Bankstown CBD Drainage Modelling

Assessment of culvert sizing in The Appian Way south of The Mall and North Terrace

Report

City of Canterbury Bankstown

Report

July 2020

The expert in WATER ENVIRONMENTS

This report has been prepared under the DHI Business Management System certified by Bureau Veritas to comply with ISO 9001 (Quality Management)

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Report

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CONTENTS

FIGURES

TABLES

APPENDICES

1 Introduction

DHI previously developed a detailed MIKE FLOOD model which couples a 2D surface model (MIKE 21 Flexible Mesh) with a 1D storm drainage network (MIKE Urban) for the Bankstown CBD and ran several drainage upgrade option scenarios[1]. MIKE Urban simulates the detailed storm drainage network including various hydraulic structures such as manholes, basins and valves, while MIKE 21 Flexible Mesh simulates the dynamic flows on the ground surface. MIKE FLOOD enables the dynamic coupling of the two models and simulates flow exchange through inlet structures from the surface to the storm water drainage network.

Discharge outputs from Council's catchment wide TUFLOW study have been applied to the 2D model at discrete locations as surface flow boundary conditions. The MIKE FLOOD model does not replace the catchment wide model, however, it can simulate flooding and dynamic flow interaction between the ground surface and the pipe network at a finer scale allowing for complexity of drainage network and interaction between overland and conduit flows with the CBD.

Canterbury-Bankstown Council (Council) has engaged DHI Water and Environment (DHI) to perform additional modelling of the Drainage System in Bankstown CBD using the most recent model version (Scenario 3 May 2019). The additional modelling focuses on the flooding conditions along the Appian way and North Terrace and includes sizing of proposed culverts.

The main objectives of the study as per the initial Council's brief were:

- Update of the May 2019 Scenario 3 Model with the latest information as per the Rickard Rd Drainage Upgrade DWG set Issue for Construction 2019. This 2019 model already incorporated the proposed Western Sydney University building at the intersection of Rickard Rd and The Appian Way.
- Assessment of the following three options of Sydney Water culverts replacement in The Appian Way south of The Mall:
    A) the western culvert remains in place with the amplified eastern culvert moved closer to it within the road reserve
    B) both existing culverts removed and replaced with a single culvert (or equivalent dual barrel culvert) in the middle of the road
    C) the western culvert remains in place with the amplified eastern culvert relocated to the opposite side (i.e. western side) of road reserve

For each replacement options, the following modifications and assessment were proposed to be carried out.

- Size culverts in The Appian Way south of The Mall to achieve a combined conduit capacity of 100 yr ARI (or as close to it as practical) with minimum or no overland flow.
- Check if the performance of the previously proposed culvert at North Terrace changes as a result of the network adjustments as above.
- Quantify improvements in flooding conditions along The Appian Way and North Terrace.

[1] The development of the detailed MIKE FLOOD model and previously ran network upgrade options in *Bankstown CBD Drainage Modelling – MIKE Storm model upgrades to MIKE FLOOD* (2017), *Bankstown CBD Drainage Modelling – Design stage – Inlet capacity upgrade at French Avenue* (2018) *and Rickard Road* and *Bankstown CBD MIKE FLOOD model upgrade – Western Sydney University Site Flood Assessment* (2019).

- Check if the proposed network adjustments make an impact on water surface levels downstream of the railway, compared to the existing conditions (i.e. Scenario1 as per DHI model of May 2019).

This report summarises modifications of the model and outcomes for OPTION B. The report includes findings and recommendations for this option based on the model results. During the preparation of the study Council had decided to put assessment of Option A and C on hold. Should it be required to append this report with the results and recommendations for these two options, at later stage.

2 Model modifications

2.1 Drainage modifications OPTION B

The May 2019 Scenario 3 model was updated with the changes described in the following sections.

2.1.1 Culverts in The Appian Way south of The Mall

Both the existing culverts were removed and replaced by new twin culverts in the middle of the road. The twin culverts extend from a transition structure just north of the intersection with The Mall to the previously modelled transitions structure (Transition structure 1) at the railway underpass between North Terrace and South Terrace. The location of the twin culverts (represented in two shades of green) and the modelled slope are shown in Figure 1. Culvert sections represented with the same colour are modelled with the same slope.

The twin culverts were modelled with a rectangular cross-section. The height was set to 1.5 m and the optimal width was determined through iterative model runs. The final dimensions are summarised in Section 3.

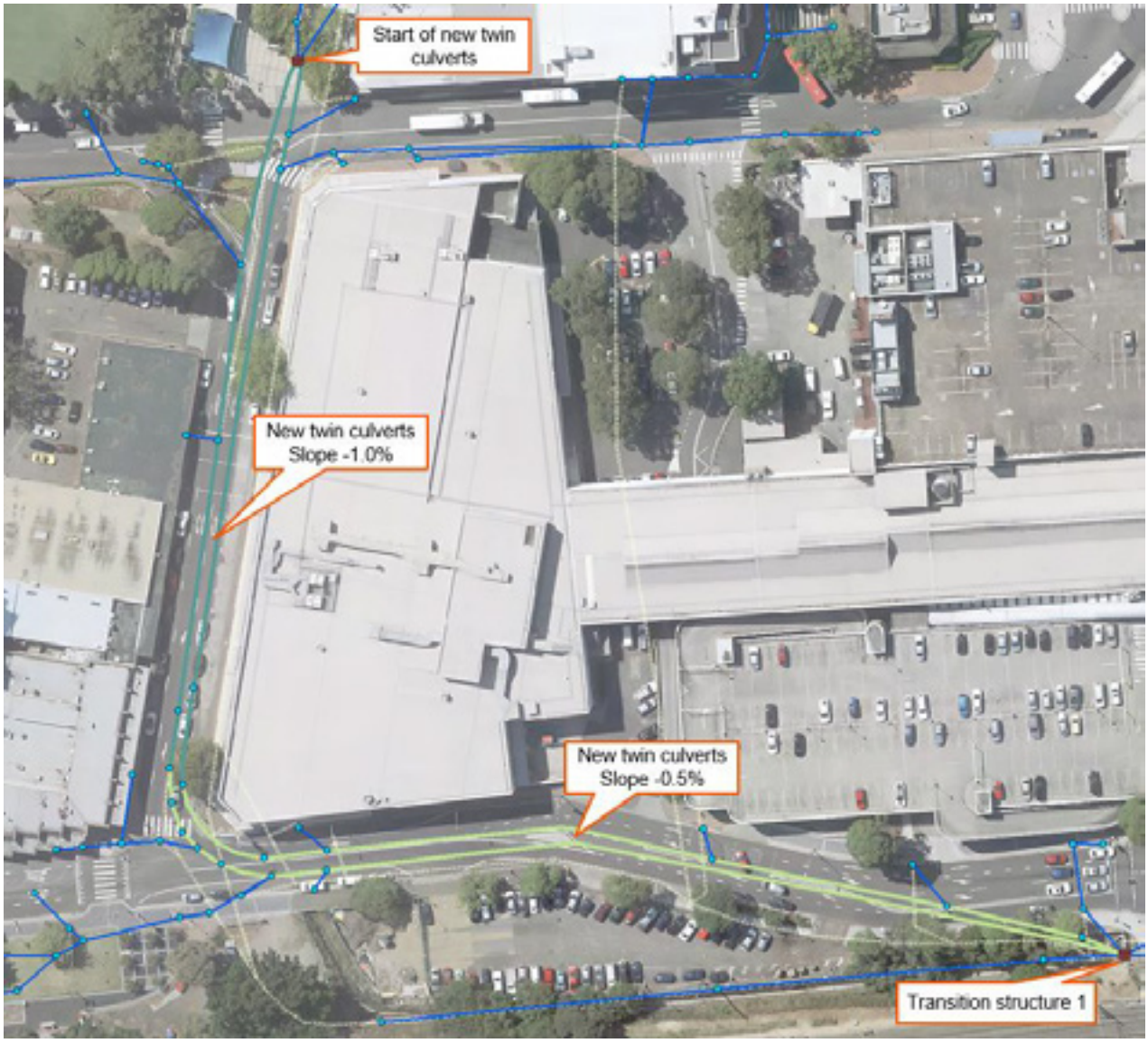


Figure 1. The modelled twin culvert in OPTION B. (the slope of the dark green pipes is 1.0%, the slope of the light green pipes is 0.5%).

2.1.2 Intersection of Rickard Rd and The Appian Way

No major design modifications for the modelled network in Rickard Rd and northern section of The Appian Way was included in this study. The Rickard Rd Drainage Upgrade DWG set Issue for Construction 2019 was based on the latest DHI modelling in 2019. Some minor modifications were incorporated to the model after the drawing set was checked for consistency.

Network upgrades applied to the MIKE URBAN model at the intersection of Rickard Rd and The Appian Way are summarised in Figure 2.

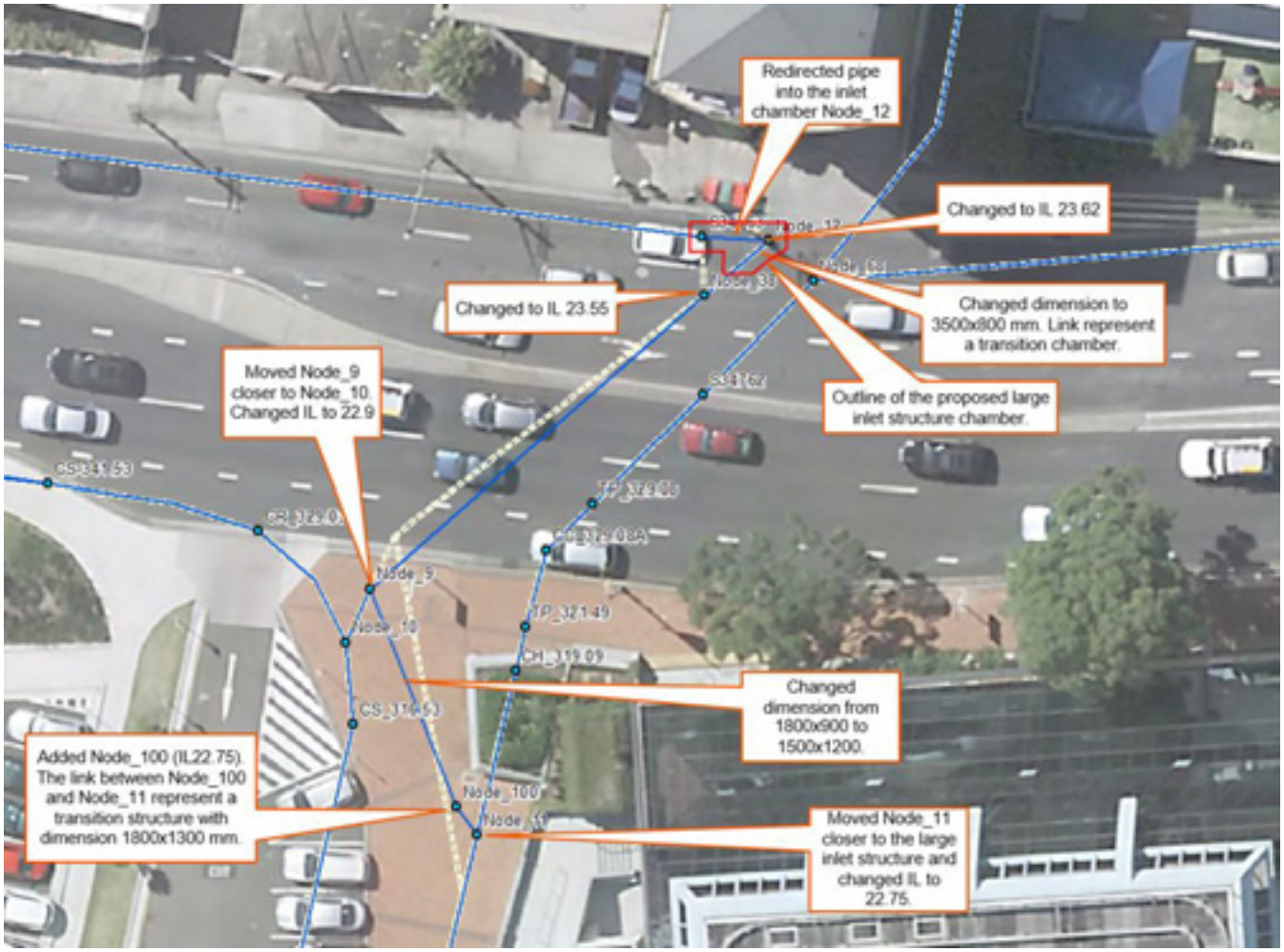


Figure 2. Network updates – intersection Rickard Rd and The Appian Way (The blue line: Updated network, the dashed white line: the network in the May 2019 Scenario 3 model).

2.1.3 Intersection of The Mall and The Appian Way

Network upgrades applied to the MIKE Urban model at the intersection of The Mall and The Appian way are shown in Figure 3.

The dimension of the twin culverts in the middle of The Appian Way was to be determined through modelling and the final dimensions are presented in Section 3.

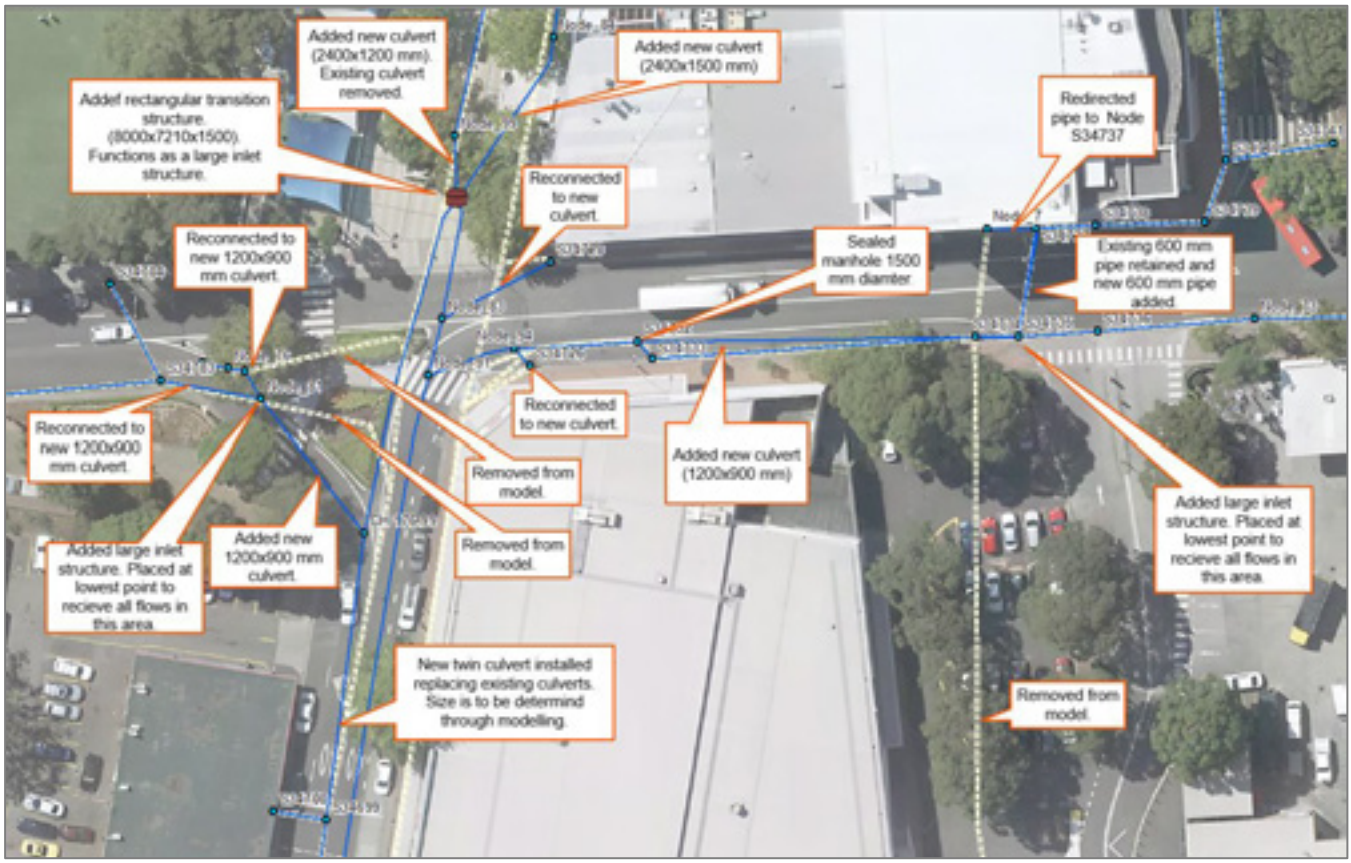


Figure 3. Network updates – Intersection The Mall and The Appian Way (The blue line: Updated network, the dashed white line: the network in the May 2019 Scenario 3 model).

2.1.4 Intersection of North Terrace and The Appian Way

Network upgrades applied to the MIKE Urban model at the intersection of North Terrace and The Appian Way and along North Terrace are shown in Figure 4 and Figure 5 respectively.

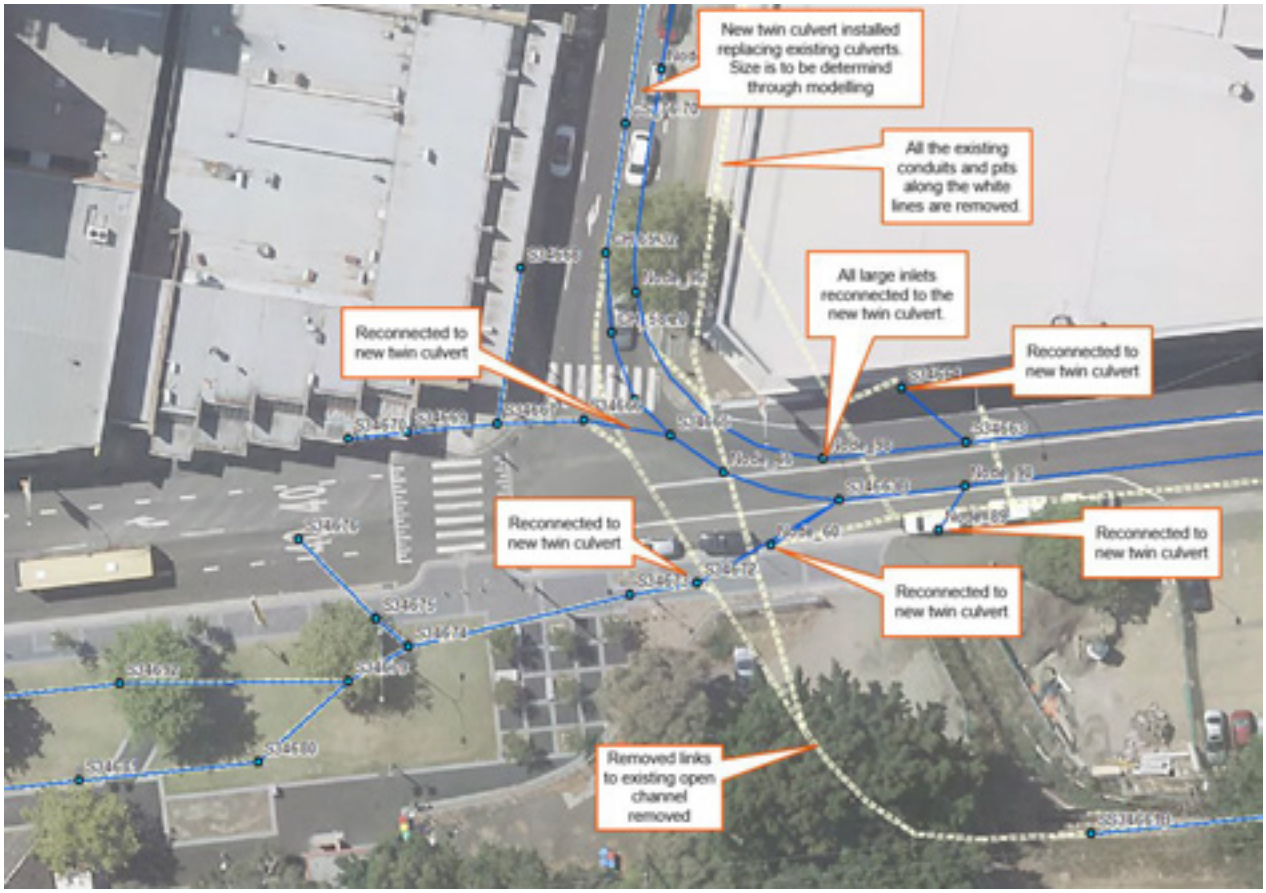


Figure 4. Network updates – intersection of North Terrace and The Appian Way (The blue line: Updated network, the dashed white line: the network in the May 2019 Scenario 3 model).

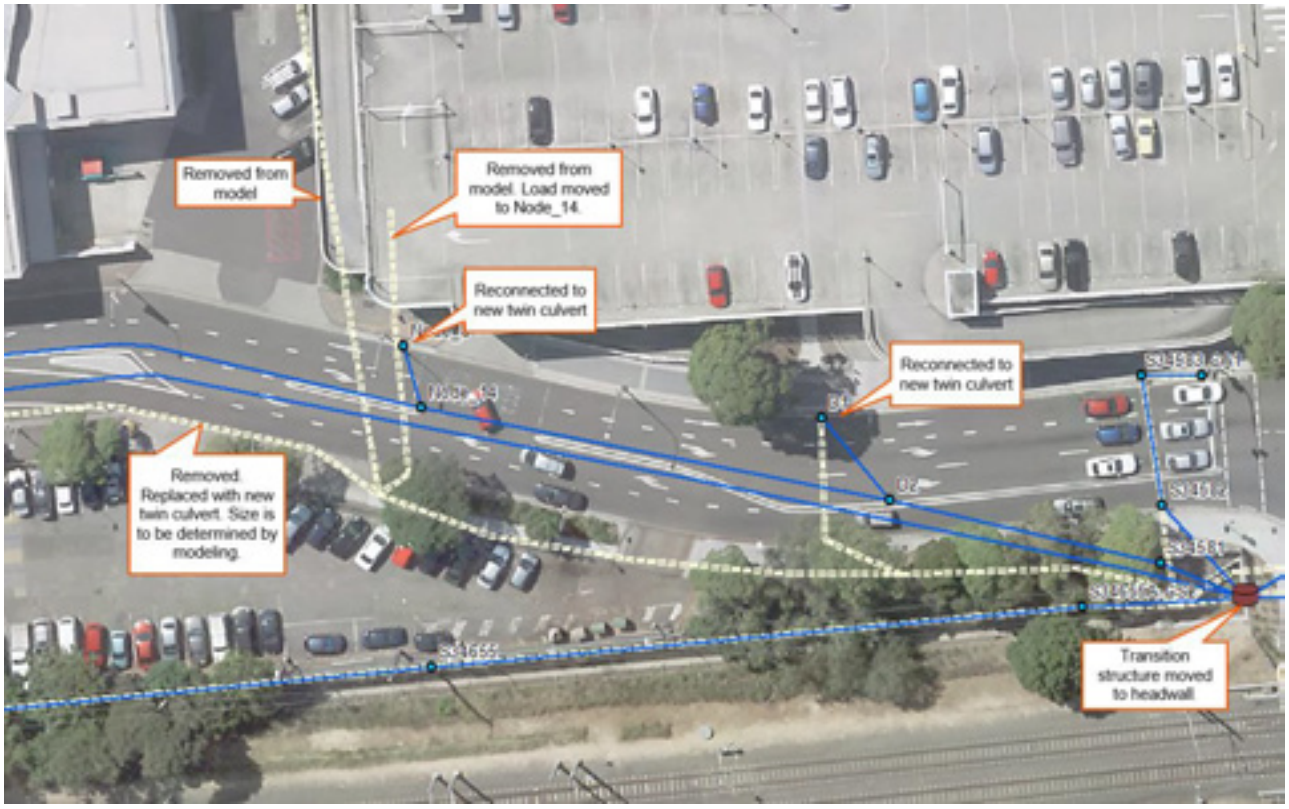


Figure 5. Network updates – North Terrace (The blue line: Updated network, the dashed white line: the network in the May 2019 Scenario 3 model).

2.2 2D model modifications

The modifications to the 2D model include:

- Adjustments of the Rickard Rd median to allow for greater overflow capacity at the road centreline.
- Incorporation of an additional raised surface at The Appian Way driveway. This works like a weir enhancing the hydraulic capacity of the existing large inlet structure and minimizing the excess overflow into The Appian Way.

The location of the adjusted median (pink polygons) and the raised surface (red line) are shown in Figure 6.

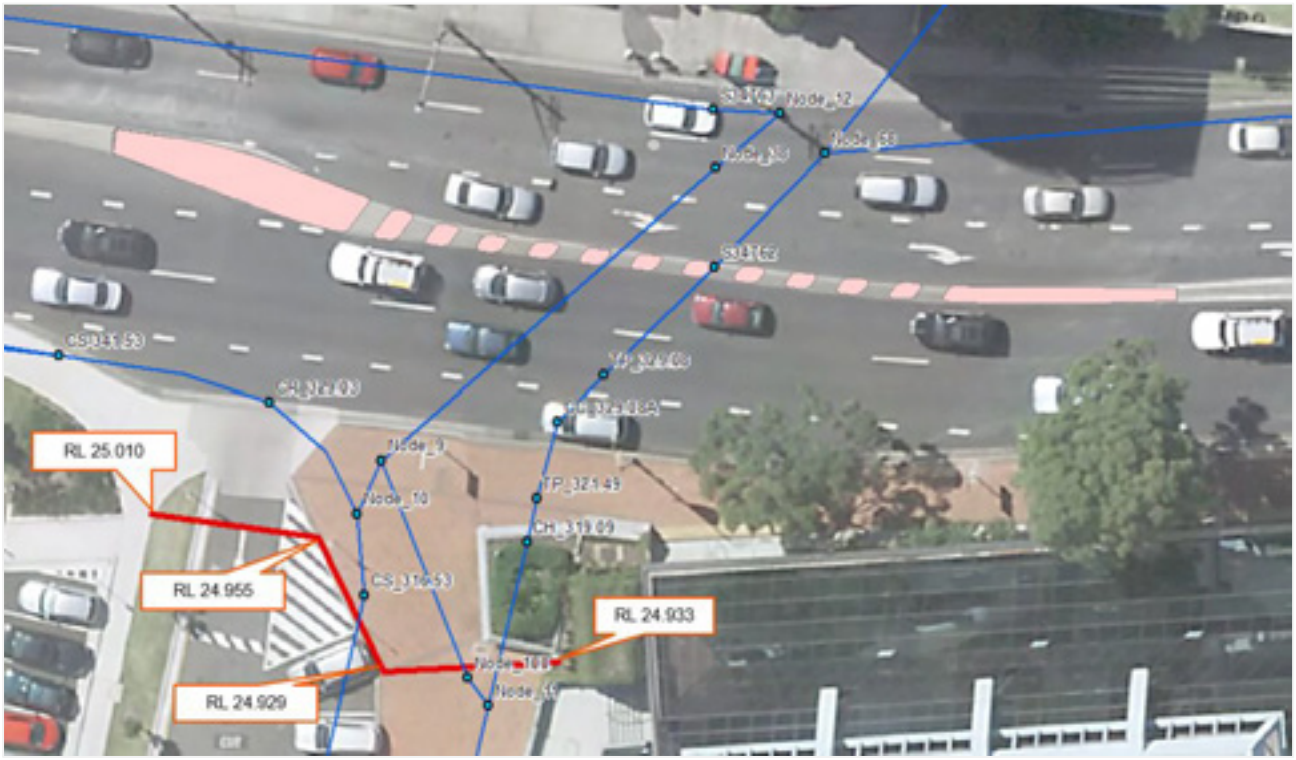


Figure 6. The locations of the adjusted centreline and the added weir.

Both the Rickard Rd median and the raised surface at The Appian Way driveway are modelled as dykes in the MIKE 21 Flexible Mesh model. To improve the representation of the new median in the 2D model the computational mesh was regenerated to align with the gaps of the median structure. The two dyke structures and the regenerated flexible mesh are shown in Figure 7.

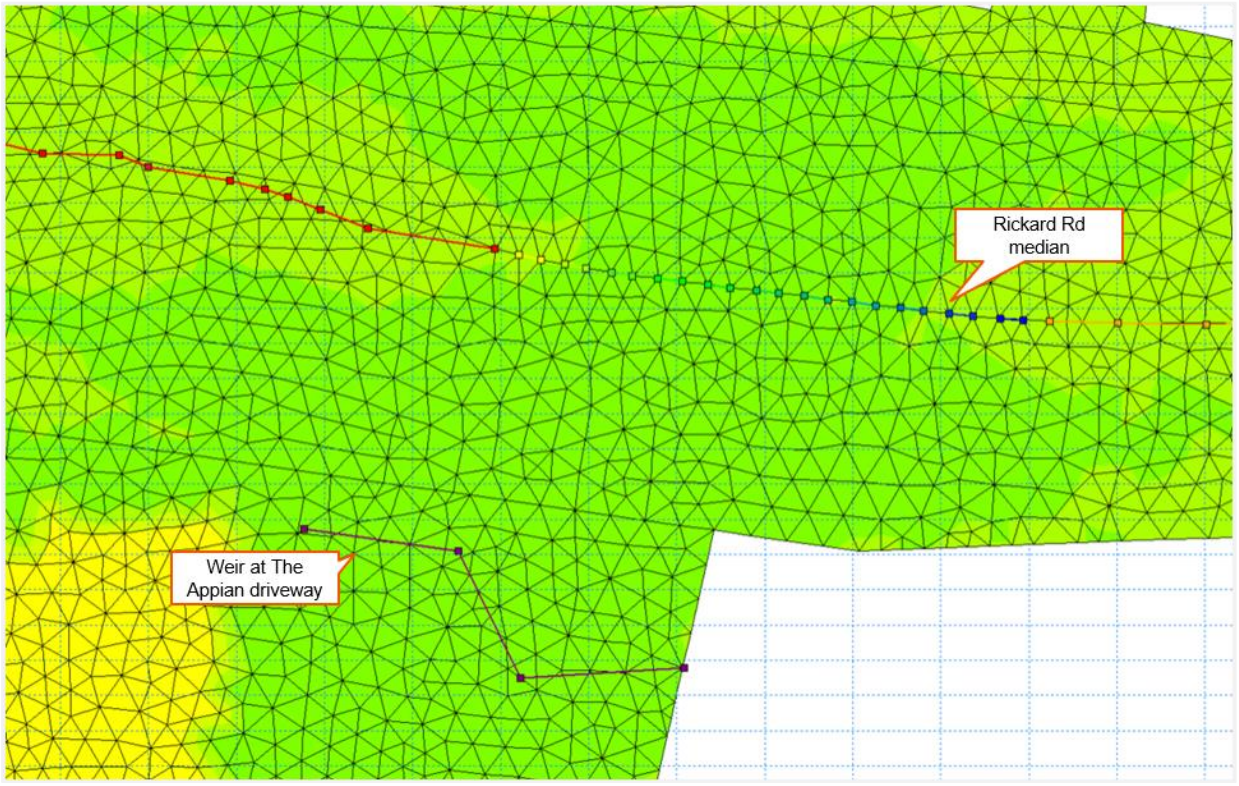


Figure 7. Dykes representing the median in Rickard Road and the weir at The Appian Way driveway.

3 Results of OPTION B

The model was run for 100 year ARI event iteratively to confirm the sizes of the new culverts. The results presented in the sections below are derived from the model run in which the culverts where the most optimally used end minimal overland flow was achieved.

3.1 Sizes of new culverts

The optimal sizes for the new culverts in OPTION B are shown in Figure 8. Culvert sections represented with the same colour have the same dimension.

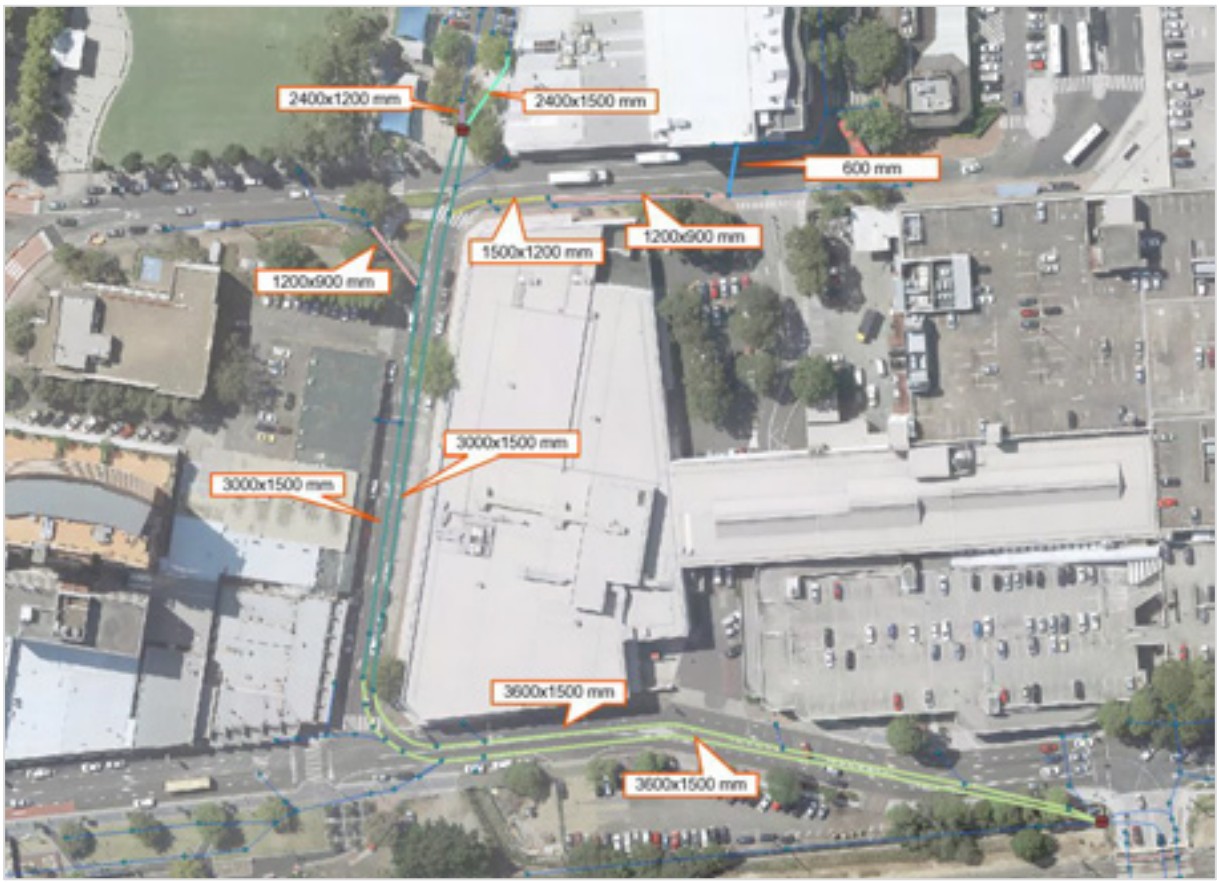


Figure 8. The optimal sizes for the new culverts for OPTION B.

3.2 Peak culvert flows

Peak culvert flows under the proposed drainage network conditions for OPTION B are shown in Figure 9, Figure 10 and Figure 11 for The Appian Way, The Mall and North Terrace.

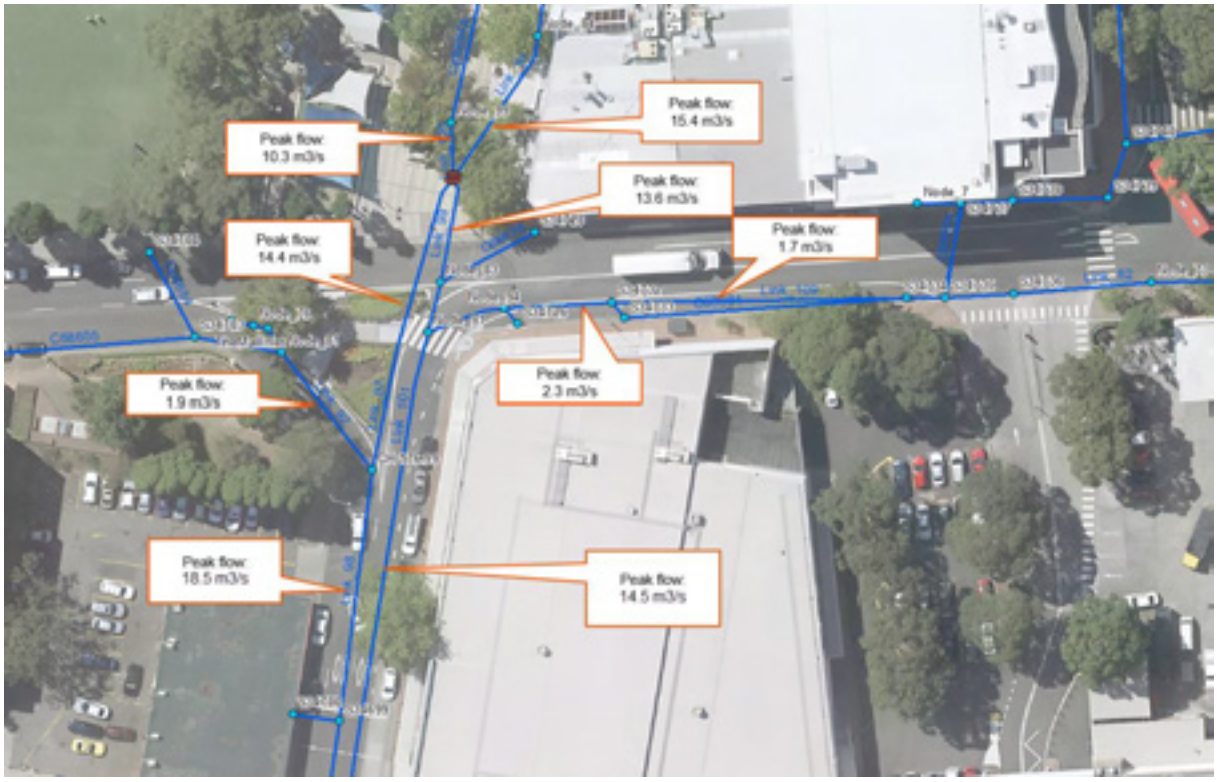


Figure 9 Peak flow in proposed drainage network (Option B) at the intersection of The Appian Way and The Mall.

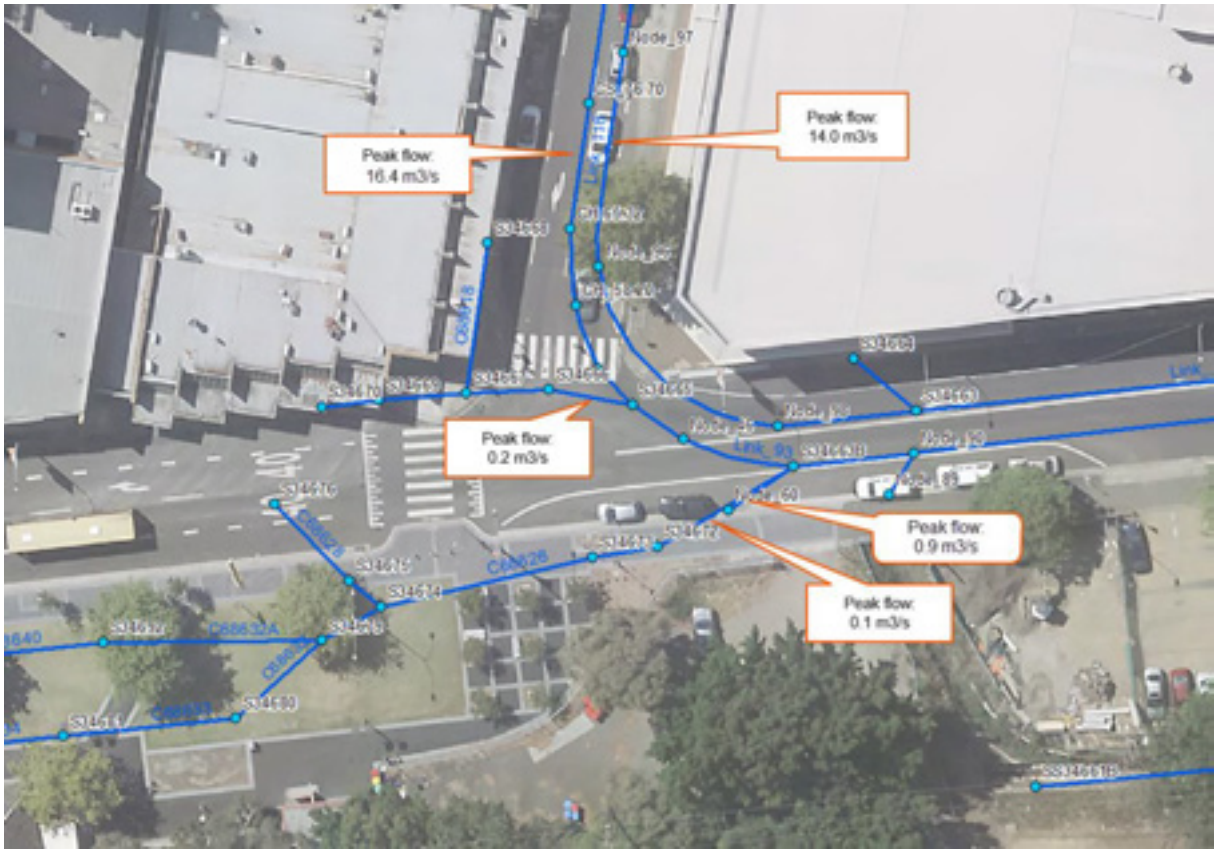


Figure 10 Peak flow in proposed drainage network (Option B) at the intersection of The Appian Way and North Terrace.

Figure 11 Peak flow in proposed drainage network (Option B) along North Terrace.

Figure 12 shows the culvert flow hydrographs at the upstream end and downstream end of Link_101, Link_118 and Link_107 (Eastern Culvert). The peak flow right downstream of The Mall is approximately 14.5 m^3/s at the Eastern Culvert. As there are no major inlet flows at the Eastern Culvert downstream of the Mall, the peak flow is reduced further downstream due to flow attenuation.

Similarly, Figure 13 shows the culvert flow hydrographs at Western Culvert. The peak flow just downstream of The Mall is approximately and 18.5 m^3/s (Link_98) and attenuates to 16.4 m^3/s further downstream. The Western culvert regains more flow from the inlet Node_60 (0.9 m^3/s) when it turns to east at North Terrace. This can be observed at Link_96 along North Terrace with the peak flow 17.2 m^3/s.

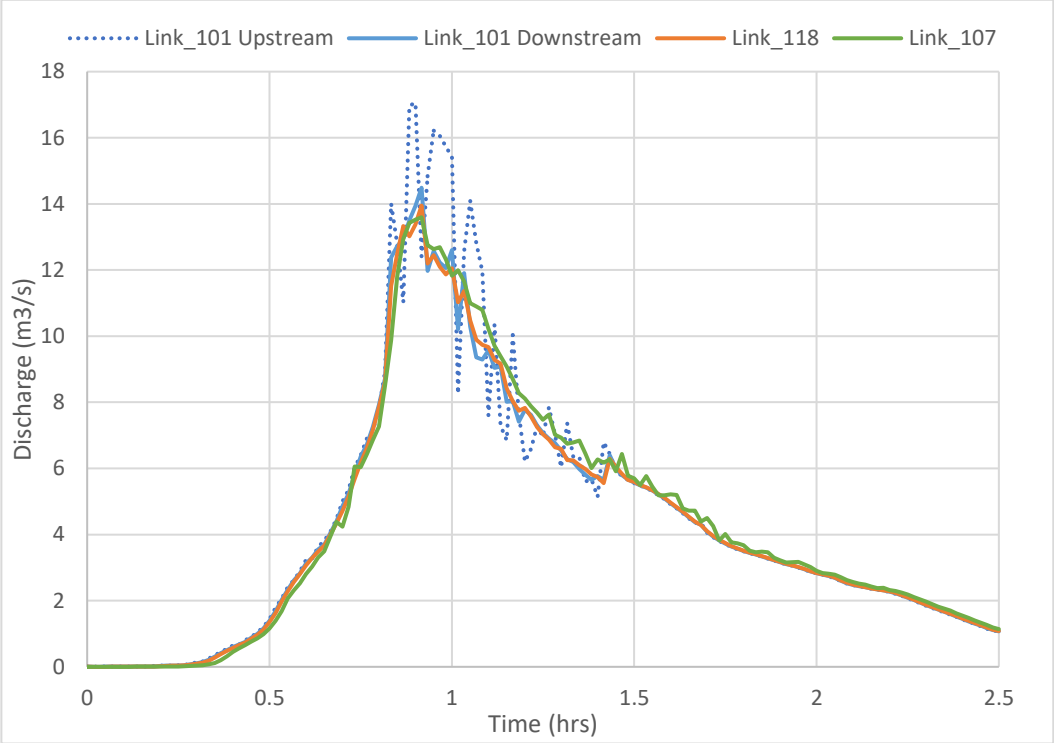


Figure 12 Discharge at Eastern Culvert.

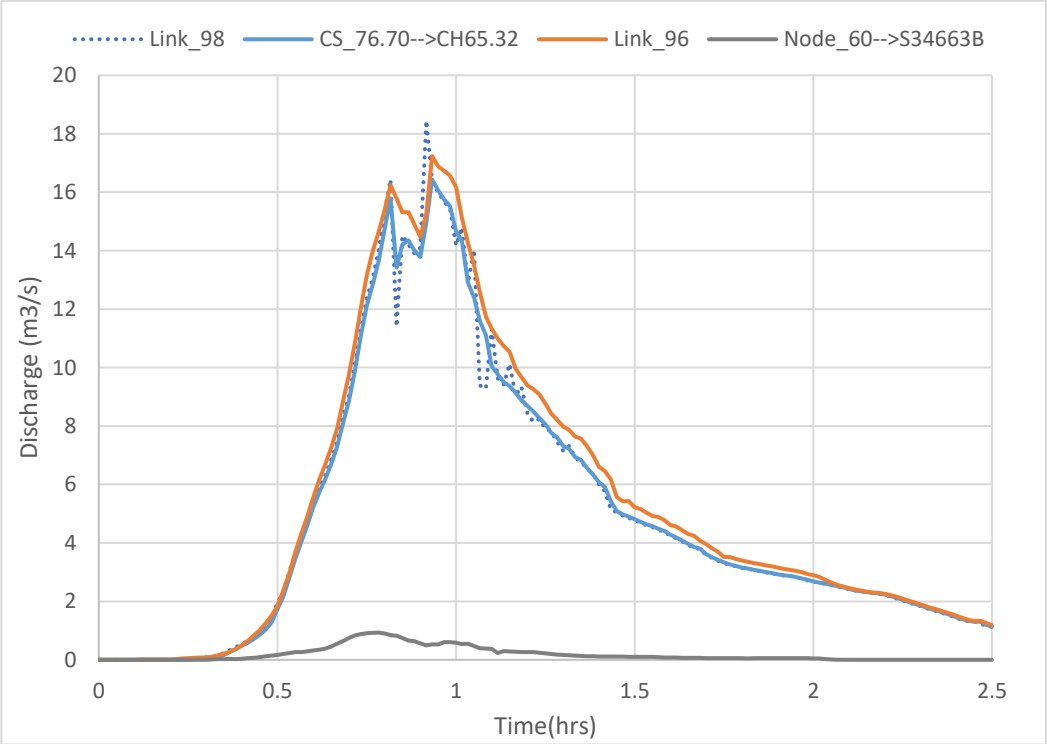


Figure 13 Discharge at Western Culvert.

3.3 Longitudinal profiles of culverts

Longitudinal water level profiles during time of peak flow are shown in Appendix B for the following culvert:

- Eastern Twin culvert along The Appian Way (Node_84 to Node_96)
- Western Twin Culvert along The Appian Way (Node_99 to CH_76.70)
- Eastern Twin Culvert along North Terrace (Node_96 to Transition Structure 1)
- Western Twin Culvert along North Terrace (CH_76.70 to Transition Structure 1
- New culvert in the Mall east of The Appian Way (Node S34735 to Node_91)
- New culvert in the Mall west of The Appian Way (Node_81 to Node CH176.99)

The long sections indicate that the hydraulic capacity of the culverts are fully utilised. The completed iterative runs indicated that further modifications to the system would not result in significant change of peak flows or overland flooding depths.

3.4 Maximum water depth

The maps for maximum water depth of OPTION B and difference of maximum water surface levels between the proposed design scenario results (OPTION B) and the existing conditions (2019 study Scenario 1) are shown in Figure 14 and Figure 15, respectively. The difference map was calculated by subtracting Scenario 1 water levels from OPTION B water levels. Hence, negative values indicate reduction in water levels under design conditions. The maximum water depth map for Scenario 1 is provided in Appendix A along with velocity-depth product maps and flood risk maps for both Option B and Scenario 1.

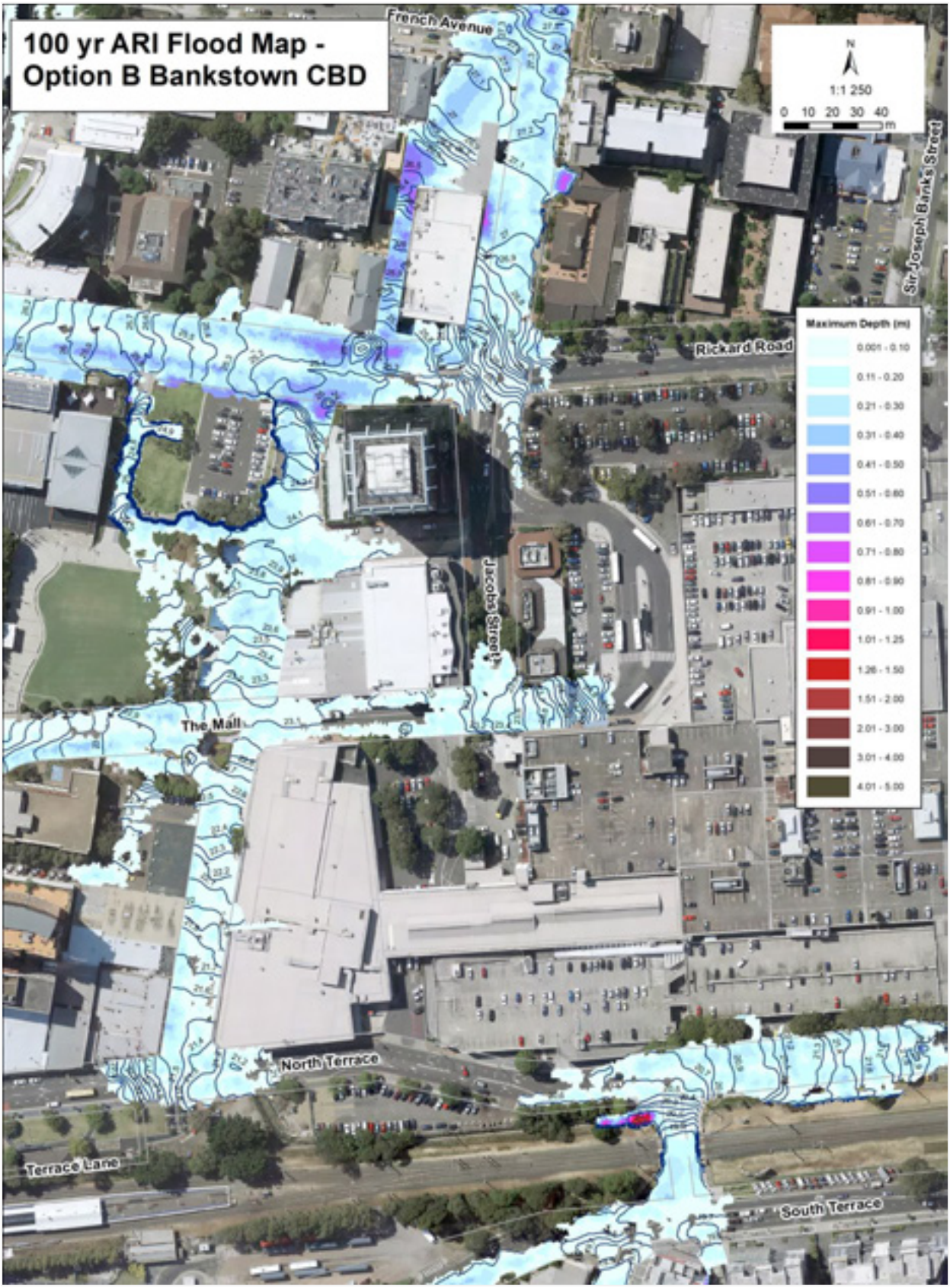


Figure 14 Maximum water depth and levels for 100 year ARI in DESIGN.

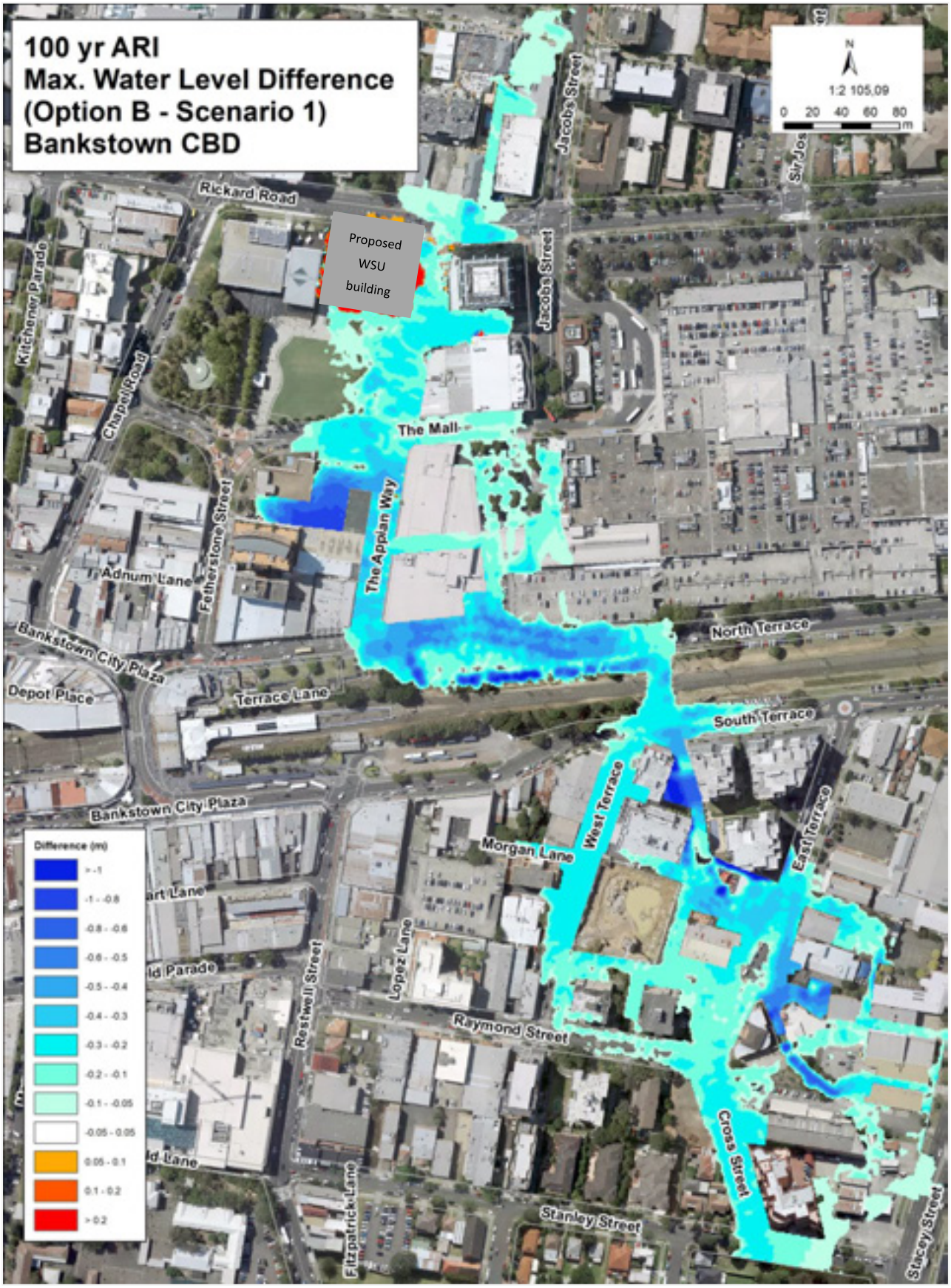


Figure 15 Difference map for maximum water surface levels between DESIGN (OPTION B) and Scenario 1 (May 2019).

3.5 Surface Flow Discharge

Residual surface flows were extracted at control flow lines, which are highlighted by the red lines in Figure 16, and the peak flows are summarised in Table 1 indicating a significant reduction as a result of the modelled drainage upgrades.

The table includes surface flows extracted at the same locations for the modelled existing conditions 2017 and 2020 for comparison.

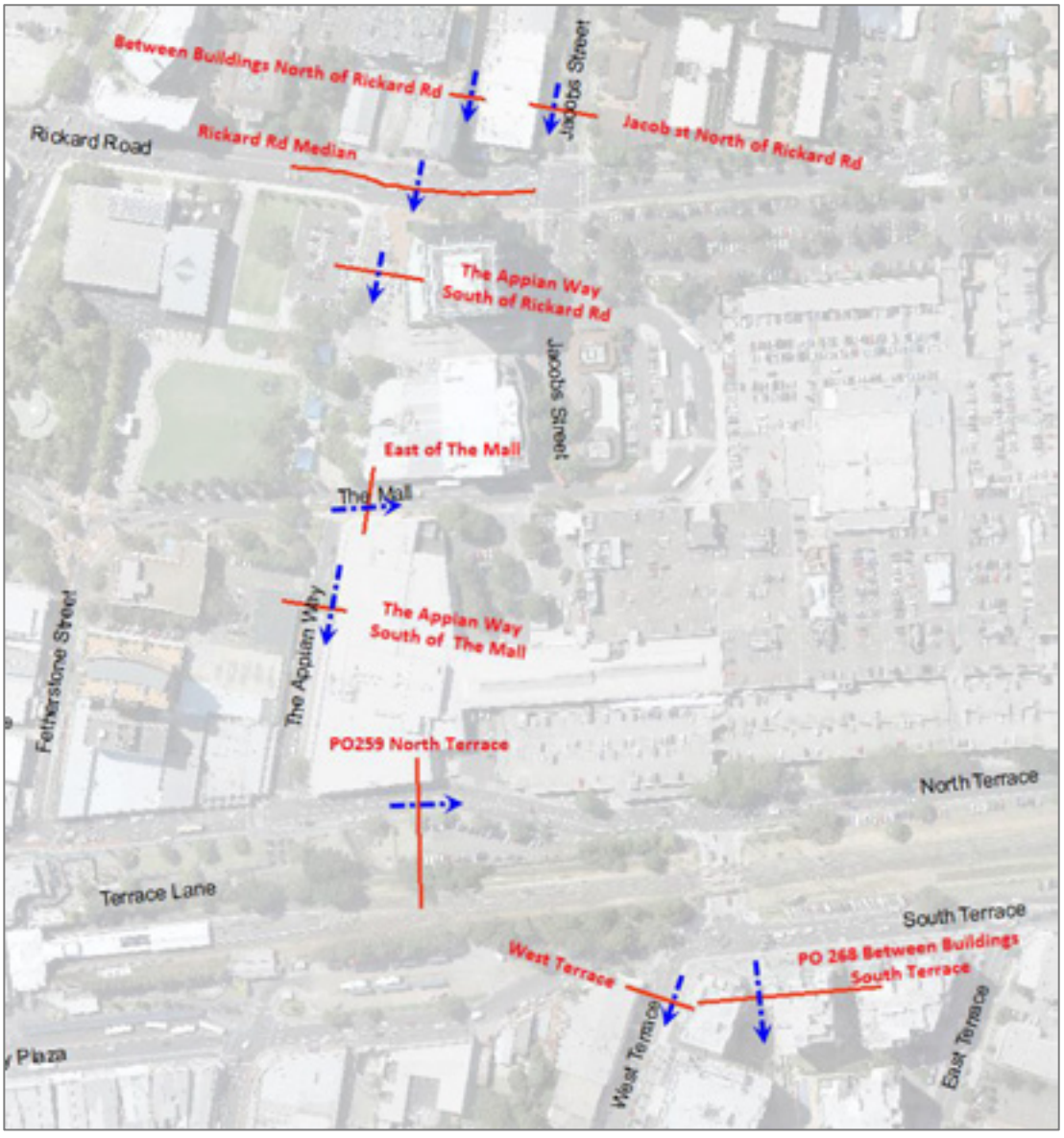


Figure 16 Surface flow discharge extraction lines (from main modelling report).

Table 1 Peak surface flows.

Location	DESIGN PEAK FLOW (m^3/s)		
	2017 Existing *	2020 Existing**	2020 Proposed***
Between buildings north of Rickard Rd	7.1	7.1	4.5
Jacob St north of Rickard Rd	2.5	2.5	2.0
Rickard Rd Median	12.0	12.2	4.0
The Appian Way south of Rickard Rd	11.4	12.2	2.6
East of The Mall	1.4	1.4	0.1
The Appian Way south of The Mall	11.8	12	0.6
PO259 North Terrace	12.0	11.6	0
West Terrace	5.1	4.4	0.1
PO268 between Building South Terrace	6.3	5.7	0.0

* Existing Scenario (BASE), DHI Aug 2017

** Existing Scenario (Scenario 1) DHI May 2019 – includes updates on complete drainage works in The Mall

*** Option B – current model

3.6 Maximum inflows at pits

Peak inflows at proposed inlet pits at the intersection of The Appian Way and The Mall and along North Terrace are presented in Figure 17, Figure 18 and Figure 19. The details of pit sizing can be found in Appendix C.

In addition, the maximum inflow of 4.4 m3/s flows into Node_12 at Rickard Rd.

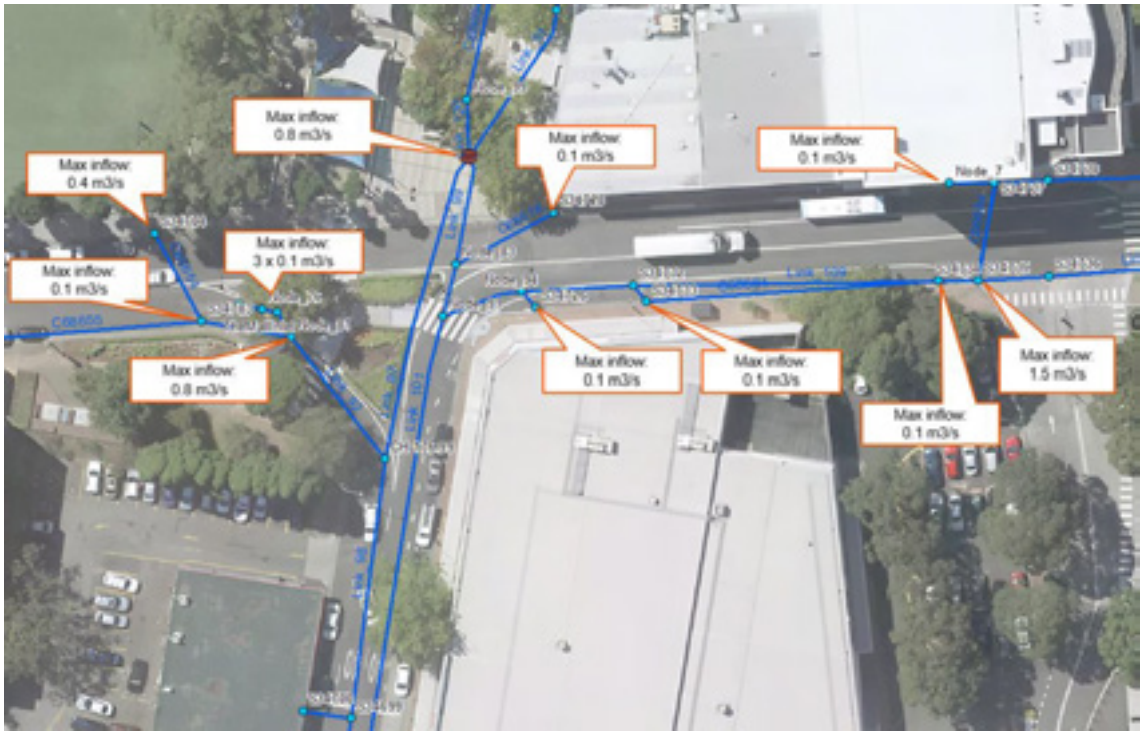


Figure 17. Peak inflows at proposed pits at the intersection of The Appian Way and The Mall.

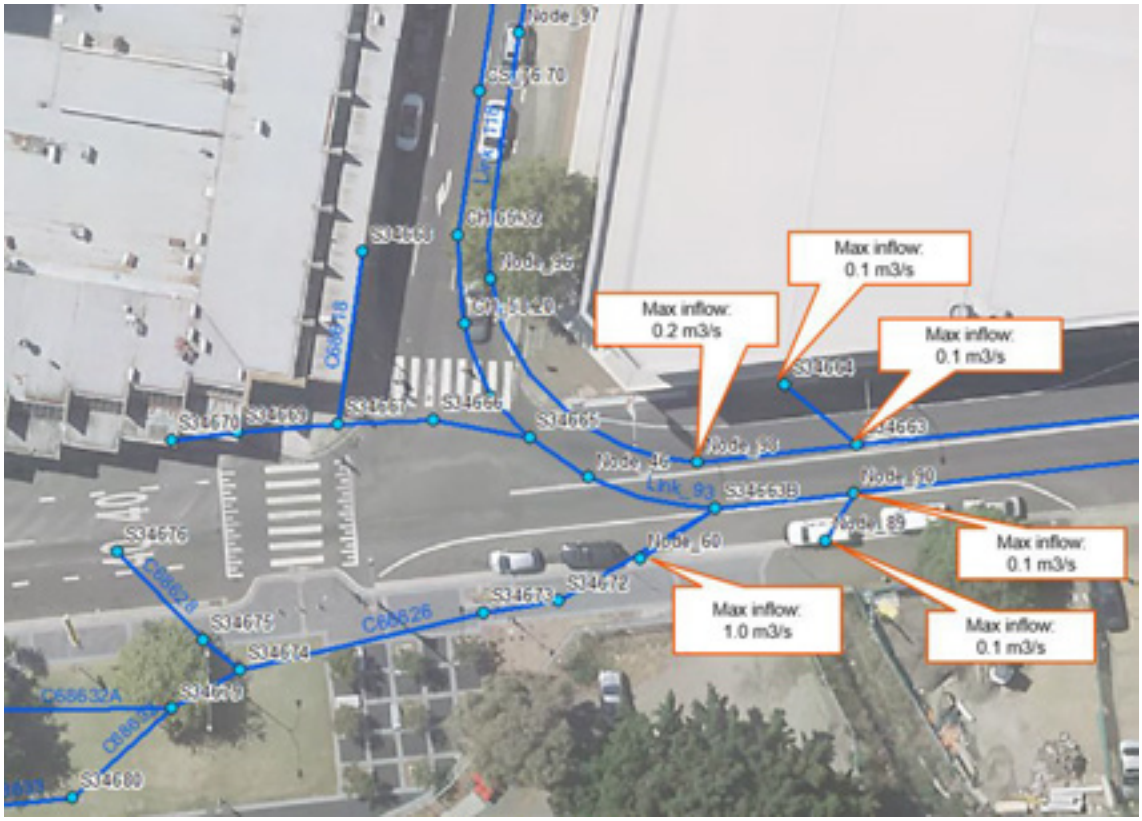


Figure 18 Peak inflows at proposed pits at the intersection of The Appian Way and North Terrace.

Figure 19 Peak inflows at proposed pits along North Terrace.

4 Summary

The modelled design upgrade does not have a negative effect on flooding downstream of the railway lane and rather create significant improvements both along the roads in which the drainage network capacity was upgraded and downstream of the railway underpass. With the proposed upgrade, a large portion of surface flow from the north of Rickard Rd is captured by the inlet Node_12 at Rickard Rd and consequently the surface flow along The Appian Way is significantly reduced. The remaining surface flow is also mostly captured by the inlets along The Appian Way and does not further flow towards the railway underpass in large quantities. The achieved reduction of water surface levels both along The Appian Way and downstream of the underpass is in order of 200-300mm. The Provisional Hydraulic Hazards is reduced from Medium-High to Low along the entire flow path in The Appian Way and North Terrace.

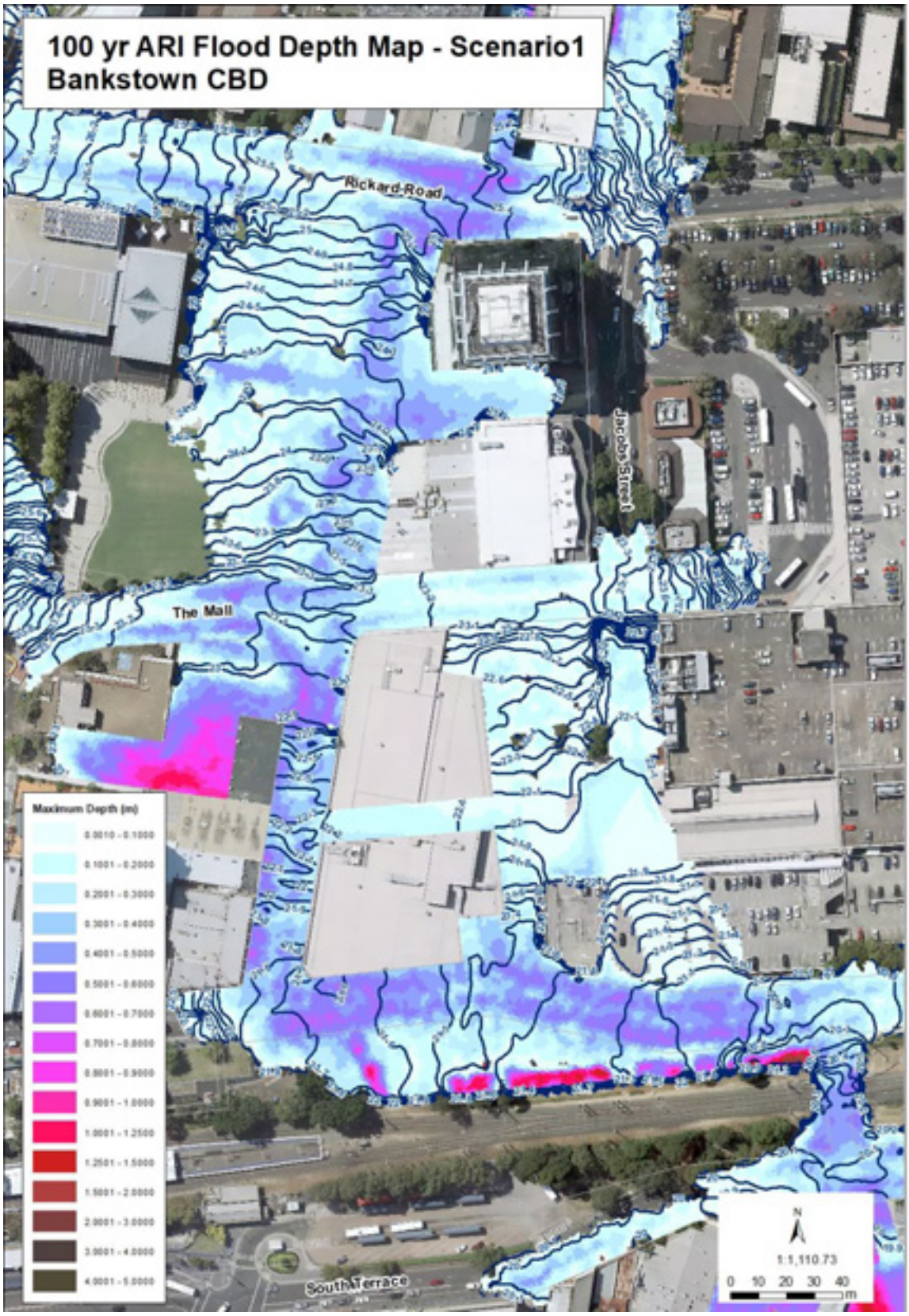
The design parameters for the network upgrade are recommended to be based on the final model run which delivered best results in terms of culvert capacity maximization (see Figure 8 for final culvert dimensions). The dimensions of the proposed inlet pits should be determined based on the modelled peak inflow. An indicative estimation of required pit inlet and grate sizes is provided in Appendix C, subject to confirmation of site construction constraints and Council's preferred pit geometry.

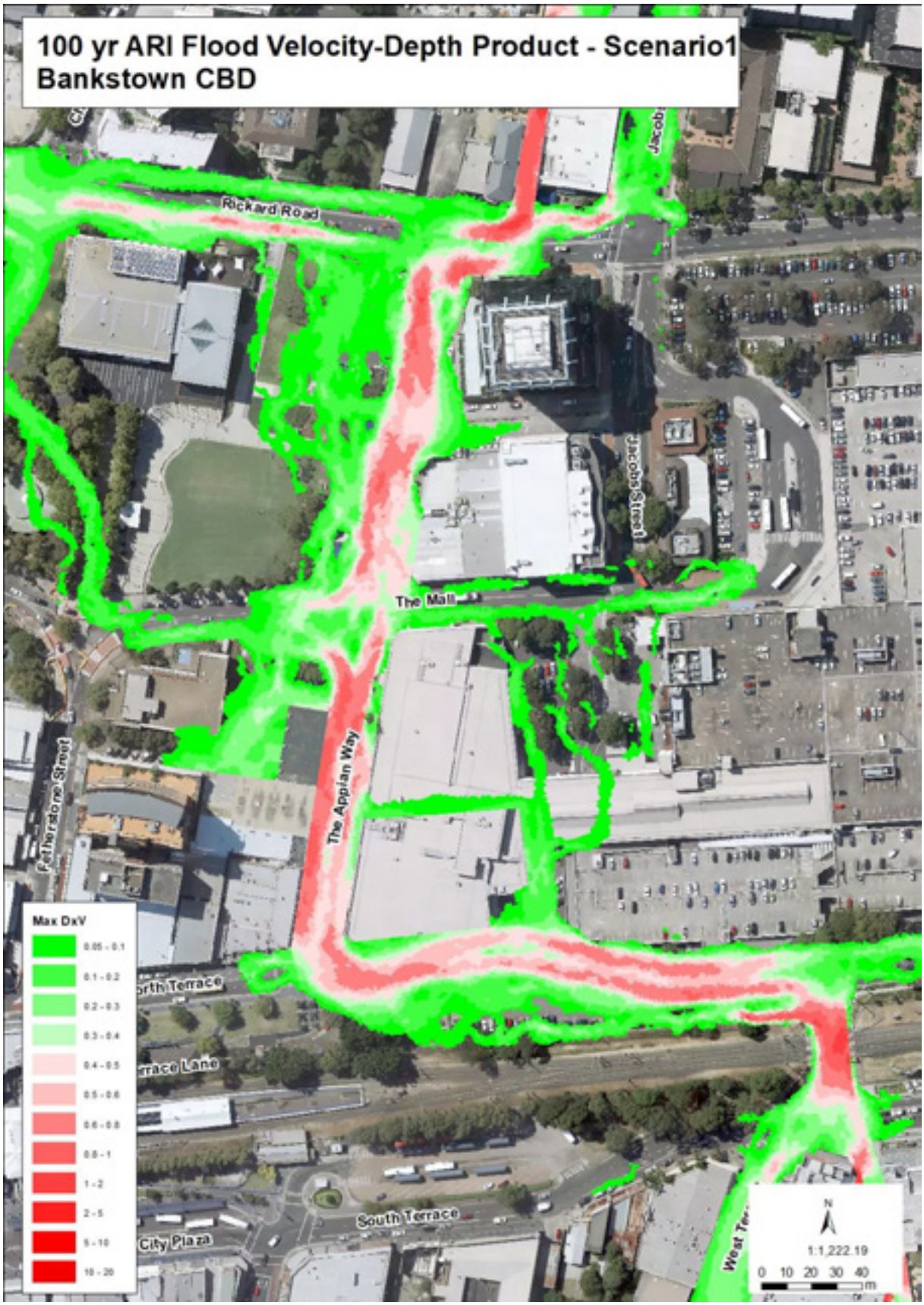
APPENDIX A – Result maps

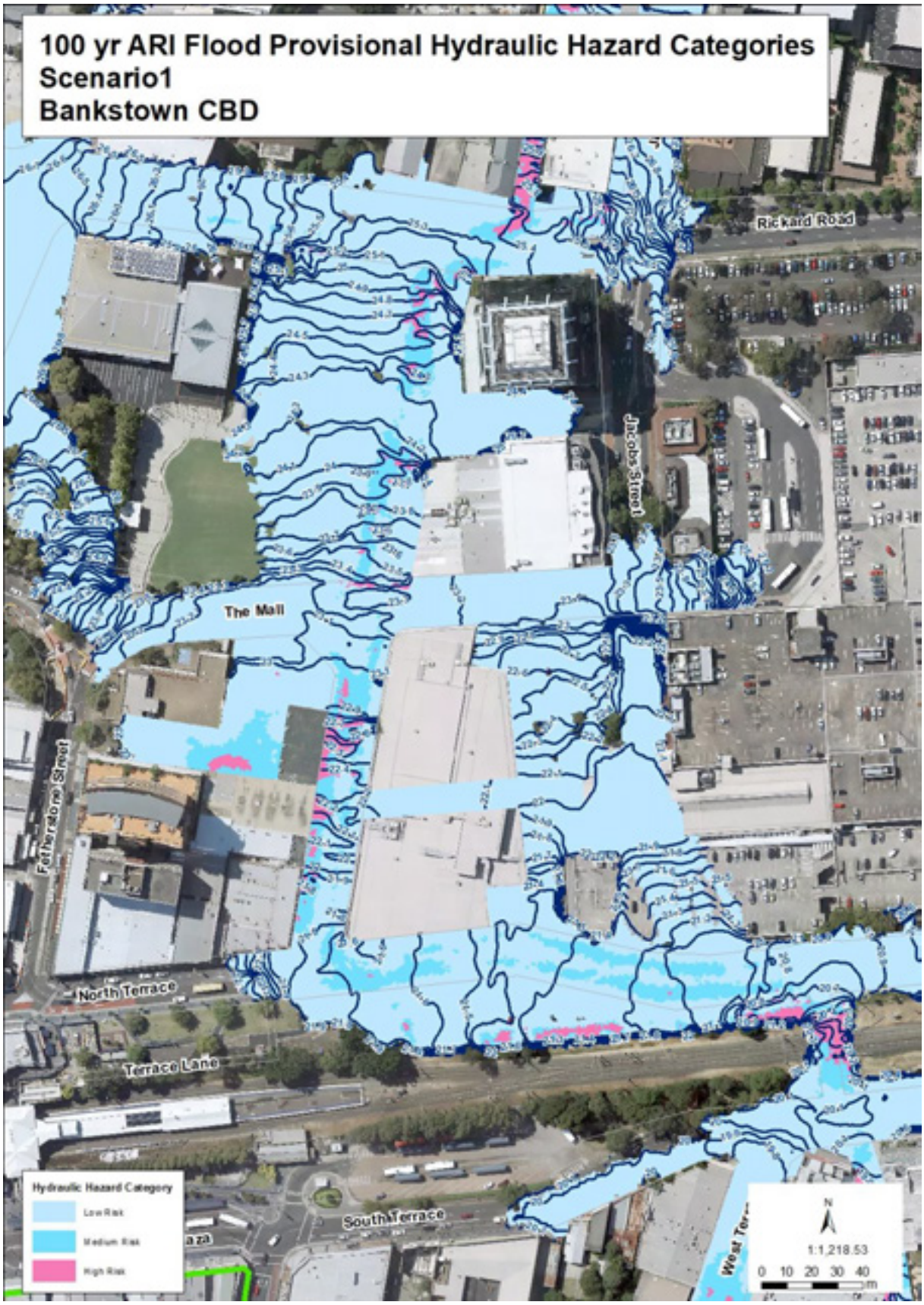
Result maps existing 2020 (Scenario 1, DHI May 2019) and proposed 2020 (Option B, DHI June 2020)

A Result Maps

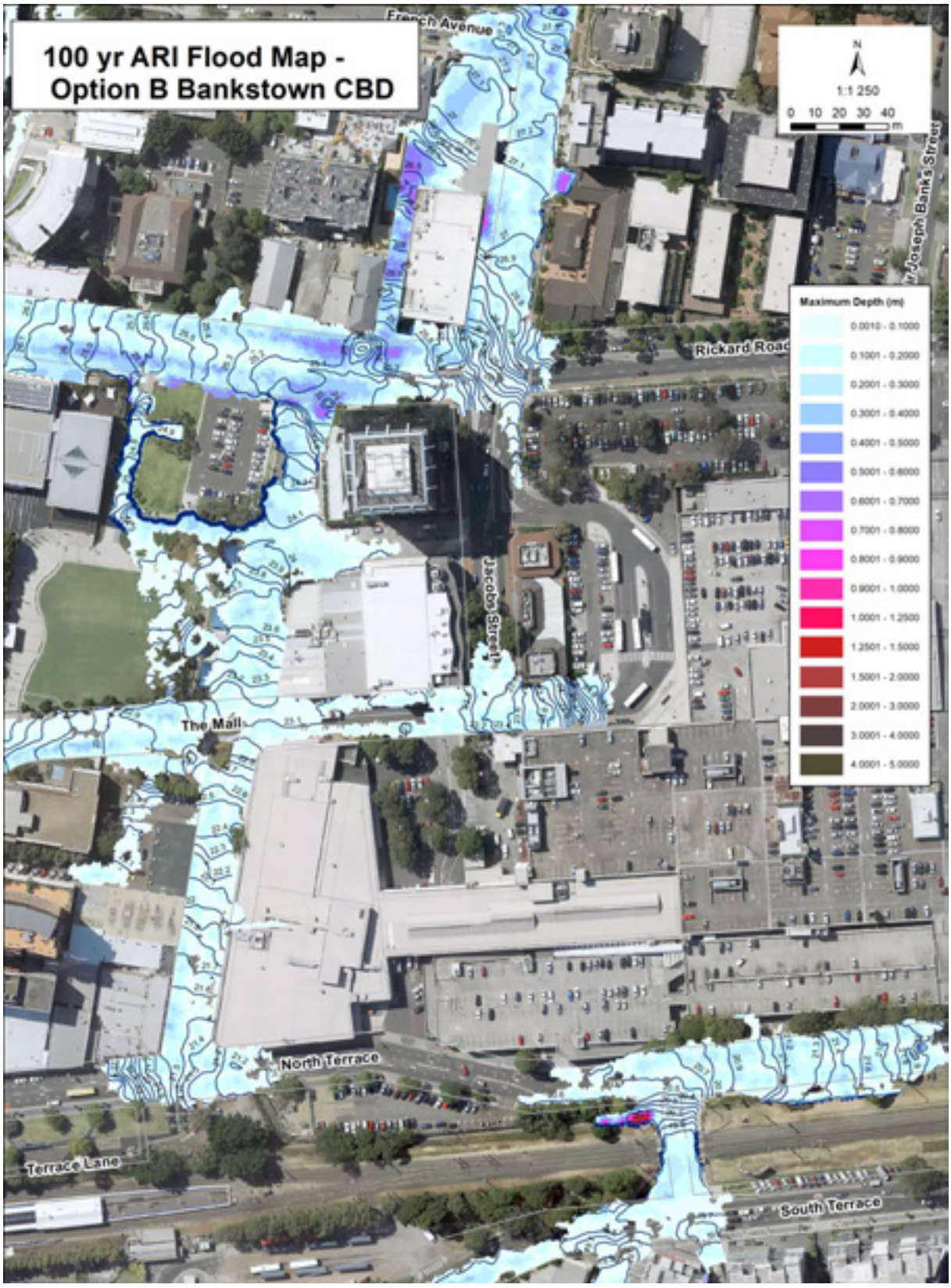
A.1 Existing conditions (Scenario1 of May 2019 study)



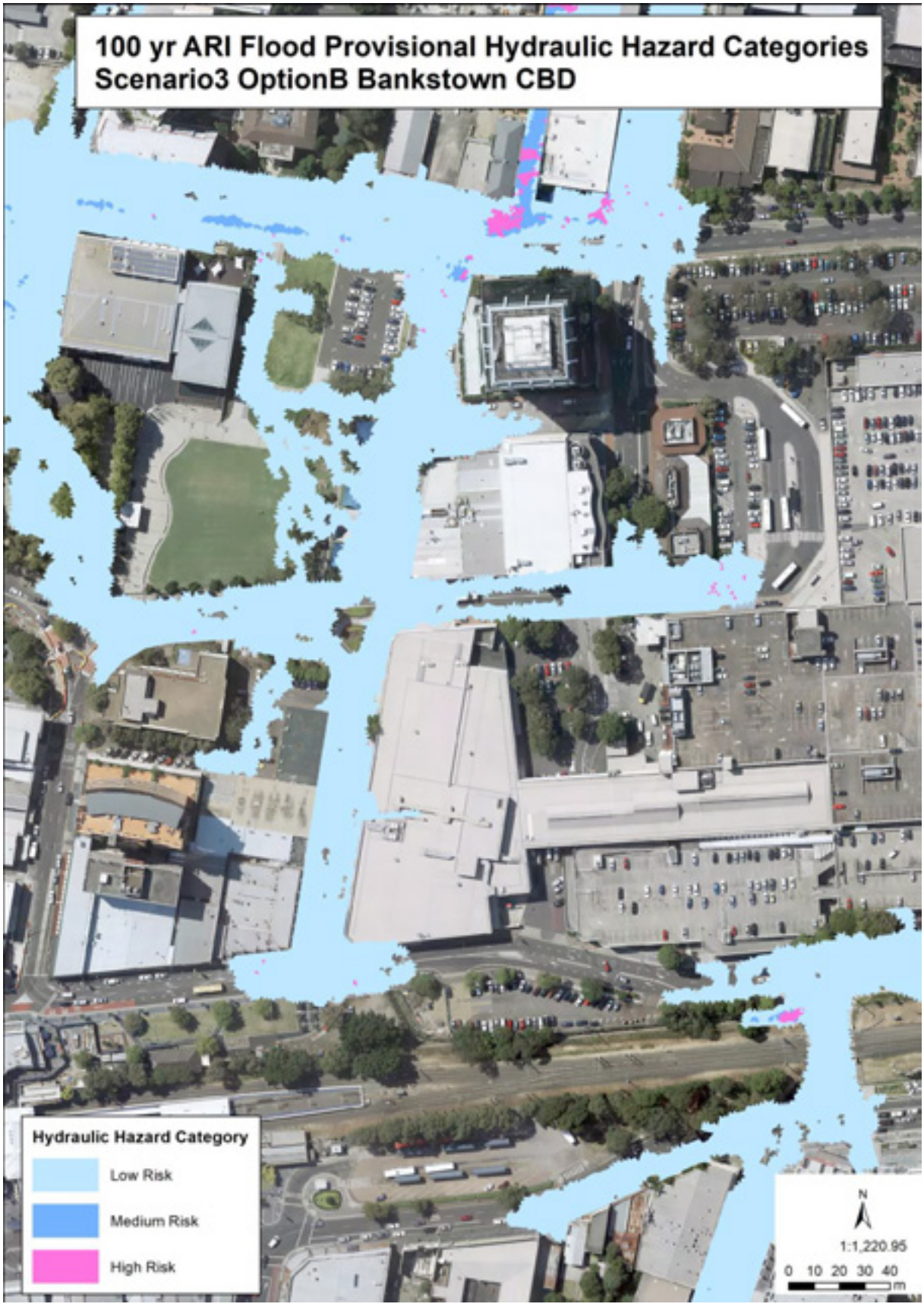

100 yr ARI Flood Velocity-Depth Product - Scenario1
Bankstown CBD
Rickard Road
Jacobs Street
The Mall
The Appian Way
Fetherstone Street
South Terrace
City Plaza
Max DxV
0.05 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.8
0.8 - 1
1 - 2
2 - 5
5 - 10
10 - 20
N
1:1,222.19
0 10 20 30 40
m


100 yr ARI Flood Provisional Hydraulic Hazard Categories
Scenario1
Bankstown CBD
Rickard Road
Jacobs Street
The Mall
Fetherstone Street
North Terrace
Terrace Lane
South Terrace
Hydraulic Hazard Category
Low Risk
Medium Risk
High Risk
N
1:1,218.53
0 10 20 30 40
m

A.2 Proposed design (Option B June 2020)



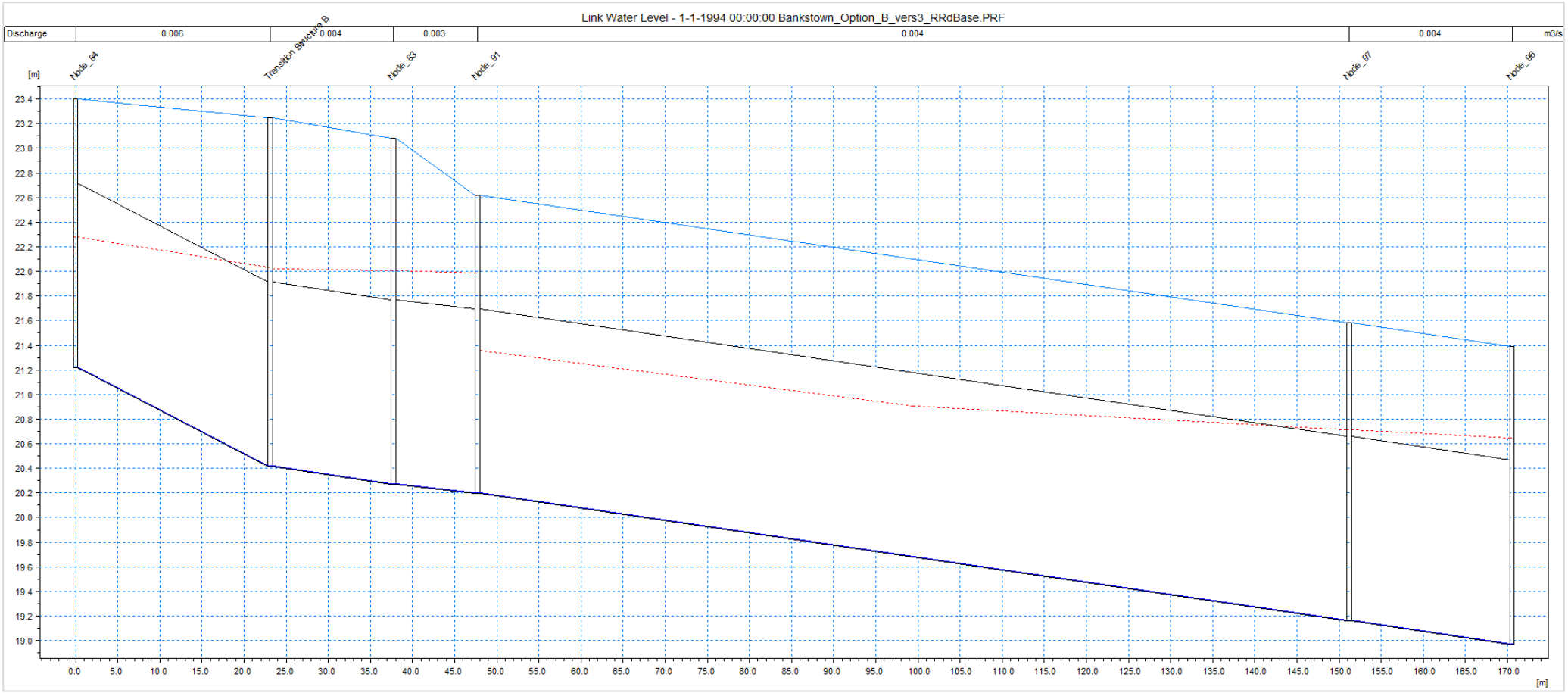

100 yr ARI Flood Velocity-Depth Map-
Option B Bankstown CBD
N
1:1 250
0 10 20 30 40
m
Max DxV
0.05 - 0.1000
0.1001 - 0.2000
0.2001 - 0.3000
0.3001 - 0.4000
0.4001 - 0.5000
0.5001 - 0.6000
0.6001 - 0.8000
0.8001 - 1.0000
1.0001 - 2.0000
2.0001 - 5.0000
5.0001 - 10.0000
10.0001 - 20.0000
Jacobs Street
Banks Street
Rickard Rd
Jacobs Street
The Mall
The Appian Way
North Terrace
Terrace Lane
South Terrace


100 yr ARI Flood Provisional Hydraulic Hazard Categories
Scenario3 OptionB Bankstown CBD
Hydraulic Hazard Category
Low Risk
Medium Risk
High Risk
N
1:1,220.95
0 10 20 30 40
m

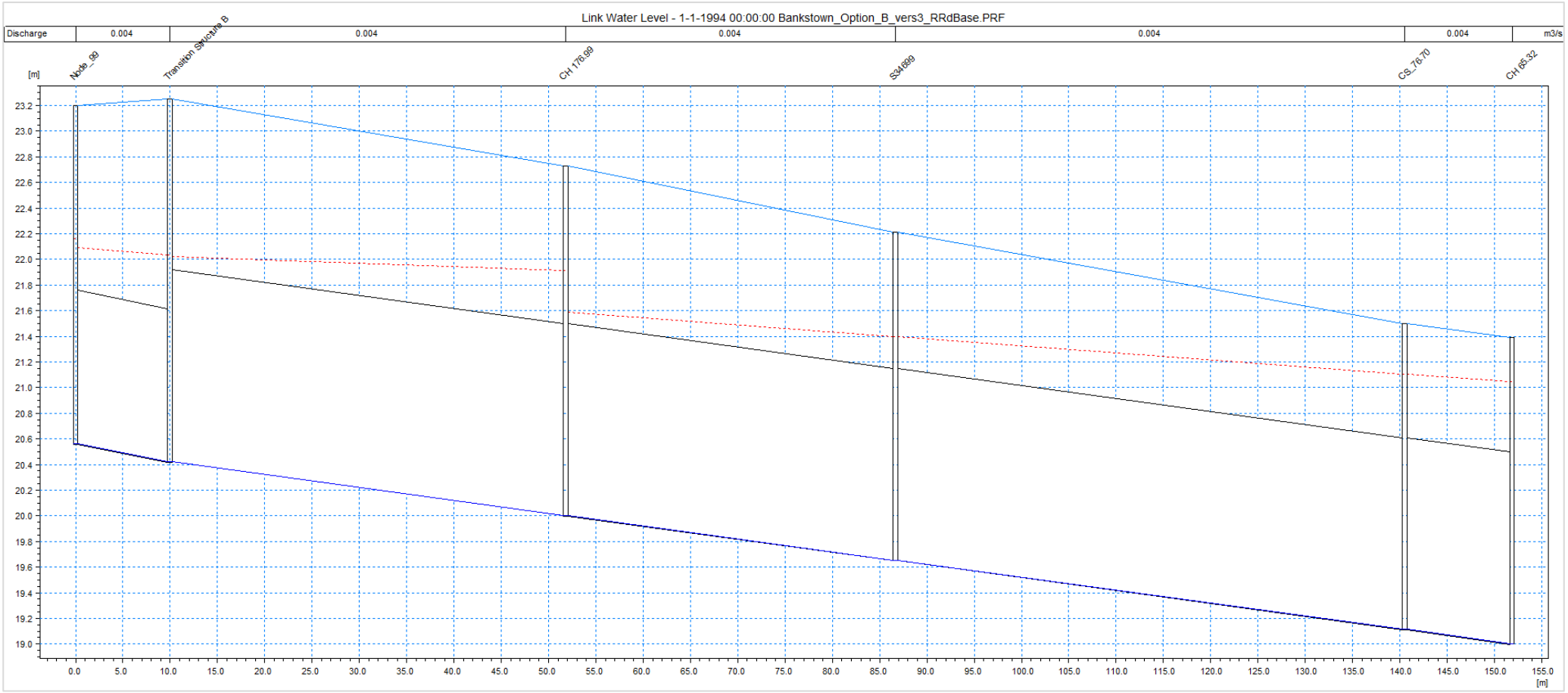
APPENDIX B – Longitudinal profile

B Longitudinal Profile of Main Culverts

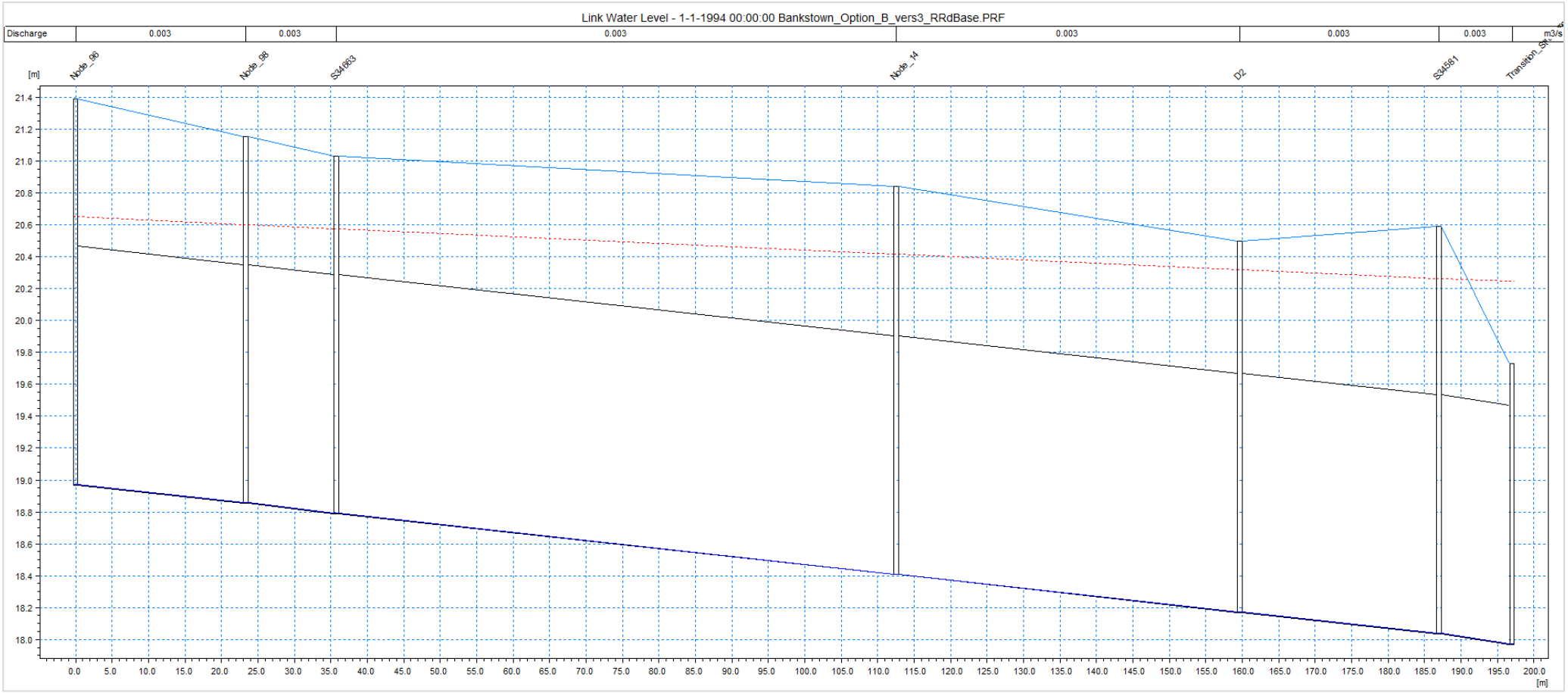
B.1 Eastern Twin Culvert along The Appian Way



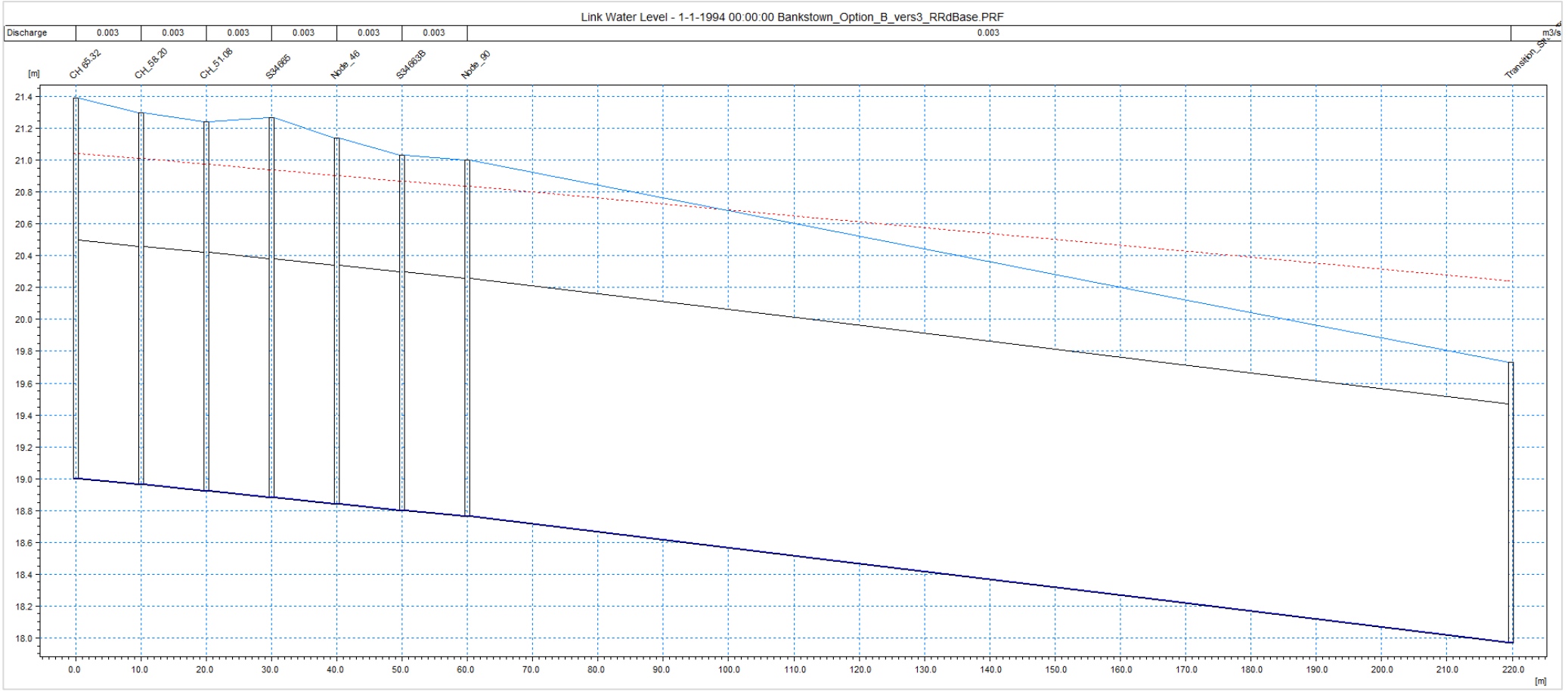
B.2 Western Twin Culvert along the Appian Way



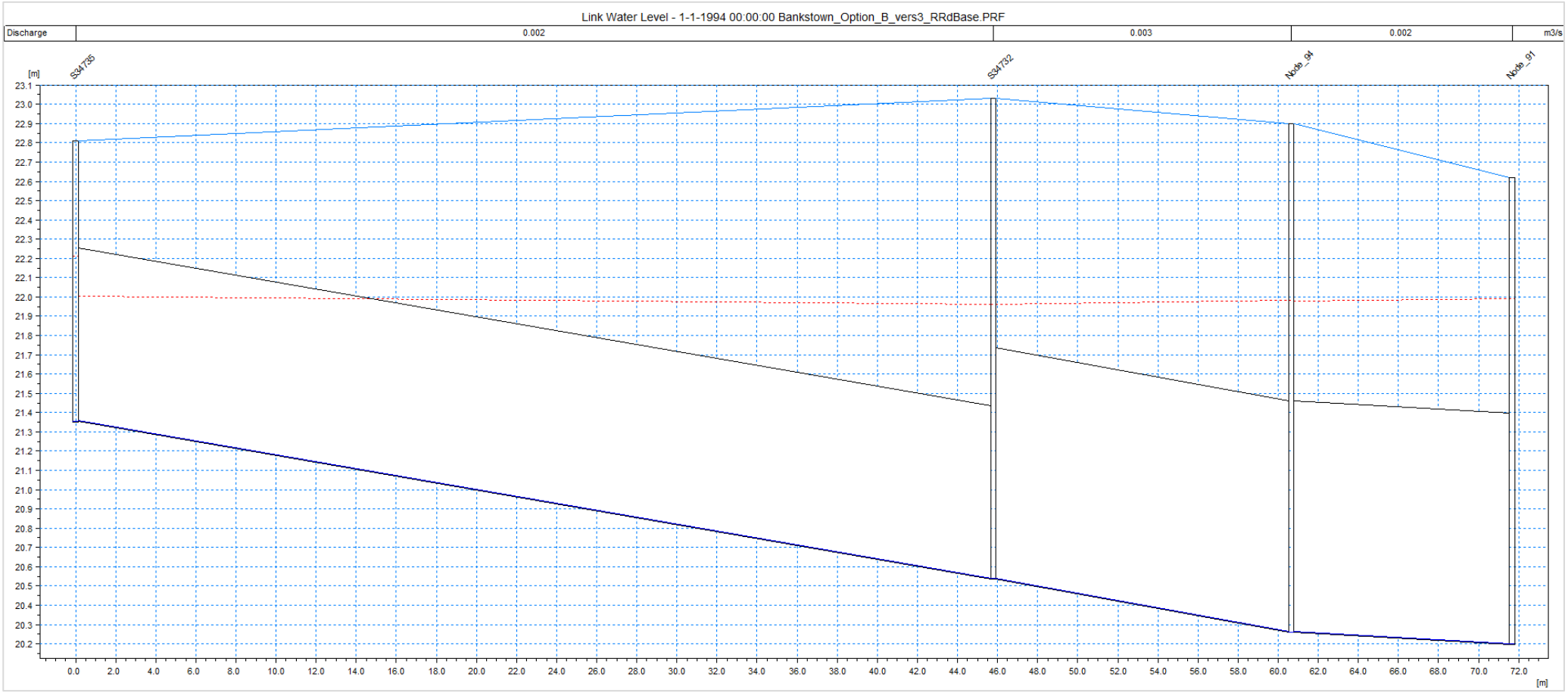
B.3 Eastern twin culvert along North Terrace



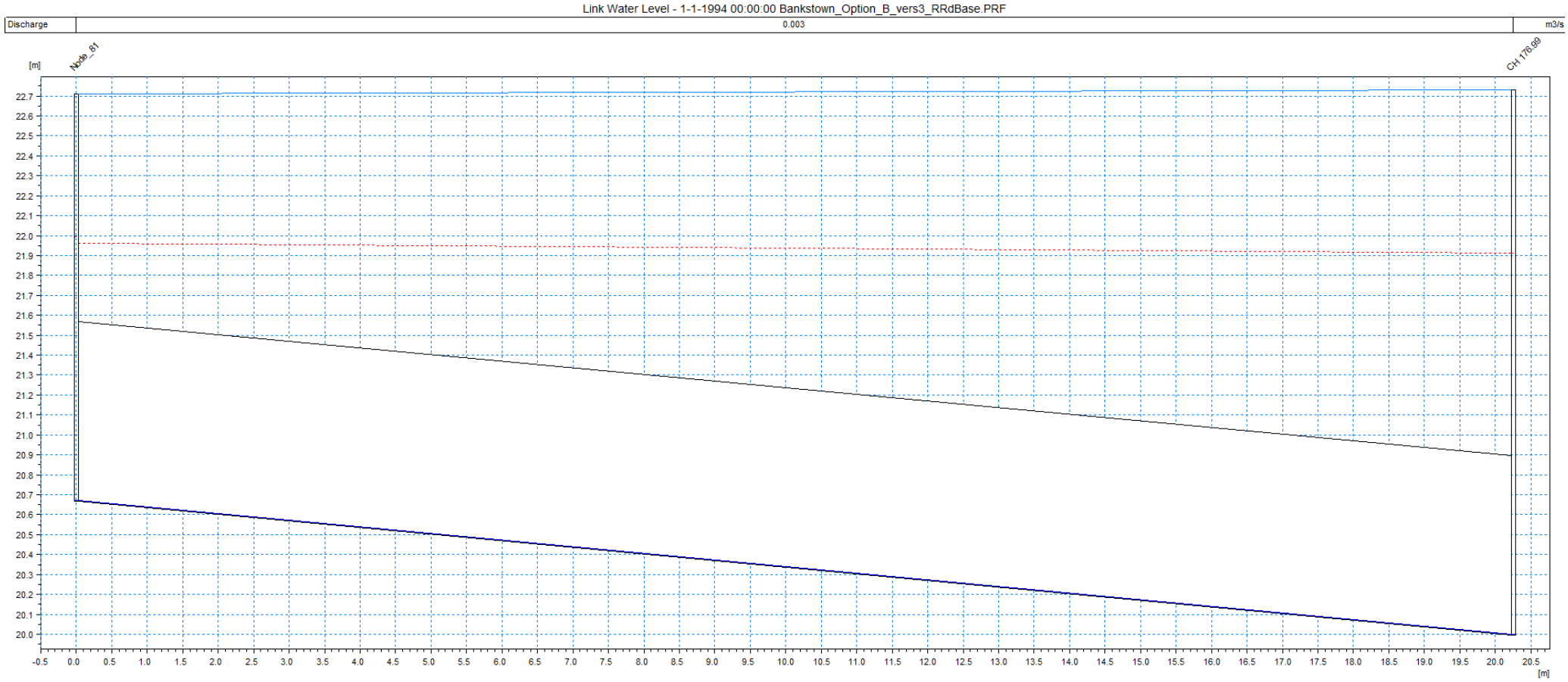
B.4 Western twin culvert along North Terrace



B.5 New culvert in the Mall east of The Appian Way



B.6 New culvert in the Mall west of The Appian Way



APPENDIX C – Estimation of pit sizing

C Estimation of pit sizing

				PARAMETERS		SIZING				
LOCATION	ID	GROUPED ID	DESIGN PIT ID	MODELLED INFLOW	MODELLED SURFACE WATER DEPTH	LINTEL	DESIGN GRATE	DESIGN DEPTH	DESIGN INFLOW	COMMENTS
				(m^3/s)	(m)	(m)	(m x m)(W x L)	(m)	(m^3/s)	
North Terrace (North)		S34664 + S34663 + Node_98	PA6	0,4	0,3	1 x 3.6	0.45 x 0.9	0,16	0,43	Single Combined Kerb Inlet with Standard Grate Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
North Terrace (South)	Node_60		PA4	1,0	0,3	1 x 4.8	0.45 x 2.7	0,25	1,06	Single Combined Kerb Inlet with Extended Grate (or Trench Drain) Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
North Terrace (South)		Node_89 + Node_90	PA5	0,2	0,3	1 x 3.6	0.45 x 0.9	0,16	0,43	Single Combined Kerb Inlet with Standard Grate Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
North Terrace (North)	Node_8	Node_8	PA7	0,0	0,0	1 x 3.0	0.45 x 0.9	0,16	0,39	Single Combined Kerb Inlet with Standard Grate Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
North Terrace (North)	D1	D1	PA8	0,0	0,0	1 x 3.0	0.45 x 0.9	0,16	0,39	Single Combined Kerb Inlet with Standard Grate Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
The Mall (North)	S34704	S34704	1 x Existing Pit	0,4	0,3	1 x 3.6	0.45 x 0.9	0,16	0,43	Single Combined Kerb Inlet with Standard Grate Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
The Mall (South)	S34703	S34703	1 x Existing Pit	0,1	0,3	1 x 3.0	0.45 x 0.9	0,16	0,39	Single Combined Kerb Inlet with Standard Grate Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
The Mall (South)		TheMallInlet + Node_76	PD1 + 2 x Existing Pits (3 Pits Total)	1,1	0,3	3 x 3.0	3 x 0.45 x 0.9	0,16	1,14	Triple Combined Kerb Inlets with Standard Grates Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
The Mall (South)	Link_99	Link_99	A1	0.8 (2.6 across The Appian Way U/S of the pit as an upper intake limit)	0,3	0	2.5 x 2.50	0,35	2,70	Single Surface Inlet with Raised Surround to allow for 300mm ponding Grate: Reticuline grate with 60% opening area Blockage: Grate (50%)
The Mall (South)	Link_99	Link_99	A1 ALTERNATIVE ARRANGEMENT	0.8 (2.6 across The Appian Way U/S of the pit as an upper intake limit)	0,3	4 x 2.5	0	0,35	2,38	Alternative letterbox type inlet with lintel slots around the base of planter box siting on a chamber opening (i.e without the grate) . Slot height: 200mm Blockage: Lintel slot (20%)
The Mall (North)	S34728	S34728	PA1	0,1	0,3	1 x 3.0	0.45 x 0.9	0,16	0,39	Single Combined Kerb Inlet with Standard Grate Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
The Mall (North)	Node_7	Node_7	PE3	0,1	0,3	1 x 3.0	0.45 x 0.9	0,16	0,39	Single Combined Kerb Inlet with Standard Grate Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
The Mall (South)	S34726	S34726	PA1	0,1	0,3	1 x 3.0	0.45 x 0.9	0,16	0,39	Single Combined Kerb Inlet with Standard Grate Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
The Mall (South)	S34733	S34733	PE2	0,1	0,3	1 x 3.0	0.45 x 0.9	0,16	0,39	Single Combined Kerb Inlet with Standard Grate Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
The Mall (South)	S34734	S34734	1 x Existing Pit	0,1	0,3	1 x 3.0	0.45 x 0.9	0,16	0,39	Single Combined Kerb Inlet with Standard Grate Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
The Mall (South)	S34735	S34735	E2	1,5	0,3	1 x 4.8	0.9 x 2.7	0,30	1,75	Single Combined Kerb Inlet with Extended Grate (or Trench Drain) Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)
The Mall (South)	S34735	S34735	E2 ALTERNATIVE	1,5	0,3	2 x 4.8	2 x .0.45 x 0.9	0,30	1,55	Dual Combined Kerb Inlets with Standard Grates Grate: Reticuline grate with 60% opening area Slot height: 100 mm at 80 degrees Blockage: Lintel slot (20%), Grate (50%)