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OSD Detailed SSD DA - STORMWATER MANAGEMENT PLAN AND FLOOD IMPACT ASSESSMENT

Victoria Cross Over Station Development

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Prepared For – Lendlease Building Pty Limited | ABN 97 000 098 162

OSD Detailed SSD DA - STORMWATER MANAGEMENT PLAN AND FLOOD IMPACT ASSESSMENT

Victoria Cross Over Station Development

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Changes made to this document since its last revision, which affect its scope or sense, are marked in the right margin by a vertical bar (|).

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Contents

Acronyms

Abbreviation	Description
AEP	Annual exceedance probability
AHD	Australian height datum
ARI	Average recurrence interval
ARR2016	Australian Rainfall and Runoff, 2016 Edition: A Guide to Flood Estimation
ARR1987	Australian Rainfall and Runoff, 1987 Edition: A Guide to Flood Estimation
BOM	Bureau of Meteorology
CCTV	Closed circuit television
CSSI	Critical State Significant Infrastructure
DDA	Disability Discrimination Act
EIS	Environmental Impact Statement
GFA	Gross floor area
IL	Invert level
FFL	Finished floor level
LEP	Local Environment Plan
LGA	Local government area
LoS	Level of Service
MGA	Map Grid Australia
NSW	New South Wales
NSW DPE	NSW Department of Planning and Environment
OSD	Over Station Development
PPE	Personal protective equipment
PMF	Probable maximum flood
RL	Reduced level
SEARs	Planning Secretary's Environmental Assessment Requirements
SSD	State Significant Development
SSD DA	State Significant Development (SSD) Development Application (DA)
SWTC	Scope of Works and Technical Criteria
TfNSW	Transport for NSW
TUFLOW	TUFLOW 2D/1D hydrodynamic modelling software

1. General

1.1 Introduction

This report has been prepared to accompany a detailed State Significant Development (SSD) development application (DA) for a commercial mixed-use Over Station Development (OSD) above the new Sydney Metro Victoria Cross Station. The detailed SSD DA is consistent with the Concept Approval (SSD 17_8874) granted for the maximum building envelope on the site, as proposed to be modified.

The Minister for Planning, or their delegate, is the consent authority for the SSD DA and this application is lodged with the NSW Department of Planning, Industry and Environment (NSW DPE) for assessment.

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 6th May 2019. Specifically, this report has been prepared to respond to the following SEARs:

Plans and Documents
'In addition, the EIS must include the following

- *Stormwater management plan'*

This report has also been prepared in response to the following condition of consent for the State Significant Development Concept (SSD 8874) for the OSD:

Flooding and Stormwater

B15. Future detailed development application(s) shall be accompanied by a Flood Impact Assessment

The detailed SSD DA seeks development consent for:

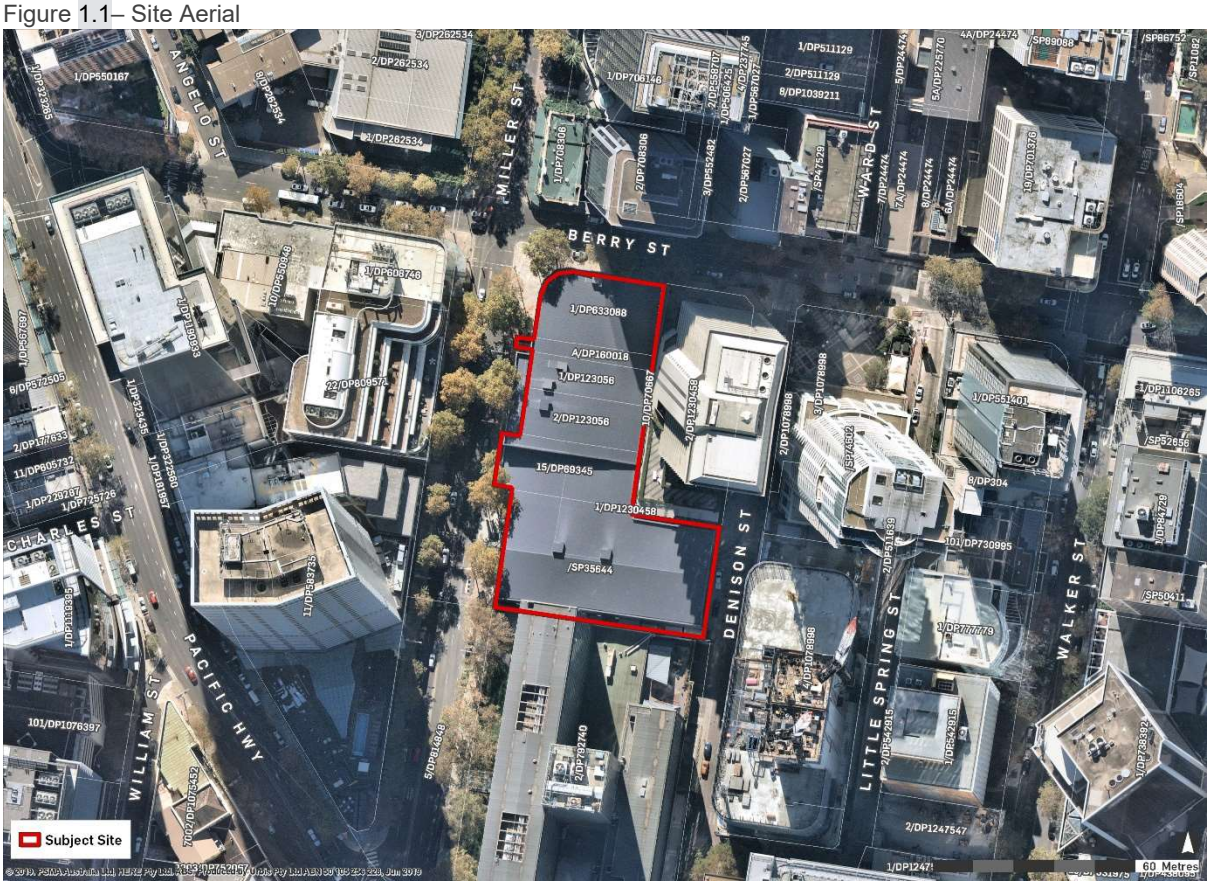
- Construction of a new commercial office tower with a maximum building height of RL 230 or 168 metres (approximately 42 storeys).
- The commercial tower includes a maximum GFA of approximately 61,500sqm, excluding floor space approved in the CSSI
- Integration with the approved CSSI proposal including though not limited to:
  - Structures, mechanical and electronic systems, and services; and
  - Vertical transfers;
- Use of spaces within the CSSI 'metro box' building envelope for the purposes of:
  - Retail tenancies;
  - Commercial office lobbies and space;
  - 161 car parking spaces within the basement for the purposes of the commercial office and retail use;
  - End of trip facilities; and
  - Loading and services access.
- Utilities and services provision.
- Signage locations (building identification signs).
- Stratum subdivision (staged).

1.2 The Site

The site is generally described as 155-167 Miller Street, 181 Miller Street, 187-189 Miller Street, and part of 65 Berry Street, North Sydney (the site). The site occupies various addresses/allotments and is legally described as follows:

- 155-167 Miller Street (SP 35644) (which incorporates lots 40 and 41 of Strata Plan 81092 and lots 37, 38 and 39 of Strata Plan 79612)
- 181 Miller Street (Lot 15/DP 69345, Lot 1 & 2/DP 123056, Lot 10/DP 70667)
- 187 Miller Street (Lot A/DP 160018)
- 189 Miller Street (Lot 1/DP 633088)
- Formerly part 65 Berry Street (Lot 1/DP 1230458)

Figure 1.1– Site Aerial



1.3 Sydney Metro Description

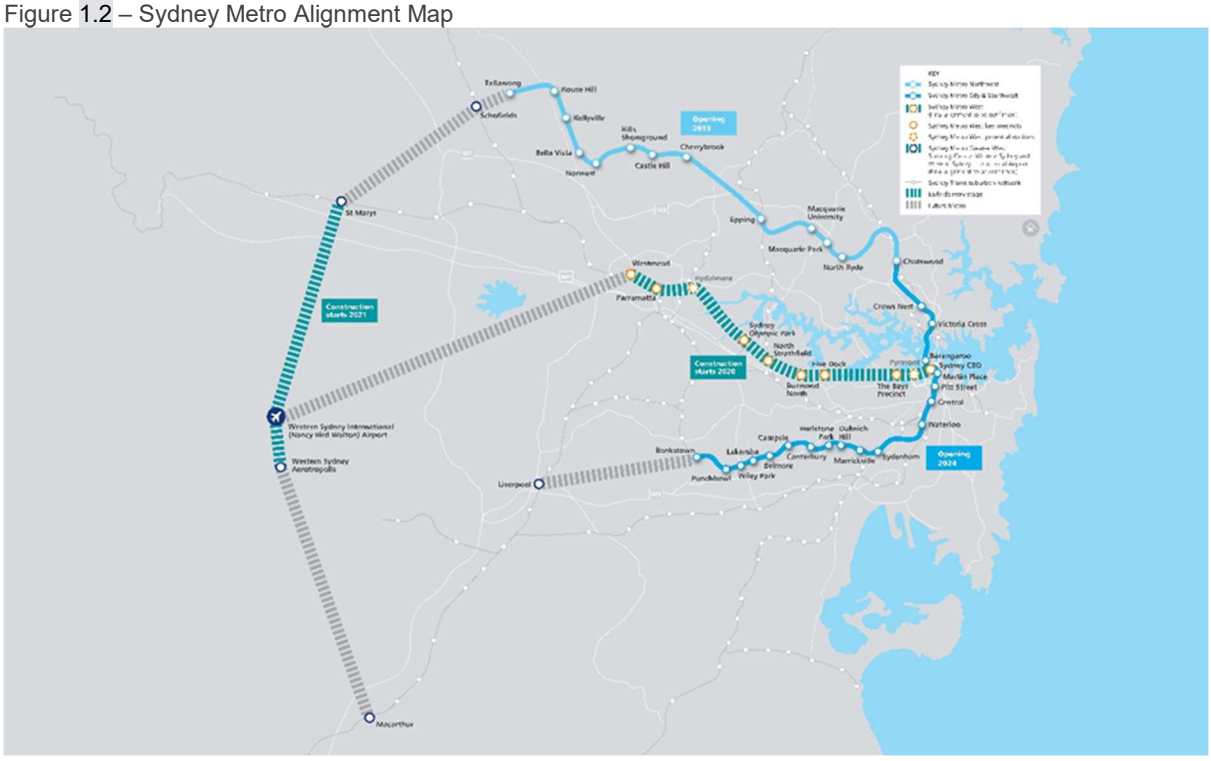
Sydney Metro is Australia's biggest public transport project. Services started in May 2019 in the city's North West with a train every four minutes in the peak. Metro rail will be extended into the CBD and beyond to Bankstown in 2024. There will be new metro railway stations underground at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, Waterloo and new metro platforms under Central.

In 2024, Sydney will have 31 metro railway stations and a 66 km standalone metro railway system – the biggest urban rail project in Australian history. There will be ultimate capacity for a metro train every two minutes in each direction under the Sydney city centre. The Sydney Metro project is illustrated in the Figure below.

On 9 January 2017, the Minister for Planning approved the Sydney Metro City & Southwest - Chatswood to Sydenham project as a Critical State Significant Infrastructure project (reference SSI 15_7400) (CSSI Approval). The terms of the CSSI Approval includes all works required to construct the Sydney Metro Victoria Cross Station, including the demolition of existing buildings and structures on both sites. The CSSI Approval also includes construction of below and above ground improvements with the metro station structure for appropriate integration with the OSD.

With regards to CSSI related works, any changes to the "metro box envelope" and public domain will be pursued in satisfaction of the CSSI conditions of approval and do not form part of the scope of the detailed SSD DA for the OSD.

Figure 1.2 – Sydney Metro Alignment Map



Source: Sydney Metro

1.4 Victoria Cross ISD (south) Development

This report relates to the stormwater management works associated with a commercial Over Station Development (OSD) above the new Sydney Metro Victoria Cross ISD (south) site i.e. the site with frontage to Miller Street, Berry Street and Denison Street.
The Victoria Cross (north) site with frontage to Miller Street and McLaren Street, does not incorporate an OSD. The stormwater aspects for this site are addressed separately.

2. Technical and Environmental Requirements

2.1 Overview and Hierarchy

In accordance with Sydney metro's requirements, the hierarchy of the codes and standards will be as follows:

(i) Acts and secondary legislation;
(ii) TfNSW and other NSW Government agencies' documents and standards as listed in this Appendix. These include ASA, RMS, NSW EPA, Sydney Buses, etc.
(iii) Australian Standards and Guidelines (AS, AS/NZS, Austroads, Engineers Australia, ISCA, etc.);
(iv) International Standards (ISO, IEC, IEEE, CENELEC, ITU, etc.);
(v) European Norms (EN, TSI); and
(vi) Other relevant International standards, which must be reviewed by TfNSW and approved by the Independent Certifier prior to use.

More specifically, the Victoria Cross station must consider overland flows paths and protection from flooding. In this regard the following specific requirements apply: -

As stated in SWTC Appendix B2- Civil and Structural works section 2.9:

- The drainage systems for the works must limit the effect on the groundwater regime such that there is no adverse effect on the natural or built environment key beyond that permitted by Environment Documents.

- Overland flow paths to convey major flows up to 100-year ARI design storm event must be provided in accordance with the NSW Floodplain Development Manual (2005) and the relevant Council standards.

As stated in SWTC Appendix B2, Section 2.3.4-Flood protection:

(a) The threshold level of all entrances, ventilation openings, tunnel portals and other openings into underground railway infrastructure must be set:

(i) above the probable maximum flood (PMF) level; and
(ii) at least 300 mm higher (crest protection) than the surrounding finished ground level or sufficient to prevent local flash flooding entering the underground structures. At the Station entrances, this requirement must be met by sloping the surface away from the threshold and not by a step.

(b) Where drainage or sewerage pipes discharge from the underground structure into the surface system, swan necks must be provided at a level above the PMF level.

(c) If gravity drainage provisions are made, the drainage exit points must be above the PMF level to prevent any back flow of water into the sub-surface structures during floods.

Additionally, as required the Standards, Guidelines, Technical Requirements and Development Control Plan of North Sydney Council are utilised for elements of the Public Domain design.

3. Salient Flood Studies and Reports

3.1 Appendix T of the EIS for the approved Concept SSD Application (16 May 2018)

A previous flood assessment and stormwater management report for the Victoria Cross Over Station Development, was prepared for Sydney Metro by AECOM. The AECOM report dated 16 May 2018, is contained in Appendix T of the Environmental Impact Statement for the concept SSD Application and was prepared in response to the Secretary's Environmental Assessment Requirements (SEARs) issued for the concept SSD Application. The AECOM report is contained in **Appendix B** of this report as it provides some background information relevant to the flooding and stormwater management aspects of the project. Selected items of interest are discussed below in sections 3.2 and 3.3.

3.2 North Sydney LGA Flood Study (2017)

In February 2017, North Sydney Council released the North Sydney LGA Flood Study, which was undertaken by WMA water. The aim of the study was to assist Council in satisfying their responsibilities for managing flood risk within the LGA. The flood study was prepared to define existing flood behaviour in the North Sydney LGA 10.9 km^2 catchment area and to establish the basis for subsequent floodplain management activities. The study incorporates key elements specific to the Victoria Cross OSD site including:

- Compilation and review of existing information;
- Review of previous flooding history; and
- Defines the flood behavior for a range of design events including the 20%, 10% and 1% AEP, and the Probable Maximum Flood (PMF) event.

It should be noted that the Council Flood Study was undertaken over the entire North Sydney LGA region and did not consider pipe elements smaller than 450mm. As such, the results of the study may not have provided a definitive flood level for the site area.

Flow estimates within Council's model were based on ARR1987 methodology using the ILSAX program.

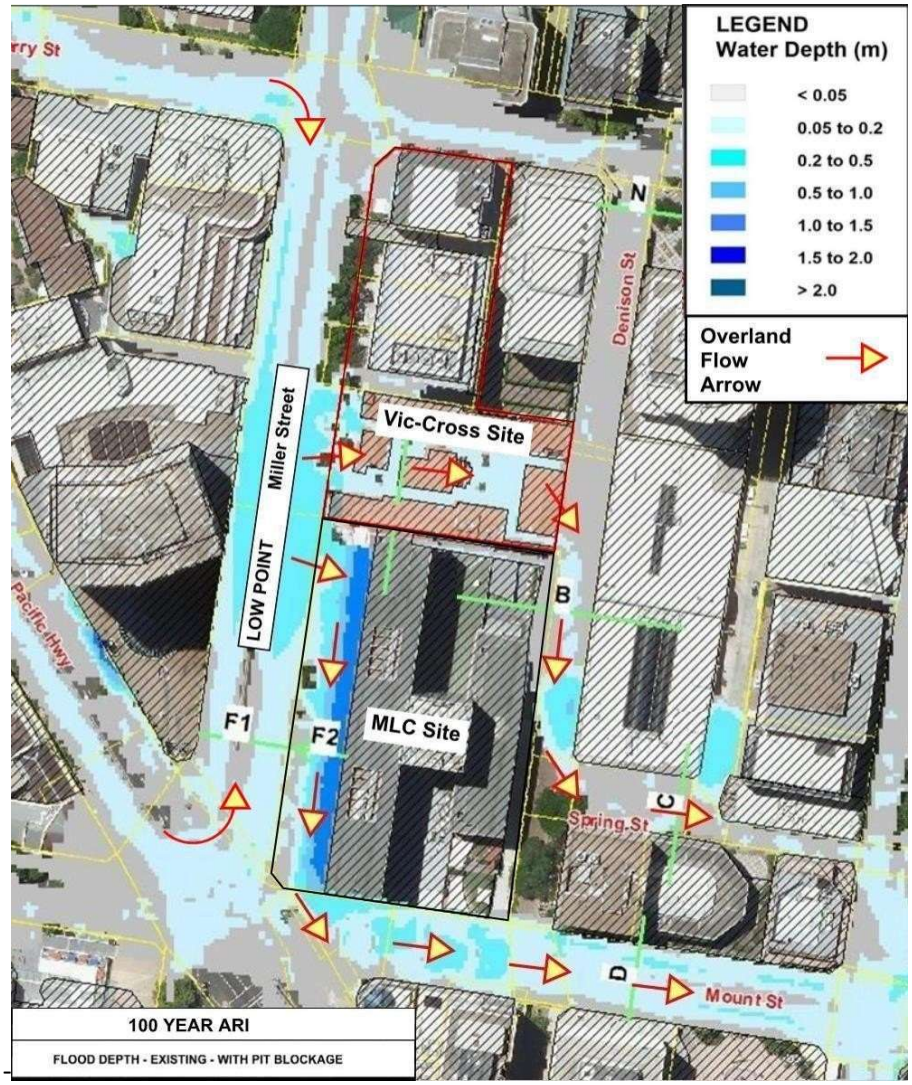
3.3 Preliminary Victoria Cross ISD Flood Modelling Strategy by Sydney Metro

A preliminary flood assessment was undertaken by Sydney Metro during the Design Stage 1 (Approved Concept SSDA design) based on the 2017 Council Flood Model as this model comprised the most up to date, comprehensive and appropriate tool available for this purpose. The assessment confirmed that the site is located in a flood affected area, noting that the previous building courtyard at Tower Square (now demolished under the terms of the CSSI Approval) provided informal flood storage during major storms greater than the 5year ARI event.

The Design Stage 1 (Approved Concept SSDA design) design refined Council's flood model to provide greater detail within the area of interest and in consultation with North Sydney Council and with Sydney Water, developed a preliminary flood management strategy for the Victoria Cross ISD, the salient points of which were as follows:

1. Pre-developed Scenario: The Victoria Cross (south) re-development site and the adjoining MLC site are located at a low point in Miller Street (approximately mid-block between Mount Street and Berry Street). Stormwater runoff collects at this low point and during larger storm events the water discharges through the two properties to the downstream street network.
    - Stormwater flows overland through the Victoria Cross (south) site and via an existing (Sydney Water) trunk stormwater line from Miller Street to Denison Street / Spring Street.
    - Stormwater flows overland only through the adjoining MLC site from Miller Street to Mount Street.

Figure 3.1 – Marked up extract from Figure A1.5 of "Victoria Cross Flood Management Addendum – Incorporating Sydney Water Requirements and Potential Design Options – Stage 1 USDTS" (Doc no. NWRLSRT-MET-SVC-CE-REP-000005 Rev P02) prepared by Metron (April2018).



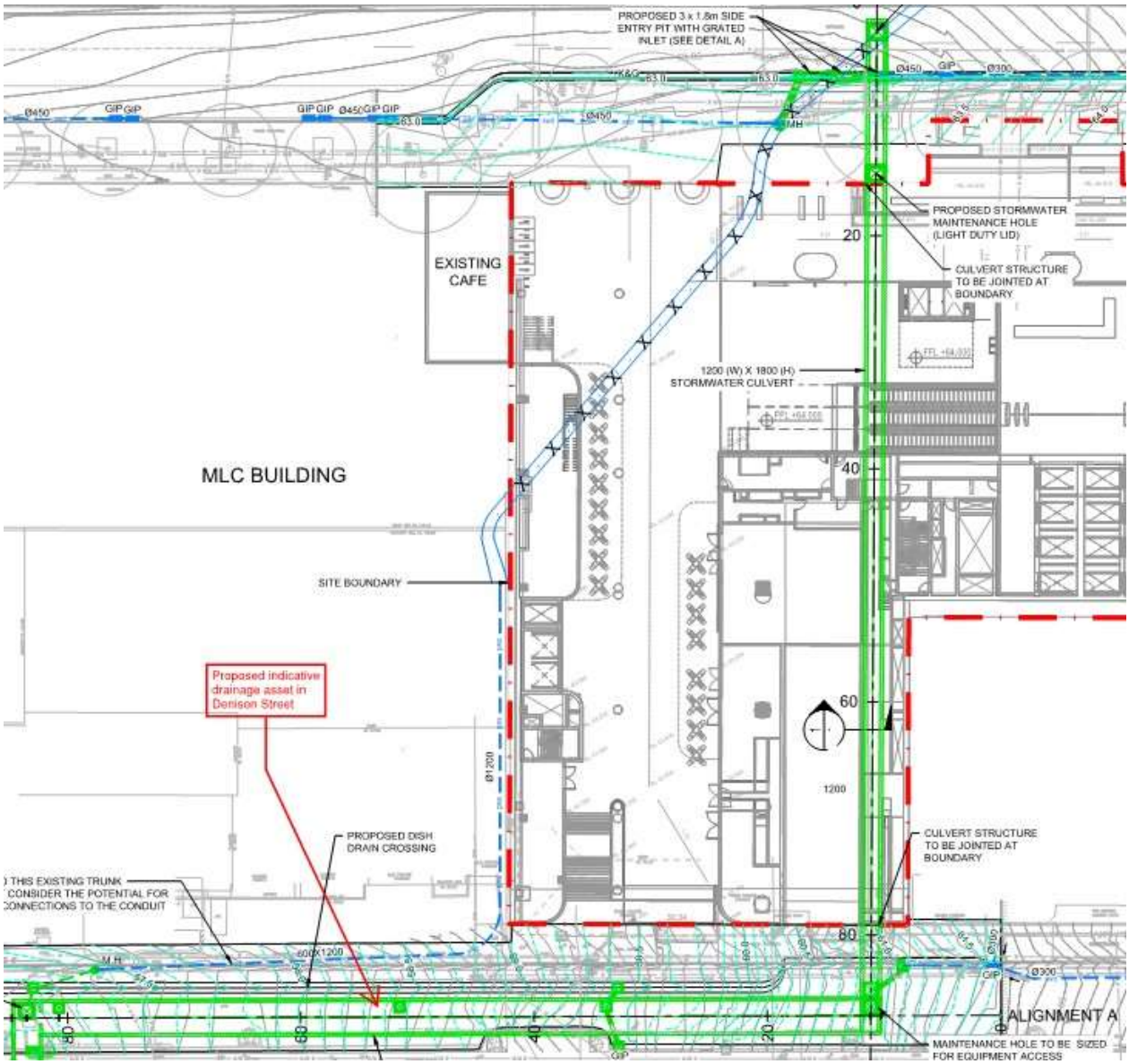
2. Sydney Metro's preliminary flood management strategy was:
   (a) to prevent flood water in Miller Street from entering the Miller Street entrance of Victoria Cross (south) i.e. entering the pedestrian through-site link, for all storm events up to and including the 100 year ARI. This was to be achieved by conveying the total flow that previously discharged through the site (via a trunk stormwater pipe and via overland flow), through a new up-sized and re-aligned trunk stormwater conduit only i.e. with no associated overland flow through the site. This strategy required the augmentation of Council's pit and pipe infrastructure in Miller Street and the introduction of detention storage in Denison Street to mitigate adverse impacts associated with the consequential changes to storage and flow regimes, and
   (b) to allow stormwater flows from all storm events that exceed a 100 year ARI to pass safely through the building.

3. Compensatory flood storage in Denison Street

Previous investigations and flood modelling by Sydney Metro indicated that for floods greater than a 5 year ARI (approximately a 20% AEP), the pre-developed layout of the project site (buildings, walkways, stairs etc) caused water to be detained (stored temporarily) within the site. This resulted in the attenuation of the peak flows through the site. The Design Stage 1 (Approved Concept SSDA Design) proposed that compensatory storage be included in the Sydney Water trunk main in Denison Street to offset the loss of flood storage and the consequential impact on flows.

"The preliminary location for the compensatory flood storage was proposed below ground in Denison Street as shown in Figure 3.2 below. It is noted that the proposed location was indicative only and subject to further design development in consultation with Sydney Water and Council." (Page 22 of Appendix T of EIS for the concept SSD Application)

Figure 3.2 – Extract from Appendix T of the Environmental Impact Statement for the concept SSD Application – Figure 12 Indicative compensatory flood storage. Source: Sydney Metro.



4. Proposed Compensatory Flood Storage in Miller Street

Figure 3.2 (above) shows the preliminary design (developed by Sydney Metro) for diverting the existing Sydney Water trunk main through the project site and incorporating compensatory flood storage in Denison Street.

Following discussions with North Sydney Council and with Sydney Water, a modification to the Design Stage 1 (Approved Concept SSDA Design) strategy has been developed, whereby the proposed storage is located in the verge in Miller Street instead of in the roadway in Denison Street. The re-design of the storage allows a smaller (1650mm dia pipe) stormwater system in Denison street to be installed which will connect into 1 Denison Street. The stormwater results in this report are based on this modification to the Design Stage 1 (Approved Concept SSDA Design).

Surface runoff will be collected by a series of Council owned existing and new stormwater inlet pits along the Miller Street kerb alignment and directed into the proposed new stormwater storage tank in the Miller Street verge before discharging into the re-aligned Sydney Water trunk main and continuing downstream through the site.

The benefits associated with locating the stormwater storage facility in the Miller Street verge rather than within Denison Street, include but are not limited to:

- minimising construction issues relating to potential clashes with existing utility services (high pressure gas and high voltage electrical services in Denison Street);
- minimising construction risks associated with deep excavations. The Stage 1 culvert storage option would have required an excavation that was up to 6m deep and a minimum of 3m wide whereas the proposed stormwater system can be laid at grade at reduced depth;
- minimising construction timing (phasing and coordination issues) and road closure;
- removal of flow restrictions such as the orifice in the Denison Street storage and restricted connection to 1 Denison Street;
- stormwater is collected and stored at the source rather than using up space in the culvert through the site,
- additional pits can be installed to collect stormwater at Miller Street without affecting the through site conveyance,
- safe future access to the storage tank which does not require road closure,
- improved hydraulic efficiency by providing curved bends (lobster back) to the Denison Street system,
- significantly greater storage volume (approx. 400m^3 in Miller Street verge vs 190m^3 in Denison Street).

Flood modelling using TUFLOW indicates that the Miller Street compensatory storage option is satisfactory in mitigating potential impacts within a reasonable tolerance on surrounding properties, see section 4.4 and Appendix A below for details on the flood impacts of the development. The details of the flood modelling undertaken to date are discussed below in section 4.1.

4.1 Flood Modelling - Miller Street Storage Option

North Sydney Council made available the 1D/2D TUFLOW models for:

- the 1 Denison Street development;
- the Metron Model; and
- the full catchment model

for use by ArcMac on the Victoria Cross ISD project. ArcMac understood from a meeting with Council, that these models were the result of refinements to the North Sydney LGA Flood Study (2017) model and represent the most accurate and complete information available.

Information obtained from the 1 Denison Street model included:

- possible future re-grading of Denison Street (.xml file);
- building layouts within the 1 Denison Street site;
- inclusion of a flood gate across the pedestrian through-site link which extends from Denison Street to Little Spring Street;
- amendment of the size of the Sydney Water culvert through the 1 Denison Street development site from a 1350mm dia stormwater pipe to a 1.8m wide x 1.6m high box culvert; and
- incorporation of a possible future pit and pipe stormwater drainage works in Denison Street and in Little Spring Street.

The Design Stage 1 model was updated to include:

(a) the above listed information obtained from the 1 Denison Street model, and

(b) the following list of amendments,

- the area of interest has been extended to the north of McLaren Street to include the area around the Victoria Cross ISD (north) site;
- a 10% increase in rainfall intensity to allow for potential future changes in climate (as specified by Sydney Metro's requirements), topography, flow paths or other factors that could impact on the behavior of future floods (for details of the flood hydrology refer to section 7 of this report);
- gaps in the Miller Street median fronting the project site (3 No. x 0.5m wide median openings);
- update the existing pit and pipe layout in Miller Street (particularly in front of the MLC site);

4.2 Pre-developed and post-developed Scenarios

1. Base Case

The resulting flood model, which incorporates the best available information regarding the existing or (it is assumed) soon to be existing street and drainage infrastructure (i.e. in Denison Street and in Miller Street) has been adopted as the *pre-developed* or *existing* condition and is referred to as the "Base Condition" for the purposes of this stormwater management plan to progress the development of the design. Note that future design stages will incorporate detailed survey as it becomes available to confirm the assumptions this analysis is based on.

2. Post Development

The post-developed scenario incorporates:

- an 8m gap in the Miller Street median in front of the project site, on the assumption that it will be needed to accommodate a new signalised pedestrian crossing in this location;
- changes to site geometry and to relevant stormwater infrastructure, within and without the site;
- a minimum 7.5m wide pedestrian through-site link fronting the retail spaces - Miller Street level and Denison Street level;
- a pool fence with 50% blockage at the eastern (downstream) end of the 7.5m wide pedestrian through-site link (Miller Street level);

- a stair case from the Miller Street level to the Denison Street level at the eastern end of the 7.5m

wide pedestrian through-site link, on the southern side of the pedestrian link;
- proposed amendments to Council's pit and pipe network and to Sydney Water's trunk drainage infrastructure as described in previous sections;
- considered grading of 7.5m wide pedestrian through-site link to 63.6m AHD to manage overland flow in events larger than the 1% AEP in the context of level of hazard;
- grading the finished surface of the pavement at the Denison Street entrance to provide a crest level which prevents flood waters entering the building;
- reconfigured layout of the retail premises fronting Denison Street to provide improved flow from the Miller Street through-site link and stairs to Denison Street in events greater than 1% AEP;
- updated finished surface modelling of both the existing and proposed pavement surfaces at the entrance to the northern building.

4.3 Flood model for the pedestrian link

A Separate TUFLOW model has been established to analyse the flood behaviour in the pedestrian link on the Denison Street level in the PMF event. The reasons to build a separate model are as follows:
- The 3.5m level difference (drop) from Miller Street to Denison Street introduces unknown instability errors in TUFLOW;
- The current model can only reflect the eastwards flow; the direction of flow on the pedestrian link would be Miller Street level -> drop-> Denison Street Level, and finally the flow is discharged to Denison Street. However, when flood drops on the Denison Street level, there is a chance that flood may go westwards and may enter the entrance on Denison Street level.
- The methodology of modelling the drop in 1D introduced mass balance errors in TUFLOW.

Considering these factors and the critical nature of the design area, a separate flood model of the pedestrian link on the Denison Street level has been established. The purpose of this separate model is to accurately model the flood behaviour when the flood water drops from Miller Street level to Denison Street level on the pedestrian link and to provide reliable flood levels on the entrance of Denison Street. The model has following key configurations:
- The model extent covers the pedestrian link on the Denison Street level and part of Denison Street;
- The flow upstream of the fence and flow downstream of the staircase have been extracted from the overall site model and have been applied to the corresponding areas on the pedestrian link;
- Detailed topography design on the pedestrian link on Denison Street level has been adopted to test whether the crest has been overtopped or not in the PMF event;
- 0.5m cell size has been adopted

The model extent and flood depth for the PMF on the Denison Street level have been documented in Appendix A – Flood Maps.

4.4 Flood Modelling Results

The results of preliminary modelling of the Miller Street Storage option (as shown on the attached Drawings) are documented in Appendix A – Flood Maps. Tabulated results are contained in Table 4.1 for overland flows and Table 4.2 for conduit flows.

Table No. 4.1 – Overland Flows

		Overland Flows m³/ sec								
		A	B	C	D	E	F1	F2	M	N
Event	Condition							MLC		

		Subject Site	Denison Street	Spring Street	Mount Street	Denison Street	Miller Street	Site	Miller Street	Denison Street
100yr	Base Case	0.53	0.54	0.48	5.49	0.00	1.51	3.79	4.26	0.01
	Post Developed	0.00	0.18	0.27	5.15	0.00	1.51	3.15	4.23	0.01
PMF	Base Case	6.06	6.62	8.62	24.65	1.86	4.63	8.11	18.93	0.36
	Post Developed	3.78	5.40	8.18	24.39	1.88	5.88	7.17	18.93	0.37

Refer to Appendix A - Flood Maps, for locations.
Pit blockage factors adopted in the area of interest (to meet council requirements) were:

- *50% blockage for sag pits, and*
- *30% blockage for on-grade pits (note this is greater than council's specified value of 20% to maintain consistency wit the Stage 1 design methodology)*

Table No. 4.2 – Conduit Flows

Event	Condition	Conduit Flow m_3 / sec		
		Sydney Water Trunk Drainage		
		Crossing Miller Street	Through Subject Site	Through 1 Denison Street
100yr	Base Case	1.83	3.31	3.98
	Post Developed	1.76	4.41	4.99
PMF	Base Case	2.67	4.76	6.17
	Post Developed	2.82	6.41	7.27

Table No. 4.3 – Peak Flood Levels

Event	Condition	Peak Flood Levels (m AHD)		
		G1	G2	X1
		Miller Street	Entrance to Escalator	Denison Street
100yr	Base Case	63.42		57.62
	Post Developed	63.40		57.59
PMF	Base Case	64.16		57.93
	Post Developed	64.17	64.15	57.92

4.4 Discussion

1 100year ARI Flood

- TUFLOW results indicate that the 100year ARI flood level in Miller Street for the post developed case remains comparable to the level calculated for the base case, any increases in depth generally do not exceed 10mm, except for isolated areas on Miller Street, Denison Street, Mount Street and around the northern buildings, where the flood level increase is less than 20mm.
- A minor decrease in flood level occurs in Denison Street.
- 100 year ARI flood water does not flow through the pedestrian through-site link from Miller Street to Denison Street with a pedestrian link width of 7.5m and a walk-way level of 63.6m AHD.
- In the north entrance, the flood level stays comparable between the base case and post-development scenario.

2 PMF Flood

TUFLOW results indicate minor afflux (flood level increase) during a PMF event. Most of the afflux is less than 50mm and located on Berry Street, Spring Street, Mount Street and around the northern buildings. There are a few spots where the afflux is between 50mm and 100mm, these locations are on Miller Street and Denison Street and a few isolated patched around the northern buildings. The afflux map of the PMF has been documented in Appendix E. However, the magnitude of increase is comparable with the flood modelling results obtained previously by the Design Stage 1 (Approved Concept SSDA Design) team.

A check for flood ingress into the station entries has been undertaken to confirm all entrances, openings, voids or paths from the street level to the station are protected from flood ingress in all storm events up to and including the PMF, refer to section 5.2 for further details.

Salient outcomes of the flood modelling carried out to date are:

- The vertical drop from the Miller Street level to the Denison Street level provides significant complexities to accurately model. A separate (focused) TUFLOW model has been prepared to better analyse flood behaviour at this location (refer to section 4.3).

- There are a few variables that would ideally be incorporated into the flood model once further information is made available. These include the works as executed stormwater infrastructure from the TSE contractor and final grading of Denison St. The current TUFLOW model incorporates assumptions for these based on design documentation however the as built information may differ slightly and have the potential to impact on the PMF flood predictions for the project.

4.5 Australian Rainfall and Runoff (ARR)

The hydrology calculations within the North Sydney Council flood model/s are based on ARR 1987 methodology. The intent is to continue with this methodology for optioneering purposes and to update hydrology calculations to the ARR 2016 methodology once the preferred option is selected.

ARR 2016 methodology will be utilised to confirm compliance with Sydney Metro requirements, and to undertake a sensitivity analysis to aid in confirming the validity of the design.

It is noted that the computations for modelling the PMF storm event is the same for both ARR 1987 and ARR 2016 and will not change. The latest (2016) methodology will apply to the 100year ARI and more frequent (less severe) storms.

4.6 Items to be further investigated and assessed in resolving detailed design

- Confirmation of authority approval of proposed future Denison Street road geometry and stormwater drainage design details (note the design has been provided, it is the approval status that is unclear);
- Authority approval (Sydney Water and North Sydney Council) of the proposed compensatory flood storage strategy (i.e. Miller Street storage);
- Works As Executed information for any construction works currently being undertaken on or around the site. This includes any stormwater works undertaken by the TSE contractor and works to Denison St by the 1 Denison St contractor;
- Potential changes to flooding impacts during the design development process;
- Complex inter-dependent flow regimes;
- Hydraulically sensitive network with numerous constraints (re-development within an existing built up area located within a flood prone area).
- Potential flood impacts caused by future changes to the external environment.

5. Safety in Design

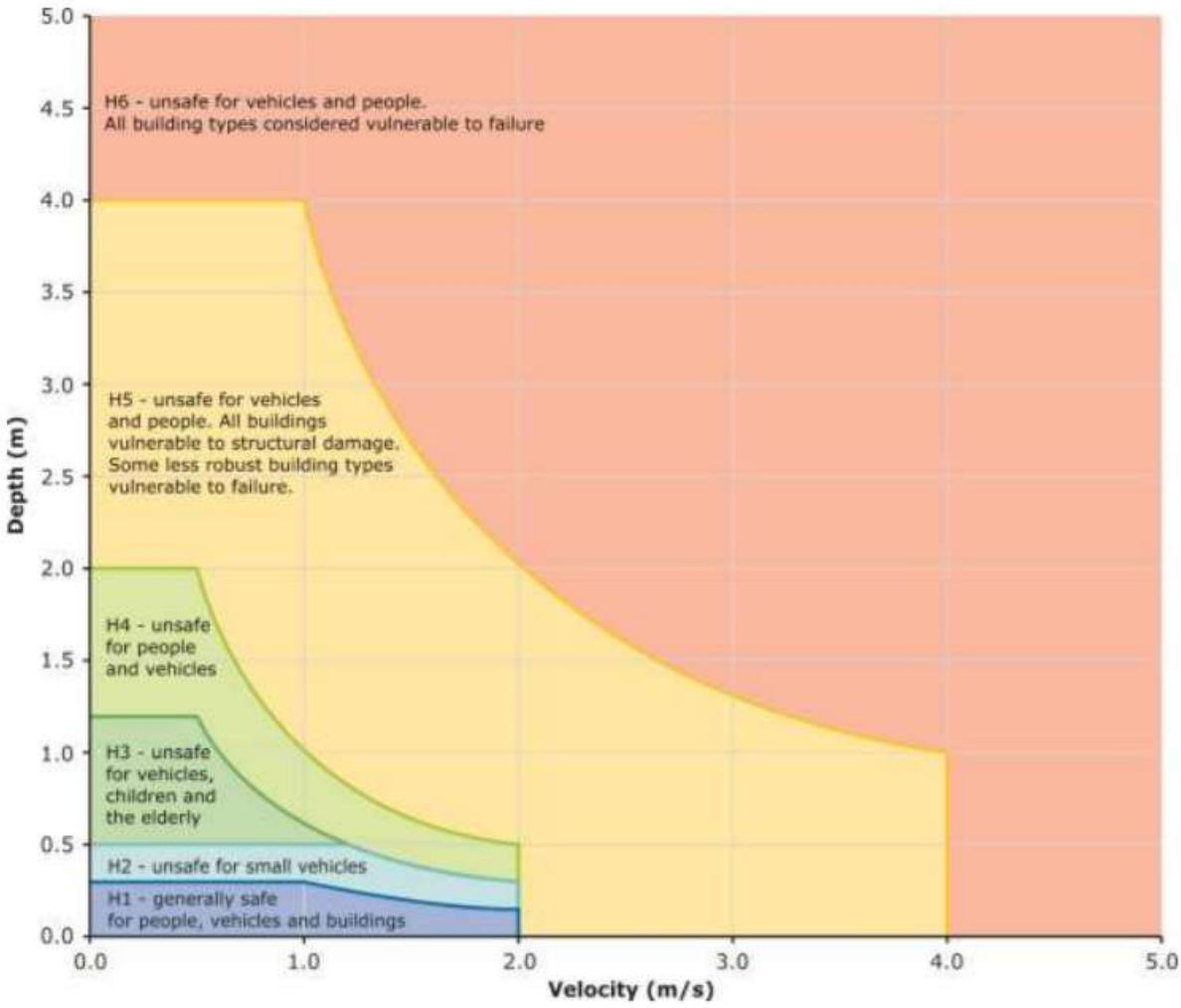
Safety is a fundamental consideration to all elements of the Victoria Cross Over Station Development. Designers have a responsibility under the WHS Act & Regulations 2011 to consider safety in all aspects of their work. A flood evacuation management plan will be developed to define the evacuation plan in the event of major storms in excess of the 1%AEP event. Major (flood related) design items are discussed in this section below:

5.1 Pedestrian through-site link

The pedestrian through-site link from Miller Street to Denison Street acts as an overland flow route during floods which exceed a 100year ARI (1% AEP). Note: Preliminary analyses indicate that no overland flow enters the station site in events up to and including the 1% AEP event.

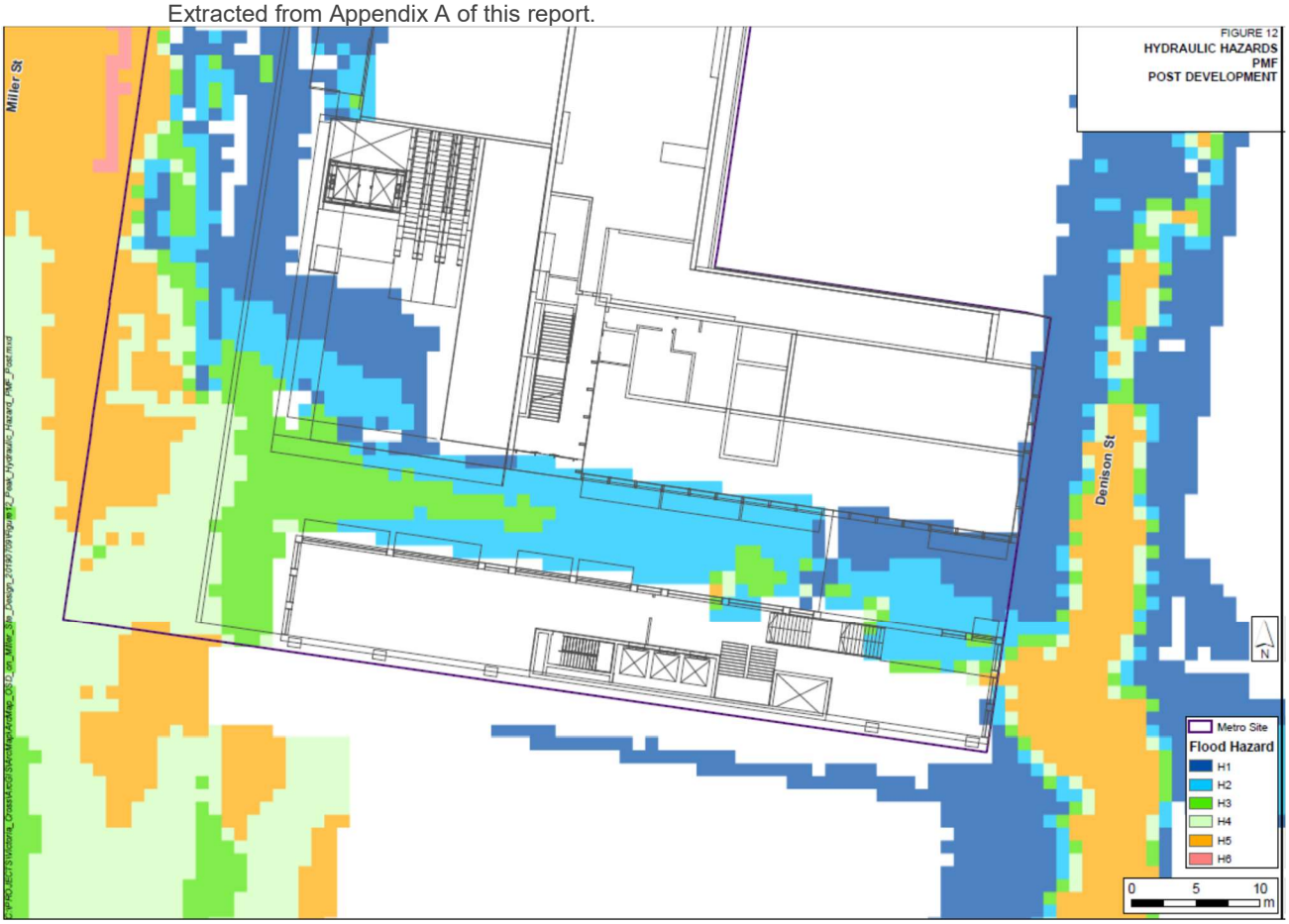
The flood hazard categories adopted are based on the Australian Emergency Management Institute, 2014 as illustrated in AR&R 2016. The descriptions and limits of each classification are depicted in Figure 5.1 below:

Figure 5.1 – General Flood Hazard Vulnerability Curves



As shown in Figure 5.2 below, preliminary modelling classifies the PMF flows within the pedestrian through-site link to be predominantly “H2” classification (unsafe for small vehicles) with localized areas of “H3” (unsafe for vehicles, children and the elderly) at the Miller Street entrance and at the vertical drop in the pedestrian link (adjacent to the stairs near the Denison Street entrance). There are areas of “H1” around the entrance to the station and on Miller street which provide flood evacuation routes. Additionally, as the station itself is flood protected pedestrians can seek shelter inside the station.

Figure 5.2 – Hydraulic Hazard Map – PMF, Post Development (Figure 12)
Extracted from Appendix A of this report.



Notes:

1 Hydrology:

The design PMF event is considered a “flash flood” with a 15-minute duration i.e. a short, high intensity rainfall event.

2 Implications:

- It is likely that there will be little warning from authorities or time for emergency response parties to prepare for or to manage an extreme storm.
- Fully eliminating the hazard (flow through the building) does not appear to be a reasonably practical solution.
- The installation of an audible/visual warning and crowd control system with appropriate signage is required, and emergency egress routes need to be accessible and clearly marked to allow safe egress (including catering for people with a disability);
- Stairs and the ‘waterfall’ from the Miller to Denison level subject to flowing flood water will be a safety hazard during an extreme flood due to high velocity flows. **Note** no hazard is shown

in the image as the stairs are modelled as a 1d element, however they have been identified as a hazardous area.

This identified hazard is currently being addressed in conjunction with the safety in design process. The following items have been incorporated into the design to minimise the impacts of flooding :

- Raised concrete plinths to risers connecting to basement levels
- Flood gates in front of the southern retail building lifts
- Extent of areas which are high risk have been reduced with adjustments of levels.

5.2 Flood Ingress Check

Flood ingress has been checked during the design process to ensure all the entrances are protected from the maximum probable flood level. There are three primary entrances to the southern site, and they are:

- escalator entrance on Miller Street shown as G2 in Appendix A;
- entrance at Denison Street level near where the “waterfall” happens, as mentioned previously the ‘focused’ model has been built to correctly model the flood behaviour near this entrance;
- loading dock entrance at Denison Street shown as D1 in Appendix A;

The comparison of peak flood levels in PMF and design levels has been shown in the table below.

Table No. 5.1 – Peak Flood Levels and Design Levels

Event	Condition	Levels (m AHD)		
			G2	D1
		Entrance at Denison Street	Entrance to Escalator	Entrance to Loading Dock
	Design Level	60.20	64.20	61.10
PMF	Flood Level	60.10	64.15	60.97

All lift shafts, openings, voids and service risers on the pedestrian link will be protected to flood water ingress by install flood barriers, waterproof upstands or hobs.
The floor level of retail buildings have been checked against the flood levels to ensure they are protected in the 100 year event.

6. OSD Stormwater Management Plan

Stormwater runoff from the OSD roofs and terraces shall be collected and conveyed to the legal point of discharge via a syphonic drainage system. As per direction from Sydney Metro this system is separate from the station stormwater system.

6.1 Connection Point

All stormwater drainage from the roof, balconies and terraces of the OSD structures shall be collected to a common point within the building and connected to the Sydney Water Stormwater culvert for discharge.

6.2 Roof and terrace areas

All stormwater drainage from the roof level and lower terraces will be collected via a syphonic stormwater system. The system shall have full redundancy via a secondary overflow system, which contains the same capacity as the primary syphonic system. The syphonic pipework will terminate at a syphonic break tank located adjacent to the on-site detention tank at B1 level. In the event an on-site detention tank is not required, the syphonic downpipes and overflows will terminate into a syphonic break tank and gravity outfall to Sydney Waters trunk stormwater main. ArcMac has contacted Sydney Water and North Sydney council is awaiting confirmation whether an on-site detention tank is required for the building runoff.

6.3 Subsoil Drainage

Seepage water from the Over station development carpark will be collected via a perimeter spoon drain at each level, downpipes will transfer water to the B6 level sump. All sub- soil and ground water drainage surrounding and under the station box is collected via a wall membrane system, water is then diverted under slab and collected in a pit at B6 level and subsequently pumped into a groundwater sump. The groundwater system shall be discharged to stormwater in compliance with relevant Sydney Water and Sydney Metro Station Works Technical Criteria (SWTC) requirements.

6.4 On-Site Stormwater Detention

In general, North Sydney Council requires on-site stormwater detention for a major development of this nature to improve the performance of the existing under capacity stormwater pit and pipe network in the subject area. Council's detention system design requirement states the maximum site discharge is not exceed that which would occur during a 5 year ARI event (under the existing conditions) for all storm events up to and including the 100 year ARI event. This detention system is provided by a tank on the mezzanine level of B1.
Further design and investigation is underway to determine if the compensatory storage proposed for Miller Street in combination with the up-sizing of the Sydney Water trunk main will satisfy this requirement. Hence, approval will be sought from North Sydney Council to forgo the need for additional on-site detention if this is confirmed.

6.5 Water Quality Requirements

Sydney Water and North Sydney council require that discharge from the site meets the following pollutant load reduction targets:

· Gross Pollutants – 90%
· Total Suspended Solids – 85%
· Total Phosphorous – 65%
· Total Nitrogen – 45%

These required pollutant reductions will be achieved for the site with a rainwater collection tank and proprietary stormwater treatment devices such as the Ocean Protect Stormfilter cartridge or similar. The rainwater tank is

located in the Level 40 plant room and collects roof water for reuse in the station cooling towers. The stormwater treatment cartridges are proposed to be located adjacent to the onsite detention tank on the mezzanine level of B1.
However, given that the significant majority of runoff from the site comes from roof areas the stormwater discharge will be relatively clean and free from pollutants. Hence, dispensation from this requirement will be sought through consultation with Sydney Water and North Sydney Council.

7. Hydrologic Model

The hydrologic model converts applied rainfall depth (distributed over time) into a rainfall excess and then into a flow. This flow is then applied to the hydraulic model for routing. The following section details the method utilised in the build of the hydrologic model. This includes detailed hydrologic modelling of the urban extent within the study area.

7.1 DRAINS

The DRAINS model is well known and widely used in NSW for urban hydrology and hydraulics modelling. In this study only the hydrologic component of DRAINS is used. The following sections provide details on DRAINS parameters adopted in the modelling.

7.2 Sub-catchment Definition

Sub-catchment definition was undertaken for local catchment flows as well as those areas upstream to the site, which nevertheless flow into the catchment under consideration. The local catchment flow area around the metro site in which sub-catchments were delineated has been refined to a finer resolution. The sub-catchment has been further refined near the south entrance of the site to achieve better accuracy in flood behaviour. The finer catchment plan and upstream catchment plan contributing to the south entrance has been provided in Appendix A.

7.3 Impervious Surface Area

Runoff from connected impervious surfaces such as roads, gutters, roofs or concrete surfaces occur significantly faster than from vegetated surfaces. This results in a faster concentration of flow within the downstream area of the catchment, and increased peak flow in some situations. It is therefore necessary to estimate the proportion of the catchment area that is covered by such surfaces.

DRAINS categorise these surface areas as either:

- paved areas (impervious areas directly connected to the drainage system);
- supplementary areas (impervious areas not directly connected to the drainage system, instead connected to the drainage system via the pervious areas); and
- grassed areas (pervious areas).

Within the North Sydney Flood Study and this study, a uniform 5% was adopted as a supplementary area across the catchment. The remaining 95% was attributed to impervious (or paved areas) and pervious surface areas, as estimated for each individual sub-catchment. This was undertaken by determining the proportion of the sub-catchment area allocated to a land-use category and the estimated impervious percentage of each land-use category. The metro site has been categorised to commercial areas with 95% impervious areas.

7.4 Rainfall Losses

Methods for modelling the proportion of rainfall that is “lost” to infiltration are outlined in Australia Rainfall and Runoff. The methods are of varying degrees of complexity, with the more complex options only suitable if sufficient data are available. The method most typically used for design flood estimation is to apply an initial and continuing loss to the rainfall. The initial loss represents the wetting of the catchment prior to runoff starting to occur and the continuing loss represents the ongoing infiltration of water into the saturated soils while rainfall continues.

Rainfall losses from a paved or impervious area are considered to consist of an initial loss (an amount sufficient to wet the pavement and fill minor surface depressions). Losses from grassed areas are comprised of an initial loss and a continuing loss. The continuing loss is calculated from an infiltration equation curve incorporated into the model and is based on the selected representative soil type and antecedent moisture condition. The catchment soil was assumed to have a slow infiltration rate and the antecedent moisture condition was considered to be rather wet. This produces conservative flow estimates, which are appropriate given that flood risk is being assessed.

The adopted parameters are summarised below:

- Paved Area Depression Storage (Initial rainfall Loss) is 1mm;
- Grassed Area Depression Storage (Initial rainfall Loss) is 5mm;
- Sold type is 3 and it means slow infiltration rates;
- Antecedent Moisture Conditions (AMC) is 3 and it stands for rather wet. The total rainfall in 5 days preceding the storm is between 12.5 to 25mm; and
- The continual rainfall loss is decided by soil type and AMC.

These are consistent with the parameters adopted in similar studies in the Sydney Metropolitan area.

8. Conclusion

This report outlines the existing conditions, previous assessments and the current design proposal relating to stormwater and flood management measures to accompany the Victoria Cross ISD.

In conclusion, stormwater calculations indicate that the stormwater collected and discharged from the proposed Victoria Cross ISD site can be managed according to the requirements of the relevant stakeholders and authorities. This has been achieved using a syphonic building drainage system, stormwater retention for re-use, stormwater detention and connection to the amplified stormwater trunk mains.

Flood modelling indicates that flood waters surrounding and internal to the development can be managed to mimic or improve existing flood impacts without having a significant impact on adjoining and downstream properties.

Significant improvement has been made to the site itself through careful grading and upgraded trunk stormwater infrastructure which allows stormwater flows to be collected and conveyed underground for storm events up to the 1% AEP (100year ARI) rather than overland as is currently the case. The impacts of climate change has been incorporated in the stormwater and flood modelling with an increase of 10% rainfall intensity which is also reflected in the design of the local and trunk stormwater drainage systems.

Due to the extreme nature of storms exceeding the 1%AEP (100year ARI) and up to the Probable Maximum Flood (PMF), it is not practical to convey flows underground so allowance has been made in the design to convey this flow through the site. Safety is of paramount importance during the design of this overland flow with careful grading to any building entrance and levels set to prevent these flows from entering the building. Where this cannot be achieved, safety measures have been incorporated in the form of flood barriers to prevent flows from entering the building (e.g. at lift shafts). Hazard has been assessed through the site link and adjacent to the building in accordance with AR&R categories (refer to section 5) to ensure that there is safe access to and from the building.

Appendix A: Flood Maps (with Miller Street storage)

FIGURE 1

PEAK FLOOD DEPTHS AND LEVEL CONTOURS 100Y ARI PLUS 10% RAINFALL BASE CASE

Berry St
Miller St
Pacific Hwy
Denison St
Spring St
Little Spring St
Walker St
Little Walker St
Mount St

A
B
C
D
E
F1
F2
G1
G2
M
N
D1
X1

N

Metro Site
Flood Level Contours Major
Flood Level Contours Minor

Depth (m)

- 0 to 0.1
- 0.1 to 0.3
- 0.3 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

0 25 50 m

C:\PROJECTS\Victoria_CrossArcGIS\ArcMap_ArcMap_OSD_on_Miller_Site_Design_20190109\Figure1_Peak_Flood_Depths_and_Level_Contours_100y_Pre.mxd

FIGURE 2

PEAK FLOOD DEPTHS AND LEVEL CONTOURS PMF BASE CASE

Berry St
Pacific Hwy
Miller St
Little Spring St
Walker St
Denison St
Spring St
Mount St

A
B
C
D
E
F1
F2
G1
G2
M
N
X1

Metro Site
Flood Level Contours Major
Flood Level Contours Minor

Depth (m)
0 to 0.1
0.1 to 0.3
0.3 to 0.5
0.5 to 1
1 to 1.5
1.5 to 2
> 2

N

0 25 50 m

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FIGURE3

HYDRAULIC HAZARDS
100Y ARI PLUS 10% RAINFALL
BASE CASE

Berry St
Miller St
Pacific Hwy
Denison St
Little Spring St
Spring St
Walker St
Little Walker St
Mount St

Metro Site

Flood Hazard

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

N

0 25 50 m

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190709\Figure3_Peak_Hydraulic_Hazard_100y_Pre.mxd

FIGURE 4

HYDRAULIC HAZARDS
PMF
BASE CASE

Berry St
Miller St
Denison St
Little Spring St
Walker St
Little Walker St
Pacific Hwy
Spring St
Mount St

N

Metro Site

Flood Hazard

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

0 25 50 m

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190109\Figure4_Peak_Hydraulic_Hazard_PMF_Pre.mxd

FIGURE 5

PEAK FLOOD DEPTHS AND LEVEL CONTOURS 100Y ARI PLUS 10% RAINFALL POST DEVELOPMENT

Berry St
Miller St
Pacific Hwy
Denison St
Little Spring St
Spring St
Walker St
Mount St
Little Walker St

A
B
C
D
D1
E
F1
F2
G1
G2
M
N
X1

Metro Site
Flood Level Contours Major
Flood Level Contours Minor

Depth (m)
0 to 0.1
0.1 to 0.3
0.3 to 0.5
0.5 to 1
1 to 1.5
1.5 to 2
> 2

N

0 25 50 m

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap_ArcMap_OSD_on_Miller_Site_Design_20190729\Figure5_Peak_Flood_Depths_and_Level_Contours_100y_Past.mxd

FIGURE 5A

PEAK FLOOD DEPTHS AND LEVEL CONTOURS 100Y ARI PLUS 10% RAINFALL POST DEVELOPMENT

Miller St

Denison St

G1

G2

D1

63.7 63.6 63.5 63.4 63.8 63.7 63.6 63.5 63.4 63.8 63.9 64 64.1 64.2 64.3 64.4 64.5 64.6 64.7 64.8

62.2 62.1 62 61.9 61.8 61.7 61.6 61.5 61.4 61.3 61.2 61.1 61 60.9 60.8 60.7 60.6 60.5 60.4 60.3 60.2 60.1 60 59.9 59.8 59.7 59.6 59.5 59.4 59.3 59.2 59.1 59 59.1 59 58.9 58.8 58.7 58.6 58.5 58.4

N

Flood Level Contours Major
Flood Level Contours Minor
Metro Site

Depth (m)

0 to 0.1
0.1 to 0.3
0.3 to 0.5
0.5 to 1
1 to 1.5
1.5 to 2
> 2

0 5 10 m

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FIGURE 6

PEAK FLOOD DEPTHS AND LEVEL CONTOURS PMF POST DEVELOPMENT

Berry St

Pacific Hwy

Miller St

Denison St

Little Spring St

Walker St

Spring St

Mount St

A

B

C

D

E

F1

F2

G1

G2

M

N

D1

X1

N

Metro Site

Flood Level Contours Major

Flood Level Contours Minor

Depth (m)

0 to 0.1

0.1 to 0.3

0.3 to 0.5

0.5 to 1

1 to 1.5

1.5 to 2

> 2

0 25 50 m

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FIGURE 7

HYDRAULIC HAZARDS
100Y ARI PLUS 10% RAINFALL
POST DEVELOPMENT

Berry St
Miller St
Pacific Hwy
Denison St
Spring St
Mount St
Walker St
Little Walker St
N

Metro Site

Flood Hazard

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

0 25 50 m

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190709\Figure7_Peak_Hydraulic_Hazard_100y_Post.mxd

FIGURE 8
HYDRAULIC HAZARDS
PMF
POST DEVELOPMENT

Berry St
Miller St
Pacific Hwy
Denison St
Little Spring St
Spring St
Walker St
Little Walker St
Mount St
N
Metro Site
Flood Hazard
H1
H2
H3
H4
H5
H6
0 25 50
m

C:\PROJECTS\Victoria_CrossArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190709\Figure8_Peak_Hydraulic_Hazard_PMF_Post.mxd

FIGURE 9

PEAK FLOOD LEVEL DIFFERENCE
100Y ARI PLUS 10% RAINFALL INCREASE
POST DEVELOPMENT VERSUS BASE CASE

Berry St
Miller St
Denison St
Little Spring St
Spring St
Walker St
Little Walker St
Pacific Hwy
Warringah Fwy
Mount St

N

Flood Level Difference (m)

- No Longer Flooded
- < -0.2
- -0.2 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.2
- > 0.2
- Newly Flooded

0 25 50 m

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FIGURE 9a

PEAK FLOOD LEVEL DIFFERENCE
5Y ARI PLUS 10% RAINFALL INCREASE
POST DEVELOPMENT WITH BASE CASE

Berry St
Miller St
Denison St
Little Spring St
Spring St
Walker St
Little Walker St
Pacific Hwy
Warringah Fwy
Mount St

N

Flood Level Difference (m)
- No Longer Flooded
- < -0.2
- -0.2 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.2
- > 0.2
- Newly Flooded

0 25 50 m

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FIGURE 9b

PEAK FLOOD LEVEL DIFFERENCE
10Y ARI PLUS 10% RAINFALL INCREASE
POST DEVELOPMENT WITH BASE CASE

Berry St
Miller St
Denison St
Little Spring St
Spring St
Walker St
Little Walker St
Pacific Hwy
Warringah Fwy
Mount St

N

Flood Level Difference (m)
- No Longer Flooded
- < -0.2
- -0.2 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.2
- > 0.2
- Newly Flooded

0 25 50 m

C:\PROJECTS\Victoria_Cross\GIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190729\Figure9b_Peak_Flood_Level_Difference_Metro_VS_base_10y.mxd

FIGURE 9c

PEAK FLOOD LEVEL DIFFERENCE
20Y ARI PLUS 10% RAINFALL INCREASE
POST DEVELOPMENT WITH BASE CASE

Berry St
Miller St
Denison St
Little Spring St
Spring St
Walker St
Little Walker St
Pacific Hwy
Warringah Fwy
Mount St

N

Flood Level Difference (m)
- No Longer Flooded
- < -0.2
- -0.2 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.2
- > 0.2
- Newly Flooded

0 25 50 m

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FIGURE 9d

PEAK FLOOD LEVEL DIFFERENCE
50Y ARI PLUS 10% RAINFALL INCREASE
POST DEVELOPMENT WITH BASE CASE

Berry St
Miller St
Denison St
Little Spring St
Spring St
Walker St
Little Walker St
Pacific Hwy
Warringah Fwy
Mount St

N

Flood Level Difference (m)

- No Longer Flooded
- < -0.2
- -0.2 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.2
- > 0.2
- Newly Flooded

0 25 50 m

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190729\Figure9d_Peak_Flood_Level_Difference_Metro_VS_base_50y.mxd

FIGURE 10

PEAK FLOOD LEVEL DIFFERENCE
PMF
POST DEVELOPMENT VERSUS BASE CASE

Berry St
Miller St
Denison St
Little Spring St
Pacific Hwy
Spring St
Walker St
Little Walker St
Warringah Fwy
Mount St

N

Flood Level Difference (m)

- No Longer Flooded
- < -0.2
- -0.2 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.2
- > 0.2
- Newly Flooded

0 25 50 m

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190729\Figure10_Peak_Flood_Level_Difference_Metro_VS_base_PMF.mxd

FIGURE 11

PEAK FLOOD DEPTHS AND LEVEL CONTOURS PMF POST DEVELOPMENT

Miller St

Denison St

G1

G2

D1

64.1 64.2 64.3 64.4 64.5 64.6 64.7 64.8 64.9 65 64 63.9 63.7 63.6 63.5 63 62.6 62.2 62.1 62 61.9 61.8 61.7 61.6 61.5 61.4 61.3 61.2 61.1 61 60.9 60.8 60.7 60.6 60.5 60.4 60.3 60.2 60.1 60 59.9 59.8 59.7 59.6 59.5 59.1 59 58.9 58.8 58.7 58.6 58.5

N

Flood Level Contours Major
Flood Level Contours Minor
Metro Site

Depth (m)

0 to 0.1
0.1 to 0.3
0.3 to 0.5
0.5 to 1
1 to 1.5
1.5 to 2
> 2

0 5 10 m

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190709\Figure11_Peak_Flood_Depths_and_Level_Contours_PMF_Post.mxd

FIGURE 12

HYDRAULIC HAZARDS
PMF
POST DEVELOPMENT

Miller St

Denison St

N

Metro Site

Flood Hazard

H1
H2
H3
H4
H5
H6

0 5 10
m

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190709\Figure12_Peak_Hydraulic_Hazard_PMF_Post.mxd

FIGURE 13

PEAK FLOOD VELOCITIES
PMF
POST DEVELOPMENT

Miller St

Denison St

N

Metro Site

Velocity (m/s)

- 0 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- >3

0 5 10 m

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190709\Figure13_Peak_Flood_Velocities_PMF_Post.mxd

FIGURE 14

PEAK FLOOD DEPTHS AND LEVEL CONTOURS PMF POST DEVELOPMENT

Berry St

Miller St

Denison St

N

Metro Site
Flood Level Contours Major
Flood Level Contours Minor

Depth (m)

0 to 0.1
0.1 to 0.3
0.3 to 0.5
0.5 to 1
1 to 1.5
1.5 to 2
> 2

0 10 20 m

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190709\Figure14_Peak_Flood_Depths_and_Level_Contours_PMF_Post.mxd

FIGURE 15

PEAK FLOOD DEPTHS AND LEVEL CONTOURS PMF POST DEVELOPMENT DENISON STREET LEVEL

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190729\Figure15_Peak_Flood_Depths_and_Level_Contours_PMF_Post_Denison.mxd

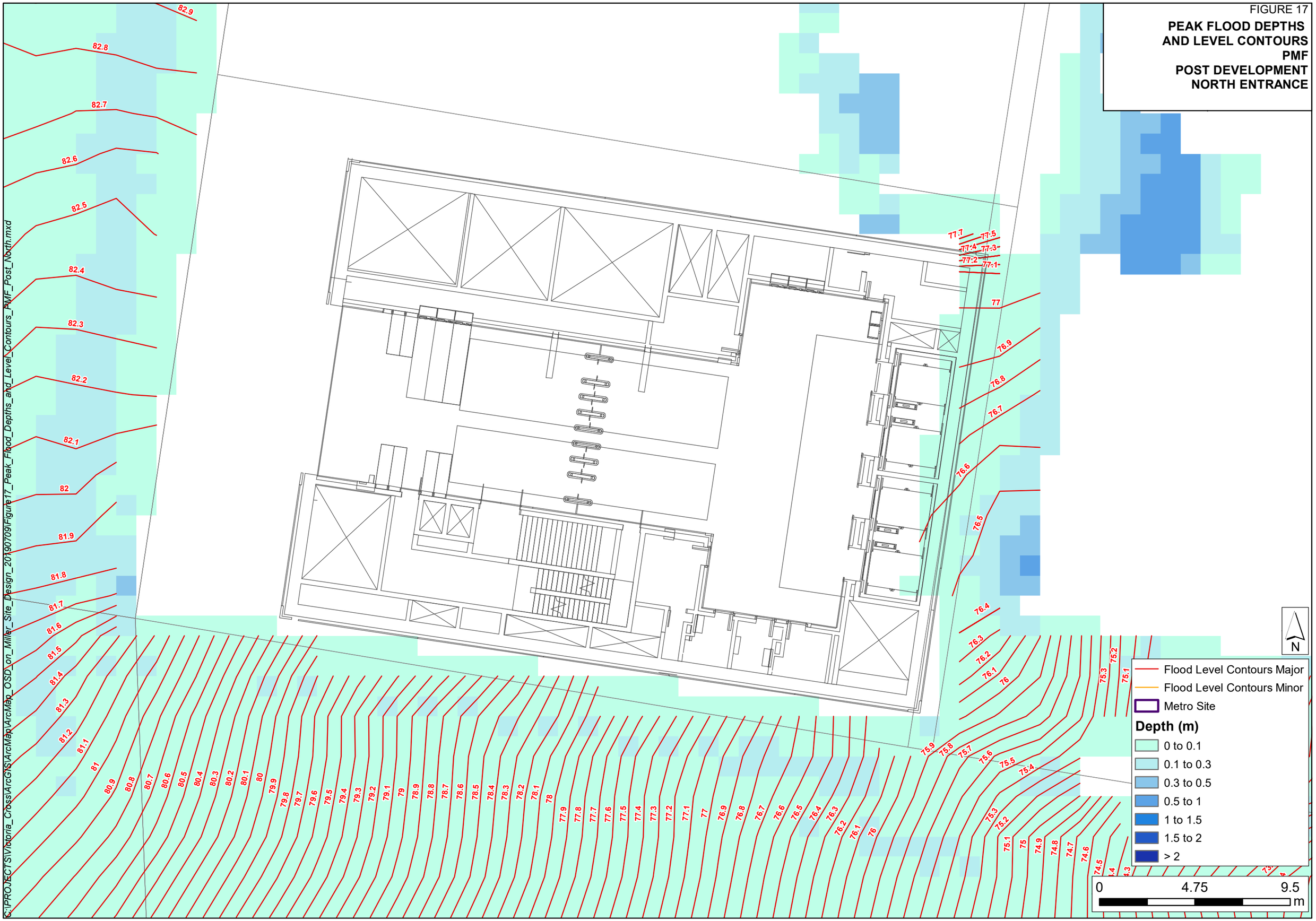
FIGURE 16

PEAK FLOOD DEPTHS
AND LEVEL CONTOURS
100Y ARI PLUS 10% RAINFALL
POST DEVELOPMENT
NORTH ENTRANCE

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190709\Figure16_Peak_Flood_Depths_and_Level_Contours_100y_Post_North.mxd

FIGURE 17

PEAK FLOOD DEPTHS AND LEVEL CONTOURS PMF POST DEVELOPMENT NORTH ENTRANCE



C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190709\Figure17_Peak_Flood_Depths_and_Level_Contours_PMF_Post_North.mxd

FIGURE 18

PEAK FLOOD LEVEL DIFFERENCE
100Y ARI PLUS 10% RAINFALL INCREASE
POST DEVELOPMENT VERSUS BASE CASE
NORTH ENTRANCE

C:\PROJECTS\Victoria_CrosstArcGIS\ArcMap\ArcMap_OSD_on_Miller_Site_Design_20190709\Figure18_Peak_Flood_Level_Difference_Metro_VS_base_North_100y.mxd

N

Flood Level Difference (m)

- No Longer Flooded
- < -0.2
- -0.2 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.2
- > 0.2
- Newly Flooded

0 12.5 25 m

FIGURE 19

PEAK FLOOD LEVEL DIFFERENCE
PMF
POST DEVELOPMENT VERSUS BASE CASE
NORTH ENTRANCE

C:\PROJECTS\Victoria_Cross\ArcGIS\ArcMap\ArcMap_QSD_on_Miller_Site_Design_20190709\Figure19_Peak_Flood_Level_Difference_Metro_VS_base_North_PMF.mxd

N

Flood Level Difference (m)

- No Longer Flooded
- < -0.2
- -0.2 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.2
- > 0.2
- Newly Flooded

0 12.5 25 m

FIGURE XX

CATCHMENT PLAN AROUND SITE

NSM093
NSM092
NSM091A
NSM091B
NSM086D
NSM085B
NSM090
NSM089
Berry St
NSM078H
NSM078F3
NSM077B
NSM076C
NSM074B
NSM086A
NSM086B
NSM085A
NSM078G
NSM078F1
NSM078F2
NSM087
NSM086C
NSM074C
NSM074A
NSM077A
Little Spring St
Pacific Hwy
Miller St
NSM078F4
NSM078A
NSM078F5
NSM077C
NSM079A
NSM076A
NSM076B
NSM078D1
NSM078D2
Denison St
Walker St
Little Walker St
NSM081
NSM07
N
Spring St
NSM078B
NSM078E2
NSM079B
NSM078E1
NSM073B
NSM073A
NSM075B
NSM075A
NSM078C
NSM082
NSM080
NSM071A
NSM075C
NSM071B
Mount St
NSM083
NSM071C
NSM070B

Metro Site
Subcatchment Delineation

0 25 50 m

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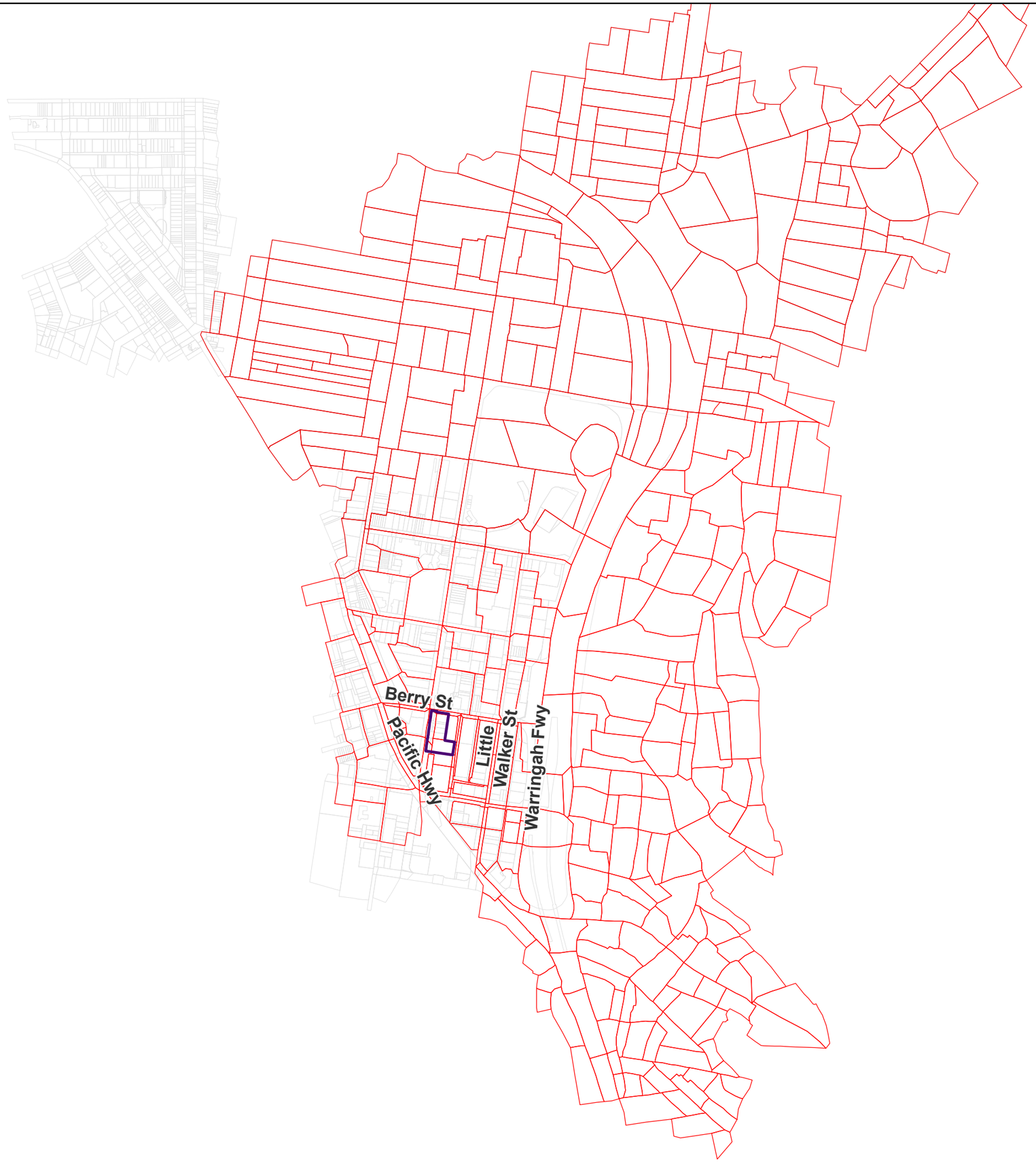
FIGURE XX

CATCHMENT PLAN
INCLUDING UPSTREAM CATCHMENT



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Appendix B: Victoria Cross Over Station Development Environmental Impact Statement Appendix T Flood assessment and stormwater management report

FLOOD ASSESSMENT AND STORMWATER MANAGEMENT REPORT

APPENDIX T

Sydney Metro City & Southwest

Victoria Cross Over Station Development:

Flood assessment and stormwater management report

Applicable to:	Sydney Metro City & Southwest
Author:	AECOM Australia Pty Ltd
Owner	Transport for NSW
Status:	Final
Version:	3
Date of issue:	16 May 2018
Review date:	16 May 2018

Table of Contents

1.0 Introduction

1.1 Purpose of this report

This report supports a concept State Significant Development Application (concept SSD Application) submitted to the Department of Planning and Environment (DP&E) pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The concept SSD Application is made under Section 4.22 of the EP&A Act.

Transport for NSW (TfNSW) is seeking to secure concept approval for a commercial office tower above the Victoria Cross Station, otherwise known as the over station development (OSD). The concept SSD Application seeks consent for a building envelope and its use as a commercial premises (office, business and retail), maximum building height, maximum gross floor area, pedestrian and vehicular access, circulation arrangements and associated car parking, future subdivision (if required) and the strategies and design parameters for the future detailed design of development.

TfNSW proposes to procure the construction of the OSD as part of an Integrated Station Development package, which would result in the combined delivery of the station, OSD and public domain improvements. The station and public domain elements form part of a separate planning approval for Critical State Significant Infrastructure (CSSI) approved by DP&E on 9 January 2017.

As the development is within a rail corridor, is associated with railway infrastructure and is for commercial premises with a Capital Investment Value of more than $30 million, the project is identified as State Significant Development (SSD) pursuant to Schedule 1, 19(2)(a) of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP).

This report has been prepared to outline the flood and stormwater management strategy for the OSD and to specifically respond to the Secretary's Environmental Assessment Requirements (SEARs) issued for the concept SSD Application on 30 November 2017 which states that the Environmental Impact Statement (EIS) is to include a flood assessment / stormwater management plan.

1.2 Overview of the Sydney Metro in its context

The New South Wales (NSW) Government is implementing *Sydney's Rail Future*, a plan to transform and modernise Sydney's rail network so that it can grow with the city's population and meet the needs of customers in the future (Transport for NSW, 2012). Sydney Metro is a new standalone rail network identified in *Sydney's Rail Future*.

Sydney Metro is Australia's biggest public transport project, consisting of Sydney Metro Northwest (Stage 1), which is due for completion in 2019 and Sydney Metro City & Southwest (Stage 2), which is due for completion in 2024 (Refer to **Figure 1**).

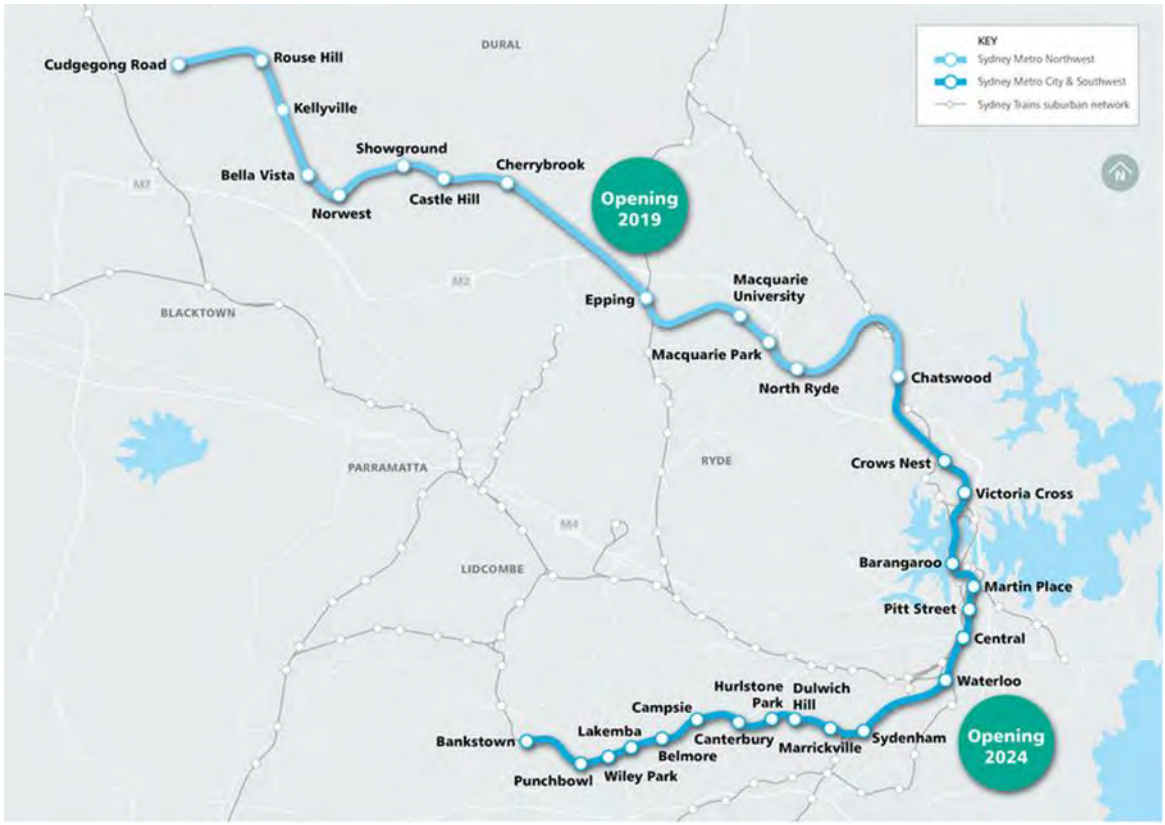


Figure 1: Sydney Metro alignment map

Stage 2 of Sydney Metro includes the construction and operation of a new metro rail line from Chatswood, under Sydney Harbour through Sydney's CBD to Sydenham and on to Bankstown through the conversion of the existing line to metro standards.

The project also involves the delivery of seven (7) new metro stations, including at North Sydney. Once completed, Sydney Metro will have the ultimate capacity for 30 trains an hour (one every two minutes) through the CBD in each direction - a level of service never seen before in Sydney.

On 9 January 2017, the Minister for Planning approved the Sydney Metro City & Southwest - Chatswood to Sydenham application lodged by TfNSW as a Critical State Significant Infrastructure project (reference SSI 15_7400), hereafter referred to as the CSSI Approval.

The CSSI Approval includes all physical work required to construct the CSSI, including the demolition of existing buildings and structures on each site. Importantly, the CSSI Approval also includes provision for the construction of below and above ground structures and other components of the future OSD (including building infrastructure and space for future lift cores, plant rooms, access, parking and building services, as relevant to each site). The rationale for this delivery approach, as identified within the CSSI application is to enable the OSD to be more efficiently built and appropriately integrated into the metro station structure.

The EIS for the Chatswood to Sydenham component of the City & Southwest project identified that the OSD would be subject to a separate assessment process.

Since the CSSI Approval was issued, Sydney Metro has lodged four modification applications to amend the CSSI Approval as outlined below:

- Modification 1- Victoria Cross and Artarmon Substation which involves relocation of the Victoria Cross northern services building from 194-196A Miller Street to 50 McLaren Street together with inclusion of a new station entrance at this location referred to as Victoria Cross North. 52 McLaren Street would also be used to support construction of these works. The modification also involves the relocation of the substation at Artarmon from Butchers Lane to 98 – 104 Reserve Road. This modification application was approved on 18 October 2017.
- Modification 2- Central Walk which involves additional works at Central Railway Station including construction of a new eastern concourse, a new eastern entry, and upgrades to suburban platforms. This modification application was approved on 21 December 2017.
- Modification 3 - Martin Place Station which involves changes to the Sydney Metro Martin Place Station to align with the Unsolicited Proposal by Macquarie Group Limited (Macquarie) for the development of the station precinct. The proposed modification involves a larger reconfigured station layout, provision of a new unpaid concourse link and retention of the existing MLC pedestrian link and works to connect into the Sydney Metro Martin Place Station. It is noted that if the Macquarie proposal does not proceed, the original station design remains approved. This modification application was approved on 22 March 2018.
- Modification 4 - Sydenham Station and Sydney Metro Trains Facility South which incorporates Sydenham Station and precinct works, the Sydney Metro Trains Facility South, works to Sydney Water's Sydenham Pit and Drainage Pumping Station and ancillary infrastructure and track and signalling works into the approved project. This modification application was approved on 13 December 2017.

Given the modifications, the CSSI Approval is now approved to operate to Sydenham Station and also includes the upgrade of Sydenham Station.

The remainder of Stage 2 of the City & Southwest project (Sydenham to Bankstown) proposes the conversion of the existing heavy rail line and the upgrade of the existing railway stations along this alignment to metro standards. This part of the project, referred to as the Sydenham to Bankstown Upgrade, is the subject of a separate CSSI Application (Application No. SSI 17_8256) which is currently being assessed by the DP&E.

1.3 Planning relationship between Victoria Cross Station and the OSD

While the Victoria Cross Station and OSD will form an Integrated Station Development, the planning pathways defined under the *Environmental Planning & Assessment Act 1979* require separate approval for each component of the development. In this regard, the approved station works (CSSI Approval) are subject to the provisions of Part 5.1 of the EP&A Act (now referred to as Division 5.2) and the OSD component is subject to the provisions of Part 4 of the EP&A Act.

For clarity, the approved station works under the CSSI Approval include the construction of below and above ground structures necessary for delivering the station and also enabling construction of the integrated OSD. This includes but is not limited to:

- Demolition of existing development
- Excavation
- Station structure including concourse and platforms
- Lobbies
- Retail spaces within the station building
- Public domain improvements
- Pedestrian through-site link
- Access arrangements including vertical transport such as escalators and lifts
- Structural and service elements and the relevant space provisioning necessary for constructing OSD, such as columns and beams, space for lift cores, plant rooms, access, parking, retail and building services.

The vertical extent of the approved station works above ground level is defined by the 'transfer slab' level' (which for Victoria Cross is defined by RL 82), above which would sit the OSD. This delineation is illustrated in **Figure 2**.

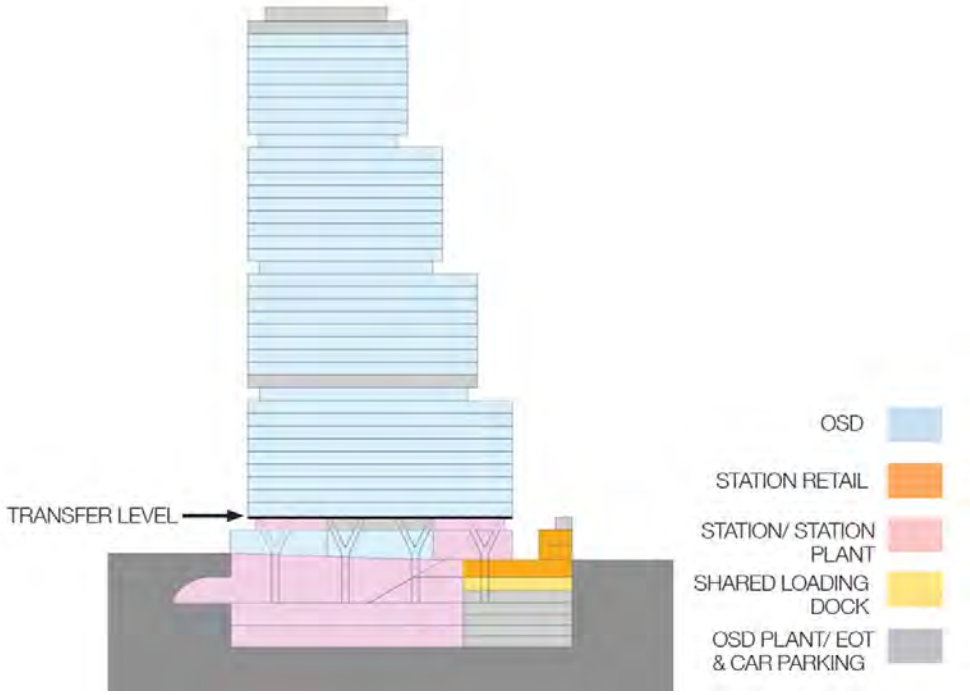


Figure 2: Delineation between the Metro station and OSD

The CSSI Approval also establishes the general concept for the ground plane of Victoria Cross Station including access strategies for commuters, pedestrians and workers. In this regard, pedestrian access to the station would be from Miller and Denison Streets and the commercial lobby would be accessed from Miller Street. Retail uses (approved under the CSSI Approval) would be located on the ground floor of the development at both the Miller Street and Denison Street levels activating the through-site link. Separate consent would be sought in the future for the fit-out and specific use of this retail space.

Since the issue of the CSSI Approval, TfNSW has undertaken sufficient design work to determine the space planning and general layout for the station and identification of those spaces within the station area that would be available for the OSD. In addition, design work has been undertaken to determine the technical requirements for the structural integration of the OSD with the station. This level of design work has informed the concept proposal for the OSD. It is noted that ongoing design development of the works to be delivered under the CSSI Approval would continue with a view to developing an Interchange Access Plan (IAP) and Station Design Precinct Plan (SDPP) for Victoria Cross Station to satisfy Conditions E92 and E101 of the CSSI Approval.

The public domain improvement works around the site would be delivered as part of the CSSI Approval.

1.4 The Site

The Victoria Cross OSD site is located at the southeast corner of the intersection of Miller and Berry Streets, North Sydney, above the southern portal of the future Victoria Cross Station (refer to **Figure 3**w). The site is located in North Sydney Centre which is identified as a "strategic centre" under *A Plan for Growing Sydney*. It is the third largest office market in Sydney and is a key component of Sydney's Global Economic Corridor.

Figure 3: Victoria Cross Station location plan

The site is located in the North Sydney Local Government Area approximately 3km north of Sydney CBD, 5km southeast of Chatswood and 2km southeast of St Leonards. The site (refer to **Figure 4**) is irregular in shape, has a total area of approximately 4,815 square metres and has street frontages of approximately 37 metres to Berry Street, 34 metres to Denison Street and 102 metres to Miller Street.

Figure 4: The site

The site comprises the following properties:

• 155–167 Miller Street	SP 35644 (formerly Tower Square)
• 181 Miller Street	Lot 15 in DP 69345, Lot 1 & Lot 2 DP 123056 and Lot 10 in DP 70667
• 187 Miller Street	Lot A in DP 160018
• 189 Miller Street	Lot 1 in DP 633088
• Formerly part 65 Berry Street	Lot 1 in DP 1230458

1.5 Overview of the proposed development

This concept SSD Application comprises the first stage of the Victoria Cross OSD project. It will be followed by a detailed SSD Application for the design and construction of the OSD to be lodged by the successful contractor who is awarded the contract to deliver the Integrated Station Development.

This concept SSD Application seeks approval for the planning and development framework and strategies to inform the future detailed design of the OSD. It specifically seeks approval for the following:

- A building envelope as illustrated in **Figure 5**

- A maximum building height of RL 230 or 168 metres (approximately 42 storeys, compromising 40 commercial storeys and 2 additional storeys for the roof top plant) for the high rise portion of building envelope and RL 118 or 55 metres (approximately 13 storeys) for the lower rise eastern portion of the building envelope
- A maximum gross floor area (GFA) of 60,000 square metres for the OSD component, which is equivalent to a floor space ratio of 12.46:1
- Use of the building envelope area for commercial premises including commercial office, retail and business premises
- Use of the conceptual OSD space provisioning within the footprint of the CSSI Approval (both above and below ground), including the OSD lobby and associated retail space, basement parking, end-of-trip facilities, services and back-of-house facilities
- Car parking for a maximum of 150 parking spaces over four basement levels with an additional 11 parking spaces allocated to the station retail approved under the terms of the CSSI Approval
- Loading, vehicle and pedestrian access arrangements from Denison Street
- Strategies for utility and services provision
- Strategies for the management of stormwater and drainage
- A strategy for the achievement of ecologically sustainable development
- Indicative signage zones
- A strategy for public art
- A design excellence framework
- The future subdivision of parts of the OSD footprint (if required).

The total GFA for the Integrated Station Development including the station GFA (i.e. retail, station circulation and associated facilities) and the OSD GFA is 67,000 square metres and is equivalent to a FSR of 13.9:1.

A drawing illustrating the proposed building envelope is provided in **Figure 5**. The concept SSD Application includes an indicative design for the OSD to demonstrate one potential design solution within the proposed building envelope (refer to **Figure 6**).

Victoria Cross Station is to be a key station on the future Sydney Metro network, providing access to the growing North Sydney Central Business District (CBD). The proposal combines the Metro station with a significant commercial office tower, contributing to the North Sydney skyline. The OSD would assist in strengthening the role of North Sydney as a key component of Sydney's global economic arc and would contribute to the diversity, amenity and commercial sustainability of the CBD.

It is noted that Victoria Cross services building and new station entrance at Victoria Cross do not form part of the concept SSD Application.

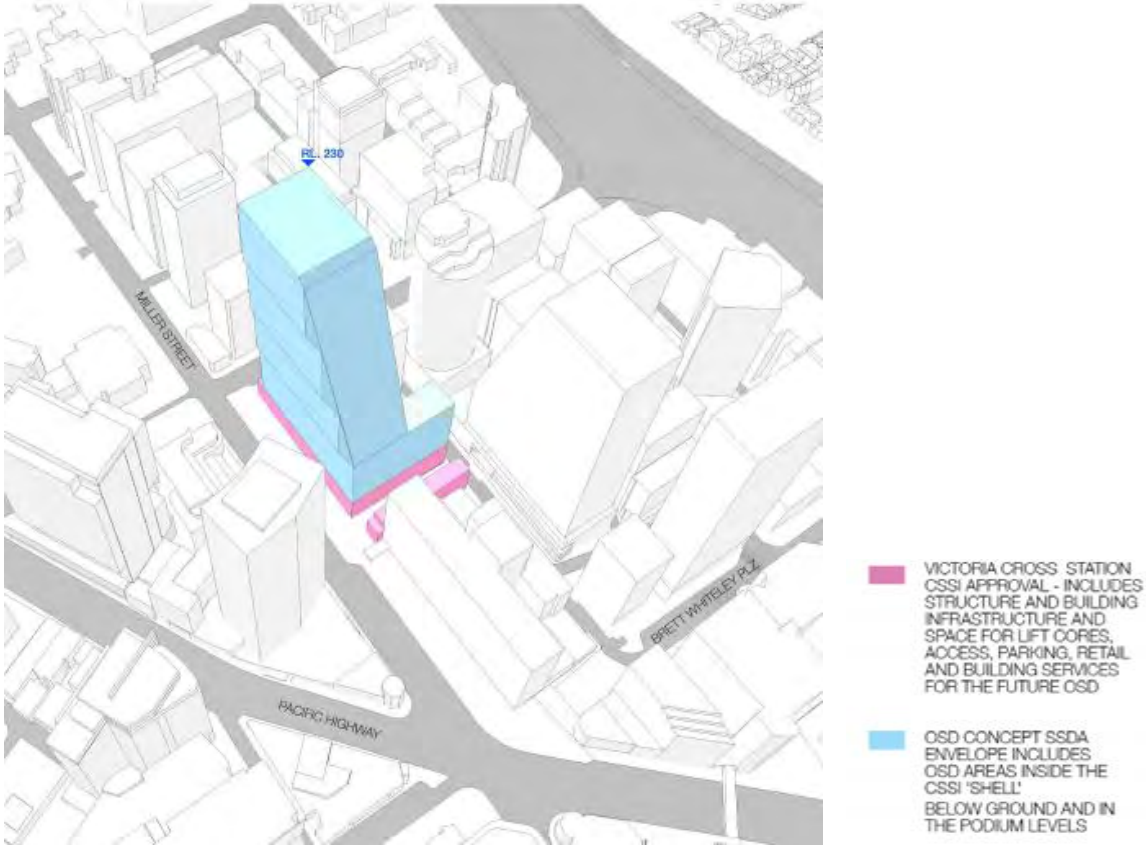


Figure 5: Proposed Victoria Cross OSD building envelope

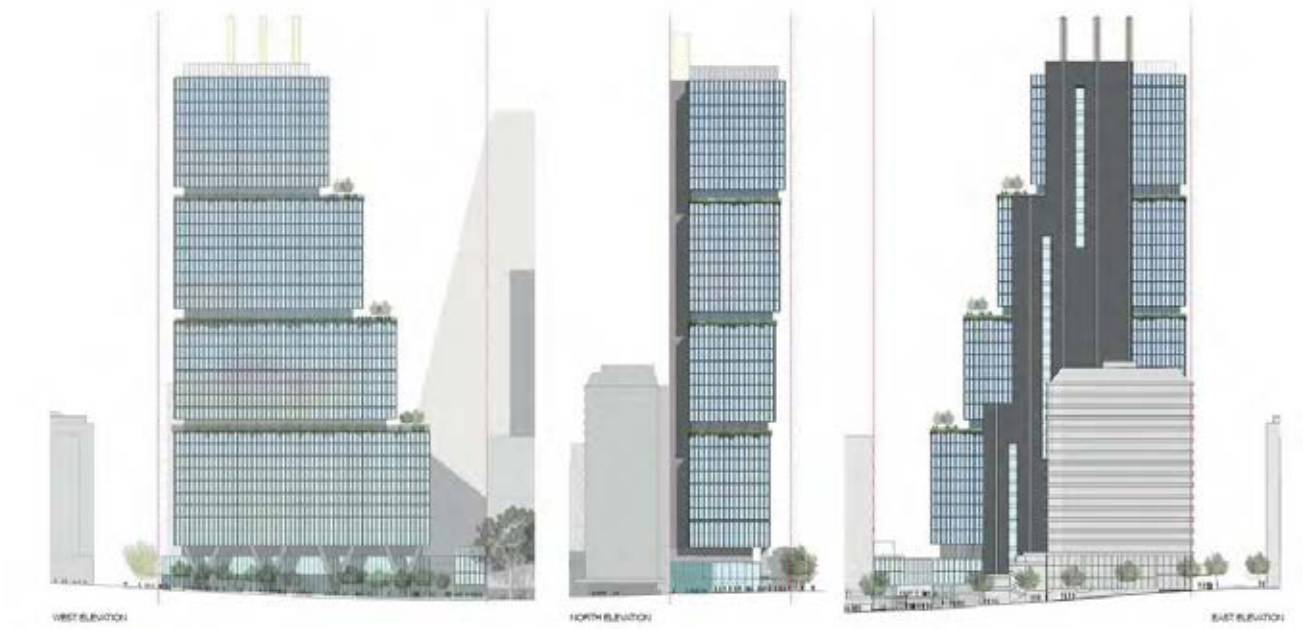


Figure 6: Victoria Cross indicative OSD design

2.0 Scope of assessment

This report is based on the OSD concept design drawings provided by TfNSW (hereafter referred to as the indicative OSD design). This report documents the flood assessment and stormwater management plan that has been undertaken for the OSD in support of the concept SSD Application.

The following tasks were undertaken as part of this report:

- Review of relevant legislation, policies and guidelines associated with stormwater management;
- Consultation with TfNSW's station design team in relation to flood modelling and mitigation and station stormwater design and management;
- Identification of preliminary OSD stormwater management strategy; and
- Estimation of preliminary OSD on-site detention volumes and configurations.

A series of collaboration workshops have been undertaken with TfNSW's Underground Station Design & Technical Services Team (METRON) to coordinate the designs, identify challenges and propose solutions. This occurred as METRON advanced towards their Stage 1 design deliverable (approximately a 40% level of definition).

It is important to note that the stormwater management and flood mitigation measures within the proposed Victoria Cross station leads the context for the assessment of flood impacts and stormwater management plans for the OSD. **Table 1** provides a summary of interfaces and responsibilities between the CSSI Approval and the concept SSD Application. Relevant references are made throughout this report to the preliminary design undertaken by TfNSW's station design team to provide context for the concept proposal and the indicative OSD design.

Table 1 Victoria Cross concept SSD & CSSI design development Interface.

Item	Responsibility	Interface Details
Flood Modelling	TfNSW are responsible for undertaking a flood assessment for the new station and public domain, under the terms of the CSSI Approval.	Preliminary flood modelling has been undertaken by TfNSW in accordance with the CSSI Approval to assess the flooding impacts of the proposed ISD. Outcomes and features of the preliminary flood modelling assessment are broadly discussed within this report.
Stormwater Management	TfNSW are responsible for providing a stormwater management plan for the station, station retail and public domain areas within the site area including in-ground stormwater asset modification/ installation under the CSSI Approval. The concept SSD Application is responsible for stormwater management of the proposed OSD including rainwater collection, storage, treatment and discharge to in-ground infrastructure.	A Stormwater management plan for the station design has been undertaken in accordance with the CSSI Approval and broadly discussed in this report. A Stormwater Management plan for the OSD is detailed within this report adopting the design criteria identified through preliminary authority liaison as part of the CSSI Approval.
Authority Liaison	TfNSW are responsible for undertaking authority liaison (Sydney Water & North Sydney Council) for the development (station & OSD).	Preliminary authority liaison with Sydney Water and Council has been undertaken by TfNSW with the principles and outcomes of the liaison discussed within this report.

3.0 Existing flood studies

A desktop study of North Sydney Council's existing flood information has been undertaken to provide a flooding context for the site.

3.1 North Sydney LGA Flood Study (2017)

In February 2017, North Sydney Council released the North Sydney LGA Flood Study, which was undertaken by WMAwater. The aim of the study is to assist Council in satisfying their responsibilities for managing flood risk within the LGA. The flood study was prepared to define existing flood behaviour in the North Sydney LGA 10.9 km2 catchment area and to establish the basis for subsequent floodplain management activities. The study incorporates key elements specific to the Victoria Cross OSD site including:

- Compilation and review of existing information;
- Review of previous flooding history; and
- Define the flood behaviour for a range of design events including the 20%, 10% and 1% AEP, and the Probable Maximum Flood (PMF) event.

Figure 7 presents the 100yr ARI flood mapping in the site area. This study notes that the OSD site area is flood prone with depths in excess of 0.3m for events up to the 5yr ARI event and in excess of 1m for the 100yr ARI event.

It should be noted that the Council Flood Study has been undertaken over the entire North Sydney LGA region and does not consider any pipe elements smaller than 450mm. As such, the results of the study may not provide a definitive flood level for the site area.

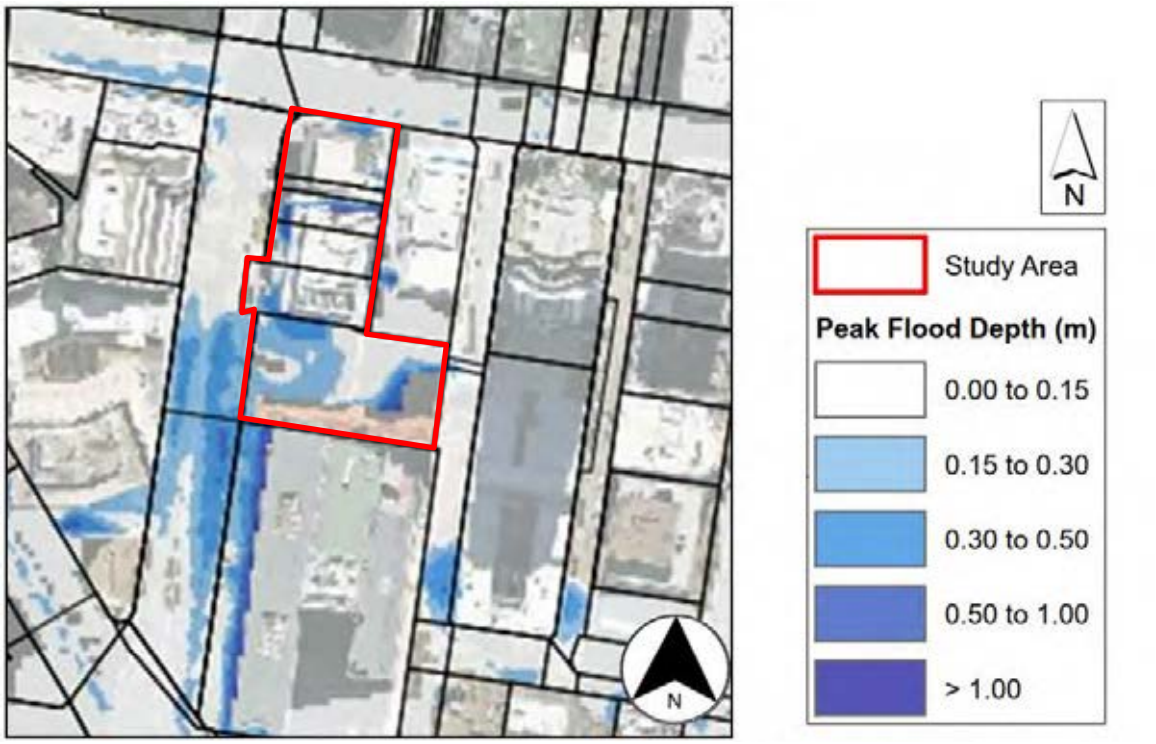


Figure 7: 100 year ARI flood
Source: North Sydney LGA Flood Study (2017)

3.2 Victoria Cross Station preliminary flood assessment

A preliminary flood assessment has been undertaken by TfNSW which has been based on the 2017 Council Flood Model.

The assessment has confirmed that the site is located in a flood affected area, noting that the previous building courtyard at Tower Square (now demolished under the terms of the CSSI Approval) provided informal flood storage during major storms greater than the 5yr ARI event.

4.0 Flood planning requirements

The following sections describe the flooding principles for the broader site area. It should be noted that flood assessment and stormwater management for the site has been undertaken as part of the CSSI Approval. The following sections will highlight the relevant features of the flood management strategy developed by TfNSW following the issue of the CSSI approval, to provide context for the broader site development.

4.1 Proposed flood planning requirements

The proposed criteria as nominated by TfNSW in their CSSI flood assessment have been noted as follows:

- Station entry levels and basement ramp thresholds are to be set to PMF flood level;
- Retail areas located within the Miller Street – Denison Street through-site link overland flow path area are to be protected to 100yr ARI flood Level;
- Lift shafts located within the Miller Street – Denison Street through-site-link overland flow path to be protected to events greater than 100yr ARI event using automatic flood barriers; and
- All other entrances are proposed to be set to the 100yr ARI flood level +500mm freeboard.

5.0 Existing drainage

The following sections describe the existing stormwater assets within the vicinity of the OSD site that interface directly with the concept proposal. It should be noted that in-ground stormwater management, including the modification or diversion of existing stormwater assets will be undertaken as part of the CSSI Approval. The following sections detail the relevant features of this application to provide context for the broader site development. Reference should be made to the CSSI Approval and subsequent design development works for further information and descriptions of modifications to any stormwater assets.

5.1 Existing trunk drainage infrastructure

Sydney Water is the service authority responsible for the operation and maintenance of the existing trunk drainage stormwater infrastructure within the site area. The existing infrastructure shown in **Figure 8** has been identified based on the dial before you dig (DBYD) response from Sydney Water.

The existing trunk drainage line that passes through the site appears to have been amplified as part of the Lane Cove Amplification works in 1980. As a result of the amplification, the stormwater asset is understood to consist of a “U-shaped” brick lined invert (0.9m diameter) and varies in depth under the existing building.

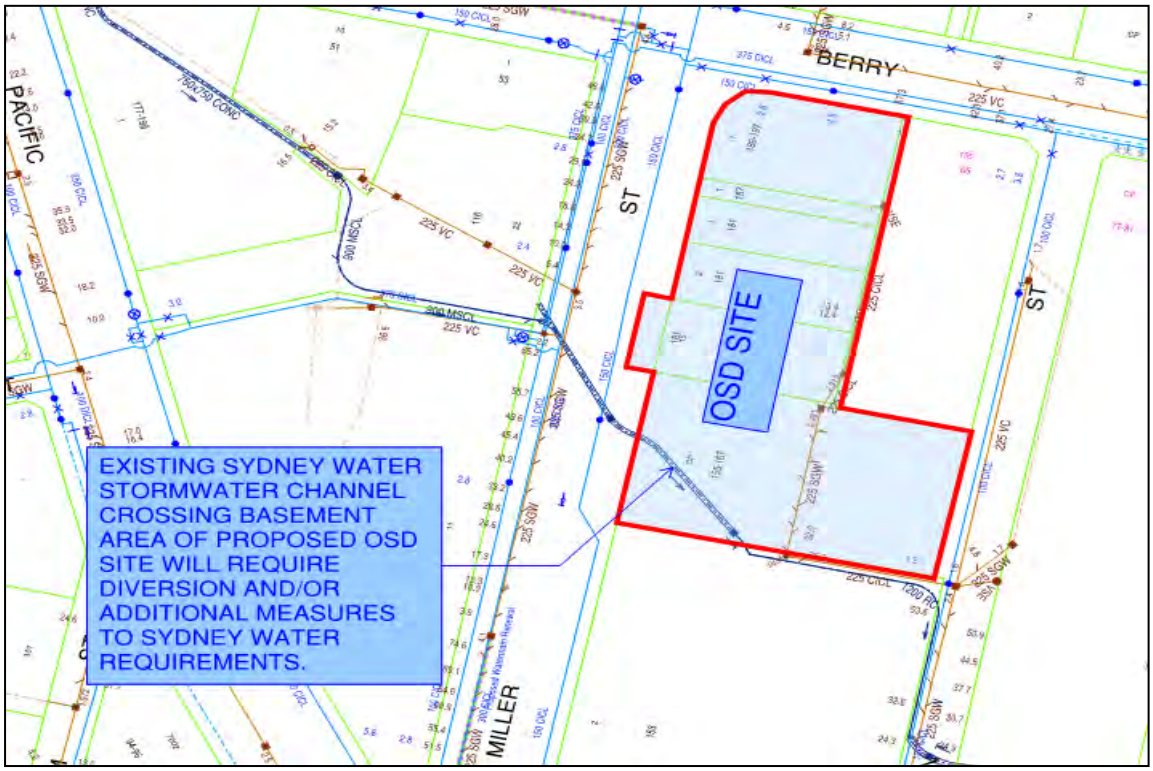


Figure 8: Existing Sydney Water DBYD stormwater assets
Source: DBYD, 2017

5.2 Existing council drainage infrastructure

North Sydney Council operate and maintain the local street drainage infrastructure around the site. The site is understood to be serviced by the local drainage infrastructure in Miller Street and Denison Street as shown below in **Figure 9**. The DBYD information suggests that the council system discharges directly to the Sydney Water trunk drainage line.

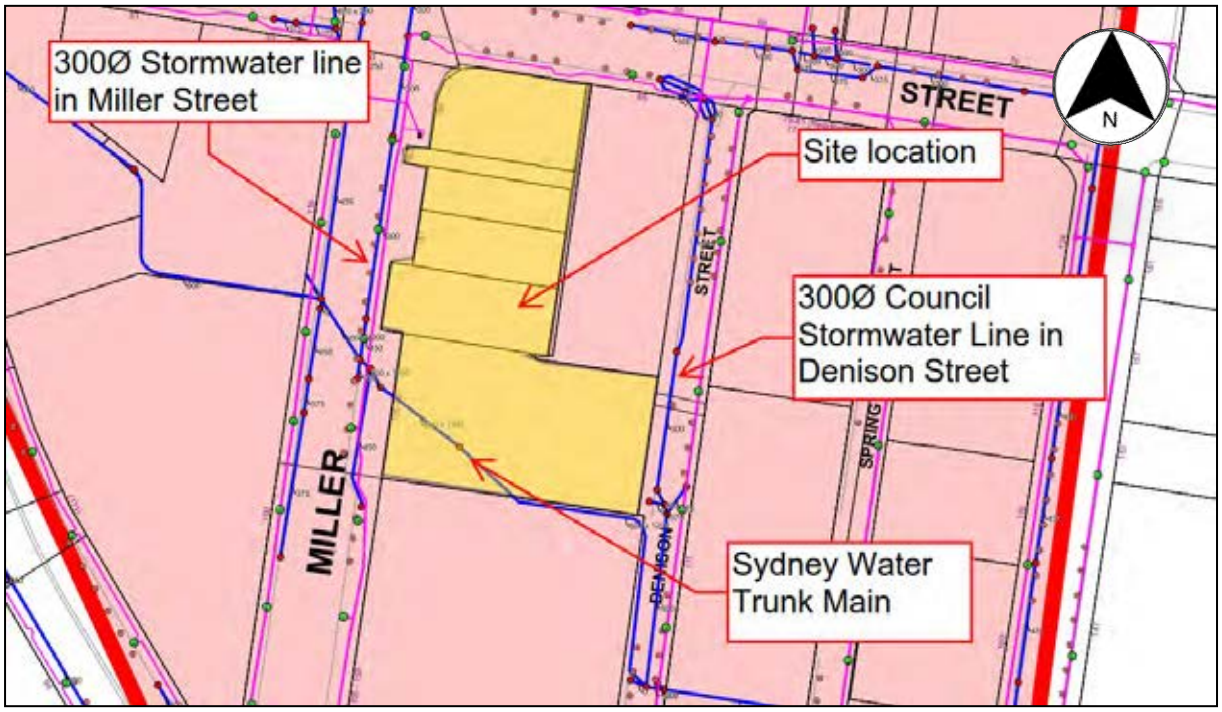


Figure 9: North Sydney Council local drainage infrastructure
Source: DBYD, 2017.

5.2.1 Existing catchment

The previously existing (now demolished under the CSSI approval) development lots were almost 100% impervious with the majority of the runoff originating from building roofs (discharged via gutter and downpipes) and surrounding pavement surfaces. There were some minor bypass areas between buildings and along public footpath areas. The previously existing (now demolished) development lot SP35644 (refer to **Figure 10**) was understood to be graded towards Miller Street with a portion of the eastern roof area discharging to Denison Street via a downpipe to the southern corner of the development lot.

Given Council's Stormwater DCP does not explicitly stipulate on-site detention to be employed in the area, it is assumed that the previous developments did not have any formalised on-site detention or rainwater reuse tanks.

The previously existing stormwater discharge from the site has been calculated using the DRAINS software program. **Figure 8** demonstrates existing roof catchment distribution and

peak discharge values can be found in **Table 2**. These values are based on the AR&R '87 ILSAX method for 100% impervious areas for a 5 minute time of concentration.

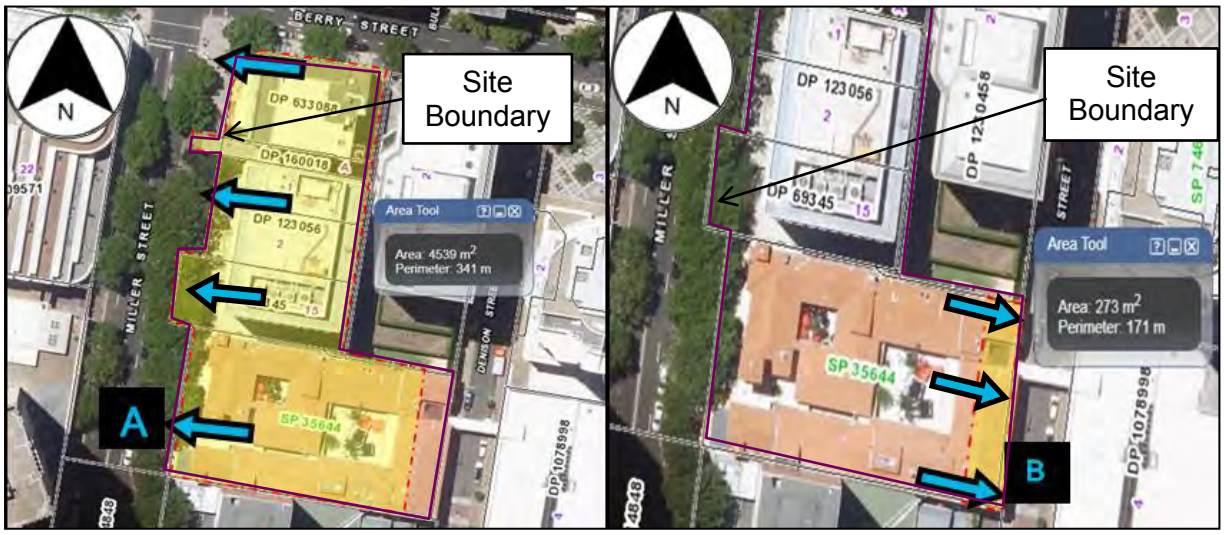


Figure 10: Existing catchment distribution - Victoria Cross South.
Source: SIX Maps

Table 2: Preliminary existing stormwater discharge – Victoria Cross South

Location1	Site area (m2)	5Yr ARI Peak Discharge Qp5yr (L/s)	10Yr ARI Peak Discharge Qp_{10yr} (L/s)	20Yr ARI Peak Discharge Qp_{20yr} (L/s)	100Yr ARI Peak Discharge Qp_{100yr} (L/s)	Comments
Vic Cross South: A	4537	203	232	269	324	Discharge to Miller Street drainage system
Vic Cross South: B	278	12	14	16	20	Discharge to Denison Street drainage system
Total	4815	215	246	285	344	Ultimately site discharges to Sydney Water culvert

Table 2 Notes:

1. Refer to **Figure 10** for discharge locations A & B.

6.0 Victoria Cross station – preliminary flood mitigation strategy

Preliminary flood modelling has been undertaken as part of the post CSSI approval design development works. Based on preliminary discussions with TfNSW, the following features form part of the flood mitigation strategy in conjunction with the proposed flood planning requirements noted in **Section 4.1.**

6.1 Overland flow path between Miller Street and Denison Street

The intent is to provide safe conveyance of flow currently discharged along the existing overland flow path during major storm events along the proposed Through-site link which adjoins Miller Street and Denison Street. Flood protection for the proposed retail tenancies and station entrances will be provided through surface grading and elevated floor levels. The surface grading will need to consider DDA accessibility. It is proposed that the station entrances and basement areas will be protected up to the PMF flood level with protection of the retail entrances up to the 100yr ARI flood level as noted in **Figure 11** below.

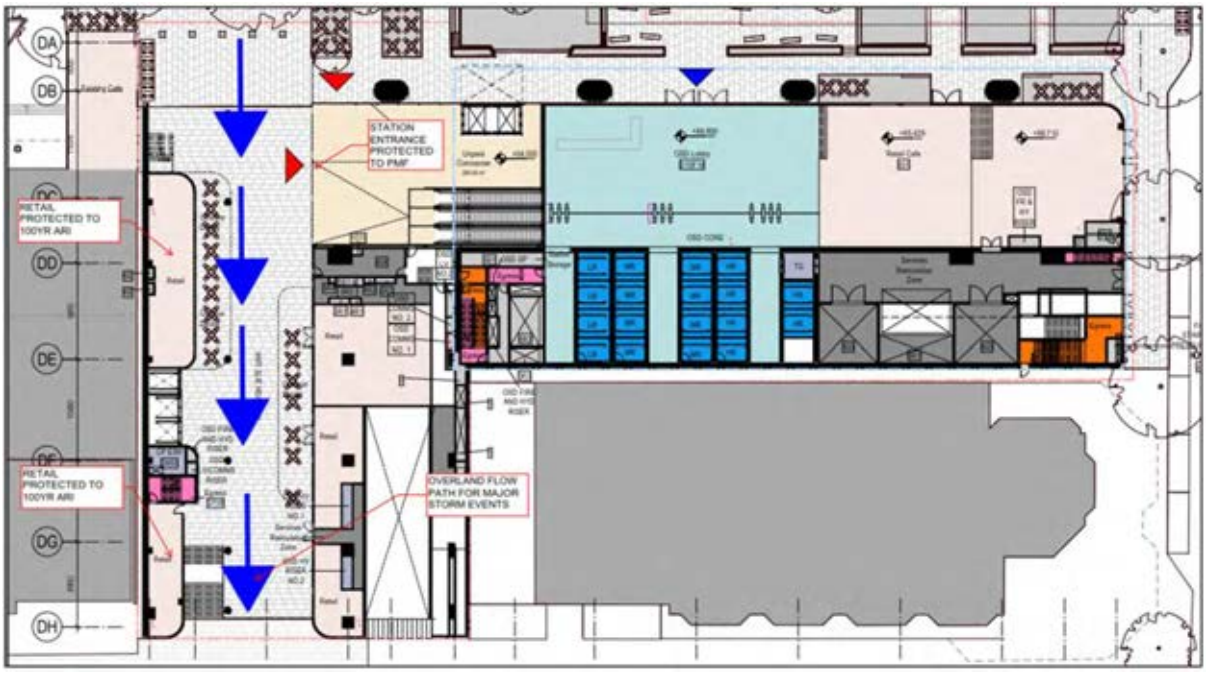


Figure 11: Flood Protection Principles

6.2 Compensatory flood storage in Denison Street

The preliminary flood analysis undertaken by TfNSW indicates that additional flood storage would be required to achieve the flood protection requirements as noted in **Section 4.1**. The preliminary location for the compensatory flood storage is proposed below ground in Denison Street as shown in **Figure 12** below. It is noted that the proposed location is indicative only and subject to further design development in consultation with Sydney Water and Council.

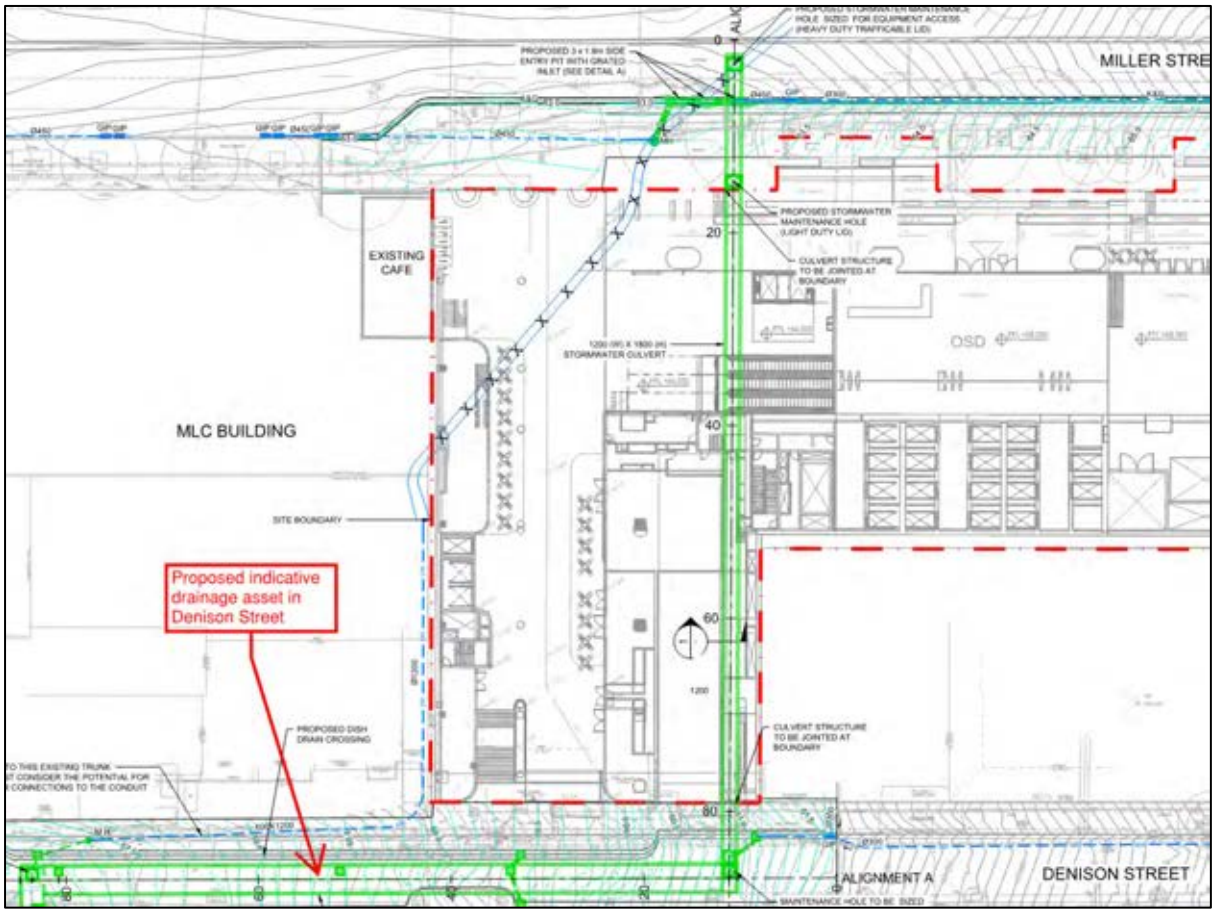


Figure 12: Indicative compensatory flood storage
Source: METRON

6.3 Realignment of existing trunk drainage

To facilitate the new development, the existing Sydney Water trunk drainage line that traverses the site will need to be relocated. The preliminary TFNSW design intent proposes that a new sealed pipeline will connect the existing trunk drainage line in Miller Street to the proposed compensatory flood storage in Denison Street as shown indicatively in **Figure 13** below.

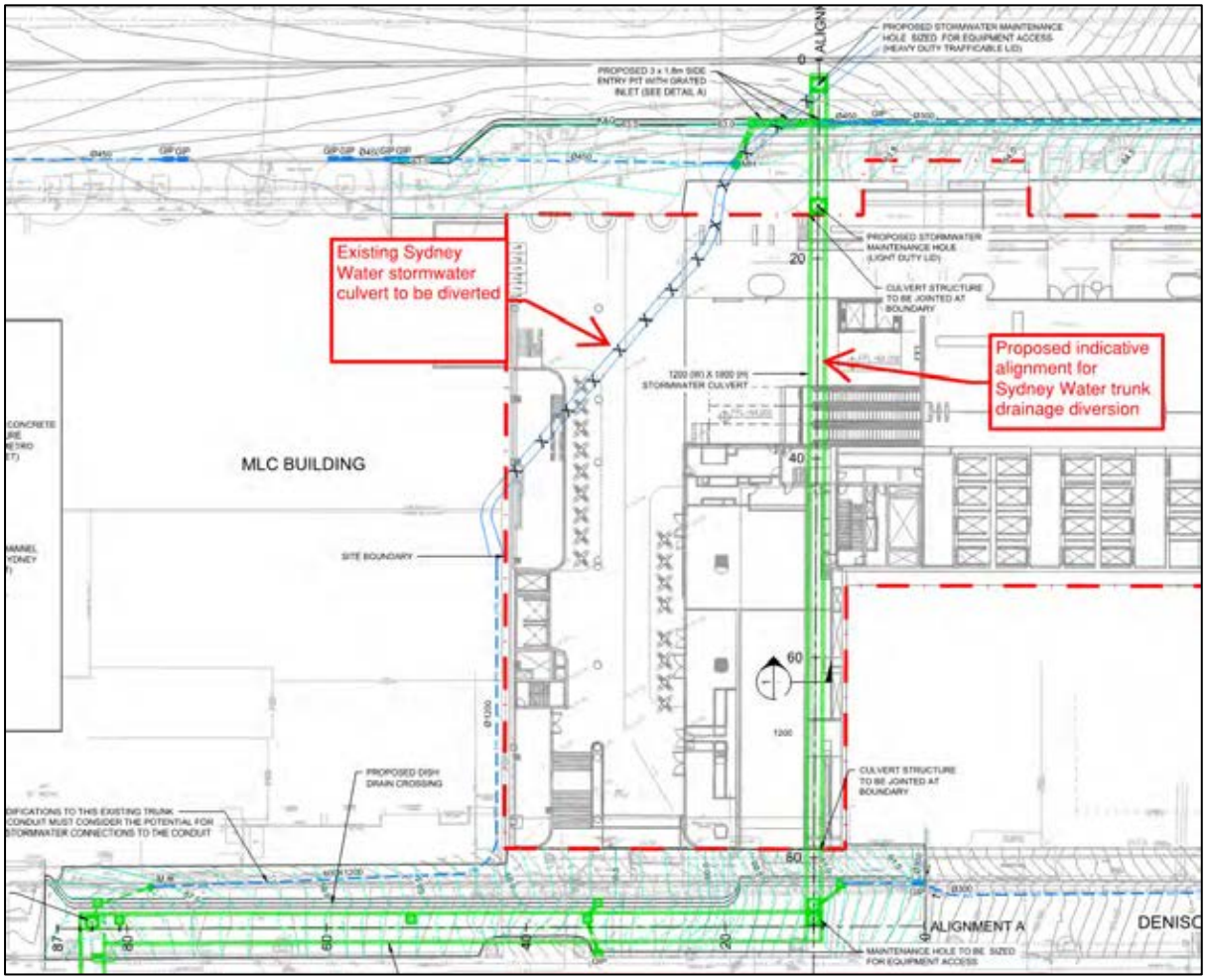


Figure 13: Indicative trunk drainage diversion.
Source: METRON

7.0 OSD Stormwater Management Plan

The following sections describe the proposed features of the stormwater management plan as applicable to the concept SSD Application for the proposed OSD.

7.1 Proposed stormwater management strategy

The proposed OSD is to be constructed over the Victoria Cross station. As requested by TfNSW, a separate stormwater system will be installed within the future OSD which will discharge directly to the Council/Sydney Water system in Denison Street.

Refer to **Appendix A** for a schematic layout for the stormwater management system. Stormwater run-off from the tower roof will be collected using a gutter and downpipe system. Run-off from the roof will be directed to the building's on-site detention and stormwater treatment system. Stormwater run-off from the building terrace areas will be graded to a series of proprietary drainage inlet systems (including rain water outlets and grated trench drains) and discharged to the buildings on-site detention and water treatment devices. **Figure 14** below demonstrates a typical terraced drainage system.

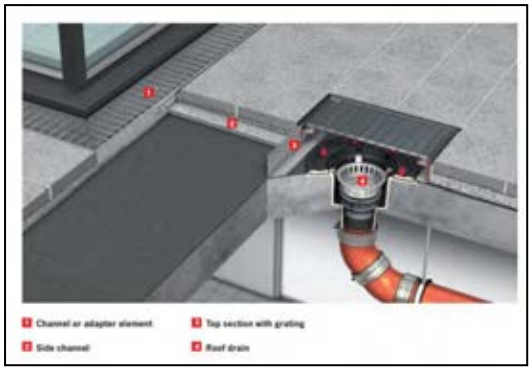


Figure 14: Typical Terrace drainage collection systems
Source: ACO Drain

The peak discharge from the site will be restricted to comply with Council and Sydney Water on-site detention and permissible site discharge requirements (refer to **Section 7.4** for further details). A suitably sized orifice plate will be used to control the peak discharge from the on-site detention tank. A debris screen or trash screen will be used to prevent the orifice/outlet pipe from potential blocking. **Figure 15** shows a typical debris screen and orifice plate detail.

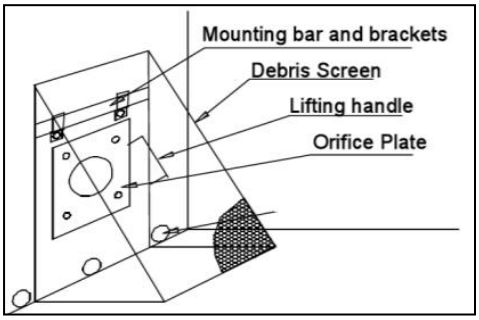


Figure 15: Typical debris screen and orifice plate detail

The on-site detention system will provide an overflow device to cater for any peak discharge in excess of the design capacity (100yr ARI storm event) with consideration for the building's vertical catchments. The overflow system will discharge via a series of separate downpipes to Denison Street to allow for visual inspection.

7.2 Water Sensitive Urban Design (WSUD)

The OSD will aim to achieve, where practical, the pollution reduction targets identified in Section 3.5.6 of the North Sydney Council DCP, as summarised below:

a. Litter and vegetation larger than 5mm: 90% reduction on the Baseline Annual Pollutant Load;

b. Total Suspended Solids: 85% reduction on the Baseline Annual Pollutant Load;

c. Total Phosphorous: 65% reduction on the Baseline Annual Pollutant Load;

d. Total Nitrogen: 45% reduction on the Baseline Annual Pollutant Load.

7.3 Stormwater treatment

To achieve Green Star rating points and Council's Water quality targets, the OSD development will need to achieve pollution reduction targets. Requirements for specific water quality targets are expected to be further refined in future design phases, however the following provides an outline of typical water treatment devices that could be used:

- First flush diversion of the captured roof water, prior to connection to water harvesting and OSD tank system; and

- Trash screens installed over the stormwater outlets on the OSD tank.

Gross Pollutant Trap is to screen all stormwater discharging from the site before entering the Council stormwater system.

The rainwater harvesting systems for the buildings shall collect rainwater from the tower roof level only and gravitate to the rainwater harvesting tank/s.

Reused treated rainwater may be re-used for toilet flushing, landscape irrigation and wash down.

Further information on ESD requirements can be found within the separate ESD report at Appendix Q within this EIS.

7.4 On-site detention requirements

Preliminary correspondence between TfNSW and Council suggests that Council may seek to enforce on-site detention requirements to restrict the proposed site peak discharge of all events up to the 100 year ARI event to that of the pre-development peak discharge for the 5 year ARI event. It is envisaged that this requirement will be further discussed with Council during future design stages, however for the purposes of the concept SSD Application, the existing site 5 year ARI event has been adopted as the permissible site discharge to demonstrate compliance should Council enforce this requirement.

A preliminary schedule of permissible site discharge (PSD) has been developed for the site (i.e. integrated development – OSD & Station areas) on the basis that all site discharge must be restricted to that of a 5yr ARI pre-development peak discharge. Noting that the pre-development site currently discharges to the Sydney Water trunk line (via Council's drainage system) maintaining distribution of flows between Denison Street and Miller Street has not been considered in the preliminary analysis.

Table 3: Preliminary PSD requirements (assuming upper limit of 5yr ARI Pre-development peak discharge)

Location	Total Site area (m^2)	5Yr ARI Peak Discharge Qp_{5yr} (L/s)	PSD ($L/s/m^2$)	Comments
Vic Cross South Over Station Development	4815	215	0.045	PSD rates to be confirmed with Sydney Water & Council during future design phases.

7.5 On-site detention options

There are several possible mechanisms to provide on-site detention and water quality enhancement for the OSD within the site. Two options are presented below which may be considered further in future design stages. For the purpose of preliminary spatial allocation of stormwater management infrastructure in the indicative OSD design, it is assumed that Option 1, an on-site detention and storage tank with separate rainwater tanks will be adopted.

Option 1

On-Site Detention Storage via segregated storage and reuse tanks to regulate the peak discharge (refer to **Figure 16** below);

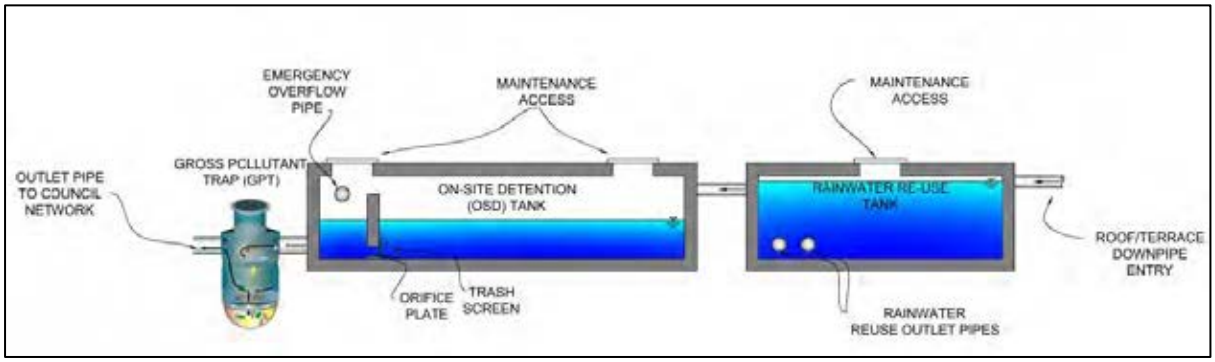


Figure 16: OSD storage tank option (refer to Appendix A for further details)

Option 2

Combined On-Site Stormwater Detention and rainwater re-use via storage tanks within the building to be considered in future design phases for spatial optimisation (refer to **Figure 17** below).

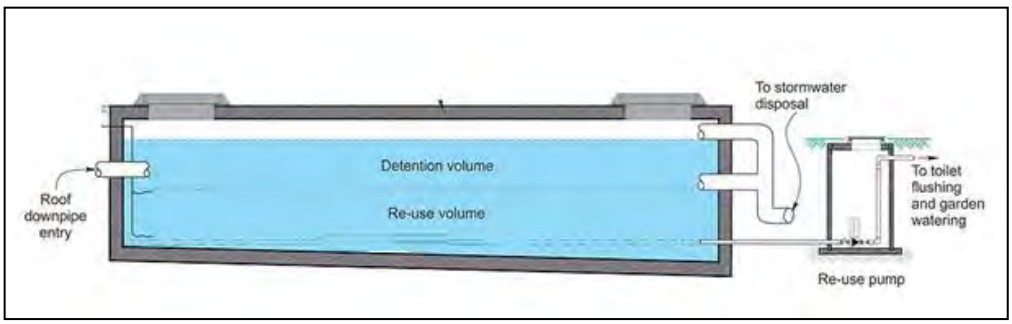


Figure 17: Typical combined on-site detention & rainwater re-use storage tank

7.6 Preliminary on-site detention storage requirements

A DRAINS ILSAX hydrology model was used to determine the minimum detention storage requirements for the OSD roof and terrace areas. It has been assumed that two detention tanks will be provided, with lower portions of the site bypassing the detention storage (upper areas being sufficiently restricted to compensate for bypass flows). The preliminary locations of the detention tanks have been shown indicatively in **Appendix A**. The outlet for each detention tank consists of an orifice and primary outlet with an emergency overflow pipe for larger magnitude storms.

The indicative OSD tanks have been sized to cater for the 100yr ARI event with no additional allowance for vertical catchments for the primary outlet and detention storage volume. Consideration for the contribution of vertical catchments has been provided within the overflow pipe. This approach will need to be confirmed with Council through consultation in future design phases. In estimating the detention storage requirements, it has been assumed that any rainwater tanks are at full capacity with no additional storage allowance.

The detention requirements for the over station development have been assessed with consideration for bypass run-off within the station areas to ensure a holistic approach to achieving Council's PSD requirements for the entire site area.

A summary of the preliminary discharge arrangements are shown below in **Table 4.**

Table 4: Preliminary discharge arrangements

Plan Catchment Area (m^2)	Peak Storm Duration	100yr ARI Catchment Peak Discharge Qp_{100yr} (L/s)
L43 – Rooftop to L22 Mid Mid Rise Terrace OSD Tank 1 (2169 m^2)	1.5 Hr Storm	*See **Figure 18*** Inflow: 135 L/s Outflow: 50 L/s
L13 – Lower Terrace OSD Tank 2 (793 m^2)	1.5 Hr Storm	*See **Figure 19*** Inflow: 77 L/s Outflow: 22 L/s
Bypass to Denison Street: (1016 m^2)	1.5Hr Storm	73 L/s
Bypass to Miller Street (837 m^2)	Varies	59 L/s
Total Site: 4815 m^2	Varies	Net combined discharge off site: 196 L/s

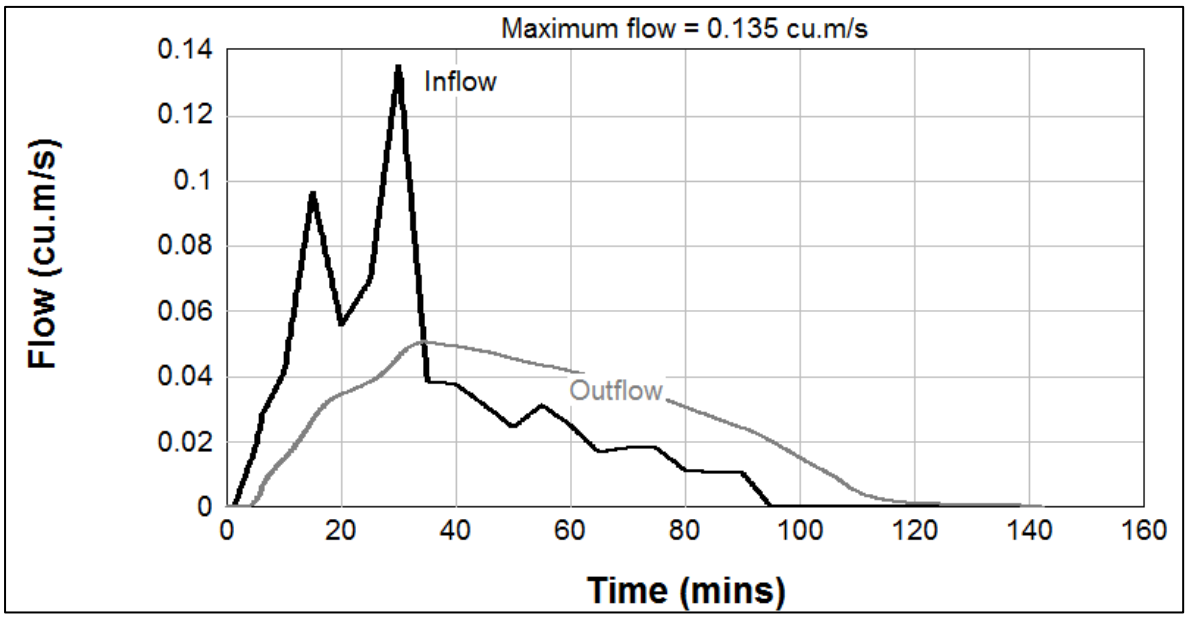


Figure 18: 100yr ARI Peak Inflow/Outflow Hydrograph (1.5Hr Storm) for the Indicative OSD Design Tank 1.

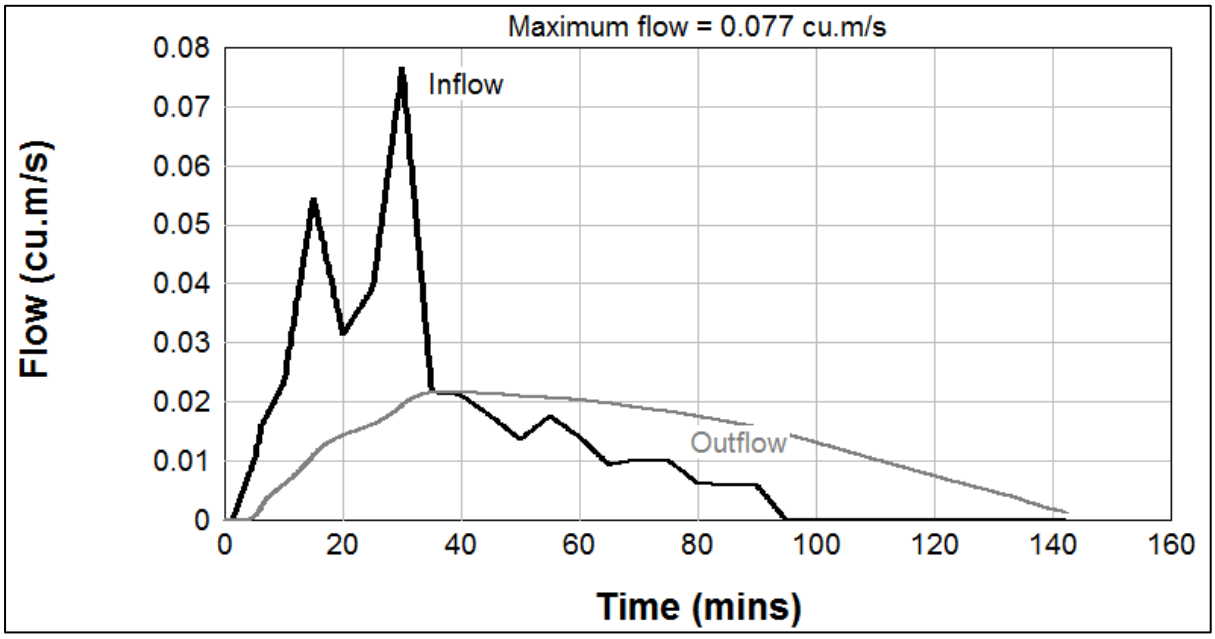


Figure 19: 100yr ARI Peak Inflow/Outflow Hydrograph (1.5Hr Storm) for the Indicative OSD Design Tank 2

7.7 Preliminary results discussion

The preliminary site discharge arrangement sketches are provided in **Appendix A** with preliminary spatial allowances presented in **Table 5**. From the preliminary hydraulic modelling results above, it is noted that post-development 100yr ARI peak discharge is compliant with a 5yr ARI pre-development permissible site discharge. Provision for on-site detention could effectively reduce the entire site discharge from 344L/s (existing condition) to 196 L/s in the 100yr ARI event.

Table 5: Preliminary OSD tank storage and spatial requirements

Indicative OSD Design Tank	Min 100yr Effective Storage Detention Volume[1] (m3)	Min Tank Volume (m3) [2]	Outlet Arrangements[3]	Preliminary Spatial Dimensions[4] (m)
OSD Tank 1	85 m^3	105 m^3	**Primary:** 130mm Orifice **Overflow:** 300mm Pipe	**Spatial allowance:** 8m x 8m x 2.2m
OSD Tank 2	45 m^3	55m^3	**Primary:** 90mm Orifice **Overflow:** 300mm Pipe	**Spatial allowance:** 5.5m x 5.5m x 2.2m

Table 5 Notes:

1. No allowance for rainwater tank.
2. Minimum tank volume based on effective storage volume with an additional 25% for freeboard & overflow
3. Outlet arrangements subject to detailed design
4. Preliminary external tank dimensions assuming maximum height of 2m, 0.25m wall thickness. Additional allowance to be considered for maintenance access.

7.8 Downpipe coordination

Discharge from the proposed on-site detention tanks will be separate to the Victoria Cross station drainage reticulation arrangements, as requested by TfNSW. A preliminary coordination exercise has been undertaken for downpipes located within the station building to avoid the station. Future design phases will need to ensure full coordination can be demonstrated.

8.0 Conclusion

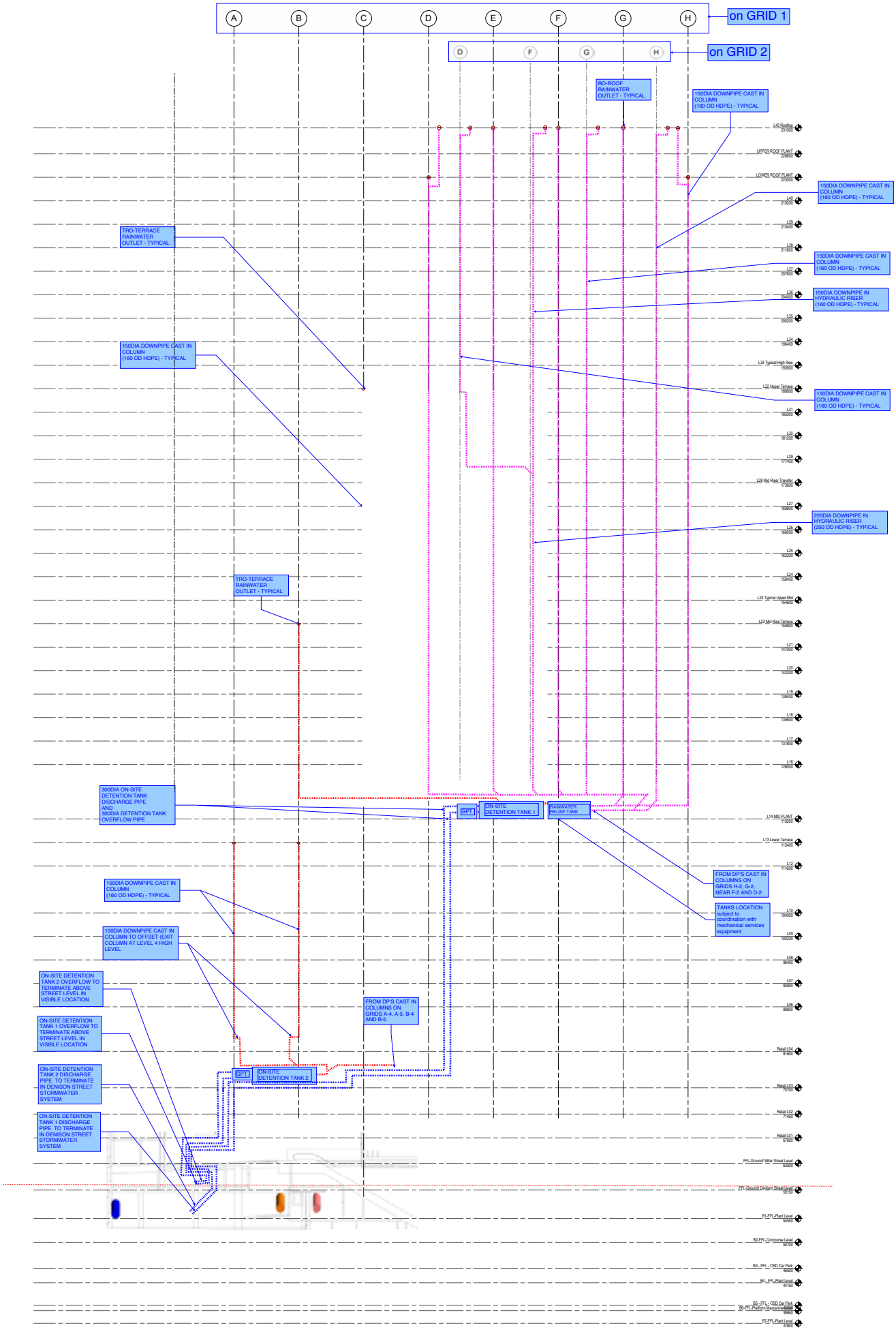
This report identifies that the site is located within a currently flood affected area. Future designs will need to consider Council and Sydney Water requirements for management of stormwater and flooding. Preliminary modelling undertaken by TfNSW has demonstrated that a solution to the flooding issues could be achieved by providing safe major storm event overland flow paths and providing flood storage in Denison Street. These works are subject to further design development and consultation with Council and Sydney Water.

On-site detention requirements discussed in this report have been derived from preliminary discussions between TfNSW and Council – i.e. the permissible site discharge for events up to and including the 100yr ARI event are to be restricted to the pre-development 5yr ARI peak discharge.

Prior to lodgement of the future detailed SSD Application, further consultation with Council and Sydney Water will be required to resolve management of site stormwater.

Appendix A

Proposed site discharge schematic layout



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