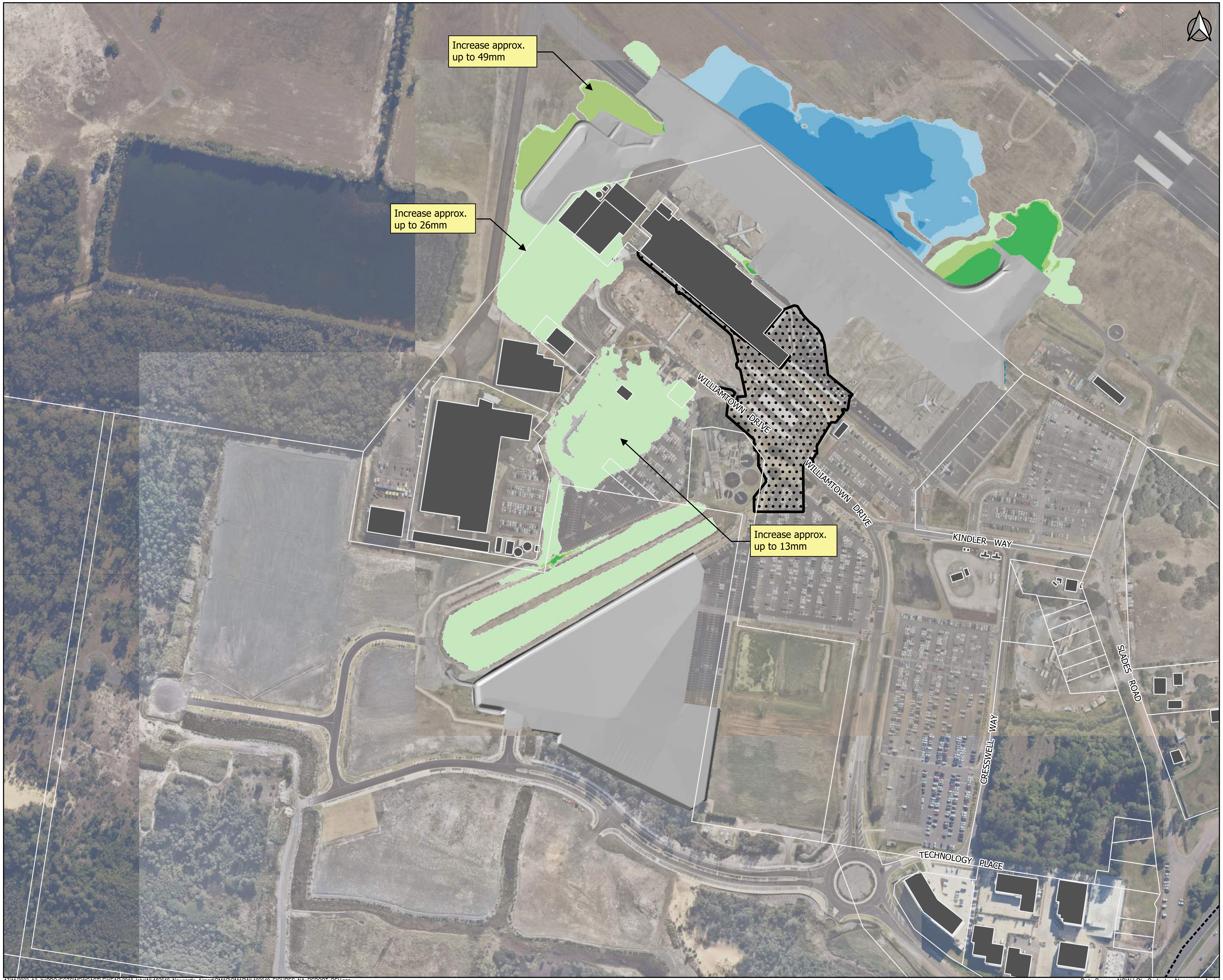
Newcastle Airport
Williamtown

NORTHROP

17/11/2023 A3 X:\PROJECTS\NEWCASTLE\YEAR 2018 Jobs\NL182640_Newcastle_Airport\QMAP\QMAP\NL182640_FIGURES_NA_REPORT_REV.qgz

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

Appendix D – Pre-to-Post Comparison Developed Case



Legend

Cadastre
2D Model Extent
Proposed Terminal Expansion
Buildings
Difference(m)

0 60 120 Metres
1:3,500

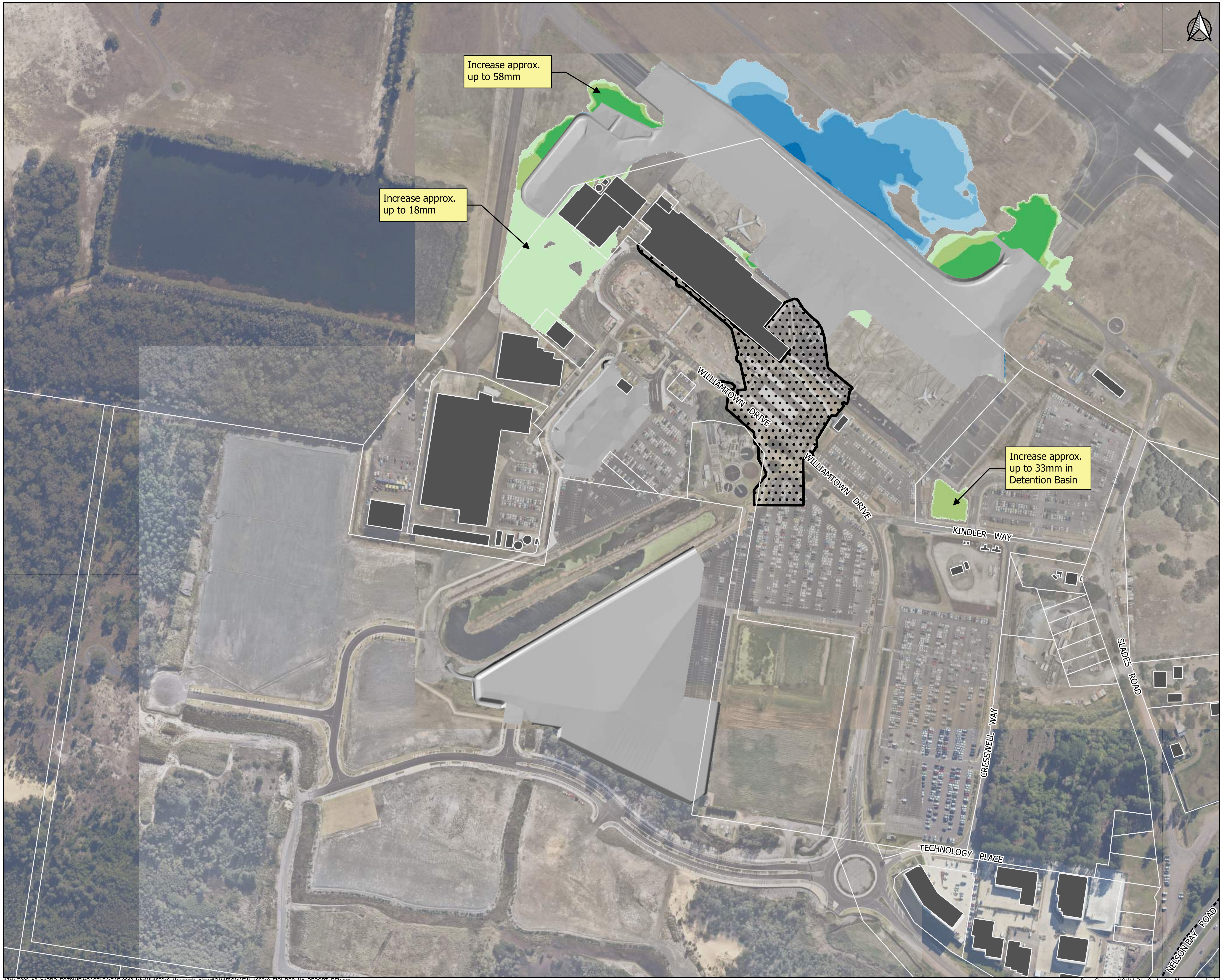
Figure D1

1% AEP Flood Elevation Difference Developed minus Base Case

Newcastle Airport
Williamtown

NORTHROP

Data Source: NSW LPI - Cadastre, Nearmap - Aerial



Legend

- Cadastre
- 2D Model Extent
- Proposed Terminal Expansion
- Buildings

Difference(m)

- <-0.10
- -0.10 - -0.05
- -0.05 - -0.03
- -0.03 - -0.01
- Less than +/-10mm
- 0.01 - 0.03
- 0.03 - 0.05
- 0.05 - 0.10
- >0.10

0 60 120 Metres

1:3,500

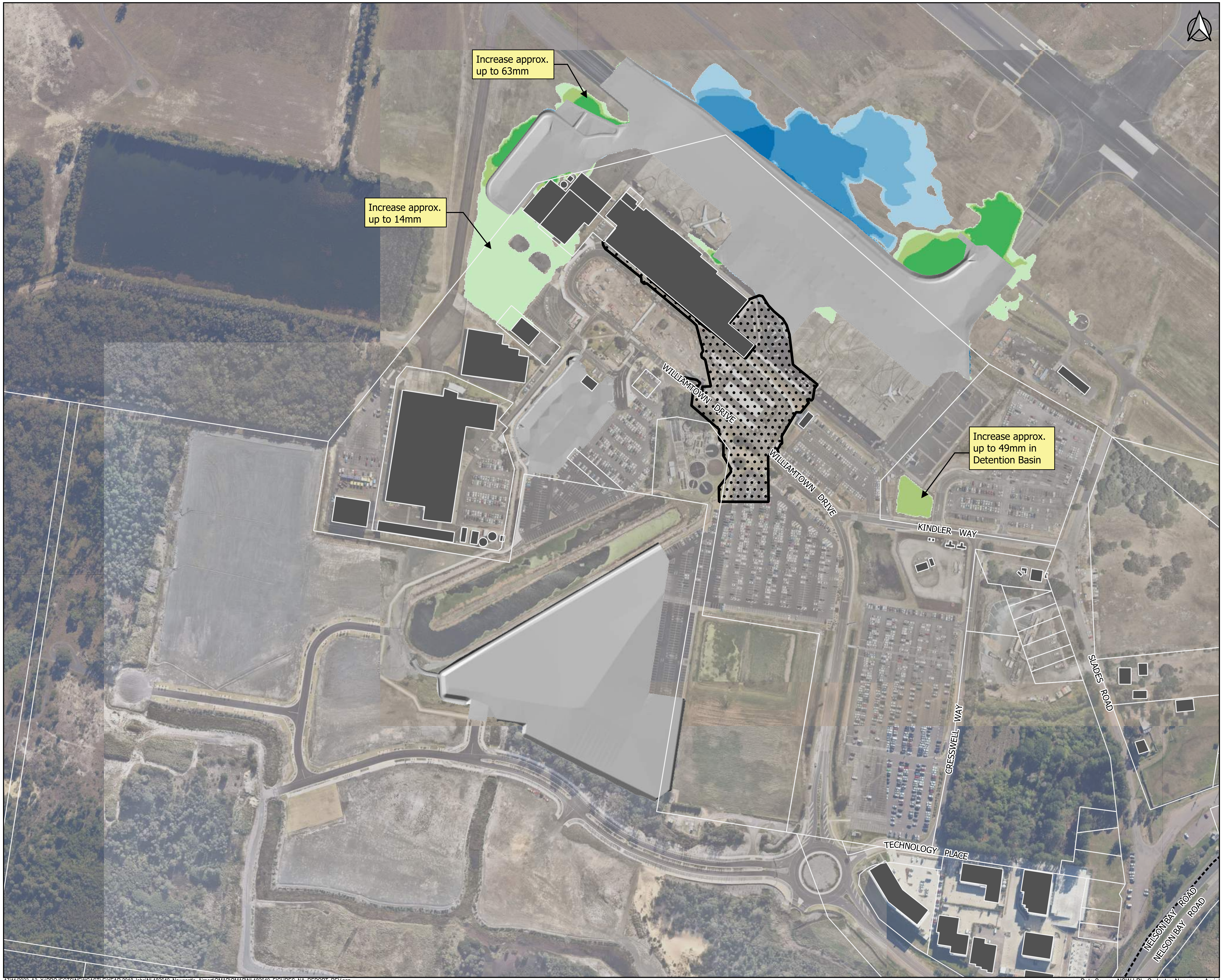
Figure D2

5% AEP Flood Elevation Difference Developed minus Base Case

Newcastle Airport
Williamtown

NORTHROP

Data Source: NSW LPI - Cadastre, Nearmap - Aerial



Legend

- Cadastre
- 2D Model Extent
- Proposed Terminal Expansion
- Buildings

Difference(m)

- <-0.10
- -0.10 - -0.05
- -0.05 - -0.03
- -0.03 - -0.01
- Less than +/-10mm
- 0.01 - 0.03
- 0.03 - 0.05
- 0.05 - 0.10
- >0.10

0 60 120 Metres

1:3,500

Figure D3

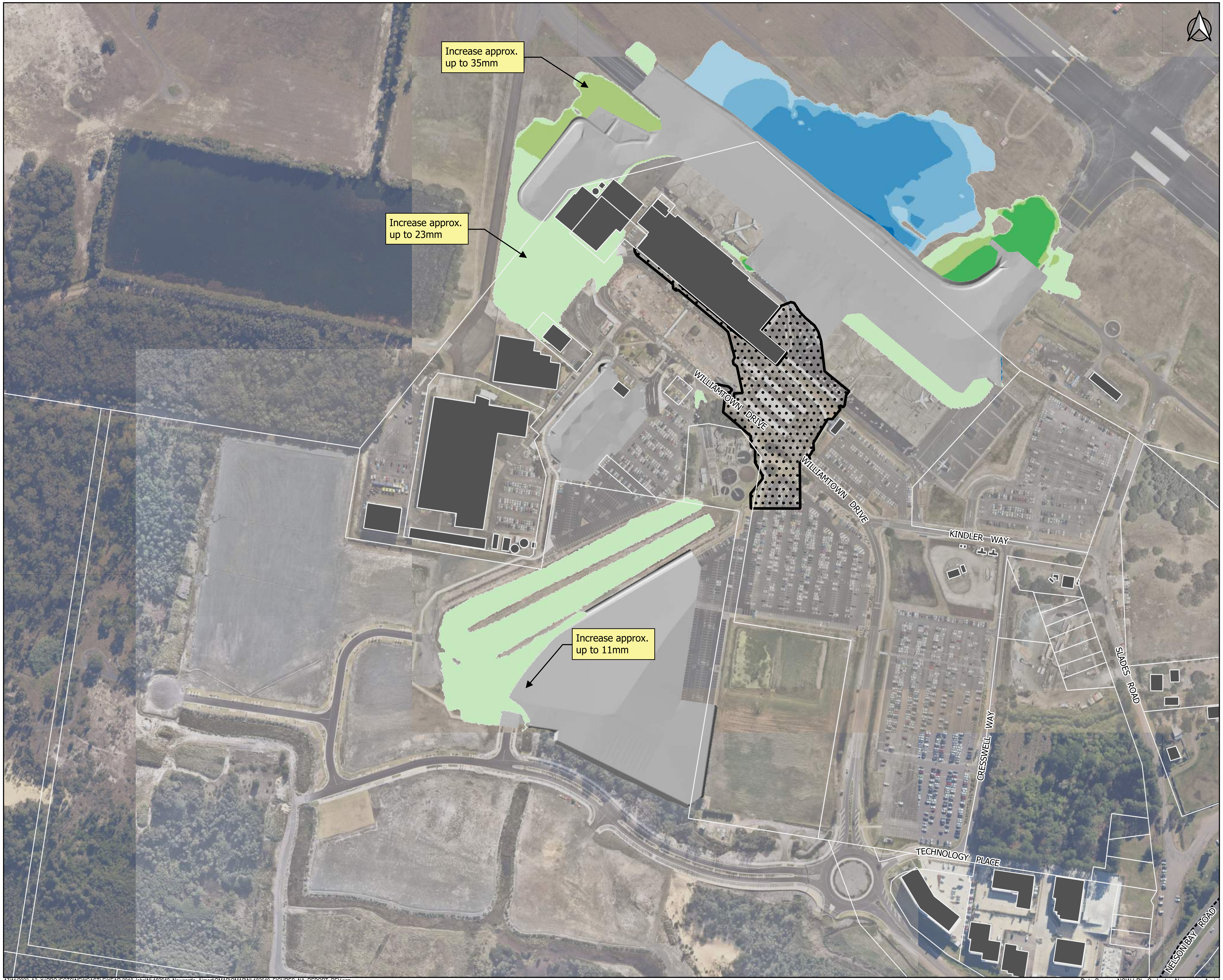
10% AEP Flood Elevation Difference Developed minus Base Case

Newcastle Airport
Williamtown

NORTHROP

17/11/2023 A3 X:\PROJECTS\NEWCASTLE\YEAR 2018 Jobs\NL182640_Newcastle_Airport\QMAP\QMAP\NL182640_FIGURES_NA_REPORT_REV.qgz

Data Source: NSW LPI - Cadastre, Nearmap - Aerial



Legend

Cadastre
2D Model Extent
Proposed Terminal Expansion
Buildings

Difference(m)

<-0.10
-0.10 - -0.05
-0.05 - -0.03
-0.03 - -0.01
Less than +/-10mm
0.01 - 0.03
0.03 - 0.05
0.05 - 0.10
>0.10

0 60 120 Metres

1:3,500

Figure D4

1% AEP Climate Change 2100 Sensitivity Flood Elevation Difference Developed minus Base Case

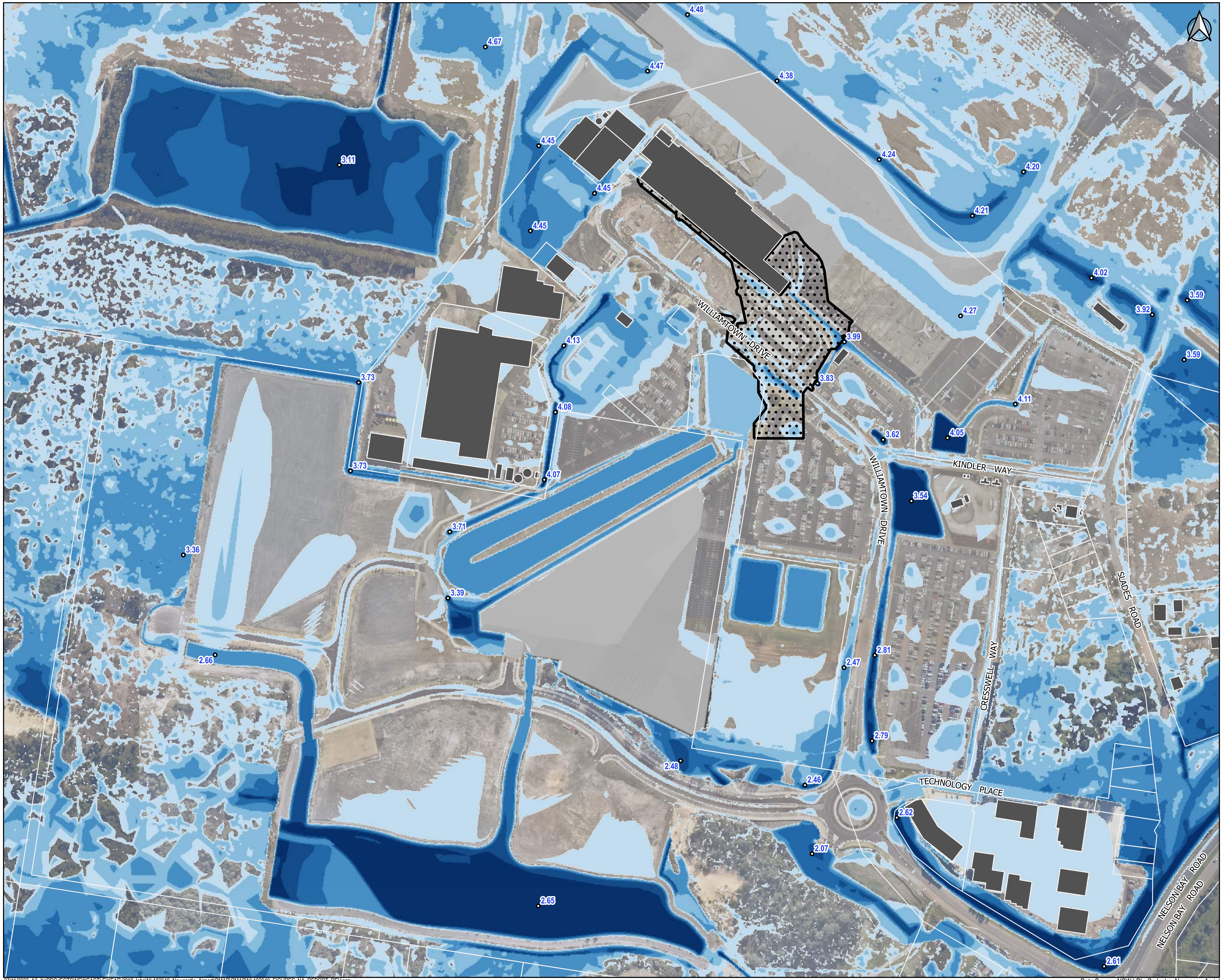
Newcastle Airport
Williamtown

NORTHROP

17/11/2023 A3 X:\PROJECTS\NEWCASTLE\YEAR 2018 Jobs\NL182640_Newcastle_Airport\QMAP\QMAP\NL182640_FIGURES_NA_REPORT_REV.qgz

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

Appendix E – Developed Case with Mitigation Measures Flood Maps



Legend

- Cadastre
- Water Level (mAHD)
- Buildings
- Proposed Terminal Expansion

Depth(m)

- <= 0.02
- 0.02 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 60 120 Metres

1:3,500

Figure C1-M1B

1% AEP Flood Depth and Elevation Developed Case with Flood Mitigation

Newcastle Airport
Williamtown

NORTHROP

27/11/2023 A3 X:\PROJECTS\NEWCASTLE\YEAR 2018 Jobs\NL182640_Newcastle_Airport\QMAP\QMAP\NL182640_FIGURES_NA_REPORT_REV.qgz

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

Legend

- Cadastre
- Water Level (mAHD)
- Buildings
- Proposed Terminal Expansion

Depth(m)

- <= 0.02
- 0.02 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 60 120 Metres

1:3,500

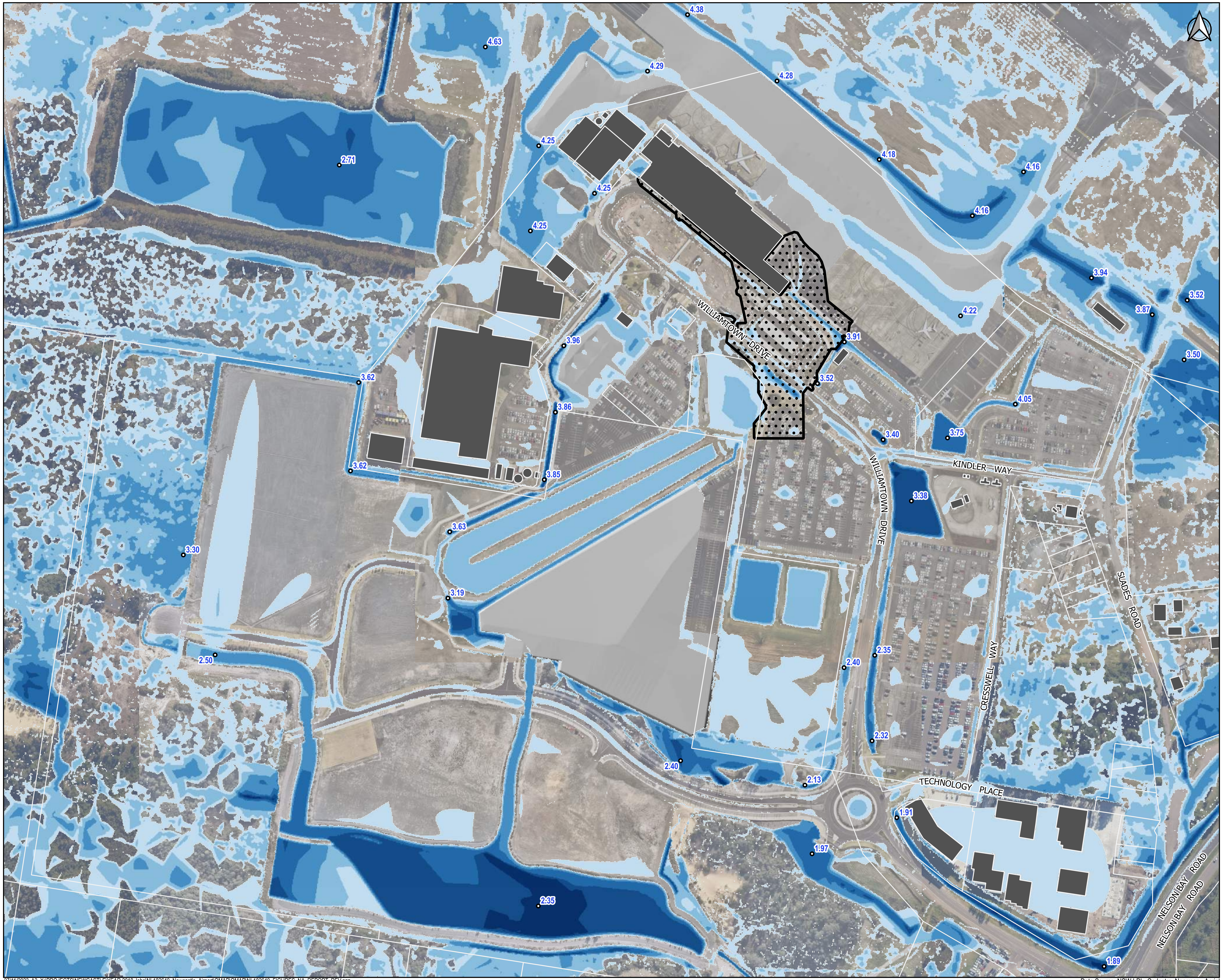
Figure C2-M1B

5% AEP Flood Depth and Elevation Developed Case with Flood Mitigation

Newcastle Airport Williamtown

NORTHROP

Data Source: NSW LPI - Cadastre, Nearmap - Aerial



Legend

- Cadastre
- Water Level (mAHD)
- Buildings
- Proposed Terminal Expansion

Depth(m)

- <= 0.02
- 0.02 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 60 120 Metres

1:3,500

Figure C3-M1B

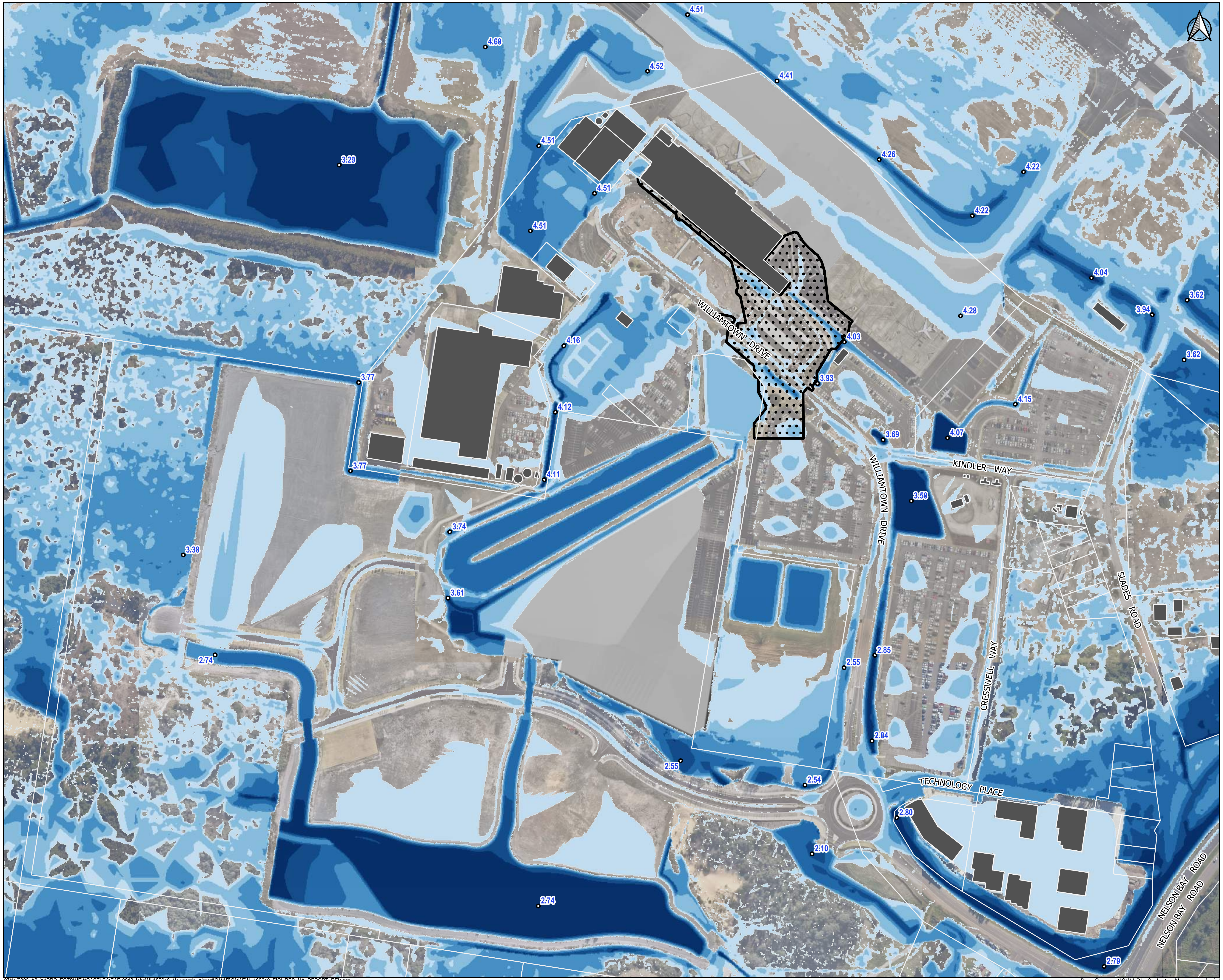
10% AEP Flood Depth and Elevation Developed Case with Flood Mitigation

Newcastle Airport
Williamtown

NORTHROP

27/11/2023 A3 X:\PROJECTS\NEWCASTLE\YEAR 2018 Jobs\NL182640_Newcastle_Airport\QMAP\QMAP\NL182640_FIGURES_NA_REPORT_REV.qgz

Data Source: NSW LPI - Cadastre, Nearmap - Aerial



Legend

- Cadastre
- Water Level (mAHD)
- Buildings
- Proposed Terminal Expansion

Depth(m)

- <= 0.02
- 0.02 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 60 120 Metres

1:3,500

Figure C4-M1B

1% AEP Climate Change Flood Depth and Elevation Developed Case with Flood Mitigation

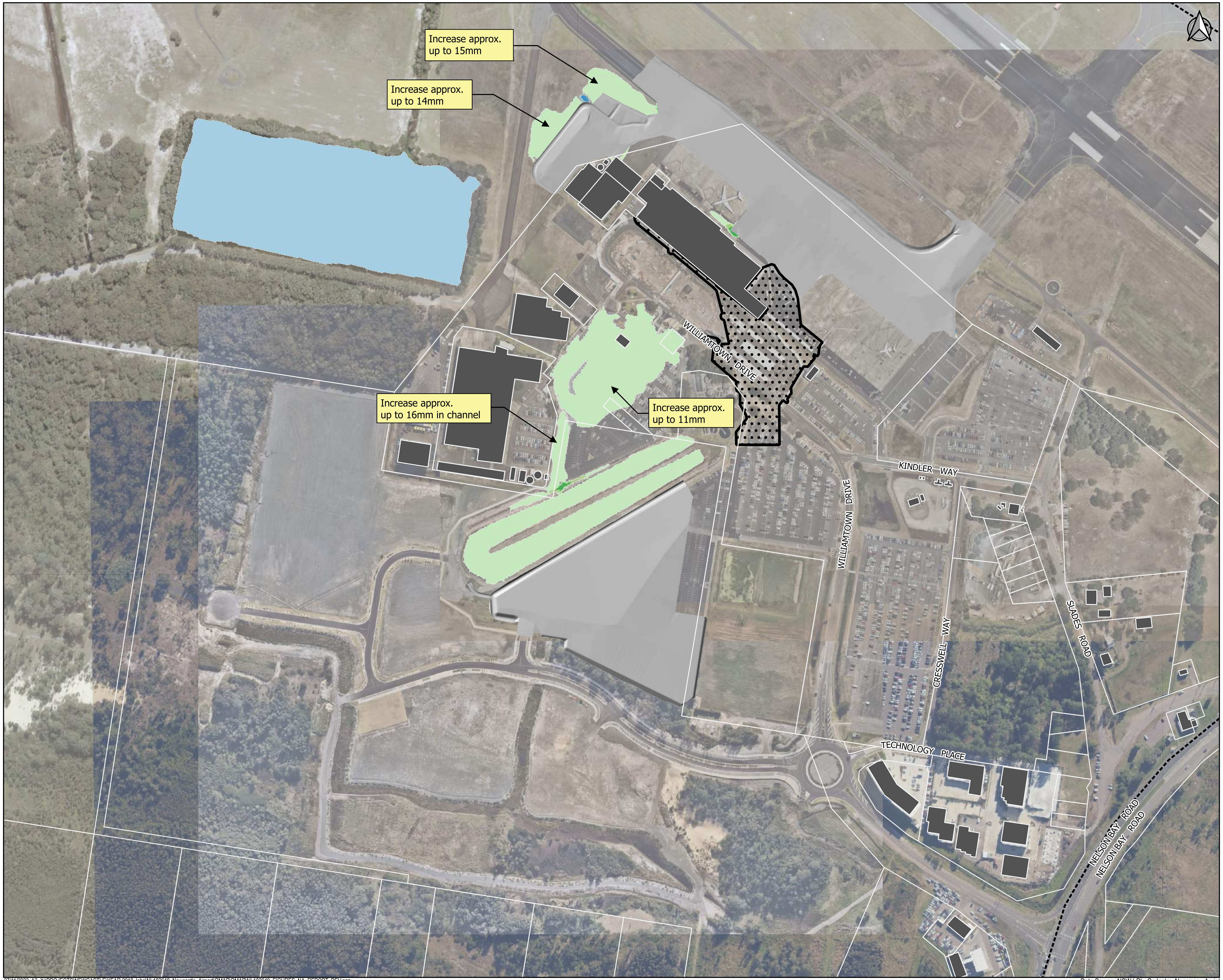
Newcastle Airport
Williamtown

NORTHROP

27/11/2023 A3 X:\PROJECTS\NEWCASTLE\YEAR 2018 Jobs\NL182640_Newcastle_Airport\QMAP\QMAP\NL182640_FIGURES_NA_REPORT_REV.qgz

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

Appendix F – Pre-to-Post Comparison Developed Case with Mitigation Measures



Legend

- Cadastre
- 2D Model Extent
- Proposed Terminal Expansion
- Buildings

Difference(m)

- <-0.10
- -0.10 - -0.05
- -0.05 - -0.03
- -0.03 - -0.01
- Less than +/-10mm
- 0.01 - 0.03
- 0.03 - 0.05
- 0.05 - 0.10
- >0.10

0 70 140 Metres

1:4,000

Figure D1-M1B

1% AEP Flood Elevation Difference Developed with Flood Mitigation munus Base Case

Newcastle Airport
Williamtown

NORTHROP

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

Figure D2-M1B

5% AEP Flood Elevation Difference Developed with Flood Mitigation minus Base Case

Newcastle Airport
Williamtown

NORTHROP

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

Legend

Cadastre
2D Model Extent
Proposed Terminal Expansion
Buildings

Difference(m)

<-0.10
-0.10 - -0.05
-0.05 - -0.03
-0.03 - -0.01
Less than +/-10mm
0.01 - 0.03
0.03 - 0.05
0.05 - 0.10
>0.10

0 70 140 Metres
1:4,000

Figure D3-M1B

10% AEP Flood Elevation Difference Developed with Flood Mitigation misus Base Case

Newcastle Airport
Williamtown

NORTHROP

27/11/2023 A3 X:\PROJECTS\NEWCASTLE\YEAR 2018 Jobs\NL182640_Newcastle_Airport\QMAP\QMAP\NL182640_FIGURES_NA_REPORT_REV.qgz

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

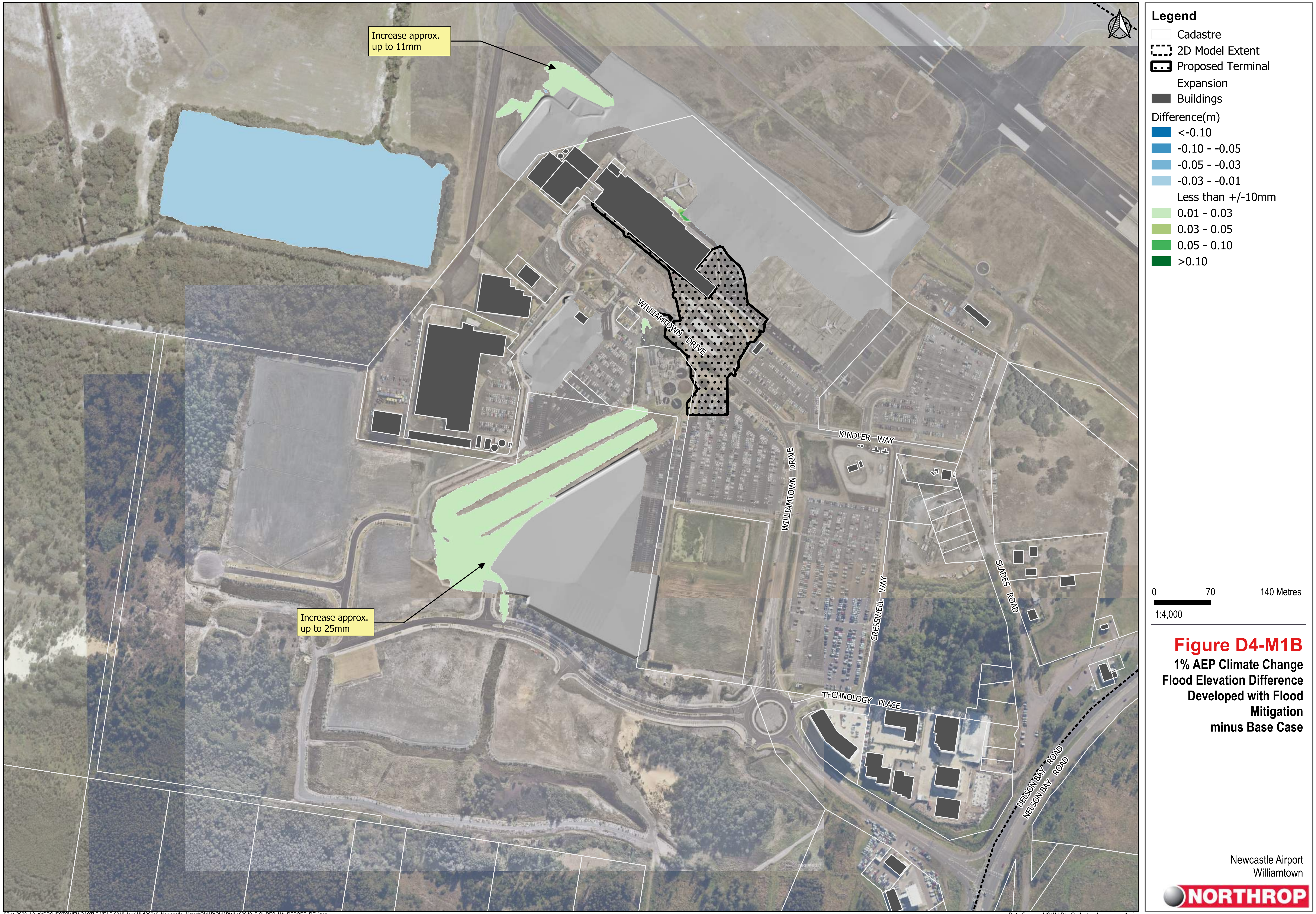


Figure D4-M1B

1% AEP Climate Change Flood Elevation Difference Developed with Flood Mitigation minus Base Case

Newcastle Airport
Williamtown

NORTHROP

27/11/2023 A3 X:\PROJECTS\NEWCASTLE\YEAR 2018 Jobs\NL182640_Newcastle_Airport\QMAP\QMAP\NL182640_FIGURES_NA_REPORT_REV.qgz

Data Source: NSW LPI - Cadastre, Nearmap - Aerial

Appendix G – Modelled Burst and Pre-Burst Rainfall Depths

Table G1 – BoM Rainfall Depth(mm)

Duration	63.20%	50%	20%	10%	5%	2%	1%
1	2.2	2.54	3.67	4.49	5.35	6.57	7.57
2	3.7	4.29	6.24	7.63	9.05	11	12.5
3	5.14	5.95	8.63	10.6	12.5	15.2	17.4
4	6.44	7.45	10.8	13.2	15.7	19.1	21.9
5	7.62	8.8	12.7	15.6	18.5	22.7	26
10	12.1	13.9	20.1	24.6	29.3	36.1	41.6
15	15.2	17.5	25.2	30.8	36.8	45.3	52.3
20	17.5	20.1	29	35.6	42.4	52.2	60.3
25	19.3	22.3	32.1	39.4	47	57.8	66.6
30	20.9	24.1	34.8	42.6	50.8	62.4	71.9
45	24.4	28.2	40.9	50.1	59.7	73.2	84.1
60	27.1	31.3	45.4	55.7	66.3	81.2	93.3
90	31.1	36.1	52.4	64.2	76.4	93.5	107
120	34.3	39.8	57.8	70.9	84.3	103	118
180	39.4	45.6	66.3	81.4	96.9	119	136
270	45.4	52.5	76.3	93.7	112	137	158
360	50.4	58.2	84.4	104	124	152	176
540	58.6	67.5	97.6	120	144	178	206
720	65.3	75.1	108	133	160	198	230
1080	76	87.1	125	155	186	231	269
1440	84.5	96.6	139	171	207	257	299
1800	91.5	104	150	185	224	278	323
2160	97.4	111	159	197	238	295	343
2880	107	122	174	215	260	322	373
4320	120	137	195	241	291	357	412
5760	129	147	209	258	310	379	434
7200	136	155	219	269	323	393	448
8640	142	161	227	278	332	402	457
10080	146	166	233	284	338	408	463

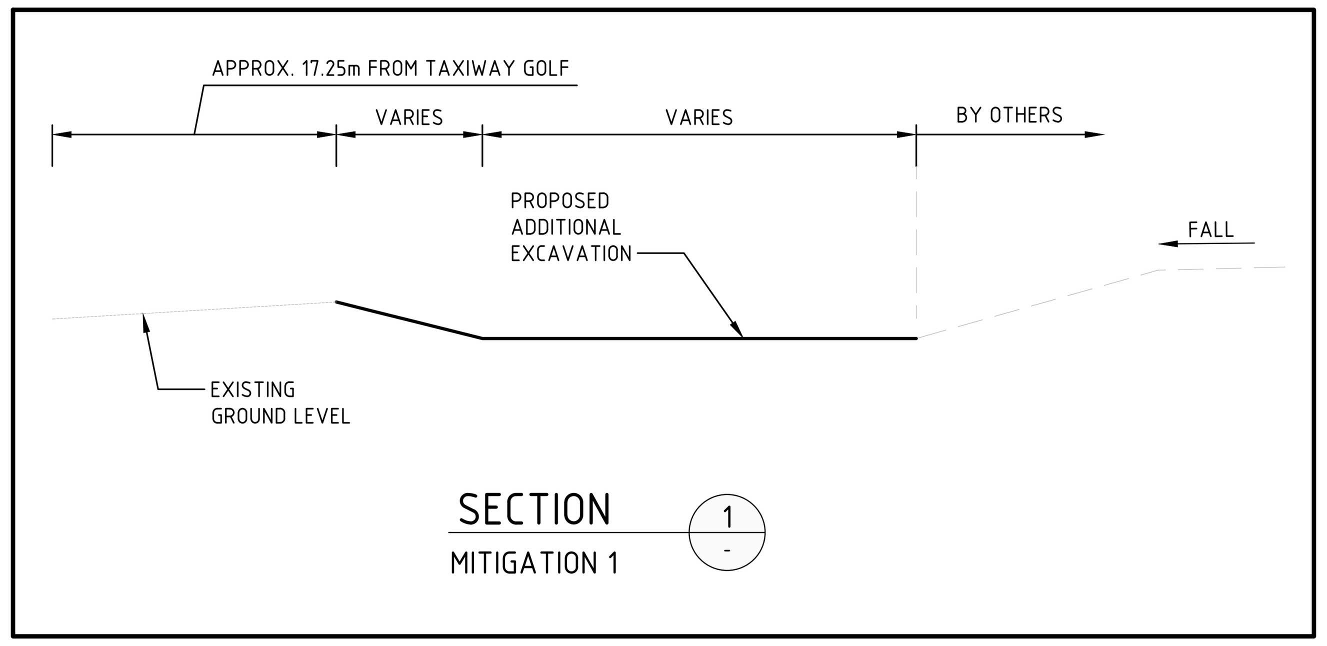
Table G2 – ARR Data Hub, Transformational Pre-burst Rainfall Depth(mm)

min (h)\ AEP (%)	50	20	10	5	2	1
60 (1.0)	7.4	8.3	7.8	8.3	6.8	9.9
90 (1.5)	6.6	7.6	7.1	8	6.8	11.5
120 (2.0)	6.6	8	7.3	8.2	6.8	11.3
180 (3.0)	5.6	7.8	7.3	8.2	6.6	11
360 (6.0)	7	9.3	9.7	8.9	7.8	10.4
720 (12.0)	5.6	7.9	8.4	8.2	8.1	9.8
1080 (18.0)	4.8	7.5	7.9	7.8	7.2	9.1
1440 (24.0)	4.3	6.8	7	7.4	5.3	8.7
2160 (36.0)	2.8	5.2	5.3	6.2	5.5	7.9
2880 (48.0)	1.5	3.6	4.4	5.4	4.9	7.6
4320 (72.0)	0	1.4	3	4.3	4.1	6.2

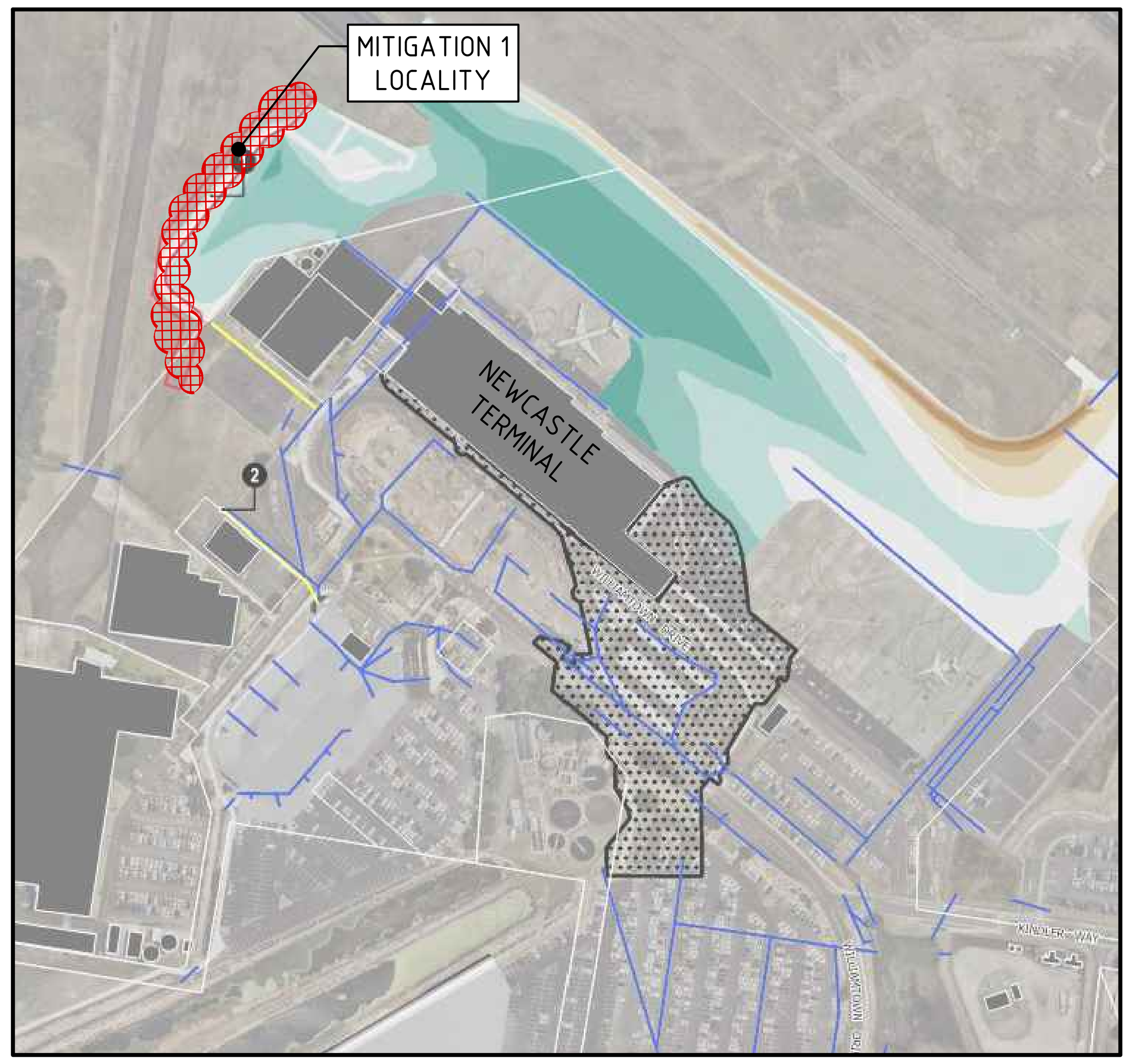
Appendix H – Mitigation Options

MITIGATION OPTION 1

APRON EXPANSION PROJECT, WILLIAMTOWN, N.S.W. 2318
CONCEPT DESIGN



SITE KEY



NOT FOR CONSTRUCTION

DRAWN: J.BEVITT
DESIGNED: J.BEVITT
JOB MANAGER: S.CROFT
VERIFIER: A.BROWN

REVISION	DESCRIPTION	ISSUED	VER'D	APP'D	DATE
A	ISSUED FOR INFORMATION	JB	JB	AB	21.11.23

CLIENT: Newcastle Airport

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SCALE 1:500@ A1 — 0 5 10 15 20 25m

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Suite 4, 215 Pacific Hwy, Charlestown NSW 2290
P.O. Box 180, Charlestown NSW 2290
Ph (02) 4943 1777 Fax (02) 4943 1577
Email newcastle@northrop.com.au ABN 81 094 433 100

PROJECT: APRON EXPANSION PROJECT, WILLIAMTOWN, N.S.W. 2318

DRAWING TITLE: CONCEPT DESIGN, MITIGATION OPTION 1

JOB NUMBER: NL182640-00

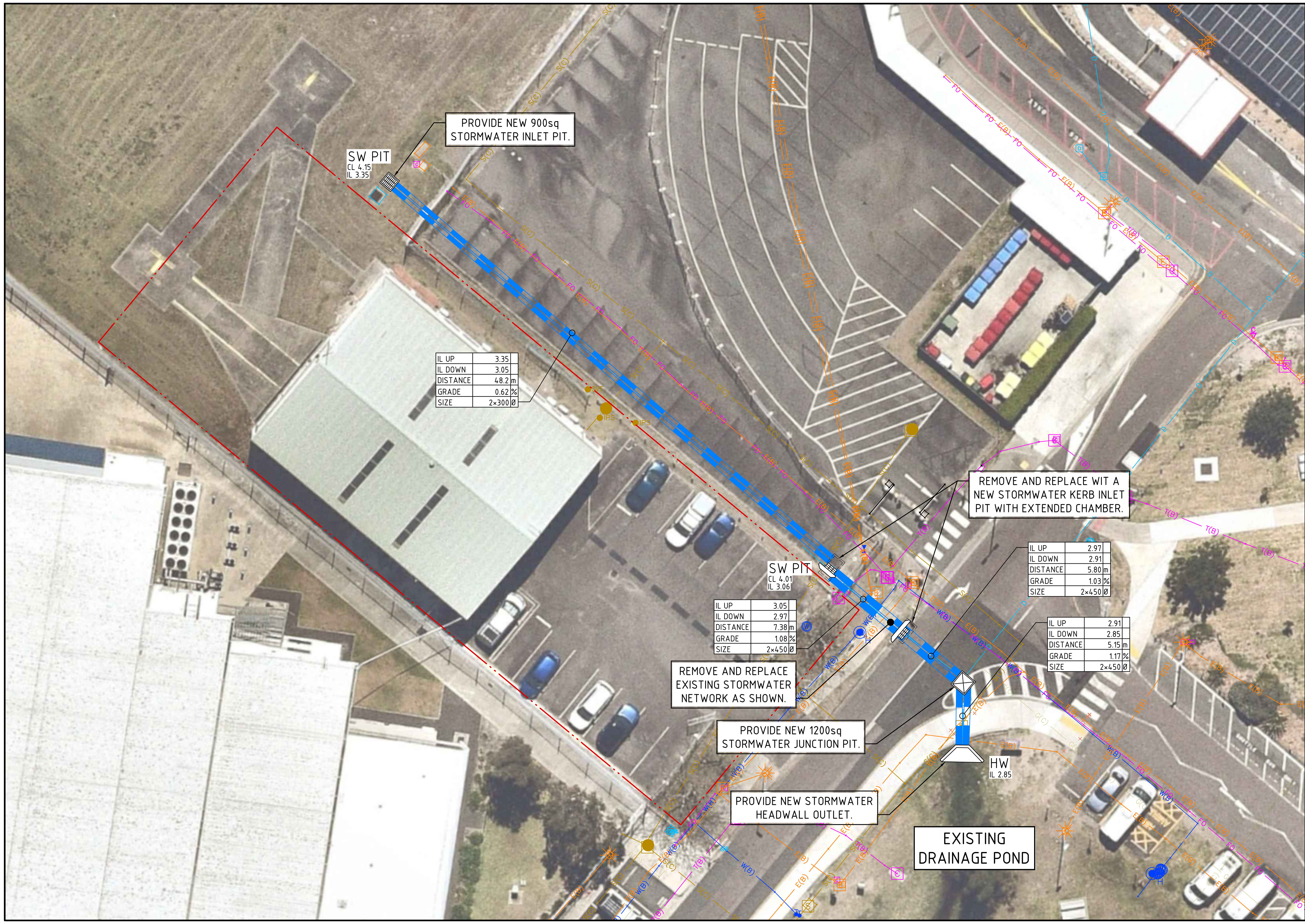
DRAWING NUMBER: CSK74.01

REVISION: A

DRAWING SHEET SIZE = A1

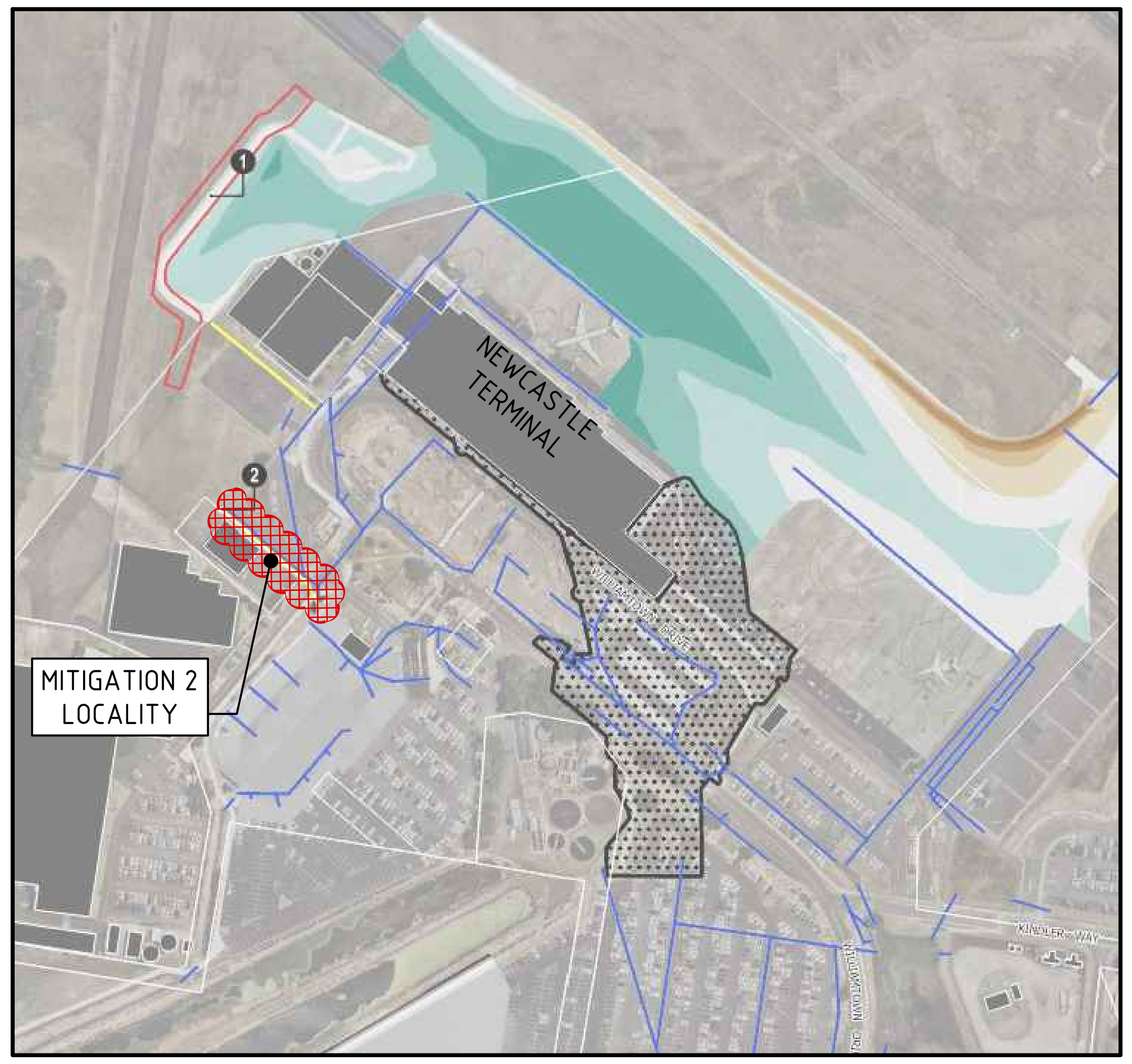
MITIGATION OPTION 2

APRON EXPANSION PROJECT, WILLIAMTOWN, N.S.W. 2318
CONCEPT DESIGN



NOTE:
LEVELS ARE PRELIMINARY AND MUST BE VERIFIED ON SITE.

SITE KEY



NOT FOR CONSTRUCTION

DRAWN: J.BEVITT
DESIGNED: J.BEVITT
JOB MANAGER: S.CROFT
VERIFIER: A.BROWN

REVISION	DESCRIPTION	ISSUED	VER'D	APP'D	DATE
A	ISSUED FOR INFORMATION	JB	JB	AB	21.11.23

CLIENT: Newcastle Airport

DRAWING NOT TO BE USED FOR CONSTRUCTION UNLESS VERIFICATION SIGNATURE HAS BEEN ADDED

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SCALE 1:200@ A1 — 0 2 4 6 8 10m

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Ph (02) 4943 1777 Fax (02) 4943 1577
Email newcastle@northrop.com.au ABN 81 094 433 100

PROJECT: APRON EXPANSION PROJECT
WILLIAMTOWN, N.S.W. 2318

DRAWING TITLE: CONCEPT DESIGN
MITIGATION OPTION 2

JOB NUMBER: NL182640-00
DRAWING NUMBER: CSK74.02
REVISION: A
DRAWING SHEET SIZE = A1