RobertBirdGroup

North Ryde Station Precinct

M2 Site

State Significant Development
Stormwater Management Plan

Prepared For: Urban Growth NSW

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Report Amendment Register

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Executive Summary

The following Stormwater Management Plan (SWMP) is in support of the State Significant Development Application (SSDA) relating to Lot 101 in DP 1131776 (M2 Site). This SWMP, prepared by Robert Bird Group (RBG) on behalf of Urban Growth NSW, relates to the North Ryde Station Urban Activation Precinct (UAP) and specifically focuses on the M2 Site works.

The aim of this SWMP is to detail the investigation and results of the two stormwater components relating to the M2 Site. These components include:

- Wicks and Waterloo Road intersection drainage augmentation; and
- M2 Site internal drainage.

Wicks Road and Waterloo Road Intersection Drainage Augmentation

Flood analysis investigations undertaken by Cardno concluded that under existing conditions emergency vehicles would be unable to safely exit the planned development through the Wicks Road and Waterloo Road intersection during a 100 year ARI flood. This is due to excessive depth and velocities of overland flow across the intersection.

A substantial upgrade of the stormwater drainage system on both sides of Waterloo Road is proposed to provide safe egress for emergency vehicles from the Site. The upgrade consists of:

- Local re-grading of Wicks Road;
- Upgrading the existing 2.7m diameter stormwater culvert which runs under the existing access road into the M2 site, into a 3.6m x 2.4m reinforced concrete box culvert (RCBC);
- Dual kerb inlet pits with 3.3m lintels on both sides of Waterloo Road, spaced at approximately 5-8m intervals;
- Twin 1.2m diameter pipes to convey the stormwater across the Wicks/Waterloo Road intersection;
- Install new drop inlet structure and RCBC under Spine Street; and
- Connect existing 2.1m diameter pipe to new 2.4m x 2.4m RCBC and extend to outlet headwall downstream of the proposed Spine Street.

Hydraulic modelling has confirmed that the proposed drainage augmentation will capture sufficient overland flows from surrounding catchments to reduce flooding on the intersection sufficiently to permit safe movement of vehicles into the Site and along Wicks Road.

M2 Site Stormwater Management Plan

A stormwater drainage system has been designed for the M2 Site. The drainage system incorporates the treatment of stormwater runoff to meet proposed water quality targets. The system is designed based on a minor/major storm drainage philosophy, whereby the minor design storm will be conveyed in stormwater drainage pipes within the road corridor, and excess stormwater from the major design storm will safely discharge within the road and overland flow paths. The designed stormwater network also ensures that all overland flows from the 100 year ARI storm are captured within the pipe network, upstream of the Wicks and Waterloo Road intersection, before discharging to Porters Creek.

The concept stormwater design for the M2 Site redirects stormwater runoff to streetscape bio-retention and in-ground treatment devices before entering the stormwater network within the road reserve. DRAINS and MUSIC models have been developed by RBG to demonstrate that the performance of the stormwater system satisfies the requirements of the City of Ryde DCP and the North Ryde Station Precinct DCP.

Flood modelling carried out by Cardno has also concluded that the M2 site can be exempt from on-site detention (OSD) for both the Public Domain and the Lot developments. Computer modelling and analysis using Tuflow has demonstrated that removing the requirement to install OSD does not adversely impact adjoining or downstream roads, properties, or watercourses.

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APPENDICES

1.0 Introduction

1.1 Purpose of Document

This Stormwater Management Plan (SWMP) has been prepared by Robert Bird Group (RBG) who has been engaged by UrbanGrowth NSW (UG NSW) to provide civil engineering design in respect of Lot 101 in DP 1131776 (M2 Site), being part of the North Ryde Station Urban Activation Precinct (UAP). In this report the land contained within this lot is referred to as the "Site" or the "M2 Site". Included in the scope of works is to provide civil engineering design to the intersection of Wicks Road and Waterloo Road situated at the northern access point of the Site.

The purpose of this document is to address the management of stormwater and water sensitive urban design (WSUD) to support a State Significant Development Application (SSDA) for the Site.

This report presents the investigation and analyses results for the proposed stormwater management systems for the Site.

The following Director General Requirements (DGRs) are addressed in this report:

- Water Quality
  - *Assess any potential impacts of proposed development on the hydrology and hydrogeology of the site and adjacent areas (including groundwater) in terms of impact on water quality having regard to relevant environmental targets. This should include consideration of all watercourses including Porters Creek and the Lane Cove River. In particular, identify how any potential water quality impacts will be avoided, mitigated or managed*. This has been addressed in Section 3.0 of this SWMP.
  - *Outline measures to be incorporated on site, including (but not limited to) on-site detention and water sensitive urban design*. Section 3.2 addresses on-site detention and Section 6.0 discusses water quality and WSUD measures.
- Flooding – *Demonstrate that the development is compatible with the flood hazard of the land, and identify any impacts of the proposed development on flood behaviour*. This has been addressed in Section 3.0.
- Construction Impacts – *Provide an assessment of construction impacts of the works associated with the development application, and propose appropriate mitigation measures*. This has been addressed in Sections 6.1 and 6.2.

1.2 References and Inputs

Various investigations and assessments were prepared in support of the rezoning for the NRSUAP. Project documentation referenced in preparation of this SWMP includes:

- North Ryde Station Precinct: Development Control Plan, NSW Government, December 2013 (DCP 2013);
- North Ryde Station Precinct: Planning Report, NSW Government, January 2013;
- North Ryde Station Urban Activation Precinct: Finalisation Report, Planning and Infrastructure, NSW Government, July 2013;
- Cardno Flood Assessment Report (ref: 59914099-L01:BCP/bcp) dated 15 April 2014 (Cardno Report);
- Preliminary Geotechnical Investigation Report, Douglas Partners, April 2014;
- Phase 1 Contamination Report, Douglas Partners, April 2014;
- Remediation Action Plan, Douglas Partners, April 2014;
- Site survey, Whelans 2011;
- Hydrology, Flooding and WSUD Report, Storm Consulting, October 2012.
- Geotechnical Investigation (Creek Scour Protection, Porters Creek, near Wicks Road, Macquarie Park), JK Geotechnics, October 2014.

Other reference documentation includes:

- Civil Design Report, 13656C-C-006, RBG, May 2014;
- Macquarie Park Floodplain Risk Management Study and Plan, Bewsher Consulting April 2010 (Bewsher 2010);
- Macquarie Park Floodplain Risk Management Study and Plan, Bewsher Consulting January 2011 (Bewsher 2011);
- City of Ryde Development Control Plan 2014 (DCP 2014);
- Managing Urban Stormwater: Soils & Construction, 4th Edition, Landcom;
- TIDC Development ECRL Underground Infrastructure Guidelines, Doc#20007300/PO-4532, May 2008;

2.0 Site Characteristics

2.1 Location

The M2 Site, located within the City of Ryde local government area, is bound by the M2 Motorway to the east, Delhi Road to the south, Epping Road to the south-west, Wicks Road to the north and low rise commercial/industrial buildings to the west. Refer Figure 2.1 for a Site Locality Plan.

The area is an irregular shaped land parcel covering approximately 9.2ha and is about 600m long and 200m wide. Site levels slope down to the north with a difference in level of approximately 28m, which is an average slope of about 5%.

At the time of this report, the site was being utilised by Leighton Contractors and Epping to Thornleigh Third Track (ETTT) Alliance as a works compound. There is an access road running north south on the western side of the site, with entry/exit at the intersection of Wicks Road and Waterloo Road. There are site sheds and parking areas to the south. Stockpiles of excavated material occupy the centre of the site. A large concrete lined water settling basin is located at the lower levels of the worked area and appears to be maintained to treat runoff from the construction site.

Bushland occupies the northern part of the site. Porters Creek runs parallel to Wicks Road at the northern end of the site within the bushland area.

The Epping to Chatswood Railway Line (ECRL) tunnels pass under the southern end of the site. Figure 2.1 below provides an indicative alignment of the ECRL.

Figure 2.1 – Site Locality Plan

2.2 Existing Geotechnical Conditions

A preliminary geotechnical investigation of the Site was prepared by Douglas Partners to provide an assessment of the existing geotechnical conditions. The following site specific geotechnical profile was provided in the preliminary report.

Unit	Material	Description
1	**Filling**	Deep filling was encountered in the majority of the borehole locations across the M2 site to depths of 1.0m to 3.0m.
2	**Silty Clay**	Hard silty clay identified at several borehole locations, to depths of 1.9m and 2.2m (up to 1.9m thick).
3	**Shale, Siltstone and Sandstone (Mittagong Formation)**	Extremely low to very low strength shale and siltstone to depths of 3.0m to 3.7m was encountered in boreholes at the southern end of the site.
		Low to medium strength siltstone to depths of 5.1m to 6.0m in boreholes at the very south of the site.
		Extremely low to low strength, fine grained sandstone to depths of 2.1m to 4.25m.
4	**Sandstone (Hawkesbury Sandstone)**	Medium to high strength sandstone, moderately to slightly fractured to unbroken with depth, was proven to depths of 9.55m to 41m. Some very low strength bands were encountered at various depths.

Table 2.1 – Geotechnical Profile

Rock is generally close to the surface in the Site, and accordingly it is anticipated that structures for the development will be founded on rock. Any surface development within the zone of influence of the ECRL will have to consider the effects on the tunnels.

For the purposes of preliminary design control measures, including sediment and erosion control, Douglas Partners recommend the soils are to be classified as Type F.

JK Geotechnics also completed a geotechnical investigation of the site and issued a letter with advice on the scour protection measures required for Porters Creek. Refer Appendix C for the letter entitled *Geotechnical Investigation: Creek Scour Protection, Porters Creek near Wicks Road, Macquarie Park, NSW*. The scour protection measures are discussed in greater detail in Section 3.4.

No groundwater was encountered during geotechnical investigations.

2.3 Existing Stormwater Infrastructure

There is minimal existing stormwater infrastructure within the Site. Stormwater runoff from the construction and stockpile areas are channelled into the existing sediment basin for treatment. Excess runoff bypasses the settling basin and ultimately discharges to Porters Creek at the northern end of the Site.

Porters Creek runs along the northern boundary of the Site, adjacent and parallel to Wicks Road. The creek drains the industrial and residential catchment to the west of the Site. A 2700mm diameter pipe culvert crosses the access road (off Wicks Road) in the northwest corner of the Site. Headwalls of the culvert are retained with gabion baskets. Upstream of the 2700mm diameter culvert, the stormwater network is piped (via a 2100mm pipe network) and discharges to a short open area before entering the 2700mm diameter culvert.

2.4 Contamination Investigation Findings

As reported by Douglas Partners in the Phase 1 Contamination Report (April 2014), it was considered that the M2 Site has generally a low to moderate potential for contamination that can be made suitable for the proposed high rise residential and mixed uses, subject to:

- A Phase 2 (detailed) contamination assessment targeting the potential; for contamination identified within the Phase 1 Contamination Report;
- Appropriate remediation and/or management of any soil and/or groundwater contamination issues identified through the targeted Phase 2 contamination assessment; and
- Validation of completion of any remediation undertaken and/or development of an appropriate plan to implement recommended management measures.

2.5 Proposed Development

The proposed development consists of a combination of residential, commercial, retail and community areas. The intention is to encourage greater use of the public transport network and create a community that is well connected to employment areas via bicycle links, pedestrian and public transport.

An indicative layout plan for the development is provided in Figure 2.2.

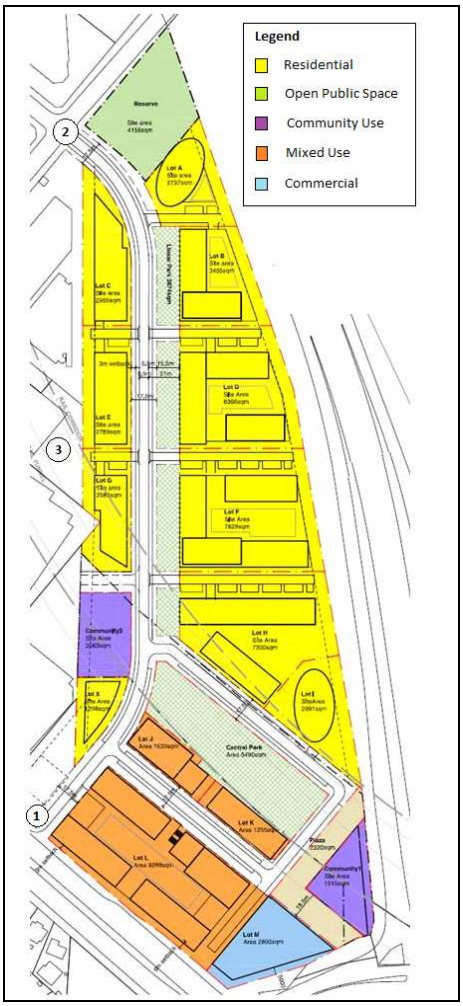

Figure 2.2 – Indicative Layout Plan (Source: Batesmart 2014)

Vehicular access to the site will consist of the following:

1. Left turn, entry only from Epping Road;
2. Entry and exit from the Wicks Road and Waterloo Road intersection; and
3. Possible future connection through the industrial area to the west.

As mentioned previously, the Epping to Chatswood Railway Line (ECRL) tunnel passes under the M2 Site. Temporary or permanent construction activities are not to adversely affect the ECRL and construction activities and building developments must be in accordance with the *ECRL Underground Infrastructure Protection Guidelines* Report (2009).

3.0 Flood Assessment

In 2011 Bewsher Consulting prepared a flood study report, on behalf of the City of Ryde Council, *Macquarie Park Floodplain Risk Management Study and Plan*, to assess the flood extents, levels, hazards, and risk precincts in a number of tributaries of the Lane Cove River, including Porters Creek. The Bewsher report identified the Wicks Road and Waterloo Road intersection, which is the main vehicular access and only egress point to the proposed development, as being located in a High Flood Risk Precinct with flood depth locally reaching around 1m in a 100 year ARI storm event.

In response to the above findings, Cardno have undertaken flood analysis investigations of the area in the vicinity of the Wicks/Waterloo Road intersection in order to assess the measures required to provide safe egress for emergency vehicles from the development via this intersection during a 100 year ARI flood event. The Cardno methodology and findings are presented in the Cardno Flood Assessment Report (ref: 59914099-L01:BCP/bcp) dated 15 April 2014 (Cardno Report). Further flood modelling (following issue of the Cardno Report) has been undertaken during design development and this has demonstrated that the proposed stormwater systems and road geometry are sufficient to reduce the flood hazard, such that emergency vehicles are able to access the site safely.

In addition to the investigation at the Wicks/Waterloo Road intersection, the Cardno Report addresses the potential impact on flooding of runoff from the proposed development. The report demonstrates that exempting the development from the requirement to install OSD will not adversely impact adjoining or downstream roads, properties or watercourses.

This section of the SWMP:

- Summarises the Cardno Report findings;
- Provides a concept design for the civil engineering works in the Wicks/Waterloo Road intersection; and
- Addresses the argument of not providing OSD in the M2 Site.

The Cardno report has been attached for reference in Appendix A.

3.1 Wicks/Waterloo Road Intersection

It is proposed that a new road (Spine Road) be constructed to connect the M2 Site to the Wicks/Waterloo Road intersection, in order to provide access to the new development. Refer to Figure 2.2 for the proposed M2 Site Precinct Development Layout Plan. The upgraded four-way intersection is proposed to be signalised.

The current assessed levels of flooding in this area pose a potential risk to vehicles entering or exiting the proposed development to evacuate south along Wicks Road or west along Waterloo Road during a major flood event. In particular, this is of concern to the ability of emergency vehicles to access the development via the Wicks/Waterloo Road intersection.

Through computer modelling using TUFLOW software, the Cardno Report further assessed existing flow depths, velocity x depth values, and peak flows in this localised area and concluded that:

> *"under existing conditions emergency vehicles would be unable to exit the planned development through the Wicks Road/ Waterloo Road intersection during a 100 year ARI flood."*

3.1.1 Drainage System Augmentation

When considering the safety of the intersection in terms of pedestrian and vehicular stability, the following velocity x depth criteria have been identified as critical values:

Velocity x Depth	Comment
≤ 0.4 m^2/s	This is typically adopted by Councils as a limit of stability for pedestrians.
0.4 – 0.6 m^2/s	Unsafe for pedestrians but safe for vehicles if overland flood depths do not exceed around 0.3m.
> 0.6 m^2/s	0.6 m^2/s is typically adopted by Councils as a limit of stability for vehicles.

Table 3.1 – Safety Criteria for Pedestrians and Vehicles

Flow depth of 0.3m is also considered as the upper limit for the safety of emergency vehicles in a 100 year ARI flood.

To achieve "safe" conditions for emergency services vehicles (i.e. V x D ≤ 0.6 m^2/s) during a 100 year ARI flood the following drainage augmentation scheme for the Wicks/Waterloo Road intersection is recommended:

- Local re-grading of Wicks Road;
- Upgrading the existing 2.7m diameter stormwater culvert which runs under the existing access road into the site, into a 3.6m x 2.4m reinforced concrete box culvert (RCBC);
- Dual kerb inlet pits with 3.3m lintels on both sides of Waterloo Road, spaced at approximately 5-8m intervals;
- Twin 1.2m diameter pipes to convey the stormwater across the Wicks/Waterloo Road intersection;
- Install new drop inlet structure and RCBC under Spine Street; and
- Connect existing 2.1m diameter pipe to new 2.4m x 2.4m RCBC and extend to outlet headwall downstream of the proposed Spine Street.

The Cardno report also recommends "replacing the existing stormwater outfall from Wicks Road which discharges into Porters Creek upstream of the existing site access road". This has been modified in the current design for constructability restrictions within Wicks Rd. The current design has the outfall from Wicks Road entering a large stormwater inlet chamber, before discharging into the new culvert, under Spine Street.

Modelling these proposed upgrades in TUFLOW, Cardno analysed the flood levels and peak flows under the proposed conditions, and concluded that:

> *"the substantial upgrade of the stormwater drainage system on both sides of Waterloo Road is able to capture a significant proportion of overland flows down Waterloo Road and in combination with the drainage augmentation under the access road would permit emergency vehicles to exit the planned development through the Wicks Road/Waterloo Road intersection during a 100 year ARI flood."*

Included in the proposed upgrade of the Wicks/Waterloo intersection is the construction of three new culverts under the proposed Spine Street. There is one 3.6m x 2.4m RCBC and two 2.4m x 2.4m RCBCs running parallel. The new culverts have excess capacity to discharge the receiving flows into Porters Creek.

3.1.2 DRAINS Modelling Approach

To confirm the performance of the proposed stormwater concept the system has been modelled using the stormwater computer software DRAINS, by Watercom Pty. Ltd. DRAINS is a computer programme for designing and analysing urban stormwater drainage systems, using design rainfall data derived from *Australian Rainfall and Runoff (AR&R)*.

The following assumptions have been adopted for this hydrological modelling exercise:

- Peak flows at each stormwater pit have been applied as per subsequent Cardno TUFLOW modelling. Refer Appendix B;
- Tailwater conditions have been applied for the 100 year ARI flood. A flood depth of RL35m at the discharge point to Porters Creek has been adopted as per the flood mapping analysis from the Bewsher Report;
- Dual kerb inlet pits with 3.3m lintels have been modelled as two side-by-side 3.3m lintel kerb inlet pits;
- Pit blockage factor of a free flowing inlet, with grate 100% blocked, have been applied as per the City of Ryde 2014 DCP; and
- Pipe grading and velocities are within the requirements of the City of Ryde 2014 DCP.

3.1.3 Results

A DRAINS network was prepared to represent the drainage augmentation under the arrangement proposed in Section 3.1.2, which is illustrated in Figure 3.1. The pipe (blue) and surface (red) flows during the major storm event are shown on this figure.

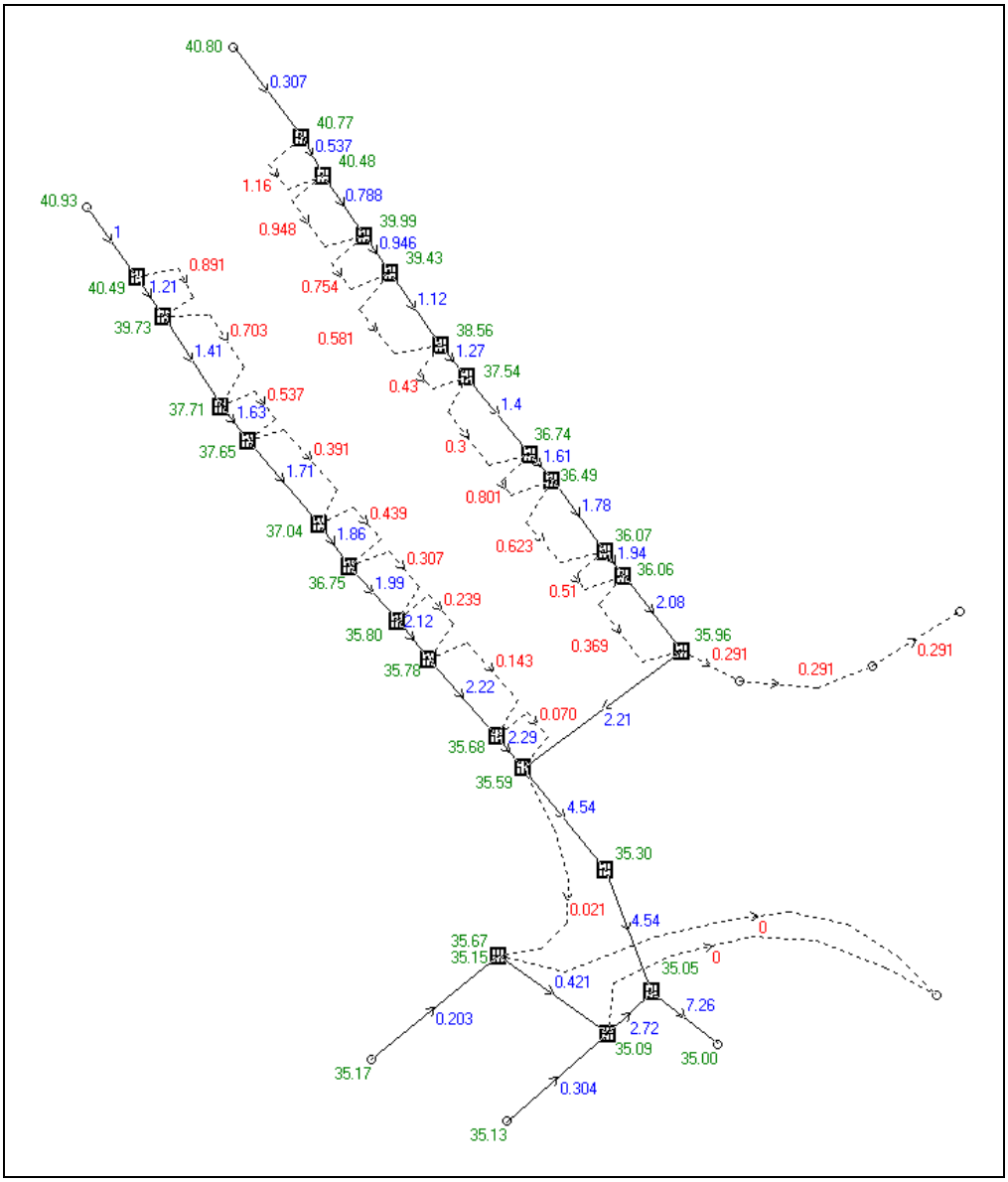

Figure 3.1 – DRAINS Network Diagram

3.1.4 Discussion of Results

Due to the high peak flow rates along both sides of Waterloo Road and the applied blockage factors on each of the stormwater pits, this system experiences some significant overland flow paths along Waterloo Road.

However, the critical overland flow paths are the two paths which cross the intersection at Wicks Road. From Figure 3.1 the overland flows across the intersection are $0m^3/s$, indicating that no overland flows from Waterloo Road should enter Spine Street from the Wicks Road Catchment.

It should also be noted that the likelihood of every single pit in this system having a 100% blocked grate is improbable; as such the modelled performance is deemed conservative.

In summary, the substantial upgrade of the Wicks/Waterloo Road intersection drainage system will capture sufficient overland flows from surrounding catchments, permitting emergency vehicles to enter/exit the planned development through the Wicks/Waterloo Road intersection in a 100 year ARI flood.

3.2 On-Site Detention – M2 Site

The Cardno Report also assessed the potential impacts on downstream receivers due to stormwater runoff from the proposed M2 Site development. Cardno modelled scenarios with and without on-site detention to determine the requirement.

Under the City of Ryde DCP Part 8.2 Schedule: Stormwater Management Technical Material:

Section 3.1.7 Exemptions from OSD Requirements:

> *On site detention requirements may be waived where (in part):*
>
> *The applicant can demonstrate to Council's satisfaction, if the total catchment containing the site were developed to its full potential while maintaining the existing infrastructure, stormwater detention on the subject site would not be beneficial in reducing adverse flooding impacts on downstream roads, properties and open watercourses. This may be the case at the lower end of major catchments.*

The following three scenarios were modelled in **xprafts**:

- Existing Conditions;
- Proposed Conditions with OSD; and
- Proposed Conditions without OSD.

For the two "Proposed Conditions" scenarios, it was assumed that the developed site has an impervious area of 75% in aggregate.

Further modelling was undertaken which assessed the combined impact of the concept drainage augmentation, discussed in Section 3.1, and the planned development without OSD for the 100 year flood levels. These results have been included in Figure 14 of the Cardno report (refer to Appendix A).

From these results, it can be seen that re-directing the precinct runoff to an outfall downstream of the access road locally reduces flooding of the existing development upstream of the access road. This, in combination with the drainage augmentation, far outweighs any minor impact of slightly increasing the peak runoff from the M2 site by not implementing OSD as part of the development.

In summary, it was concluded that:

- the precinct will discharge runoff at the lower end of the developed catchments; and
- exempting the planned development from the requirement to install OSD does not adversely impact on the flood behaviour of adjacent and downstream roads and properties.

3.3 M2 Site Flood Conditions

3.3.1 Existing Conditions

Due to the majority of the Site being located on a local ridgeline and generally higher than adjacent land, flooding of the Site from external catchment overland flows is not expected.

The Bewsher Report (April 2010) provides flood mapping for the Porters Creek catchment, including flood levels, and flood extents for the stretch of open channel at the north of the M2 site. Refer Figure 3.3 below.

The Bewsher Report (April 2010) also indicates localised flooding in several areas along the western boundary of the M2 site. It is believed that the geospatial data used in the flood modelling indicated localised depressions in these areas including the ECRL decline.

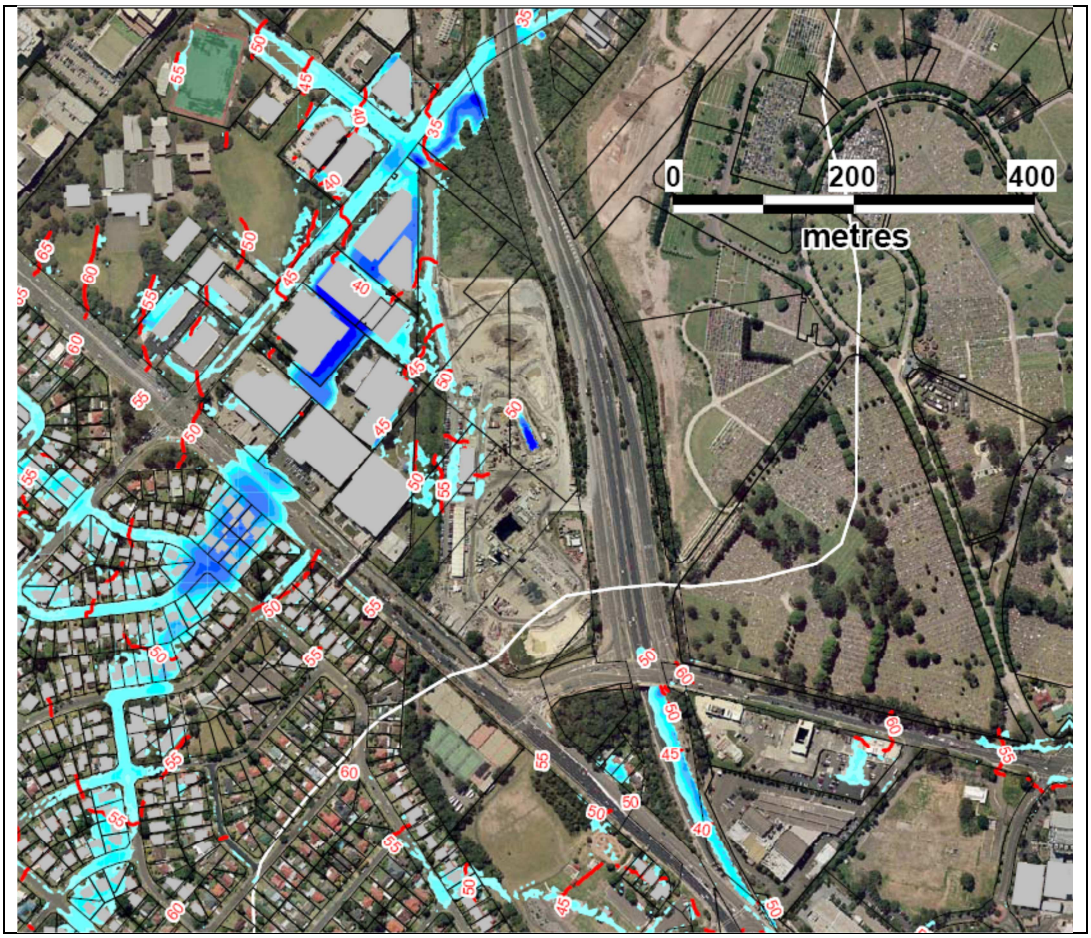

Figure 3.3 – Simulation of 100 Year ARI Flood (Bewsher, April 2010)

3.3.2 Proposed Development

The proposed development of the Site has considered flood risk, both within the Site and adjacent lands.

A review of the flood mapping and existing surface profiles was undertaken. Consideration has been made to drainage along the western boundary of the M2 site, where adjacent lands are indicated as being flood prone. Development of the M2 site shall ensure overland flows generated on the sites are contained and conveyed within the site to appropriate discharge points. A drainage easement is proposed along the western M2 boundary (refer Civil Design drawings C-0-6-00 and C-0-6-01) to collect runoff flowing to the boundary.

3.4 Porters Creek Scour Protection

Scour protection measures are proposed to protect the Porters Creek stream banks during 100 year ARI flood event. As specified in the JK Geotechnics Creek Scour Protection Report (refer Appendix C), where there are flood flow velocities in excess of 0.7 m/s scour protection should be provided to avoid erosion of the stream banks. Cardno TUFLOW modelling (refer Appendix D) has identified flows in excess of 0.7m/s and appropriate scour protection has been proposed in accordance with the requirements of AR&R. Scour protection is to be placed carefully around retained trees in accordance with an approved Vegetation Management Plan.

3.5 Flooding Conclusions

Based on the RBG and Cardno flood assessments it is concluded that:

- Under existing conditions emergency vehicles would be unable to safely exit the planned development through the Wicks/Waterloo Road intersection during a 100 year ARI flood;
- The upgrade of the stormwater drainage system on both sides of Waterloo Road and Wicks Road is able to capture a significant portion of overland flows. By discharging into Porters Creek through the upgraded culverts overland flows are reduced permitting emergency vehicles to exit the planned development through Wicks/Waterloo Road intersection during a 100 year ARI flood;
- Exempting the planned development from the requirement to install OSD does not adversely impact downstream watercourses, roads or properties; and
- Flood velocities in Porter's Creek are in excess of 0.7m/s and in accordance with geotechnical advice, areas of the creek channel experiencing velocities in excess of 0.7 m/s, will require stream bank scour protection measures to be provided.

4.0 Integrated Stormwater Management Plan

This section describes the Integrated Water Management Plan for the Site as required by Section 4.4 of the North Ryde Station DCP.

In order to align with the staged delivery of the North Ryde Station UAP, the Integrated Water Management Plan has been separated into two components:

1. Public Domain Strategy; and
2. Lot-Based Strategy.

The Public Domain is defined as the proposed road reserve area of Spine Street, Plaza Street, Park Street and Retail Street, and also includes the public open spaces and reserve. The Public Domain area totals approximately 2.75ha.

The lot-based strategy is detailed below, but will be delivered by future lot developers. Individual lots will be required to meet the City of Ryde Council requirements and NSW Best Practice water quality and quantity criteria before discharging into the stormwater network. The proposed stormwater network has made allowance for each lot to connect into the drainage system.

4.1 Proposed Development Controls

This Integrated Water Management Plan has been based on the following guidelines and reports:

- Landcom WSUD Guidelines;
- City of Ryde Stormwater Management Technical Manual (DCP 2014);
- Cardno Flood Analysis Report (2014); and
- Hydrology, Flooding and WSUD Report, North Ryde Station Precinct, Storm Consulting (2012).

A water sensitive urban design (WSUD) approach has been adopted for the Site to mitigate any water quality issues on downstream receiving environments. WSUD management principles that have been adopted for the Site include:

- Safe conveyance of stormwater;
- Water quality treatment of runoff, in order to minimise adverse impacts on downstream waterways;
- Source control; and
- Incorporating stormwater management measures into the streetscape.

In accordance with Section 4.4 of the North Ryde Station Precinct DCP 2013: Stormwater Management, the following Stormwater Management objectives are outlined:

a) Provide for a Precinct-wide approach to stormwater management;
b) Reduce stormwater discharge; and
c) Improve stormwater quality and minimise water consumption through implementation of water sensitive urban design measures.

The North Ryde Station Precinct DCP also stipulates that the objectives and performance standards for water cycle outcomes that are to be achieved during construction and operation of the project be consistent with the stormwater management provisions in the Ryde DCP 2014.

Future lot developers will be required to meet the water management controls and targets set out in this section.

4.1.1 Environmental and Water Quality Objectives

Environmental and water quality objectives for the development are as per the City of Ryde DCP and the Landcom WSUD guidelines. The target objectives are summarised in Table 4.1.

	Water Quality (Percentage Reduction in Pollutant Load)			
	Gross Pollutants (GP)	Total Suspended Solids (TSS)	Total Phosphorus (TP)	Total Nitrogen (TN)
Objective	90 %	85 %	65 %	45 %

Table 4.1 – Water Quality Target Objectives

Two other preferred water quality objectives of the proposed works have been adopted from the Storm Consulting Hydrology, Flooding and WSUD report (2012). These are:

- 100% of all impervious surfaces within the Public Domain to drain through WSUD features prior to entering stormwater network; and
- Specify indigenous species with zero or low water/irrigation requirements (other than for bio-retention systems whereby species are specified as appropriate for the system).

Refer Section 6.0 for further details on water quality.

4.1.2 Lot-Based Stormwater Management Objectives

The following development targets, adopted from the Storm Consulting report, are proposed to be applied to the NRSUAP in order to ensure that future developers of each lot realises the Lot-Based Stormwater Management strategies and objectives.

Development Targets for Water Conservation

Development Targets	Reference
Reduce the Precinct's potable water needs by 50% through the use of efficient fixtures and appliances and precinct scale initiatives such as alternative water supplies for non-potable end uses	Sustainability Target
Reduce potable water demand in residential buildings by at least 50% from BASIX baseline for an average household	Minimum requirement for Residential Buildings: 40% reduction from BASIX benchmark for an average household, equivalent to 107kL/dwelling/year.
Reduce potable water demand in commercial buildings by at least 75% from NABERS baseline, matching a minimum of NABERS water 4.5 stars	Sustainability Target
Reduce potable water demand in retail buildings to achieve a 4.0 star NABERS water rating	Sustainability Target
Water use within public open space (for uses such as irrigation, pools, water features etc.) should be supplied from sources other than potable mains water (e.g. stormwater, greywater or wastewater) to meet 80% water use demand	City of Ryde WSUD DCP

Table 4.2 – Water Conservation Targets

Refer Section 5.1 for further details on how these water conservation targets are addressed.

5.0 Stormwater Quantity Assessment

A stormwater quantity assessment has been undertaken for the M2 Site, addressing water conservation and the safe conveyance of stormwater runoff. Details of the assessment and results from the modelling exercise are summarised in the following sections.

5.1 Water Conservation

For the Public Domain, low water-use plant species are proposed by the Landscape Architect in order to reduce water use within public open spaces. Irrigation will be required for planted areas during establishment, however these areas should not require irrigation thereafter.

Lot-based water conservation targets will be addressed by future lot developers in accordance with the DCP.

5.2 Stormwater Quantity Modelling Approach

Stormwater runoff quantity has been considered for the entire M2 Site catchment to determine any potential stormwater quantity impacts as a result of the proposed development. An in-ground stormwater drainage network within the road corridor is proposed, sized to adequately cater for Lot and road runoff. Lot runoff is collected and treated (in accordance with the proposed development controls) and discharged to the in-ground network at a specified discharge point for each Lot. Pipe sizes and stormwater pits have been designed using the computer software DRAINS. Refer drawing C-0-6-00 and C-0-6-01 for stormwater layout plan.

A major/minor storm drainage philosophy has been adopted for the M2 Site. The minor design storm considered is the 20 year ARI and will be conveyed in stormwater drainage pipes. The major storm event is the 100 year ARI, with excess stormwater runoff safely discharging within the roads and overland flows paths. The system has been modelled such that all excess stormwater runoff will be received by adequately sized pits at the northern end of Spine Road, and discharged safely to Porters Creek.

As discussed in Section 3.2, On-Site Detention (OSD) is not required for the M2 Site, based on an assumed maximum impervious area of 75% of the Site. As such, no OSD will be provided for the Public Domain areas. Private Lot developers will only be required to provide OSD if the development exceeds the maximum impervious ratio for each Lot (refer to Section 5.4.2). For the purpose of the DRAINS model, it has been assumed that the Site will be up to 75% impervious and no OSD will be provided.

5.3 Site Sub-Catchment

For the post-development stormwater catchment plan refer to drawing C-0-6-50 and C-0-6-51.

5.4 DRAINS

DRAINS was used to model the proposed network to adequately size stormwater pits and pipes and to ensure the stormwater design was in accordance with the City of Ryde DCP requirements.

5.4.1 Model Parameters

The rainfall IFD data utilised in this investigation was taken from the Bureau of Meteorology website, using the City of North Ryde coordinates (33.8°S, 151.125°E). The design IFD data is presented in Table 5.1.

Duration	Minor Storm Event Intensities (mm/hr)	Major Storm Event Intensities (mm/hr)
5 mins	190	243
10 mins	148	189
20 mins	109	140
30 mins	89.4	115
1 hr	61.9	80.4
2 hrs	41.8	54.8
3 hrs	33.0	43.6
6 hrs	22.0	29.4
12 hrs	14.7	19.8
24 hrs	9.78	13.2
48 hrs	6.33	8.59

Table 5.1 – IFD Data

5.4.2 Site Impervious Area Limits

Limits have been adopted with respect of the percentage impervious of the Lots and Public Domain, as indicated in Table 5.2.

Type	Area (m^2)	Percentage Impervious (maximum)	Impervious Area (m^2 - maximum)
Residential (Lots 107, 201, 202, 203, 204, 205, 206, 207, 208)	40,196	70%	28,137
Mixed Use (Lots 104, 105)	14,376	100%	14,376
Plaza (Lot 103)	4,395	100%	4,395
Social Infrastructure (Lot 108)	2,075	70%	1,452
Central Park (Lot 106)	5,538	50%	2,769
Linear Park (Lot 111)	3,769	50%	1,885
Bushland Reserve (Lot 101)	4,437	5%	222
Road Reserve (Proposed roads including Lot 109)	17,212	90%	15,491
Total	**91,998 m^2**	**74.7%**	**68,727 m^2**

Table 5.2 – Impervious Area Breakdown

The above limits have been set to ensure compliance with the 75% maximum impervious area, as adopted in the Cardno Report (refer to Appendix A). If future lot developers propose greater percentage impervious limitations than that specified in Table 5.2, OSD will be required to be assessed on a lot-by-lot basis.

5.4.3 Pipe Design

All piped drainage within the Public Domain has been sized to adequately convey runoff from the minor storm event. In accordance with the City of Ryde DCP the stormwater design complies with the following requirements:

- Minimum pipe size shall be 375mm diameter to facilitate cleaning and maintenance;

- Pipe velocities shall be between 0.5 m/s and 7.0 m/s and preferably between 1.0 m/s and 5.0 m/s during the design storm to ensure the flow is self-cleansing but not likely to cause scour;
- The minimum pipe grade shall be generally 1.0%, however under exceptional circumstances a grade of 0.5% may be permitted.

5.4.4 Pit Design

In accordance with the City of Ryde DCP: Stormwater Management Technical Material, pit inlet capacity blockage factors have been applied to the DRAINS model. These are summarised in Table 5.3.

Inlet Type	Percentage Capacity Blockage
Side Entry	10%
Grated	30%
Combination	100% Side Inlet Capacity Only
Letterbox	50%

Table 5.3 – Pit Blockage Factors

5.4.5 Proposed Development (with no OSD) DRAINS Results

The DRAINS network model was developed and illustrated in Figure 5.1.

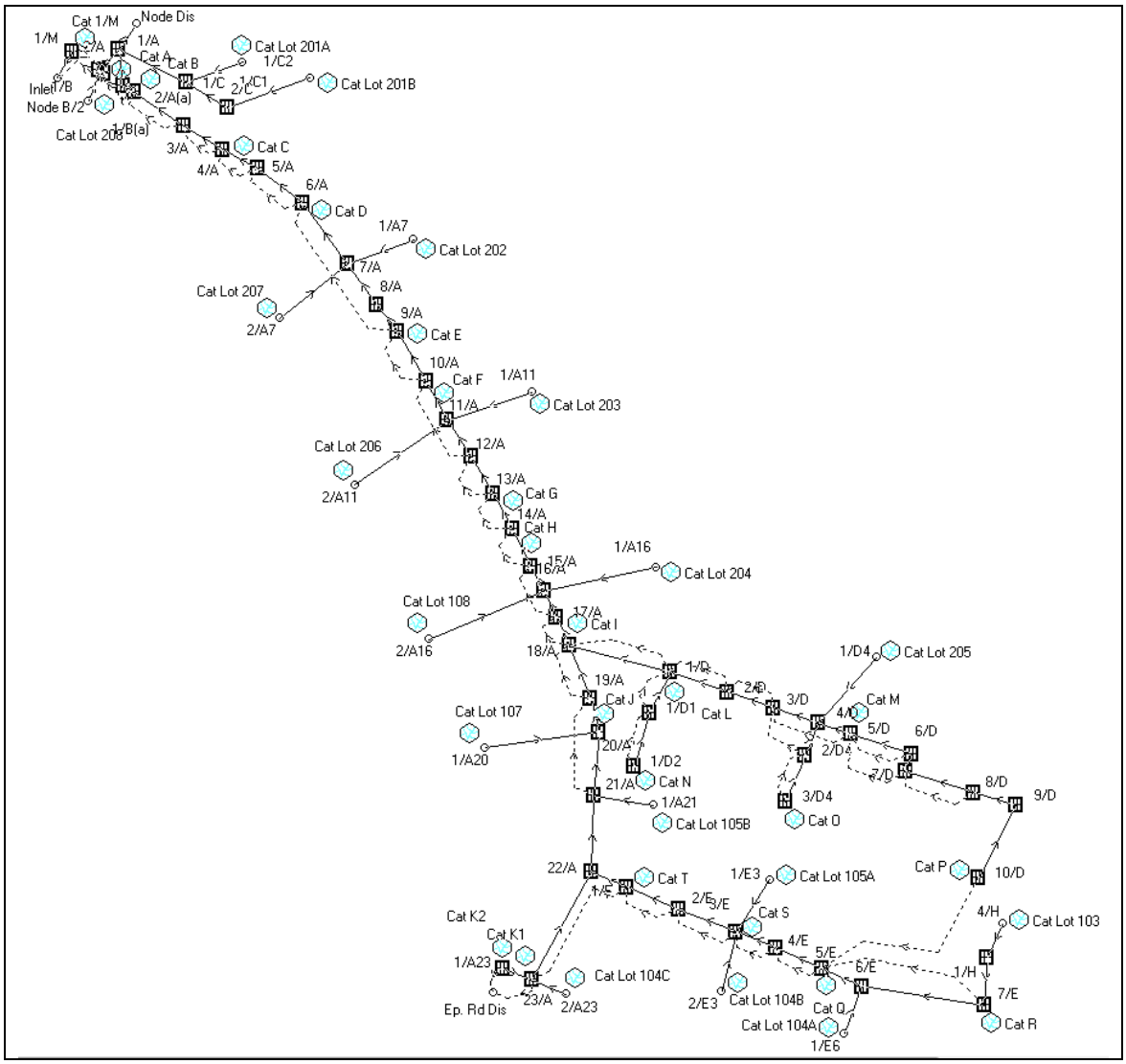

Figure 5.1 – M2 Site DRAINS Network Diagram

The results from this model have been summarised in Table 5.4.

	Post Development Flows
Peak Discharge (Q_{20})	3.91 m^3/s
Peak Discharge (Q_{100})	4.68 m^3/s

Table 5.4 – Post Development Peak Discharge Rates

5.5 Point of Discharge

The point of discharge for the site is to be into Porters Creek, downstream of the proposed box culvert under the Spine Road. The entire upgrade of this area includes:

- 2.4m x 2.4m RCBC to discharge flows from the M2 Site development;
- Upgrade the existing culvert under the existing access road to a 3.6m x 2.4m box culvert;
- Proposed stormwater inlet chamber to discharge flows from the Wicks and Waterloo Road intersection;
- Connect the existing 2.1m pipe which runs through the neighbouring lot into a 2.4m x 2.4m RCBC;
- New culvert headwall to incorporate the three discharge structures listed above (refer Drawing C-0-6-02 and C-0-6-03); and
- Scour protection and local modifications to the stream bank to suit the new culvert headwall. Refer Drawing C-0-6-02.

5.6 Summary

A stormwater drainage system has been designed using the design criteria specified in this section. Pipe sizes range from diameter 375mm at the very top of the catchment, to an end of line discharge 2.4m x 2.4m RCBC. Pits have been arranged to sufficiently reduce overland flows to 'pedestrian safe' values throughout the site and to capture the 100 year ARI storm within the pipe network before discharging to Porters Creek. No OSD has been provided for the Public Domain or Lot Developments.

6.0 Stormwater Quality Assessment

A stormwater quality assessment has been undertaken for the development, addressing the quality of stormwater discharge from the Site during construction stage and the post-development conditions. Details of the assessment and results from the modelling exercise are summarised in following sections.

6.1 Construction Stage

Prior to construction commencing, a Water Management Plan, including erosion and sediment control measures, is to be implemented in accordance with the City of Ryde's specifications (Ryde DCP 2014), and the Landcom guideline *Managing Urban Stormwater: Soils and Construction* (The Blue Book).

Before construction activities begin, the following measures are to be implemented:

- Sedimentation fences constructed to the perimeter of the constructed area;
- Designation of areas for plant and construction material storage;
- Diversion of upstream stormwater runoff around disturbed areas of the development;
- Stabilisation of disturbed areas;
- Monitoring of stormwater quality discharging from the development and maintenance of systems to ensure controls are effective;
- Drainage structure protection devices installed to existing stormwater inlet structures within the site, and within the road ways adjacent to the site; and
- Education of site personnel to the sediment and erosion control measures implemented on site.

During and Post-construction following measures are to be implemented:

- WSUD elements are to be protected from flowing stormwater by adopting surface protection measures;
- Construction activities to be confined to designated construction areas;
- Regular inspection and maintenance of the erosion control measures. Following rainfall events of more than 20mm, inspection of erosion control measures and removal of collected material shall be undertaken. Replacement of any damaged equipment shall be performed immediately; and
- Monitoring of water quality impacts from construction activities.

6.2 Erosion and Sediment Control Plan

Preliminary erosion and sediment control plans have been prepared for the M2 Site based on existing site survey data and geotechnical information. Reference is made to compliance with the Landcom guidelines – Managing Urban Stormwater Runoff: Soils and Construction ("Blue Book").

The preliminary geotechnical report indicates that some in-situ soils (i.e. clays and uncontrolled fill) may display a high degree of erosiveness. Due to the altered nature of the site, with historic construction activities, soil types will vary considerably. The preliminary geotechnical report nominates Soil Type C and Type F as being suitable classifications for design of control measures. Type F soil category has been adopted for preliminary design including for the sediment basin settling zone and sediment storage zone volume calculations.

In order to address the staged nature of the development, the erosion and sediment control measures are detailed in two stages as follows:

1. Construction phase of the Public Domain (during Stage 1 works); and
2. Post construction phase (Stage 1 works complete).

The erosion and sediment control measures proposed for the M2 Site include:

- Sediment basins with sediment storage volume and “clean water channel” catch drains for discharge into Porters Creek;
- Sediment fences around stockpiles and construction zones where soils are exposed;
- Catch drains/bunds to collect construction site runoff and convey flows to the settling basin; and
- Sediment protection devices on existing and proposed inlet pits i.e. geotextile inlet filters.

Vehicular access shall be provided to all sediment basins to enable regular maintenance and sediment removal.

Soil management measures shall be in accordance with City of Ryde Council DCP 2014.

Details of the Erosion and Sediment Control plan are included in the Civil Design Drawings, refer drawings C-0-1-00, C-0-1-01, C-0-1-10 and C-0-1-11.

6.3 Post Development Conditions

Stormwater quality modelling has been undertaken for the Public Domain, in order to quantify the WSUD measures required to meet the Water Quality Objectives as set out in Section 4.1.1.

For the purposes of modelling, it has been assumed that discharges from the private domain (Lot-Based Strategies) will meet the minimum water quality targets. The design of the Lot-based WSUD measures is not within the scope of this SWMP. For the MUSIC model the Public Domain excludes the Bushland Reserve.

Water quality control will be achieved using a *treatment train* approach. All stormwater runoff from the Public Domain is filtered through either the streetscape bio-retention systems, or where bio-retention is not practical, through a proprietary in-ground treatment device (such as Stormwater360 StormFilter, Enviropods, or similar).

Details of the MUSIC modelling exercise and results from that analysis are summarised in the following sections.

6.3.1 Assessment Methodology (MUSIC)

MUSIC, or Model for Urban Stormwater Improvement Conceptualisation, is a modelling tool for urban stormwater systems that predicts the performance of stormwater management systems. For this analysis the software will be used to simulate the effectiveness of the treatment devices in achieving the required minimum WSUD targets.

For this model, the Public Domain has been separated into sub-catchment areas with appropriate WSUD devices individually treating each sub-catchment. This simulates the stormwater runoff from the road reserve sub-catchments as passing through either the streetscape bio-retention or an in-ground treatment device (i.e. Enviropod), before entering the stormwater drainage system and discharging from the site.

The City of Ryde Council’s *Water Sensitive Urban Design Music Modelling Guidelines* outlines the preferred rainfall and evapotranspiration datasets to be use when undertaking stormwater quality assessments in the North Ryde area. The parameters used in this assessment are in accordance with those guidelines and are discussed in the following sub-sections.

6.3.2 Rainfall

Council requires all stormwater quality modelling in MUSIC to use rainfall data from the Sydney Airport AMO station. The modelling period is recommended to be from 1988 to 1998 with a rainfall interval of 6 minutes. The recommended rainfall data for the M2 Site is summarised in Table 6.1.

Rainfall Station	Modelling Period	Annual Rainfall (mm)
066037 – Sydney Airport AMO	1988 to 1998	1087

Table 6.1 – Recommended MUSIC Rainfall Station

6.3.3 Potential Evapotranspiration Data

Local Potential Evapotranspiration (PET) data was not available for the M2 Site, hence average monthly data from Sydney has been used. Average Sydney PET is suitable for use in modelling water quality and hydrology as discussed in the Council's MUSIC guidelines. A summary of the monthly PET for the Sydney region is summarised in Table 6.2.

Month	J	F	M	A	M	J	J	A	S	O	N	D
PET (mm)	180	135	128	85	58	43	43	58	88	127	152	163

Table 6.2 – Monthly Evapotranspiration Data for Sydney

6.3.4 Soil Properties

The following soil characteristics are recommended in the Council's MUSIC guidelines:

Parameter	Units	Urban	Non-Urban
Impervious Area Parameters			
Rainfall Threshold	mm	1.4	1.4
Pervious Area Parameters			
Soil Capacity	mm	170	210
Initial Storage	%	30	30
Field Capacity	mm	70	80
Infiltration Capacity Coefficient a		210	175
Infiltration Capacity Coefficient b		4.7	3.1
Groundwater Properties			
Initial Depth	mm	10	10
Daily Recharge Rate	%	50	35
Daily Baseflow Rate	%	4	20
Deep Seepage	%	0	0

Table 6.3 – Soil Properties for MUSIC Source Nodes

6.3.5 Pollution Generation

The pollutant parameters that have been adopted for this model are outlined in Table 6.4. They align with the comprehensive literature review undertaken by Duncan et.al. (1999) and forms the basis for the default values of event mean concentration in MUSIC for Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN).

Land Use Category		Log_{10}TSS (mg/L)		Log_{10}TP (mg/L)		Log_{10}TN (mg/L)	
		Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow
General Urban Residential Industrial Commercial	Mean Std Dev	1.20 0.17	2.15 0.32	-0.85 0.19	-0.60 0.25	0.11 0.12	0.30 0.19
Forest/Natural	Mean Std Dev	0.78 0.17	1.60 0.32	-1.52 0.19	-1.10 0.25	-0.52 0.12	-0.05 0.19
Road Areas	Mean Std Dev	- -	2.43 0.32	- -	-0.30 0.25	- -	0.34 0.19
Roof Areas	Mean Std Dev	- -	1.30 0.32	- -	-0.89 0.25	- -	0.30 0.19

Table 6.4 – Pollutant Generation for MUSIC Source Nodes

6.4 Post-Development Model

A post development (with treatment devices) scenario has been modelled using MUSIC with the parameters discussed in Section 6.3.

For the M2 Site Public Domain areas it is proposed that the water quality treatment measures will include forty-three (43) roadside bio-retention treatment 'tree-pits' or 'raingardens' (equating to approximately 500m^2 of filter area) and eight (8) number of Enviropods filter baskets (or similar). The tree pit/raingarden beds have been standardised in two sizes, 6.4m in length (one car space) and 3.2m in length (half of one car space), for ease of constructability and for symmetry within the site. Bio-retention treatment area (or equivalent proprietary device) is also required in the Central Park and Bridge Landing area. This will be to landscape architects design.

This system is designed such that each sub-catchment area passes through the WSUD device before entering the proposed stormwater infrastructure.

It is the responsibility of the future lot developers to meet water quality targets for areas outside the Public Domain, and select appropriate treatment devices for each lot.

The MUSIC network diagram is displayed in Figure 6.1. The streetscape bio-retention is explained in greater detail in Section 6.4.1 including the node properties for the MUSIC model. The percentage impervious assumptions have been previously explained in Section 5.4.2.

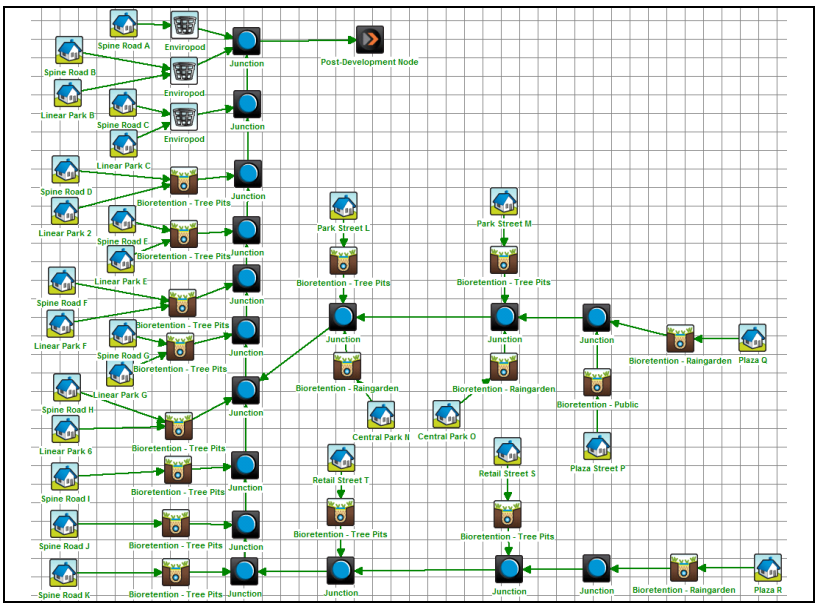

Figure 6.1 – Music Treatment Train Diagram

6.4.1 Streetscape Bio-Retention Treatment

Bio-retention treatment facilitates the removal of pollutants from local catchments, by capturing runoff in the bio-retention areas that remove pollutants via plants (nutrient uptake) and filter media. They are effective in reducing the concentration of suspended solids (TSS), phosphorus (TP) and nitrogen (TN).

In accordance with general tree-pit design and Council's MUSIC guidelines, the properties detailed in Figure 6.2 have been adopted for modelling the bio-retention nodes. Filter depth of 0.6m has been adopted as a conservative value for all tree pit nodes (0.8m depth is commonly provided for trees to ensure adequate area for root growth).

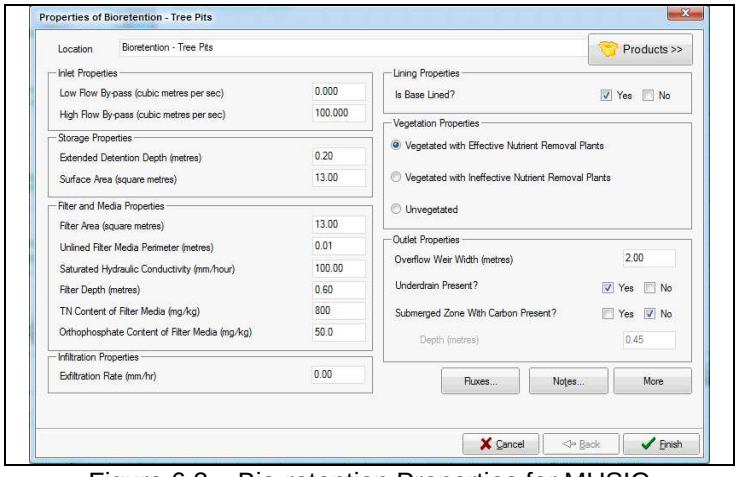

Figure 6.2 – Bio-retention Properties for MUSIC

6.4.2 Stormwater360 Enviropod

The Stormwater360 Enviropod is a cost-effective and easily maintained gully pit insert that is effective at removing significant portions of litter, debris, and other pollutants from urban runoff. In the proposed treatment train, eight (8) Enviropods have been modelled to treat sub-catchment areas where bio-retention is not practical. Stormwater360 have specific MUSIC nodes for their proprietary in-ground treatment devices, including the Enviropod which has been used for simulating these proprietary products in the model.

Other proprietary devices may be substituted subject to demonstration they meet the required water quality treatment requirements.

6.5 Water Quality Treatment Train Performance

The MUSIC model was used to evaluate the performance of the water quality treatment devices for a range of rainfall conditions over an eleven year period (1988-1998). The results for the proposed treatment arrangement are summarised in Table 6.5.

Pollutant	Sources	Residual Load	Percentage Reduction	Water Quality Objective Required
Flow (ML/yr)	21.9	20.6	-	-
Gross Pollutants (kg/yr)	562	0	**100%**	90%
Total Suspended Solids (kg/yr)	6180	905	**85.6%**	85%
Total Phosphorus (kg/yr)	10.8	3.46	**68.0%**	65%
Total Nitrogen (kg/yr)	49.8	22.4	**55.4%**	45%

Table 6.5 – WSUD Performance Summary

These results demonstrate that the proposed WSUD treatment arrangement for the Public Domain provides adequate pollution reduction rates to stormwater runoff and meet the minimum Water Quality Objectives for the project.

6.6 Maintenance of Water Quality Treatment Devices

Water quality treatment devices require regular maintenance. A detailed maintenance plan is to be developed following final selection of the treatment devices to be installed. An indicative maintenance plan is provided below.

- **Bio-retention**
  - Routine inspection (3-6 monthly and after heavy rain), cleaning and maintenance of the bio-retention systems. Check inlets and overflow structures/drainage pipes for scour and sediment. Removal of litter, debris and sediment;
  - Inspection of filter media porosity (3-6 monthly and after heavy rain). Check for accumulation of impermeable layer. Remove sediment and scarify;
  - Over time, the filter media will accumulate fine sediments. The filter media should be replaced when its infiltration capacity is reduced due to binding. Typically, filtration media should be replaced every 5-7 years.

- **Stormwater360 Enviropods**
  - In accordance with the manufacturer's technical manual and owner's manual;
  - Periodic (6 monthly) inspection, cleaning and removal of any gross pollutants and coarse sediment that is deposited in the device.

7.0 Summary

This Stormwater Management Plan demonstrates that under the proposed plan, stormwater management for the site addresses the relevant DGRs, including:

- Water quality – water quality targets and reductions in pollutant levels for discharges from the site are addressed and met. Proposed water quality treatment measures and results are included in Section 6.0.

- Flooding – This SWMP, combined with the Cardno Flood Analysis Report (2014), demonstrates that the M2 Site development is compatible with the flood hazard of the land. Analysis and modelling concludes the design provides safe egress for vehicles at Wicks Road in a 100 year ARI flood event.

- Construction Impacts – an erosion and sediment control plan has been prepared as required by Section 6.3.4 of Part 4.5 of the Ryde DCP, in order to minimise the construction impacts of the works associated with the development.

Appendix A
Cardno Flood Assessment Report

Our Ref: 59914099-L01:BCP/bcp
Contact: Dr Brett C. Phillips

15th April 2014

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The Manager
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Attention: Mr Wayne Doney
Mr Mark Tooker

Dear Wayne/Mark,

FLOOD ASSESSMENT: EMERGENCY VEHICLE ACCESS VIA WICKS ROAD AND WATERLOO ROAD INTERSECTION AND JUSTIFICATION FOR NO ON-SITE DETENTION (OSD)

We are pleased to provide the findings of our assessment of flooding in the vicinity of the Wicks Road and Waterloo Road intersection under existing conditions and of measures required to provide safe egress for emergency vehicles from the proposed M2 development adjacent to the M2 Motorway. The merit of not implementing OSD on the M2 site is also assessed..

1. BACKGROUND

In April 2010 Ryde City Council released a flood study report[1] which was prepared by Bewsher Consulting as the first stage of the preparation of the Macquarie Park Floodplain Risk Management Study & Plan.

Bewsher Consulting, 2010 in part discussed the study as follows:

The study area consists of a portion of the Lane Cove River floodplain and those City of Ryde areas which drain in a north-easterly or easterly direction to it (refer **Figure 1**). *Much of the 1,558 ha study area is developed. It is crossed by a number of major roads including Epping Road, Lane Cove Road and the M2 Motorway and the underground Epping to Chatswood railway line.*

The consultants drew on both previous flood study reports and additional community consultation to review historical records about flood problems that have been experienced in the catchment and this process found that the two most widely reported floods were in November 1984 and February 1990.

[1] Bewsher Consulting (2010) "Macquarie Park Floodplain Risk Management Study and Plan", *Flood Study Report*, prepared for City of Ryde, April.

Computer-based (DRAINS) hydrologic models and (TUFLOW) hydraulic models were developed. While substantial efforts have been made to compile as best a picture as possible of several relatively recent floods (i.e. November 1984 and February 1990), the resultant rainfall and water level data sets were found to provide only very general information about the floods.

As a consequence, while the models generally reproduce the observed flood regimes, formal calibration against those events was not possible. The modelling confirmed that the November 1984 event was worse than the February 1990 event and significant number of properties in natural depressions experienced overland flow inundation. Additionally, some properties located adjacent to open creek channels experienced substantial depths of water.

Design flood event modelling followed and this report presents the results of modelling the 20 year average recurrence interval (ARI) flood, the 100 year ARI flood and the Probable Maximum flood (PMF).

The detailed DRAINS and TUFLOW models provide a sound platform for the further flood modelling tasks that will be undertaken during preparation of the Floodplain Risk Management Study and Plan.

1.1 M2 Site: North Ryde Station Precinct

It is proposed to develop the M2 Site as part of the North Ryde Station Precinct. The March 2014 Masterplan layout of the precinct which will drain to an outfall into Porters Creek within a reserve just upstream of the underpass which conveys Wicks Road under the M2 Motorway is indicated in **Figure 2.**

The Macquarie Park Floodplain Risk Management Study and Plan has defined flood extents, levels, hazards and risk precincts in a number of tributaries of the Lane Cove River including Porters Creek which drains through the industrial estate bounded by Epping Road to the south and Wicks Road to the west. A feature of the catchment is that Porters Creek downstream of the M2 Motorway has been culverted and filling of the floodplain has occurred which prevents/impedes overland flows from Porter Creek discharging into the Lane Cove River.

The estimated 100 yr ARI flood depths in the vicinity of the development site are mapped in **Figure 3.**

The 2011 study[2] also identifies that the Waterloo Road / Wicks Road intersection is located in a High Flood Risk Precinct with flood depth locally reaching around 1 m in a 100 yr ARI flood (refer **Figure 4**)

It is currently proposed that a new road be constructed to connect the subdivision to the Waterloo Road / Wicks Road intersection (refer **Figure 2**). The current assessed levels of flooding in this area poses a challenge to any vehicles that in the future might want to exit the precinct and evacuate south along Wicks Road or west along Waterloo Road during a major flood.

The proposed development on the site would be above the PMF levels and hence evacuation is not necessary in a severe flood. During floods, emergency vehicles can access the site to deal with an emergency however egress would need to be via the intersection of Wicks Road and Waterloo Road.

[2] Bewsher Consulting (2011) “Macquarie Park Floodplain Risk Management Study and Plan”, *Final Report*, prepared for City of Ryde, February.

2. OBJECTIVES

The first objective of the study was to undertake an assessment of flooding in the vicinity of the Waterloo Road / Wicks Road intersection in order to assess the trafficability of this intersection in a 100 yr ARI flood under current conditions and to identify any measures which would be required to be implemented to enable safe emergency vehicular egress from the M2 site through this intersection during a 100 yr ARI flood.

A second objective was to assess the potential impact on flooding of runoff from the proposed M2 development and the merit of not incorporating OSD into the planned development.

The City of Ryde DCP 2010 Part 8.2 Stormwater Management states in part:

> *Increases in the quantity of water entering the drainage system can result in pipelines overloading and flooding. Higher velocities of stormwater cause erosion of the natural waterways, siltation in the watercourses and increased weed growth in adjoining bushland areas. To combat these problems Council has established a protocol of stormwater quantity control through the requirements of detention systems and land use planning. Detention systems in general terms "hold back" or "detain" the increased runoff until the rainfall has lessened in intensity.*
>
> Objectives for On-Site Stormwater Detention Systems
>
> 1. *To counteract the effects of each development within a catchment by reducing the peak discharge during storms. This is achieved by storing water on site, then slowly releasing it.*
> 2. *On-site detention systems are installed in conjunction with property development and building works. The construction and maintenance of these systems is the responsibility of the property owner.*

Part 8.2 Schedule: Stormwater Management Technical Material also identifies in Section 3.1.7:

> *3.1.7 Exemptions from OSD Requirements*
>
> *On site detention requirements may be waived where* (in part):
>
> *The applicant can demonstrate to Council's satisfaction, if the total catchment containing the site were developed to its full potential while maintaining the existing infrastructure, stormwater detention on the subject site would not be of benefit in reducing adverse flooding impacts on downstream roads, properties and open watercourses. This may be the case at the lower end of major catchments.*

The M2 site is the last precinct which offers opportunities for development within the southern branch of the Porters Creek catchment south-west of the M2 Motorway. The remainder of the catchment upstream of this precinct is fully developed. It is possible that OSD would not be required for this development as it may satisfy the above requirements for exemption.

3. APPROACH

In 2010 Bewsher Consulting developed an overall TUFLOW model covering the five catchments located in the Macquarie Park study area which drain to the Lane Cove River.

Stormwater conduits, culverts and/or open channels were represented as 1 D elements while the floodplain is represented in the 2D domain.

The adopted grid size was 3 m x 3 m.

Inflow hydrographs were obtained from a DRAINS model of the study catchments and were input at drainage inlets and other key locations across the study catchments.

Copies of the TUFLOW models and DRAINS models assembled by Bewsher Consulting were provided by Ryde City Council and were used in this flood assessment.

4. BENCHMARK CONDITIONS

The approach which was undertaken was to base the modelling assessment on the TUFLOW model assembled by Bewsher Consulting and supplied by Council and to refine the model for assessment purposes as follows:

- Truncate the model to the Porters Creek catchment with some overlap on adjacent catchments;
- Update the roughness map as appropriate; and
- Re-grid the model at a 2m x 2 m grid spacing to improve the definition of any local hydraulic controls.

Figure 5 shows the study area and roughness zones established in the local TUFLOW model.

It is currently proposed that vehicles could enter the Precinct from Epping Road by a left turn only and there will be no provision for egress onto Epping Road. Residents, visitors and/or workers will be also able to enter and depart from the Precinct via the Wicks Road / Waterloo Road intersection (refer **Figure 2**). Consequently the safety of emergency vehicle movements through the Wicks Road / Waterloo Road intersection during major floods is a key consideration in the event that residents, visitors and/or workers need to access emergency services during a major flood.

When considering pedestrian and vehicular stability, three velocity x depth criteria have been identified historically as follows:

Velocity x Depth	Comment
≤ 0.4 m^2/s	This is typically adopted by Councils as a limit of stability for pedestrians
0.4 – 0.6 m^2/s	Unsafe for pedestrians but safe for vehicles if overland flood depths do not exceed around 0.3 m
> 0.6 m^2/s	This is typically adopted by Councils as a limit of stability for vehicles

As part of the current revision of Australian Rainfall & Runoff (ARR) a series of research projects have been undertaken to inform the updating of the current edition of ARR. This includes ARR Project 10 Appropriate safety criteria for vehicles. Most recently in December 2013 a draft version of Book 9 Chapter 6 Safety Design Criteria has been released by Engineers Australia for industry review (Download from: http://www.arr.org.au/downloads-and-software/chapters/).

In the draft Chapter 6 Book 9 *stability criteria based on the best available information for stationary small passenger cars, large passenger cars and large 4WD vehicles in various flow situations are presented in Figure 9.6.6 and Table 9.6.2* This Table and Figure are reproduced below.

Table 9.6.2. Interim Flow Hazard Regimes for Vehicles (Shand et al, 2011)

Class of vehicle	Length (m)	Kerb Weight (kg)	Ground clearance (m)	Limiting still water depth[1]	Limiting high velocity flow depth[2]	Limiting velocity[3]	Equation of stability
Small passenger	< 4.3	< 1250	< 0.12	0.3	0.1	3.0	$DV \leq 0.3$
Large passenger	> 4.3	> 1250	> 0.12	0.4	0.15	3.0	$DV \leq 0.45$
Large 4WD	> 4.5	> 2000	> 0.22	0.5	0.2	3.0	$DV \leq 0.6$

[1]At velocity = 0 ms^{-1}; [2]At velocity = 3.0 ms^{-1}; [3]At low depth

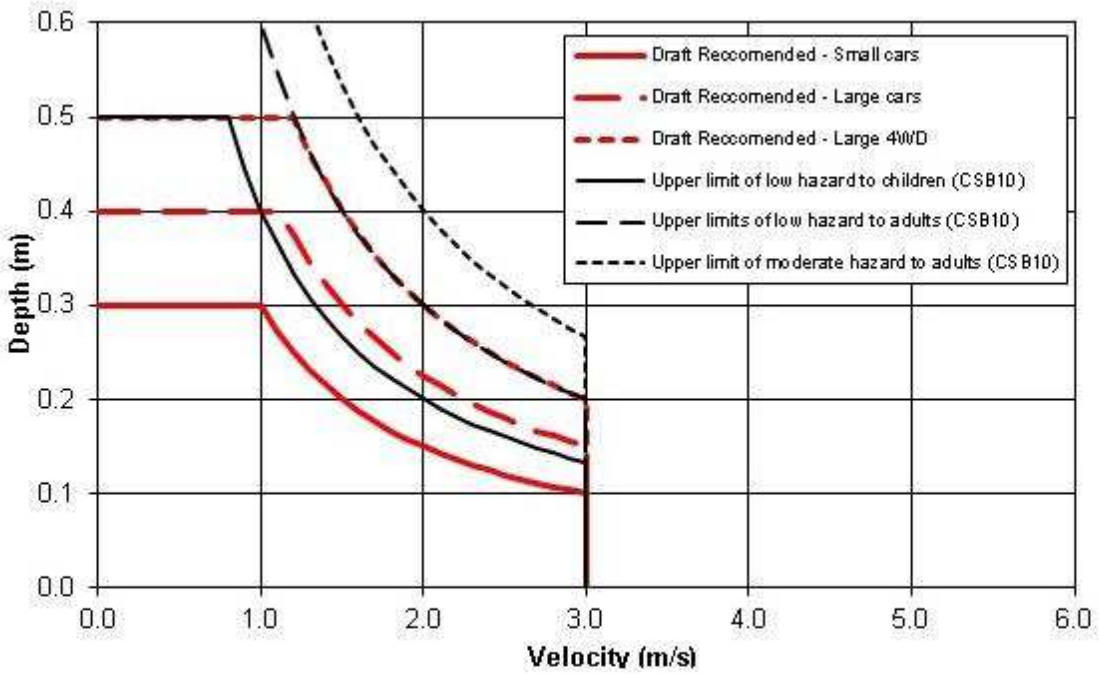

Figure 9.6.6. Interim Safety Criteria for Vehicles in Variable Flow Conditions (After Shand et al, 2011)

In the draft Chapter 6 Book 9 it is further advised that:

> *Shand et al (2011) concludes that the available datasets do not adequately account for the following factors and that more research is needed in these areas:*
>
> - *Friction coefficients for contemporary vehicle tyres in flood flows;*
> - *Buoyancy changes in modern cars;*
> - *The effect of vehicle orientation to flow direction (including vehicle movement);*
> - *Information for additional categories including small and large commercial vehicles and emergency service vehicles*

In the absence of particular criteria for emergency service vehicles and based on consideration of the criteria for "Large 4WD" vehicles and historical stability criteria the following criteria were adopted for assessing areas which would be unsafe for emergency vehicles in a 100 yr ARI flood:

- Flow depth > 0.3 m; or
- Velocity x depth > 0.6 m^2/s

The 100 yr ARI flood was assessed under Existing Conditions. The areas that would be unsafe for emergency vehicles in a 100 yr ARI flood levels in Wicks Road and Waterloo Road are given **Figure 6** while these areas in the vicinity of the Waterloo Road / Wicks Road intersection are mapped in **Figure 7**.

The estimated inflows to the existing drainage system and the peak flows in the drainage system are also given in **Figure 7**. The estimated peak flows in the road reserves in the vicinity of the Wicks Road / Waterloo Road intersection are as follows:

- Around 30 m^3/s in Wicks Road south of the intersection
- Around 28 m^3/s in Wicks Road north of the intersection
- Around 11 m^3/s in Waterloo Road west of intersection

It is concluded from **Figures 6** and **7** that in a 100 yr ARI flood:

- The trunk pipe upstream of the access road (2.1 m diameter) conveys around 8 m^3/s while the M2 culvert conveys around 21 m^3/s - 22 m^3/s;
- A 375 mm diameter RCP under the access road (as included in the supplied TUFLOW model) has minimal capacity in comparison to the 100 yr ARI flow;
- That local bunding and/or landforming (as included in the supplied TUFLOW model) is directing overland flows out of the overland flowpath across to the Wicks Road / Waterloo Road intersection. Some of this flow returns to the flowpath downstream of the access road but it appears a proportion of the flow continues to discharge down Wicks Road north of the intersection.
- Wicks Road has a local low point south of the Waterloo Road intersection.

It is noted that the recent survey (refer **Attachment A**) indicates that the 375 mm diameter RCP under the access road conduit has been replaced by a 2.5 m diameter conduit since the TUFLOW model was adopted by Council.

It is concluded that under Existing Conditions that emergency vehicles would be unable to exit the planned development through the Wicks Road / Waterloo Road intersection during a 100 yr ARI flood.

5. OPTIONS ASSESSMENT

5.1 Initial Assessments

A feature of the drainage system downstream of the M2 Motorway is that in the past the Porters Creek watercourse has been culverted in a series of stepped sections on the southern branch (which conveys flows from the Wicks Road underpass beneath the M2 Motorway to an outfall in Porters Creek and stepped sections on the northern branch (which conveys flows from Talavera Road upstream of the M2 Motorway to the southern branch) (refer **Figure 8**). The floodplain was then filled substantially higher than the upstream and downstream floodplain levels such that there is up to 30 m of fill placed over the culverts.

A large number of detailed assessments of various possible drainage augmentation options downstream of the Wicks Road / Waterloo Road intersection based on augmentation of various sections of the downstream drainage system including the culvert under the underpass were undertaken. These assessments disclosed that the flooding in the vicinity of the intersection is governed by local features and is insensitive to reductions in flood levels downstream of the access road until a major culvert is installed under the access road.

It was concluded that the required approach to achieve "safe" conditions for emergency services vehicles if needed during a 100 yr ARI flood is expected to comprise:

- appropriate grading of the new access road;
- local re-grading of Wicks Road to remove a local low point south of the Waterloo Road intersection;
- a substantial upgrade of the stormwater drainage system on both sides of Waterloo Road in combination with a new culvert located under the M2 site access road.

The intent of the substantial upgrade of the stormwater drainage system on both sides of Waterloo Road is to capture a sufficient proportion of the significant overland flows down Waterloo Road to reduce surface flows to acceptable levels within the Wicks Road intersection.

5.2 Drainage System Augmentation

After a number of iterative assessments the concept drainage augmentation scheme given in **Figure 9** was formulated. Features of this scheme include:

- local re-grading of Wicks Road to remove a local low point south of the Waterloo Road intersection;
- a substantial upgrade of the stormwater drainage system on both sides of Waterloo Road comprising enlarged and/or new stormwater conduits and multiple new high capacity inlets, in combination with
- disusing the existing stormwater outfall from Wicks Road which discharges into Porters Creek upstream of the access road; and
- construction of a new culvert located under the access road (of the same size as the culvert located under the underpass).

The 100 yr ARI flood was assessed with the concept drainage augmentation implemented. The areas that would be unsafe for emergency vehicles in a 100 yr ARI flood levels in Wicks Road and Waterloo Road are given **Figure 10**.

The estimated inflows to the existing drainage system and the peak flows in the drainage system are also given in **Figure 10**. The estimated peak overland flows in the road reserves in the vicinity of the Wicks Road / Waterloo Road intersection are:

- Reduced to around 2 m^3/s in Wicks Road south of the intersection
- Reduced to < 2 m^3/s in Wicks Road north of the intersection
- Reduced to around 1.5 m^3/s in Waterloo Road west of intersection

The impact of the concept drainage augmentation on 100 yr ARI flood levels is given in **Figure 11.** It can be seen that the proposed drainage works reduce 100 yr ARI flood levels in Wicks Road, Waterloo Road and immediately upstream of the access road which leads to a local increase in the 100 yr ARI flood levels between the M2 site access road and the headwall of the culvert which discharges under the M2 Motorway underpass. These local increases do not adversely impact any existing development.

It is concluded that the substantial upgrade of the stormwater drainage system on both sides of Waterloo Road is able to capture a significant proportion of overland flows down Waterloo Road and in combination with the drainage augmentation under the access road would permit emergency vehicles to exit the planned development through the Wicks Road / Waterloo Road intersection during a 100 yr ARI flood.

6. ON-SITE DETENTION

The potential impact of proposed M2 site development on flood behaviour and the merit of not incorporating OSD into the planned development was also assessed.

Under benchmark conditions (as described in Section 4) runoff from the precinct is input into the TUFLOW model at the two locations (CA and CB) indicated in **Figure 12.**

The 100 yr ARI peak inflows input into the Council's TUFLOW model at these locations CA and CB are 2.88 m^3/s and 0.76 m^3/s respectively. In the vicinity of CB the estimated combined peak flow is around 3.5 m^3/s allowing for the time for overland flows from CA to reach CB (refer **Figure 13**). This peak flow is around 10% of the peak flow conveyed in the southern branch of the drainage system located downstream of the M2 Motorway (refer Figure 8).

As part of the planned development it is proposed to re-direct all runoff from the precinct to a single outfall located downstream of the access road. In order to assess the impact of this planned approach on estimated peak flows a simple **xprafts** model was assembled based on local catchment attribute data extracted from the DRAINS model. The vector average slope was adjusted until the peak flows matched the peak flows input into Council's TUFLOW model.

The adopted breakdown of development, park and reserve under future conditions (refer Figure 2) was as follows:

	Area (ha)			
ID	Impervious	Pervious	Total	% Imp
Subcatchment CA				
Development	4.75	0.9	5.65	84%
Park	0	0.55	0.55	0%
Subcatchment CB				
Development	2.13	0.41	2.54	84%
Reserve	0	0.41	0.41	0%
Total	6.88	2.27	9.15	75%

A local **xprafts** model of future conditions was also assembled based on the adopted areas and accounting for the lag time from CA to CB in a new drainage system the estimated peak discharge at CB (from the whole precinct) is 3.9 m^3/s.

The impact that OSD would have on peak flows was also assessed based on the nominated Zone 1 SSR of 0.0275 m^3/m^2 and PSD of 0.0265 $L/s/m^2$. Applying this SSR and PSD to the proposed areas of development (but excluding the park and reserve) gave a PSD of 1.5 m^3/s and SSR of 1.55 ML for Subcatchment CA and a PSD of 0.67 m^3/s and SSR of 0.7 ML for Subcatchment CB.

The local **xprafts** model of future conditions was modified to incorporate the concept lumped OSD systems and run to estimate the impact on peak discharge into Porters Creek. The estimated peak discharge at CB (from the whole precinct with OSD) is 2.4 m^3/s.

The inflow hydrographs estimated under benchmark conditions and future conditions (without and with OSD) are plotted in **Figure 13**.

It is noted that the implementation of OSD would reduce the peak discharge from the precinct into Porters Creek well below the estimated combined peak flow in the vicinity of CB under benchmark conditions.

The merit or otherwise of incorporating OSD into the planned development was also assessed by modifying the local TUFLOW model with the concept drainage augmentation by removing the inflow at location CA and inputting the precinct runoff under Future Conditions without OSD (3.9 m^3/s) at location CB and re-running the 100 yr ARI flood.

The impact of the concept drainage augmentation and planned development without OSD on 100 yr ARI flood levels is given in **Figure 14.** It can be seen that re-directing the precinct runoff to an outfall downstream of the access road locally reduces flooding of existing development upstream of the access road and this in combination with the drainage augmentation far outweigh any minor impact of slightly increasing the peak runoff from the M2 site by not implementing OSD as part of the development.

It is concluded that the precinct will discharge runoff at the lower end of the developed catchments and exempting the planned development from the requirement to install on site detention does not adversely impact on the flood behaviour on downstream roads or properties and nor on the downstream watercourse which has previously been culverted downstream of the M2 Motorway.

The proposed M2 development would lower flood levels upstream of the intersection of Wicks Road and Waterloo Road and would substantially reduce the flood hazard on Wicks Road and Waterloo Road which provides a benefit to local and regional traffic.

7. CONCLUSIONS

Based on the above assessments it was concluded that:

(i) under existing conditions emergency vehicles would be unable to safely exit the planned development through the Wicks Road / Waterloo Road intersection during a 100 yr ARI flood;

(ii) the substantial upgrade of the stormwater drainage system on both sides of Waterloo Road is able to capture a significant proportion of overland flows down Waterloo Road and in combination with the drainage augmentation under the access road would permit emergency vehicles to exit the planned development through the Wicks Road / Waterloo Road intersection during a 100 yr ARI flood; and

(iii) exempting the planned development from the requirement to install OSD does not adversely impact on downstream roads or properties and nor on the downstream watercourse which has previously been culverted downstream of the M2 Motorway.

We would be pleased to further discuss our findings with you upon your request.

Yours faithfully

……
Dr Brett C. Phillips
Director, Water Engineering
for **Cardno**

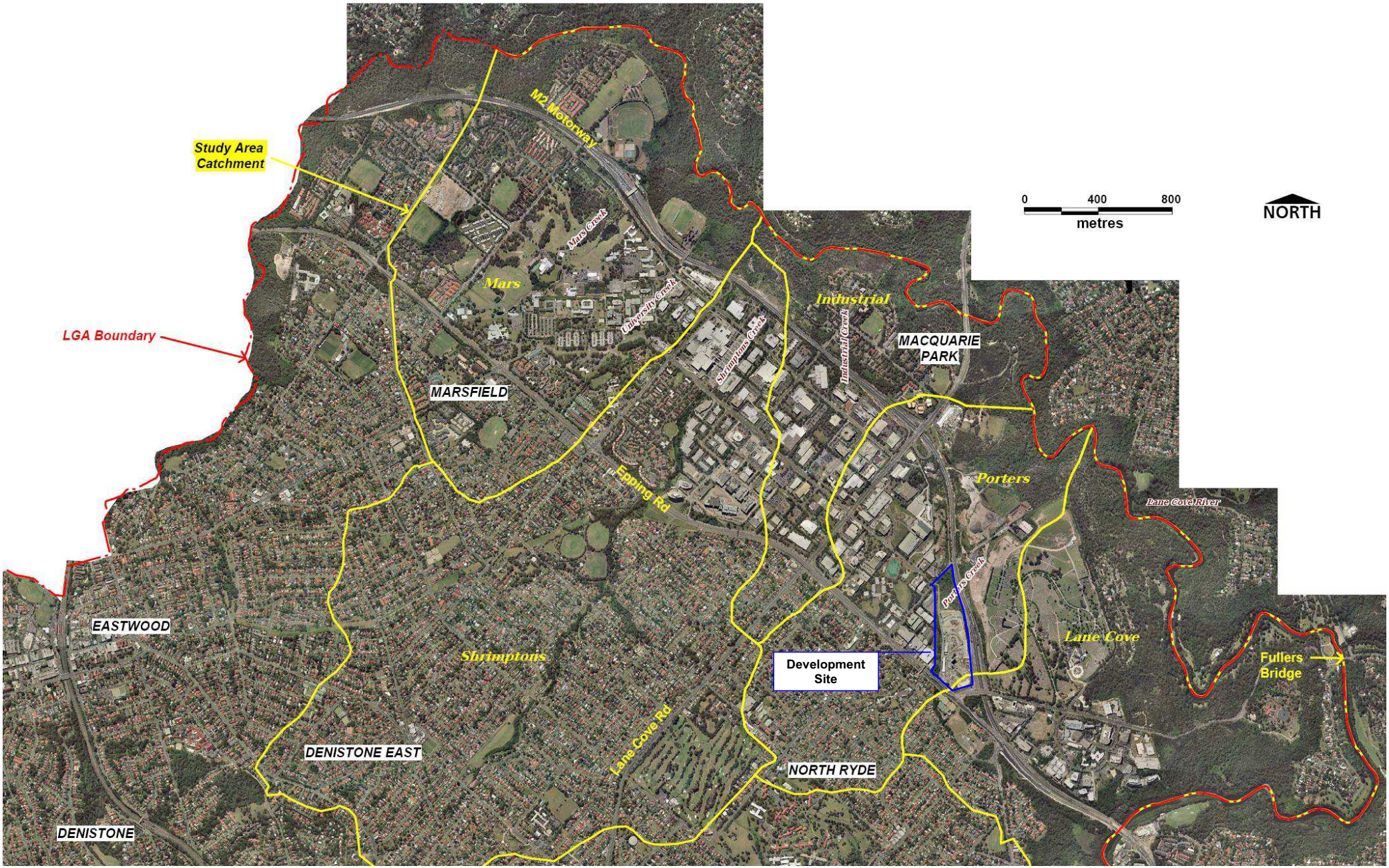

Figure 1 Macquarie Park Floodplain Catchments and Development Site (after Bewsher Consulting, 2010)

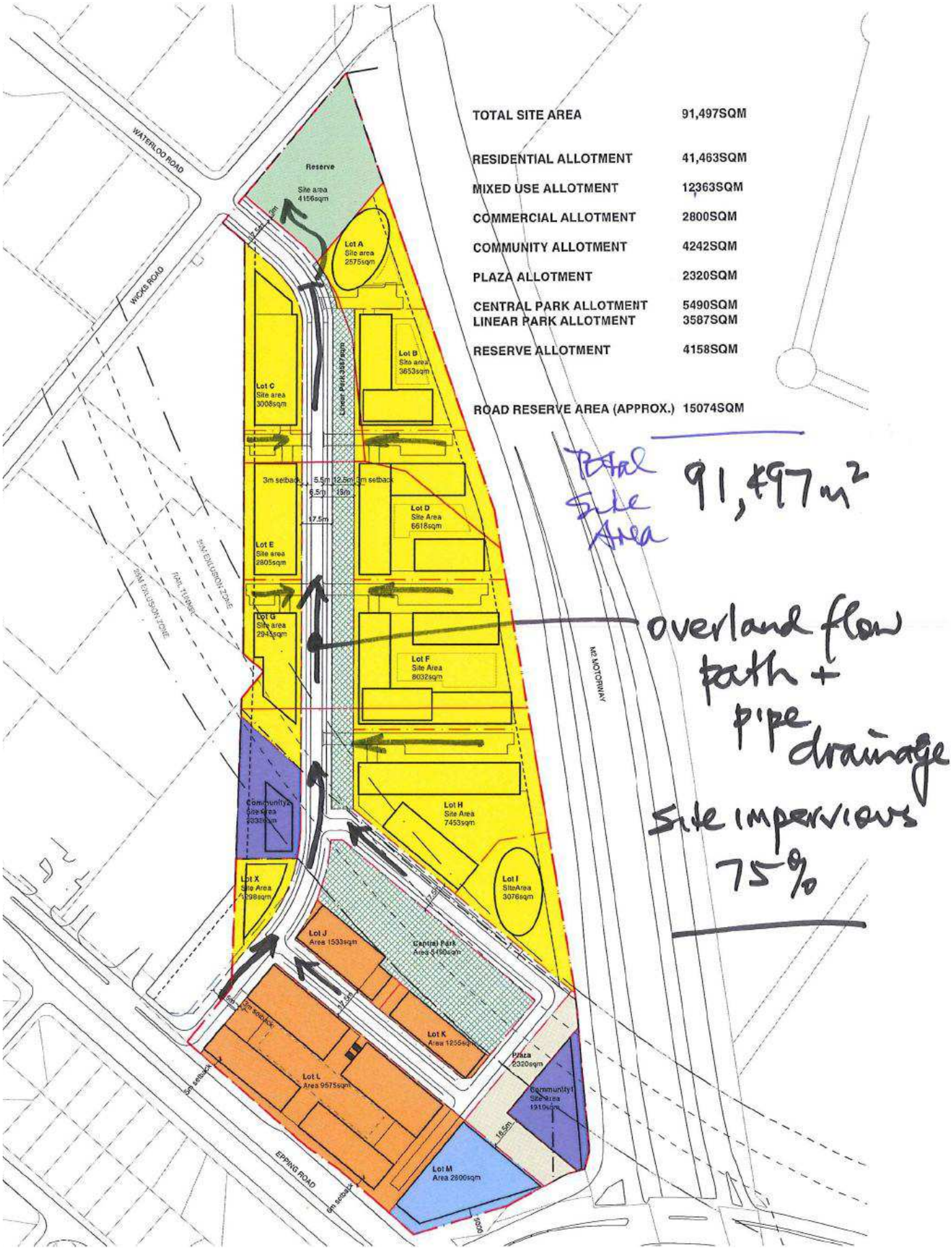

Figure 2 M2 Site: North Ryde Station Precinct