ATTACHMENTS TO REPORTS OF THE BLAYNEY SHIRE COUNCIL MEETING HELD ON MONDAY 16 MAY 2022

PART 2

INFRASTRUCTURE SERVICES REPORTS

11 Floodplain Management

Addendum to Blayney Flood Study

Update to Australian Rainfall and Runoff 2019 Guidelines

For Blayney Shire Council

INDEX

DOCUMENT CONTROL				
Revision	Date	Details	Author	Reviewed
Draft	23.12.21	Draft report	TP/JK/LZ	MG
V1	10.02.22	Final report	TP/JK/LZ	MG

1 Introduction

1.1 Project Background

Blayney Shire Council (Council) have recently determined to update the Blayney (Town) Flood Study (Jacobs, 2015) and Floodplain Risk Management Study and Plan for Blayney (Jacobs, 2016). The update is to address the recommendations set out in the Blayney Flood and Floodplain Management Study Peer Review (Storm, 2021).

Council has developed a flood study for the township of Blayney noted as the *Blayney Flood Study – Flood Study Report – Rev 2* (Jacobs, 2015) which provided details of the Belubula River flood behaviour and the overland flood behaviour affecting the town of Blayney. This Flood Study was primarily undertaken in accordance with Australian Rainfall and Runoff 1987 which has since become obsolete and replaced with the Australian Rainfall and Runoff 2019 (ARR19) guidelines.

Following this, a flood risk management study was prepared and noted as *Floodplain Risk Management Study and Floodplain Risk Management Plan for Blayney – Rev 04*' (Jacobs, 2016). This provided further details on the existing flood behaviour within the Blayney township and proposed nine detention basins, to manage the overland flooding of the Blayney township.

Subsequently a peer review was undertaken of the above-mentioned studies and noted as '*Blayney Flood and Floodplain Management Study Peer Review Report* (Storm, 2021) which reviewed the modelling approaches and provided recommendations for improvement. These are further discussed in Section 1.2 Objectives and Scope.

1.2 Objectives and Scope

The objective of this report is to document the update of the existing Flood Study Report from the outdated AR&R 1987 standards to the current AR&R 2019 standards. This addendum report is an extension of the modelling carried out in the Blayney (Town) Flood Study (Jacobs, 2015) which should be referenced for background information and the development of modelling components.

Specifically, the following recommendations of the *Blayney Flood and Floodplain Management Study Peer Review Report* (Storm, 2021) will be addressed in this report:

- *It is recommended that the RAFTS design flow estimates for the Belubula River catchment and Blayney be updated in accordance with the recent updates in Australian Rainfall and Runoff (2019).*
- *It is recommended that the design flood levels for the Belubula River and across the town of Blayney be updated and revised using the design flows obtained with ARR (2019).*
- *It is recommended that Jacobs' TUFLOW hydraulics model be updated to incorporate the main stormwater drainage lines discharging into the Belubula River, which are currently not in Jacobs' model.*

The existing hydrologic and hydraulic models (RAFTS and TUFLOW) will be updated using ARR19 methodology for the following storm events:

- 20% AEP – 25min, 3hr, 9hr, 30hr, 36hr

- 5% AEP - 25min, 1hr, 6hr, 30hr, 36hr
- 1% AEP – 25min, 1h, 2hr, 6hr

This report outlines the modelling approach and results of the ARR19 flood modelling for Blayney.

2 Flood Study

2.1 Introduction

This flood study is an extension of the original Blayney (Town) Flood Study (Jacobs, 2015). The hydrologic and hydraulic models prepared by Jacobs were updated to be in accordance with ARR19 so that a like for like comparison can be made between the original flood results and the results of this study.

2.2 Study Area

The '*Blayney Flood Study – Flood Study Report – Rev 2*' (Jacobs, 2015) study area focused on the riverine flood behaviour of the Belubula River to downstream Carcoar Dam and the overland flow within the Blayney township.

The study catchment area stretches from the uppermost streams forming the Belubula River to the downstream Carcoar Dam. The total study catchment area is approximately 160 km^2 and is presented in Figure 1.

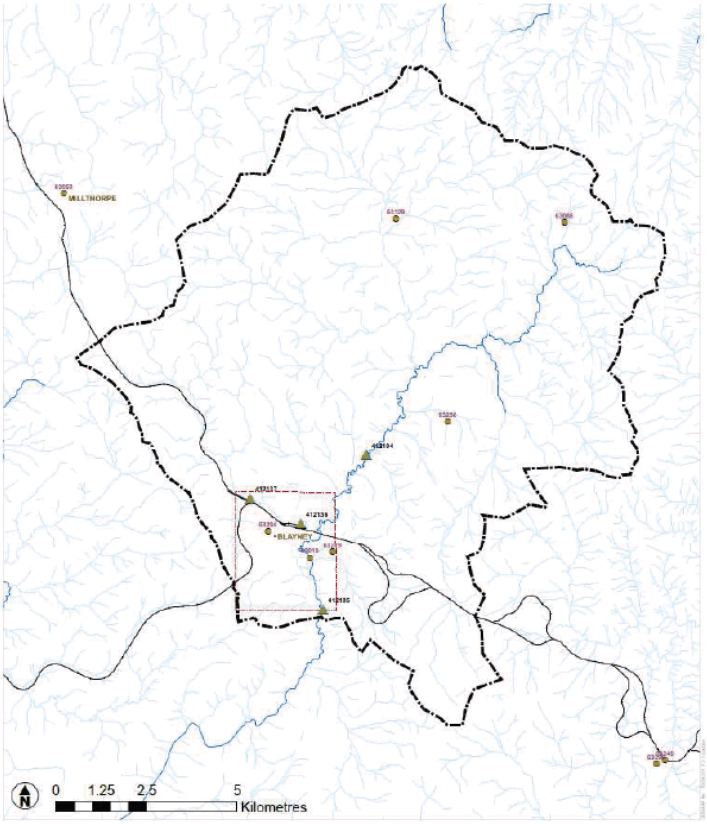


Figure 1 Belubula River Catchment Extent (to Carcoar Dam) *Source: Jacobs Flood Study*

2.3 Nature of Flooding

The town of Blayney is located adjacent to the Belubula River. The river is flood prone due to the large upstream contributing catchments and as such there are little practical options to attenuate the static flood levels from the rising Belubula River during rain events.

While properties close to the Belubula River are at high risk from the rising Belubula River floodwaters, properties away from the Belubula River are also at risk from overland flooding as a result of the large upstream catchments draining through the Blayney township.

2.4 Available Existing Information

2.4.1 Belubula River & Blayney Catchment Mapping

Catchment delineations of the Belubula River and Blayney Town have been undertaken as part of the '*Blayney Flood Study – Flood Study Report – Rev 2*' (Jacobs, 2015).

2.4.2 Hydrologic/Hydraulic Models

RORB, XP-RAFTS and TUFLOW modelling has been undertaken as part of the '*Blayney Flood Study – Flood Study Report – Rev 2*' (Jacobs, 2015). The RORB hydrological model of the river catchments has been integrated into the XP_RAFTS model by Jacobs as direct inflow hydrographs. The XP-RAFTS and TUFLOW models used in this flood study have been provided by Jacobs to be updated by Storm.

The following 'existing scenario' XP-RAFTS models have been supplied by Council/Jacobs:

- 20% AEP – 25min, 3hr, 9hr, 30hr, 36hr
- 5% AEP - 25min, 1hr, 6hr, 30hr, 36hr
- 1% AEP – 25min, 1h, 2hr, 6hr

3 Hydrologic Modelling

Two separate hydrologic model (XP-RAFTS) scenarios have been prepared for this study. These are the 'existing' and 'proposed' scenarios. The 'existing' scenario is defined as the scenario adopting 'existing' catchment assumptions in the '*Blayney Flood Study – Flood Study Report – Rev 2*' (Jacobs, 2015). The 'existing' scenario models have been amended to ARR19 procedures as described in the following sections.

The 'proposed' scenario is defined as the scenario generally adopting the catchment assumptions from the '*existing*' scenario but with the addition of proposed future developments and stormwater drain upgrades. This will reflect the runoff from the township in the near future and should be adopted for future flood scenarios. The 'proposed' scenario model follows ARR19 procedures as described in the following sections.

3.1 Catchment Mapping and Parameters

Catchment mapping undertaken by Jacobs in '*Blayney Flood Study – Flood Study Report – Rev 2 - Appendix C: Figure C002*' (Jacobs, 2015) has been adopted and applied to the *XP-RAFTS* model.

Catchment parameters in the 'existing' and 'proposed" scenarios including catchment areas, slope and fraction imperviousness remain unchanged to the parameters adopted in the Flood Study (Jacobs, 2015). However, the fraction imperviousness of the catchments in the 'proposed' scenario have been increased to reflect future development of these areas (see Table 1 below – changed figures shown in red)

Table 1 'Proposed' Scenario catchments with increased %Imperviousness

Catchment ID	%Impervious (Existing Scenario)	%Impervious (Proposed Scenario)
C0	5	5
C1	5	5
C2	5	5
C3	5	5
C4	5	5
C5	5	5
C6	5	5
C7	5	5
C8a	22	22
C8b	11	11
C9a	5	5
C9b	5	5
C10a	8	8
C10b	5	5
C11	5	5

C12	5	5
C13	5	5
C14a	15	15
C14b	17	17
C15a	38	38
C15b	34	34
C16	19	19
C17a	34	34
C17b	19	19
C18	5	5
C19a	5	5
C19b	5	5
C20a	5	5
C20b	5	5
C21	5	5
C22	24	24
C23	29	29
C24	33	33
C25a	5	5
C25b	5	5
C25c	5	5
C25d	5	5
C26	43	43
C27	24	24
C28	5	25
C29	8	8
C30	5	20
C31	15	15
C32	10	25
C33a	48	48
C33b	38	38
C33c	5	5
C34	11	11
C35a	29	29
C35b	34	34
C35c	24	24

C36	19	19
C37a	5	20
C37b	5	20
C38a	5	20
C38b	5	20
C39	5	5
C40	5	5
C41	5	5
C42	5	5

3.2 Catchment Routing

Catchment routing (XP-RAFTS lag times), for both 'existing' and 'proposed' scenarios have been retained from the original *XP-RAFTS* models in '*Blayney Flood Study – Flood Study Report – Rev 2*' (Jacobs, 2015).

3.3 Design Flood Estimation Input Parameters

The 'existing' and 'proposed' XP-RAFTS models have been revised using ARR19 procedures.

3.3.1 Rainfall Depths (IFD)

Rainfall IFD depths have been sourced from ARR Datahub at location of Blayney town centre and is presented in Table 2.

Table 2 Adopted Rainfall IFD Depths (in mm) as per ARR19 Data

	Annual Exceedance Probability (AEP)		
Duration	**20%**	**5%**	**1%**
25 min	19.2	26.4	35.3
1 hour	26	35.4	46.8
3 hour	36.5	48.9	63.9
6 hour	46	61.1	79.5
9 hour	53.1	70.2	91.2
30 hour	80.3	106	136
36 hour	84.9	112	144

3.3.2 Temporal Patterns

Temporal patterns have been sourced from ARR Datahub at location of Blayney town centre. A total of ten temporal patterns are provided for each storm duration.

3.3.3 Design Rainfall Losses

The Initial Loss/Continuing Loss (IL/CL) model was adopted for the 'rural' and 'developed' land type and for the pervious and impervious portions of each land type as presented in Table 3.

Table 3 Adopted IL/CL as per ARR19 Data

	PERVIOUS		IMPERVIOUS	
	IL	CL	IL	CL
RURAL	REFER Table 6 FOR PREBURST MODIFIED LOSS	2*	1**	0**
URBAN	14.4****	2***	1**	0**
	* 0.4 multiplier to ARR Datahub CL losses (Refer Table 4) as per ARR Datahub 'NSW Specific Data Info' ** Retained from Jacobs Flood Study *** ARR19 recommends typical 2.5mm/h with 1-3mm/h range for S.E Aust. 2mm/h adopted **** ARR19 recommends 60-80% of ARR Datahub IL. 60% adopted			

ARR87 modelling generally assumed the ground was dry at the beginning of a storm event. In reality, rainfall may have occurred prior to the main rainfall burst resulting in wetter (more saturated) soil conditions. This in turn results in surface runoff occurring sooner. ARR19 takes this into account by modifying initial losses with "pre-burst" losses to obtain the Pre-burst Modified Loss.

The Pre-burst Modified Loss (refer Table 6) is calculated by subtracting Pre-Burst Loss (refer Table 5) from the Initial Loss (refer Table 4) for each storm duration/AEP.

Table 4 ARR Datahub Storm Losses ARR19 for Blayney

ARR DATAHUB STORM LOSSES	
INITIAL LOSS (mm)	24
CONTINUING LOSSES (mm/h)	5

Table 5 ARR Datahub Median Pre-burst Loss Depths (mm) for Blayney

ARR DATAHUB MEDIAN PREBURST DEPTHS (mm)			
Durn/AEP	20% AEP	5% AEP	1% AEP
25m	1.1	1.3	1.4
1h	-	1.3	1.4
2h	-	-	1
3h	1	-	-
6h	-	0.7	4.2
9h*	0.8	-	-
30h*	0	0	-
36h	0	0	-
* Loss Value interpolated			

Table 6 Adopted Pre-Burst Modified Initial Loss for Blayney

PREBURST MODFIED IL (mm)

	20% AEP	5% AEP	1% AEP
25m	22.9	22.7	22.6
1h	-	22.7	22.6
2h	-	-	23
3h	23	-	-
6h	-	23.3	19.8
9h	23.2	-	-
30h	24	24	-
36h	24	24	-

The pre-burst modified initial losses were input into the XP-RAFTS hydrologic models to obtain hydrographs for each storm event.

3.4 Hydrologic Model Methodology

The source of flooding within the Blayney township is largely attributed to the surface runoff within the township's catchments and from the external catchments upstream of the township. The Belubula River mostly affects the lower (eastern) parts of the town which in turn creates a tailwater restriction for the drainage of Blayney.

The Belubula River has a long hydrograph and accounts for the majority of flow in the overall hydrologic model. This skews the data when choosing a 'critical' storm for the overall study. The runoff from the town is relatively minor compared to the flow in the Belubula River.

To determine the critical storm of the overland flooding within the Blayney township, the direct river inflow hydrograph and contributing Belubula River catchments (Catchments C, C0, C1, C10a, C10b, C11, C12 and C18 shown in red in Figure 2) were temporarily removed from the hydrologic model. This allowed for more appropriate critical storms to be chosen for hydraulic modelling. They were reinstated once the critical storms were observed.

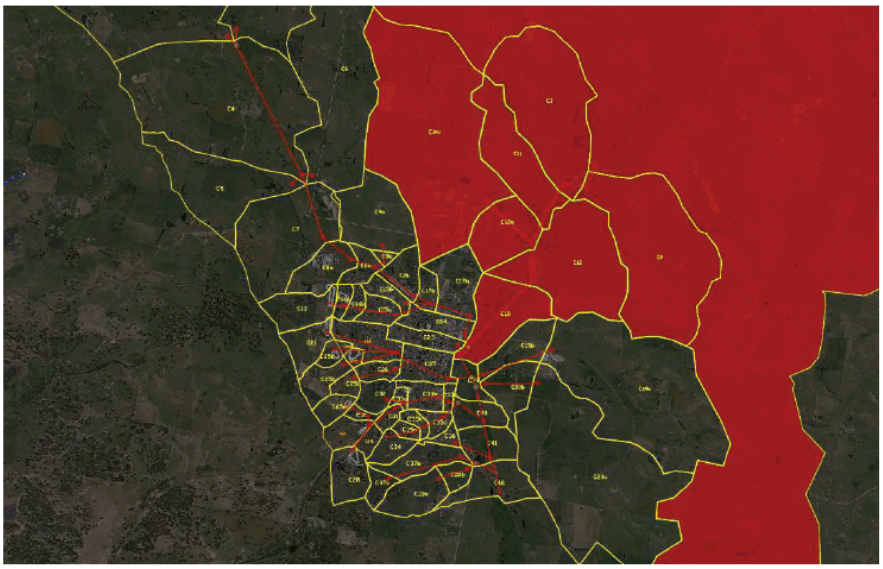


Figure 2 XP-RAFTS Model Layout with Belubula River Catchments Removed

The 20%, 5% and 1% AEP storms were then run for each duration as adopted in Jacobs Flood Study. This allows for direct comparison with the original flood modelling. For each duration, the temporal pattern corresponding to the median peak flow (as per ARR19) was assigned as the critical temporal pattern for that duration at the most downstream node (Node C42) in the model.

To determine the critical duration for each AEP, the duration producing the largest median peak flow was chosen. The 'existing' scenario critical durations for each AEP is shown in Table 7 below.

Table 7 'Existing' scenario critical durations for each AEP at Node C42

EXISTING MODEL (Without Belubula River Catchment)		
	Median Total Flow (m^3/s)	Median Temporal Pattern
20%AEP*		
25m	6.11	#8
3h	29.69	#7
9h	**37.54**	**#3**
30h	35.07	#3
36h	35.14	#2
5%AEP*		
25m	15.4	#9
1h	39.79	#5

6h	**77.69**	**#7**
30h	52.89	#7
36h	50.32	#2
1%AEP*		
25m	42.16	#2
1h	78.85	#8
2h	114.24	#8
6h	**128.85**	**#7**

The 'proposed' scenario critical durations for each AEP is shown in Table 8.

Table 8 'Proposed' scenario critical durations for each AEP at Node C42

PROPOSED MODEL (Without Belubula River Catchment)		
	Median Total Flow (m^3/s)	Median Temporal Pattern
20%AEP*		
25m	11.06	#8
3h	29.89	#7
9h	**38.07**	**#3**
30h	35.41	#3
36h	35.49	#2
5%AEP*		
25m	22.06	#3
1h	38.29	#9
6h	**76.68**	**#7**
30h	53.46	#7
36h	50.14	#2
1%AEP*		
25m	42.95	#1
1h	79.01	#2
2h	114	#8
6h	**128.98**	**#7**

4 Hydraulic Modelling

4.1 Model Development

As part of the original flood study '*Blayney Flood Study – Flood Study Report – Rev 2*' (Jacobs, 2015) a hydraulic model was created using TUFLOW to determine flood behaviour in 2D and provide flood maps. The original TUFLOW model was adopted for this study as the foundation for detailed hydraulic modelling.

The hydraulic model was setup to represent the flood behaviour under existing conditions (as per original Flood Study) and a proposed development condition which was used to assess the flood conditions for the 20% AEP, 5% AEP, and 1% AEP storm events as discussed in Section 2.4.2. The modelled storm durations for the 20% AEP, 5% AEP and 1% AEP storms were unchanged from the existing Jacobs flood study.

4.2 Existing Conditions

The following modelling elements were modified from the Jacobs flood study and adopted for the existing conditions scenario:

1. The TUFLOW software version was updated to the latest at the time of modelling (2020-10-AB).
2. As the RAFTS hydrological model was updated in accordance with ARR19, the hydrograph inflows to the source area boundary conditions were updated, however the sub-catchment and boundary condition delineations remain unchanged.
3. Additional stormwater drainage data was added to the model as a 1D network to convey flows throughout the township.
    a. Pit and pipe sizes, invert levels and locations were based on detailed survey by Craig & Rhodes (2020).
    b. No pit or pipe blockages were assumed as is consistent with the other existing 1D network elements from the original Flood Study.

All other model inputs and assumptions were adopted as per the Jacobs flood study.

4.3 Proposed Development Conditions

The following model elements were adopted for the proposed conditions scenario:

1. The sub-catchment delineations in the RAFTS hydrological model were modified in accordance with future proposed developments in Blayney (as per Table 1 in Section 3.1), and subsequently the source area boundary conditions were modified to reflect these catchments accordingly.
2. The 1D network was updated with a stormwater drainage network from Oliver Street, discharging to a culvert underneath Orange Road.
    a. Pit and pipe sizes, invert levels and locations were based on detailed design by Craig & Rhodes (2021).
    b. No pit or pipe blockages were assumed as is consistent with the existing 1D network elements.

c. The terrain at the downstream end of the 1D network was smoothed out to allow the pipe to discharge to the surface.

All other modelling elements remain unchanged from the existing conditions model.

4.4 Results Mapping

4.4.1 Introduction

The hydraulic model was run for the exiting and proposed scenarios for the following storms:

- 20% AEP – 25min, 3hr, 9hr, 30hr, 36hr
- 5% AEP - 25min, 1hr, 6hr, 30hr, 36hr
- 1% AEP – 25min, 1h, 2hr, 6hr

Flood maps were developed and are shown in **Appendix A and Appendix B.**

4.4.2 Flood Depth and Level Mapping

Flood depths and levels of the existing condition are shown in **Appendix A** as Maps 01-03 for the 20%, 5% and 1% storms. They represent the combination of the modelled storm durations for each AEP.

Upon review, the 20% AEP storm shows minor flooding within the north-west and central regions of Blayney. The Belubula River shows more significant flood depth which partially impacts the town in the north-eastern regions. The 5% AEP storm shows further flooding within the central and north-western portions of Blayney with increased flooding along Plumb St.

The 1% AEP storm shows more widespread flooding particularly along the Orange/Church St corridor and the Plumb/Water Street corridor. More significant flooding is experienced along the eastern edge of Blayney due to the inundation from Belubula River.

Flood depths and levels of the proposed condition are shown in **Appendix B** as Maps 11-13 for the 20%, 5% and 1% storms. The results between the existing and proposed scenarios are very similar with only minor differences.

4.4.3 Flow Velocities

Flood velocities of the existing condition are shown in **Appendix A** as Maps 04-06 for the 20%, 5% and 1% storms. Apart from the more significant velocities along the Belubula River corridor, majority of the higher flow velocities (1m/s +) are mostly contained within road corridors.

Flood velocities of the proposed condition are shown in **Appendix B** as Maps 14-16 for the 20%, 5% and 1% storms. The results between the existing and proposed scenarios are very similar with only minor differences.

4.4.4 Hazard Maps

Hazard maps for the existing condition are shown in **Appendix A** as Maps 07-09 for the 20%, 5% and 1% storms. Hazard maps for the proposed condition are shown in **Appendix B** as Maps 17-19 for the 20%, 5% and 1% storms. These are shown for reference and are discussed in the *'Addendum to Blayney Floodplain Risk Management Study'* (Storm, 2021).

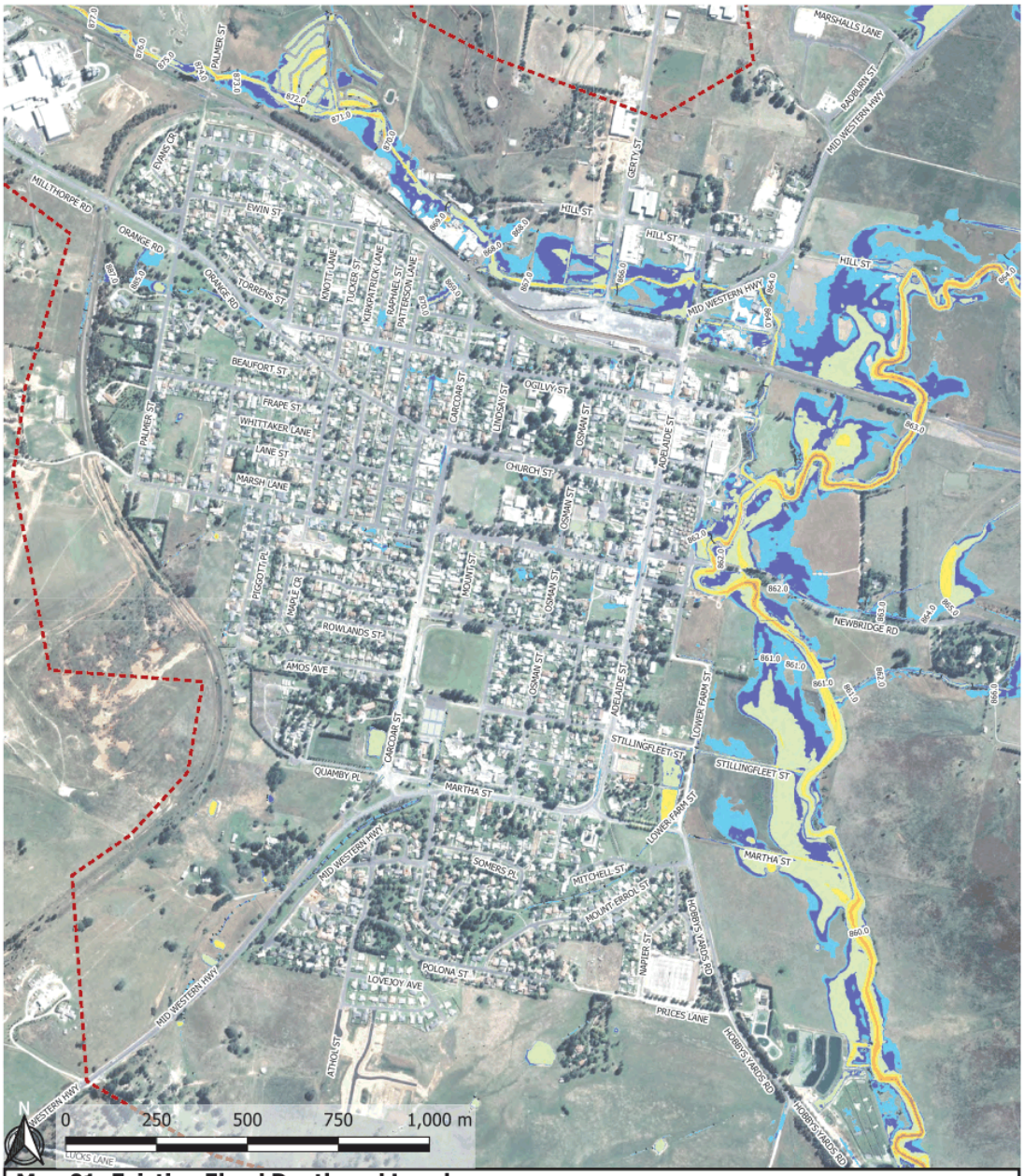
4.4.5 Change in Afflux between ARR87 and ARR19

An afflux map showing the water level differences between the ARR87 modelling and ARR19 modelling has been generated as Map 10 and shown in Appendix C. It shows a significant amount of change however the changes are relatively slight. For the most part, reductions are in the order of 0.01 to 0.2m throughout the township with only minor increases in depth in concentrated areas. These increases are primarily due to the higher rainfall runoff rates (as per ARR19 conditions) in the rural catchments to the west of town.

5 REFERENCES:

- '*Blayney Flood Study – Flood Study Report – Rev 2*' (Jacobs, 2015)
- '*Floodplain Risk Management Study and Floodplain Risk Management Plan for Blayney – Rev 04*' (Jacobs, 2016)
- '*Blayney Retarding Basins Study – Concept Design Report – Draft*' (Storm, 2021)
- *Blayney Flood and Floodplain Management Study Peer Review Report* (Storm, 2021)

APPENDICES



Map 01: Existing Flood Depth and Level
20% AEP Event (ARR 2019)

Legend

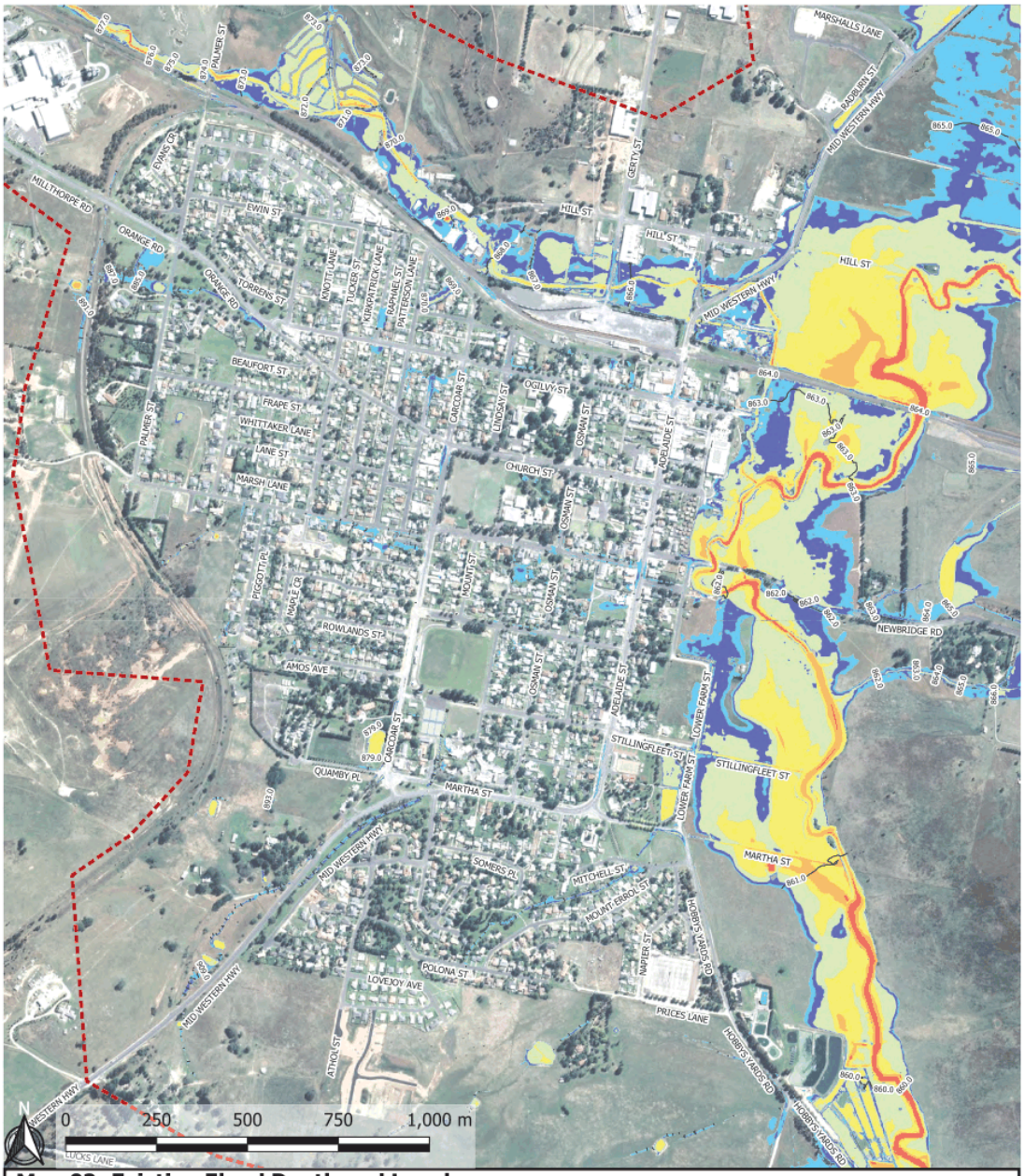
Flood Depth (m)
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary
1m Flood Level Contour (mAHD)

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 02: Existing Flood Depth and Level
5% AEP Event (ARR 2019)

Legend

Flood Depth (m)

- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

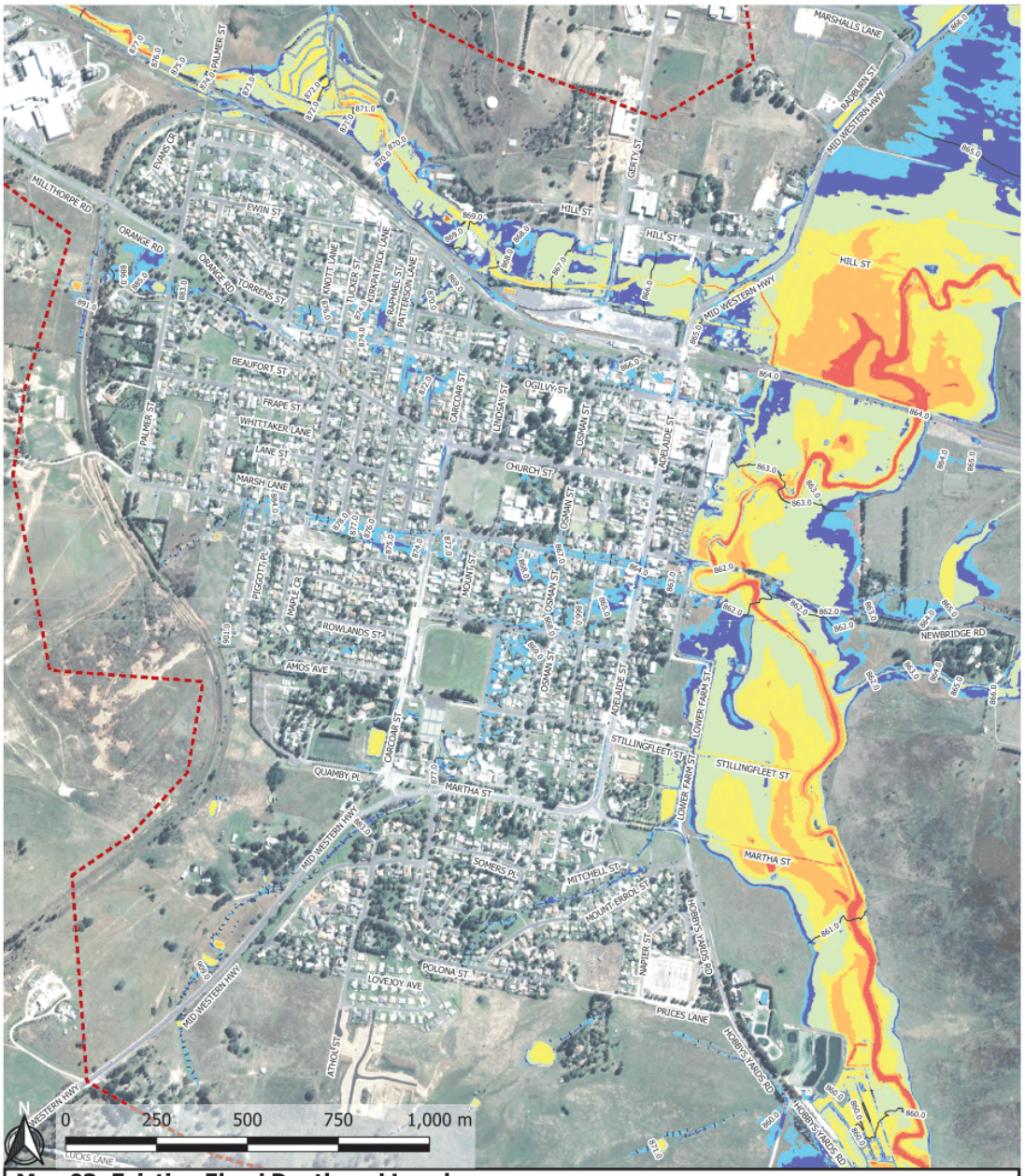
Model Boundary

1m Flood Level Contour (mAHD)

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 03: Existing Flood Depth and Level
1% AEP Event (ARR 2019)

Legend

Flood Depth (m)

- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

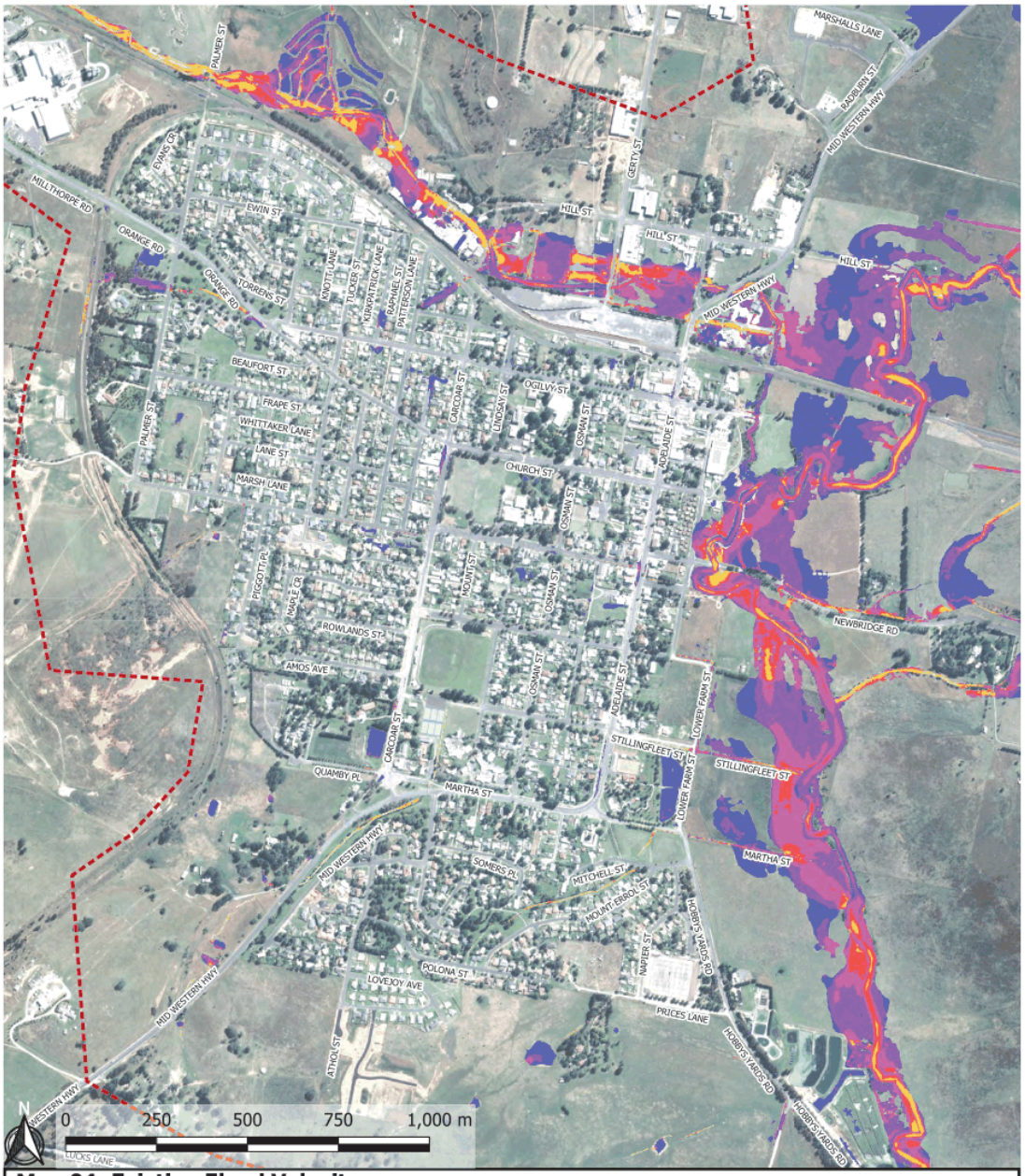
Model Boundary

1m Flood Level Contour (mAHD)

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 04: Existing Flood Velocity
20% AEP Event (ARR 2019)

Legend

Flood Velocity (m/s)

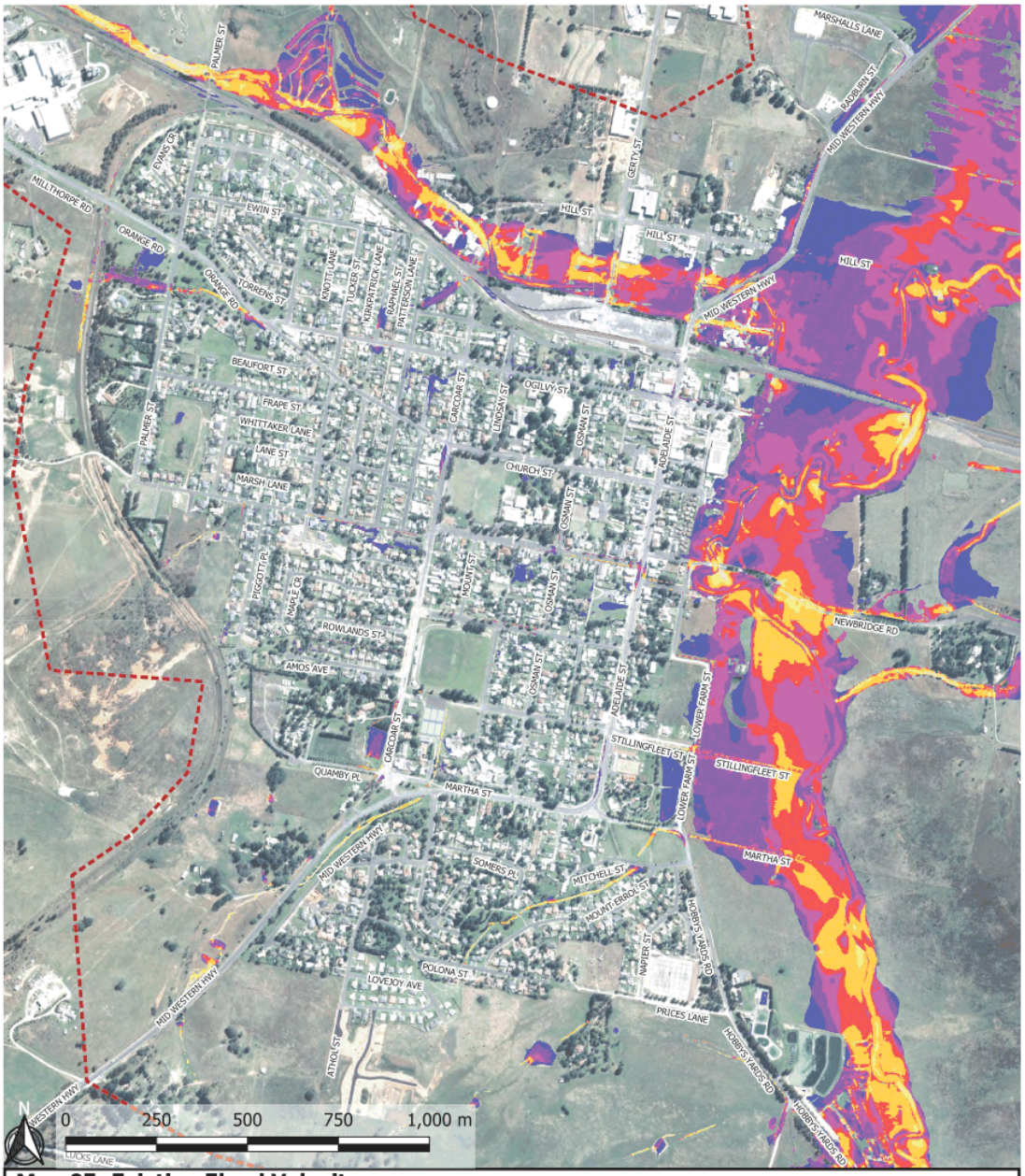
- 0.00 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 05: Existing Flood Velocity
5% AEP Event (ARR 2019)

Legend

Flood Velocity (m/s)

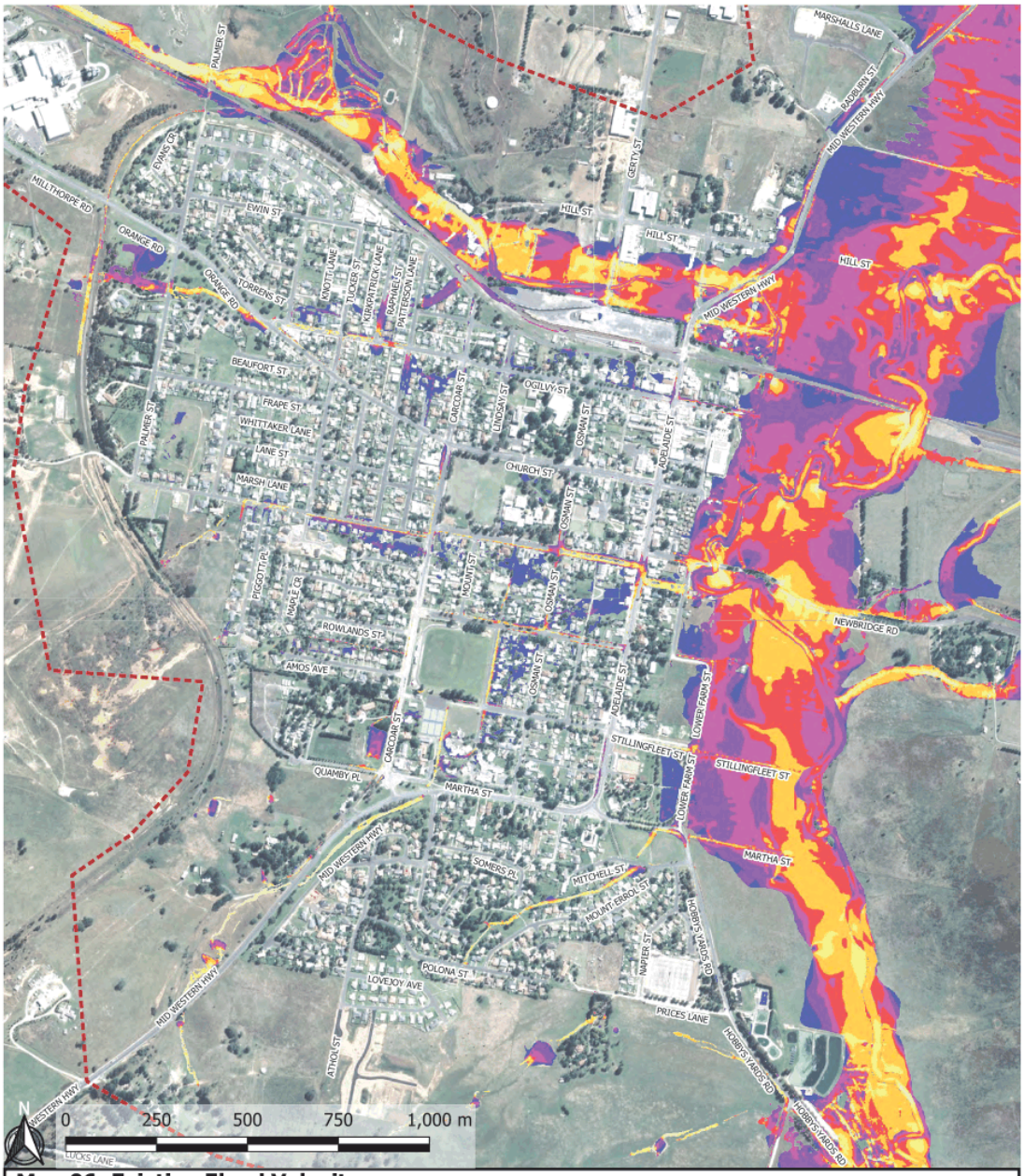
- 0.00 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 06: Existing Flood Velocity
1% AEP Event (ARR 2019)

Legend

Flood Velocity (m/s)

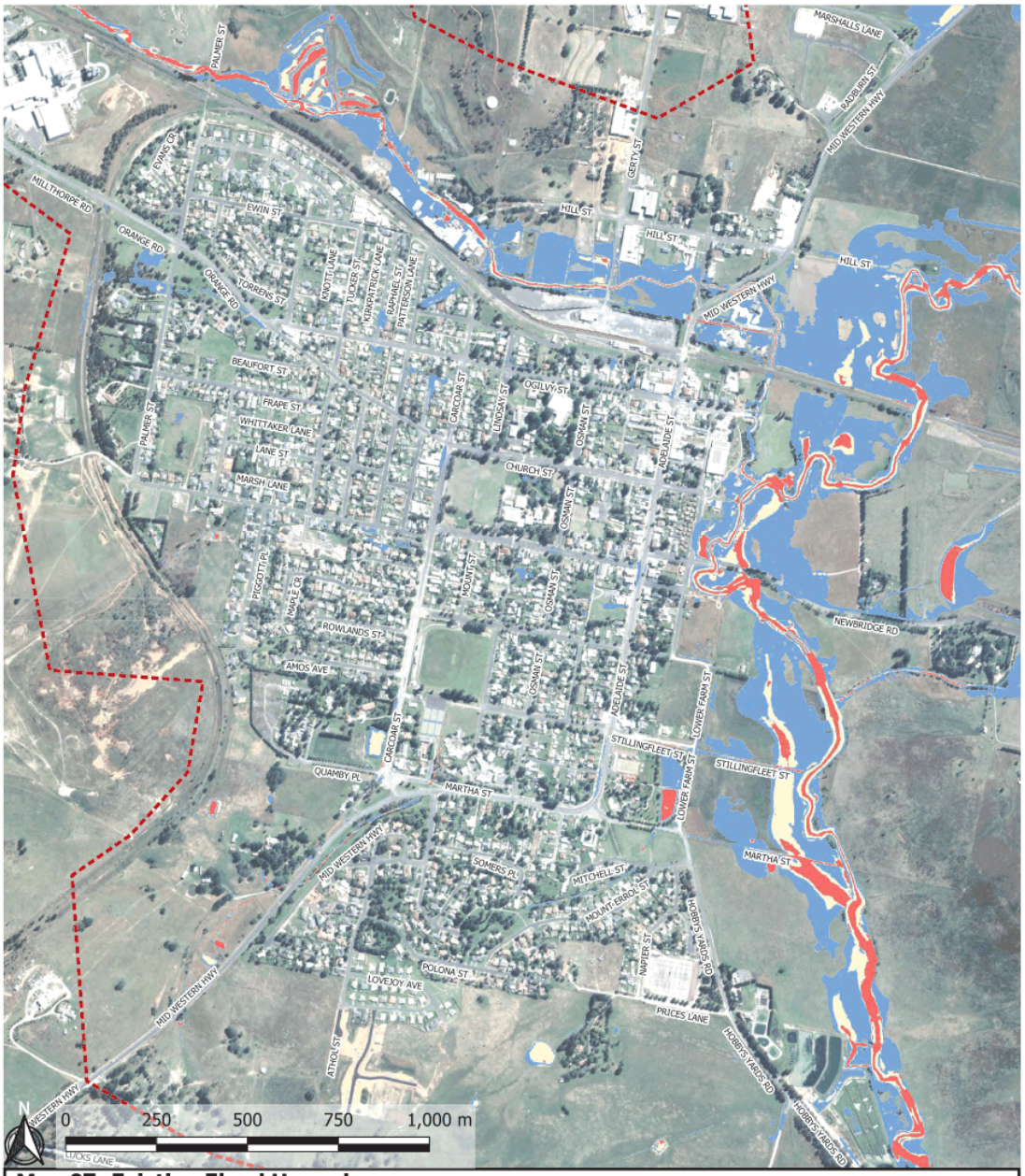
- 0.00 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 07: Existing Flood Hazard
20% AEP Event (ARR 2019)

Legend

Flood Hazard (FDM 2005)

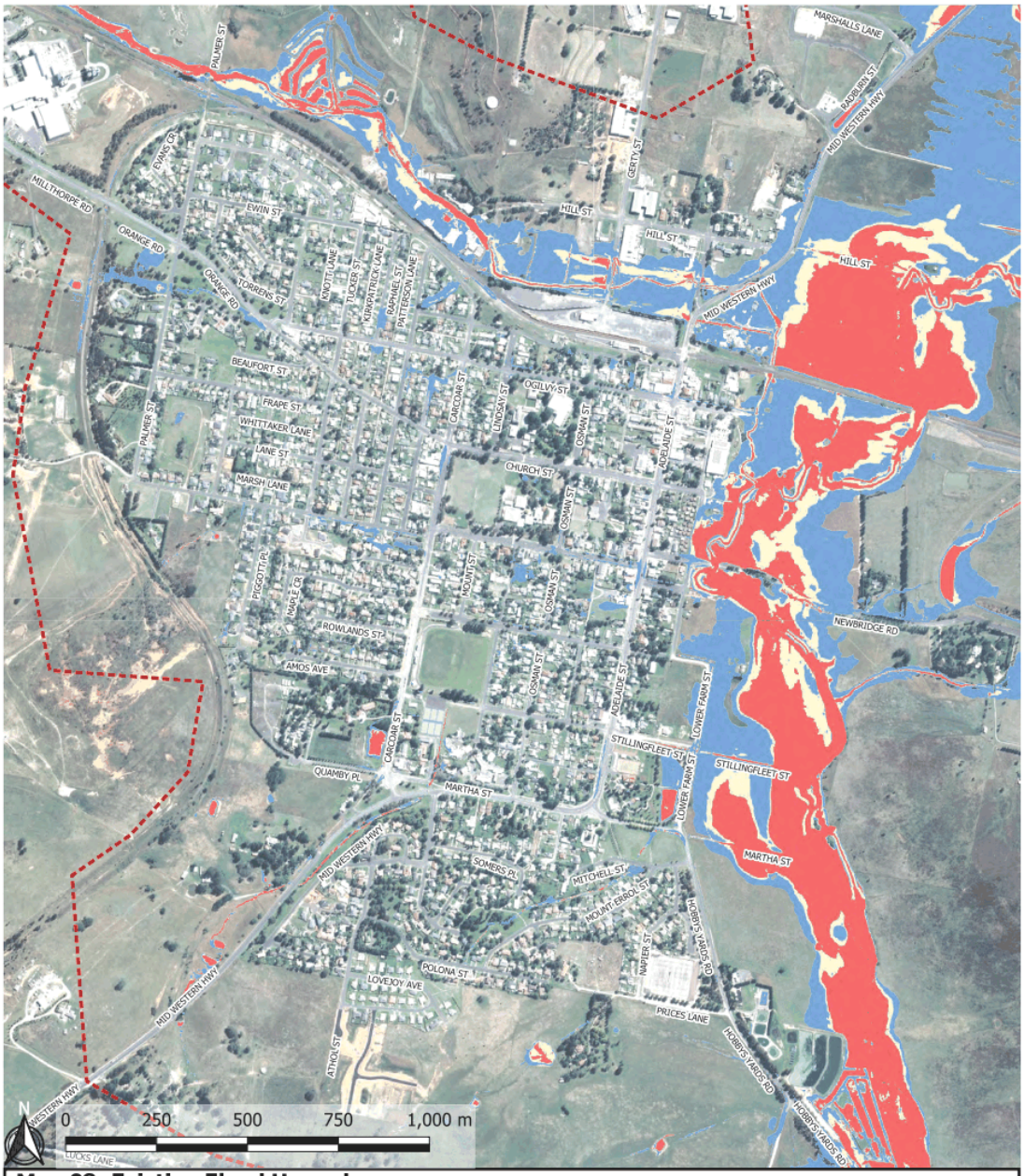
- Low Hazard
- Transitional Hazard
- High Hazard

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 08: Existing Flood Hazard
5% AEP Event (ARR 2019)

Legend

Flood Hazard (FDM 2005)

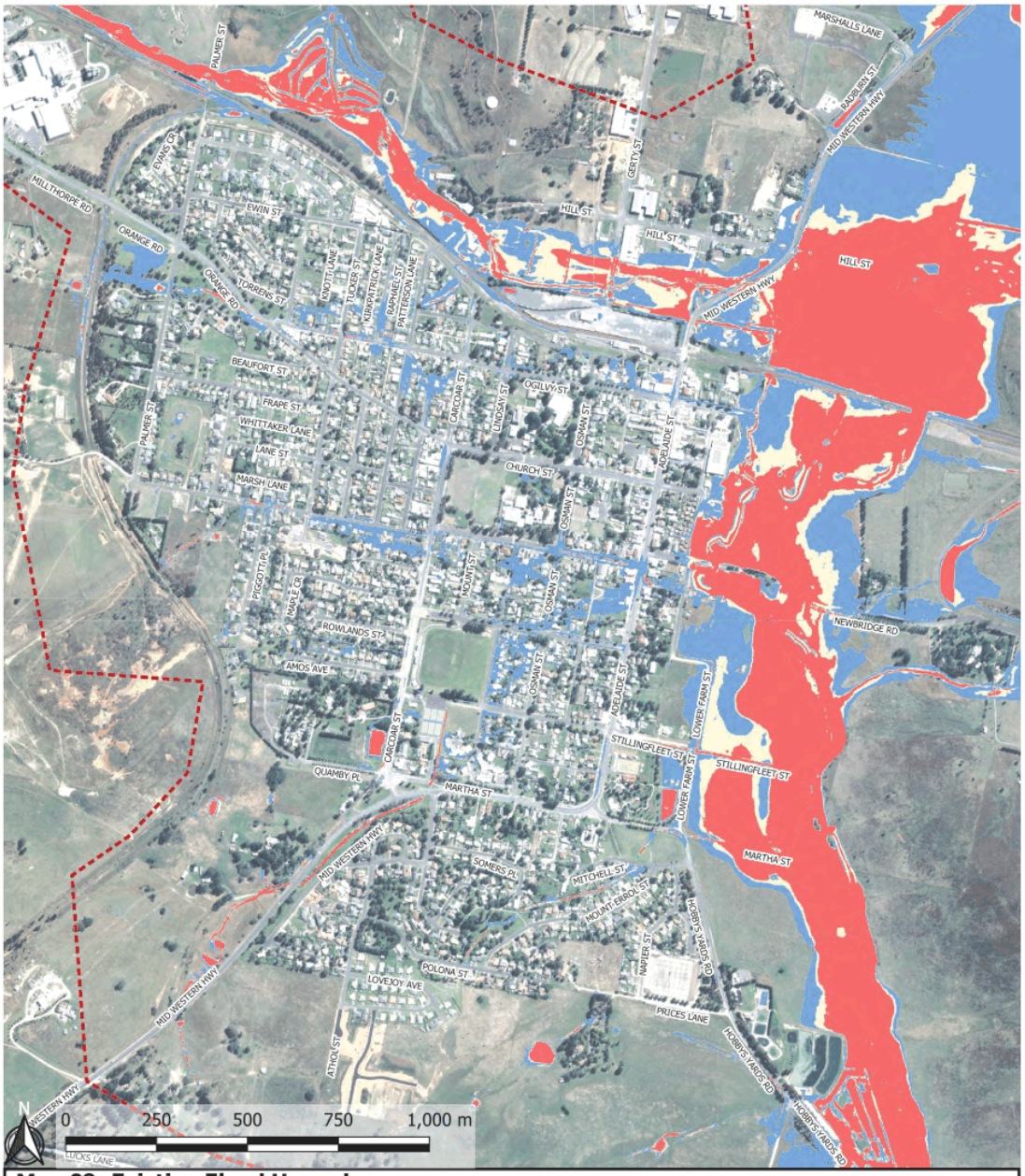
- Low Hazard
- Transitional Hazard
- High Hazard

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 09: Existing Flood Hazard
1% AEP Event (ARR 2019)

Legend

Flood Hazard (FDM 2005)

- Low Hazard
- Transitional Hazard
- High Hazard

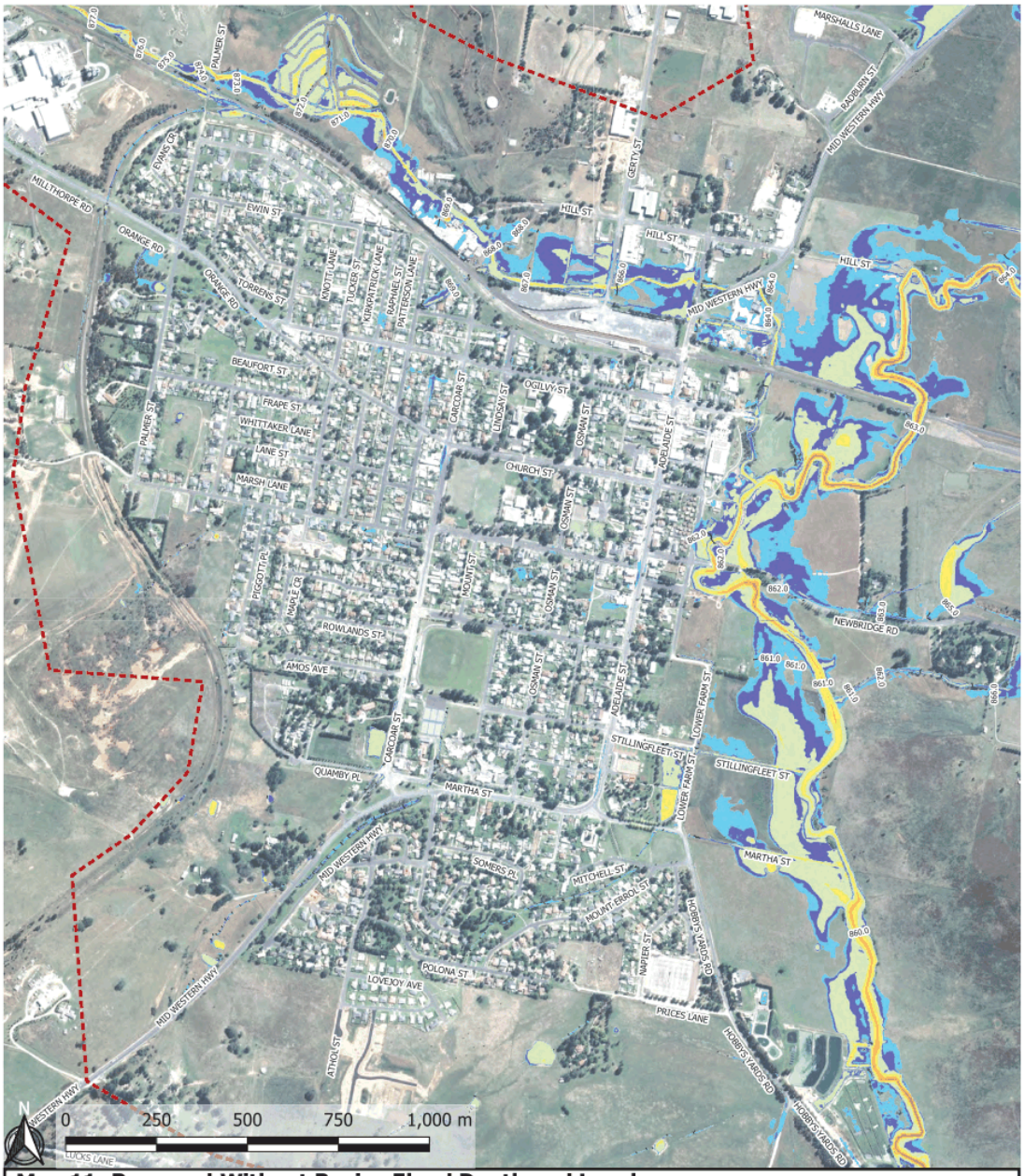
Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm

Appendix B – Flood Mapping of the Proposed Conditions



Map 11: Proposed Without Basins Flood Depth and Level
20% AEP Event (ARR 2019)

Legend

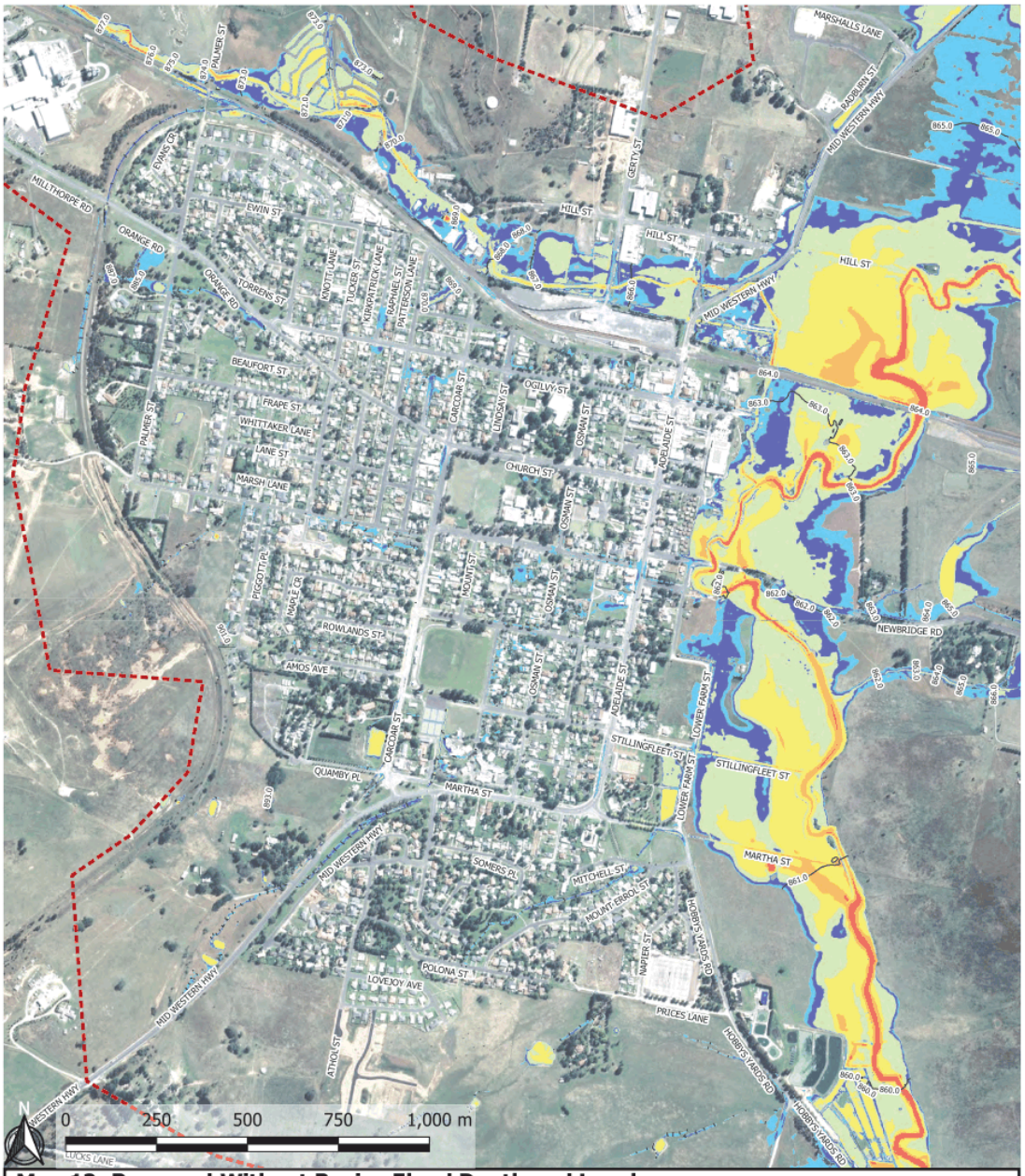
Flood Depth (m)
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary
1m Flood Level Contour (mAHD)

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 12: Proposed Without Basins Flood Depth and Level
5% AEP Event (ARR 2019)

Legend

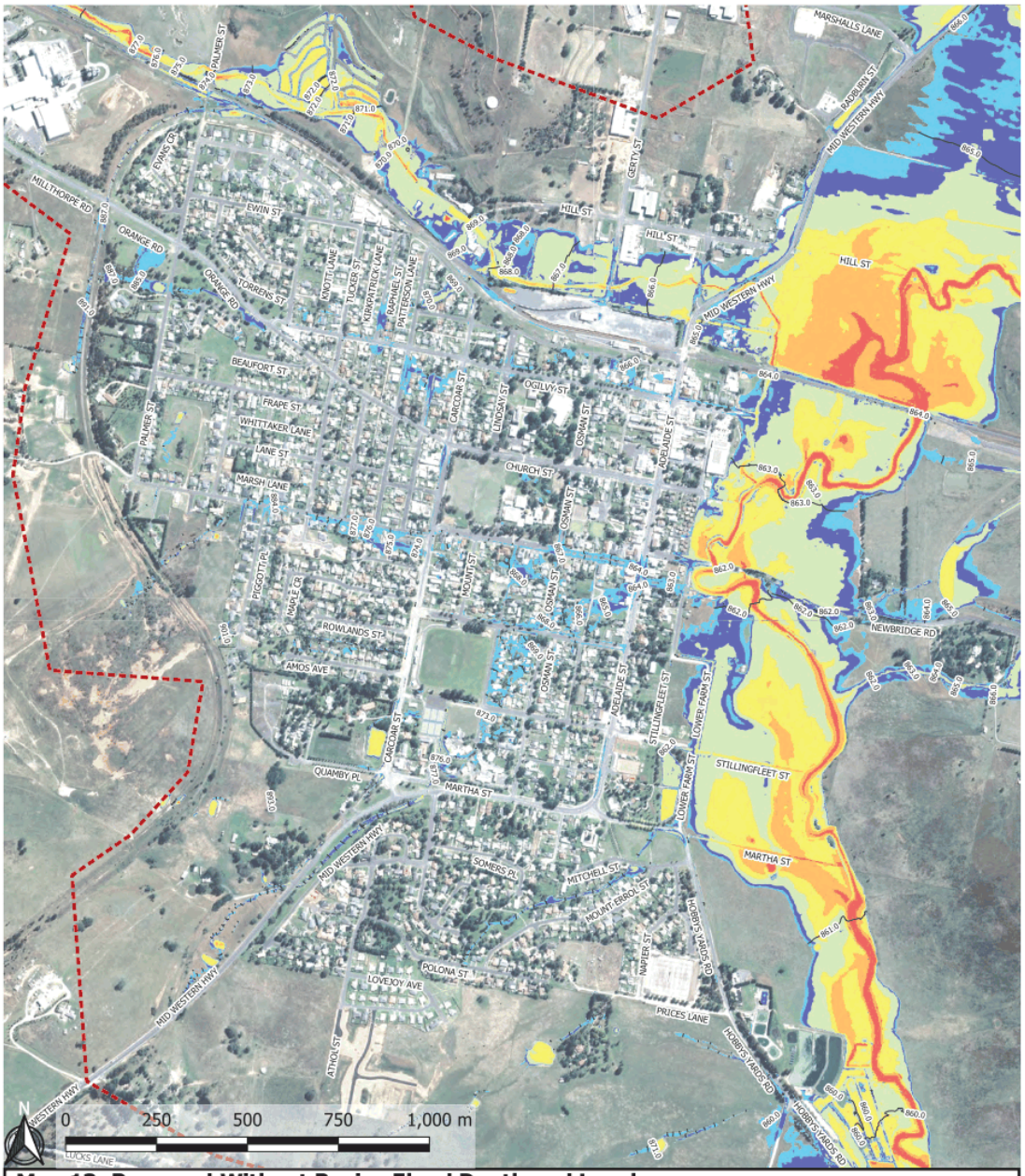
Flood Depth (m)
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary
1m Flood Level Contour (mAHD)

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 13: Proposed Without Basins Flood Depth and Level
1% AEP Event (ARR 2019)

Legend

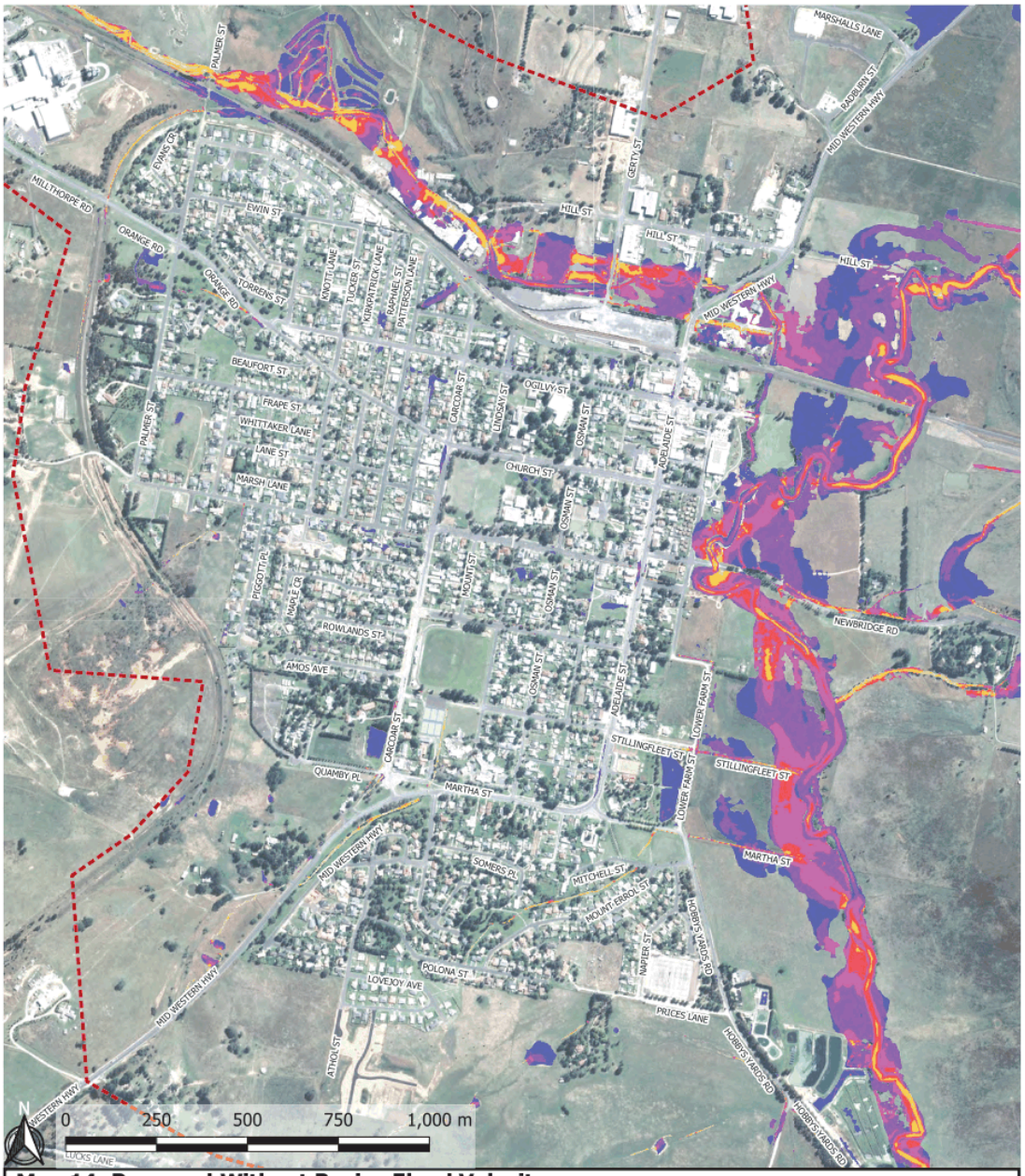
Flood Depth (m)
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary
1m Flood Level Contour (mAHD)

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 14: Proposed Without Basins Flood Velocity
20% AEP Event (ARR 2019)

Legend

Flood Velocity (m/s)

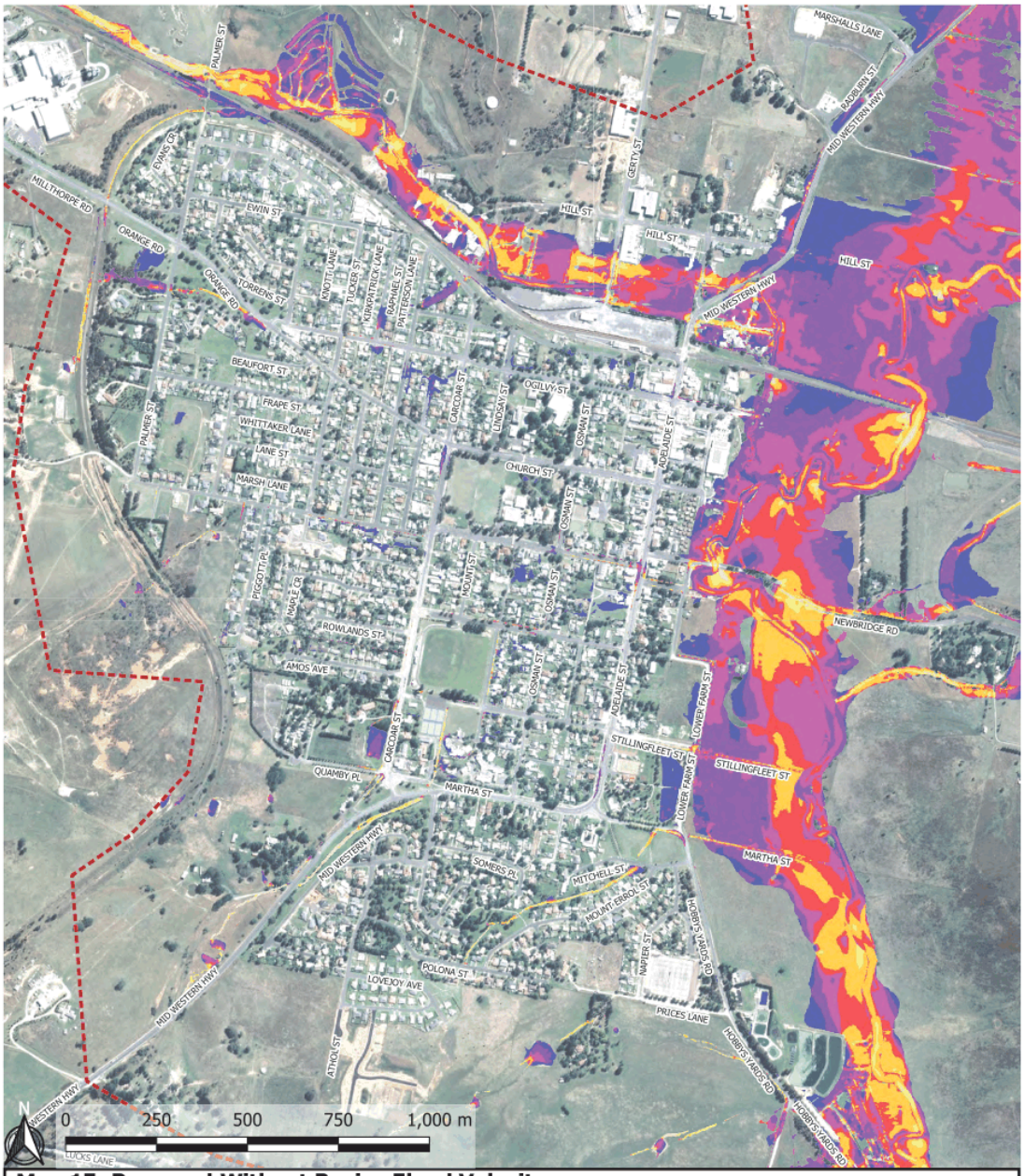
- 0.00 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 15: Proposed Without Basins Flood Velocity
5% AEP Event (ARR 2019)

Legend

Flood Velocity (m/s)

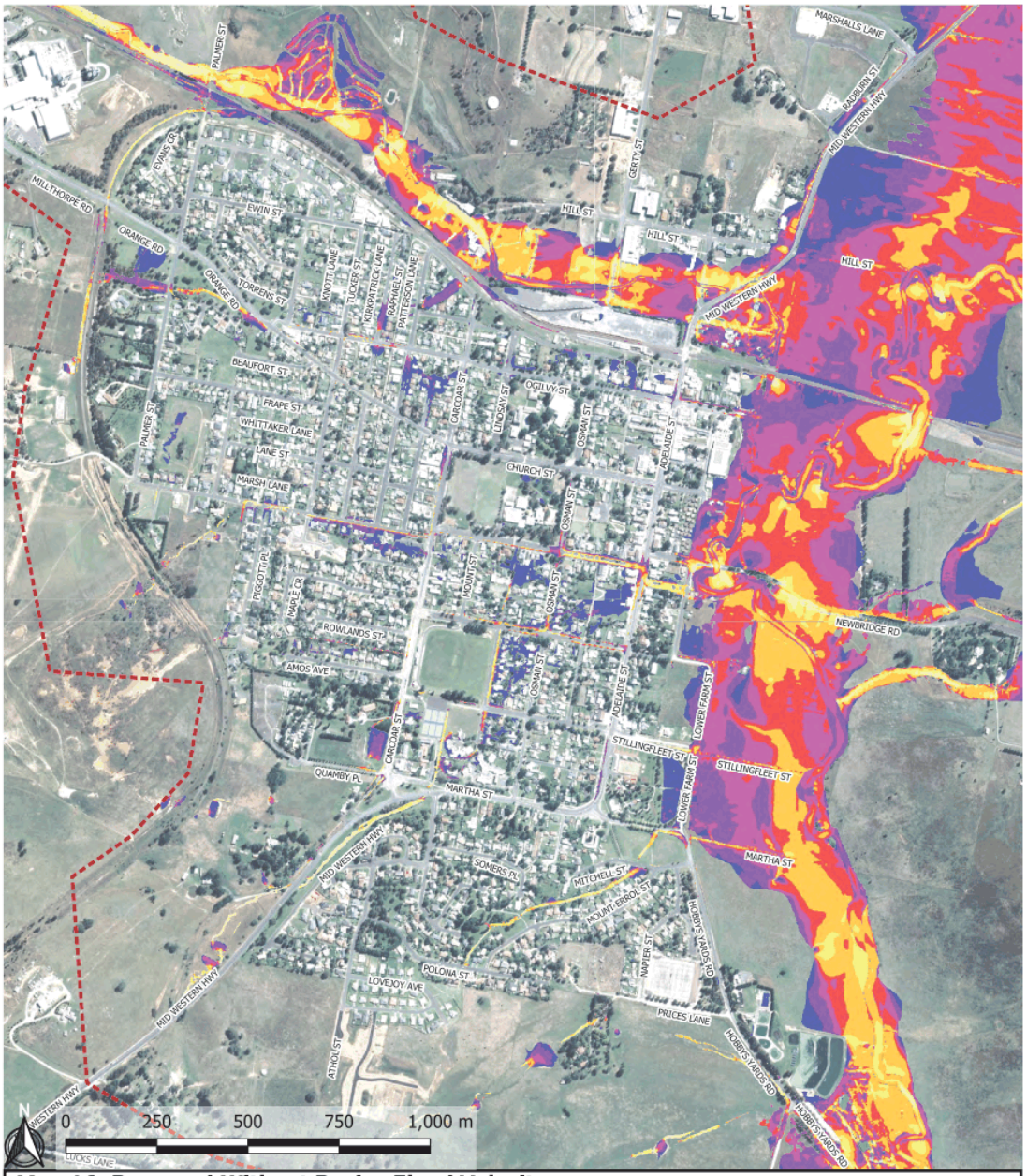
- 0.00 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 16: Proposed Without Basins Flood Velocity
1% AEP Event (ARR 2019)

Legend

Flood Velocity (m/s)

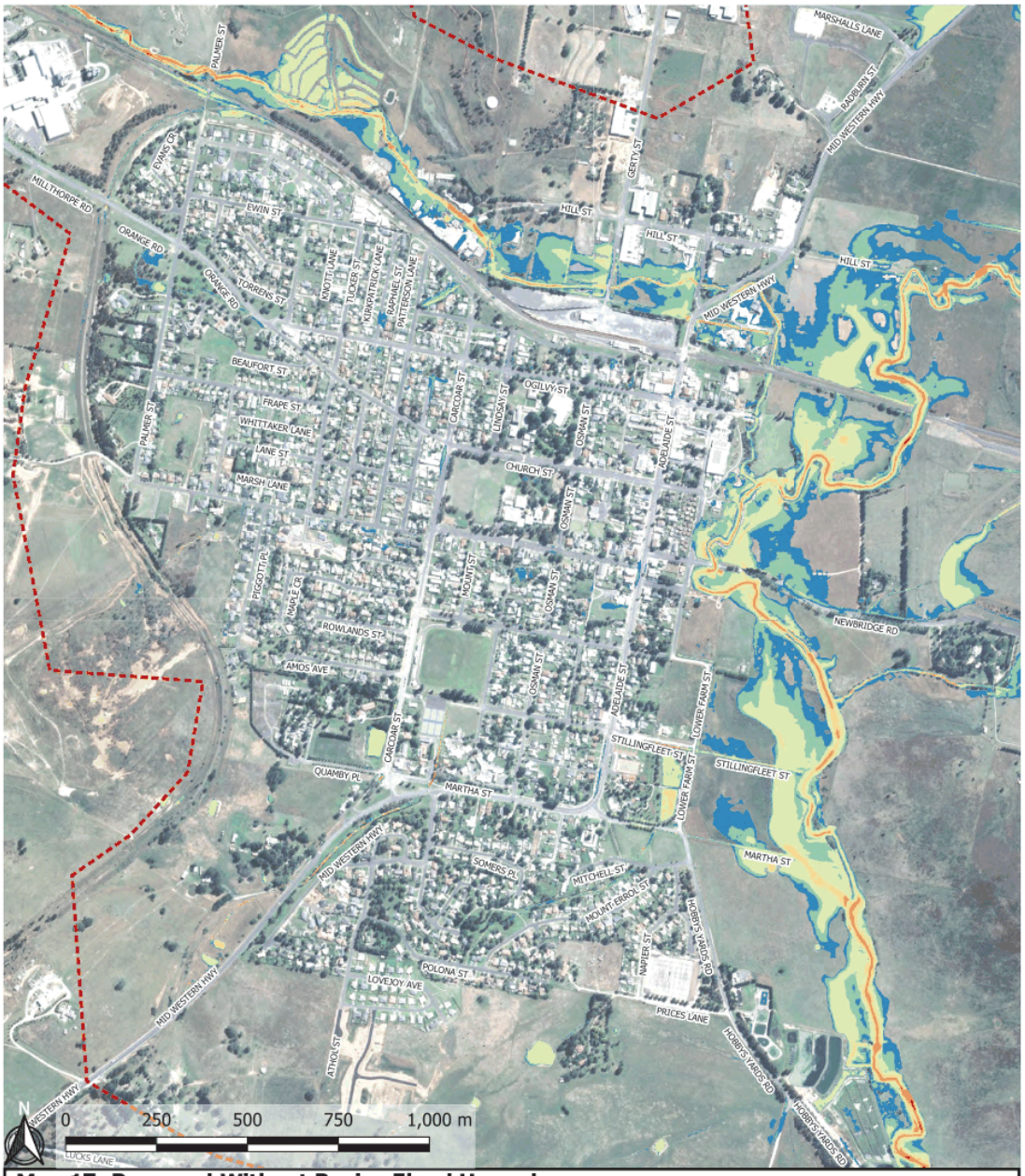
- 0.00 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 17: Proposed Without Basins Flood Hazard
20% AEP Event (ARR 2019)

Legend

Flood Hazard (ARR 2019)

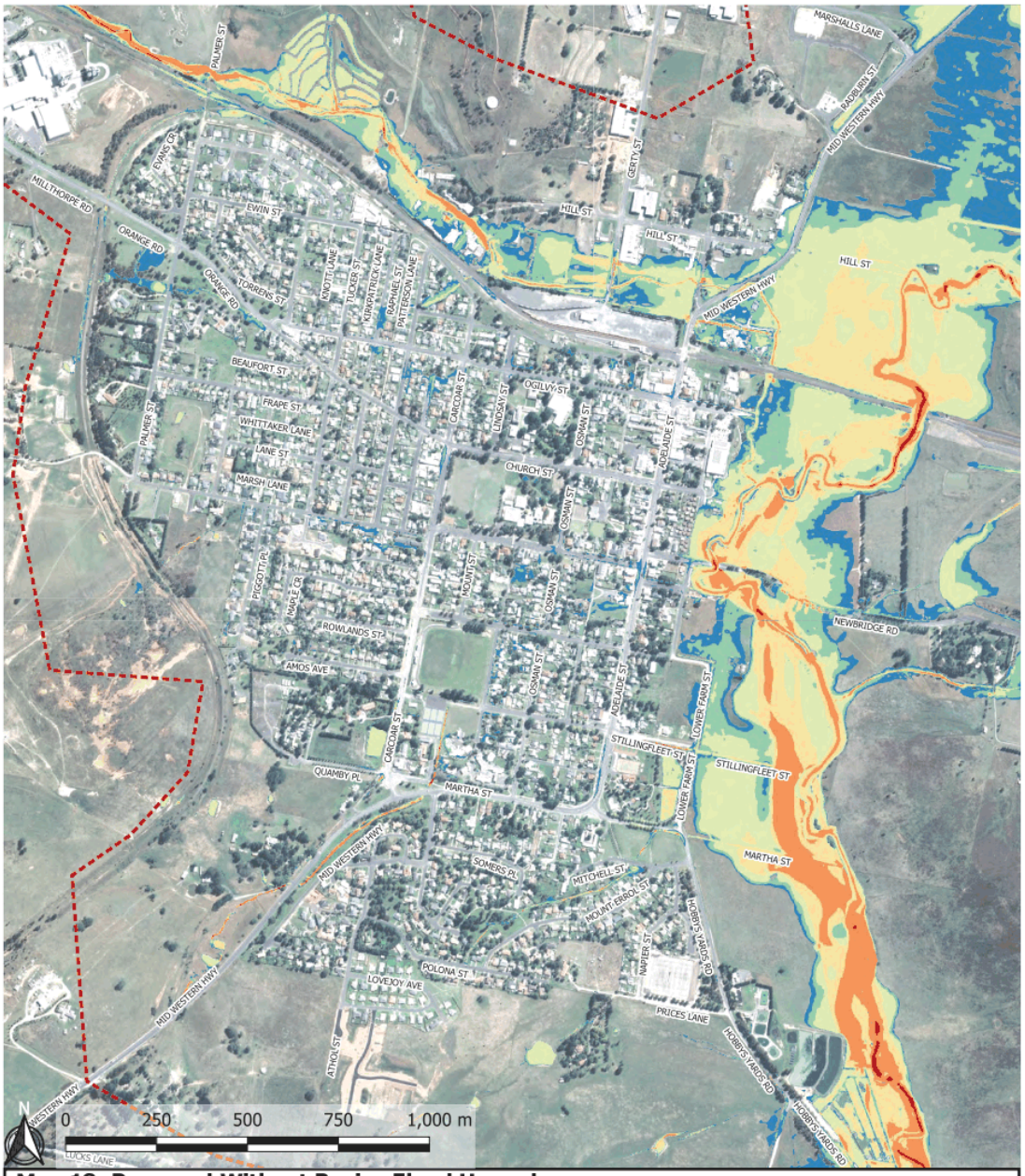
- H1
- H2
- H3
- H4
- H5
- H6

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 18: Proposed Without Basins Flood Hazard
5% AEP Event (ARR 2019)

Legend

Flood Hazard (ARR 2019)

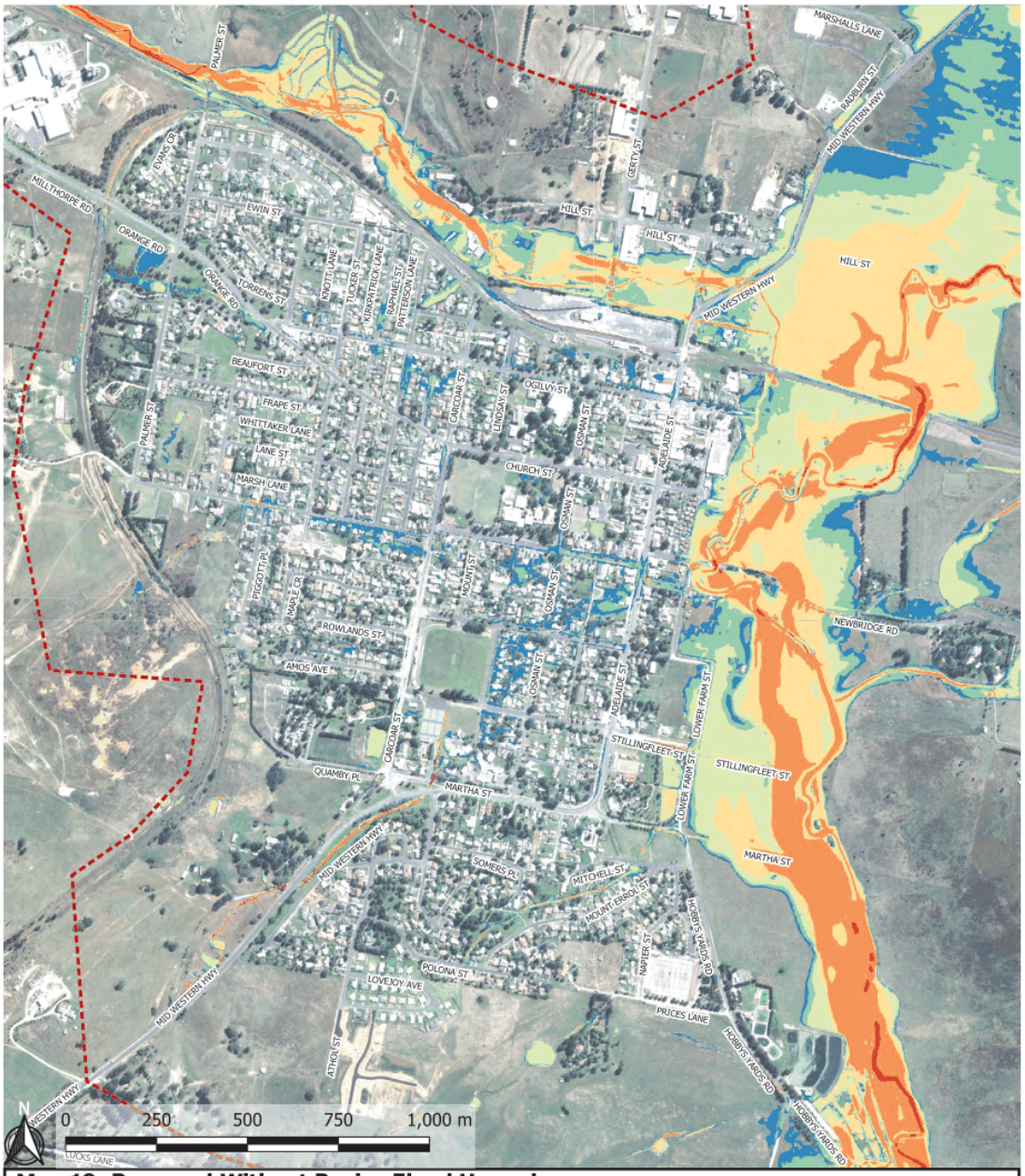
- H1
- H2
- H3
- H4
- H5
- H6

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 19: Proposed Without Basins Flood Hazard
1% AEP Event (ARR 2019)

Legend

Flood Hazard (ARR 2019)

- H1
- H2
- H3
- H4
- H5
- H6

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm

Appendix C – Change in Afflux

Map 10: Water Level Afflux
1% AEP Event (Storm's ARR 2019 - Jacobs' ARR 87)

Legend

Flood Level Afflux (m)

- <= -0.50
- -0.50 - -0.20
- -0.20 - -0.10
- -0.10 - -0.01
- -0.01 - 0.01
- 0.01 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- > 0.50
- Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm

Addendum to Blayney Floodplain Risk Management Study

Update to Australian Rainfall and Runoff 2019 Guidelines

For Blayney Shire Council

INDEX

DOCUMENT CONTROL				
Revision	Date	Details	Author	Reviewed
Draft	23.12.21	Draft report	TP/JK/LZ	MG
V1	10.02.22	Final Report	TP/JK/LZ	MG

1 Introduction

1.1 Project Background

Blayney Shire Council (Council) have recently determined to update the Blayney (Town) Flood Study (Jacobs, 2015) and Floodplain Risk Management Study and Plan for Blayney (Jacobs, 2016). The update is to address the recommendations set out in the Blayney Flood and Floodplain Management Study Peer Review (Storm, 2021).

The updated Flood Study 'Addendum to Blayney Flood Study (Storm, 2021)' revised the modelling from the Blayney (Town) Flood Study (Jacobs, 2015) to be in accordance with Australian Rainfall and Runoff 2019 (ARR19) guidelines which have replaced the ARR87 guidelines. The Addendum was prepared to define the flood behaviour of the 20%, 5% and 1% AEP storms for critical storm durations.

The recommendations from the '*Blayney Flood and Floodplain Management Study Peer Review Report* (Storm, 2021) relevant to the Floodplain Risk Management Study and Plan for Blayney (Jacobs, 2016) are discussed in Section 1.2 Objectives and Scope.

1.2 Objectives and Scope

The objective of this report is to document the impacts of 'Addendum to Blayney Flood Study (Storm, 2021)' to the Flood Study Report (Jacobs, 2015) on the Floodplain Risk Management Study and Plan for Blayney (Jacobs, 2016) which should be referenced for background information and the development of modelling and assessment components.

Specifically, the following recommendations of the *Blayney Flood and Floodplain Management Study Peer Review Report* (Storm, 2021) will be addressed in this report:

- *It is recommended that the flood hazard across the town of Blayney and surrounds be updated in accordance with the hazard vulnerability classifications in ARR (2019).*
- It is recommended that the floor levels assumed for the 436 properties not surveyed be reviewed to determine if the assumption is adequate. Consideration should also be given to including the property grounds in the flood damage assessment, as well as intangible damages.
- *It is recommended that the flood damage assessment in Jacobs' Floodplain Risk Management Study (2016) be completed to establish the cost benefit ratio for the proposed basins.*

The existing hydrologic and hydraulic models (RAFTS and TUFLOW) relevant to this study have been updated using ARR19. This modelling is presented in the 'Addendum to Blayney Flood Study (Storm, 2021)' and modelled the following storm events:

- 20% AEP – 25min, 3hr, 9hr, 30hr, 36hr
- 5% AEP - 25min, 1hr, 6hr, 30hr, 36hr
- 1% AEP – 25min, 1h, 2hr, 6hr

This report outlines the flood hazard classification and flood damage assessment based on flood behaviour using ARR19 methods.

2 Flood Hazard Categorisation

2.1 Introduction

The updated Flood Study 'Addendum to Blayney Flood Study (Storm, 2021)' generated flood depth and velocity maps for the 'existing' and 'proposed' scenarios where the 'existing' scenario used the same catchments as the original Flood Study (Jacobs, 2015) following ARR19 guidelines and the 'proposed' scenario using updated catchments to reflect proposed/future development in Blayney.

The hydraulic model (TUFLOW) was used to calculate the hazard rating at each cell for each time step. The highest velocity may not necessarily coincide with the highest water level in a given cell, therefore TUFLOW is used to calculate the most critical interactions between velocity and depth.

2.2 Flood Hazard Mapping – Existing Conditions

To match the hazard categorisation of the '*Blayney Flood Study – Flood Study Report – Rev 2*' (Jacobs, 2015) the existing conditions hazard mapping was generated following the NSW Floodplain Development Manual. The hazard category diagram is shown in Figure 1.

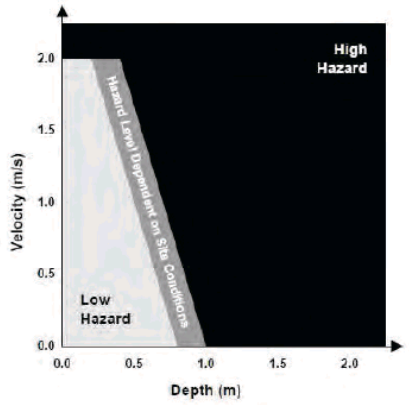


Figure 1 Hydraulic Hazard Category Diagram *Source: NSW Floodplain Development Manual*

The hazard maps are shown in Appendix A for the 20%, 5% and 1% AEP storms which were modelled to ARR19 guidelines. Upon review of the results, the hazard rating for the 20% and 5% AEP storms are considered low for the majority of the Blayney township with the high hazard rating being mostly within the Belubula River corridor. The hazard rating in the 1% AEP storm has shown some areas within the township with a high hazard however this is mostly contained within the road corridors of Orange, Plumb and Water Streets.

2.3 Flood Hazard Mapping – Proposed Conditions

The proposed conditions hazard category mapping accounts for runoff from the future developed state based on proposed developments within Blayney. The hazard mapping for the proposed scenario was developed using the latest ARR19 hazard classification as shown in Figure 2.

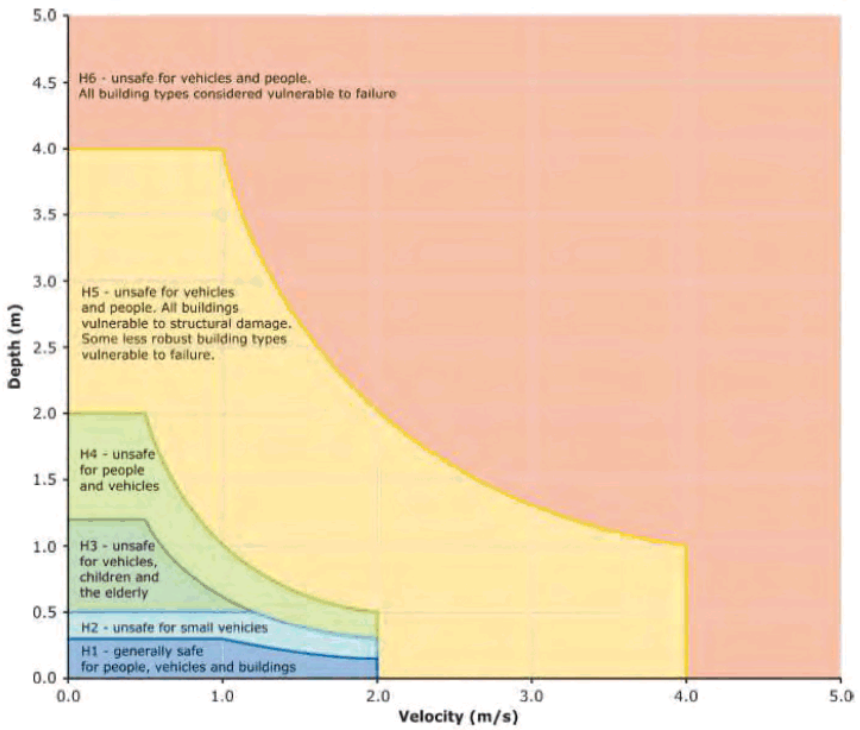


Figure 2 General Flood Hazard Curves *Source: ARR19 Book 6*

The ARR19 flood hazard curves set thresholds that identify risks to the community when interacting with flood waters. More specifically, the flood hazard ratings are classified in ARR19 Book 6 to have the risks ranging from H1-H6 with the risk classification descriptions explained in Figure 3 and the specific threshold limits shown in Figure 4.

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

Figure 3 Hazard Classifications *Source: ARR19 Book 6 (Table 6.7.3)*

Hazard Vulnerability Classification	Classification Limit (D and V in combination)	Limiting Still Water Depth (D)	Limiting Velocity (V)
H1	D*V ≤ 0.3	0.3	2.0
H2	D*V ≤ 0.6	0.5	2.0
H3	D*V ≤ 0.6	1.2	2.0
H4	D*V ≤ 1.0	2.0	2.0
H5	D*V ≤ 4.0	4.0	4.0
H6	D*V > 4.0	-	-

Figure 4 Hazard Classification Limits *Source: ARR19 Book 6 (Table 6.7.4)*

These parameters and limits were used to prepare the updated flood hazard mapping shown in Appendix B. The results show that for all storm events, the flood hazard within the township does not exceed H3 outside of roadways and dedicated channels/roads. The hazard created by the Belubula River does however generate hazard risks in the H4-H5 range at the properties within the river banks.

3 Flood Damages

3.1 Introduction

As part of their Floodplain Risk Management Study and Floodplain Risk Management Plan for Blayney (2016), Jacobs prepared a flood damage assessment of the township. The assessment focused on just the tangible damages to residential and non-residential buildings based on the depth of flooding above a threshold level (usually floor level). In conducting their assessment, Jacobs used a residential damage spreadsheet developed by the NSW Department of Environment, Climate Change and Water (DECCW, now NSW Office of Environment and Heritage, 2007).

The Floodplain Risk Management Study and Plan for Blayney (Jacobs, 2016) estimated that 106 properties are potentially affected by above floor flooding for the 1% AEP event, and up to 621 properties for the PMF event.

This includes both residential and non-residential properties, as well as mainstream and overland flooding (Table 1). Potential flood damages costs are estimated to range from $6 million to $52.4 million for the range of events assessed.

Table 1: Number of Properties and Cost of Damage due to Above Floor Flooding from Jacobs' Results

No. of Properties Affected by Above Floor Flooding	Design Flood Events % AEP				
	20%	5%	1%	0.5%	PMF
Residential above-floor flooding	45	60	87	124	555
Non-residential above floor flooding	10	13	19	19	66
Total No. Properties affected	55	73	106	143	621
Tangible Flood Damage $ M	**6.23**	**8.08**	**12.24**	**13.87**	**52.43**

The results in Table 1 equate to an Average Annual Damage (AAD) of approximately $2.66 million under existing conditions and are based on nominal flood levels. This is estimated to increase to $7.99 million with the inclusion of freeboard.

The update of the Flood Study 'Addendum to Blayney Flood Study (Storm, 2021)' has revised the flood modelling to ARR19 guidelines. This updated modelling has added more of the existing stormwater drainage network which was missing in the original Flood Study (Jacobs, 2015) for both the existing and the proposed conditions scenarios. However, the Addendum has only focused on the 20%, 5% and 1% AEP storms so the AAD prepared by Jacobs in the original Flood Study would not be comparable as it also accounted for the 0.5% and PMF storm events.

Due to this, the AAD calculation provided by Jacobs has been re-calculated (see Section 3.2) to include only the 20%, 5% and 1% AEP storms (as modelled by Jacobs). This will allow for a better comparison with the AAD calculated from the ARR19 flood assessment.

3.2 Flood Damages to ARR19

To update the flood damages, this study has adopted the same approach and methodology as the Jacobs assessment and adapted their spreadsheet calculation with the latest flood modelling results based on the latest version of TUFLOW and the ARR19 methodology. Survey levels of 188 properties were used in the assessment and where no survey data was

available, property and floor level values were adopted using the same floor level assumptions as Jacobs (0.15 m above LiDAR). The total estimated flood damage results presented in Table 2 below are representative of the damage based on the nominal flood levels without freeboard.

Table 1: Estimated tangible flood damage for Blayney

Flood Event AEP	Jacobs Existing Conditions (ARR 87)		Storm Existing Conditions (ARR 19)		Storm Proposed Conditions Without Basins (ARR 19)	
	Number of properties flooded above floor level	Estimated Flood Damage ($ Million)	Number of properties flooded above floor level	Estimated Flood Damage ($ Million)	Number of properties flooded above floor level	Estimated Flood Damage ($ Million)
20%	55	6.23	42	4.49	41	4.63
5%	73	8.08	51	6.67	51	6.67
1%	106	12.24	87	8.81	87	8.86

Based on the tangible flood damage results, the Annual Average Damage (AAD) was calculated as per Table 3. Due to the PMF and 0.5% AEP events not being modelled as part of the addendum, these results were excluded from the calculation of the "Jacobs Existing Conditions' AAD.

Table 3: Calculated Average Annual Damage (AAD) for Blayney

Item	Jacobs Existing Conditions (ARR 87)	Storm Existing Conditions (ARR 19)	Storm Proposed Conditions
AAD ($ M) Nominal	2.45	1.40	1.41

3.3 Conclusion

Upon review of the flood damage values and the AAD, the damages estimated by the ARR19 modelling has shown a significant reduction. While this assessment will need to be finetuned with better property floor level data, it confirms the assumption that ARR19 modelling generally results in lower flowrates and therefore reduced flooding.

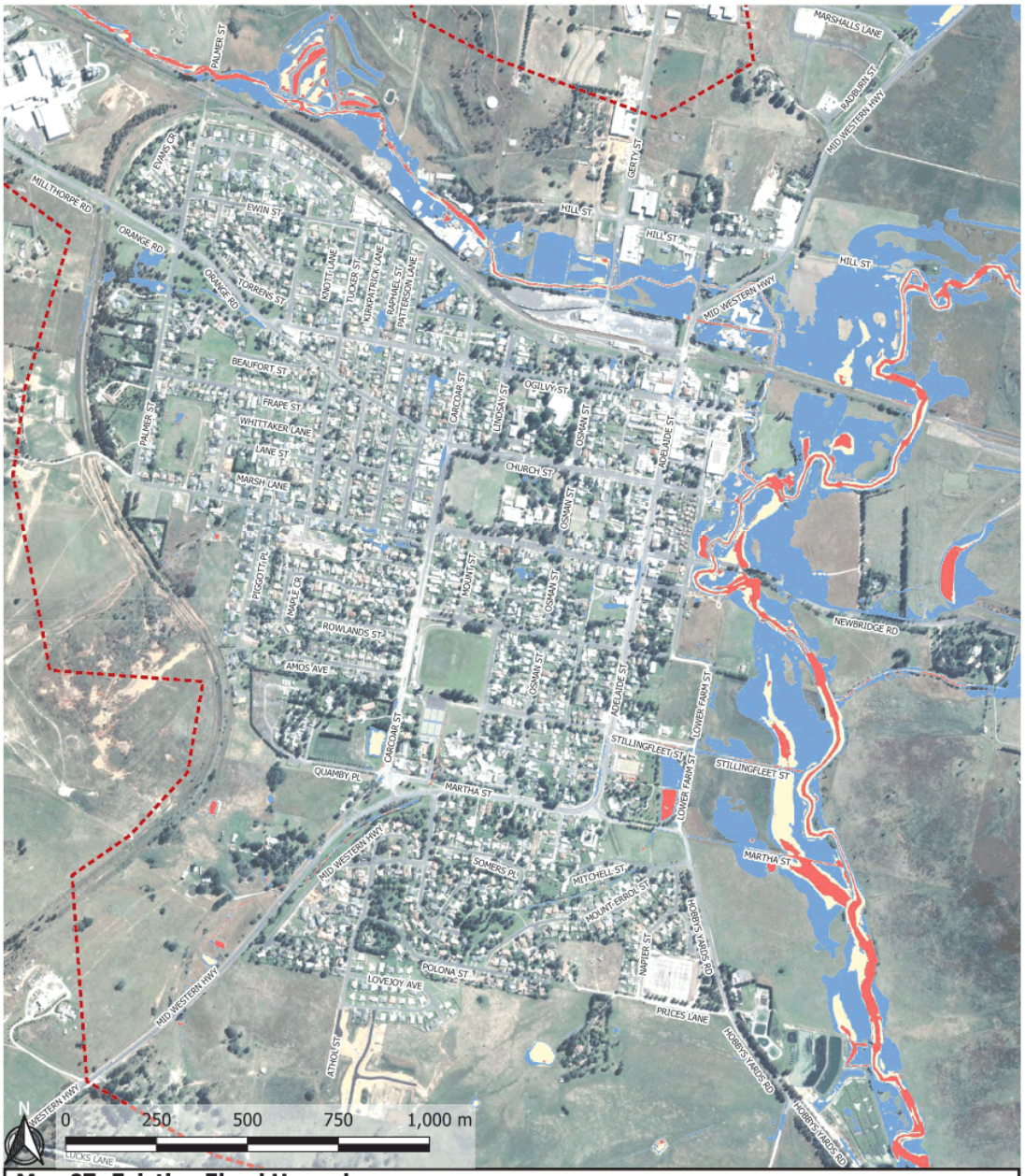
Further to the above, the added existing drainage network that was not modelled in the Jacobs modelling has made a considerable difference to the flooding. A significant amount of water is being conveyed in underground drains in the latest models as opposed to flowing on the surface with the previous modelling. Therefore, there is a reduction in overland flow and in turn a reduction in damages.

4 REFERENCES:

- '*Blayney Flood Study – Flood Study Report – Rev 2*' (Jacobs, 2015)
- '*Floodplain Risk Management Study and Floodplain Risk Management Plan for Blayney – Rev 04*' (Jacobs, 2016)
- '*Blayney Retarding Basins Study – Concept Design Report – Draft*' (Storm, 2021)
- '*Australian Rainfall and Runoff 2019*' (Engineers Australia, 2019)
- '*Addendum to Blayney Flood Study*' (Storm, 2021)
- *'NSW Floodplain Development Manual'* (NSW Government, 2005)

APPENDICES

Appendix A – Hazard Maps (Existing Conditions – As per NSW Floodplain Development Manual)



Map 07: Existing Flood Hazard
20% AEP Event (ARR 2019)

Legend

Flood Hazard (FDM 2005)

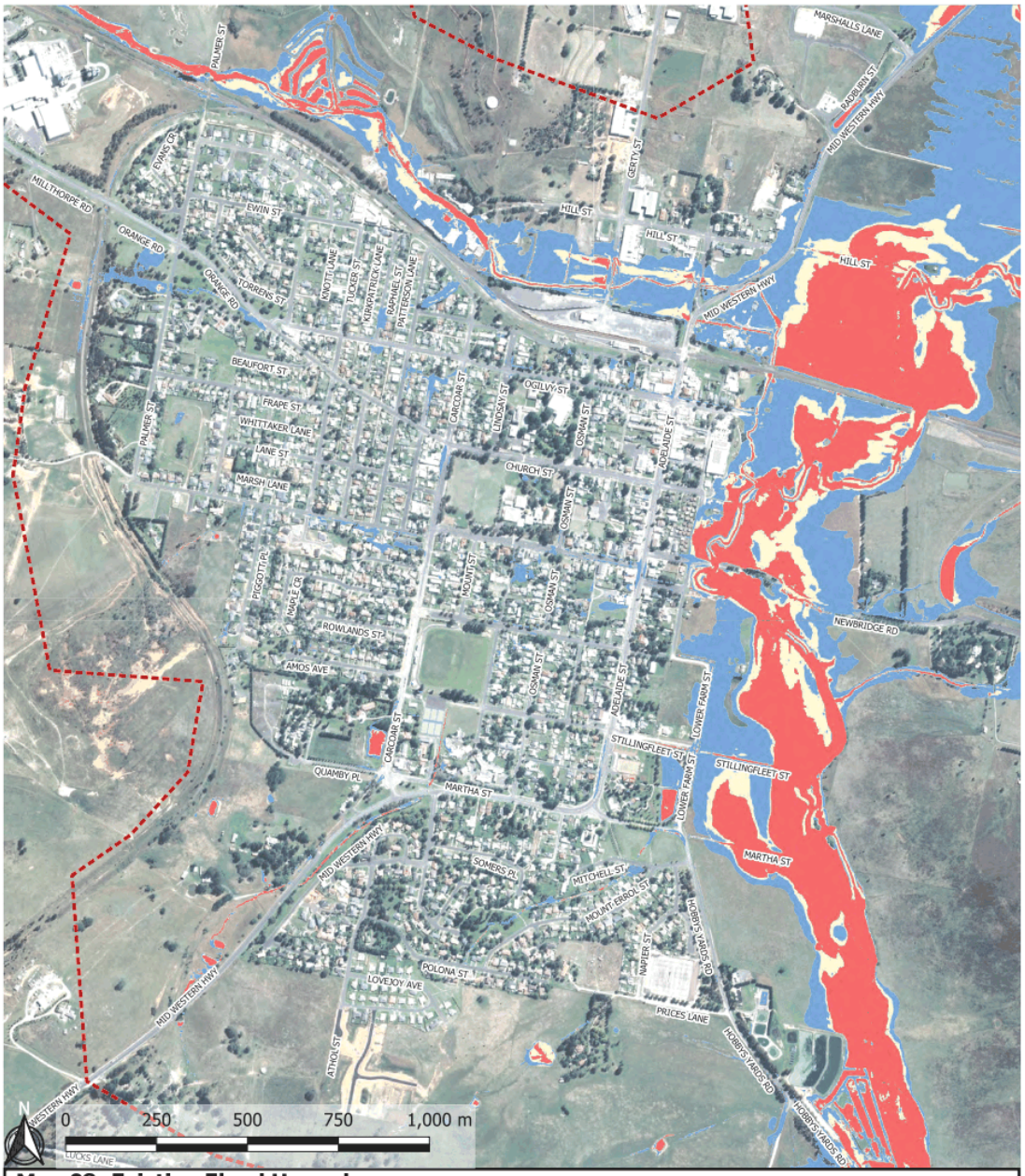
- Low Hazard
- Transitional Hazard
- High Hazard

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 08: Existing Flood Hazard
5% AEP Event (ARR 2019)

Legend

Flood Hazard (FDM 2005)

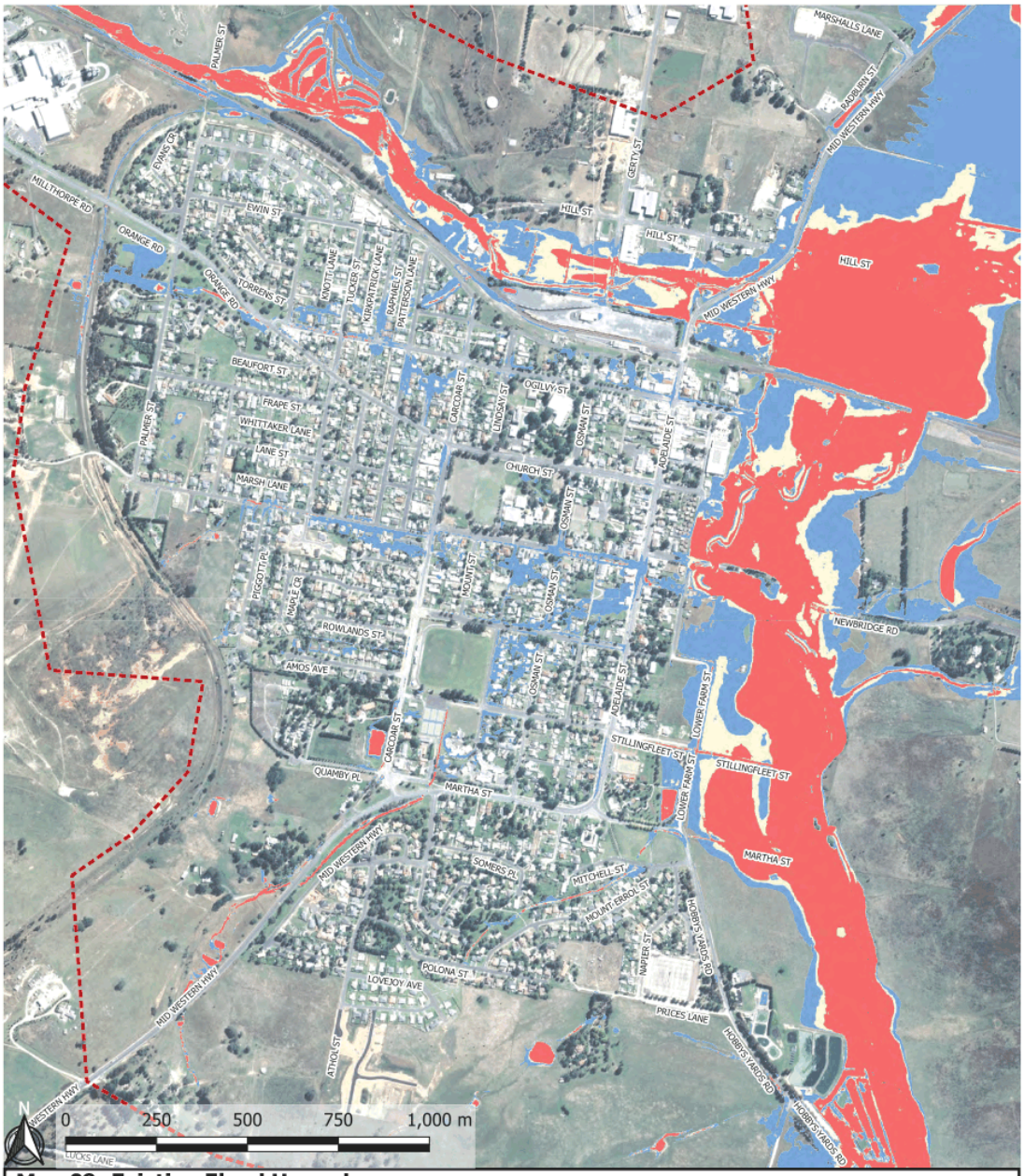
- Low Hazard
- Transitional Hazard
- High Hazard

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 09: Existing Flood Hazard
1% AEP Event (ARR 2019)

Legend

Flood Hazard (FDM 2005)

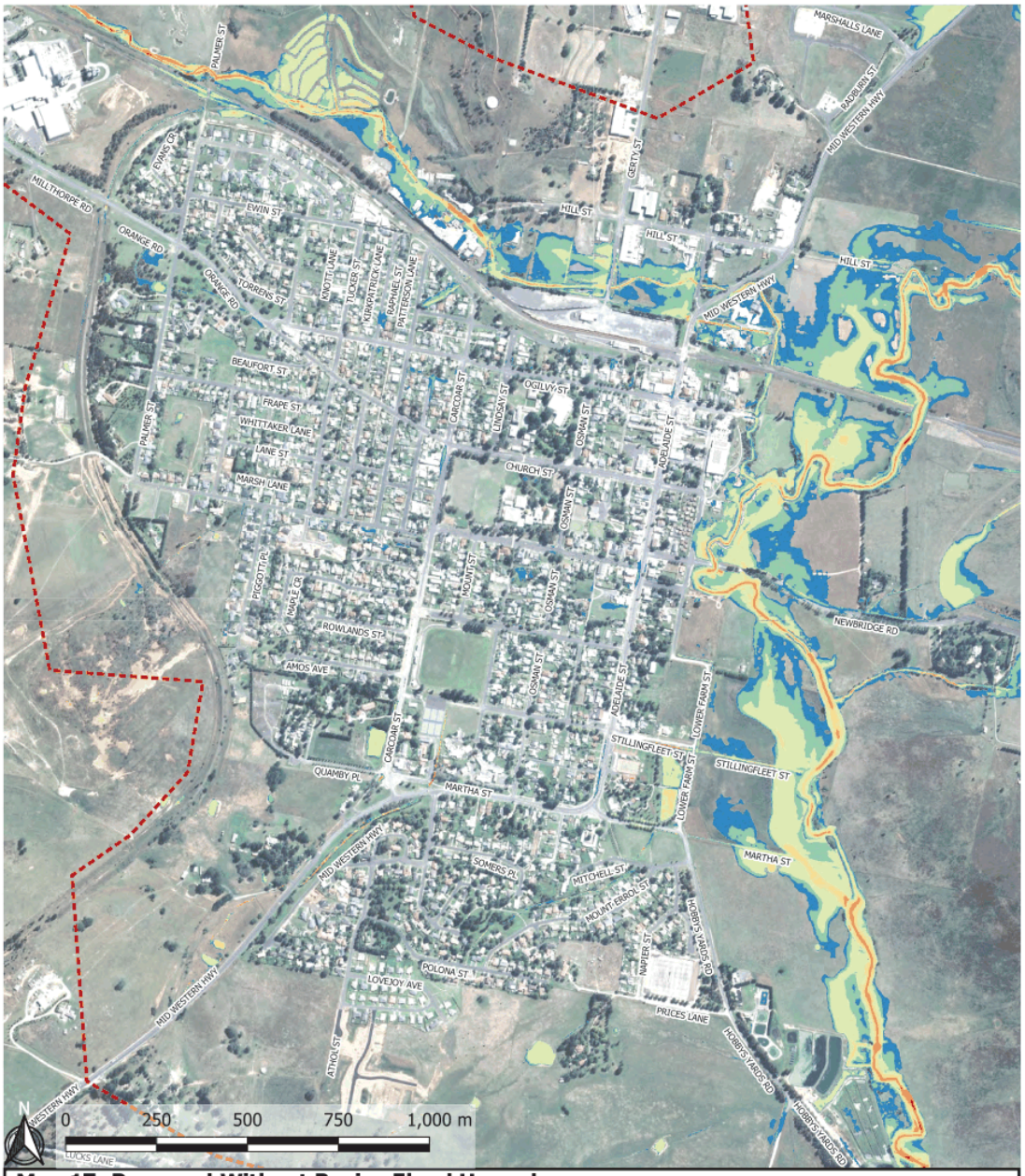
- Low Hazard
- Transitional Hazard
- High Hazard

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 17: Proposed Without Basins Flood Hazard
20% AEP Event (ARR 2019)

Legend

Flood Hazard (ARR 2019)

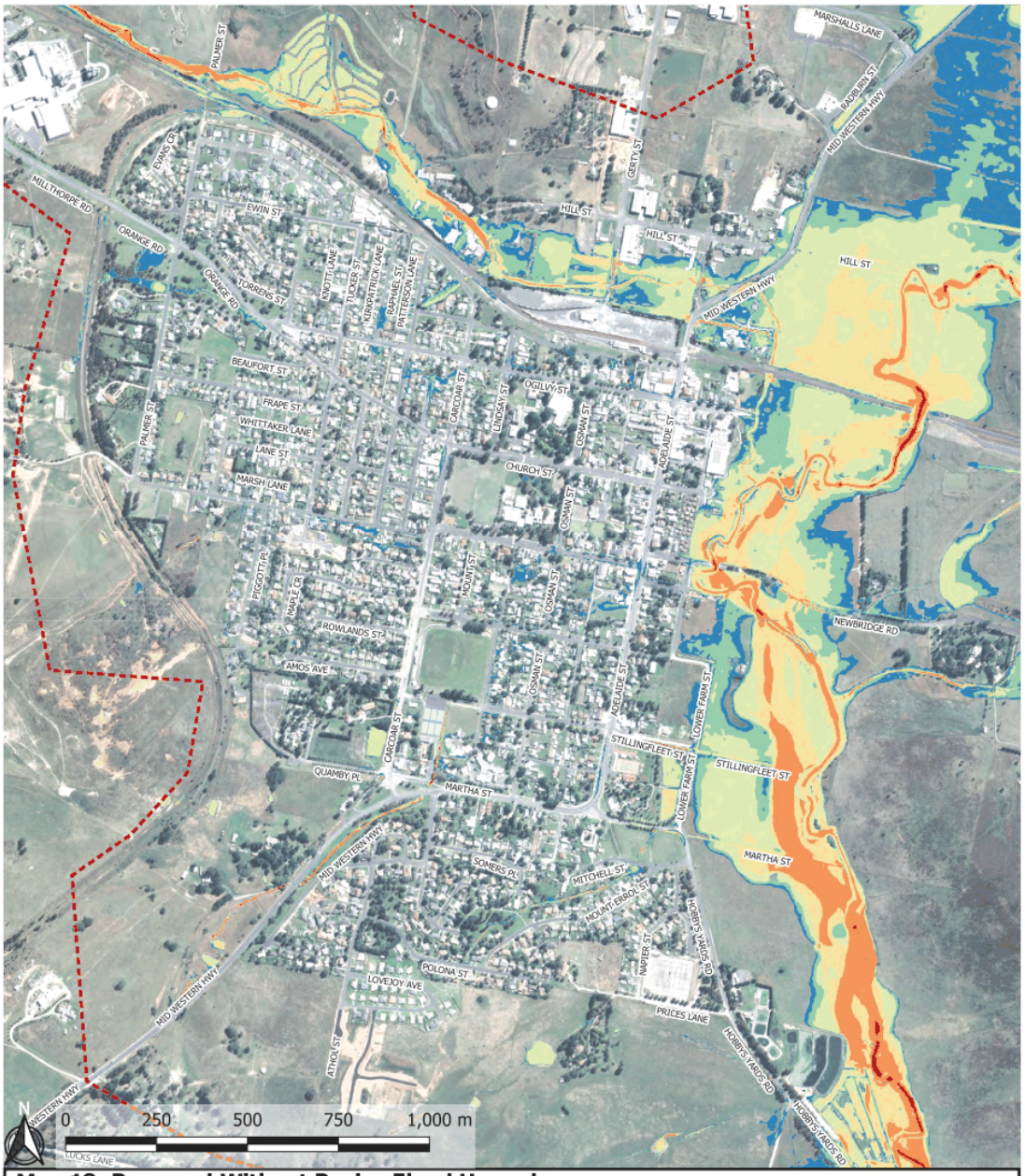
- H1
- H2
- H3
- H4
- H5
- H6

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 18: Proposed Without Basins Flood Hazard
5% AEP Event (ARR 2019)

Legend

Flood Hazard (ARR 2019)

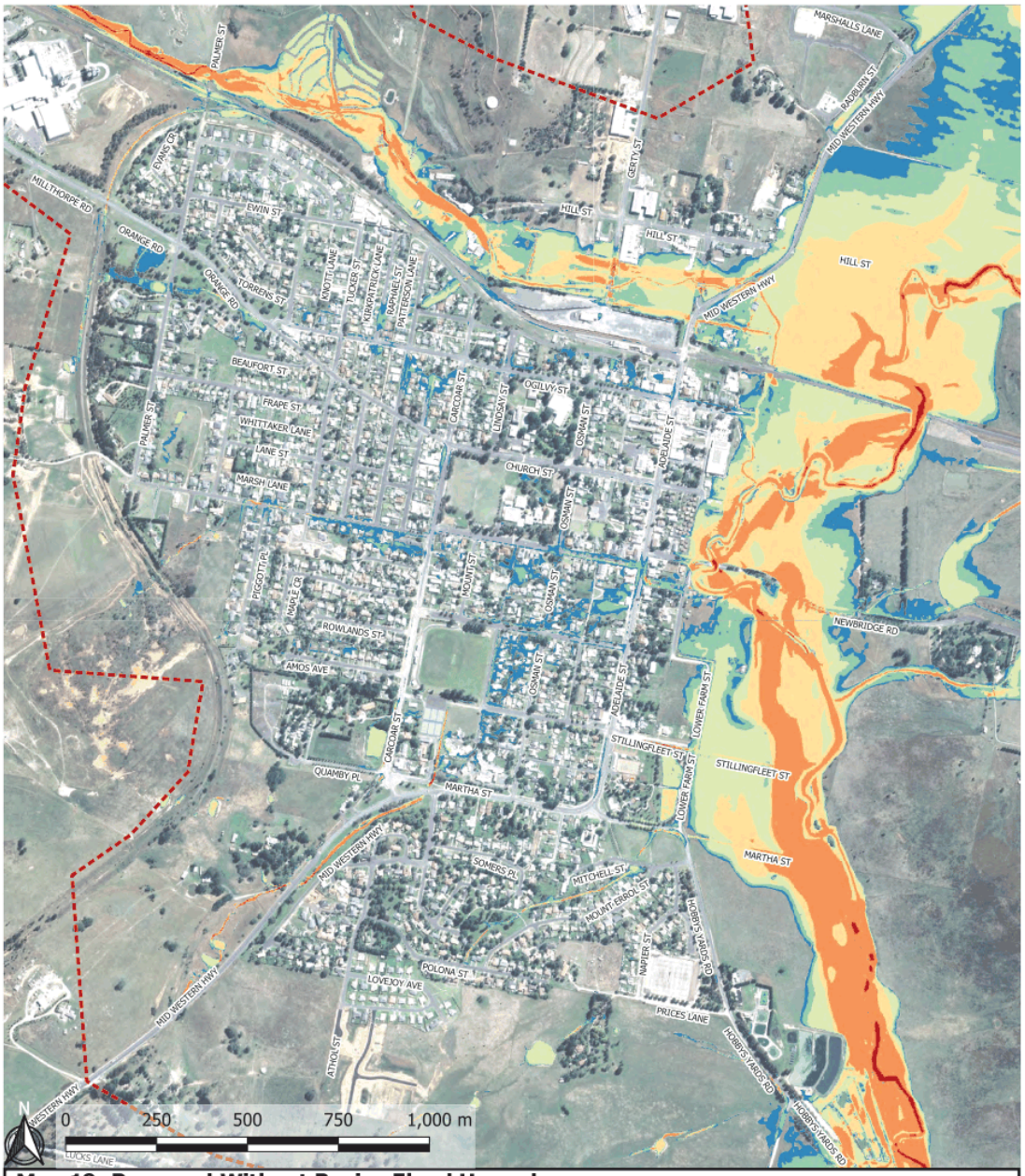
- H1
- H2
- H3
- H4
- H5
- H6

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm



Map 19: Proposed Without Basins Flood Hazard
1% AEP Event (ARR 2019)

Legend

Flood Hazard (ARR 2019)

- H1
- H2
- H3
- H4
- H5
- H6

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	23.12.2021
REVISION:	A

Storm

Storm
Bringing engineering to life

Our Reference: 2261

Blayney Retarding Basins Study

Concept Design Report

DRAFT

For Blayney Shire Council

Prepared by:
Storm Consulting
Suite 7.01 Level 7
3 Rider Boulevarde
Rhodes NSW 2138

P: 02 9869 1855
F: 02 9869 2341
E: reception@crhodes.com.au
W: stormconsulting.com.au

INDEX

DOCUMENT CONTROL				
Revision	Date	Details	Author	Reviewed
Draft	22.04.2021	Draft report	RK/DD	RK
Draft	13.01.2022	Draft report	TP/LZ	MG
V1	02.03.2022	Final Report	TP/LZ	MG

1 Introduction

Storm has been engaged by Blayney Shire Council to undertake an investigation report and concept design of nine retarding basins in the town of Blayney.

The nine retarding basins (Basin Nos 1-9) were previously identified by Jacobs in their Flood Study (2015) and Floodplain Risk Management Study and Plan (2016). Of the nine proposed basins, eight basins (Basins No. 1-8) are located at the western rural fringe, and one basin (Basin No. 9) within the urban town area.

This project is focusses on the concept design of the nine basins. This includes assessing the feasibility of the proposed basins, considering new local survey, potential services conflicts, and updating the original Flood Study to the latest Australian Rainfall and Runoff 2019 (ARR19) guidelines.

1.1 Objective

The scope of work for this project includes the following tasks:

- Review of available data, including past reports, assumptions, flood study and floodplain risk management study reports, adopted basin sites, hydrology (RAFTS) and hydraulic (TUFLOW) models,
- Strategic assessment and planning;
- Incorporation of new development areas;
- Updating flood mapping to new ARR19 guidelines;
- Ground level survey at basin locations and surrounds;
- Identification of existing services at sites and potential conflicts;
- Potholing of services;
- Community engagement in partnership with Council;
- Review of Environmental Factors (REF);
- Concept design of proposed works;
- Concept design report;
- Cost-Benefit analysis; and
- Recommendations for detailed design.

This concept report is essentially a progress report at this stage and will be updated and refined as the investigation and design progresses. This is because some aspects of the work are pending the outcome of further review and discussions. Specifically, the results of the investigation indicated that there may be an opportunity to reduce or combine some of the proposed basins, and thus reduce the construction costs. Similarly, other design and development proposals pending in the catchment will also need to be incorporated. These additional aspects will be discussed in the later sections of the report.

1.2 *Site Description*

Blayney is located in the Central Tablelands of NSW approximately 35km west of Bathurst and 240km west of Sydney. The Mid-Western Highway passes through the town and the Blayney-Demondrille Railway, which provides a link between the Western and Southern lines and rail access to Melbourne, is located to the north of the town (Figure 1).

Blayney falls within the Belubula River catchment and is surrounded by hills with elevations ranging from between 890 to 930m above sea level. The local catchments at Blayney generally drain in a north or north-easterly direction and then east into the Belubula River.

The Belubula River rises near Vittoria approximately 15km north-east of Blayney and generally flows in a south-westerly direction until it reaches Blayney, where the river meanders and aligns more generally in a north-south direction. At Blayney, the Belubula river has a catchment of about 120km^2. Its main channel is located approximately 190m east of the nearest stretch of Mid-Western Highway and between 25-60m from Henry Street, where Newbridge Road crosses the river.

Up to seven tributaries drain into the Belubula River near Blayney. However, most of these tributaries are unnamed, except for Abattoir Creek (20 km^2 catchment). Abattoir Creek flows in a south-easterly direction, is located north of the Blayney-Demondrille railway line and discharges into the Belubula River approximately 140m east of the Church Street-Henry Street intersection.

The Belubula River has a total length of about 165km and ultimately discharges onto the Lachlan River near Gooloogong.

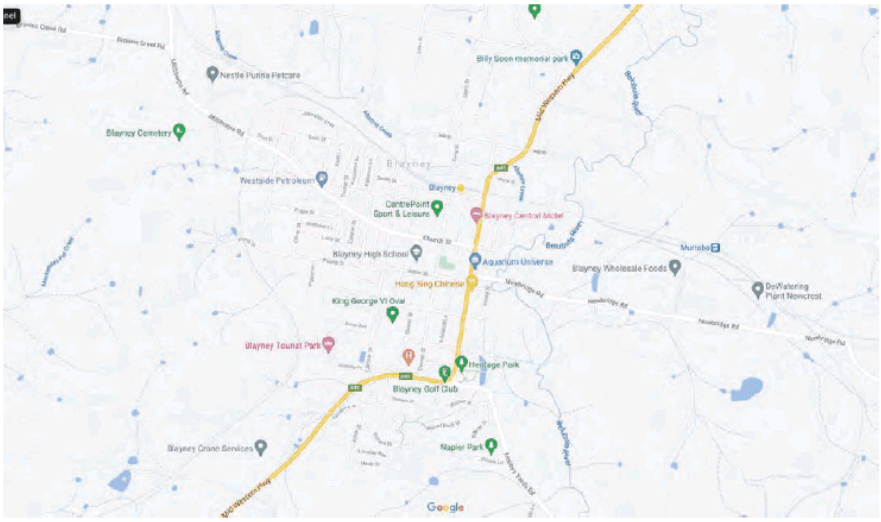


Figure 1: Blayney and Surrounds

2 Available Data

Data obtained and adopted for this project included the following:

- Flood study and floodplain risk management study reports (Jacobs 2015, 2016);
- RAFTS hydrology model (Jacobs 2015);
- TUFLOW hydraulics model (Jacobs 2015, 2016);
- Newly updated Flood Study using ARR19 (Storm/Craig & Rhodes 2021)
- Newly updated RAFTS hydrology model using ARR19 (Storm/Craig & Rhodes 2021)
- Newly updated TUFLOW hydraulics model using ARR19 (Storm/Craig & Rhodes 2021)
- New survey data for the basin sites (Storm/Craig & Rhodes, 2020);
- New survey of stormwater network (Storm/Craig and Rhodes 2020);
- Dial-Before-You-Dig (DBYD) services information;
- Potholing of identified services (Storm 2020);
- Geotechnical investigation (Storm Consulting/ AssetGeo, Oct 2020); and
- Review of Environmental Factors (REF) (Storm Consulting/ Applied Ecology, Jan 2021).

Jacobs' Flood Study and Floodplain Risk Management Study (FRMS) were undertaken in accordance with Australian Rainfall and Runoff (1987). This included both the RAFTS (hydrology) and TUFLOW (hydraulics) models.

Jacobs' FRMS (2016) identified up to 106 properties potentially affected by above floor flooding for the 1% AEP event, and up to 621 properties affected by above floor flooding for the PMF event. This included both mainstream flooding and overland flooding.

Nine basins were subsequently proposed in order to manage and reduce the potential risks to property and life in the event of floods. A map of the nine basins proposed by Jacobs (2016) is shown in Figure 2. Available basin details documented in the report are shown in Table 1.

Review and subsequent discussions with Jacobs during the course of this study indicated that the final RAFTS and TUFLOW models with and without the proposed nine basins were not available or fully modelled. This could be due to a lack of accurate survey data at the basin sites and other project constraints.

Similarly, review of the TUFLOW hydraulics model indicated that several major stormwater network lines were incomplete or missing from the model, which could impact on the overall performance of the system.

New survey of the nine basin sites was commissioned and undertaken as part of this study. This was later extended to incorporate other potential sites resulting from Council's discussions with some of the landowners. Additional sections of the stormwater network system were also surveyed to supplement the existing data available.

Potholing was undertaken in association with preliminary DBYD information to identify potential service conflicts with the proposed basins and to facilitate the designs. Other data commissioned for this study included a Review of Environmental Factors for the proposed works and a geotechnical and borehole investigation at the sites.

All new data obtained for this project was managed and undertaken either directly by Storm Consulting (Craig & Rhodes) or in association with its sub-consultants.

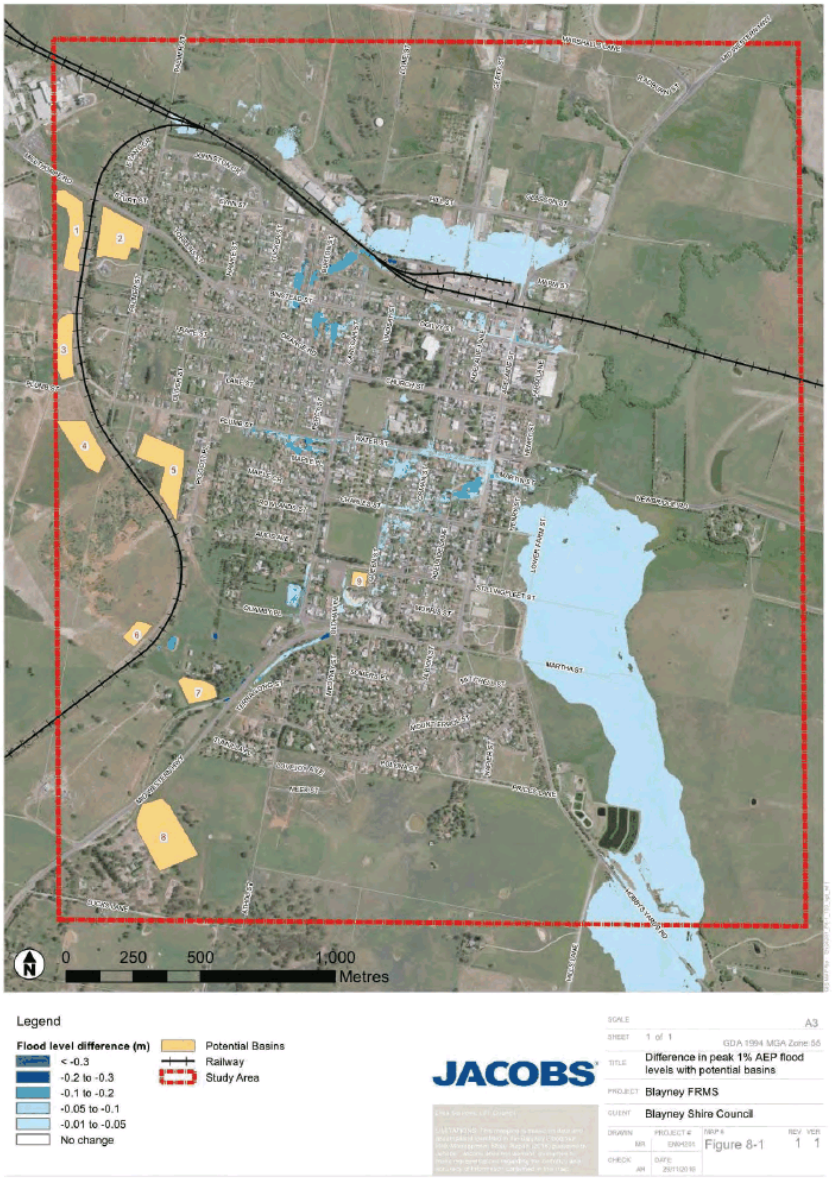


Figure 2: Proposed Basin Locations (Jacobs 2015, 2016)

Table 1: Proposed Basin Details (Jacobs 2016)

Basin Number	Basin Area (ha)	5% AEP - Peak flood depth (m)	1% AEP - Peak flood depth (m)	0.5% AEP - Peak flood depth (m)
1	1.81	0.84	1.16	1.18
2	2.37	0.32	0.39	0.42
3	1.53	0.76	1.13	1.23
4	1.79	0.18	0.24	0.25
5	2.62	0.40	0.59	0.64
6	0.55	0.65	1.02	1.21
7	0.98	1.21	1.46	1.48
8	3.66	0.35	0.48	0.50
9	0.32	0.94	1.22	1.43

3 Concept Design

The concept design was prepared in consultation with Council and included hydrological/ flood modelling and analysis, community consultation, geotechnical advice, environmental assessment and 3D modelling of the proposed earthworks.

3.1 Design Scenarios

This concept design is primarily based on the development of nine detention basins as proposed in the original Flood Study (Jacobs, 2015 and 2016). However, through subsequent investigations and review of modelling, it was determined that some basins were underperforming (too small due to space constraints) and provided little benefit to flood attenuation. In an effort to achieve best value for money, a second design scenario was developed. The design scenarios are described below.

Scenario 1: incorporates the assessment of the original nine basins as proposed in the Flood Study by Jacobs (original scope).

Scenario 2: a refined scenario using only the best performing basins from Scenario 1 and the inclusion of any new additional basins which were proven to perform well through additional flood modelling.

The Hydrological and Hydraulic assessment of the two scenarios is discussed in Section 3.2 below.

3.2 Hydrology and Hydraulics

This study was initially undertaken in accordance with Australian Rainfall and Runoff 1987 (ARR87) which matched the original Flood Study (Jacobs, 2015 and 2016). Recently the Flood Study was updated by Storm Consulting in accordance with ARR19 guidelines which changed the flood levels and extents. Therefore, this study was also updated to use the latest ARR2019 flood modelling and compare like for like.

The existing RAFTS model (Jacobs 2015 and Storm 2021) was reviewed and re-modelled for the full range of storm durations and events up to the 1% AEP using ARR19 guidelines. Sub-catchments delineated at the basins and throughout the catchment are shown in Figure 3.

3.2.1 Scenario 1: Original nine basins

Civil 3D digital terrain modelling of the original nine basins was undertaken using detailed survey data obtained as part of the current study and supplemented by existing and lidar data available for the entire catchment. The 3D modelling also took into account services data obtained from the potholing investigations (Appendix A). The design DTM surface was then established and adopted for the hydraulic analysis for the catchment.

The design flows derived from the RAFTS model were fed into the TUFLOW model to analyse the flood behaviour in the town and Belubula River system. Tailwater conditions were estimated for the downstream side of the basins based on catchment flow and cross-sectional information derived from topographical survey. It is noted that the TUFLOW model was also updated to include some additional stormwater pipes obtained as part of this study.

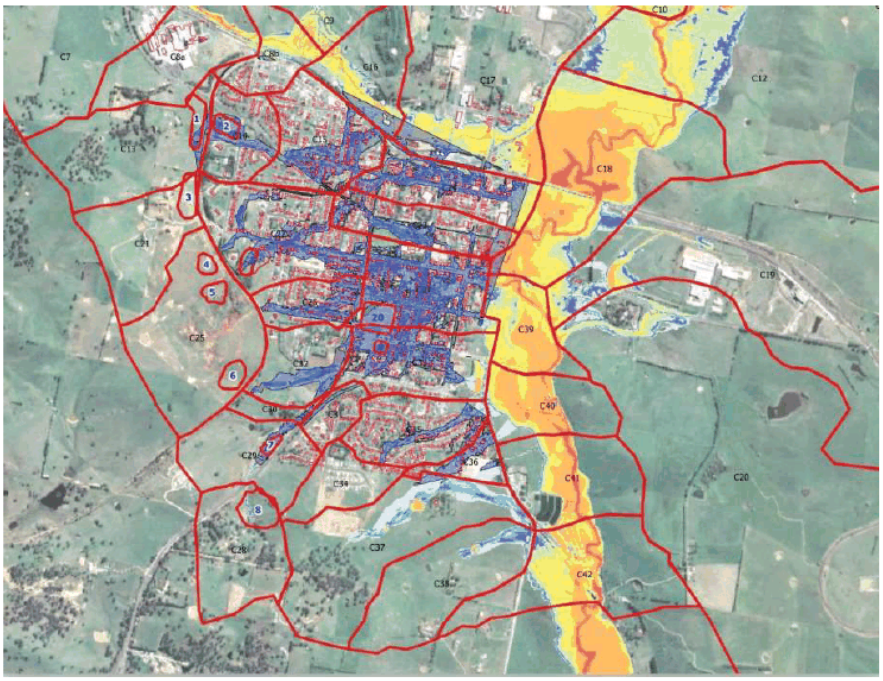


Figure 3: Blayney Sub-catchments and Basin Locations

The TUFLOW model results with the nine proposed basins were initially checked and verified against Jacob's (2016) results and found to be consistent (for ARR87 method). This was then re-run using the latest ARR19 methodology to reflect the update to the Flood Study. The results are shown in Table 2 (Figure 2).

Table 2: Scenario 1: TUFLOW Model Results with Proposed 9 Basins (Current Study)

Basin	Weir Level (m AHD)	Bottom of Basin	Peak Water Level (m AHD)	Weir Height (m)	Storage to weir level (m^3)
1	890.0	888.1	890.06	1.9	15,960
2	884.6	883.1	884.63	1.5	10,773
3	894.8	893	895.01	1.8	9,910
4	907.0	905	905.84	2.0	5,668
5	911.5	909.5	910.80	2.0	14,000
6	915.0	913.5	914.80	1.5	3,983
7	899.0	897.5	899.61	1.5	1,875
8	924.0	922.5	923.74	1.5	12,548
9	873.9	872.6	874.16	1.3	3,475
TOTAL Volume (m^3)					**78,192**

In Table 2, it can be seen that approximately 78,000 m^3 of flood storage volume would be provided. Flood afflux mapping for this scenario relative to that for existing conditions is included in Appendix B. The results of the flood mapping indicate that the proposed basins would generally be effective in reducing flood depths across the catchment.

3.2.2 Scenario 2: Refined basins

Further investigations were subsequently carried out to assess whether some of the proposed basins in Scenario 1 could be eliminated or optimised. In particular, it was considered that Basins 4, 6, 7, 8 and 9 were relatively small storages compared to the amount of excavation required, and may therefore be less cost effective. The location of Basin 7 also had some resistance from the landowner. Basin 9, proposed within the town, did not appear to be at an optimal location. Similarly, it was necessary to reassess the location and role of Basin 5 as the area west of the railway is currently being designed by another consultant as a mining storage dam for Newcrest Mining.

The results of the above investigations indicated that the originally proposed basins could be optimised. This would include the removal of Basins 4, 6, 7, 8 and 9. However, a new Basin 20 would be introduced at the existing King George VI Oval. Basin 5 was also relocated and re-designed to be wholly to the west of the railway line. This basin will require further calibration and re-sizing in consultation with Council.

TUFLOW modelling results for Scenario 2 with Basins 4, 6, 7, 8 and 9 removed, Basin 20 added, and Basin 5 relocated are shown in Table 3.

Table 3: Scenario 2: TUFLOW Model results with Reduced Basins (Current Study using ARR19)

Basin	Weir Level (m AHD)	Bottom of Basin	Peak Water Level (m AHD)	Weir Height (m)	Storage to weir level (m^3)
1	890.0	888.1	890.20	1.9	15,960
2	884.6	883.1	884.70	1.5	10,773
3	894.8	893	895.00	1.8	9,910
5	911.5	909.5	910.80	2.0	14,000
20	870.4	869.4	870.90	1.5	23,290
TOTAL Volume (m^3)					**73,933**

In Table 3, it can be seen that the overall flood storage volume provided for Scenario 2 is approximately 74,000 m^3, which is only about 4,000 m^3 less than that of Scenario 1. Flood afflux mapping included in Appendix C also indicated that the proposed combination of basins for Scenario 2 is effective in reducing the flood risk to a level similar to that for Scenario 1.

Overall, it is expected that Scenario 2 would be more cost effective due to the fewer number of proposed basins. However, it is noted that Council approval for the King George VI Oval to be used as Basin 20 has yet to be confirmed. Design details of the proposed Basin 5 will need to be further investigated and approved by Council.

Scenario 2 would need to be updated and refined once the above information becomes available.

3.3 *Concept Design Drawings*

Notwithstanding the pause in the project pending confirmation of some elements of the design, concept design of the basins undertaken to date is presented in this section.

The concept design drawings for Scenario 1 (9 basins) are included in Appendix D. This also includes the newly located Basin 5 and additional Basin 20 for Scenario 2. The concept designs are currently in a draft state and will be finalised once the preferred scenario is chosen.

4 Cost Benefit Analysis

There are two proposed scenarios to consider at this stage. These are:

1. Construction of nine basins as per the original Jacobs study
2. Construction of six basins as recommended in Section 3.

There may be further scenarios however Scenario 1 is considered the base case and Scenario 2 is considered the optimal case.

4.1 *Average Annual Damages*

Average Annual Damages (AAD) were calculated and presented within the *'Addendum to Blayney Floodplain Risk Management Study'* (Storm 2021). These are summarised below.

Table 4: Estimated tangible flood damage for Blayney with freeboard

Flood Event AEP	Existing Conditions (ARR 87)		Existing Conditions (ARR 2019)		Proposed Conditions Without Basins (ARR 2019)	
	Number of properties flooded above floor level	Estimated Flood Damage ($ Million)	Number of properties flooded above floor level	Estimated Flood Damage ($ Million)	Number of properties flooded above floor level	Estimated Flood Damage ($ Million)
20%	266	19.95	158	11.51	176	12.69
5%	328	24.79	206	14.93	250	17.53
1%	455	34.56	322	22.19	338	23.26

Table 5: Estimated tangible flood damage for Blayney (proposed conditions with basins) with freeboard

Flood Event AEP	Proposed Conditions With Jacobs Basins (ARR 2019)		Proposed Conditions With Storm Basins (ARR 2019)	
	Number of properties flooded above floor level	Estimated Flood Damage ($ Million)	Number of properties flooded above floor level	Estimated Flood Damage ($ Million)
20%	159	11.28	162	11.63
5%	185	13.06	220	15.28
1%	243	16.97	282	19.54

Table 6: Calculated Average Annual Damage (AAD) for Blayney (nominal floor level with freeboard)

Item	Existing Conditions (ARR 87)	Existing Conditions (ARR 2019)	Proposed Conditions Without Basins (ARR 2019)	Proposed Conditions With Jacobs Basins (ARR 2019)	Proposed Conditions With Storm Basins (ARR 2019)
AAD ($ M) Nominal	7.62	4.51	5.05	4.16	4.51

The expected AAD without any mitigation measures is expected to be $4.96m for the proposed developed case. This would be reduced to $4.16m for Scenario 1 and $4.52m for Scenario 2.

4.2 Basin Costs

Table 7 below outlines approximate individual costs based on the current concept design. These costs will be updated as the concept design is progressed and should be considered as high-level costing.

Table 7: Approximate Basin Costs -

Basin	Approximate Cost	
	Scenario 1	**Scenario 2**
1	$828,720	$828,720
2	$610,464	$610,464
3	$752,070	$752,070
4	$601,554	-
5	$1,084,854	$1,084,854
6	$1,987,098	-
7	$432,042	-
8	$4,134,672	-
9	$182,028	-
20	-	$1,983,606
Total	**$10,613,502**	**$5,259,714**

In total, the cost of Scenario 1 is approximately $10.61m and the cost of Scenario 2 is approximately $5.26m.

4.3 Cost Benefit Analysis

4.3.1 Benefits

The benefit of constructing the basins is the reduction in Average Annual Damages (AAD) as shown in Table 6. Scenario 1 reduces the AAD from the baseline $4.96m to $4.16m which is a reduction of $0.8m AAD per year. For Scenario 2, the AAD is reduced to $4.52m which is a reduction of $0.44m per year from the base case. It should be noted that if further storm events were modelled (i.e. 0.5% AEP and PMF storms), the reductions would likely be greater.

To represent this benefit to present day values, a Net Present Value (NPV) calculation was undertaken. It was assumed that the design life of the detention basins are 50 years and the discount rate applied was 7% which is consistent with NSW guidelines. This assessment provides a present day value of savings in flood damages which will be assessed against the mitigation costs for the Cost-Benefit assessment.

The NPV of damages over 50 years without any mitigation is $74.74m. With the implementation of Scenario 1 basins, the NPV of damages total $61.57m which is a $13.17m reduction. With the streamlined Scenario 2, the NPV of damages totals $66.75m which is a $7.99m reduction over the 50 year life.

4.3.2 Cost Benefit Ratio

The Cost Benefit Ratio (CBR) calculation is summarised in Table 8 Below.

Table 8: Cost Benefit Ratios

Scenario	Cost	Benefit	Cost Benefit Ratio
Scenario 1	$10.61m	$13.17m	1.24
Scenario 2	$5.26m	$7.99m	1.51

Both scenarios have a CBR greater than 1 meaning that the basins will pay themselves off during the life of the detention basins. There is enough contingency in the CBR to account for rising costs of construction. It is also important to note that the AAD only focus on property damage (tangible items) and not intangible damages. The intangible damages can be significant and are often overlooked because it is difficult to place a dollar value on them. Therefore, the calculated benefits of the basins used in the CBR calculation are considered to be the absolute minimum and the CBR values would be higher in reality.

5 Review of Environmental Factors

The key environmental findings for the project are as follows:

- One threatened species was recorded during the flora and fauna survey, and present as two planted specimens;
- The proposed basin sites contain very limited habitat for threatened species and no endangered ecological community was recorded;
- The potential impacts on threatened species from the proposal (Scenario 2) are not significant and do not require a Species Impact Statement nor referral under the EPBC Act.

Recommendations for the mitigation of potential terrestrial impacts include the following:

- Protect, move or replace any Eucalyptus Nicholii that may be impacted, a threatened flora species from the Northern Tablelands. Replace with a suitable species for the area;
- Include control of priority weed species on site as part of the site preparation. Aim to manage problem environmental weeds to reduce the potential for their spread into other areas;

- Designate stockpile sites, compound and machinery storage areas away from better quality natural assets and drainage lines;
- Prepare Soil and Water Management Plan as part of the site Construction Environmental Management Plan. Ensure adequate measures are implemented for erosion control;
- Clearly delineate vegetation 'no go' zones and provide protective barriers for sensitive vegetation. Use tree protection fencing; and
- Offset the removal of koala feed trees by planting additional resources in the vicinity of the subject sites or near where there have been sightings of these animals.

Recommendations for the mitigation of potential aquatic impacts include the following:

- Ensure no sediment is discharged downstream;
- Prepare Soil and Water Management Plan as part of the site Construction Environmental Management Plan. Ensure adequate measures are implemented for erosion control; and
- Apply and comply with the 'Hygiene protocol for the control of disease in frogs' guidelines (NPWS/DECC, 2008).

In summary, the proposed works are not expected to pose any significant adverse impacts on the existing environment, including any existing threatened species in the area. Further details are provided in Appendix E.

6 Geotechnical Investigation

The results and recommendations of the geotechnical investigation include the following:

- With the basin depth being typically 2.5m below existing ground level, the excavation will be predominantly in firm to stiff clay, becoming hard clay with depth;
- The excavated silt/clay is suitable for reuse with careful control over field moisture content;
- The recommended maximum slopes for permanent and temporary batters are presented in this Table.

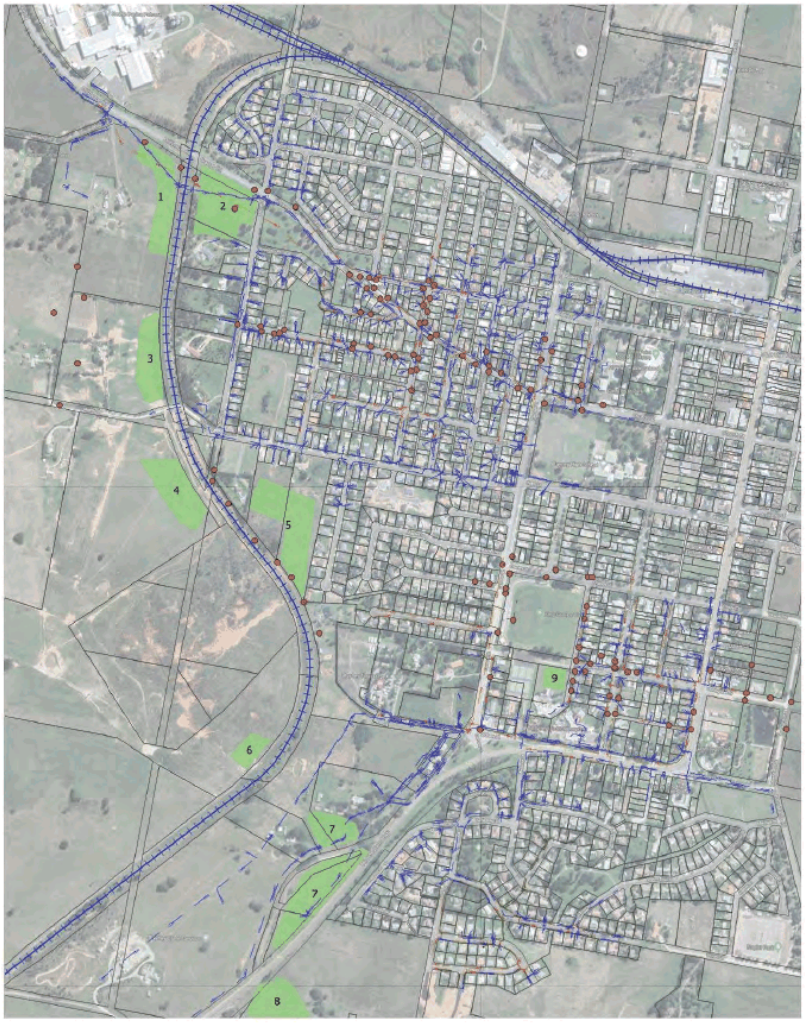
Unit	Maximum Batter Slope (H : V)	
	Permanent	Temporary
Residual Clay & Alluvial Clay	2 : 1	1 : 1
Extremely weathered siltstone or better	1.5 : 1	0.75 : 1

- The observations indicate that groundwater is unlikely to be a constraint to the proposed development. However, good practice should be followed to cater for potential groundwater, such as designing retaining walls with adequate subsoil drainage. Further geotechnical advice must be sought if significant groundwater is encountered during construction.

Full details of the geotechnical investigation are included in Appendix F.

APPENDICES

Appendix A – Dial Before You Dig and Potholing Data



Dial Before You Dig Data

Location	Essential Energy	Jemena	NBN	Telstra	Checked Date	Checked By
Basin 1	Yes (electrical Pole)	Yes (150 dia. 1050 kPa)	Yes	Yes	22.04.2020	KZL
Basin 2	Yes (electrical Pole)	Yes (150 dia. 1050 kPa)	Yes	Yes	22.04.2020	KZL
Basin 3	NO CLASH	NO CLASH	NO CLASH	NO CLASH	22.04.2020	KZL
Basin 4	NO CLASH	NO CLASH	NO CLASH	NO CLASH	22.04.2020	KZL
Basin 5	Maybe (Electrical pole along the rail corridor for 122)	NO CLASH	NO CLASH	NO CLASH	22.04.2020	KZL
Basin 6	NO CLASH	NO CLASH	NO CLASH	NO CLASH	22.04.2020	KZL
Basin 7	NO CLASH	NO CLASH	Yes	Yes	22.04.2020	KZL
Basin 8	NO CLASH	NO CLASH	NO CLASH	NO CLASH	22.04.2020	KZL
Basin 9	NO CLASH	NO CLASH	NO CLASH	NO CLASH	22.04.2020	KZL
Basin 9 Large Extent	Maybe (Electrical pole Stillingfleet st)	Yes	Yes	Yes	05.08.2020	KZL
Frape St	Yes	Yes	Yes	Yes	05.08.2020	KZL
Lovejoy Ave	Yes	Yes	Yes	Yes	05.08.2020	KZL

Appendix B – Flood Mapping for 1% AEP Event (Scenario 1)

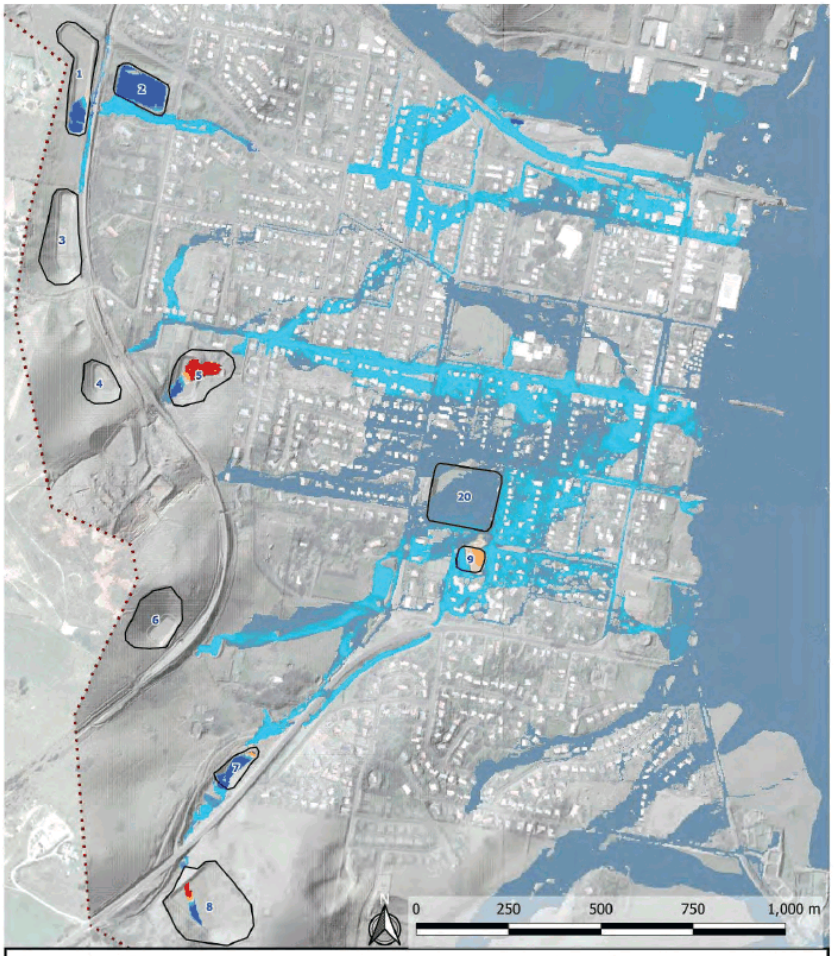


Figure C100-2: Flood Level Difference Map for 100-year ARI (Jacob's Proposed - Existing)

Legend - Difference (m)

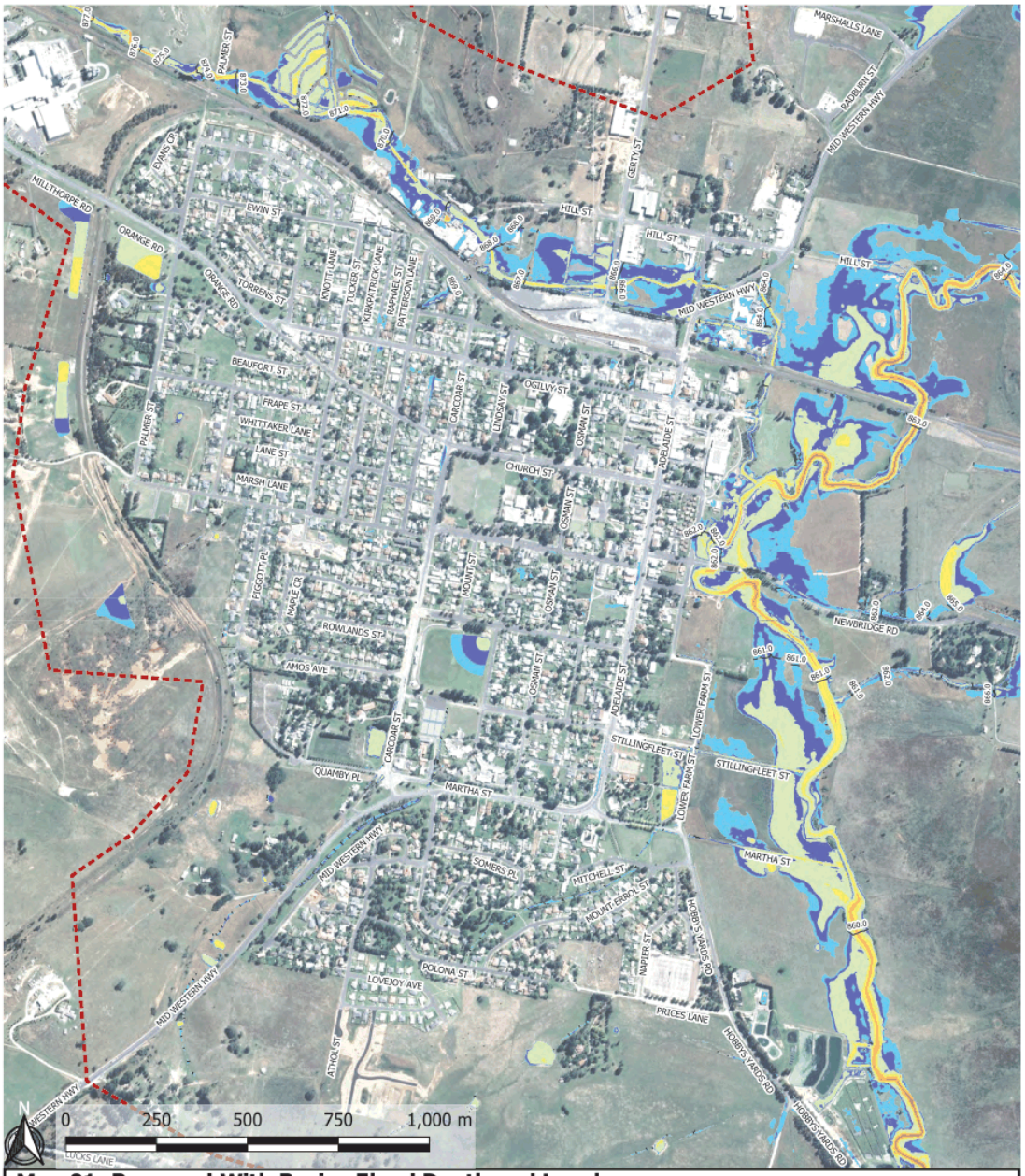
- Model Boundary
- < -0.50
- -0.5 to -0.05
- -0.05 to -0.01
- -0.01 to 0.00
- 0
- 0.00 to 0.01
- 0.01 to 0.05
- 0.05 to 0.50
- > 0.50

PROJECT ID:	117-20
DATE:	21.04.2021
REVISION:	A

Storm
Bringing engineering to life

Scenario 1 Flood Afflux for 1% AEP Event with 9 Basins

Appendix C – Flood Mapping for 1% AEP Event (Scenario 2) – ARR19



Map 01: Proposed With Basins Flood Depth and Level
20% AEP Event (ARR 2019)

Legend

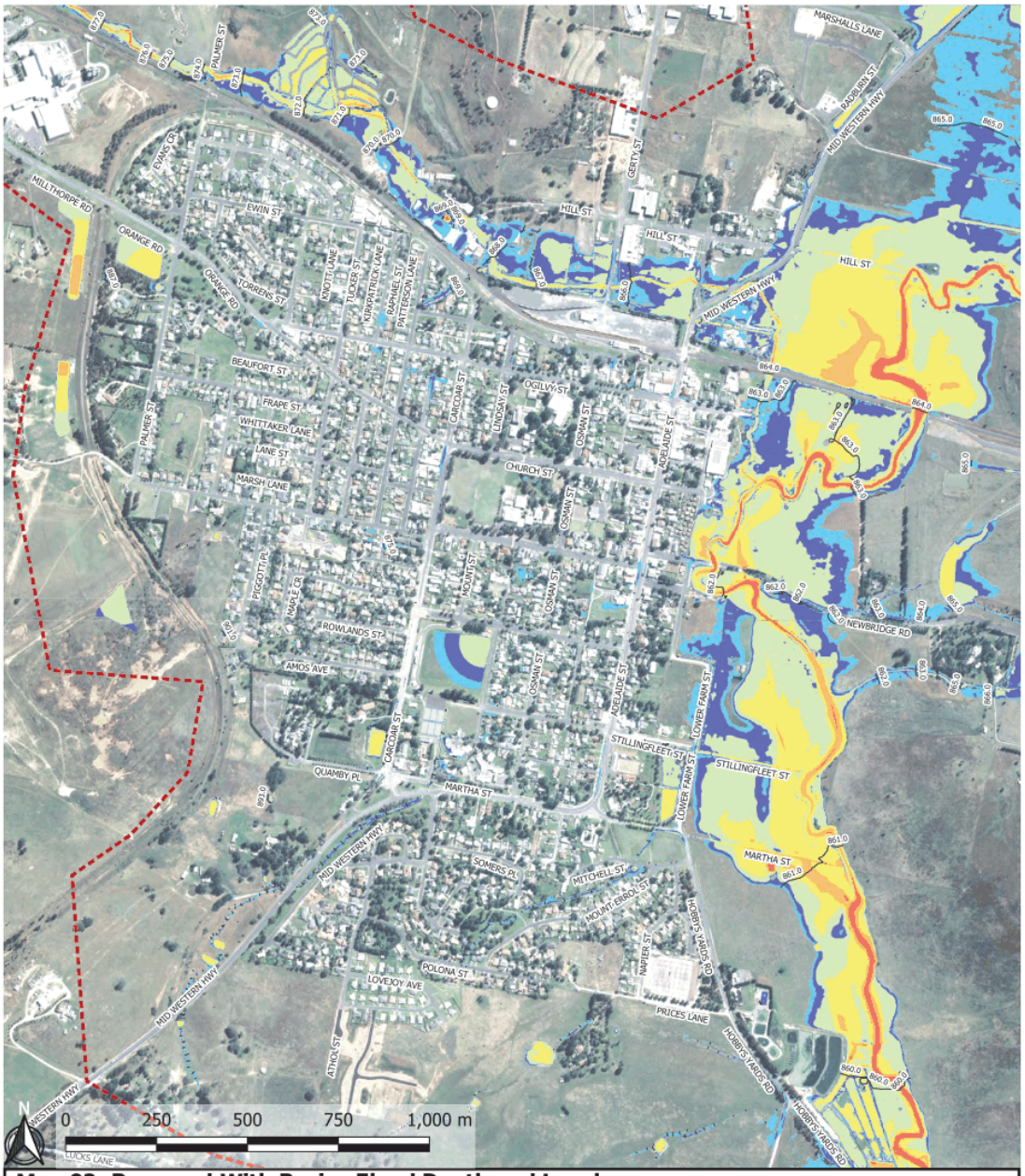
Flood Depth (m)
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary
1m Flood Level Contour (mAHD)

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	01.03.2022
REVISION:	B

Storm



Map 02: Proposed With Basins Flood Depth and Level
5% AEP Event (ARR 2019)

Legend

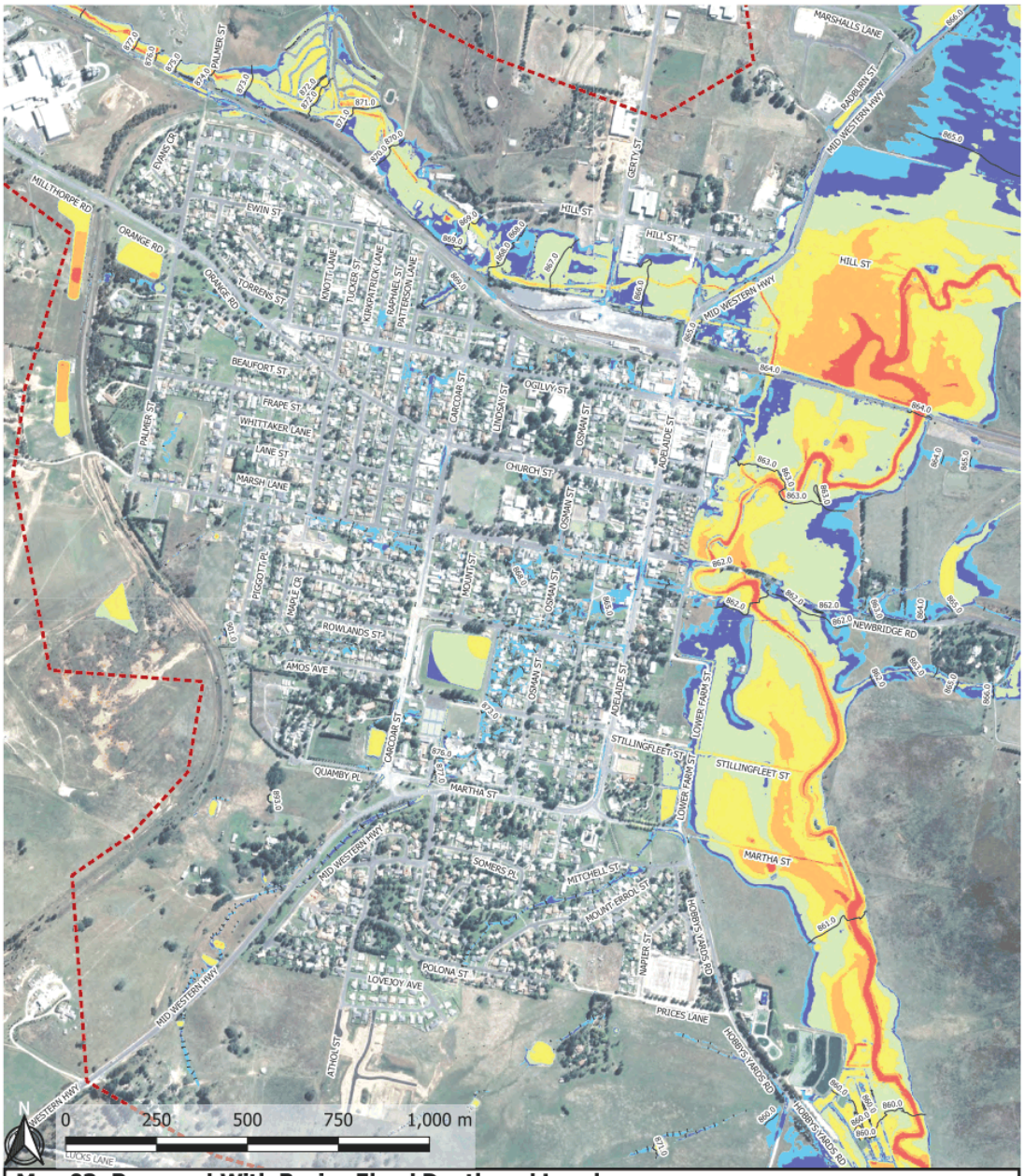
Flood Depth (m)
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary
1m Flood Level Contour (mAHD)

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	01.03.2022
REVISION:	B

Storm



Map 03: Proposed With Basins Flood Depth and Level
1% AEP Event (ARR 2019)

Legend

Flood Depth (m)

- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

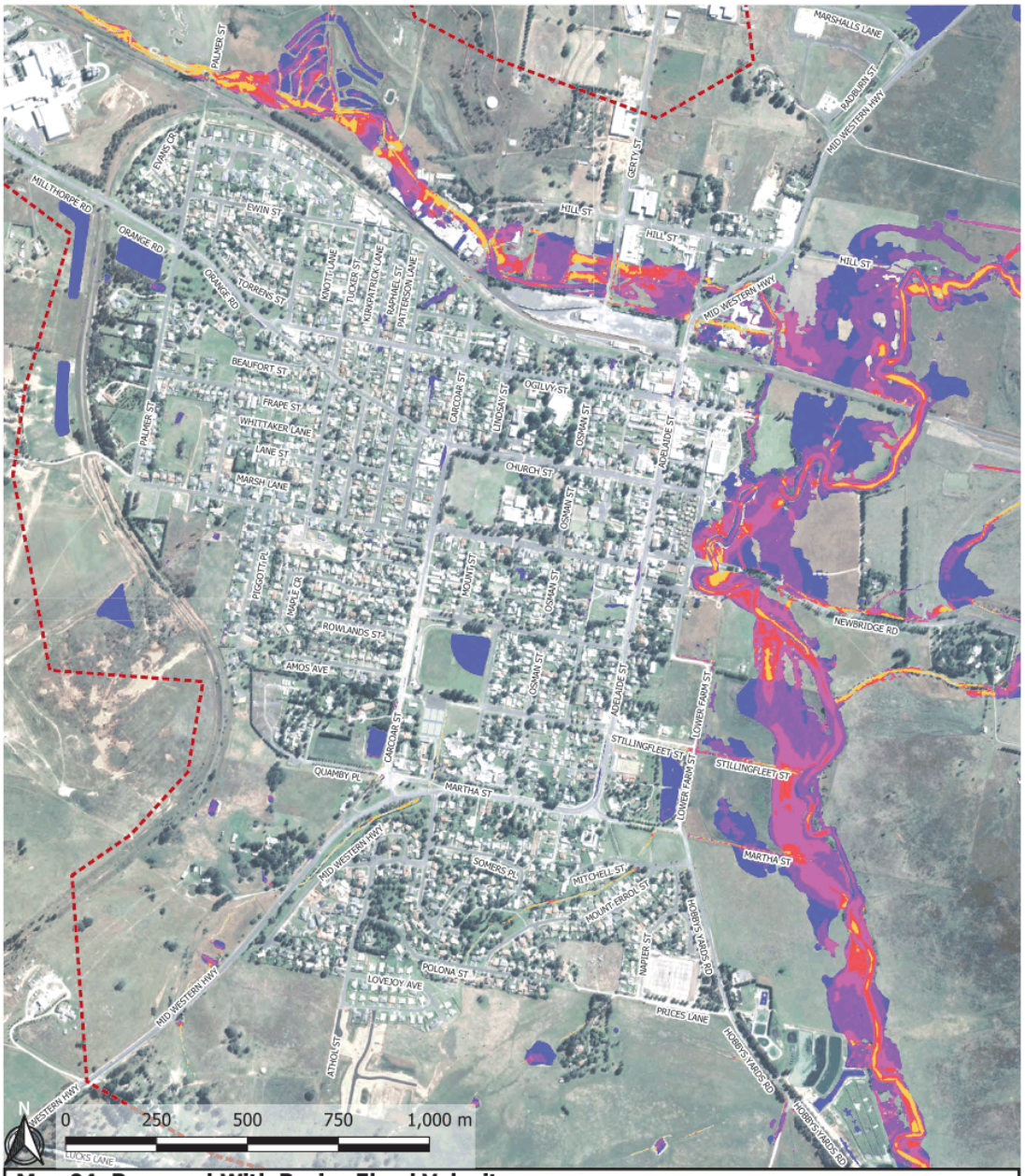
Model Boundary

1m Flood Level Contour (mAHD)

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	01.03.2022
REVISION:	B

Storm



Map 04: Proposed With Basins Flood Velocity
20% AEP Event (ARR 2019)

Legend

Flood Velocity (m/s)

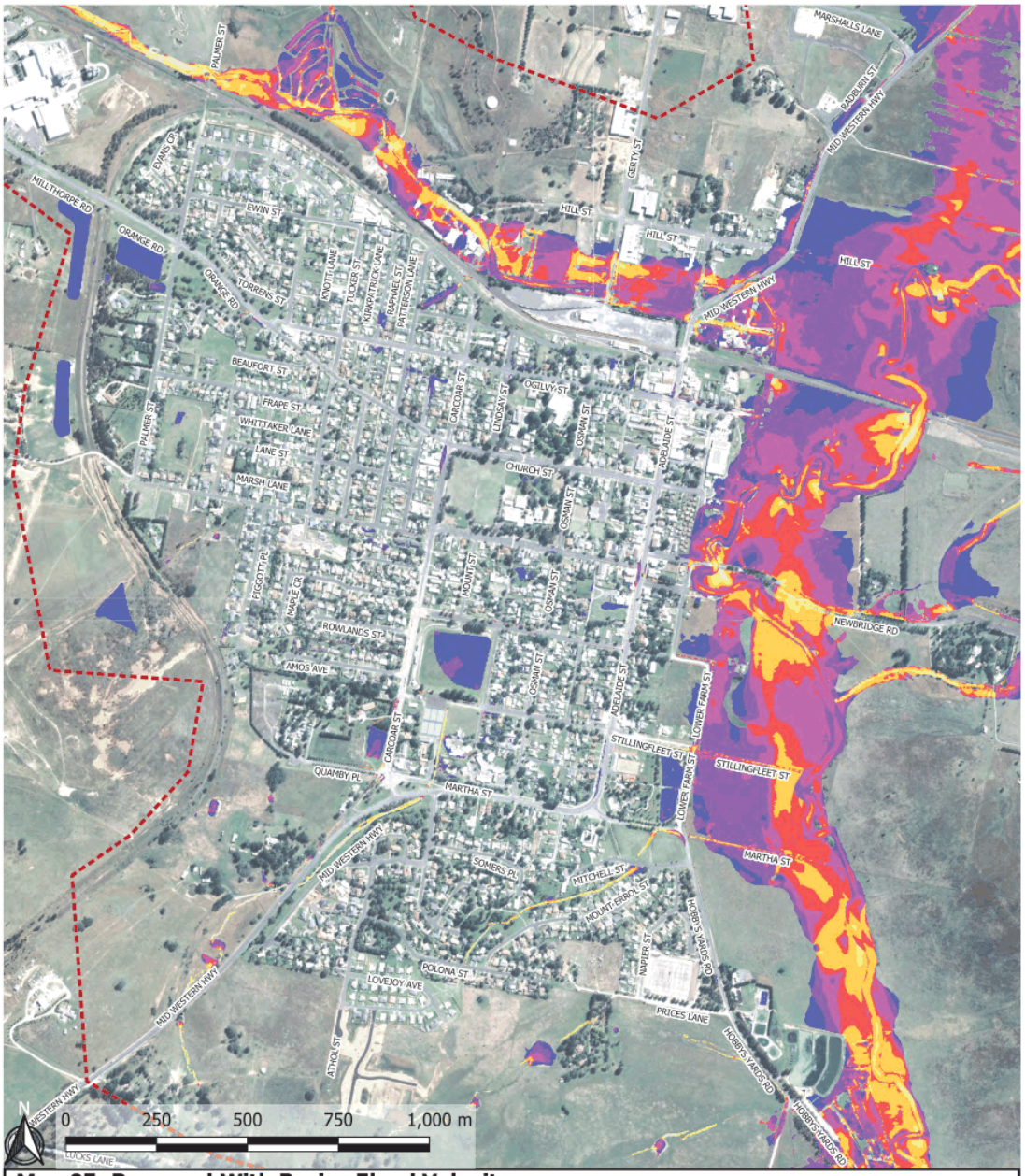
- 0.00 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	01.03.2022
REVISION:	B

Storm



Map 05: Proposed With Basins Flood Velocity
5% AEP Event (ARR 2019)

Legend

Flood Velocity (m/s)

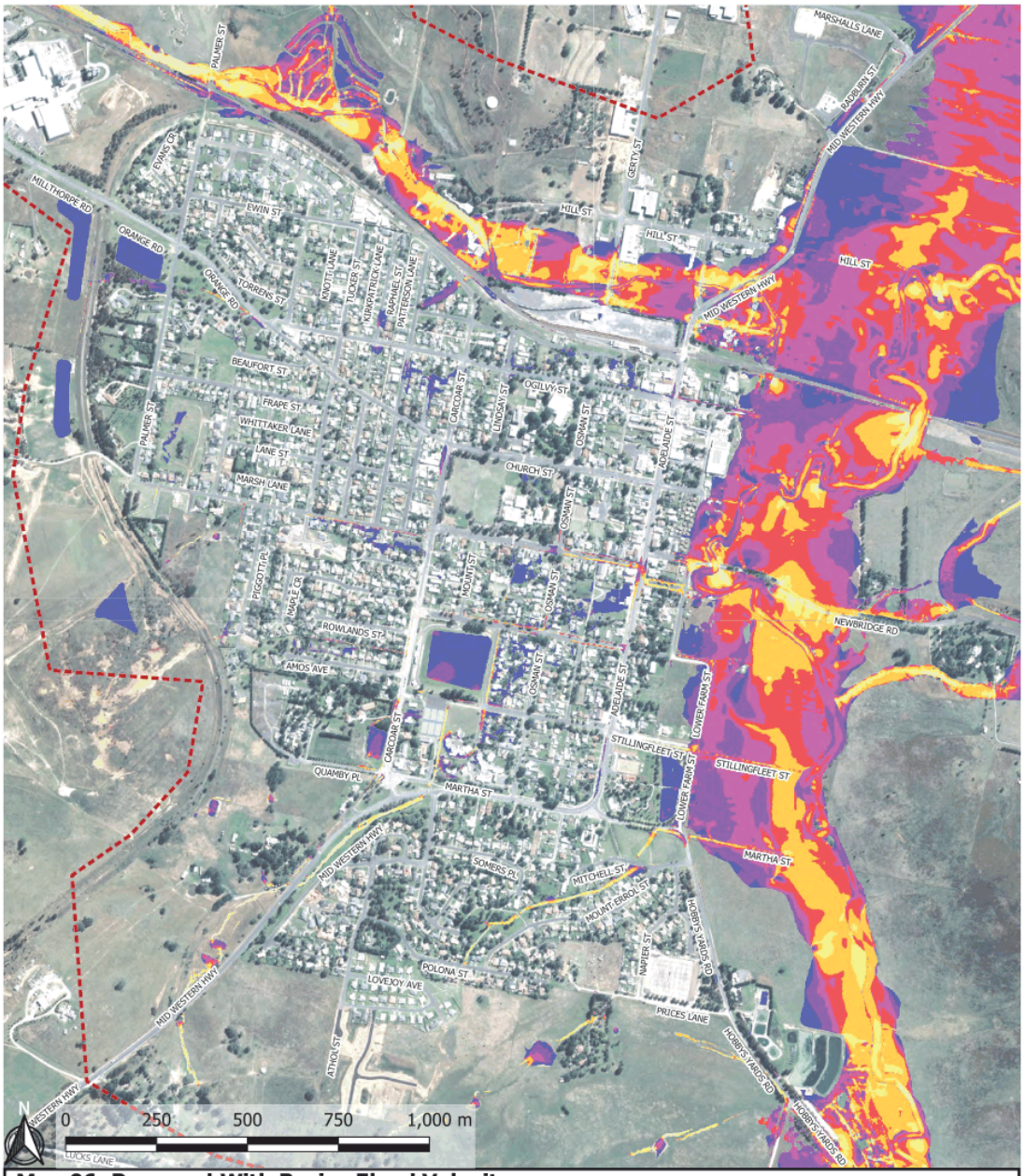
- 0.00 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	01.03.2022
REVISION:	B

Storm



Map 06: Proposed With Basins Flood Velocity
1% AEP Event (ARR 2019)

Legend

Flood Velocity (m/s)

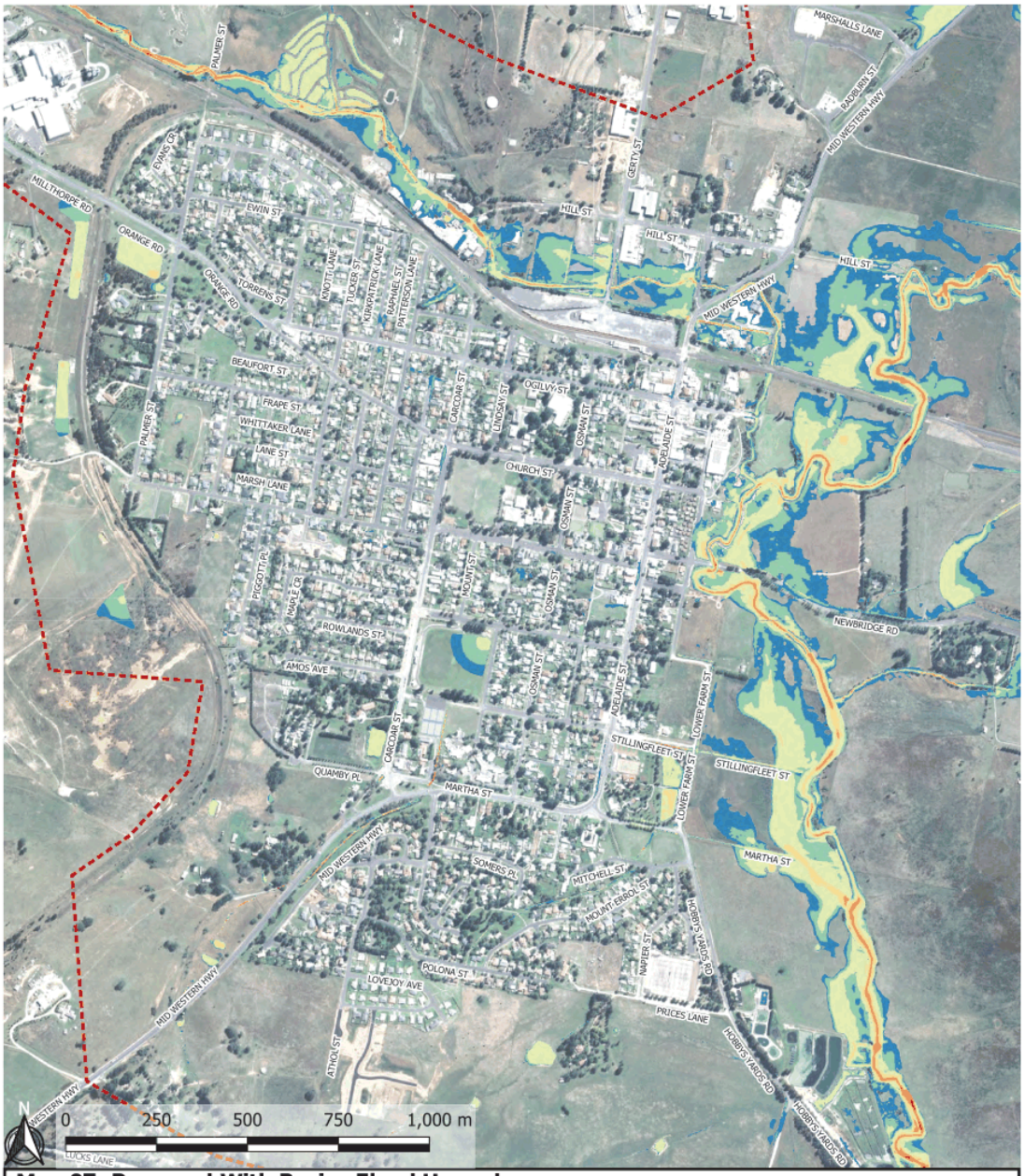
- 0.00 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	01.03.2022
REVISION:	B

Storm



Map 07: Proposed With Basins Flood Hazard
20% AEP Event (ARR 2019)

Legend

Flood Hazard (ARR 2019)

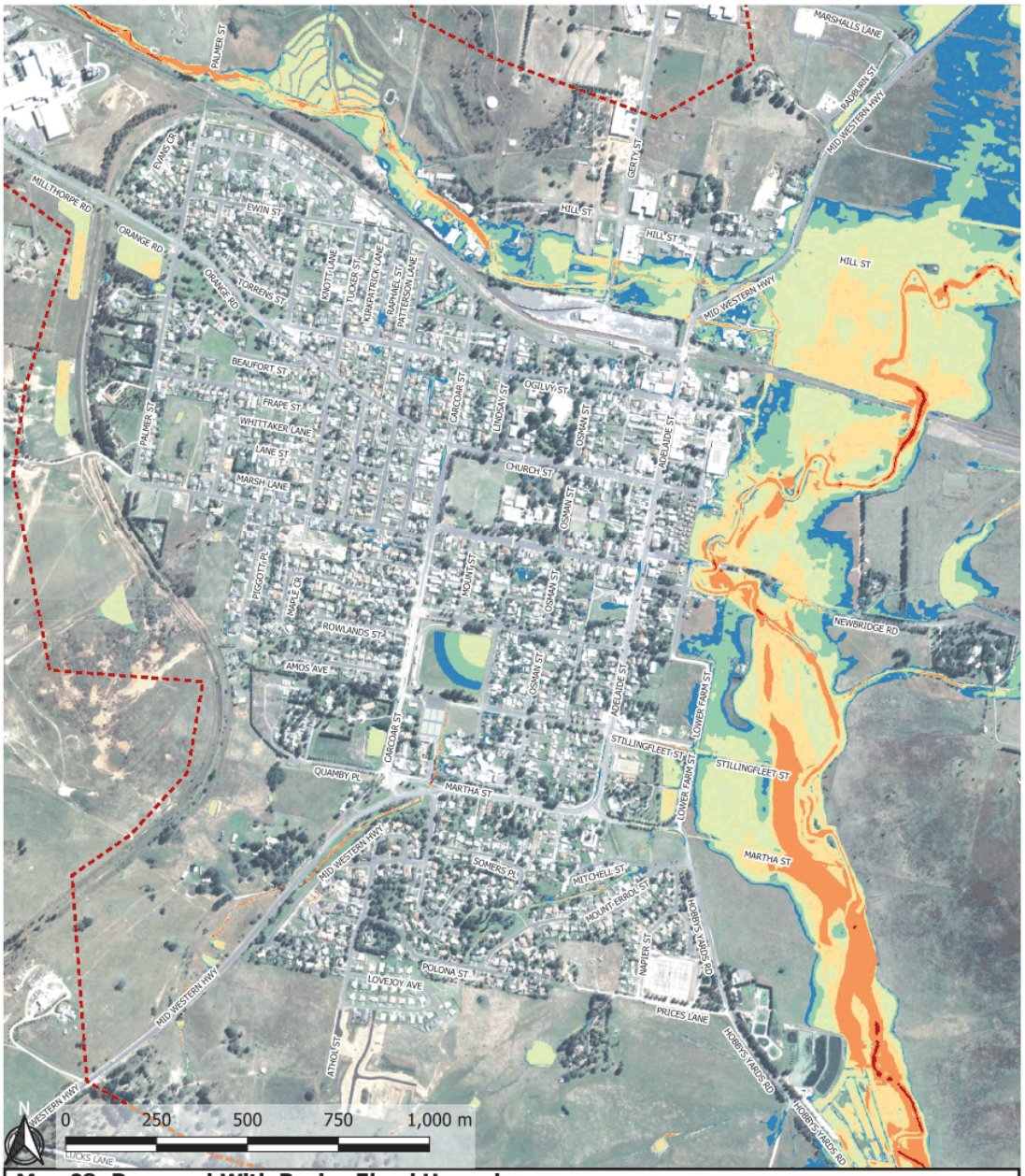
- H1
- H2
- H3
- H4
- H5
- H6

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	01.03.2022
REVISION:	B

Storm



Map 08: Proposed With Basins Flood Hazard
5% AEP Event (ARR 2019)

Legend

Flood Hazard (ARR 2019)

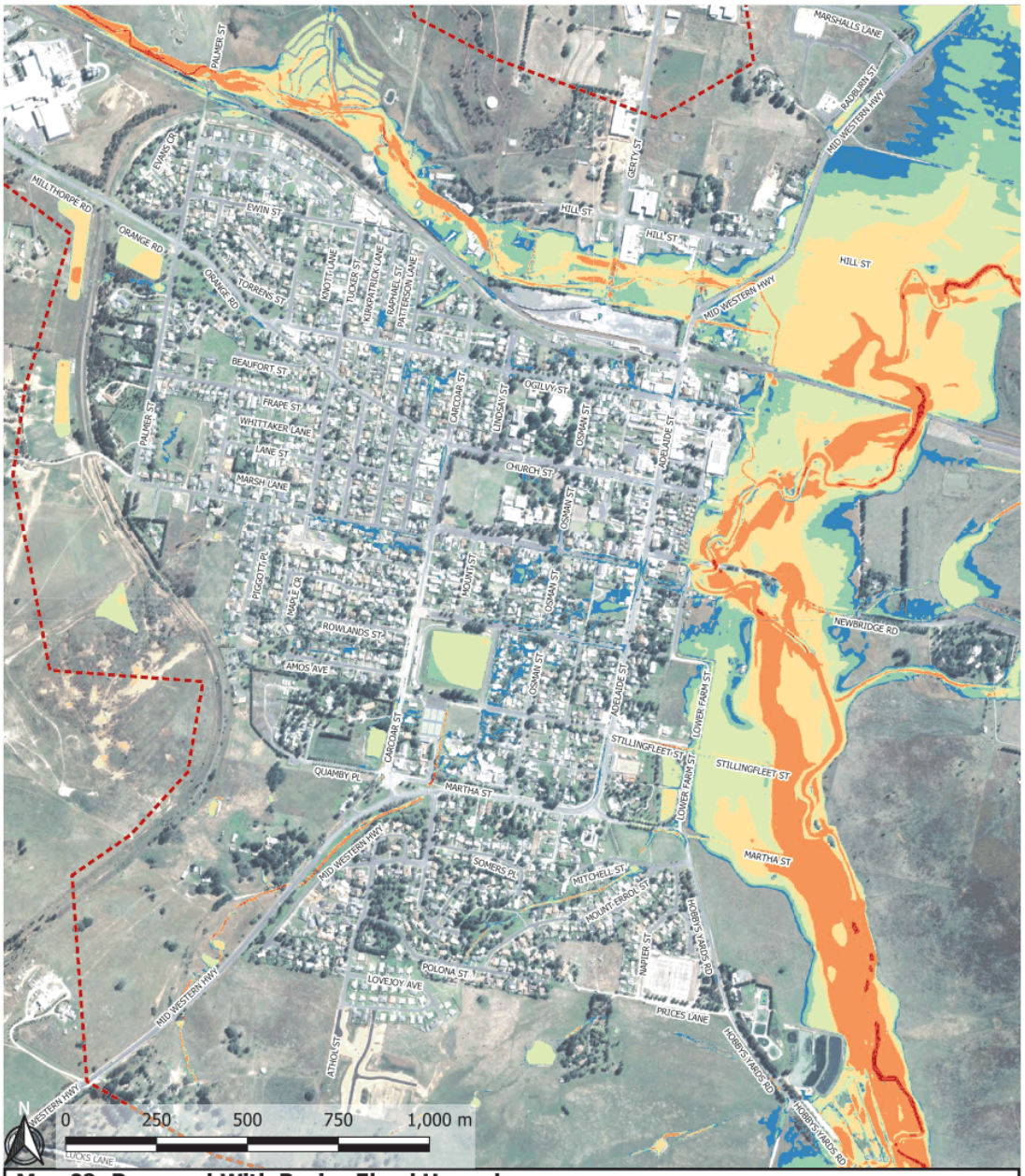
- H1
- H2
- H3
- H4
- H5
- H6

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	01.03.2022
REVISION:	B

Storm



Map 09: Proposed With Basins Flood Hazard
1% AEP Event (ARR 2019)

Legend

Flood Hazard (ARR 2019)

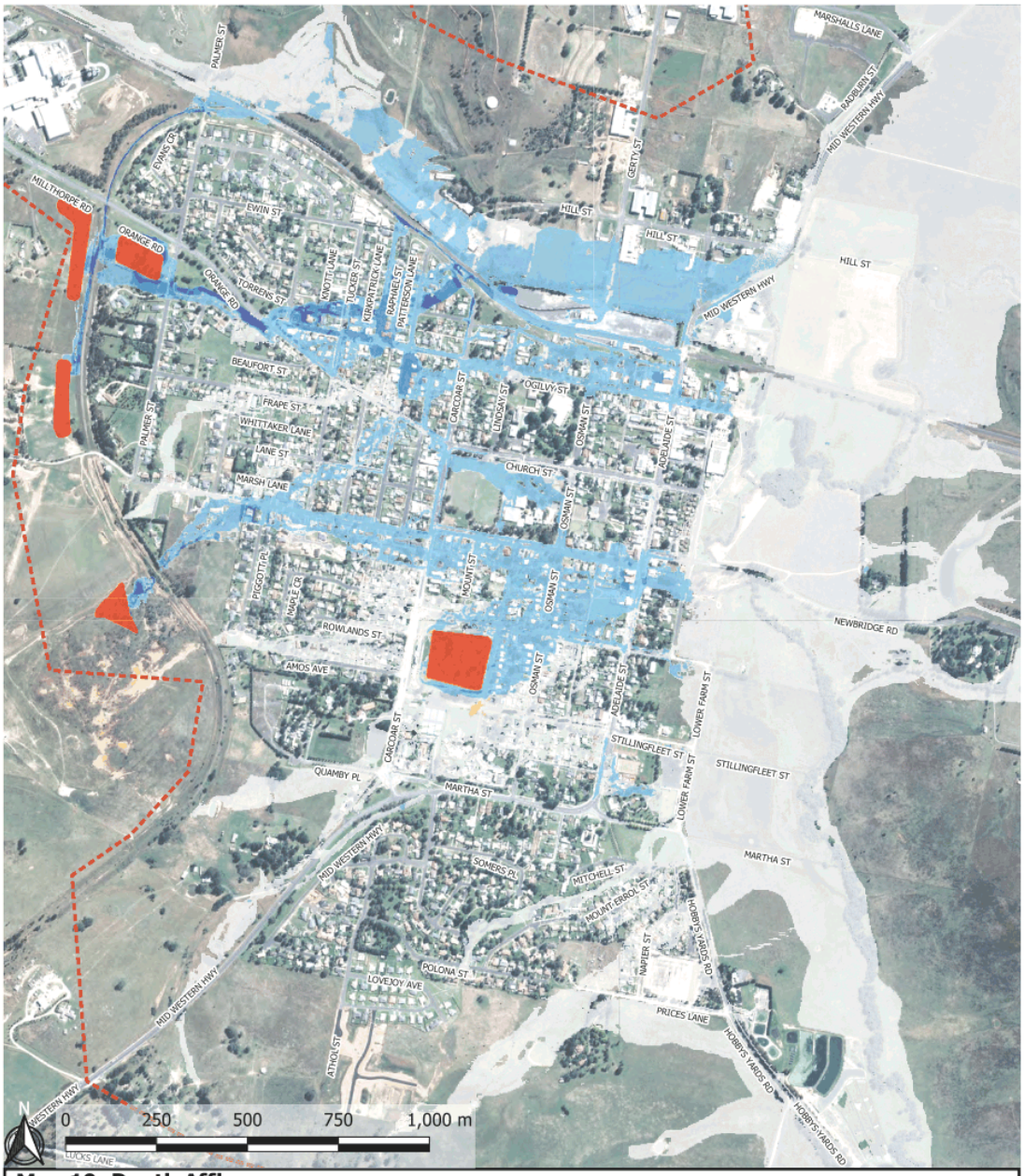
- H1
- H2
- H3
- H4
- H5
- H6

Model Boundary

Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	01.03.2022
REVISION:	B

Storm



Map 10: Depth Afflux
1% AEP Event (Proposed With Basins - Proposed Without Basins)

Legend

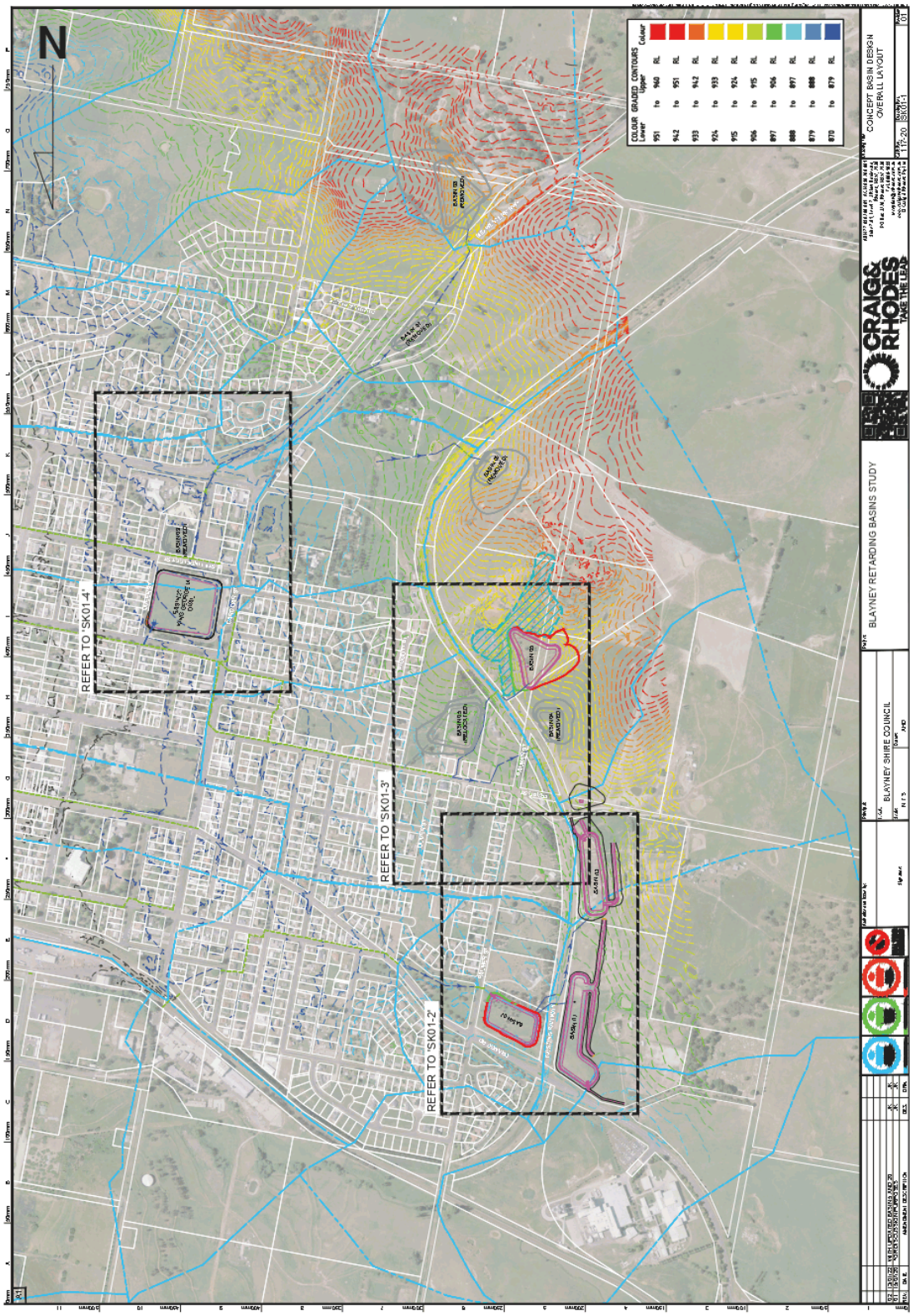
Depth Afflux (m)

- <= -0.50
- -0.50 - -0.20
- -0.20 - -0.10
- -0.10 - -0.01
- -0.01 - 0.01
- 0.01 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- > 0.50
- Model Boundary

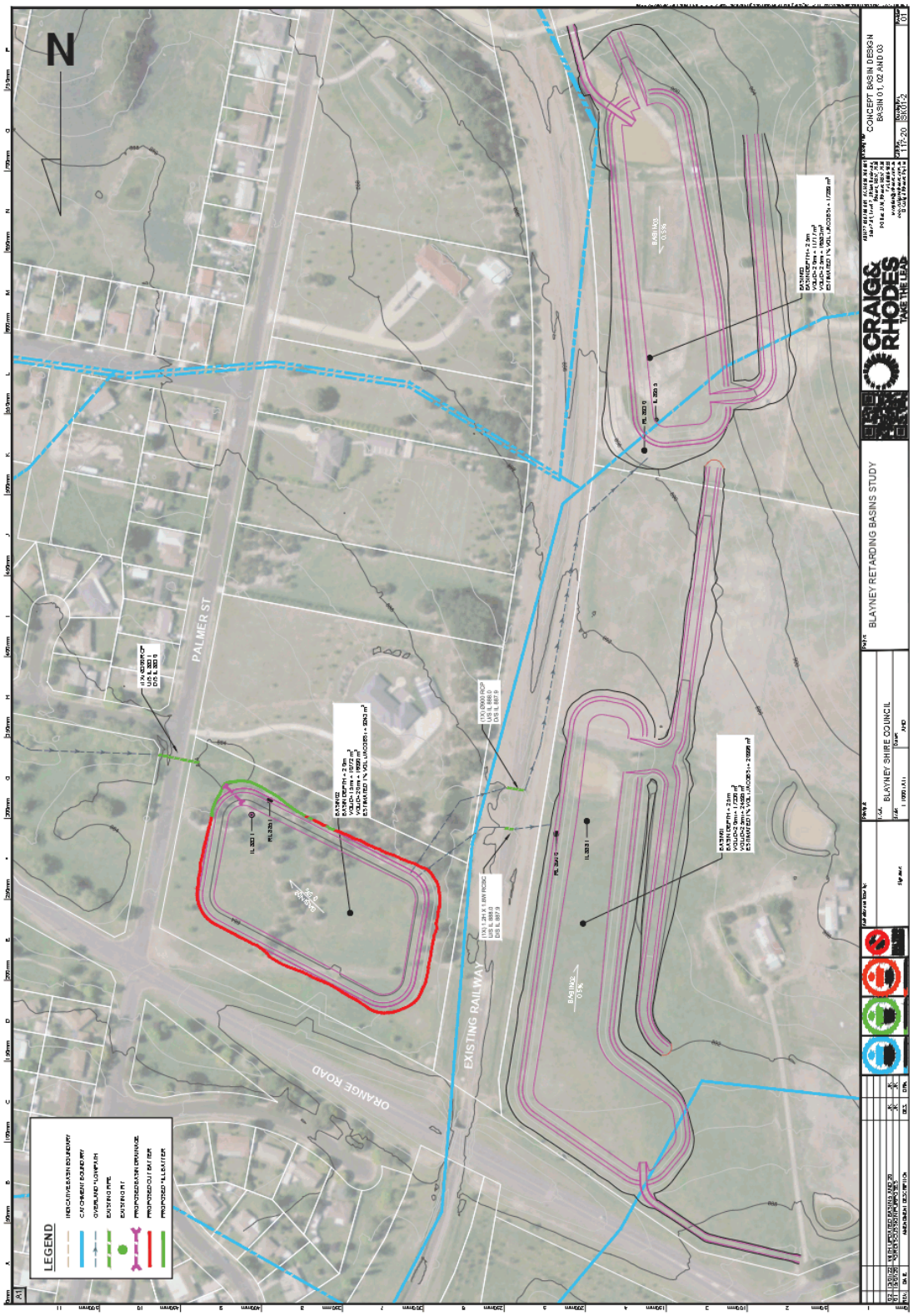
Note: A 150 mm cutoff depth has been applied to this map.

PROJECT ID:	117-20
DATE:	01.03.2022
REVISION:	B

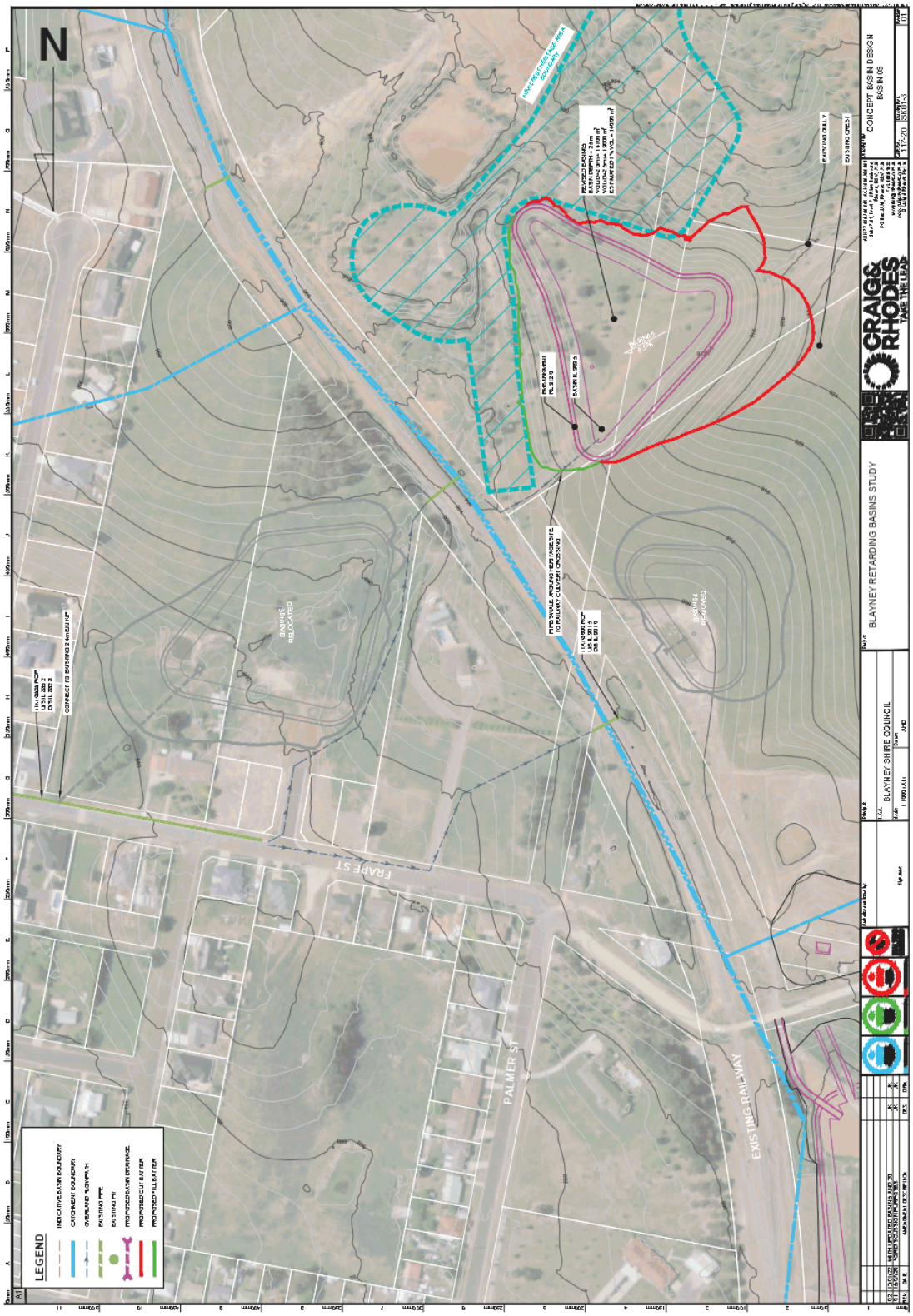
Storm



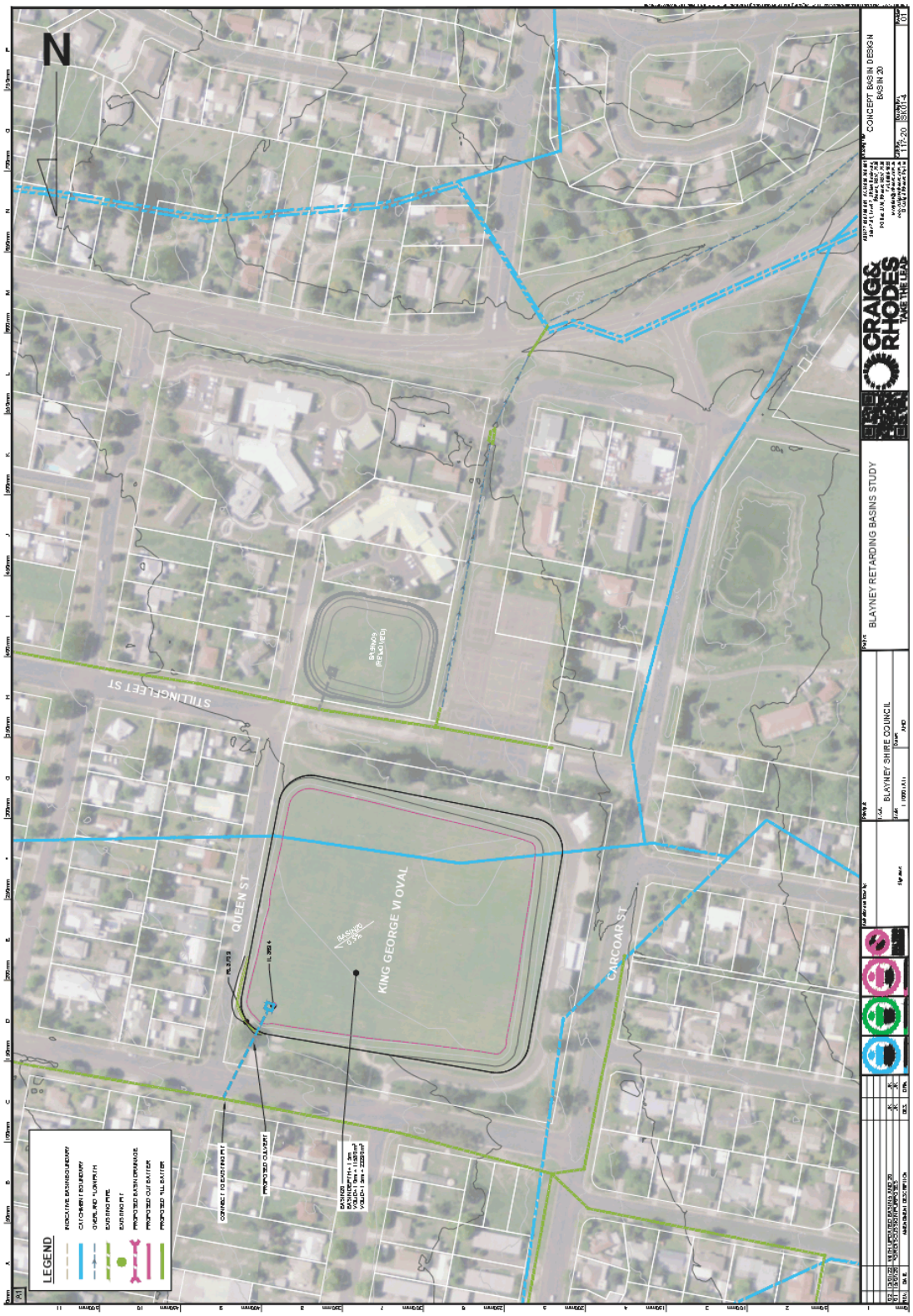
NO: 3 - BLAYNEY RETARDING BASINS STUDY - CONCEPT DESIGN REPORT **ITEM NO: 11**



NO: 3 - BLAYNEY RETARDING BASINS STUDY - CONCEPT DESIGN REPORT **ITEM NO: 11**



NO: 3 - BLAYNEY RETARDING BASINS STUDY - CONCEPT DESIGN REPORT **ITEM NO: 11**



NO: 3 - BLAYNEY RETARDING BASINS STUDY - CONCEPT DESIGN REPORT **ITEM NO: 11**

FLORA AND FAUNA ASSESSMENT REPORT

BLAYNEY RETARDATION BASINS

Prepared for STORM CONSULTING

on behalf of BLAYNEY SHIRE COUNCIL

By Applied Ecology Pty Ltd

28/07/2020, updated 15/01/2021

applied ecology
applied ecology.com.au
38 Bridge Street, RYDALMERE, NSW 2116
7/150 Keppel Street, BATHURST, NSW 2795
PO BOX 397, KATOOMBA, NSW 2780
P (02) 63377229
F (02) 47824862
M 422857086|0428131796
contact@appliedecology.com.au www.appliedecology.com.au

DOCUMENT VERIFICATION

Project Title	BLAYNEY RETARDATION BASINS
Document Title	Flora and Fauna Assessment - BLAYNEY RETARDATION BASINS
Client	STORM CONSULTING on behalf of BLAYNEY SHIRE COUNCIL
Client contact	Ricky Kwan

Revision	Prepared by	Reviewed by	Date
Draft (D)	MB	AC	14/06/2020
D2	MB	Storm Consulting	17/06/2020
D3	MB	(2 additional basins surveyed)	15/01/2021
F_1			

DISCLAIMER

This report is prepared by APPLIED ECOLOGY Pty Limited for its clients' purposes only. The contents of this report are provided expressly for the named client for its own use. No responsibility is accepted for the use of or reliance upon this report in whole or in part by any third party. This report is prepared with information supplied by the client and possibly other stakeholders. While care is taken to ensure the veracity of information sources, no responsibility is accepted for information that is withheld, incorrect or that is inaccurate. This report has been compiled at the level of detail specified in the report and no responsibility is accepted for interpretations made at more detailed levels than so indicated.

CONTENTS

1 SUMMARY

Applied Ecology Pty Limited undertook a snapshot flora and fauna survey and habitat assessment of the locations of 11 potential stormwater retardation basin sites around the township of Blayney, primarily to identify any ecological constraints on the subject site that may need to be considered as part of the proposed construction of a bridge. One commonly planted threatened species was recorded, and no threatened populations were identified on or near the site by desktop searches or during this field survey. No listed migratory species were noted near the proposed retardation basins and many of them are heavily impacted though grazing and unlikely to support these species. There was no evidence of koala use of the site (scats, scratches, etc). All of the native trees on the subject sites have been planted. Many of these species are koala feed trees and need to be protected or replaced.

To progress the project, works planning needs to address mitigation methods listed in section 7 of this report.

2 INTRODUCTION

2.1 PROJECT BACKGROUND

Blayney Shire Council through Storm Consulting P/L has commissioned a Flora and Fauna Assessment report as part of a feasibility study for the proposed series of storm/flood retardation basins. This project is expected to improve the safety of the residents of Blayney during storm events and reduce flooding in the lower areas of the town, near the Belubula River.

This report is prepared for the purpose of identifying any environmental constraints that may affect the proposed activity. The Flora and Fauna Assessment report provides a comprehensive snapshot of flora and fauna recorded on site on the 23rd July 2020 with additional basins surveyed on 9th January 2021.

This report comprises a flora and fauna assessment at the locations of the proposed flood retardation basins, including assessment of:

- Whether there will be any impact on koala habitat as defined by the State Environmental Planning Policy for Koala Habitat Protection 2020 (updated from the Koala SEPP 2019),
- Whether the proposed activity is likely to have a significant impact on threatened species, as listed under the NSW Biodiversity Conservation Act (TSC), and therefore the requirement for a Species Impact Statement (SIS) under Section 5A of the EP&A Act, and
- The potential for the proposed activity to significantly impact on a matter of national environmental significance and therefore the need to make a referral to the Commonwealth Environment Minister in accordance with the EPBC Act.

2.2 SITE DESCRIPTION

Nine potential basin sites were initially identified for assessment, most of which are on private land (Figure 1). The landholder for the property where basin 8 is proposed has refused access to this site. Two basins were added later, and all the basins are predominantly located around the western and southern perimeter of Blayney, a small town in the Central Tablelands of NSW (Figure 2).

Figure 1 Locations of proposed stormwater basins around Blayney

Figure 2 Site context (initial basins in red, additional basins in yellow)

2.3 PROPOSED WORKS

Blayney Shire Council has undertaken a Flood Study (Jacobs 2015) and Floodplain Risk Management Study and Plan (Jacobs 2016) of the Town of Blayney, that identified as a High Priority measure, the "Initial investigations and assessments required in the preparation of concept design and cost estimates for the required works involving flood retarding basins". The Floodplain Risk Management Study identifies up to 9 retarding basin locations (8 on the western fringe, and 1 within the urban

area) of Blayney. This report forms part of these initial investigations. Since project commencement there have been two potential basin locations added to the site investigations: Basin 5b and 20.

3 FLORA AND VEGETATION

3.1 DESKTOP SURVEYS

Searches of several databases were made to identify threatened species and Endangered Ecological Communities (EECs) that may potentially be found on the subject site. Databases were accessed on 14th July 2020. These included:

- NSW Wildlife Atlas (www.bionet.nsw.gov.au/),
- EPBC Act database (www.environment.gov.au/erin/ert/epbc/index.html).

Results of these searches were used to inform site surveys and the 5 Part Test (see section 6 of this report).

3.2 FIELD SURVEY RESULTS

Field surveys were conducted on 23rd July 2020 for eight of the nine basins (Basin 8 was excluded due to the refusal of permission to access). Weather was cool, becoming warm and sunny, with little breeze and some clouds forming.

A total of 19 species of native flora were recorded across the proposed basin locations, ranging from zero to 9 species (Table 1). One planted threatened species was recorded in two locations, while no threatened populations were recorded during the current study.

Table 1 Native flora species recorded at locations for proposed stormwater retardation basins, July 2020

SPECIES NAME	COMMON NAME	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5a	BASIN 5b	BASIN 6	BASIN 7a	BASIN 7b	BASIN 9	BASIN 20
Acacia dealbata	Silver Wattle				y	y	y		y	y		
Carex appressa	Tall Carex									y		
Eucalyptus blakelyi	Blakely's Red Gum		y			y	y					
Eucalyptus dives	Broad-leaved Peppermint		y			y	y					
Eucalyptus melliodora	Yellow Box		y			y	y					
Eucalyptus nicholii	Nicholii Gum (planted)	y		y								
Geranium homeanum	Native Geranium	y										
Geranium solanderi	Native Geranium					y	y		y			
Juncus usitatus	Common Rush											
Lachnagrostis filiformis	Blown Grass							y	y	y		
Oxalis perennans						y	y					
Rytidosperma sp	Wallaby Grass					y	y		y	y		
Eucalyptus viminalis	Ribbon Gum		y									
Melaleuca ericifolia			y									
Eucalyptus bicostata	Southern Blue Gum		y									
Eucalyptus cinerea	Argyle Apple		y									
Eucalyptus radiata subsp radiata	Narrow-leaved Peppermint		y									
Eleocharis sphaceolata			y									
TOTAL SPECIES PER SITE		**2**	**9**	**1**	**1**	**7**	**7**	**1**	**4**	**4**	**(none)**	**(none)**

A total of 36 species of introduced flora were recorded across the proposed basin locations, ranging from 6 to 20 species (Table 2). Some species may not have been detected at some sites due to the season (winter) and the effects of heavy grazing by horses. Flowering parts were typically absent, and often foliage was

degraded through grazing or in early formative stages following removal of grazing pressure. The Biosecurity Act 2015 lists priority control weeds for the Central Tablelands LLS region. Control requirements for these weeds are provided after the following table. All weeds listed under the Act have a General Biosecurity Duty as follows:

*All plants are regulated with a **general biosecurity duty** to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.*

Table 2 Introduced flora species recorded at locations for proposed stormwater retardation basins, July 2020

SPECIES NAME	COMMON NAME	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5a	BASIN 5b	BASIN 6	BASIN 7a	BASIN 7b	BASIN 9	BASIN 20
Acetosella vulgaris	Sheep Sorrell					y	y	y				
Arctotheca calendula	Cape Daisy	y	y	y	y						y	y
Avena fatua	Oat Grass		y	y	y							
Brassica fruticulosa	Twiggy Turnip		y			y	y		y	y		
Bromus catharticus	Prairie Grass		y			y	y		y	y		
Cirsium vulgare	Spear Thistle								y	y		
Conyza sp	Fleabane		y			y	y		y	y		
Cynodon dactylon	Common Couch		y						y			
Cyperus eragrostis	Umbrella Sedge		y									
Cytisus scoparius *	Scotch Broom				y	y	y					
Dactylus glomeratus	Cocksfoot	y	y			y	y		y	y		
Echium plantagineum	Patersons Curse	y	y			y	y	y	y	y		
Echium vulgare	Vipers Bugloss	y						y	y	y	y	y
Eragrostis cilianensis	Stink Grass								y			
Gamochaeta sp	Cudweed		y								y	y
Hedera helix	English Ivy		y									
Hirshfeldia incana	Buchan Weed				y							
Hypericum perforatum *	St Johns Wort							y				

SPECIES NAME	COMMON NAME	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5a	BASIN 5b	BASIN 6	BASIN 7a	BASIN 7b	BASIN 9	BASIN 20
Hypochaeris radicata	Flatweed		y			y	y	y				
Lactuca serriola	Prickly Lettuce								y	y		
Ligustrum lucidum *	Large-leaved Privet								y	y		
Malva nicaeensis	Mallow of Nice	y				y	y				y	y
Marrubium vulgare	Horehound					y	y					
Modiola caroliniana	Red-flowered Mallow		y	y	y				y	y	y	y
Nassella trichotoma *	Serrated Tussock		y						y	y		
Paspalum dilatatum	Paspalum		y						y	y	y	y
Phalaris paradoxa	Phalaris	y				y	y		y			
Pinus radiata	Radiata Pine			y		y	y				y	y
Plantago lanceolata	Plantain		y	y	y				y	y		
Poa annua	Winter Grass	y	y								y	y
Populus nigra	Lombardy Poplar									y		
Rubus fruticosus aggregate species *	Blackberry		y	y	y	y	y	y		y		
Rumex obtusifolia	Broad-leaved Dock								y	y		
Salix fragilis *	Crack Willow								y	y		
Sonchus oleraceus	Milk Thistle, Sowthistle								y	y		
Trifolium spp	Clovers	y	y			y	y	y	y			
TOTAL SPECIES PER SITE		**8**	**19**	**6**	**7**	**14**	**14**	**7**	**20**	**18**	**8**	**8**

* See below

Priority control weeds recorded on the subject site have the following control requirements:

- Blackberry (*Rubus fruticosus* aggregate species): **Prohibition on dealings** - *Must not be imported into the State or sold*
  Regional Recommended Measure - Land managers should mitigate the risk of new weeds being introduced to their land. Land managers should mitigate spread from their land. The plant should not be bought, sold, grown, carried or released into the environment.
  Protect conservation areas, natural environments and primary production lands that are free of blackberry

- Serrated Tussock (*Nassella trichotoma*): **Prohibition on dealings** - *Must not be imported into the State or sold*
  Regional Recommended Measure – Land managers should mitigate the risk of new weeds being introduced to their land. Land managers should mitigate spread from their land. The plant should not be bought, sold, grown, carried or released into the environment.
  Protect conservation areas, natural environments and primary production lands that are free of serrated tussock

- Crack Willow (*Salix fragilis*): **Prohibition on dealings** - *Must not be imported into the State or sold.* **All species in the *Salix* genus have this requirement, except *Salix babylonica* (weeping willows), *Salix x calodendron* (pussy willow) and *Salix x reichardtii* (sterile pussy willow)**

- Scotch Broom *(Cytisus scoparius* subsp. *scoparius)*: **Prohibition on dealings** - Must not be imported into the State or sold.
  Regional Recommended Measure - Land managers should mitigate the risk of new weeds being introduced to their land. Land managers should mitigate spread from their land. The plant should not be bought, sold, grown, carried or released into the environment. **Protect conservation and natural environments that are free of Scotch broom.**

- St Johns Wort (*Hypericum perforatum*): **Regional Recommended Measure** - Land managers should mitigate the risk of new weeds being introduced to their land. Land managers should mitigate spread from their land. The plant should not be bought, sold, grown, carried or released into the environment. **Protect grazing land that is free of St. John's wort.**

- Broad-leaved Privet (*Ligustrum lucidum*): **Regional Recommended Measure** - Exclusion zone: urban areas of Bathurst Council, Blayney Council, Lithgow Council, Oberon Council, and Orange City Council. Whole region: The plant should not be bought, sold, grown, carried or released into the environment. Exclusion zone: The plant is prevented from flowering and fruiting. Land managers should mitigate spread from their land. Land managers should mitigate the risk of the plant being introduced to their land.

Weed control in the road corridor is managed by Blayney Shire Council who are the local control authority for biosecurity weed threats in the Blayney area.

3.3 MAPPED VEGETATION

Vegetation in and around the Blayney township has been mapped by OEH (2017; Figure 3). Small areas of Ribbon Gum – Snow Gum grassy woodland have been mapped for areas west of Basins 1, 3, and 4, and south of Basin 8 (excluded from the current study). No other native vegetation was reported for the area.

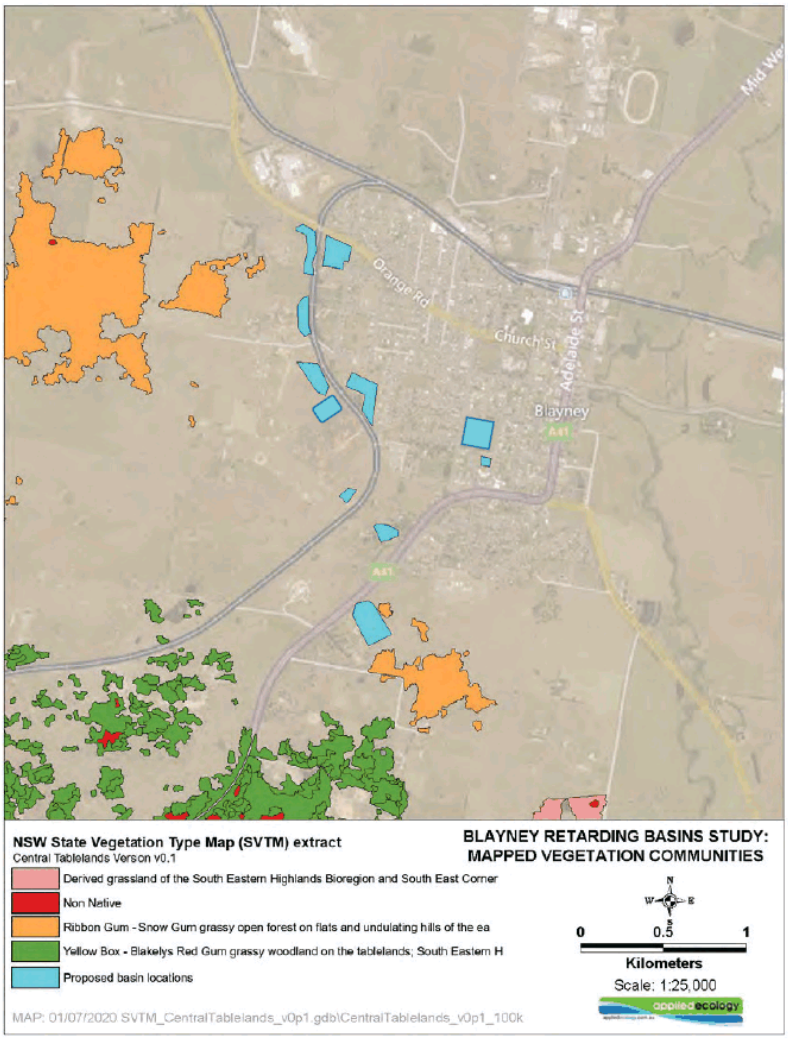


Figure 3 Mapped vegetation for Blayney township and surrounds (OEH, 2017)

3.4 FLORA AND VEGETATION ON SITE

3.4.1 Basin 1

Basin 1 is to be located south of Orange Rd and west of the Blayney – Demondrille railway line. Access is via Memorial Drive and the site is on private property. The site consists of three paddocks, all currently grazed by horses (Figure 4). The southernmost paddock has a small dam and a single remaining tree that is a planted Narrow-leaved Black Peppermint (*Eucalyptus nicholii*; Figure 5), a threatened species found on the ranges in Northern NSW. With only a single planted tree, vegetation throughout is highly modified. Only one species of native groundcover was recorded and the remainder were common pasture improved grasses or pasture weeds (Table 3).

Table 3 Summary of flora species recorded on site – number per category, Basin 1

NATIVE SPECIES	THREATENED SPECIES	INTRODUCED SPECIES	PRIORITY WEEDS
2	1	8	0

Figure 4 Basin 1 is south of the Orange Rd, and comprises two horse paddocks – this is the northern paddock

Figure 5 The second paddock is beside the railway corridor, and has a small dam with a planted Eucalyptus nicholii beside it

3.4.2 Basin 2

Basin 2 is to be located south of the Orange Rd and east of the Blayney – Demondrille railway line. It is adjacent to residential properties on the edge of Blayney and is currently being managed as an urban reserve. The lower end of the site has numerous mixed eucalypt plantings with a mown grass understorey (Figure 6). A small drainage swale meanders through these eucalypts which form a vegetative screen for nearby housing (Figure 7). The swale then drains through a small wetland area at the southern corner of the park before entering the reticulated stormwater network (Figure 8). The upper end of the park, nearest to the Orange Rd, is predominantly open space which takes up more than half of the reserve (Figure 9).

Of the native flora species on site, seven are planted eucalypt species, one is a planted native shrub, and one a native sedge in the wetland area (Table 4). Introduced species are numerous and mainly consist of common introduced lawn grasses with common lawn and pasture weeds.

Table 4 Summary of flora species recorded on site – number per category, Basin 2

NATIVE SPECIES	THREATENED SPECIES	INTRODUCED SPECIES	PRIORITY WEEDS
9	0	19	2

Figure 6 Basin 2 is located in an urban park with planted mixed eucalypt species

Figure 7 A small drainage swale meanders through the planted eucalypts and beside nearby housing

Figure 8 A small wetland area is located at the lower end of the park, near the drainage outflow

Figure 9 More than half the park is predominantly open space located towards Orange Rd in the upper end of the site

3.4.3 Basin 3

Basin 3 is located north of Plumb St and west of the Blayney – Demondrille railway line. The location consists of several horse paddocks that are all currently grazed. The southernmost paddock is currently sown with oats and has a moderately large dam with waterfowl on it (Figure 10). A second dam is in the next paddock and is located beside the railway line (Figure 11). This paddock is also grazed with mixed stock including ponies and sheep.

Vegetation on site is highly modified (Table 5). A row of Radiata Pines has been planted along the eastern boundary beside the railway line. A single planted Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) is present at the northern end of the pines. This is the only native flora species recorded on site, and is a threatened species that is typically found on the Northern Tablelands.

Table 5 Summary of flora species recorded on site – number per category, Basin 3

NATIVE SPECIES	THREATENED SPECIES	INTRODUCED SPECIES	PRIORITY WEEDS
1	1	6	1

Figure 10 Basin 3 comprises a cropped paddock with a small dam and currently grazed by horses

Figure 11 A second dam is located in the second paddock and beside the railway line

3.4.4 Basin 4

Basin 4 is a heavily grazed horse paddock that slopes eastward towards the Blayney – Demondrille railway line, culminating in a small dam near the eastern boundary (Figure 12). Vegetation in this location is heavily modified (Table 6), with the only native flora species present being a single specimen of Silver Wattle (*Acacia dealbata*). Trees are absent and the groundcover vegetation consists of pasture grasses and common pasture weeds. Two priority control weeds are present, namely Scotch Broom and Blackberry. Other species may be present but difficult to locate given the recent heavy grazing of the site.

Table 6 Summary of flora species recorded on site – number per category, Basin 4

NATIVE SPECIES	THREATENED SPECIES	INTRODUCED SPECIES	PRIORITY WEEDS
1	0	7	2

Figure 12 Basin 4 is a heavily grazed horse paddock that drains to a small dam, all located above the railway line

3.4.5 Basin 5a

Basin 5a is located south of Plumb St behind new housing on the outskirts of the urban area of Blayney (Figure 13). This location currently has mixed uses. The western section includes a deep drainage swale that has mixed eucalypts sparsely planted along each bank (Figure 14). The drainage gully has become infested with Blackberry which has recently been sprayed. Older dumped farm rubbish is present in the bottom of the channel. This area is sporadically grazed, evidenced by the temporary fencing across the gateway to the site. The eastern part of the site consists of several horse paddocks. The gully drains to a small dam located in one of the paddocks, currently grazed (Figure 15). This part of the site is heavily grazed and weed infested (Figure 16).

Vegetation on site has been highly modified, with evidence of fairly recent revegetation planting with eucalypts along the gully within the last ten years (Table 7). This part of the site has several native grasses and groundcovers present, unlike the horse paddocks which have introduced pasture grasses and weeds. Blackberry and Scotch Broom are present on this site.

Table 7 Summary of flora species recorded on site – number per category, Basin 5a

NATIVE SPECIES	THREATENED SPECIES	INTRODUCED SPECIES	PRIORITY WEEDS
7	0	14	2

Figure 13 Basin 5 is located on the outskirts of urban Blayney

Figure 14 Eucalypts have been planted along a drainage gully that had a heavy blackberry infestation, recently sprayed

Figure 15 A small dam is located at the lower end of the horse paddock and fed by the drainage swale

Figure 16 Much of the site is heavily grazed, especially the two horse paddocks

3.4.6 Basin 5b

Basin 5b is located next to Basin 5a, south of Plumb St on the outskirts of Blayney. This location has evidence of historic mining and more recent erosion. A car has been dumped in the area at the base of the mining area (Figure 17). This adjoins the small farm dam that is the likely site of the proposed basin (Figure 18). This dam is surrounded by introduced grasses and a fruit tree, and has been regularly used by stock. The dam outflow has become eroded as well, indicating that the soils are likely to be highly erosive (Figure 19).

Vegetation on site has been highly modified (Table 7). This part of the site has several native grasses and groundcovers present, unlike the adjoining horse paddocks which have introduced pasture grasses and weeds (Figure 20). Blackberry Serrated Tussock and Scotch Broom are present on this site.

Table 8 Summary of flora species recorded on site – number per category, Basin 5

NATIVE SPECIES	THREATENED SPECIES	INTRODUCED SPECIES	PRIORITY WEEDS
7	0	14	2

Figure 17 There is evidence of historic mining and more recently the dumping of a car in the erosion gully

Figure 18 There is a small farm dam that is the likely site of the proposed basin

Figure 19 The dam outflow has become eroded as well, indicating that the soils are likely to be highly erosive

Figure 20 This part of the site has several native grasses and groundcovers present, along with introduced grasses

3.4.7 Basin 6

Basin 6 is a heavily grazed paddock that also slopes eastward towards the Blayney – Demondrille railway line, culminating in a small dam near the eastern boundary (Figure 21). Vegetation in this location is heavily modified (Table 9), with Blown Grass (*Lachnogrostis filiformis*) being the only native flora species present. Trees are absent and the groundcover vegetation consists primarily of pasture grasses and common pasture weeds. Two priority control weeds are present, namely St Johns Wort and Blackberry. Other species may be present but difficult to locate given the recent heavy grazing of the site.

Table 9 Summary of flora species recorded on site – number per category, Basin 6

NATIVE SPECIES	THREATENED SPECIES	INTRODUCED SPECIES	PRIORITY WEEDS
1	0	7	2

Figure 21 Basin 6 is in a heavily grazed paddock that drains to a small dam above the railway line

3.4.8 Basin 7A

Basin 7A includes the lower section of the area between Mid Western Highway and the old highway on the southern outskirts of Blayney. This section has been cleared in the past and has some vegetation along the old road route and a small dam (Figure 22). The outflow from the dam is conveyed from the spillway via a swale that runs to the lowest corner of the site. This swale has been filled with felled timber, most likely the remains of willows that used to be in this location (Figure 23).

Vegetation on this site is highly modified and currently ungrazed (Table 10). Several Acacias and native grasses are present but the site is dominated by introduced pasture grasses and common pasture weeds. Three priority control weeds are located on this site, namely Serrated Tussock, Crack Willows and Large-leaved Privet.

Table 10 Summary of flora species recorded on site – number per category, Basin 7A

NATIVE SPECIES	THREATENED SPECIES	INTRODUCED SPECIES	PRIORITY WEEDS
4	0	20	3

Figure 22 Basin 7A is the lower of the two dams in this location

Figure 23 A swale from the dam outflow has been partially filled with willows that have been killed and dropped on site

3.4.9 Basin 7B

Basin 7B is located in the upper section of the area. A small dam is located immediately above the fence that separates 7B from 7A (Figure 24). This dam drains a narrow triangle of land on a steep hillside beside the Mid Western Highway (Figure 25). The site is almost entirely cleared of native vegetation except for several Acacias and some native grasses and groundcovers (Table 11). Again, the site is dominated by introduced pasture grasses and common pasture weeds. Three priority control weeds are located on this site, namely Blackberry, Serrated Tussock, Crack Willows and Large-leaved Privet.

Table 11 Summary of flora species recorded on site – number per category, Basin 7B

NATIVE SPECIES	THREATENED SPECIES	INTRODUCED SPECIES	PRIORITY WEEDS
4	0	18	4

Figure 24 Basin 7B has a smaller dam and is located immediately above basin 7B

Figure 25 Basin 7B drains a steep hillside beside the Mid Western Highway on the southern outskirts of Blayney

3.4.10 Basin 9

Basin 9 is located in the urban area of Blayney at the intersection of Queen St and Stillingfleet St. It adjoins King George VI Oval to the north and includes a drainage swale that follows an unformed section of Stillingfleet St (Figure 26). A planted row of Radiata Pines separates the swale and surrounding areas from the oval. Immediately south is the Lee Hostel aged care facility and part of the basin is proposed to fall within the front grassed area of the hostel (Figure 27).

Vegetation in the area has been highly modified during the process of urbanization. No native flora species were recorded during the current study (Table 12), and the vegetation on site consisted of Radiata Pines and introduced lawn grasses and common weeds. The entire area is regularly mown as part of its management by council.

Table 12 Summary of flora species recorded on site – number per category, Basin 9

NATIVE SPECIES	THREATENED SPECIES	INTRODUCED SPECIES	PRIORITY WEEDS
0	0	8	0

Figure 26 Basin 9 is located in urban Blayney on a drainage swale beside a sports ground

Figure 27 Part of the basin will be located in the grassed grounds of a nearby aged care hostel

3.4.11 Basin 20

Basin 9 is located in the urban area of Blayney at the intersection of Charles St and Carcoar St. It comprises part or all of the King George VI Oval grounds (Figure 28). A planted row of Radiata Pines separates the oval from the adjoining swale and surrounding areas (Figure 29). The oval is fully fenced and all gates are generally locked, unless an organized event is in progress (Figure 30).

Vegetation in the area has been highly modified during the process of urbanization. No native flora species were recorded during the current study (Table 12), and the vegetation on site consisted of Radiata Pines and introduced lawn grasses and common weeds. The entire area is regularly mown as part of its management by council.

Table 13 Summary of flora species recorded on site – number per category, Basin 9

NATIVE SPECIES	THREATENED SPECIES	INTRODUCED SPECIES	PRIORITY WEEDS
0	0	8	0

Figure 28 The proposed stormwater basin location comprises part or all of the King George VI Oval grounds

Figure 29 A planted row of Radiata Pines separates the oval from the adjoining swale and surrounding areas

Figure 30 The oval is fully fenced and all gates are generally locked, unless an organized event is in progress

4 FAUNA SURVEYS

Fauna surveys were conducted on 23rd July 2020 and included diurnal surveys and targeted searches for evidence of koalas using the area. Weather was cool, becoming warm and sunny, with little breeze and some clouds forming.

4.1 FIELD SURVEY RESULTS

A total of 11 species of birds (including 1 introduced species), 3 species of frogs and 3 species of introduced mammals were recorded from the subject site during the diurnal surveys (Table 14). Total number of species per site ranged from 3 to 7 species. Frogs were only recorded at Basin 7A and 7B. European rabbits were the most common mammal species recorded, closely followed by horses. Several species of aquatic birds were recorded and avian fauna was generally larger species that are typically well adapted to urban living.

Table 14 Diurnal fauna survey results (indicates introduced species)*

SPECIES NAME	COMMON NAME	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5a	BASIN 5b	BASIN 6	BASIN 7a	BASIN 7b	BASIN 9	BASIN 20
MAMMALIA	**SPECIES PER SITE:**	**3**	**0**	**1**	**1**	**3**	**3**	**1**	**1**	**0**	**0**	**0**
Canis lupus familiaris	Domestic dog*	y				y	y					
Equus caballus	Horse*	y		y	y	y	y					
*Oryctolagus cuniculus**	European Rabbit*	y				y	y	y	y			
AVES	**SPECIES PER SITE:**	**3**	**6**	**6**	**3**	**4**	**4**	**2**	**1**	**2**	**3**	**3**
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	y	y			y	y	y		y		
Chenonetta jubata	Australian Wood Duck	y		y						y		
Corvus coronoides	Australian Raven			y	y			y			y	y
Eolophus roseicapilla	Galah	y	y	y								
Grallina cyanoleuca	Magpie Lark		y									
Gymnorhina tibicen	Australian Magpie		y	y	y	y	y		y		y	y
Ocyphaps lophotes	Crested Pigeon			y								
Platycercus elegans	Crimson Rosella					y	y					
Rhipidura leucophrys	Willy Wagtail			y								
Sturnus vulgaris	European Starling*		y			y	y		y		y	y
Vanellus miles	Masked Lapwing		y		y							
HERPETOFAUNA	**SPECIES PER SITE:**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2**	**0**	**0**
Crinia signifera	Common Eastern Froglet								y	y		
Limnodynastes tasmaniensis	Spotted Marsh Frog									y		
Pseudophryne bibronii	Bibrons Toadlet								y			
TOTAL SPECIES RECORDED PER SITE		**6**	**6**	**7**	**4**	**7**		**3**	**5**	**4**	**3**	

Two eBird survey sites are located in or near the township of Blayney (Figure 31). The northern site is located in the centre of Blayney and the southern site at the stormwater treatment wetlands beside Heritage Park. Aves fauna records were assessed to get a more holistic picture of the avian fauna that is likely to use the habitat resources at the basin sites. The resulting list of 69 species gives an indication of the species that could be found on a basin site (Table 15).

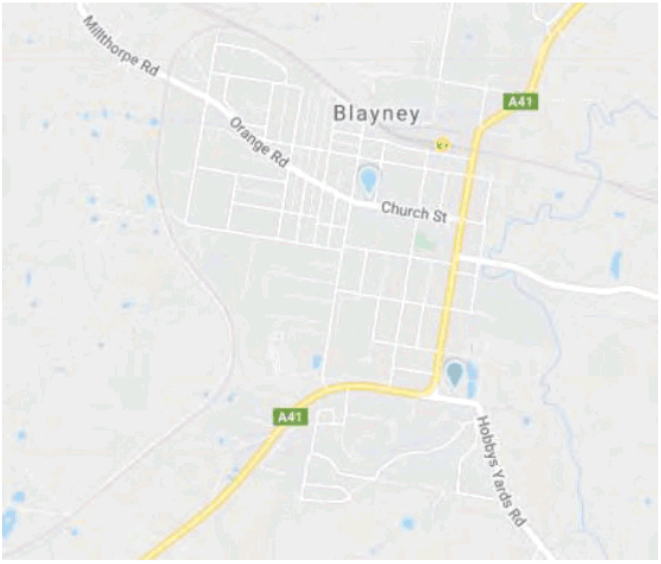


Figure 31 Locations of eBird survey sites around Blayney

Table 15 eBird survey data (Blayney urban area – 10 surveys, Blayney stormwater treatment wetlands – 12 surveys)

eBIRD surveys	NORTHERN SITE (10 surveys)		SOUTHERN SITE (12 surveys)	
SPECIES NAME	COUNT	DATE	COUNT	DATE
Australasian Grebe	3	17/05/2014	5	7/02/2020
Australasian Swamphen	5	22/05/2017	1	13/10/2019
Australian Ibis	1	7/02/2020	1	29/09/2019
Australian Kestrel			1	14/02/1985
Australian King-Parrot			2	5/03/2016
Australian Magpie	3	9/03/2020	4	7/02/2020
Australian Raven	30	7/02/2020	2	7/02/2020
Australian Reed Warbler	1	7/02/2020	4	13/10/2019
Australian Shoveler	8	7/02/2020	1	29/08/2019
Black Falcon	2	8/10/2013		
Black Kite	1	7/02/2020		
Black-faced Cuckooshrike			1	13/10/2019
Black-fronted Dotterel	2	17/05/2014		

eBIRD surveys	NORTHERN SITE (10 surveys)		SOUTHERN SITE (12 surveys)	
SPECIES NAME	COUNT	DATE	COUNT	DATE
Black-shouldered Kite	X	30/01/2012		
Brown Songlark	2	26/12/2018		
Cattle Egret	1	17/05/2014		
Cockatiel	X	13/10/2009		
Crested Pigeon	1	9/03/2020	4	7/02/2020
Crimson Rosella	2	7/02/2020	5	7/02/2020
Dusky Moorhen	1	22/05/2017	5	7/02/2020
Dusky Woodswallow			2	13/10/2019
Eastern Rosella	2	17/05/2014	2	5/03/2016
Eurasian Blackbird*	1	7/02/2020	1	7/02/2020
Eurasian Coot	30	7/02/2020	4	7/02/2020
Eurasian Skylark*	2	17/05/2014		
European Goldfinch*	3	7/02/2020	3	7/02/2020
European Starling*	2	9/03/2020	50	7/02/2020
Freckled Duck			2	22/08/2019
Galah	2	9/03/2020	40	7/02/2020
Golden-headed Cisticola			1	14/02/1985
Gray Butcherbird			1	28/07/2018
Gray Fantail	2	7/02/2020		
Gray Teal	15	7/02/2020	2	7/02/2020
Hardhead	3	17/05/2014	1	13/10/2019
Hoary-headed Grebe	10	7/02/2020		
House Sparrow*	2	7/02/2020	6	7/02/2020
Latham's Snipe			1	14/02/1985
Laughing Kookaburra	1	17/05/2014	2	5/03/2016
Little Eagle	1	13/02/2020	1	13/10/2019
Little Grassbird			1	30/10/2018
Little Pied Cormorant	1	17/05/2014	1	7/02/2020
Little Raven			3	28/07/2018
Magpie-lark	3	9/03/2020	4	7/02/2020
Mallard (Domestic type)*			1	29/09/2019
Maned Duck	1	26/12/2018	4	13/10/2019
Masked Lapwing	2	7/02/2020	2	7/02/2020
Pacific Black Duck	10	7/02/2020	8	7/02/2020
Pacific Heron	1	26/12/2018		
Pallid Cuckoo	1	30/09/2017		
Peregrine Falcon	1	8/08/2017		
Pied Currawong	1	19/08/2015		
Pink-eared Duck	20	7/02/2020	1	30/10/2018
Rainbow Lorikeet	2	6/01/2017		

eBIRD surveys	NORTHERN SITE (10 surveys)		SOUTHERN SITE (12 surveys)	
SPECIES NAME	COUNT	DATE	COUNT	DATE
Red Wattlebird	1	17/05/2014	3	7/02/2020
Red-rumped Parrot	2	17/05/2014		
Sacred Kingfisher	1	26/12/2018		
Silvereye	X	31/03/2012	2	5/03/2016
Striated Thornbill	4	17/05/2014		
Sulphur-crested Cockatoo	1	12/02/2017	1	7/02/2020
Superb Fairywren	3	7/02/2020	2	7/02/2020
Superb Parrot	30	3/11/2019		
Wedge-tailed Eagle	1	17/05/2014		
Welcome Swallow	6	7/02/2020	4	13/10/2019
White-browed Woodswallow	1	26/12/2018		
White-faced Heron	1	7/02/2020	X	22/08/2019
White-plumed Honeyeater	2	7/02/2020	2	7/02/2020
Willie-wagtail	1	17/05/2014	2	13/10/2019
Yellow-faced Honeyeater	X	13/10/2009	2	7/02/2020
Yellow-rumped Thornbill	3	17/05/2014	6	13/10/2019

4.2 FAUNA HABITAT

Habitat resources throughout the basin sites are relatively limited, and included open space areas, farm dams, limited canopy trees and little else. Open space foragers dominated the avian fauna, including Galahs and Masked Lapwings at Basin 2, one of the mown grassed areas (Figure 32).

Figure 32 Galah and Masked Lapwing – Basin 2

Several sites had revegetation planting which was generally mixed eucalypt species. These provided habitat resources for seed feeders, such as the Crimson Rosellas seen at Basin 5 (Figure 33, left), and species that feed on the insects that feed on these flowers and fruit, such as Yellow-rumped Thornbills seen at several sites including Basin 7A (Figure 33, right).

Figure 33 (left) Crimson Rosella Basin 5; (right) Yellow-rumped Thornbill, Basin 7A

Figure 34 Australian Wood Ducks on one of the farm dams at Basin 3

Many sites had farm dams, most of which lacked any aquatic or riparian vegetation. Aquatic birds were seen on several of these, such as Australian Wood Ducks recorded at Basin 3 (Figure 34). Generally, however, the more common bird species were the more urban adapted species, including the Australian Magpie seen at several sites, including Basin 9 (Figure 35, left), and the introduced European Starling, seen in large numbers in a deciduous tree near Basin 7A (Figure 35, right).

Figure 35 Australian Magpie, Basin 9; European Starlings Basin 7A

Horses were commonly seen grazing in paddocks that fell within basin locations, or their presence was evident from overgrazing and scats. At Basin 4 there were horses grazing around heritage machinery left to rust in the paddock (Figure 36).

Figure 36 Horses were common at many basin sites, including Basin 4 where they were seen with heritage machinery

4.3 KOALA AND KOALA HABITAT ASSESSMENT

The State Environmental Planning Policy (Koala Habitat Protection) 2020 is an interim planning instrument that replaces the controversial Koala Habitat Protection SEPP 2019. Unlike the Koala SEPP 2020, SEPP 2019 listed specific feed trees for each of the regions where koala populations are currently recorded. This updated the previous SEPP 44 which included a list of 10 koala feed trees that are required to be protected. Extensive scientific research underpinned the 2019 Koala SEPP and provided a list of 135 koala feed trees across 9 Koala Management Areas. Strenuous objection to the expansion of the list of koala feed trees resulted in the repeal of the 2019 Koala SEPP and the development of the 2020 Koala SEPP, which has largely reverted to the information and requirements of the 1994 version (SEPP 44).

None of the koala feed trees currently listed in the 2020 Koala SEPP occur on any of the subject site, although all of the tree species present were listed in the 2019 Koala SEPP as koala feed trees for the Central Tablelands Koala Management Area. Currently, the 2020 Koala SEPP does not apply to this activity.

5 FAUNA, FLORA AND THE LEGISLATIVE CONTEXT

5.1 EP&BC PROTECTED MATTERS (EPBC ACT)

Databases were accessed on 14th July 2020, and the results obtained are summarised in the following sections.

5.1.1 Summary of Protected Matters databases

The databases summarise the matters of national environmental significance that may occur in, or may relate to, the area nominated. The following results were obtained for a 5km buffer of the subject site (Table 16)

Table 16. Summary of Protected Matters searches.

PROTECTED MATTERS	PRESENT AT OR NEAR THE STUDY SITE
World Heritage Properties	NONE
National Heritage Places	NONE
Wetlands of International Significance (RAMSAR Sites)	4
Great Barrier Reef Marine Park	NONE
Commonwealth Marine Areas	NONE
Threatened Ecological Communities	2
Threatened Species	27
Migratory Species	11

5.1.2 Assessment of Impacts for Migratory Species

A number of faunal groups, including migratory terrestrial birds and migratory wetland birds, are identified as having potential presence within a 2km radius of the study site. These were assessed for likely presence on the site (Table 17) using records from NSW Wildlife Atlas (BioNet) since 1990 to determine known presence within 10kms of the site.

Table 17. Migratory terrestrial species protected under EP&BC Act.

SPECIES NAME	COMMON NAME	TYPE OF PRESENCE	HABITAT PRESENT ON SITE	RECORDS WITHIN 10km OF SITE	SIGNIFICANT IMPACT LIKELY
TERRESTRIAL MIGRATORY BIRDS					
Hirundapus caudacutus	White-throated Needletail	Species or species habitat likely to occur within area	Marginal habitat– presence very unlikely	NIL	No
Motacilla flava	Yellow Wagtail	Species or species habitat may occur within area	Some habitat present	NIL	No
Myiagra cyanoleuca	Satin Flycatcher	Species or species habitat known to occur within area	Some habitat present	NIL	No
Rhipidura rufifrons	Rufous Fantail	Species or species habitat may occur within area	Some habitat present	NIL	No

6 IMPACT ON THREATENED SPECIES (5 PART TEST)

A search of the NSW Wildlife Atlas was undertaken of an area within a 5km radius buffering the subject site. A total of 3 threatened fauna species have been recorded in this area (Table 18). The topography and level of modification and hence soils, vegetation and availability of surface water is highly variable over this range. These variables greatly affect the distribution of species within this area, however, most of the study sites have been heavily modified and have limited habitat value or potential.

Table 18 Threatened species records within 10km of the subject site from 1995-2020

CLASS	SCIENTIFIC NAME	COMMON NAME	NSW STATUS	COMM. STATUS	RECORDS
Aves	*Daphoenositta chrysoptera*	Varied Sittella	V,P		3 (2012)
Aves	*Stagonopleura guttata*	Diamond Firetail	V,P	E	1 (2007)
Mammalia	*Phascolarctos cinereus*	Koala	V,P	V	10 (2014-9)

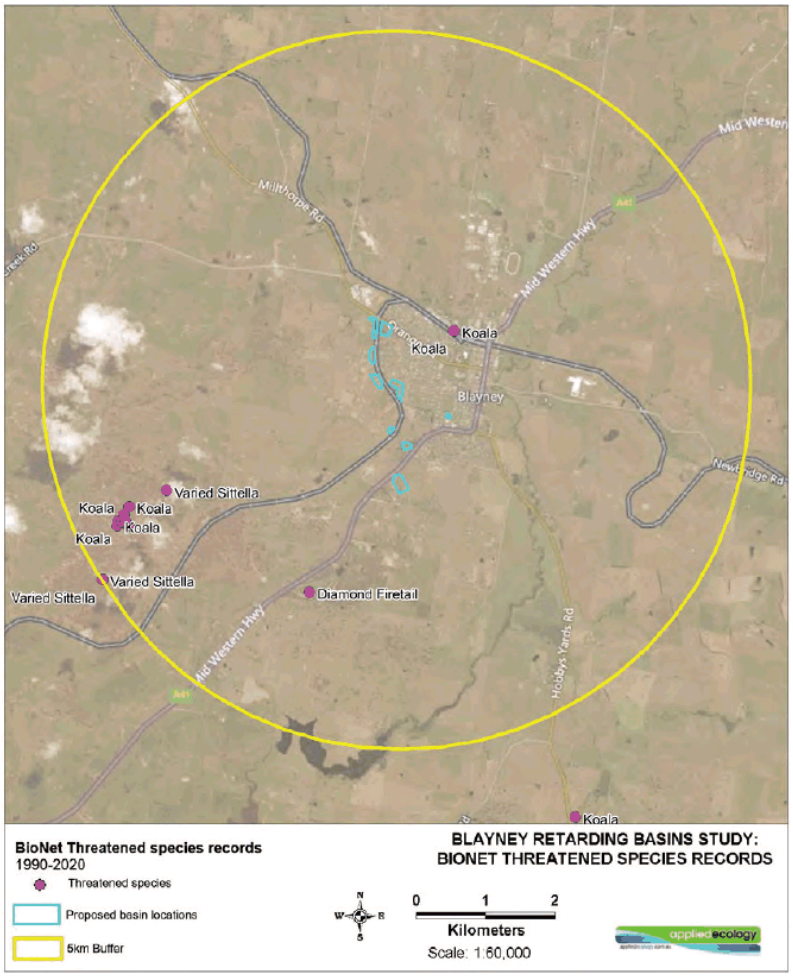


Figure 37 Threatened and migratory species records within 5km of the study sites in Blayney since 1995 (BioNet 2020)

As identified in Part 7, Division 1, section 7.3 of the Biodiversity Conservation Act 2016 the following matters need to be addressed to determine whether or not a significant effect on threatened species, populations or ecological communities or their habitats is likely to result from the proposed development. A review of the availability of habitat and an assessment of the actual recordings of flora, fauna and EECs present is provided elsewhere in this report. The following species descriptions are extracted from threatened species profiles prepared by OEH.

a) **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.**

6.1 FLORA

One threatened flora species was recorded on the subject sites, however these two plants have been planted well outside its natural range.

6.1.1 *Eucalyptus nicholii* Nicholi Gum, Narrow-leaved Black Gum

Conservation status in NSW: Vulnerable
Commonwealth status: Vulnerable
A medium-sized tree 10-20 m tall with rough, thick, grey-brown bark which extends to the larger branches. Adult leaves are slightly broader than the juvenile leaves, and are a dull grey-green, 6-12 cm long and 5-10 mm wide and have a strong peppermint smell when crushed. The gumnuts are hemispherical or cone shaped, 2-5 mm long and 3-4 mm wide, and grow in groups of seven.

Typically grows in dry grassy woodland, on shallow soils of slopes and ridges. Found primarily on infertile soils derived from granite or metasedimentary rock. Seedling recruitment is common, even in disturbed soils, if protected from grazing and fire. This species is sparsely distributed but widespread on the New England Tablelands from Nundle to north of Tenterfield, being most common in central portions of its range. Found largely on private property and roadsides, and occasionally in conservation reserves. Planted as urban trees, windbreaks and corridors.

Planted specimens of *Eucalyptus nicholii* has been found on several grazing properties within 5km of the subject site. In each case the area is heavily grazed, affecting the likelihood of establishment success. It is considered that the proposed activity would not have an adverse effect on the life cycle of the species to the extent that a viable local population of the species is likely to be placed at risk of extinction.

6.2 FAUNA

No threatened fauna species were recorded on the subject sites, however there is potential habitat for several threatened fauna species recorded within the vicinity. These are assessed below.

6.2.1 *Daphoenositta chrysoptera* (Varied Sittella)

Conservation status in NSW: Vulnerable
Commonwealth status: Not listed
The Varied Sittella is a small (10 cm) songbird with a sharp, slightly upturned bill, short tail, barred undertail, and yellow eyes and feet. In flight the orange wing-bar and white rump are prominent. In NSW most individuals have a grey head and are streaked with dark brown, but in the extreme north-east they have a white head, and in the extreme south-west a black cap. Varied Sittellas are more active and acrobatic among branches than the larger treecreepers. They fly into the heads of trees, typically working their way down branches and trunk with constant motion.

The Varied Sittella is sedentary and inhabits most of mainland Australia except the treeless deserts and open grasslands. Inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. Feeds on arthropods gleaned from crevices in rough or decorticating bark, dead branches, standing dead trees and small branches and twigs in the tree canopy.

Within the subject site there is very limited suitable habitat for this species. It is considered that the proposed activity would not have an adverse effect on the life cycle of the species to the extent that a viable local population of the species is likely to be placed at risk of extinction.

6.2.2 *Stagonopleura guttata* (Diamond Firetail)

Conservation status in NSW: Vulnerable
Commonwealth status: Not listed
The Diamond Firetail is a large (length 10 to 12 cm, weight 17 grams), striking finch with a bright red bill, and red eyes and rump. The white throat and lower breast are separated by a broad black breast-band that extends into the strongly white-spotted, black flanks. It has a grey back and head, and ashy-brown wings. The call is a plaintive, drawn-out, nasal 'twoo-wheee'. Flight is low and direct, with slight undulations.

The Diamond Firetail is endemic to south-eastern Australia, extending from central Queensland to the Eyre Peninsula in South Australia. It is widely distributed in NSW, with a concentration of records from the Northern, Central and Southern Tablelands, among other locations. Found in grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum *Eucalyptus pauciflora* Woodlands. Also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities. Often found in riparian areas (rivers and creeks), and sometimes in lightly wooded farmland. Feeds exclusively on the ground, on ripe and partly-ripe grass and herb seeds and green leaves, and on insects (especially in the breeding season).

Within the subject site there is very limited foraging or roosting habitat for this species. It is considered that the proposed activity would not have an adverse effect on the life cycle of the species to the extent that a viable local population of the species is likely to be placed at risk of extinction.

6.2.3 *Phascolarctos cinereus* (Koala)

Conservation status in NSW: Vulnerable
Commonwealth status: Not listed
Listed NSW Wildlife Atlas within 5km of the subject site: not listed
The Koala is an arboreal marsupial with fur ranging from grey to brown above, and is white below. It has large furry ears, a prominent black nose and no tail. It spends most of its time in trees and has long, sharp claws, adapted for climbing.

Koalas inhabit eucalypt woodlands and forests. Feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species. Inactive for most of the day, feeding and moving mostly at night. Spend most of their time in trees, but will descend and traverse open ground to move between trees.

Within the subject site there is limited foraging habitat for this species. It is considered that the proposed activity would not have an adverse effect on the life cycle of the species to the extent that a viable local population of the species is likely to be placed at risk of extinction.

(b) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

No Endangered Ecological Community or Critically Endangered Ecological Community was recorded on any of the subject sites therefore the proposed activities will not affect the extent of an EEC such that its local occurrence is likely to be placed at risk of extinction.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

It is considered that the proposed action would not substantially and adversely modify the composition of an EEC such that its local occurrence is likely to be placed at risk of extinction.

(c) in relation to the habitat of a threatened species or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and

The proposed works will be confined to areas where there is very limited habitat resources, thus no habitat will be removed.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and

No additional fragmentation or isolation is anticipated by the proposed works.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality

No TEC habitat will be removed

(d) whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),

The site is not listed on the Register of Declared Areas of Outstanding Biodiversity Value.

(e) whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.

Of the 39 key threatening processes described in Schedule 4 of the Biodiversity Conservation Act 2016, four are potentially applicable to the proposed works. These are threats associated with removal of hollow bearing trees and the accidental transfer of seed propagules and pathogens from affected areas to unaffected areas in mud carried on cars and trucks, and boots of workers and include:

- Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis;
- Infection of native plants by *Phytophthora cinnamomi*;
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of Scotch Broom (*Cytisus scoparius*)

Table 19. BC Act 2016, Schedule 4- Key Threatening Processes Assessment.

KEY THREATENING PROCESS	TYPE OF THREAT	APPLICABLE TO PROPOSED WORKS?
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands (as described in the final determination of the Scientific Committee to list the threatening process)	Habitat loss/change	No
Bushrock removal (as described in the final determination of the Scientific Committee to list the threatening process)	Habitat loss/change	No
Clearing of native vegetation (as defined and described in the final determination of the Scientific Committee to list the key threatening process)	Habitat loss/change	No
Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners, *Manorina melanocephala* (Latham, 1802)	Pest animal	No
Alteration of habitat following subsidence due to longwall mining	Habitat loss/change	No
Competition and grazing by the feral European Rabbit, *Oryctolagus cuniculus (L.)*	Pest animal	Existing
Competition and habitat degradation by Feral Goats, *Capra hircus* Linnaeus 1758	Pest animal	No
Competition from feral honey bees, *Apis mellifera* L.	Pest animal	No
Death or injury to marine species following capture in shark control programs on ocean beaches (as described in the final determination of the Scientific Committee to list the key threatening process)	Other threat	No
Ecological consequences of high frequency fires	Habitat loss/change	No
Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments (as described in the final determination of the Scientific Committee to list the key threatening process)	Other threat	No
Forest eucalypt dieback associated with over-abundant psyllids and Bell Miners	Other threat	No
Habitat degradation and loss by Feral Horses (brumbies, wild horses), Equus caballus Linnaeus 1758	Pest animal	No
Herbivory and environmental degradation caused by feral deer	Pest Animal	No
Human-caused Climate Change	Habitat loss/change	No
Importation of Red Imported Fire Ants *Solenopsis invicta* Buren 1972	Pest animal	No
Infection by Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species and populations	Disease	No
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	Disease	Yes
Infection of native plants by *Phytophthora cinnamomi*	Disease	Yes
Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	Disease	No
Introduction of the Large Earth Bumblebee *Bombus terrestris* (L.)	Pest animal	No
Invasion and establishment of exotic vines and scramblers	Weed	No
Invasion and establishment of Scotch Broom (*Cytisus scoparius*)	Weed	Yes
Invasion and establishment of the Cane Toad (*Bufo marinus*)	Pest animal	No
Invasion of native plant communities by exotic perennial grasses	Weed	Yes
Invasion of native plant communities by bitou bush and boneseed	Weed	No
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	Weed	No
Invasion of the Yellow Crazy Ant, *Anoplolepis gracilipes* (Fr. Smith) into NSW	Pest animal	No
Invasion, establishment and spread of Lantana (*Lantana camara* L. *sens. lat*)	Weed	No

KEY THREATENING PROCESS	TYPE OF THREAT	APPLICABLE TO PROPOSED WORKS?
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	Weed	No
Loss of hollow-bearing trees	Habitat loss/change	No
Loss and/or degradation (or both) of sites used for hill-topping by butterflies	Habitat loss/change	No
Predation and hybridisation by Feral Dogs, *Canis lupus familiaris*	Pest animal	No
Predation by *Gambusia holbrooki* Girard, 1859 (Plague Minnow or Mosquito Fish) (as described in the final determination of the Scientific Committee to list the threatening process)	Pest animal	No
Predation by the European Red Fox *Vulpes vulpes* (Linnaeus, 1758)	Pest animal	No
Predation by the Feral Cat *Felis catus* (Linnaeus, 1758)	Pest animal	No
Predation by the Ship Rat *Rattus rattus* on Lord Howe Island	Pest animal	No
Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa* Linnaeus 1758	Pest animal	No
Removal of dead wood and dead trees	Habitat loss/change	No

6.3 SUMMARY OF 5 PART TEST

One threatened species was recorded during this survey – present as two planted specimens. The site contains very limited habitat for threatened species and no endangered ecological community was recorded on site. Applied Ecology has found that impacts on threatened species from the proposal are not significant and do not require a Species Impact Statement nor referral under the EPBC Act.

7 POTENTIAL ENVIRONMENTAL IMPACTS AND MITIGATION

7.1 POTENTIAL IMPACTS

Potential environmental impacts can be broadly grouped into terrestrial impacts and aquatic impacts.

7.1.1 Potential terrestrial impacts

- Areas of good quality vegetation on site need to be protected from damage from machinery movement, including accidental damage. This includes canopy trees outside the works footprint.
- There is potential for impacts from storage and movement of plant and machinery on site.
- Noise and vibration during construction may disturb fauna nearby.
- There is potential for the introduction of weed propagules (seeds and other plant parts) and for transfer of plant and other pathogens to the site on plant and machinery.

- There is potential for minor disruptions to air quality, including dust, as a result of the additional vehicle movements associated with construction.

7.1.2 Potential aquatic impacts

- Disturbance of sediments may be carried downstream, affecting the downstream environment.
- Spills from plant and machinery have potential to contaminate surface waters and nearby sediments.
- Other factors that may affect water quality include uncontrolled discharge of washdown water and mobilisation of construction site and domestic wastes.

7.2 RECOMMENDATIONS FOR MITIGATION

7.2.1 Mitigation for terrestrial impacts

- Protect, move or replace the *Eucalyptus nicholii*, a threatened flora species from the Northern Tablelands. Replace with a suitable species for the area.
- Include control of priority weed species on site as part of the site preparation. Aim to manage problem environmental weeds as well to reduce the potential for their spread into other areas
- Designate stockpile sites, compound and machinery storage areas away from better quality natural assets and drainage lines
- Prepare Soil and Water Management Plan as part of the site Construction Environmental Management Plan. Ensure adequate measures are implemented for erosion control.
- Clearly delineate vegetation 'no go' zones and provide protective barriers for sensitive vegetation. Use tree protection fencing
- Offset the removal of koala feed trees by planting additional resources in the vicinity of the subject sites or near where there have been sightings of these animals.

7.2.2 Mitigation for aquatic impacts

- Ensure no sediment is discharged downstream.
- Prepare Soil and Water Management Plan as part of the site Construction Environmental Management Plan. Ensure adequate measures are implemented for erosion control.
- Apply and comply with the 'Hygiene protocol for the control of disease in frogs' guidelines (NPWS/DECC, 2008; Appendix 1)

Appendix F – Geotechnical Investigation

This will be completed as the project progresses.

assetgeoenviro

Storm Consulting

Proposed Retarding Basins
8 Sites in Blayney, NSW

Geotechnical Investigation

Our ref: 6006-G1
27 October 2020

Your trusted engineering professionals

Document Authorisation

Proposed Retarding Basins
8 Sites in Blayney, NSW
Geotechnical Investigation

Prepared for Storm Consulting

Our ref: 6006-G1
27 October 2020

For and on behalf of
AssetGeoEnviro

Mark Bartel

Mark Bartel
BE, MEngSc, GMQ, CPEng, RPEQ/NER(Civil), APEC IntPE(Aus)
Managing Director | Senior Principal Geotechnical Engineer

Document Control

Distribution Register

Copy	Media	Recipient	Location
1	Secure PDF	Ricky Kwan	Storm Consulting
2	Secure PDF	Mark Bartel	AssetGeoEnviro

Document Status

Rev	Revision Details	Author	Reviewer		Approved for Issue		
			Name	Initials	Name	Initials	Date
–	Interim for review	A. To	M. Green	MAG	M. Bartel	MAB	14 October 2020
0	Final issue including lab results	M. Green	M. Bartel	MAB	M. Bartel	MAB	27 October 2020

Suite 2.06 / 56 Delhi Road
North Ryde NSW 2113
02 9878 6005
assetgeoenviro.com.au

ISO 9001:2015
ISO 14001:2015
ISO 45001:2018 AS/NZS 4801:2001

Contents

1. Introduction

1.1 General

This report presents the results of a geotechnical investigation for the above project. The investigation was commissioned on 18 August 2020 by Ricky Kwan of Storm Consulting. The work was carried out in accordance with the proposal by AssetGeoEnviro (Asset) dated 14 August 2020, reference 6006-P1-Rev1.

Based on the information provided by the client, we understand that the project involves construction of eight retention basins in and around Blayney. Nine were originally planned, but Basin 4 (re BH4) has been cancelled. Concept design drawings have been prepared by Storm (Craig & Rhodes). The simple earthwork basins are typically 2.5m deep though Basin 2 is shown to be 2m deep and Basin 9 to be 1.5m deep. The storage capacity of each has been developed by Storm to suit the catchment and allowable outflow rate.

Drawings referenced are: Civil Drawings by Craig & Rhodes, Project 117-20, drawings SK01-1 to SK01-6.

1.2 Scope of Work

The main objectives of the investigation were to assess the surface and subsurface conditions and to provide comments and recommendations relating to:

- Key geotechnical constraints to the development.
- Excavation conditions and methodology
- Subgrade preparation and earthworks.
- Suitable foundation options for auxiliary structures.
- Allowable bearing pressure and shaft adhesion for piles.
- Commentary on settlement.
- Groundwater conditions.
- Maximum allowable permanent and temporary batter slopes.
- Suitability of soils for engineering reuse on site.

The following scope of work was carried out to achieve the project objectives:

- A review of existing regional maps and reports relevant to the site held within our files.
- Clearance of underground services at proposed test locations.
- Visual observations of surface features.
- Subsurface investigation at eight locations to sample and assess the nature and consistency of subsurface soils and bedrock at accessible areas of the site.
- Carrying out laboratory tests on the recovered soil samples to provide engineering data.
- Engineering assessment and reporting.

This report must be read in conjunction with the attached "Important Information about your Geotechnical Report" in Appendix A. Attention is drawn to the limitations inherent in site investigations and the importance of verifying the subsurface conditions inferred herein.

2. Site Description

All sites are in and around Blayney NSW, as shown in Figures 1a/1b. Most of the sites are currently used for residential purposes. The sites are predominantly covered with grassland at the time of the investigation.

Topographically, the sites are located within undulating terrain with a ground level of around 890-940m AHD. The overall ground surface slopes in the region are typically about 0-5°. Based on a visual observation of the proposed development areas, the sites appear to be in an overall good condition with no signs of erosion or ground movement.

3. Fieldwork & Laboratory Testing

3.1 Borehole Investigation

The fieldwork was undertaken on 1 October 2020 & 2 October 2020 under the full-time supervision of a Geotechnical Engineer from Asset and included invasive investigation at eight locations.

The test locations are shown in the attached Figure 2 and were set out by our Geotechnical Engineer by measurements relative to existing site features. Surface levels at the test locations were estimated by interpolation from levels shown on the scheme design drawings provided by Storm.

Buried metallic services and utilities within the site boundaries near the test locations were cleared by an accredited service location subcontractor and by referring to DBYD utility maps.

The invasive investigation included drilling of machine-drilled boreholes and conducting Dynamic Cone Penetrometer (DCP) soundings at eight locations. The boreholes were auger drilled to depths of 1.4m to 3.0m below ground level (bgl) and were discontinued at the recorded depths due to reaching target depth or practical refusal. The DCP soundings were terminated at depths of 0.8m to 3.0m at 'practical' refusal.

Selected soil samples were retained for laboratory testing.

The subsurface conditions encountered were logged during drilling and testing. On completion of logging and sampling, the boreholes were backfilled with the drilling spoil.

Engineering logs are provided in Appendix B together with their explanatory notes.

3.2 Laboratory Testing

Soil and rock samples recovered during the fieldwork were delivered to a NATA registered laboratory. The following tests were carried out on selected samples:

- Field moisture content (8Nº).
- Atterberg Limits (8Nº).
- Particle Size Distribution by Hydrometer (6Nº).
- Standard compaction (8Nº).
- Emerson Crumb value (8Nº).

Test results are attached. Testing was carried out generally in accordance with AS1289 "Methods of Testing Soil for Engineering Purposes" or as described in the laboratory test results.

4. Subsurface Conditions

4.1 Geology

The Blayney 1:100,000 Geological Map indicates that the eights sites are variably underlain by Blayney Volcanics, Wombiana Formation siltstone, limestone, and marble, with occasional minor copper ore deposits. Closer to the Belubula River, alluvial deposits are present.

4.2 Subsurface Conditions

A generalised geotechnical model for each basin has been developed is shown in Table 1 to Table 8. For a detailed description of the subsurface conditions, refer the attached engineering logs and explanatory notes. For specific design input, reference should be made to the logs and/or the specific test results, in place of the following summary.

Table 1 - Generalised Site Geotechnical Model – Basin 1

Unit	Origin	Description	Depth to Top of Unit [1] (m)	Unit Thickness [1] (m)
1	Topsoil	TOPSOIL, Silty CLAY, 30% Silty, low to medium plasticity, grey/ pale grey/ pale brown, medium to high permeability, Soft clay.	Ground surface	0.1
2	Deposits	CLAY, medium to high plasticity, brown/ grey/ dark brown / red brown, trace gravels, 5%, subangular, low to medium permeability, becoming low permeability with depth, stiff clay, becoming hard clay with depth.	0.1	Not proven beyond a depth of 3.0m.

Table 2- Generalised Site Geotechnical Model – Basin 2

Unit	Origin	Description	Depth to Top of Unit [1] (m)	Unit Thickness [1] (m)
1	Topsoil	TOPSOIL, Silty CLAY, 30% Silty, low to medium plasticity, grey/ brown, medium to high permeability, Soft clay.	Ground surface	0.1
2	Deposits	CLAY, medium to high plasticity, pale brown/ pale grey/ dark brown, trace gravels, 5-10%, subangular, low to medium permeability, becoming low permeability with depth, stiff clay, becoming hard clay with depth.	0.1	1.4
3	Bedrock	Inferred Siltstone, extremely weathered, very low strength.	1.5	Not proven beyond a depth of 1.5m.

Table 3- Generalised Site Geotechnical Model – Basin 3

Unit	Origin	Description	Depth to Top of Unit [1] (m)	Unit Thickness [1] (m)
1	Topsoil	TOPSOIL, Silty CLAY, 50% Silty, low plasticity, pale grey/ brown, high permeability, Soft.	Ground surface	0.1
2	Deposits	CLAY, medium to high plasticity, brown/ pale grey/ red brown, medium to high permeability, becoming low permeability with depth, stiff clay, becoming hard clay with depth.	0.1	Not proven beyond a depth of 3.0m

Table 4- Generalised Site Geotechnical Model – Basin 5

Unit	Origin	Description	Depth to Top of Unit [1] (m)	Unit Thickness [1] (m)
1	Deposits	CLAY, medium to high plasticity, pale brown/ pale grey/ red brown, medium permeability, becoming low permeability with depth, stiff clay, becoming hard clay with depth.	Ground surface	Not proven beyond a depth of 3.0m

Table 5- Generalised Site Geotechnical Model – Basin 6

Unit	Origin	Description	Depth to Top of Unit [1] (m)	Unit Thickness [1] (m)
1	Topsoil	TOPSOIL, Silty CLAY, 50% Silty, low plasticity, dark brown/ brown, high permeability, Stiff clay.	Ground surface	0.1
2	Deposits	CLAY, medium to high plasticity, pale brown/ grey/ dark grey, medium permeability, trace gravel, 10% gravel, subangular, becoming low permeability with depth, stiff clay, becoming hard clay with depth.	0.1	Not proven beyond a depth of 3.0m

Table 6- Generalised Site Geotechnical Model – Basin 7

Unit	Origin	Description	Depth to Top of Unit [1] (m)	Unit Thickness [1] (m)
1	Topsoil	TOPSOIL, Silty CLAY, 30% Silty, low to medium plasticity, brown /dark grey, trace grass roots, medium to high permeability, Soft clay.	Ground surface	0.1
2	Deposits	CLAY, medium to high plasticity, pale brown/ pale grey/ dark grey, medium permeability, trace gravel, 5% gravel, subangular, becoming low permeability with depth, firm to stiff clay, becoming hard clay with depth.	0.1	Not proven beyond a depth of 3.0m

Table 7- Generalised Site Geotechnical Model – Basin 8

Unit	Origin	Description	Depth to Top of Unit [1] (m)	Unit Thickness [1] (m)
1	Topsoil	TOPSOIL, Silty CLAY, 30% Silty, low to medium plasticity, dark brown /brown, medium to high permeability, Soft clay.	Ground surface	0.1
2	Deposits	CLAY, medium to high plasticity, dark brown/ dark grey, medium permeability, becoming low permeability with depth, firm to stiff clay, becoming hard clay with depth.	0.1	1.3
3	Bedrock	Inferred Siltstone, extremely weathered, very low strength.	1.4	Not proven beyond 1.4m

Table 8- Generalised Site Geotechnical Model – Basin 9

Unit	Origin	Description	Depth to Top of Unit [1] (m)	Unit Thickness [1] (m)
1	Topsoil	TOPSOIL, Silty CLAY, 30% Silty, low to medium plasticity, dark brown, medium to high permeability, Very Soft clay.	Ground surface	0.1
2	Deposits	CLAY, medium to high plasticity, brown/ dark grey light brown/ light grey, medium permeability, trace gravel, 5%, subangular becoming low permeability with depth, firm to stiff clay, becoming hard clay with depth.	0.1	Not proven beyond a depth of 3.0m

Notes:

1. The depths and unit thicknesses are based on the information from the test locations only and do not necessarily represent the maximum and minimum values across the site.

Special Note for DCP testing

Caution must be used when inferring subsurface conditions from DCP results. Refusal can be encountered on obstructions such as gravel, cemented materials, rock floaters, or other inclusions within a soil mass. DCP testing on soils with a gravel component or cementation can indicate a higher density than actual. Also, the DCP results in clay soils are significantly affected by the in-situ moisture content. It is therefore strongly recommended that an experienced Geotechnical Engineer is engaged to confirm the inferred subsurface conditions during construction and to provide advice where subsurface conditions are significantly different.

4.3 Groundwater

Groundwater was not observed in the boreholes during auger drilling to depths of 1.4m to 3.0m bgl, except BH9 in Basin 9. During the site investigation, BH9 encountered groundwater level at 2.8m bgl.

Likewise, groundwater was not observed through all DCP tests except in Basin 9. Groundwater detection via DCP test is indicated by wet soil materials attached on the DCP rods and conical tip after rods extraction. For all DCP tests, the soil materials attached on the DCP rods and conical tip were dry except DCP9 in Basin 9 which encountered wet soil materials at approximately 2.7m bgl. No long-term groundwater monitoring was carried out.

4.4 Laboratory Test Results

Results from the laboratory testing undertaken on selected soil samples are included in Appendix C and are summarised in Table 9.

Table 9 – Laboratory Test Results

Test Location & Depth (m)	Atterberg Limits			Dispersion	Moisture Content (%)		Laboratory Description
	Plastic Limit %	Liquid Limit %	Plastic Limit %	Emerson Crumb	Field Moisture	Standard Optimum	
BH1 /0.9–2.0	17	37	20	5	16.2	15.6	Slightly sandy, silt and clay, moderate plasticity, trace fine gravel
BH2 / 0.7–1.5	20	51	31	5	17.9	19.3	Slightly sandy, silt and clay, high plasticity, trace sand and fine gravel
BH3 / 1.0–2.2	18	41	23	5	13.6	16.3	Slightly sandy, silt and clay, moderate plasticity, trace fine gravel
BH5 / 0.9–2.5	17	35	18	5	17.6	18.1	Slightly sandy, silt and clay, low to moderate plasticity, trace fine gravel
BH6 / 1.1–2.0	17	30	13	5	13.9	16.0	Sandy, silt and clay, low plasticity, trace fine gravel
BH7 / 1.0–2.2	21	41	20	5	17.5	18.3	Slightly sandy, silt and clay, moderate plasticity, trace fine gravel
BH8 / 0.5–1.4	20	40	20	5	19.3	19.9	Slightly sandy, silt and clay, moderate plasticity, trace fine gravel
BH9 / 0.9–2.0	18	36	18	5	18.7	16.1	Slightly sandy, silt and clay, low to moderate plasticity, trace fine gravel

Note – Emerson Crumb Value of 5 indicates soil of low dispersion activity.

5. Discussions & Recommendations

5.1 Key Geotechnical Site Constraints

With the basin depth being typically 2.5m below existing ground level, the excavation will be predominantly in firm to stiff clay, becoming hard clay with depth.

Table 10 – Basin Soil Materials

Basin	Max depth (m bgl)	Strata to be encountered
1	2.5	Firm to stiff clay becoming hard with depth. dry
2	2.0	Stiff clay becoming hard with depth. Probably rock (siltstone?) below 1.5m bgl. Dry
3	2.5	Stiff clay becoming hard with depth. Dry
5	2.5	Stiff clay becoming hard with depth. Dry
6	2.5	Stiff clay becoming hard with depth. Dry
7	2.5	Firm clay becoming hard with depth. Dry
8	2.5	Firm clay becoming hard with depth. Probably rock (siltstone?) below 1.4m bgl. Dry
9	1.5	Firm becoming stiff clay. Dry

See Table 9 for laboratory test results. The clays are generally low to moderate plasticity and of low dispersion activity (high stability). They have a minor sand and gravel content and, with carefully controlled moisture content, can be suitable for re-use on site.

Key geotechnical constraints to the development include variable excavation and foundation conditions. Recommendations for design and construction of the development are provided in the following sections.

5.2 Earthworks

5.2.1 Excavation

The excavation for the proposed development is anticipated to be predominantly within stiff to hard clay soils. There is a small possibility in Basin 2 and 8 that weathered siltstone bedrock may be encountered. Excavation within the soils and extremely weathered bedrock would be achievable using conventional earthmoving equipment (i.e. hydraulic excavator bucket).

Excavation within deeper, less weathered or stronger bedrock (such as marble) may require the use of ripper tooth fitted to a hydraulic excavator bucket, a dozer fitted with ripper tooth, or a hydraulic hammer fitted to an excavator, possibly supplemented by rock saw and rock splitting techniques.

5.2.2 Vibration Management

Australian Standard AS 2187: Part 2-2006 recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 "Evaluation and measurement for vibration in buildings Part 2" as they "are applicable to Australian conditions". The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where the minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (e.g. compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

For residential structures, BS 7385 recommends vibration criteria of 7.5 mm/s to 10 mm/s for frequencies between 4 Hz and 15 Hz, and 10 mm/s to 25 mm/s for frequencies between 15 Hz to 40 Hz and above. These values would normally be applicable for new residential structures or residential structures in good condition. Higher values would normally apply to commercial structures, and more conservative criteria would normally apply to heritage structures.

However, structures can withstand vibration levels significantly higher than those required to maintain comfort for their occupants. Human comfort is therefore likely to be the critical factor in vibration management.

Excavation methods should be adopted which limit ground vibrations at the adjoining developments to not more than 10mm/sec. Vibration monitoring is recommended to verify that this is achieved. However, if the contractor adopts methods and/or equipment in accordance with the recommendations in Table 11 for a ground vibration limit of 5mm/sec, vibration monitoring may not be required.

The limits of 5mm/sec and 10mm/sec are expected to be achievable if rock breaker equipment or other excavation methods are restricted as indicated in Table 11.

Table 11 – Recommendations for Rock Breaking Equipment

Distance from adjoining structure (m)	Maximum Peak Particle Velocity 5mm/sec		Maximum Peak Particle Velocity 10mm/sec*	
	Equipment	Operating Limit (% of Maximum Capacity)	Equipment	Operating Limit (% of Maximum Capacity)
1.5 to 2.5	Hand operated jackhammer only	100	300 kg rock hammer	50
2.5 to 5.0	300 kg rock hammer	50	300 kg rock hammer or 600 kg rock hammer	100 50
5.0 to 10.0	300 kg rock hammer or 600 kg rock hammer	100 50	600 kg rock hammer or 900 kg rock hammer	100 50

* Vibration monitoring is recommended for 10mm/sec vibration limit.

At all times, the excavation equipment must be operated by experienced personnel, per the manufacturer's instructions, and in a manner, consistent with minimising vibration effects.

Use of other techniques (e.g. chemical rock splitting, rock sawing), although less productive, would reduce or possibly eliminate risks of damage to adjoining property through vibration effects transmitted via the ground. Such techniques may be considered if an alternative to rock breaking is necessary. If rock sawing is carried out around excavation boundaries in not less than 1m deep lifts, a 900kg rock hammer could be used at up to 100% maximum operating capacity with an assessed peak particle velocity not exceeding 5 mm/sec, subject to observation and confirmation by a Geotechnical Engineer at the commencement of excavation.

Further geotechnical advice must be sought if rock excavation characteristics are critical to the proposed development.

It should be noted that vibrations that are below threshold levels for building damage may be experienced at adjoining developments. Rock excavation methodology should also consider acceptable noise limits as per the "Interim Construction Noise Guideline" (NSW EPA).

5.2.3 Subgrade Preparation

The following general recommendations are provided for subgrade preparation for earthworks, pavements, slab-on-ground construction, and minor structures:

- Strip existing topsoil. Remove unsuitable materials from the site (e.g. material containing deleterious matter). Stockpile remainder for re-use as landscaping material or remove from site.
- Excavate alluvial and residual clayey soils (and rock if encountered) to design subgrade level, stockpiling for re-use as engineered fill or remove to spoil.
- Where rock is exposed at footing invert level, it should be free of loose, "drummy" and softened material before concrete is poured.
- Where soil is exposed at bulk excavation level, compact the upper 150mm depth to a dry density ratio (AS1289.5.4.1–2007) not less than 100% Standard.
- Areas which show visible heave under compaction equipment should be over-excavated a further 0.3m and replaced with approved fill compacted to a dry density ratio not less than 100%.

Any waste soils being removed from the site must be classified in accordance with current regulatory authority requirements to enable appropriate disposal to an appropriately licensed landfill facility. Asset can provide further advice on this matter if required.

5.2.4 Filling

The excavated silt/clay is suitable for reuse with careful control over field moisture content.

Where filing is required, place in horizontal layers over prepared subgrade and compact as per Table 12.

Table 12 – Compaction Specifications

Parameter	Cohesive Fill	Non Cohesive Fill
Fill layer thickness (loose measurement): • Within 1.5m of the rear of retaining walls • Elsewhere	 0.2m 0.3m	 0.2m 0.3m
Density: • Beneath Pavements • Beneath Structures • Upper 150mm of subgrade	 ≥ 95% Std ≥ 98% Std ≥ 100% Std	 ≥ 70% ID ≥ 80% ID ≥ 80% ID
Moisture content during compaction	± 2% of optimum	Moist but not wet

Filling within 1.5m of the rear of any retaining walls should be compacted using lightweight equipment (e.g. hand-operated plate compactor or ride-on compactor not more than 3 tonnes static weight) to limit compaction-induced lateral pressures.

Any soils to be imported onto the site for backfilling and reinstatement of excavated areas should be free of contamination and deleterious material and should include appropriate validation documentation in accordance with current regulatory authority requirements which confirms its suitability for the proposed land use. Asset can provide further advice on this matter if required.

5.2.5 Batter Slopes

Recommended maximum slopes for permanent and temporary batters are presented in Table 13.

Table 13 – Recommended Maximum Dry Batter Slopes

Unit	Maximum Batter Slope (H : V)	
	Permanent	Temporary
Residual Clay & Alluvial Clay	2 : 1	1 : 1
Extremely weathered siltstone or better	1.5 : 1	0.75 : 1

5.3 Site Classification for Ancillary Structures

Where footings are founded on the underlying natural clay soils or siltstone bedrock, then footings may be designed and constructed in accordance with the requirements in AS2870-2011 for a Class M site (clays) or a Class A site (siltstone).

Footings should also be designed as per the recommendations in Section 5.5.

The classification and footing recommendations given above and in Section 5.5 are provided on the basis that the performance expectations set out in Appendix B of AS2870–2011 are acceptable and that future site maintenance is in accordance with CSIRO BTF 18, a copy of which is attached.

5.4 Salinity & Aggressivity

Whilst no specific laboratory testing has been carried out to assess the aggressiveness of soil to concrete and steel, based on the subsurface profile as described above and the site conditions, we consider that the soils would likely be non-saline, mildly-aggressive with respect to buried concrete and non-aggressive to buried steel structures. Further testing would be required to confirm this if considered critical to the design.

5.5 Footings for Ancillary Structures

Suitable footings might comprise a slab on ground, or shallow pad and strip footings supporting the upper building loads. Where some footings are taken to bedrock, it is recommended that all footings are founded on bedrock to reduce the risk of differential settlement due to variable founding conditions.

Edge beams for slabs, pad footings, and piles may be designed for the parameters in Table 14.

Table 14 – Footing Design Parameters

Founding Stratum	Maximum Allowable (Serviceability) Values (kPa)			Ultimate Strength Limit State Values (kPa)			
	End Bearing	Shaft Friction – Compression #	Shaft Friction – Tension	End Bearing	Shaft Friction – Compression #	Shaft Friction – Tension *	Typical E_{field} MPa
Stiff Clay (shallow)	150	20	10	600	60	30	20
Hard Clay (shallow)	200	40	20	1,200	120	60	40
Extremely weathered siltstone, if encountered	800	80	40	2,400	240	120	100

Note:

* Uplift capacity of piles in tension loading should also be checked for inverted cone pull out mechanism.

clean socket of roughness category R2 or better is assumed

In accordance with AS2159-2009 "Piling–Design and Installation", for limit state design, the ultimate geotechnical pile capacity shall be multiplied by a geotechnical reduction factor (Φg). This factor is derived from an Average Risk Rating (ARR) which considers geotechnical uncertainties, redundancy of the foundation system, construction supervision, and the quantity and type of pile testing (if any). Where testing is undertaken, or more comprehensive ground investigation is carried out, it may be possible to adopt a larger Φg value that results in a more economical pile design. Further geotechnical advice will be required in consultation with the pile designer and piling contractor, to develop an appropriate Φg value.

Settlements for footings on rock are anticipated to be about 1% of the minimum footing dimension, based on serviceability parameters as per Table 14. Settlements for pad footings on stiff clay are anticipated to be up to about 15mm where loading does not exceed the maximum allowable values.

Options for piles, if required, include:

Bored Piles. It assessed that the construction of sockets would require the use of a truck-mounted drilling rig. It is also assessed that the bored pile holes would not require liners to support the overburden soils, although some over break and minor fretting should be allowed for. Groundwater may be expected within bored pile holes at the soil: rock interface, if encountered, and dewatering by a down-hole pump may be required to limit softening of the bases prior to concreting.

Continuous Flight Auger (CFA) Piles. CFA piles are constructed by drilling a hollow-stemmed continuous flight auger to the required founding depth. Concrete is then injected under pressure through the auger stem as the auger is extracted from the soil. The reinforcing cage is then inserted upon completion of the concreting process. Pile diameters vary from 300mm to 1200mm. Drilled spoil is produced during CFA piling, and must subsequently be removed from the site. CFA piles are considered non-displacement piles as defined in AS2159.

Steel Screw Piles. Hollow-stemmed steel piles fitted with a single or double helix at the tip are installed using specially modified hydraulic excavators. Shaft diameters typically vary from 90mm to 220mm and helix diameters vary from 350mm to 600mm. Single pile capacities range from 2 to 65 tonnes.

An experienced Geotechnical Engineer should review footing designs to check that the recommendations of the geotechnical report have been included and should assess footing excavations to confirm the design assumptions.

5.6 Groundwater Control

Limited groundwater observations made for this investigation are described in Section 4.3. The observations indicate that groundwater is unlikely to be a constraint to the proposed development. However, good practice should be followed to cater for potential groundwater, such as designing retaining walls with adequate subsoil drainage. Further geotechnical advice must be sought if significant groundwater is encountered during construction.

5.7 Excavation Support

Excavation of soil and rock results in stress changes in the remaining material and some ground movement is inevitable. The magnitude and extent of lateral and vertical ground movements will depend on the design and construction of the excavation support system. Experience and published data suggest that lateral movements of an adequately designed and installed retention system in soil and weathered rock will typically be in the range of 0.2% to 0.5% of the retained height. The extent of the horizontal movement behind the excavation face typically varies from 1.5 to 3 times the excavated height.

5.7.1 Excavation Support Construction Methodology

Where temporary or permanent batter slopes as per Section 5.2.5 cannot be accommodated in the development or are not desired, temporary shoring and/or permanent retaining will be required.

It is considered likely that temporary excavation batters could be adopted for the site. Therefore, any permanent retaining walls could be constructed without temporary shoring.

Design of retaining walls will need to consider both long-term (i.e. permanent) and short-term (i.e. during construction) loading conditions, as well as the possible impact on adjoining developments.

We recommend the use of cantilever walls where the retained height is less than 3.5m.

5.7.2 Excavation Support Design Parameters

Support system design may be based on the parameters given in Table 15. Cantilever walls or walls with only a single row of anchors/props may be designed for a triangular earth pressure distribution with the lateral pressure being determined as follows:

$\sigma_z = K_{o,a,p}\ z\ \gamma$ where σ_z = lateral earth pressure (kPa) at depth z
$K_{o,a,p}$ = earth pressure coefficient
o = 'at rest', a = 'active', p = 'passive'
z = depth (m)
γ = unit weight of soil / rock (kN/m^3)

Table 15 – Excavation Support Design Parameters

Material	Moist Unit Weight (γ_m) kN/m^3	'Active' Lateral Earth Pressure Coefficient [1] (K_a)	'At Rest' Coefficient [1] (K_o)	'Passive' Coefficient [2] (K_p)
Alluvial / Residual Clay	19.0	0.35	0.5	2.5
Extremely weathered siltstone, if encountered [3]	22.0	0.2	0.4	6

Notes to table:

1. These values assume that some wall movement and relaxation of horizontal stress will occur due to the excavation. Actual in-situ K_o values may be higher, particularly in the rock units.
2. Includes a reduction factor to the ultimate value of K_p to consider strain incompatibility between active and passive pressure conditions. Parameters assume horizontal backfill and no back of wall friction.
3. The values for rock assume no adversely dipping joints or other defects are present in the bedrock. All excavation rock faces should be inspected regularly by an experienced Geotechnical Engineer / Engineering Geologist as excavation proceeds.

The parameters for the 'at rest' condition (K_o) should be used for the design of lateral earth pressures where adjacent footings/structures are located within the 'zone of influence' of the wall. The 'zone of influence' may be taken as a line extending upwards and outwards at 45° above horizontal from the base of the wall. Piles for cantilever walls should be socketed below bulk excavation level by a depth at least equal to the retained height. For assessment of passive restraint embedded below excavation level, we recommend a triangular pressure distribution.

5.7.3 Surcharge

Allowance must also be made for surcharge loadings and footing loads from adjacent structures.

5.7.4 Hydrostatic Pressure

Where an adequate subsoil drainage system designed by an appropriately qualified and experienced Hydraulic / Stormwater Engineer is provided behind non-tanked retaining walls, no allowance for hydrostatic pressure would be necessary.

5.8 Site Classification – Earthquake Actions

In accordance with the earthquake loading standard, AS1170.4 (2007), this site has a site sub-soil Class Ce – Shallow soil site, as more than 3 m depth of soil or highly weathered rock (with UCS not more than 1MPa) is present.

A Hazard Factor, z, of 0.09 for Blayney region is recommended.

6. Limitations

In addition to the limitations inherent in site investigations (refer to the attached Information Sheets), it must be pointed out that the recommendations in this report are based on assessed subsurface conditions from limited investigations. To confirm the assessed soil and rock properties in this report, further investigation would be required such as coring and strength testing of rock and should be carried out if the scale of the development warrants, or if any of the properties are critical to the design, construction or performance of the development.

It is recommended that a qualified and experienced Geotechnical Engineer be engaged to provide further input and review during the design development; including site visits during construction to verify the site conditions and provide advice where conditions vary from those assumed in this report. Development of an appropriate inspection and testing plan should be carried out in consultation with the Geotechnical Engineer.

This report may have included geotechnical recommendations for design and construction of temporary works (e.g. temporary batter slopes or temporary shoring of excavations). Such temporary works are expected to perform adequately for a relatively short period only, which could range from a few days (for temporary batter slopes) up to six months (for temporary shoring). This period depends on a range of factors including but not limited to: site geology; groundwater conditions; weather conditions; design criteria; and level of care taken during construction. If there are factors which prevent temporary works from being completed and/or which require temporary works to function for periods longer than originally designed, further advice must be sought from the Geotechnical Engineer and Structural Engineer.

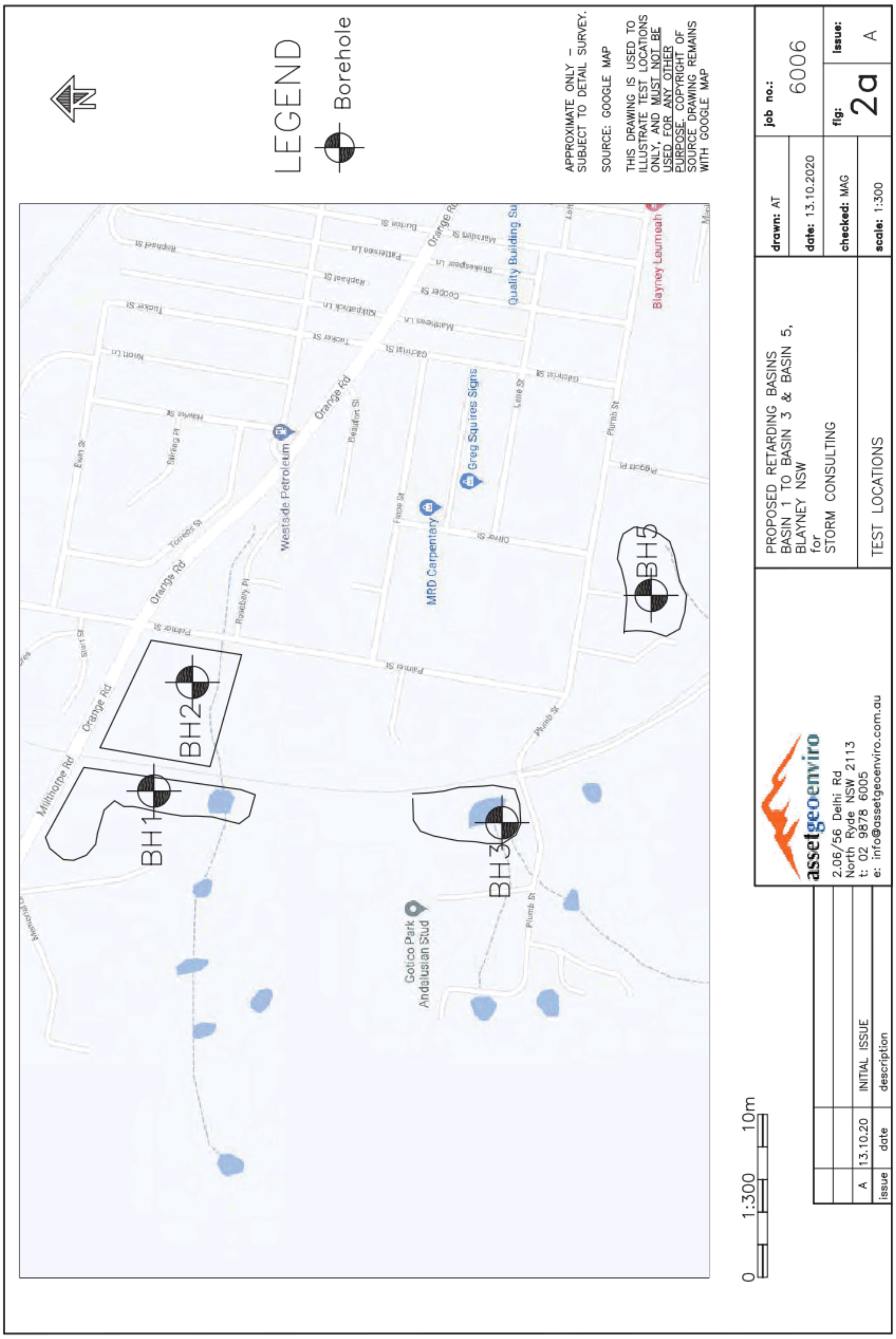
This report and details for the proposed development should be submitted to relevant regulatory authorities that have an interest in the property (e.g. Council) or are responsible for services that may be within or adjacent to the site (e.g. Utility asset owners, TfNSW, Regional Railways), for their review.

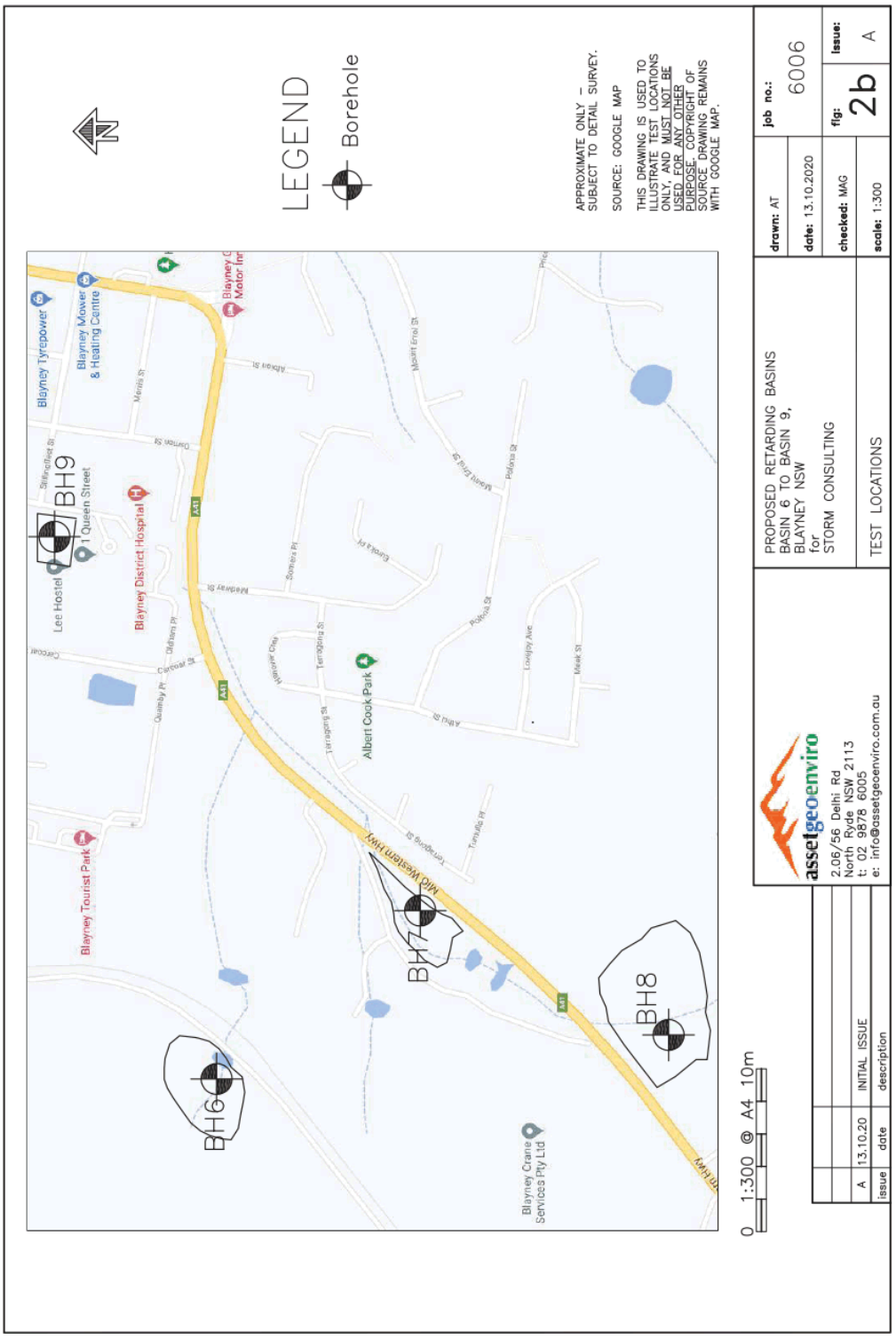
Asset accepts no liability where our recommendations are not followed or are only partially followed. The document "Important Information about your Geotechnical Report" in Appendix A provides additional information about the uses and limitations of this report.

Figures


APPROXIMATE ONLY - SUBJECT TO DETAIL SURVEY.
SOURCE: GOOGLE MAPS
THIS DRAWING IS USED TO ILLUSTRATE TEST LOCATIONS ONLY, AND MUST NOT BE USED FOR ANY OTHER PURPOSE. COPYRIGHT OF SOURCE DRAWING REMAINS WITH GOOGLE MAPS
Basin 1
Basin 2
Basin 3
Basin 5
Orange Rd
Millthorpe Rd
Westside Petroleum
MRD Carpentary
Greg Squires Signs
Quality Building Su
Blayney Lourmiah
Golico Park Andalusian Stud
PROPOSED RETARDING BASINS BASIN 1 TO BASIN 3 & BASIN 5, BLAYNEY NSW for STORM CONSULTING
SITE LOCALITY
drawn: AT
date: 13.10.2020
checked: MAG
scale: NTS
job no.: 6006
fig: 1a
issue: A
assetgeoenviro
2.06/56 Delhi Rd
North Ryde NSW 2113
t: 02 9878 6005
e: info@assetgeoenviro.com.au
A 13.10.20 INITIAL ISSUE
issue date description


APPROXIMATE ONLY - SUBJECT TO DETAIL SURVEY.
SOURCE: GOOGLE MAPS
THIS DRAWING IS USED TO ILLUSTRATE TEST LOCATIONS ONLY, AND MUST NOT BE USED FOR ANY OTHER PURPOSE. COPYRIGHT OF SOURCE DRAWING REMAINS WITH GOOGLE MAPS
Basin 6
Basin 7
Basin 8
Basin 9
Blayney Tyrepower
Blayney Mower & Heating Centre
1 Queen Street
Lee Hostel
Blayney District Hospital
Albert Cook Park
Blayney Tourist Park
Blayney Crane Services Pty Ltd
Mid Western Hwy
A41
PROPOSED RETARDING BASINS BASIN 6 TO BASIN 9, BLAYNEY NSW for STORM CONSULTING
SITE LOCALITY
drawn: AT
date: 13.10.2020
checked: MAG
scale: NTS
job no.: 6006
fig: 1b
issue: A
assetgeoenviro
2.06/56 Delhi Rd
North Ryde NSW 2113
t: 02 9878 6005
e: info@assetgeoenviro.com.au
A 13.10.20 INITIAL ISSUE
issue date description


LEGEND
Borehole
APPROXIMATE ONLY – SUBJECT TO DETAIL SURVEY.
SOURCE: GOOGLE MAP
THIS DRAWING IS USED TO ILLUSTRATE TEST LOCATIONS ONLY, AND MUST NOT BE USED FOR ANY OTHER PURPOSE. COPYRIGHT OF SOURCE DRAWING REMAINS WITH GOOGLE MAP
BH1
BH2
BH3
BH5
0
1:300
10m
drawn: AT
date: 13.10.2020
checked: MAG
scale: 1:300
job no.: 6006
fig: 2a
issue: A
PROPOSED RETARDING BASINS BASIN 1 TO BASIN 3 & BASIN 5, BLAYNEY NSW
for
STORM CONSULTING
TEST LOCATIONS
assetgeoenviro
2.06/56 Delhi Rd
North Ryde NSW 2113
t: 02 9878 6005
e: info@assetgeoenviro.com.au
A
13.10.20
INITIAL ISSUE
issue
date
description


LEGEND
Borehole
APPROXIMATE ONLY - SUBJECT TO DETAIL SURVEY.
SOURCE: GOOGLE MAP
THIS DRAWING IS USED TO ILLUSTRATE TEST LOCATIONS ONLY, AND MUST NOT BE USED FOR ANY OTHER PURPOSE. COPYRIGHT OF SOURCE DRAWING REMAINS WITH GOOGLE MAP.
BH6
BH7
BH8
BH9
Blayney Tyrepower
Blayney Mower & Heating Centre
Lee Hostel
Blayney District Hospital
Blayney Tourist Park
Albert Cook Park
Blayney Crane Services Pty Ltd
Mid Western Hwy
A41
0 1:300 @ A4 10m
assetgeoenviro
2.06/56 Delhi Rd
North Ryde NSW 2113
t: 02 9878 6005
e: info@assetgeoenviro.com.au
PROPOSED RETARDING BASINS
BASIN 6 TO BASIN 9,
BLAYNEY NSW
for
STORM CONSULTING
TEST LOCATIONS
drawn: AT
date: 13.10.2020
checked: MAG
scale: 1:300
job no.: 6006
fig: 2b
issue: A
A 13.10.20 INITIAL ISSUE
issue date description

Appendix A

Important Information about your Geotechnical Report
CSIRO BTF 18

Important Information about your Geotechnical Report

assetgeoenviro

Scope of Services

The geotechnical report ("the report") has been prepared in accordance with the scope of services as set out in the contract, or as otherwise agreed, between the Client and Asset Geotechnical Engineering Pty Ltd ("Asset"), for the specific site investigated. The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

The report should not be used if there have been changes to the project, without first consulting with Asset to assess if the report's recommendations are still valid. Asset does not accept responsibility for problems that occur due to project changes if they are not consulted.

Reliance on Data

Asset has relied on data provided by the Client and other individuals and organizations, to prepare the report. Such data may include surveys, analyses, designs, maps and plans. Asset has not verified the accuracy or completeness of the data except as stated in the report. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations ("conclusions") are based in whole or part on the data, Asset will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Asset.

Geotechnical Engineering

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared for a specific client, for a specific project and to meet specific needs, and may not be adequate for other clients or other purposes (e.g. a report prepared for a consulting civil engineer may not be adequate for a construction contractor). The report should not be used for other than its intended purpose without seeking additional geotechnical advice. Also, unless further geotechnical advice is obtained, the report cannot be used where the nature and/or details of the proposed development are changed.

Limitations of Site Investigation

The investigation program undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions. The data derived from the site investigation program and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behavior with regard to the proposed development. Despite investigation, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel. The actual interface between materials may be more gradual or abrupt than a report indicates.

Therefore, the recommendations in the report can only be regarded as preliminary. Asset should be retained during the project implementation to assess if the report's recommendations are valid and whether or not changes should be considered as the project proceeds.

Subsurface Conditions are Time Dependent

Subsurface conditions can be modified by changing natural forces or man-made influences. The report is based on conditions that existed at the time of subsurface exploration. Construction operations adjacent to the site, and natural events such as floods, or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. Asset should be kept appraised of any such events, and should be consulted to determine if any additional tests are necessary.

Verification of Site Conditions

Where ground conditions encountered at the site differ significantly from those anticipated in the report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the report that Asset be notified of any variations and be provided with an opportunity to review the recommendations of this report. Recognition of change of soil and rock conditions requires experience and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly.

Reproduction of Reports

 Where information from the accompanying report is to be included in contract documents or engineering specification for the project, the entire report should be included in order to minimize the likelihood of misinterpretation from logs.

Report for Benefit of Client

The report has been prepared for the benefit of the Client and no other party. Asset assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of Asset or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

Data Must Not Be Separated from The Report

The report as a whole presents the site assessment, and must not be copied in part or altered in any way.

Logs, figures, drawings, test results etc. included in our reports are developed by professionals based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These data should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Partial Use of Report

Where the recommendations of the report are only partially followed, there may be significant implications for the project and could lead to problems. Consult Asset if you are not intending to follow all of the report recommendations, to assess what the implications could be. Asset does not accept responsibility for problems that develop where the report recommendations have only been partially followed if they have not been consulted.

Other Limitations

Asset will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report.

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction
There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion
All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation
This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil
All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure
This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

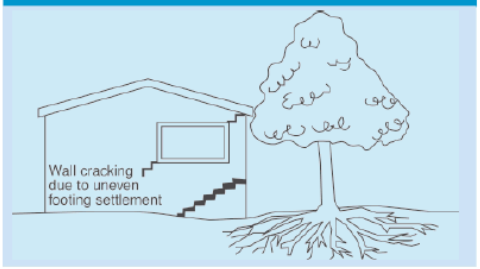
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

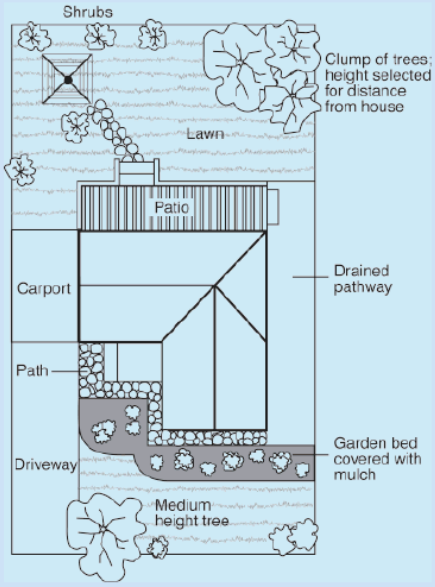
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

Distributed by

CSIRO PUBLISHING PO Box 1139, Collingwood 3066, Australia

Freecall 1800 645 051 Tel (03) 9662 7666 Fax (03) 9662 7555 www.publish.csiro.au

Email: publishing.sales@csiro.au

Appendix B

Soil & Rock Explanation Sheets
Borehole Logs
DCP Logs

Soil and Rock Explanation Sheets (1 of 2)

assetgeoenviro

Log Abbreviations & Notes

METHOD

borehole logs		excavation logs	
AS	auger screw *	NE	natural excavation
AD	auger drill *	HE	hand excavation
RR	roller / tricone	BH	backhoe bucket
W	washbore	EX	excavator bucket
CT	cable tool	DZ	dozer blade
HA	hand auger	R	ripper tooth
D	diatube		
B	blade / blank bit		
V	V-bit		
T	TC-bit		

* bit shown by suffix e.g. ADV

coring
NMLC, NQ, PQ, HQ

SUPPORT

borehole logs		*excavation logs*	
N	nil	N	nil
M	mud	S	shoring
C	casing	B	benched
NQ	NQ rods		

CORE–LIFT

||| casing installed

⊢ barrel withdrawn

NOTES, SAMPLES, TESTS

D	disturbed
B	bulk disturbed
U50	thin-walled sample, 50mm diameter
HP	hand penetrometer (kPa)
SV	shear vane test (kPa)
DCP	dynamic cone penetrometer (blows per 100mm penetration)
SPT	standard penetration test
N*	SPT value (blows per 300mm) * denotes sample taken
Nc	SPT with solid cone
R	refusal of DCP or SPT

USCS SYMBOLS

GW	Gravel and gravel-sand mixtures, little or no fines.
GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels
GM	Gravel-silt mixtures and gravel-sand-silt mixtures.
GC	Gravel-clay mixtures and gravel-sand-clay mixtures.
SW	Sand and gravel-sand mixtures, little or no fines.
SP	Sand and gravel sand mixtures, little or no fines.
SM	Sand-silt mixtures.
SC	Sand-clay mixtures.
ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity.
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays.
OL	Organic silts
MH	Inorganic silts
CH	Inorganic clays of high plasticity.
OH	Organic clays of medium to high plasticity, organic silt
PT	Peat, highly organic soils.

MOISTURE CONDITION

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

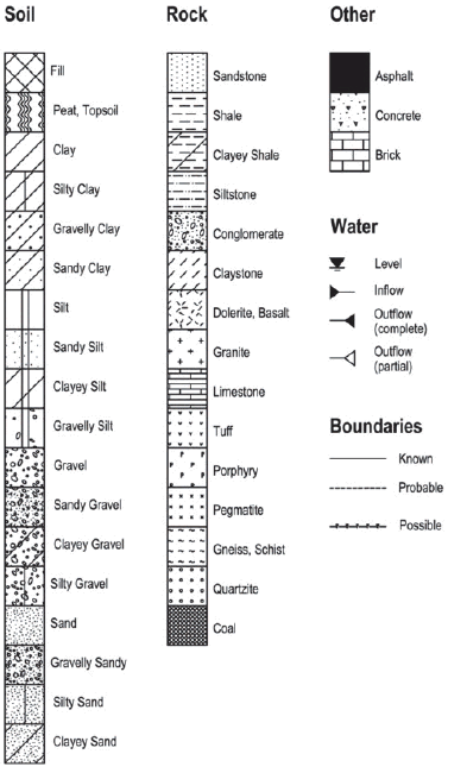
CONSISTENCY

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable

DENSITY INDEX

VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Graphic Log



WEATHERING

XW	extremely weathered
HW	highly weathered
MW	moderately weathered
SW	slightly weathered
FR	fresh

STRENGTH

VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

RQD (%)

= $\frac{\text{sum of intact core pieces > 2 x diameter}}{\text{total length of core run drilled}} \times 100$

DEFECTS:

type		*coating*	
JT	joint	cl	clean
PT	parting	st	stained
SZ	shear zone	ve	veneer
SM	seam	co	coating

shape		*roughness*	
pl	planar	po	polished
cu	curved	sl	slickensided
un	undulating	sm	smooth
st	stepped	ro	rough
ir	irregular	vr	very rough

inclination
measured above axis and perpendicular to core

Soil and Rock Explanation Sheets (2 of 2)

assetgeoenviro

AS1726-2017

Soils and rock are described in the following terms, which are broadly in accordance with AS1726-2017.

Soil

MOISTURE CONDITION

Term	Description
Dry	Looks and feels dry. Fine grained and cemented soils are hard, friable or powdery. Uncemented coarse grained soils run freely through hand.
Moist	Soil feels cool and darkened in colour. Fine grained soils can be moulded. Coarse soils tend to cohere.
Wet	As for moist, but with free water forming on hand.

Moisture content of cohesive soils may also be described in relation to plastic limit (W_P) or liquid limit (W_L) [>> much greater than, > greater than, < less than, << much less than].

CONSISTENCY OF FINE-GRAINED SOILS

Term	Su (kPa)	Term	Su (kPa)
Very soft	< 12	Very Stiff	>100 – ≤200
Soft	>12 – ≤25	Hard	> 200
Firm	>25 – ≤50	Friable	–
Stiff	>50 – ≤100		

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Term	Density Index (%)	Term	Density Index (%)
Very Loose	< 15	Dense	65 – 85
Loose	15 – 35	Very Dense	>85
Medium Dense	35 – 65		

PARTICLE SIZE

Name	Subdivision	Size (mm)
Boulders		> 200
Cobbles		63 – 200
Gravel	coarse	19 – 63
	medium	6.7 – 19
	fine	2.36 – 6.7
Sand	coarse	0.6 – 2.36
	medium	0.21 – 0.6
	fine	0.075 – 0.21
Silt & Clay		< 0.075

MINOR COMPONENTS

Term	Proportion by Mass: *coarse grained*	*fine grained*
Trace	≤ 15%	≤ 5%
With	>15% – ≤30%	>5% – ≤12%

SOIL ZONING

Layers	Continuous across exposures or sample.
Lenses	Discontinuous, lenticular shaped zones.
Pockets	Irregular shape zones of different material.

SOIL CEMENTING

Weakly	Easily broken up by hand pressure in water or air.
Moderately	Effort is required to break up by hand in water or in air.

USCS SYMBOLS

Symbol	Description
GW	Gravel and gravel-sand mixtures, little or no fines.
GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels.
GM	Gravel-silt mixtures and gravel-sand-silt mixtures.
GC	Gravel-clay mixtures and gravel-sand-clay mixtures.
SW	Sand and gravel-sand mixtures, little or no fines.
SP	Sand and gravel sand mixtures, little or no fines.
SM	Sand-silt mixtures.
SC	Sand-clay mixtures.
ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity.
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays.
OL	Organic silts
MH	Inorganic silts
CH	Inorganic clays of high plasticity.
OH	Organic clays of medium to high plasticity, organic silt
PT	Peat, highly organic soils.

Rock

SEDIMENTARY ROCK TYPE DEFINITIONS

Rock Type	Definition (more than 50% of rock consists of .....)
Conglomerate	... gravel sized (>2mm) fragments.
Sandstone	... sand sized (0.06 to 2mm) grains.
Siltstone	... silt sized (<0.06mm) particles, rock is not laminated.
Claystone	... clay, rock is not laminated.
Shale	... silt or clay sized particles, rock is laminated.

LAYERING

Term	Description
Massive	No layering apparent.
Poorly Developed	Layering just visible. Little effect on properties.
Well Developed	Layering distinct. Rock breaks more easily parallel to layering.

STRUCTURE

Term	Spacing (mm)	Term	Spacing
Thinly laminated	<6	Medium bedded	200 – 600
Laminated	6 – 20	Thickly bedded	600 – 2,000
Very thinly bedded	20 – 60	Very thickly bedded	> 2,000
Thinly bedded	60 – 200		

STRENGTH (NOTE: Is50 = Point Load Strength Index)

Term	Is50 (MPa)	Term	Is50 (MPa)
Extremely Low	<0.03	High	1.0 – 3.0
Very low	0.03 – 0.1	Very High	3.0 – 10.0
Low	0.1 – 0.3	Extremely High	>10.0
Medium	0.3 – 1.0		

WEATHERING

Term	Description
Residual Soil	Material is weathered to an extent that it has soil properties. Rock structures are no longer visible, but the soil has not been significantly transported.
Extremely	Material is weathered to the extent that it has soil properties. Mass structures, material texture & fabric of original rock is still visible.
Highly	Rock strength is significantly changed by weathering; rock is discolored, usually by iron staining or bleaching. Some primary minerals have weathered to clay minerals.
Moderately	Rock strength shows little or no change of strength from fresh rock; rock may be discolored.
Slightly	Rock is partially discolored but shows little or no change of strength from fresh rock.
Fresh	Rock shows no signs of decomposition or staining.

DEFECT DESCRIPTION

Type	
Joint	A surface or crack across which the rock has little or no tensile strength. May be open or closed.
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub-parallel to layering/bedding. May be open or closed.
Sheared Zone	Zone of rock substance with roughly parallel, near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects.
Seam	Seam with deposited soil (infill), extremely weathered insitu rock (XW), or disoriented usually angular fragments of the host rock (crushed).
Shape	
Planar	Consistent orientation.
Curved	Gradual change in orientation.
Undulating	Wavy surface.
Stepped	One or more well defined steps.
Irregular	Many sharp changes in orientation.
Roughness	
Polished	Shiny smooth surface.
Slickensided	Grooved or striated surface, usually polished.
Smooth	Smooth to touch. Few or no surface irregularities.
Rough	Many small surface irregularities (amplitude generally <1mm). Feels like fine to coarse sandpaper.
Very Rough	Many large surface irregularities, amplitude generally >1mm. Feels like very coarse sandpaper.
Coating	
Clean	No visible coating or discolouring.
Stained	No visible coating but surfaces are discolored.
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	Visible coating =1mm thick. Thicker soil material described as seam.

assetgeoenviro

Borehole Log

BH no:	BH1 -Basin 1
sheet:	1 of 1
job no.:	6006

client:	Storm Consulting	started:	1.10.2020
principal:		finished:	1.10.2020
project:	Proposed Retarding Basins	logged:	AT
location:	8 Sites in Blayney, NSW	checked:	MAG
equipment:	Ute-Mounted Drill Rig- MG 32	RL surface:	890 m approx.
diameter:	100mm inclination: -90° bearing: --- E: 707879.23m N: 6288253.65m	datum:	AHD

drilling information | material information

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa	structure and additional observations
ADT/DCP	N	None Observed					CL-ML	TOPSOIL, Silty CLAY, low to medium plasticity, grey/light grey/light brown, trace grass roots, medium to high permeability, 30% silt.	D	S		TOPSOIL.
					0.1		CL-ML	Silty CLAY, low to medium plasticity, light grey/light brown, medium to high permeability, 30% silty.		F		ALLUVIUM.
				889.5	0.5		CL-CH	CLAY, medium plasticity, trace gravel, 5% gravel, subangular, low to medium permeability, dark brown/brown/grey.		St		
				889.0	1.0							
			Bs	888.5	1.5		CH	CLAY, medium to high plasticity, red brown/brown, low permeability.				
				888.0	2.0							
					2		CH	CLAY, medium to high plasticity, grey pale brown, low permeability.		VSt		
										H		
ADT								DCP reached practical refusal @ 2.4m on hard clay.				
				887.5	2.5							
					2.5		CH	CLAY, medium to high plasticity, dark grey/brown, low permeability.				
				887.0	3.0							
					3			Borehole reached target depth @ 3.0m on hard clay. Borehole No: BH1 -Basin 1 terminated at 3m				
				886.5	3.5							

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED — Borehole Log - Revision 10

6006 BH LOGS.GPJ 13/10/20

A: 2.05 / 56 Delhi Road, North Ryde NSW 2113 P: 02 9878 6005 W: assetgeoenviro.com.au

assetgeoenviro

Borehole Log

BH no:	BH2 -Basin 2
sheet:	1 of 1
job no.:	6006

client:	Storm Consulting	started:	1.10.2020
principal:		finished:	1.10.2020
project:	Proposed Retarding Basins	logged:	AT
location:	8 Sites in Blayney, NSW	checked:	MAG
equipment:	Ute-Mounted Drill Rig - MG 32	RL surface:	883 m approx.
diameter:	100mm inclination: -90° bearing: --- E: 708096.31m N: 6288219.04m	datum:	AHD

drilling information | material information

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
ADT/DCP	N	None Observed			0.1		CL-ML	TOPSOIL, Silty CLAY, low to medium plasticity, medium to high permeability, 30% silt, grey/ brown.	D	S		TOPSOIL
							CH	CLAY, medium to high plasticity, low to medium permeability, light brown/ light grey.				ALLUVIUM.
				882.5	0.5					St		
			Bs	882.0	1.0							
					1.2		CH	CLAY, medium to high plasticity, low permeability, trace gravels, 5-10% gravels, subangular, brown/ dark brown.		VSt		
				881.5	1.5					H		
					1.5			DCP & TC-Bit Auger reached practical refusal @ 1.5m on hard clay. Borehole No: BH2 -Basin 2 terminated at 1.5m				
				881.0	2.0							
				880.5	2.5							
				880.0	3.0							
				879.5	3.5							

6006 BH LOGS.GPJ 13/10/20

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED — Borehole Log - Revision 10

A: 2.05 / 56 Delhi Road, North Ryde NSW 2113 P: 02 9878 6005 W: assetgeoenviro.com.au

assetgeoenviro

Borehole Log

BH no:	BH3 -Basin 3
sheet:	1 of 1
job no.:	6006

client:	Storm Consulting	started:	1.10.2020
principal:		finished:	1.10.2020
project:	Proposed Retarding Basins	logged:	AT
location:	8 Sites in Blayney, NSW	checked:	MAG
equipment:	Ute-Mounted Drill Rig - MG 32	RL surface:	896 m approx.
diameter:	100mm inclination: -90° bearing: --- E: 707824.48m N: 6287715.14m	datum:	AHD

drilling information | material information

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT/DCP	N	None Observed			0.08		CL-ML	TOPSOIL, Silty CLAY, low plasticity, high permeability, 50% silt, brown/ pale grey.	D	St		TOPSOIL
							CL	CLAY, low plasticity, high permeability, brown/ pale grey.				ALLUVIUM
										F		
				895.5	0.5					St		
					0.7		CL	CLAY, low to medium plasticity, medium permeability, brown/ orange brown/ pale grey.				
				895.0	1.0					VSt		
					1.3		CH	CLAY, medium to high plasticity, low to medium permeability, red brown/ brown.		H		
				894.5	1.5							
			Bs							VSt		
				894.0	2.0							
					2.2		CH	CLAY, high plasticity, low permeability, red brown/ pale grey.				
				893.5	2.5					H		
										VSt		
ADT								DCP reached practical refusal @ 2.8m on hard clay.		H		
				893.0	3.0							
					3			Borehole reached target depth @ 3.0m on hard clay. Borehole No: BH3 -Basin 3 terminated at 3m				
				892.5	3.5							

6006 BH LOGS.GPJ 13/10/20

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED — Borehole Log - Revision 10

A: 2.05 / 56 Delhi Road, North Ryde NSW 2113 P: 02 9878 6005 W: assetgeoenviro.com.au

assetgeoenviro

Borehole Log

BH no:	BH5 -Basin 5
sheet:	1 of 1
job no.:	6006

client:	Storm Consulting	started:	1.10.2020
principal:		finished:	1.10.2020
project:	Proposed Retarding Basins	logged:	AT
location:	8 Sites in Blayney, NSW	checked:	MAG
equipment:	Ute-Mounted Drill Rig - MG 32	RL surface:	892 m approx.
diameter:	100mm inclination: -90° bearing: --- E: 708175.22m N: 6287499.61m	datum:	AHD

drilling information | material information

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT/DCP	N	None Observed		891.5	0.5		CL-CH	CLAY, medium plasticity, low to medium permeability, pale grey/ pale brown.	D	St		ALLUVIUM.
										F		
					0.8		CH	CLAY, medium to high plasticity, low to medium permeability, brown.		St		
				891.0	1.0					VSt		
										St		
										VSt		
				890.5	1.5					H		
					1.5		CH	CLAY, high plasticity, low permeability, red brown.				
			Bs									
ADT								DCP reached practical refusal @ 1.9m on hard clay.				
				890.0	2.0							
					2		CL-CH	CLAY, medium plasticity, low to medium permeability, pale brown.				
				889.5	2.5							
				889.0	3.0							
					3			Borehole reached target depth @ 3.0m on hard clay. Borehole No: BH5 -Basin 5 terminated at 3m				
				888.5	3.5							

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED — Borehole Log - Revision 10

6006 BH LOGS.GPJ 13/10/20

A: 2.05 / 56 Delhi Road, North Ryde NSW 2113 P: 02 9878 6005 W: assetgeoenviro.com.au

assetgeoenviro

Borehole Log

BH no:	BH6 -Basin 6
sheet:	1 of 1
job no.:	6006

client:	Storm Consulting	started:	1.10.2020
principal:		finished:	1.10.2020
project:	Proposed Retarding Basins	logged:	AT
location:	8 Sites in Blayney, NSW	checked:	MAG
equipment:	Ute-Mounted Drill Rig - MG 32	RL surface:	914 m approx.
diameter:	100mm inclination: -90° bearing: --- E: 708066.97m N: 6286716.76m	datum:	AHD

drilling information | material information

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa	structure and additional observations
ADT/DCP	N	None Observed					CL-ML	TOPSOIL, Silty CLAY, low plasticity, high permeability, 50% silt, dark brown/ brown.	D	St		TOPSOIL.
					0.1		CL-CH	CLAY, low to medium plasticity, medium permeability, pale brown/ grey.				ALLUVIUM
				913.5	0.5					H		
ADT								DCP reached practical refusal @ 0.8m on hard clay.				
				913.0	1.0							
			Bs		1.4		CL-CH	CLAY, medium plasticity, trace gravels, 10% gravels, subangular, low to medium permeability, pale brown/ brown.				
				912.5	1.5							
				912.0	2.0							
					2		CH	CLAY, medium to high plasticity, low permeability, pale brown/ dark grey/ brown.				
				911.5	2.5							
				911.0	3.0							
					3			Borehole reached target depth @ 3.0m pn hard clay. Borehole No: BH6 -Basin 6 terminated at 3m				
				910.5	3.5							

6006 BH LOGS.GPJ 13/10/20

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED — Borehole Log - Revision 10

A: 2.05 / 56 Delhi Road, North Ryde NSW 2113 P: 02 9878 6005 W: assetgeoenviro.com.au

assetgeoenviro

Borehole Log

BH no:	BH7 -Basin 7
sheet:	1 of 1
job no.:	6006

client:	Storm Consulting	started:	2.10.2020
principal:		finished:	2.10.2020
project:	Proposed Retarding Basins	logged:	AT
location:	8 Sites in Blayney, NSW	checked:	MAG
equipment:	Ute-Mounted Drill Rig - MG 32	RL surface:	899 m approx.
diameter:	100mm inclination: -90° bearing: --- E: 708318.22m N: 6286398.58m	datum:	AHD

drilling information | material information

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
ADT/DCP	N	None Observed			0.1		CL-ML	TOPSOIL, Silty CLAY, low to medium plasticity, medium to high permeability, trace grass roots, 30% silt, brown/ dark grey.	D	S		TOPSOIL.
							CL	CLAY, low to medium plasticity, medium permeability, brown/ dark grey.		F		ALLUVIUM.
				898.5	0.5					St		
					0.7		CH	CLAY, medium to high plasticity, medium permeability, pale brown/ brown.		F		
				898.0	1.0					St		
				897.5	1.5		CL-CH	CLAY, medium plasticity, low to medium permeability, trace gravel, 5% gravel, subangular, dark grey/ dark brown.				
			Bs							VSt		
				897.0	2.0							
ADT								DCP reached practical refusal @ 2.2m on hard clay.		H		
				896.5	2.5							
					2.5		CH	CLAY, high plasticity, low permeability, pale brown/ pale grey/ brown.				
				896.0	3.0							
					3			Borehole reached target depth @ 3.0m on hard clay. Borehole No: BH7 -Basin 7 terminated at 3m				
				895.5	3.5							

6006 BH LOGS.GPJ 13/10/20

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED — Borehole Log - Revision 10

A: 2.05 / 56 Delhi Road, North Ryde NSW 2113 P: 02 9878 6005 W: assetgeoenviro.com.au

assetgeoenviro

Borehole Log

BH no:	BH8 -Basin 8
sheet:	1 of 1
job no.:	6006

client:	Storm Consulting	started:	2.10.2020
principal:		finished:	2.10.2020
project:	Proposed Retarding Basins	logged:	AT
location:	8 Sites in Blayney, NSW	checked:	MAG
equipment:	Ute- Mounted Drill Rig - MG 32	RL surface:	924 m approx.
diameter:	100mm inclination: -90° bearing: --- E: 708135.54m N: 6286066.02m	datum:	AHD

drilling information | material information

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
ADT/DCP	N	None Observed			0.075		CL-ML	TOPSOIL, Silty CLAY, low to medium plasticity, medium to high permeability, dark brown, 30% silt.	D	S		TOPSOIL
							CL-ML	Silty CLAY, low to medium plasticity, medium permeability, 30% silt, dark brown/ brown.		F		ALLUVIUM.
				923.5	0.5							
										St		
			Bs							VSt		
				923.0	1.0							
ADT					1		CH	CLAY, medium to high plasticity, low to medium permeability, dark grey. DCP reached practical refusal @ 1.1m on hard clay.		H		
					1.4			Auger TC- bit reached practical refusal @ 1.4m. Borehole No: BH8 -Basin 8 terminated at 1.4m				
				922.5	1.5							
				922.0	2.0							
				921.5	2.5							
				921.0	3.0							
				920.5	3.5							

6006 BH LOGS.GPJ 13/10/20

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED — Borehole Log - Revision 10

A: 2.05 / 56 Delhi Road, North Ryde NSW 2113 P: 02 9878 6005 W: assetgeoenviro.com.au

assetgeoenviro

Borehole Log

BH no:	BH9 -Basin 9
sheet:	1 of 1
job no.:	6006

client:	Storm Consulting	started:	2.10.2020
principal:		finished:	2.10.2020
project:	Proposed Retarding Basins	logged:	AT
location:	8 Sites in Blayney, NSW	checked:	MAG
equipment:	Ute- Mounted Drill Rig - MG 32	RL surface:	872 m approx.
diameter:	100mm inclination: -90° bearing: --- E: 708910.94m N: 6286961.3m	datum:	AHD

drilling information | material information

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT/DCP	N				0.1		CL-ML	TOPSOIL, Silty CLAY, low to medium plasticity, 30% silt, medium to high permeability, dark brown.	D	VS		TOPSOIL.
							CH	CLAY, medium to high plasticity, medium permeability, trace gravels, 5% gravels, subangular, dark grey/ brown.		F		ALLUVIUM.
				871.5	0.5					VS		
										F		
				871.0	1.0					St		
					1.2		CH	CLAY, medium to high plasticity, medium permeability, pale brown/ brown.				
			Bs	870.5	1.5							
					1.5		CH	CLAY, high plasticity, low to medium permeability, trace gravels, 5% gravels, subangular, brown.				
				870.0	2.0					VSt		
										H		
				869.5	2.5							
		▼			2.5		CH	CLAY, high plasticity, low permeability, pale grey/ pale brown.	M-W	VSt		
										H		
				869.0	3.0							
					3			Borehole reached target depth @ 3.0m on hard clay. DCP reached practical refusal @ 3.0m on hard clay. Borehole No: BH9 -Basin 9 terminated at 3m				
				868.5	3.5							

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED — Borehole Log - Revision 10

6006 BH LOGS.GPJ 13/10/20

A: 2.05 / 56 Delhi Road, North Ryde NSW 2113 P: 02 9878 6005 W: assetgeoenviro.com.au

assetgeoenviro

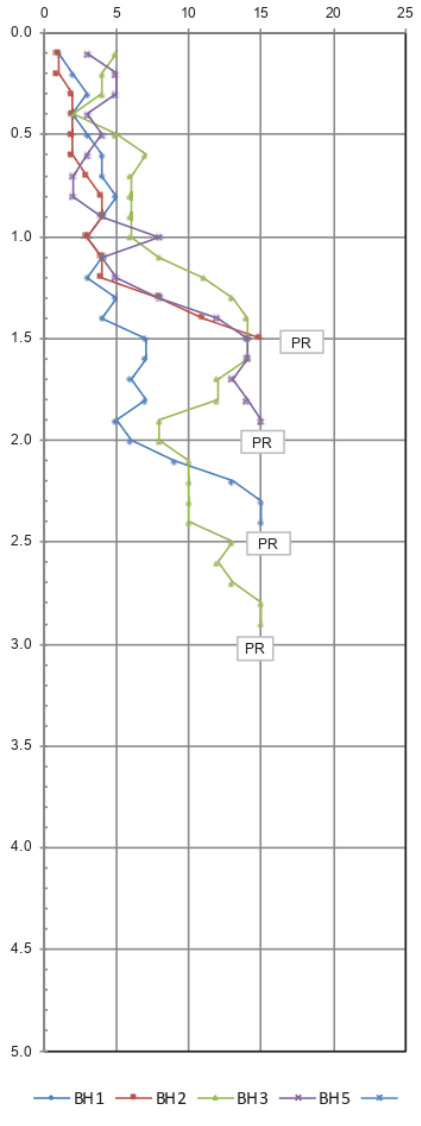
Dynamic Cone Penetrometer

Sheet: 1 of 1
Job No: 6006

client:	Storm Consulting	started:	1/10/2020
principal:		finished:	1/10/2020
project:	Proposed Retarding Basins	logged:	AT
location:	Basin 1 to Basin 3 & Basin 5, Blayney NSW	checked:	MAG
equipment:	9kg hammer, 510mm drop, cone tip		
standard:	AS1289.6.3.2-1997		

Depth (m)	Test Results (blows / 100mm) BH1	BH2	BH3	BH5
0.00 – 0.10	1	1	5	3
0.10 – 0.20	2	1	4	5
0.20 – 0.30	3	2	4	5
0.30 – 0.40	2	2	2	3
0.40 – 0.50	3	2	5	4
0.50 – 0.60	4	2	7	3
0.60 – 0.70	4	3	6	2
0.70 – 0.80	5	4	6	2
0.80 – 0.90	4	4	6	4
0.90 – 1.00	3	3	6	8
1.00 – 1.10	4	4	8	4
1.10 – 1.20	3	4	11	5
1.20 – 1.30	5	8	13	8
1.30 – 1.40	4	11	14	12
1.40 – 1.50	7	15	14	14
1.50 – 1.60	7	PR	14	14
1.60 – 1.70	6		12	13
1.70 – 1.80	7		12	14
1.80 – 1.90	5		8	15
1.90 – 2.00	6		8	PR
2.00 – 2.10	9		10	
2.10 – 2.20	13		10	
2.20 – 2.30	15		10	
2.30 – 2.40	15		10	
2.40 – 2.50	PR		13	
2.50 – 2.60			12	
2.60 – 2.70			13	
2.70 – 2.80			15	
2.80 – 2.90			15	
2.90 – 3.00			PR	
3.00 – 3.10				
3.10 – 3.20				
3.20 – 3.30				
3.30 – 3.40				
3.40 – 3.50				
3.50 – 3.60				
3.60 – 3.70				
3.70 – 3.80				
3.80 – 3.90				
3.90 – 4.00				
4.00 – 4.10				
4.10 – 4.20				
4.20 – 4.30				
4.30 – 4.40				
4.40 – 4.50				
4.50 – 4.60				
4.60 – 4.70				
4.70 – 4.80				
4.80 – 4.90				
4.90 – 5.00				

Plot (blows / 100mm vs depth)



Notes:
RL = ground surface level (m) AHD
TD = target depth, PR = practical refusal (15+ blows per 100mm), SR = "solid" refusal (no further penetration and "solid" ringing sound from slide hammer)

Refer to Information Sheets for Terms and Symbols — DCP Log - Revision 19

A: 2.05 / 56 Delhi Road, North Ryde NSW 2113 T: 02 9878 6005 W: assetgeoenviro.com.au

assetgeoenviro

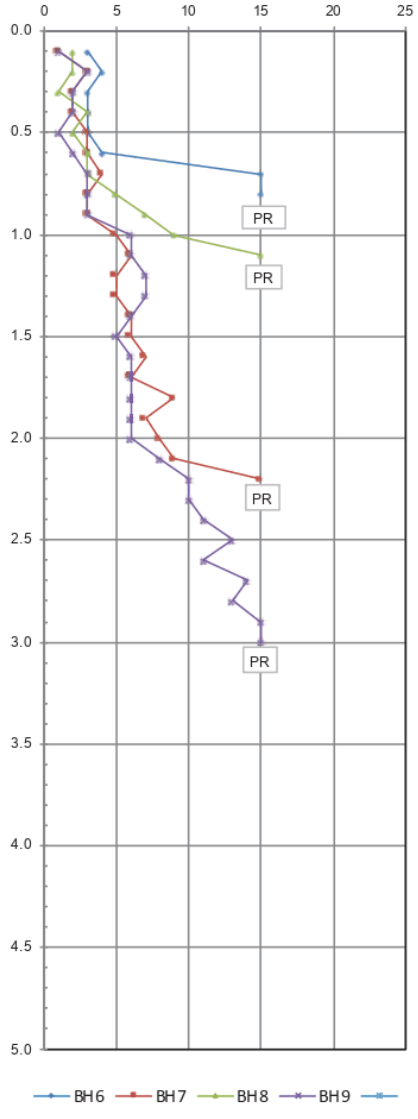
Dynamic Cone Penetrometer

Sheet: 1 of 1
Job No: 6006

client:	Storm Consulting	started:	2/10/2020
principal:		finished:	2/10/2020
project:	Proposed Retarding Basins	logged:	AT
location:	Basin 6 to Basin 9, Blayney NSW	checked:	MAG
equipment:	9kg hammer, 510mm drop, cone tip		
standard:	AS1289.6.3.2-1997		

Depth (m)	Test Results (blows / 100mm) BH6	BH7	BH8	BH9
0.00 – 0.10	3	1	2	1
0.10 – 0.20	4	3	2	3
0.20 – 0.30	3	2	1	2
0.30 – 0.40	3	2	3	2
0.40 – 0.50	3	3	2	1
0.50 – 0.60	4	3	3	2
0.60 – 0.70	15	4	3	3
0.70 – 0.80	15	3	5	3
0.80 – 0.90	PR	3	7	3
0.90 – 1.00		5	9	6
1.00 – 1.10		6	15	6
1.10 – 1.20		5	PR	7
1.20 – 1.30		5		7
1.30 – 1.40		6		6
1.40 – 1.50		6		5
1.50 – 1.60		7		6
1.60 – 1.70		6		6
1.70 – 1.80		9		6
1.80 – 1.90		7		6
1.90 – 2.00		8		6
2.00 – 2.10		9		8
2.10 – 2.20		15		10
2.20 – 2.30		PR		10
2.30 – 2.40				11
2.40 – 2.50				13
2.50 – 2.60				11
2.60 – 2.70				14
2.70 – 2.80				13
2.80 – 2.90				15
2.90 – 3.00				15
3.00 – 3.10				PR
3.10 – 3.20				
3.20 – 3.30				
3.30 – 3.40				
3.40 – 3.50				
3.50 – 3.60				
3.60 – 3.70				
3.70 – 3.80				
3.80 – 3.90				
3.90 – 4.00				
4.00 – 4.10				
4.10 – 4.20				
4.20 – 4.30				
4.30 – 4.40				
4.40 – 4.50				
4.50 – 4.60				
4.60 – 4.70				
4.70 – 4.80				
4.80 – 4.90				
4.90 – 5.00				

Plot (blows / 100mm vs depth)



Notes:
RL = ground surface level (m) AHD
TD = target depth, PR = practical refusal (15+ blows per 100mm), SR = "solid" refusal (no further penetration and "solid" ringing sound from slide hammer)

Refer to Information Sheets for Terms and Symbols — DCP Log - Revision 19

A: 2.05 / 56 Delhi Road, North Ryde NSW 2113 T: 02 9878 6005 W: assetgeoenviro.com.au

Appendix C

Laboratory Test Results

MOISTURE CONTENT TEST REPORT

Client:	AssetGeoEnviro	**Job No:**	S20437-1
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Report No:**	S63754-MC
Project:	Proposed Retarding Basins (6006)		

Test Procedure:

- ☑ AS 1289 2.1.1 Soil moisture content tests - Determination of the moisture content of a soil - Oven drying method (Standard method).
- ☐ AS4133 1.1.1 Rock moisture content tests - Determination of the moisture content of rock - Oven drying method (standard method)
- ☐ RMS T120 Moisture content of road construction materials (Standard method)
- ☐ RMS T262 Determination of moisture content of aggregates (Standard method)

Sampling:	Sampled by Client - results apply to the sample as received	**Date Sampled:**	01-02/10/2020
Preparation:	Prepared in accordance with the test method		

Sample No.	Source	Sample Description	Moisture Content %
S63754	BH1 (Basin 1)	Silty CLAY trace of Sand and Gravel.	**16.2**
S63755	BH2 (Basin 2)	Silty CLAY	**17.9**
S63756	BH3 (Basin 3)	Silty CLAY trace of Sand and Gravel.	**13.6**
S63757	BH5 (Basin 5)	Silty CLAY trace of Sand and Gravel.	**17.6**
S63758	BH6 (Basin 6)	Silty CLAY with Sand and Gravel.	**13.9**
S63759	BH7 (Basin 7)	Silty CLAY trace of Sand and Gravel.	**17.5**
S63760	BH8 (Basin 8)	Silty CLAY	**19.3**
S63761	BH9 (Basin 9)	Silty CLAY trace of Gravel and Sand.	**18.7**

Notes:

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

EMERSON CLASS REPORT

Client:	AssetGeoEnviro	**Source:**	BH1 (Basin 1)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY trace of Sand and Gravel.
Project:	Proposed Retarding Basins (6006)	**Report No:**	S63754-ECT
Job No:	S20437-1	**Lab No:**	S63754

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method

"IMMERSION"
- ☐ does not slake
- ☑ slakes
  - 7 ☐ swells
  - 8 ☐ does not swell

1 ☐ complete dispersion
2 ☐ partial dispersion
☑ no dispersion
- 2.1 ☐ moderate
- 2.2 ☐ slight

"REMOULD ETC."
3 ☐ disperses
☑ does not disperse
- 3.1 ☐ complete
- 3.2 ☐ moderate
- 3.3 ☐ slight

"CARBONATE & GYPSUM"
4 ☐ present
☑ absent

"VIGOROUS SHAKING"
- ☑ disperses 5
- ☐ does not disperse 6

Water Type	Distilled
Water Source	Laboratory
Water Temperature (°c)	22

RESULT:

Emerson Class No. 5

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

20/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

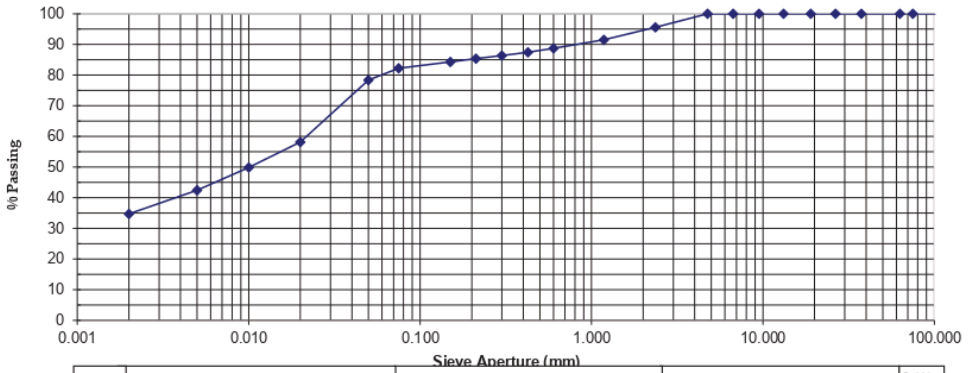
PARTICLE SIZE DISTRIBUTION (HYDROMETER) REPORT

Client:	AssetGeoEnviro	**Source:**	BH1 (Basin 1)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY trace of Sand and Gravel.
Project:	Proposed Retarding Basins (6006)	**Report No.:**	S63754-HYD
Job No.:	S20437-1	**Lab No.:**	S63754

Test Procedure: ☑ AS1289.3.6.3 Soil classification tests – Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
☑ AS1289.3.6.1 Soil classification tests - Determination of particle size distribution of a soil standard method sieving

Sampling: Sampled by Client - results apply to the sample as received | Date Sampled: 01-02/10/2020

Preparation: Prepared in accordance with the test method



Clay	Silt	Sand	Gravel	Cobbles

Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	-		1.180	92	
75	-		0.600	89	
63	-		0.425	87	
37.5	-		0.300	86	
26.5	-		0.212	85	
19.0	-		0.150	84	
13.2	-		0.075	82	
9.5	-		0.050	78	
6.7	-		0.020	58	
4.75	100		0.010	50	
2.36	96		0.005	42	
			0.002	35	

Loss in Pre-treatment of Material (%)	0
Method of Dispersion:	Sodium Hexametaphosphate / Sodium Carbonate
Hydrometer Type:	ASTM

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

20/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 1 - 18/06/18 W44R - S63754-HYD Page 1 of 1

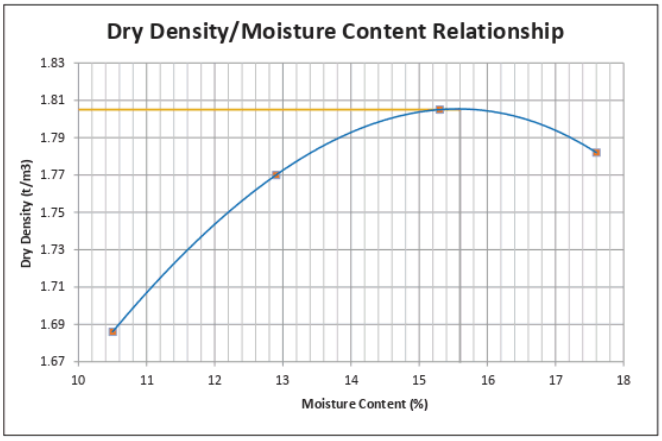
DRY DENSITY / OPTIMUM MOISTURE CONTENT REPORT

Client	AssetGeoEnviro	**Source**	BH1 (Basin 1)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY trace of Sand and Gravel.
Project	Proposed Retarding Basins (6006)	**Report No**	S63754-MDD
Job No	S20437-1	**Sample No**	S63754

Test Procedure:
- ☑ AS1289.5.1.1 Dry Density / Moisture Content Relationship - Standard Compaction
- ☑ AS1289.2.1.1 Moisture Content - Oven Drying Method (Standard Method)

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Maximum Dry Density (t/m^3)	1.805
Optimum Moisture Content (%)	15.6
Oversize Retained on 19mm sieve (%)	0.0
Oversize Retained on 37.5mm sieve (%)	0.0
Curing Time	121 hrs
Liquid Limit Determination	Technician Assessment

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

20/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 10 - 12/03/20 W49 - S63754-MDD Page 1 of 1

SOIL CLASSIFICATION REPORT

Client	AssetGeoEnviro	**Source**	BH1 (Basin 1)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY trace of Sand and Gravel.
Project	Proposed Retarding Basins (6006)	**Report No**	S63754-PI
Job No	S20437-1	**Lab No**	S63754

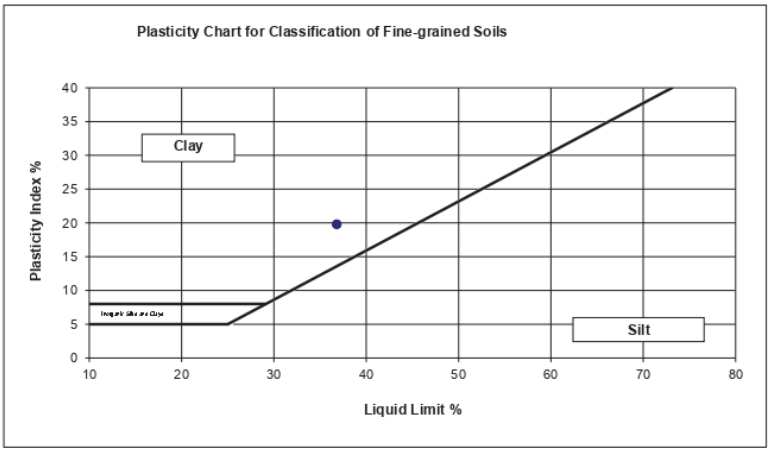
Test Procedure:

- ☐ AS1289 2.1.1 Soil moisture content tests (Oven drying method)
- ☑ AS1289 3.1.1 Soil classification tests - Determination of the liquid limit of a soil - Four point casagrande method
- ☐ AS1289 3.1.2 Soil classification tests - Determination of the liquid limit of a soil - One point Casagrande method (subsidiary method)
- ☑ AS1289 3.2.1 Soil classification tests - Determination of the plastic limit of a soil - Standard method
- ☑ AS1289 3.3.1 Soil classification tests - Calculation of the plasticity index of a soil
- ☐ AS1289 3.4.1 Soil classification tests - Determination of the linear shrinkage of a soil - Standard method

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method

Liquid Limit (%)	37	**Linear Shrinkage (%)**	-
Plastic Limit (%)	17	**Plasticity Index**	20



Soil Preparation Method: Dry Sieved
Soil History: Oven Dried
Soil Condition: N/A

Notes

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

Date: 20/10/2020

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 4 - 21/09/18 W41R - S63754-PI Page 1 of 1

EMERSON CLASS REPORT

Client:	AssetGeoEnviro	**Source:**	BH2 (Basin 2)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY
Project:	Proposed Retarding Basins (6006)	**Report No:**	S63755-ECT
Job No:	S20437-1	**Lab No:**	S63755

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method

"IMMERSION"

- ☐ does not slake
- ☑ slakes

7 ☐ swells
8 ☐ does not swell

1 ☐ complete dispersion
2 ☐ partial dispersion
☑ no dispersion

2.1 ☐ moderate
2.2 ☐ slight

"REMOULD ETC."

3 ☐ disperses
☑ does not disperse

3.1 ☐ complete
3.2 ☐ moderate
3.3 ☐ slight

"CARBONATE & GYPSUM"

4 ☐ present
☑ absent

"VIGOROUS SHAKING"

☑ disperses 5
☐ does not disperse 6

Water Type	Distilled
Water Source	Laboratory
Water Temperature (°c)	22

RESULT:

Emerson Class No.	5

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

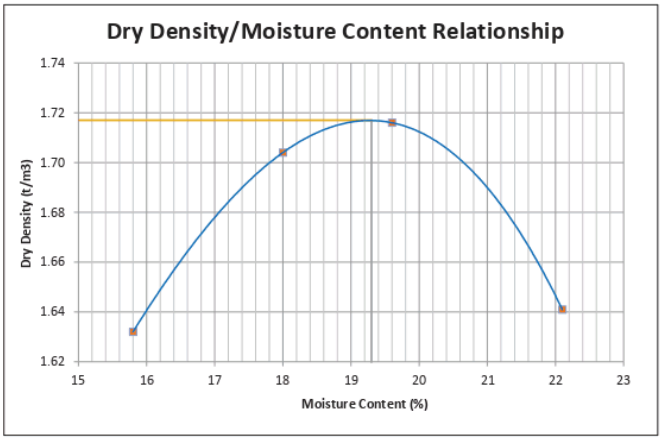
DRY DENSITY / OPTIMUM MOISTURE CONTENT REPORT

Client	AssetGeoEnviro	**Source**	BH2 (Basin 2)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY
Project	Proposed Retarding Basins (6006)	**Report No**	S63755-MDD
Job No	S20437-1	**Sample No**	S63755

Test Procedure:
- ☑ AS1289.5.1.1 Dry Density / Moisture Content Relationship - Standard Compaction
- ☑ AS1289.2.1.1 Moisture Content - Oven Drying Method (Standard Method)

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Maximum Dry Density (t/m^3)	1.717
Optimum Moisture Content (%)	19.3
Oversize Retained on 19mm sieve (%)	0.0
Oversize Retained on 37.5mm sieve (%)	0.0
Curing Time	118 hrs
Liquid Limit Determination	Technician Assessment

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 10 - 12/03/20 W49 - S63755-MDD Page 1 of 1

SOIL CLASSIFICATION REPORT

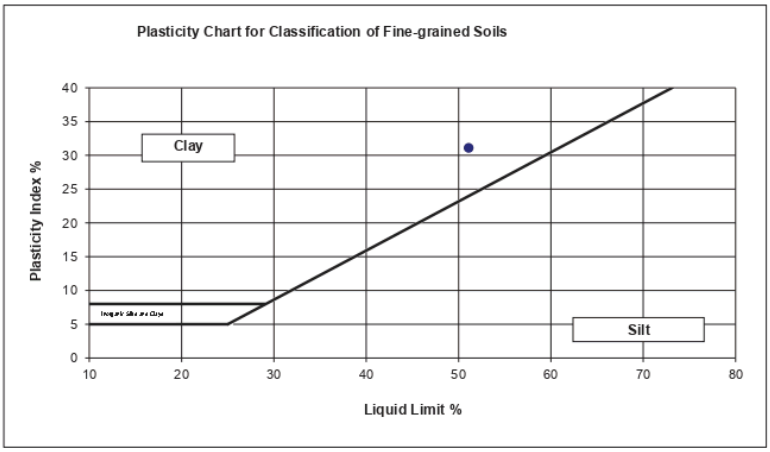
Client	AssetGeoEnviro	**Source**	BH2 (Basin 2)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY
Project	Proposed Retarding Basins (6006)	**Report No**	S63755-PI
Job No	S20437-1	**Lab No**	S63755

Test Procedure:

- ☐ AS1289 2.1.1 Soil moisture content tests (Oven drying method)
- ☑ AS1289 3.1.1 Soil classification tests - Determination of the liquid limit of a soil - Four point casagrande method
- ☐ AS1289 3.1.2 Soil classification tests - Determination of the liquid limit of a soil - One point Casagrande method (subsidiary method)
- ☑ AS1289 3.2.1 Soil classification tests - Determination of the plastic limit of a soil - Standard method
- ☑ AS1289 3.3.1 Soil classification tests - Calculation of the plasticity index of a soil
- ☐ AS1289 3.4.1 Soil classification tests - Determination of the linear shrinkage of a soil - Standard method

Sampling:	Sampled by Client - results apply to the sample as received	**Date Sampled:**	01-02/10/2020
Preparation:	Prepared in accordance with the test method		

Liquid Limit (%)	51	**Linear Shrinkage (%)**	-
Plastic Limit (%)	20	**Plasticity Index**	31



Soil Preparation Method: Dry Sieved
Soil History: Oven Dried
Soil Condition: N/A

Notes

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

22/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

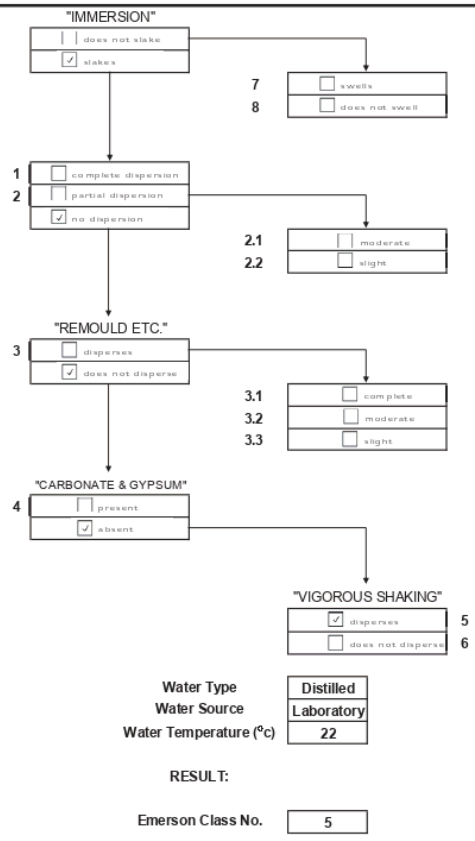
EMERSON CLASS REPORT

Client:	AssetGeoEnviro	**Source:**	BH3 (Basin 3)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY trace of Sand and Gravel.
Project:	Proposed Retarding Basins (6006)	**Report No:**	S63756-ECT
Job No:	S20437-1	**Lab No:**	S63756

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Water Type	Distilled
Water Source	Laboratory
Water Temperature (°c)	22

RESULT:

Emerson Class No. 5

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 1 - 18/06/18 W45R - S63756-ECT Page 1 of 1

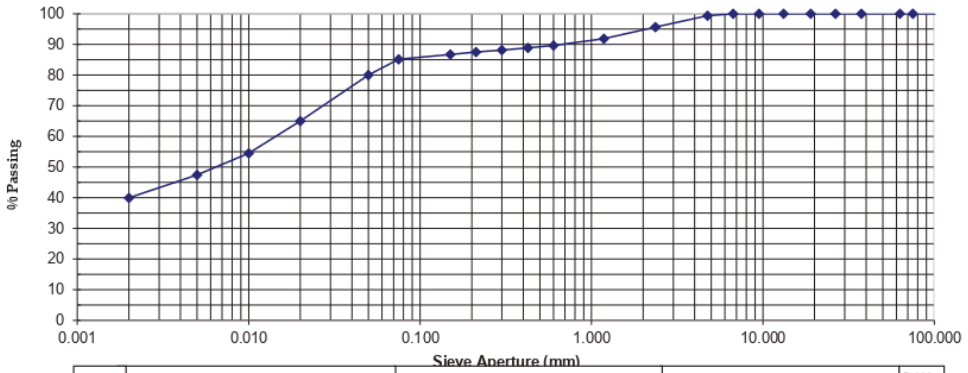
PARTICLE SIZE DISTRIBUTION (HYDROMETER) REPORT

Client:	AssetGeoEnviro	**Source:**	BH3 (Basin 3)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY trace of Sand and Gravel.
Project:	Proposed Retarding Basins (6006)	**Report No.:**	S63756-HYD
Job No.:	S20437-1	**Lab No.:**	S63756

Test Procedure: ☑ AS1289.3.6.3 Soil classification tests – Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
☑ AS1289.3.6.1 Soil classification tests - Determination of particle size distribution of a soil standard method sieving

Sampling: Sampled by Client - results apply to the sample as received | Date Sampled: 01-02/10/2020

Preparation: Prepared in accordance with the test method



Clay	Silt	Sand	Gravel	Cobbles

Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	-		1.180	92	
75	-		0.600	90	
63	-		0.425	89	
37.5	-		0.300	88	
26.5	-		0.212	88	
19.0	-		0.150	87	
13.2	-		0.075	85	
9.5	-		0.050	80	
6.7	100		0.020	65	
4.75	99		0.010	55	
2.36	96		0.005	47	
			0.002	40	

Loss in Pre-treatment of Material (%)	0
Method of Dispersion:	Sodium Hexametaphosphate / Sodium Carbonate
Hydrometer Type:	ASTM

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 1 - 18/06/18 W44R - S63756-HYD Page 1 of 1

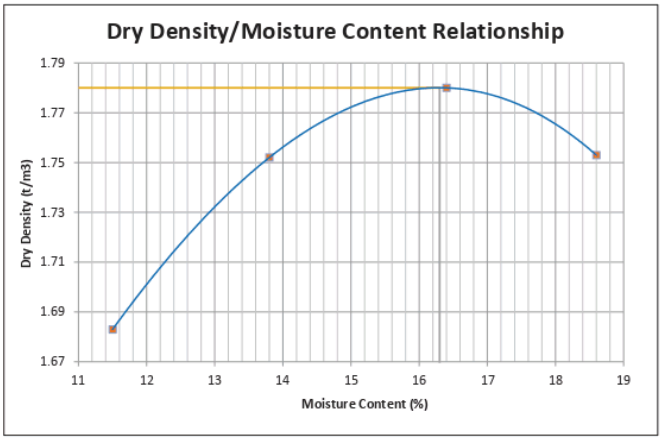
DRY DENSITY / OPTIMUM MOISTURE CONTENT REPORT

Client	AssetGeoEnviro	**Source**	BH3 (Basin 3)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY trace of Sand and Gravel.
Project	Proposed Retarding Basins (6006)	**Report No**	S63756-MDD
Job No	S20437-1	**Sample No**	S63756

Test Procedure:
- ☑ AS1289.5.1.1 Dry Density / Moisture Content Relationship - Standard Compaction
- ☑ AS1289.2.1.1 Moisture Content - Oven Drying Method (Standard Method)

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Maximum Dry Density (t/m^3)	1.780
Optimum Moisture Content (%)	16.3
Oversize Retained on 19mm sieve (%)	0.0
Oversize Retained on 37.5mm sieve (%)	0.0
Curing Time	96 hrs
Liquid Limit Determination	Technician Assessment

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

SOIL CLASSIFICATION REPORT

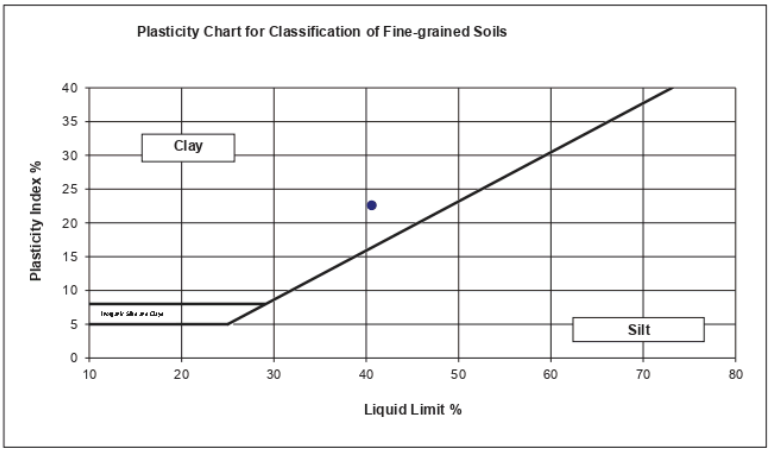
Client	AssetGeoEnviro	**Source**	BH3 (Basin 3)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY trace of Sand and Gravel.
Project	Proposed Retarding Basins (6006)	**Report No**	S63756-PI
Job No	S20437-1	**Lab No**	S63756

Test Procedure:

- ☐ AS1289 2.1.1 Soil moisture content tests (Oven drying method)
- ☑ AS1289 3.1.1 Soil classification tests - Determination of the liquid limit of a soil - Four point casagrande method
- ☐ AS1289 3.1.2 Soil classification tests - Determination of the liquid limit of a soil - One point Casagrande method (subsidiary method)
- ☑ AS1289 3.2.1 Soil classification tests - Determination of the plastic limit of a soil - Standard method
- ☑ AS1289 3.3.1 Soil classification tests - Calculation of the plasticity index of a soil
- ☐ AS1289 3.4.1 Soil classification tests - Determination of the linear shrinkage of a soil - Standard method

Sampling:	Sampled by Client - results apply to the sample as received	**Date Sampled:**	01-02/10/2020
Preparation:	Prepared in accordance with the test method		

Liquid Limit (%)	41	**Linear Shrinkage (%)**	-
Plastic Limit (%)	18	**Plasticity Index**	23



Soil Preparation Method: Dry Sieved
Soil History: Oven Dried
Soil Condition: N/A

Notes

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

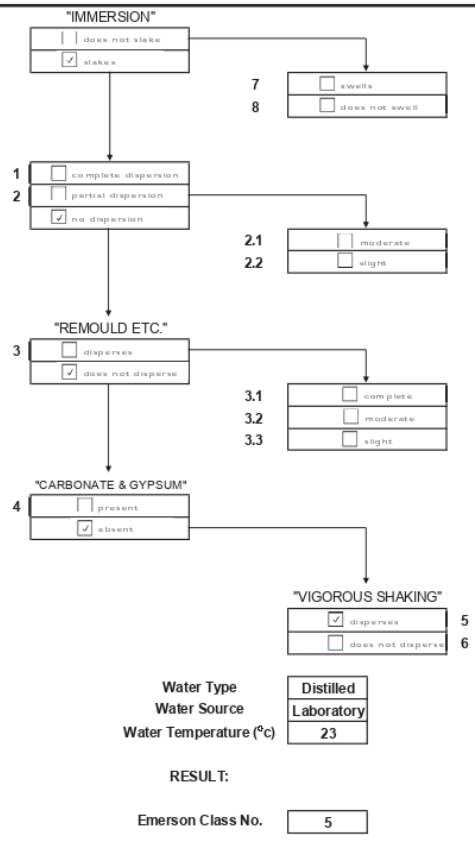
EMERSON CLASS REPORT

Client:	AssetGeoEnviro	**Source:**	BH5 (Basin 5)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY trace of Sand and Gravel.
Project:	Proposed Retarding Basins (6006)	**Report No:**	S63757-ECT
Job No:	S20437-1	**Lab No:**	S63757

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Water Type	Distilled
Water Source	Laboratory
Water Temperature (°c)	23

RESULT:

Emerson Class No.	5

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 1 - 18/06/18 W45R - S63757-ECT Page 1 of 1

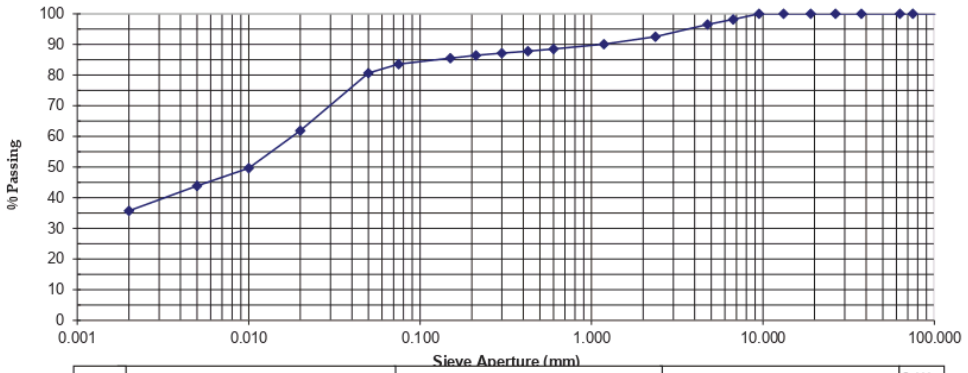
PARTICLE SIZE DISTRIBUTION (HYDROMETER) REPORT

Client:	AssetGeoEnviro	**Source:**	BH5 (Basin 5)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY trace of Sand and Gravel.
Project:	Proposed Retarding Basins (6006)	**Report No.:**	S63757-HYD
Job No.:	S20437-1	**Lab No.:**	S63757

Test Procedure: ☑ AS1289.3.6.3 Soil classification tests – Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
☑ AS1289.3.6.1 Soil classification tests - Determination of particle size distribution of a soil standard method sieving

Sampling: Sampled by Client - results apply to the sample as received | Date Sampled: 01-02/10/2020

Preparation: Prepared in accordance with the test method



Clay	Silt	Sand	Gravel	Cobbles

Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	-		1.180	90	
75	-		0.600	88	
63	-		0.425	88	
37.5	-		0.300	87	
26.5	-		0.212	86	
19.0	-		0.150	86	
13.2	-		0.075	84	
9.5	100		0.050	81	
6.7	98		0.020	62	
4.75	97		0.010	50	
2.36	93		0.005	44	
			0.002	36	

Loss in Pre-treatment of Material (%)	0
Method of Dispersion:	Sodium Hexametaphosphate / Sodium Carbonate
Hydrometer Type:	ASTM

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 1 - 18/06/18 W44R - S63757-HYD Page 1 of 1

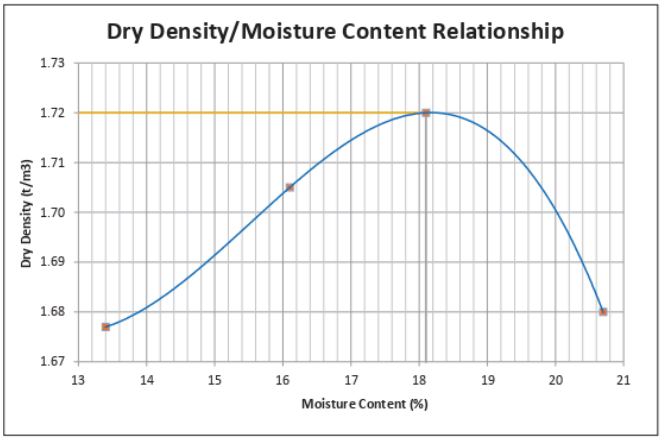
DRY DENSITY / OPTIMUM MOISTURE CONTENT REPORT

Client	AssetGeoEnviro	**Source**	BH5 (Basin 5)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY trace of Sand and Gravel.
Project	Proposed Retarding Basins (6006)	**Report No**	S63757-MDD
Job No	S20437-1	**Sample No**	S63757

Test Procedure:
- ☑ AS1289.5.1.1 Dry Density / Moisture Content Relationship - Standard Compaction
- ☑ AS1289.2.1.1 Moisture Content - Oven Drying Method (Standard Method)

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Maximum Dry Density (t/m^3)	1.720
Optimum Moisture Content (%)	18.1
Oversize Retained on 19mm sieve (%)	0.0
Oversize Retained on 37.5mm sieve (%)	0.0
Curing Time	119 hrs
Liquid Limit Determination	Technician Assessment

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 10 - 12/03/20 W49 - S63757-MDD Page 1 of 1

SOIL CLASSIFICATION REPORT

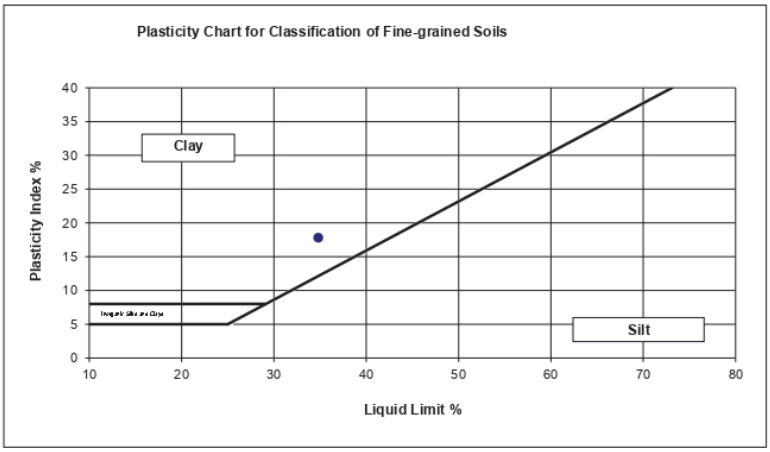
Client	AssetGeoEnviro	**Source**	BH5 (Basin 5)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY trace of Sand and Gravel.
Project	Proposed Retarding Basins (6006)	**Report No**	S63757-PI
Job No	S20437-1	**Lab No**	S63757

Test Procedure:

- ☐ AS1289 2.1.1 Soil moisture content tests (Oven drying method)
- ☑ AS1289 3.1.1 Soil classification tests - Determination of the liquid limit of a soil - Four point casagrande method
- ☐ AS1289 3.1.2 Soil classification tests - Determination of the liquid limit of a soil - One point Casagrande method (subsidiary method)
- ☑ AS1289 3.2.1 Soil classification tests - Determination of the plastic limit of a soil - Standard method
- ☑ AS1289 3.3.1 Soil classification tests - Calculation of the plasticity index of a soil
- ☐ AS1289 3.4.1 Soil classification tests - Determination of the linear shrinkage of a soil - Standard method

Sampling:	Sampled by Client - results apply to the sample as received	**Date Sampled:**	01-02/10/2020
Preparation:	Prepared in accordance with the test method		

Liquid Limit (%)	35	**Linear Shrinkage (%)**	-
Plastic Limit (%)	17	**Plasticity Index**	18



Soil Preparation Method: Dry Sieved
Soil History: Oven Dried
Soil Condition: N/A

Notes

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

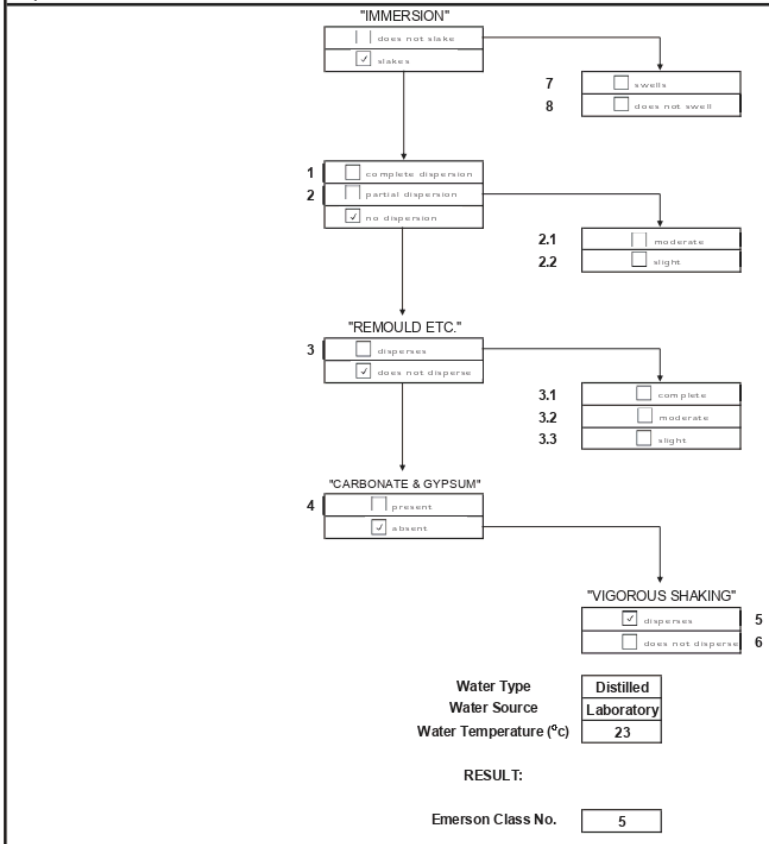
EMERSON CLASS REPORT

Client:	AssetGeoEnviro	**Source:**	BH6 (Basin 6)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY with Sand and Gravel.
Project:	Proposed Retarding Basins (6006)	**Report No:**	S63758-ECT
Job No:	S20437-1	**Lab No:**	S63758

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Water Type	Distilled
Water Source	Laboratory
Water Temperature (°c)	23

RESULT:

Emerson Class No. 5

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 1 - 18/06/18 W45R - S63758-ECT Page 1 of 1

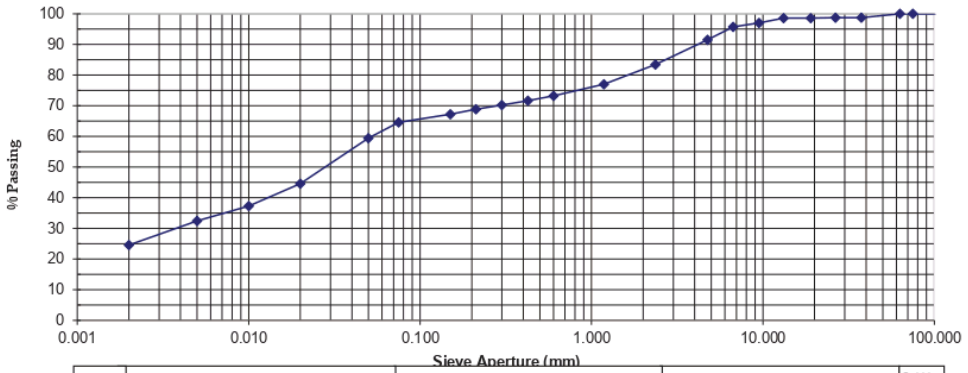
PARTICLE SIZE DISTRIBUTION (HYDROMETER) REPORT

Client:	AssetGeoEnviro	**Source:**	BH6 (Basin 6)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY with Sand and Gravel.
Project:	Proposed Retarding Basins (6006)	**Report No.:**	S63758-HYD
Job No.:	S20437-1	**Lab No.:**	S63758

Test Procedure: ☑ AS1289.3.6.3 Soil classification tests – Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
☑ AS1289.3.6.1 Soil classification tests - Determination of particle size distribution of a soil standard method sieving

Sampling: Sampled by Client - results apply to the sample as received | Date Sampled: 01-02/10/2020

Preparation: Prepared in accordance with the test method



Clay	Silt	Sand	Gravel	Cobbles

Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	-		1.180	77	
75	-		0.600	73	
63	100		0.425	72	
37.5	99		0.300	70	
26.5	99		0.212	69	
19.0	99		0.150	67	
13.2	99		0.075	65	
9.5	97		0.050	59	
6.7	96		0.020	45	
4.75	92		0.010	37	
2.36	83		0.005	32	
			0.002	25	

Loss in Pre-treatment of Material (%)	0
Method of Dispersion:	Sodium Hexametaphosphate / Sodium Carbonate
Hydrometer Type:	ASTM

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 1 - 18/06/18 W44R - S63758-HYD Page 1 of 1

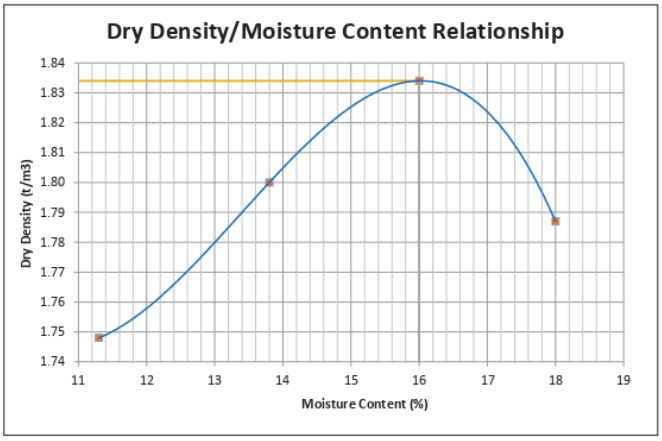
DRY DENSITY / OPTIMUM MOISTURE CONTENT REPORT

Client	AssetGeoEnviro	**Source**	BH6 (Basin 6)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY with Sand and Gravel.
Project	Proposed Retarding Basins (6006)	**Report No**	S63758-MDD
Job No	S20437-1	**Sample No**	S63758

Test Procedure:
- ☑ AS1289.5.1.1 Dry Density / Moisture Content Relationship - Standard Compaction
- ☑ AS1289.2.1.1 Moisture Content - Oven Drying Method (Standard Method)

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Maximum Dry Density (t/m^3)	1.834
Optimum Moisture Content (%)	16.0
Oversize Retained on 19mm sieve (%)	1.2
Oversize Retained on 37.5mm sieve (%)	1.1
Curing Time	96 hrs
Liquid Limit Determination	Technician Assessment

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 10 - 12/03/20 W49 - S63758-MDD Page 1 of 1

SOIL CLASSIFICATION REPORT

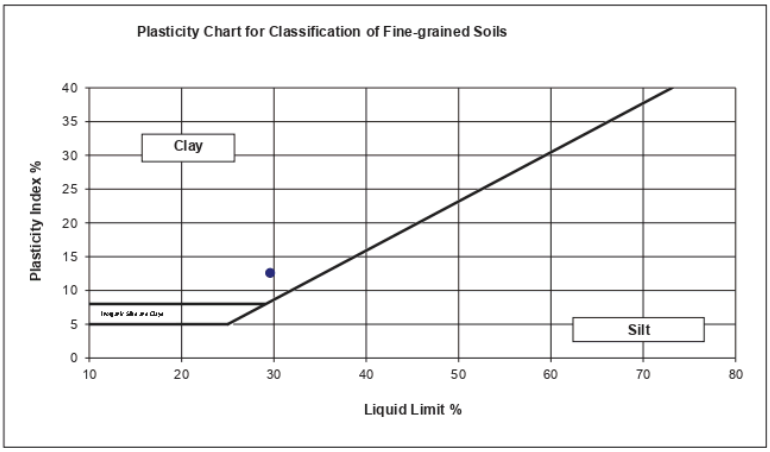
Client	AssetGeoEnviro	**Source**	BH6 (Basin 6)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY with Sand and Gravel.
Project	Proposed Retarding Basins (6006)	**Report No**	S63758-PI
Job No	S20437-1	**Lab No**	S63758

Test Procedure:

- ☐ AS1289 2.1.1 Soil moisture content tests (Oven drying method)
- ☑ AS1289 3.1.1 Soil classification tests - Determination of the liquid limit of a soil - Four point casagrande method
- ☐ AS1289 3.1.2 Soil classification tests - Determination of the liquid limit of a soil - One point Casagrande method (subsidiary method)
- ☑ AS1289 3.2.1 Soil classification tests - Determination of the plastic limit of a soil - Standard method
- ☑ AS1289 3.3.1 Soil classification tests - Calculation of the plasticity index of a soil
- ☐ AS1289 3.4.1 Soil classification tests - Determination of the linear shrinkage of a soil - Standard method

Sampling:	Sampled by Client - results apply to the sample as received	**Date Sampled:**	01-02/10/2020
Preparation:	Prepared in accordance with the test method		

Liquid Limit (%)	30	**Linear Shrinkage (%)**	-
Plastic Limit (%)	17	**Plasticity Index**	13



Soil Preparation Method: Dry Sieved
Soil History: Oven Dried
Soil Condition: N/A

Notes

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

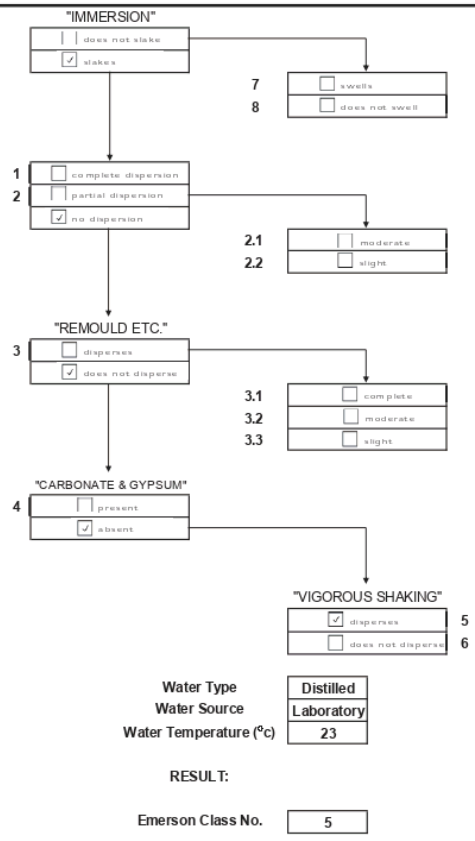
EMERSON CLASS REPORT

Client:	AssetGeoEnviro	**Source:**	BH7 (Basin 7)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY trace of Sand and Gravel.
Project:	Proposed Retarding Basins (6006)	**Report No:**	S63759-ECT
Job No:	S20437-1	**Lab No:**	S63759

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Water Type	Distilled
Water Source	Laboratory
Water Temperature (°c)	23

RESULT:

Emerson Class No. 5

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

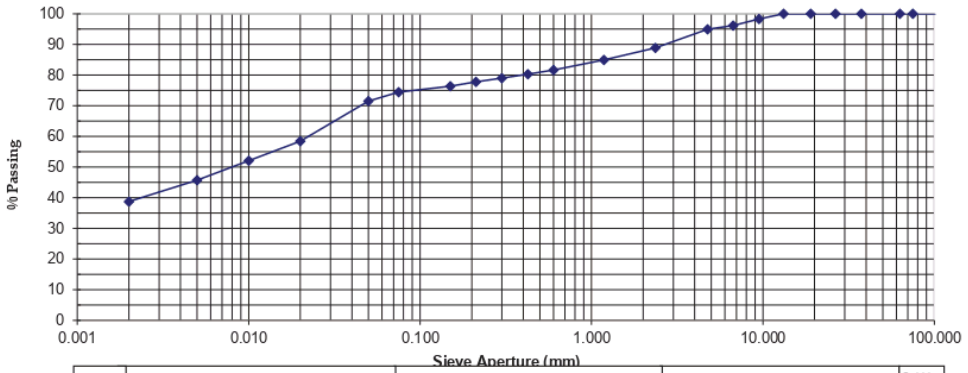
PARTICLE SIZE DISTRIBUTION (HYDROMETER) REPORT

Client:	AssetGeoEnviro	**Source:**	BH7 (Basin 7)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY trace of Sand and Gravel.
Project:	Proposed Retarding Basins (6006)	**Report No.:**	S63759-HYD
Job No.:	S20437-1	**Lab No.:**	S63759

Test Procedure: ☑ AS1289.3.6.3 Soil classification tests – Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
☑ AS1289.3.6.1 Soil classification tests - Determination of particle size distribution of a soil standard method sieving

Sampling: Sampled by Client - results apply to the sample as received | Date Sampled: 01-02/10/2020

Preparation: Prepared in accordance with the test method



Clay	Silt	Sand	Gravel	Cobbles

Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	-		1.180	85	
75	-		0.600	82	
63	-		0.425	80	
37.5	-		0.300	79	
26.5	-		0.212	78	
19.0	-		0.150	76	
13.2	100		0.075	74	
9.5	98		0.050	72	
6.7	96		0.020	58	
4.75	95		0.010	52	
2.36	89		0.005	46	
			0.002	39	

Loss in Pre-treatment of Material (%)	0
Method of Dispersion:	Sodium Hexametaphosphate / Sodium Carbonate
Hydrometer Type:	ASTM

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

19/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 1 - 18/06/18 W44R - S63759-HYD Page 1 of 1

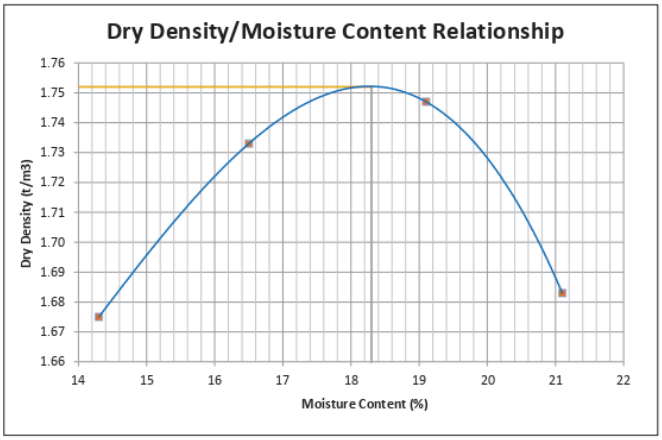
DRY DENSITY / OPTIMUM MOISTURE CONTENT REPORT

Client	AssetGeoEnviro	**Source**	BH7 (Basin 7)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY trace of Sand and Gravel.
Project	Proposed Retarding Basins (6006)	**Report No**	S63759-MDD
Job No	S20437-1	**Sample No**	S63759

Test Procedure:
- ☑ AS1289.5.1.1 Dry Density / Moisture Content Relationship - Standard Compaction
- ☑ AS1289.2.1.1 Moisture Content - Oven Drying Method (Standard Method)

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Maximum Dry Density (t/m^3)	1.752
Optimum Moisture Content (%)	18.3
Oversize Retained on 19mm sieve (%)	0.0
Oversize Retained on 37.5mm sieve (%)	0.0
Curing Time	100 hrs
Liquid Limit Determination	Technician Assessment

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

SOIL CLASSIFICATION REPORT

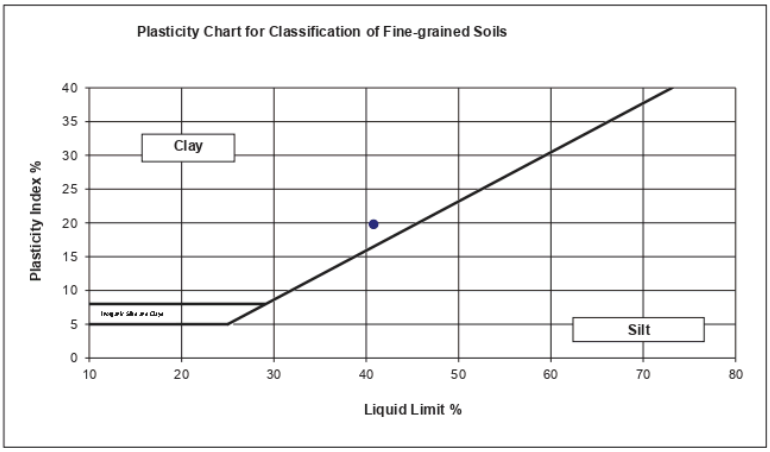
Client	AssetGeoEnviro	**Source**	BH7 (Basin 7)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY trace of Sand and Gravel.
Project	Proposed Retarding Basins (6006)	**Report No**	S63759-PI
Job No	S20437-1	**Lab No**	S63759

Test Procedure:

- ☐ AS1289 2.1.1 Soil moisture content tests (Oven drying method)
- ☑ AS1289 3.1.1 Soil classification tests - Determination of the liquid limit of a soil - Four point casagrande method
- ☐ AS1289 3.1.2 Soil classification tests - Determination of the liquid limit of a soil - One point Casagrande method (subsidiary method)
- ☑ AS1289 3.2.1 Soil classification tests - Determination of the plastic limit of a soil - Standard method
- ☑ AS1289 3.3.1 Soil classification tests - Calculation of the plasticity index of a soil
- ☐ AS1289 3.4.1 Soil classification tests - Determination of the linear shrinkage of a soil - Standard method

Sampling:	Sampled by Client - results apply to the sample as received	**Date Sampled:**	01-02/10/2020
Preparation:	Prepared in accordance with the test method		

Liquid Limit (%)	41	**Linear Shrinkage (%)**	-
Plastic Limit (%)	21	**Plasticity Index**	20



Soil Preparation Method: Dry Sieved
Soil History: Oven Dried
Soil Condition: N/A

Notes

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

EMERSON CLASS REPORT

Client:	AssetGeoEnviro	**Source:**	BH8 (Basin 8)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY
Project:	Proposed Retarding Basins (6006)	**Report No:**	S63760-ECT
Job No:	S20437-1	**Lab No:**	S63760

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method

"IMMERSION"

- ☐ does not slake
- ☑ slakes

7 ☐ swells
8 ☐ does not swell

1 ☐ complete dispersion
2 ☐ partial dispersion
☑ no dispersion

2.1 ☐ moderate
2.2 ☐ slight

"REMOULD ETC."

3 ☐ disperses
☑ does not disperse

3.1 ☐ complete
3.2 ☐ moderate
3.3 ☐ slight

"CARBONATE & GYPSUM"

4 ☐ present
☑ absent

"VIGOROUS SHAKING"

☑ disperses 5
☐ does not disperse 6

Water Type	Distilled
Water Source	Laboratory
Water Temperature (°c)	22

RESULT:

Emerson Class No.	5

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 1 - 18/06/18 W45R - S63760-ECT Page 1 of 1

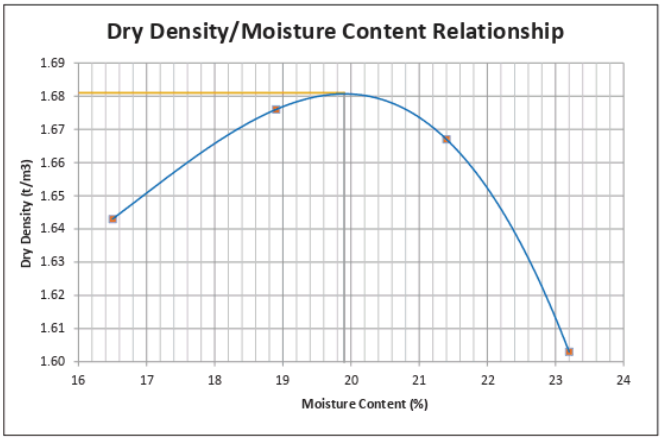
DRY DENSITY / OPTIMUM MOISTURE CONTENT REPORT

Client	AssetGeoEnviro	**Source**	BH8 (Basin 8)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY
Project	Proposed Retarding Basins (6006)	**Report No**	S63760-MDD
Job No	S20437-1	**Sample No**	S63760

Test Procedure:
- ☑ AS1289.5.1.1 Dry Density / Moisture Content Relationship - Standard Compaction
- ☑ AS1289.2.1.1 Moisture Content - Oven Drying Method (Standard Method)

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Maximum Dry Density (t/m^3)	1.681
Optimum Moisture Content (%)	19.9
Oversize Retained on 19mm sieve (%)	0.3
Oversize Retained on 37.5mm sieve (%)	0.0
Curing Time	100 hrs
Liquid Limit Determination	Technician Assessment

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

SOIL CLASSIFICATION REPORT

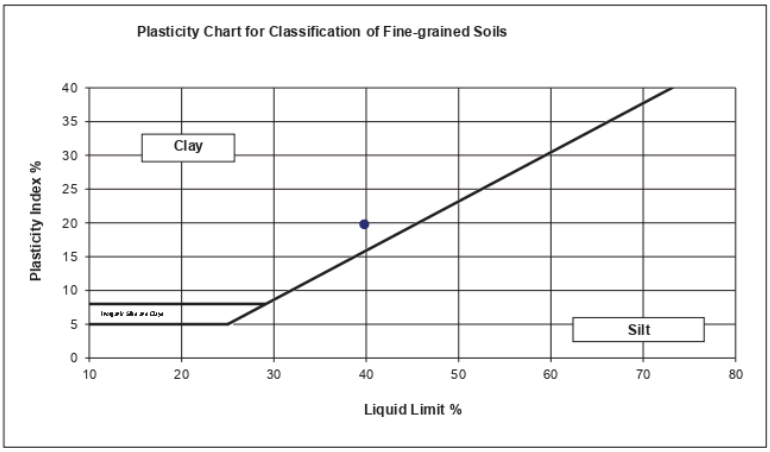
Client	AssetGeoEnviro	**Source**	BH8 (Basin 8)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY
Project	Proposed Retarding Basins (6006)	**Report No**	S63760-PI
Job No	S20437-1	**Lab No**	S63760

Test Procedure:

- ☐ AS1289 2.1.1 Soil moisture content tests (Oven drying method)
- ☑ AS1289 3.1.1 Soil classification tests - Determination of the liquid limit of a soil - Four point casagrande method
- ☐ AS1289 3.1.2 Soil classification tests - Determination of the liquid limit of a soil - One point Casagrande method (subsidiary method)
- ☑ AS1289 3.2.1 Soil classification tests - Determination of the plastic limit of a soil - Standard method
- ☑ AS1289 3.3.1 Soil classification tests - Calculation of the plasticity index of a soil
- ☐ AS1289 3.4.1 Soil classification tests - Determination of the linear shrinkage of a soil - Standard method

Sampling:	Sampled by Client - results apply to the sample as received	**Date Sampled:**	01-02/10/2020
Preparation:	Prepared in accordance with the test method		

Liquid Limit (%)	40	**Linear Shrinkage (%)**	-
Plastic Limit (%)	20	**Plasticity Index**	20



Soil Preparation Method: Dry Sieved
Soil History: Oven Dried
Soil Condition: N/A

Notes

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

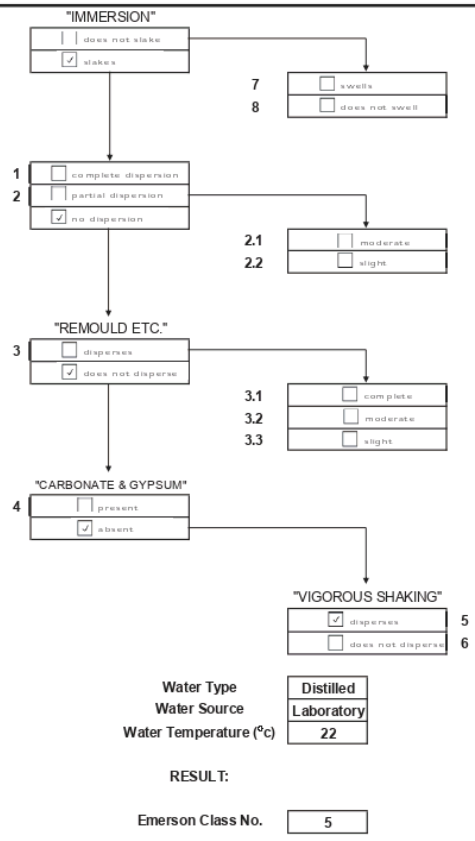
EMERSON CLASS REPORT

Client:	AssetGeoEnviro	**Source:**	BH9 (Basin 9)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY trace of Gravel and Sand.
Project:	Proposed Retarding Basins (6006)	**Report No:**	S63761-ECT
Job No:	S20437-1	**Lab No:**	S63761

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Water Type	Distilled
Water Source	Laboratory
Water Temperature (°c)	22

RESULT:

Emerson Class No.	5

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

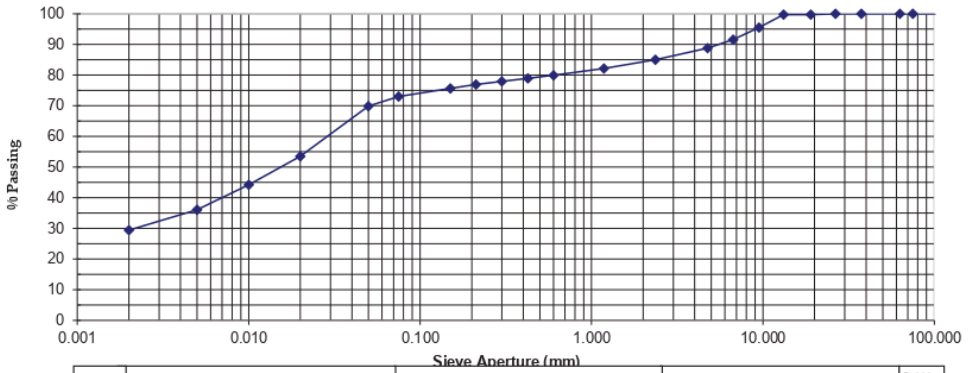
PARTICLE SIZE DISTRIBUTION (HYDROMETER) REPORT

Client:	AssetGeoEnviro	**Source:**	BH9 (Basin 9)
Address:	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description:**	Silty CLAY trace of Gravel and Sand.
Project:	Proposed Retarding Basins (6006)	**Report No.:**	S63761-HYD
Job No.:	S20437-1	**Lab No.:**	S63761

Test Procedure: ☑ AS1289.3.6.3 Soil classification tests – Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
☑ AS1289.3.6.1 Soil classification tests - Determination of particle size distribution of a soil standard method sieving

Sampling: Sampled by Client - results apply to the sample as received — Date Sampled: 01-02/10/2020

Preparation: Prepared in accordance with the test method



Clay	Silt	Sand	Gravel	Cobbles

Sieve Apperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	-		1.180	82	
75	-		0.600	80	
63	-		0.425	79	
37.5	-		0.300	78	
26.5	100		0.212	77	
19.0	100		0.150	76	
13.2	100		0.075	73	
9.5	96		0.050	70	
6.7	92		0.020	54	
4.75	89		0.010	44	
2.36	85		0.005	36	
			0.002	29	

Loss in Pre-treatment of Material (%)	0
Method of Dispersion:	Sodium Hexametaphosphate / Sodium Carbonate
Hydrometer Type:	ASTM

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Issue 1 - 18/06/18 W44R - S63761-HYD Page 1 of 1

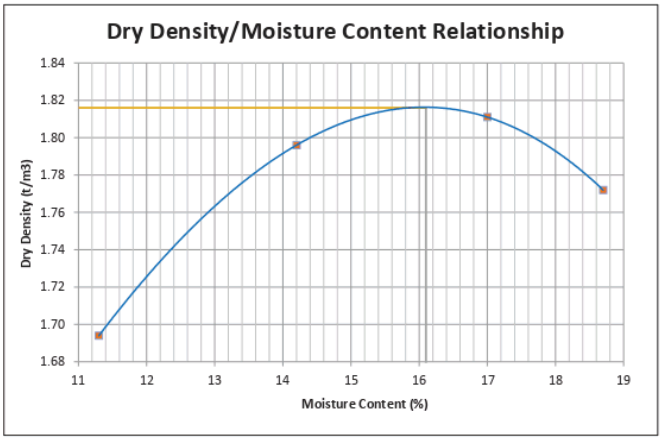
DRY DENSITY / OPTIMUM MOISTURE CONTENT REPORT

Client	AssetGeoEnviro	**Source**	BH9 (Basin 9)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY trace of Gravel and Sand.
Project	Proposed Retarding Basins (6006)	**Report No**	S63761-MDD
Job No	S20437-1	**Sample No**	S63761

Test Procedure:
- ☑ AS1289.5.1.1 Dry Density / Moisture Content Relationship - Standard Compaction
- ☑ AS1289.2.1.1 Moisture Content - Oven Drying Method (Standard Method)

Sampling: Sampled by Client - results apply to the sample as received — **Date Sampled:** 01-02/10/2020

Preparation: Prepared in accordance with the test method



Maximum Dry Density (t/m^3)	1.816
Optimum Moisture Content (%)	16.1
Oversize Retained on 19mm sieve (%)	0.0
Oversize Retained on 37.5mm sieve (%)	0.0
Curing Time	102 hrs
Liquid Limit Determination	Technician Assessment

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

SOIL CLASSIFICATION REPORT

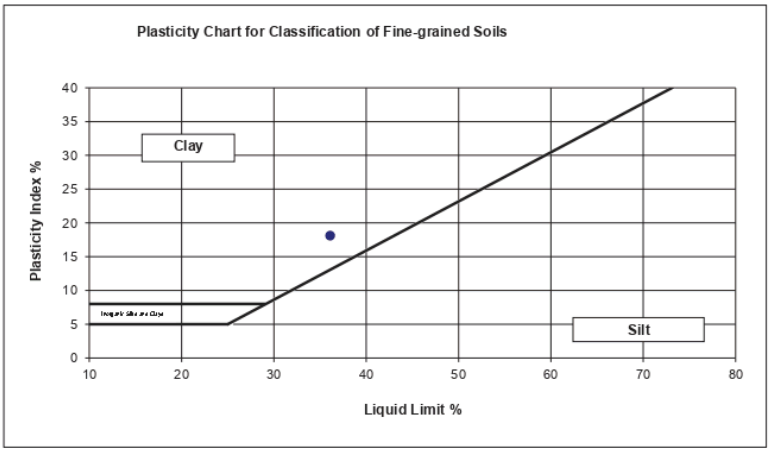
Client	AssetGeoEnviro	**Source**	BH9 (Basin 9)
Address	Suite 2.05, 56 Delhi Road, North Ryde, NSW 2113	**Sample Description**	Silty CLAY trace of Gravel and Sand.
Project	Proposed Retarding Basins (6006)	**Report No**	S63761-PI
Job No	S20437-1	**Lab No**	S63761

Test Procedure:

- ☐ AS1289 2.1.1 Soil moisture content tests (Oven drying method)
- ☑ AS1289 3.1.1 Soil classification tests - Determination of the liquid limit of a soil - Four point casagrande method
- ☐ AS1289 3.1.2 Soil classification tests - Determination of the liquid limit of a soil - One point Casagrande method (subsidiary method)
- ☑ AS1289 3.2.1 Soil classification tests - Determination of the plastic limit of a soil - Standard method
- ☑ AS1289 3.3.1 Soil classification tests - Calculation of the plasticity index of a soil
- ☐ AS1289 3.4.1 Soil classification tests - Determination of the linear shrinkage of a soil - Standard method

Sampling:	Sampled by Client - results apply to the sample as received	**Date Sampled:**	01-02/10/2020
Preparation:	Prepared in accordance with the test method		

Liquid Limit (%)	36	**Linear Shrinkage (%)**	-
Plastic Limit (%)	18	**Plasticity Index**	18



Soil Preparation Method: Dry Sieved
Soil History: Oven Dried
Soil Condition: N/A

Notes

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

21/10/2020

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Appendix G – Cost Estimation

This will be completed as the project progresses.