# Mamre Road

## Flood, Riparian Corridor and Integrated Water Cycle Management Strategy

October 2020

# Acknowledgement of Country

Sydney Water respects the traditional ‘Caring for Country’ restorative approaches practiced over tens of thousands of years by Aboriginal people and play our part to improve the health of the landscape by recognising and nurturing all values of water in our environment.

In doing so, we acknowledge the traditional custodians and their ancestors of the lands and waters in Western Sydney where we are working and learning: the D’harawal and Dharug nations, as well as their neighbours the Gundungurra. Their lore, traditions and customs nurtured and continue to nurture the sweet waters in this area, creating wellbeing for all. We also pay our respects to Elders, past, present and emerging.

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# 1. Introduction

The Department of Planning, Industry and Environment (DPIE) have amended the State Environmental Planning Policy (Western Sydney Employment Area) 2009 (WSEA SEPP) to rezone the Mamre Road Precinct (the Precinct) for primarily industrial purposes.

On behalf of DPIE, Sydney Water have developed this integrated water cycle management plan to inform the water servicing, and flood management for the Precinct.

## 1.1 Mamre Road Precinct

The Precinct is located approximately 40 km west of the Sydney CBD and 12 km southeast of the Penrith CBD. It is located entirely within the Penrith City Council Local Government Area (LGA). It is bordered by the WaterNSW Warragamba Pipeline to the north, Wianamatta South Creek and Kemps Creek to the west, Ropes Creek to the east and Mount Vernon to the south. The precinct has an approximate gross site area of 1002 ha.

## 1.2 Study Objectives

This Integrated Water Cycle Management study has been prepared to inform and support the rezoning of the Mamre Road Precinct. Controls prescribed by this study will inform the Precinct DCP and ensures that:

- Land use is compatible with flood risk
- Flood management approaches are effective and consistent across the catchment
- Water sensitive urban design approaches achieve pollution reduction targets and contribute to emerging waterway health targets in a flexible and cost-effective way
- Sufficient land is allocated for stormwater and flood management on private lots and in the public domain

### Water Servicing Strategy

The ultimate water demands for the Precinct have been compiled for toilet flushing, irrigation, urban cooling, drinking water, wastewater, stormwater and recycled water.

The non-potable, irrigation and urban cooling demands have been used to inform the size of stormwater harvesting elements and effectiveness of stormwater volume reductions.

### Flooding

An assessment of flood constraints associated with the land use change includes:

- defining flood behaviour within the Precinct’s unnamed tributaries
- an assessment of flood behaviour post-development and the impacts the change in land use will have on local catchment flood behaviour, including impacts on existing infrastructure and lands outside the Precinct

- an assessment of the flood mitigation requirements for the Precinct.

### Riparian Corridor Management Strategy

Waterways across the site have been ground truth-ed to determine the presence of riparian lands and those that are to be retained. A riparian corridor strategy (Appendix E) has been developed for the Precinct that recommends the retention of waterways based on ground truthing and consultation with NSW Natural Resources Access Regulator.

### Waterway Health (Stormwater Quantity and Quality) Management

A management strategy for stormwater (low flows) is provided that demonstrates compliance with:

1. current pollution reduction targets prescribed by Council
2. interim waterway health targets drafted for the Wianamatta South Creek catchment by DPIE EES
3. the *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions* and
4. Western Sydney Employment Area SEPP Clause.

# 2. Predeveloped Site Conditions

The following section summarises the environmental constraints and context of the local environment that have informed the development of the IWCMS for the Precinct.

## 2.1 Land Use

The Precinct has been zoned as mainly Industrial from its previous zonings shown in Figure A-3 comprising Rural Landscape (RU2), Infrastructure (SP2), Environmental Living (E4) to the east, and Environmental Conservation (E4).

Figure A-4 shows the current Industrial zoning but at the at the time of preparing this study the Precinct area is mostly pasture, minor roads, sheds, out buildings and farm dams with pockets of intensive farming. The northern portion of the site includes Mamre Anglican School, Emmaus Catholic College, Trinity Primary School and several retirement villages.

## 2.2 Topography

The Precinct encompasses an area known as Mount Vernon and includes a prominent hill line that divides the Precinct with approximately one third draining east to Ropes Creek, one third to the main dam on Kemps Creek and one third below the Kemps Creek and Wianamatta South Creek confluence. Upper reaches are very steep with grades of 10 to 20 % while lower hill slopes are gentler approaching floodplains. Topography of the Precinct is presented in Figure A-5.

## 2.3 Waterways and Riparian Corridors

Reference to the 1:25000 topographic maps show ten minor tributaries crossing the Precinct. Many waterways are broad, poorly defined and highly impacted by land use. Farm dams have been formed along their reaches, some significant in size and volume. These farm dams account for approximately 30 ha in area which accounts for approximately 3% of the total Precinct area. As such, these structures likely play a significant part in the hydrology of the region, recharging groundwater and supplying baseflows to downstream waterways.

## 2.4 Drainage Structures

The Precinct is crossed by Mamre Road which has 17 transverse drainage structures controlling runoff from undeveloped catchments upstream. Flow discharging from the transverse drainage structures is conveyed along a series of semi-natural channels that join Kemps Creek and Wianamatta South Creek around 200 m to 1 km to the west of the road corridor.

Access to the eastern portion of the Precinct is via Abbots Road, Aldington Road and Bakers Lane which are crossed by six culverts located at local sags. These have significantly smaller catchments than the Mamre Road culvert crossings.

The northern edge of the Precinct runs along the WaterNSW Warragamba Pipeline and the Precinct drains to the north via four minor transverse drainage structures and the two main crossings of Wianamatta South Creek and Ropes Creek.

The Kemps Creek Dam (24.7 ha) is a significant hydrologic feature in the catchment. The dam likely contributes baseflow to the downstream reach by retaining wet weather flows and recharging the groundwater table. Anecdotally, Wianamatta South Creek is thought to become more perennial downstream of the Kemps Creek confluence (Pers Comm Tippler, 2019).

The Wianamatta South Creek Dam is another significant structure that has been partly demolished leaving a breach in the dam wall that allows the passage of stream flows. The base of the dam provides retention of water which has a significant capacity to retain stream flow and recharge groundwater.

## 2.5 Soils and Salinity

The Precinct is dominated by low permeability clays and alluvial soils in the floodplain comprising the following groups according to the Soil Landscapes of the Penrith and Wollongong 1:100,000 Sheet map and reports (Soil Conservation Service of NSW, 1990):

**Luddenham (lu) 15,414 Erosional**

Brown loam to clay loam over light to medium clay. Slopes 5-20%. Shallow on crests (<100 cm) to moderately deep (<150 cm) on lower slopes and drainage lines.

Low permeability, low available water capacity, low fertility, high erodibility, very low infiltration in B horizon, lateral water flow, water erosion hazard.

Infiltration rate - low

**Blacktown (bt) 42,752 Residual**

Shallow to moderately deep (>100 cm) hard setting mottled texture contrast soils. Brown loam over mottled brown light clay to grey plastic heavy clay.

Susceptible to ponding, waterlogging in A horizon, low infiltration rate in B horizon, lateral water flow, seepage, potential expression of salts.

Infiltration rate - low

**South Creek (sc) 7,160 Alluvial**

Very deep layered sediments over bedrock or relict soils. Brown sandy loam to clay loam over brown light to medium clay.

Low fertility, flood hazard, seasonal waterlogging, permanently high water tables (localised), low infiltration rate in B horizon, lateral water flow, seepage, potential expression of salts.

Infiltration rate - moderate

The Precinct soils are dominated by relatively low permeable saline clay soils. Groundwater recharge from over irrigation must be managed to reduce the mobilisation of natural salts in the catchment.

Land capability mapping commissioned by Sydney Water found that the Precinct has a moderate salinity risk, however it is likely that earthworks to form industrial lands will significantly alter the composition of the upper soil horizons (Aurecon, 2019).

## 2.6 South Creek Wianamatta Floodplain

The Precinct accounts for 10 $km^2$ within the middle reach of the overall 627 $km^2$ Wianamatta South Creek catchment. Flood data for the catchment is defined by Penrith Council's flood study of South Creek.

The adopted 1% AEP flood extent of Kemps and Wianamatta South Creeks defines the western boundary of the Precinct. Areas of the Precinct that lie to the west of Mamre Road are flood prone and affected by the PMF.

## 2.7 Riparian Corridors

A riparian corridor strategy has been developed for the Precinct that recommends the retention of waterways based on ground truthing and consultation with NSW Natural Resources Access Regulator.

The riparian corridor strategy has been included in Appendix A.

# 3. Design Standards and Approach

The following sections compile the SEPP objectives and design standards that have informed the Integrated Water Cycle Management Study.

## 3.1 State Environmental Planning Policy (Western Sydney Employment Area) 2009

Clause 33L of this SEPP requires that adverse impacts from stormwater on adjoining properties, riparian land, native bushland, waterways, groundwater dependent ecosystems and groundwater systems are avoided or minimised.

The SEPP has been summarised below:

(a) water sensitive design principles are incorporated into the design of the development, and

(b) riparian, stormwater and flooding measures are integrated, and

(c) the stormwater management system includes all reasonable management actions to avoid adverse impacts on the land to which the development is to be carried out, adjoining properties, riparian land, native bushland, waterways, groundwater dependent ecosystems and groundwater systems, and

(d) if a potential adverse environmental impact cannot be feasibly avoided, the development minimises and mitigates the adverse impacts of stormwater runoff on adjoining properties, riparian land, native bushland, waterways, groundwater dependent ecosystems and groundwater systems, and

(e) the development will have an adverse impact on—

> (i) the water quality or quantity in a waterway, including the water entering the waterway, and
>
> (ii) the natural flow regime, including groundwater flows to a waterway, and
>
> (iii) the aquatic environment and riparian land (including aquatic and riparian species, communities, populations and habitats), and
>
> (iv) the stability of the bed, banks and shore of a waterway, and

(f) the development includes measures to retain, rehabilitate and restore riparian land.

(3) For the purposes of subclause (2)(a), the water sensitive design principles are as follows—

(a) protection and enhancement of water quality, by improving the quality of stormwater runoff from catchments,

(b) minimisation of harmful impacts of development on water balance and on surface and groundwater flow regimes,

(c) integration of stormwater management systems into the landscape in a manner that provides multiple benefits, including water quality protection, stormwater retention and detention, public open space, habitat improvement and recreational and visual amenity,

(d) retention, where practical, of on-site stormwater for use as an alternative supply to mains water, groundwater or river water.

## 3.2 Penrith DCP 2014

The following provides a summary of relevant Council controls that would normally apply to new development and are included in this IWCM for consistency.

### 3.2.1 Flood Planning

The 1% AEP flood event is a tool for broadly assessing the suitability of land for development. It is not an assessment of flood risk, nor does reference to the 1% AEP flood event mean that properties and development above this level are not subject to flood risk.

Developments that may have a significant impact on the extent of flooding experienced by nearby or downstream properties may be asked to consider floods larger than the 1% AEP flood event.

#### Industrial Development

Floor levels shall be at least 0.5m above the 1% AEP flood or the buildings shall be flood-proofed to a least 0.5m above the 1% AEP flood.

Flood safe access and emergency egress shall be provided to all new developments.

#### Filling of Land

Council will not grant consent to filling of floodways or high hazard areas. The filling of other land at or below the flood planning level will generally not be supported; however, Council will adopt a merits-based approach where the following criteria are applied:

- Flood levels are not increased by more than 0.1m by the proposed filling;
- Downstream velocities are not increased by more than 10% by the proposed filling;
- Proposed filling does not redistribute flows by more than 15%;
- The potential for cumulative effects of possible filling proposals in that area is minimal;
- There are alternative opportunities for flood storage;
- The development potential of surrounding properties is not adversely affected by the filling proposal;
- The flood liability of buildings on surrounding properties is not increased;
- No local drainage flow/runoff problems are created by the filling; and
- The filling does not occur within the drip line of existing trees.

#### Rezoning of Land

Council will not support the rezoning of any land located in a floodway or high hazard area.

Council will generally not support the rezoning of rural land situated below the 1% AEP flood where the development of that land may require or permit the erection of buildings or works even if the surface of the land can be raised to a level above the 1% AEP flood by means of filling.

### 3.2.2 Stormwater Management and Drainage

#### Natural Environment

Permeable ground surfaces are to be maintained as far as possible, and where suitable conditions exist, stormwater is to be infiltrated on-site.

#### Drainage

Appropriate drainage measures, including on-site detention will be required.

Development will not overload trunk drains during peak storm events or cause localised flooding.

All drainage will be designed to ensure that the intensity, quantity and quality of surface runoff is not detrimental to downstream properties and watercourses.

#### On-Site Stormwater Detention (OSD)

Adequate stormwater systems shall be designed and constructed to ensure that, for all rainwater events up to and including the 1% AEP event, new developments and redevelopments do not increase stormwater peak flows in any downstream areas.

On-site stormwater detention systems must release water after any rainfall event to maximise future capacity and therefore, cannot include rainwater tanks, water retention basins or dams.

On-site detention systems are to be designed using a catchment wide approach.

#### Water Sensitive Urban Design

Pollution load reduction requirements for new development will deliver:

- 90% reduction in the post development mean annual load of total gross pollutant (greater than 5 mm)
- 85% reduction in the post development mean annual load of Total Suspended Solids (TSS)
- 60% reduction in the post development mean annual load of Total Phosphorus (TP)
- 45% reduction in the post development mean annual load of Total Nitrogen (TN)
- changes to the flow rate and flow duration within the receiving watercourses as a result of the development shall be limited as far as practicable.
- natural flow paths, discharge points and runoff volumes from the Precinct should also be retained and maintained as far as practicable
- impervious areas directly connected to the stormwater system shall be minimised. Runoff from impervious areas such as roofs, driveways and rainwater tank overflows shall be directed onto grass and other landscaped areas designed to accept such flows
- the post-development duration of stream forming flows shall be no greater than 3.5 times the pre-developed duration of stream forming flows. The comparison of post development

and pre-development stream forming flows is commonly referred to as the Stream Erosion Index (SEI).

A summary of how the IWCM study complies with these requirements is provided in Section 3.5

## 3.3 Draft South Creek Floodplain Risk Management Study

The *Draft South Creek Floodplain Risk Management Study* (Advisian, 2019) defines the Flood Planning Area (FPA) as land at or below the 1% AEP flood plus 0.5 m freeboard and proposes the flood related development controls for any development proposed within the FPA.

Current FPA extents are based upon the results of hydraulic modelling completed for Wianamatta South Creek and its tributaries as part of the *Updated South Creek Flood Study (*WorleyParsons, 2015) mapped to align with topographic elevations defined by the 2002 Aerial Laser Survey (ALS).

Where land below the FPA is currently zoned to permit urban development, Council will generally not support the rezoning of land to higher economic use or an increase in the density of development control 15(c).

**Recommended Changes to the DCP by the FRMP**

The FRMS recommends the following new standards to replace the current flood controls and these have been considered in the rezoning the Precinct:

- On the Precinct, flood hazard is not increased to greater than “low” based on current ARR criteria for hazard. Low hazard zones are defined in ARR as where the depth velocity product is (D.V) less than 0.4 $m^2/s$ for children and less than 0.6 $m^2/s$ for adults and should be applied depending on the type of development. Isolated areas of high hazard may be considered at Council’s discretion where people are prevented from entering the area i.e. dedicated flow paths. Hazard should never increase to exceed 0.8 $m^2/s$ as this is the limiting working flow for experienced personnel such as trained rescue workers. Flood hazard should be assessed for the duration of the event and is not necessarily the flood hazard at the time of the peak flood level.
- Flood hazard on surrounding properties should not increase.
- The potential for cumulative effects of possible development proposals in that area is minimal.
- Where possible, any losses in floodplain storage are to be offset by compensatory cut at the same or a similar elevation.
- There is enough time to evacuate all persons from the site during all events up to and including the PMF.

## 3.4 Controlled activities on waterfront land - Guidelines for riparian corridors on waterfront land

The overarching objective of the controlled activities provisions of the WM Act is to establish and preserve the integrity of riparian corridors. Ideally the environmental functions of riparian corridors should be maintained or rehabilitated by applying the following principles:

- identify whether or not there is a watercourse present and determine its stream order in accordance with the Strahler System

- if a watercourse is present, define the riparian corridor (RC)/vegetated riparian zone (VRZ) on a map
- seek to maintain or rehabilitate a RC/VRZ with fully structured native vegetation
- seek to minimise disturbance and harm to the recommended RC/VRZ
- minimise the number of creek crossings and provide perimeter road separating development from the RC/VRZ
- locate services and infrastructure outside of the RC/VRZ. Within the RC/VRZ provide multiple service easements and/or utilise road crossings where possible
- treat stormwater runoff before discharging into the RC/VRZ.

## 3.5 Summary of Performance and Guidance

Key requirements of current policies relating to stormwater and flooding are summarised below in Table 1 with reference to the section of this report that specifically addresses those requirements

Table 1 Summary of IWCM compliance with existing requirements above

| Existing Policy or Control | How this is to be achieved in the Precinct |
|---|---|
| Floor levels shall be at least 0.5m above the 1% AEP flood or the buildings shall be flood-proofed to a least 0.5m above the 1% AEP flood | Industrial land use zones are set outside of the 1% AEP flood extents of Ropes, Wianamatta South and Kemps Creeks.<br>Overland flow paths have been mapped across the site to indicate areas where trunk drainage flow paths shall be provided. These demonstrate that development can be accommodated on lands outside high flood hazard land.<br>Detailed design of trunk drainage channels including flood impact mapping will be required for development sites crossed by overland flow paths |
| Changes in filling does not impact on flooding outside the precinct and there is no loss of floodplain storage | Industrial land use zones are set outside of the 1% AEP flood extents of Ropes, Wianamatta South and Kemps Creeks to eliminate any risk of filling impacting 1% AEP flood levels outside of the precinct.<br>Channelising overland flow paths through the precinct will reduce the flood storage within the precinct but on-site stormwater detention will compensate for changes in conveyance.<br>Development within overland flow paths in the Ropes Creek catchment must provide evidence through detailed flood impact assessment that there are no local impacts on existing development on Bowood Road, Mt Vernon. |

| Existing Policy or Control | How this is to be achieved in the Precinct |
|---|---|
| Flood safe access and emergency egress shall be provided to all new developments | Culvert upgrades are proposed on Mamre Road and local roads to facilitate egress. Works shall occur during Precinct road upgrades. |
| New developments do not increase stormwater peak flows in any downstream areas up to and including the 1% AEP event | A catchment wide approach has been used to size on-site stormwater detention for private industrial sites. This approach ensures no increase in peak flows on lands outside the Precinct and accounts for chanelisation of overland flow paths. This OSD approach can be applied to single sites or at an estate scale. |
| Pollution reduction targets are achieved for new development<br>Stream erosion index is limited to 3.5 | Pollution reduction targets will be achieved through a combination of<br>- water sensitive urban design on industrial lots.<br>- biofiltration street trees on new and upgraded local roads |
| Changes to the natural flow regime (volume, flow rate and flow duration) shall be limited as far as practicable | A range of additional stormwater management measures are proposed to achieve reductions in stormwater runoff volumes and closely match the natural flow regime.<br>These measures demonstrate the cost effectiveness of each measure in limiting changes in flow rate and flow duration and allow site designers to select measures that best suit their development.<br>These measures are consistent with new stormwater targets being established by DPIE EES for the Western Sydney Aerotropolis. These measures have been developed by applying the Risk-based Framework and it is therefore appropriate that state significant development applications apply the same approach. |

# 4. Land Use and Urban Form

The Precinct land zoning is shown in Figure A-4 (DPIE 2019). The paper identifies an opportunity to meet the shortfall of industrial land in Western Sydney by expanding the Western Sydney Employment Area. The Precinct will help alleviate the current shortfall in industrial land and provide approximately 780 ha of new industrial land.

## 4.1 Industrial Development

The Mamre Road Precinct structure plan provides for a new industrial zoned precinct which will become a warehousing industrial hub providing around 17,000 new jobs in Western Sydney.

Surrounding rural residential areas are protected from industrial activities with buffers between homes and the industrial hub. The Precinct preserves approximately 95 hectares of environmentally sensitive land, including Cumberland Plain Woodland.

Over 50 hectares of open space, recreation areas, cycle and walking paths will be included within the Precinct. Critical transport corridors are preserved and opportunities for an intermodal terminal are maintained.The total area of the Precinct is approximately 1000 ha and has been rezoned as outlined in Table 2.

Table 2 Summary of Parameters

| Land Use Zone | | Area (Ha) |
|---|---|---|
| E2 | Environmental Conservation | 72.9 |
| IN1 | General Industrial | 850.0 |
| SP2 | Infrastructure | 27.3 |
| RE2 | Private Recreation | 23.2 |
| RE1 | Public Recreation | 28.2 |
| **Total** | | **1001.6** |

## 4.2 Urban Form and Imperviousness

Urban form is an important consideration in integrated water cycle management as it defines many of the sources and opportunities for the generation and reuse of stormwater and wastewater and the need for management of residual discharges to the environment.

The rates of imperviousness within the build form influence the generation of stormwater volumes that can influence downstream waterway health and flood behaviour.

*Business as usual impervious* rates are adopted for flood planning while *effective imperviousness* is proposed for stormwater balance calculations associated with low flows. Disconnecting impervious areas is a concept for managing frequent and low intensity rainfall events which are associated with waterway health and the bulk of annual site runoff volumes.

### 4.2.1 Large Format Industrial Sites

Total imperviousness and a suggested effective imperviousness land use split (Architectus 2019) for the purpose of calculating stormwater balance modelling is provided in Table 3. A schematic of the reduced imperviousness typology and a land use schematic is provided in Figure 4-1. Employment rates of 20 jobs/Ha are adopted for this land use type.

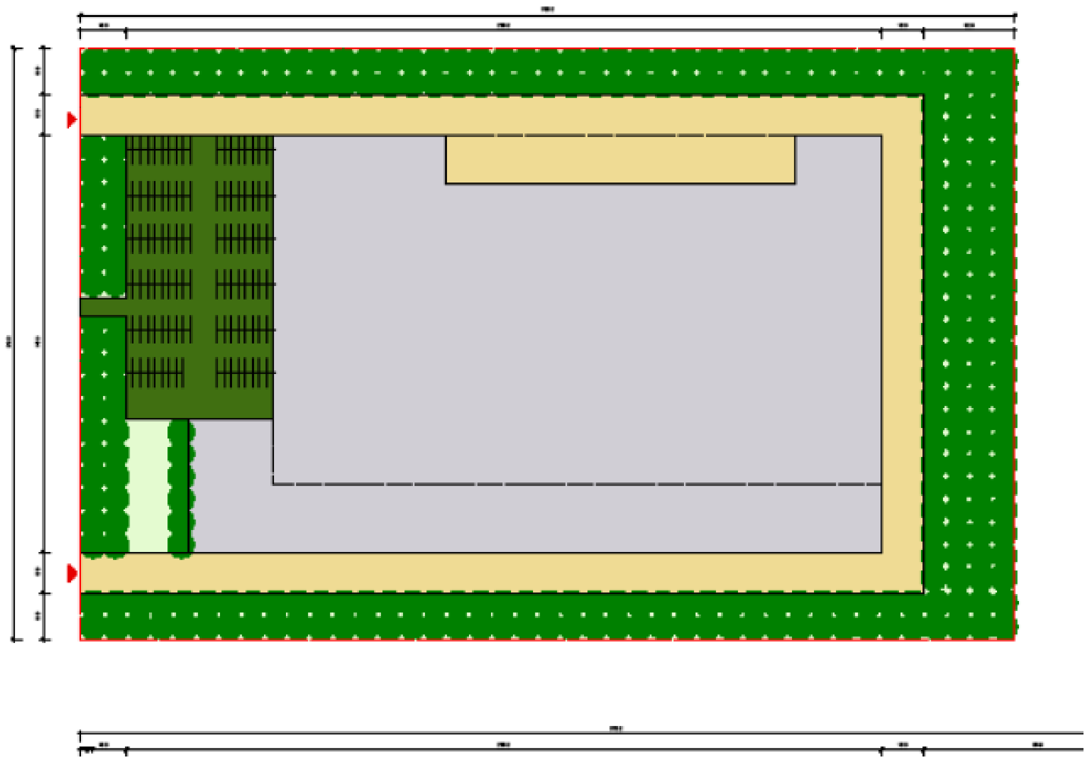
Table 3 Suggested Site Coverage for Large Format Industrial and Logistics Centres

| | Business as Usual Approach (Adopted for Flood Planning Modelling) | | Effective Imperviousness (Adopted for Stormwater Treatment Train Modelling) | | Ideal Imperviousness | |
|---|---|---|---|---|---|---|
| **For IN1 zoned lands*** | **% of land zoning*** | **% Imperviousness** | **% of land zoning*** | **% Imperviousness** | **% of land zoning*** | **% Imperviousness** |
| Roof | 61% | 100% | 48% | 100% | 48% | 100% |
| Hardstand | 10% | 100% | 10% | 100% | 0% | 100% |
| Concrete/asphalt car parks and driveway cross overs | 13% | 100% | 6% | 100% | 0% | 100% |
| Permeable pavement | 0% | 50% | 15%*** | 50% | 32% | 50% |
| Landscape | 10% | 0% | 14% | 0% | 14% | 0% |
| Public roads** | 7% | 75% | 7% | 70% | 7% | 60% |
| **Sum total (excluding public open space)** | | **88%** | | **76%** | | **68%** |

** Excludes all RE1, RE2, SP2 and Mamre Road*

*** Based on proposed precinct local network provided by land owners group*

**** Includes car parks draining to biofiltration street trees within car parks*



Typology overview:

- 61,000m² lot size
- Single storey factory with upper storey office.
- Lightweight tilt-up + roof frame construction.
- On grade car parking
- Hardstand areas including loading areas and parking (50% permeable assumed)

Key metrics:

| Lot size | Approx. GFA | Approx. FSR X:1 |
|---|---|---|
| 61,000m² | 37123m² | 0.61:1 |

| Permeable surfaces | Permeability | Area | Max. Tree Canopy |
|---|---|---|---|
| Deep soil | 100% | 9330m² (15%) | 10m |
| Parking hardstand | 50% | 6279m² (10%) | 7m |
| Service hardstand | 50% | 14446m² (24%) | |
| Building site coverage | 0% | 30929m² (51%) | |
| | 32% average | 61000m² total | 15028 m² canopy(25%) |

Figure 4-1 New urban typology for large format industrial *(Source: Architectus 2019)*

### 4.2.2 Business Campus and Strata Industrial

Steeper areas of the catchment require terracing at more frequent intervals which may lead to smaller building footprints. A schematic and summary are provided in Figure 4-2 and Table 4 respectively. Employment rates of 60 jobs/Ha are likely for this typology.

Table 4 Suggested Site Coverage for Business Campuses

| | Business as Usual Approach (Adopted for Flood Planning Modelling) | | Reduced Imperviousness (Adopted for Stormwater Treatment Train Modelling) | | Ideal Imperviousness | |
|---|---|---|---|---|---|---|
| **For IN1 zoned lands** | **% of land zoning*** | **% Imperviousness** | **% of land zoning*** | **% Imperviousness** | **% of land zoning*** | **% Imperviousness** |
| Roof | 23% | 100% | 23% | 100% | 23% | 100% |
| Hardstand | 13% | 100% | 13% | 100% | 14% | 100% |
| Concrete/asphalt car parks and driveway cross overs | 36% | 100% | 18% | 100% | 0% | 100% |
| Permeable pavement | 0% | 50% | 18% | 50% | 36% | 50% |
| Landscape | 18% | 0% | 18% | 0% | 18% | 0% |
| Public roads | 10% | 70% | 10% | 70% | 10% | 60% |
| **Sum total (excluding public open space)** | | **80%** | | **70%** | | **61%** |

** Excludes all RE1, RE2, SP2 and Mamre Road*

Typology overview:

- 63500m² lot size
- Large floor plate commercial office campus
- Internal road + parking network.
- On grade + basement car parking
- Hardstand areas including loading areas and parking (50% permeable assumed)

Key metrics:

| Lot size | Approx. GFA | Approx. FSR X:1 |
|---|---|---|
| 40,652m² | 51,876m² | 1.28:1 |

| Permeable surfaces | Permeability | Area | Max. Tree Canopy |
|---|---|---|---|
| Deep soil | 100% | 8000m² (20%) | 10m |
| Parking hardstand | 50% | 13350m² (33%) | 7m |
| Service hardstand | 50% | 3027m² (7%) | |
| Building site coverage | 0% | 10170m² (25%) | |
| Non building hardstand | 0% | 6105m² (15%) | |
| | 40% average | 40652m² total | 12189 m² canopy(30%) |

Figure 4-2 New urban typology for business campuses (Source: Architectus, 2019)

# 5. Integrated Water Cycle Management

## 5.1 Water Demands

Water planning for the precinct is based on a range of 20 to 40 equivalent people per net hectares of industrial land (NHa).

Lower range water demands of 3.5 kL/NHa/day are typical for traditional industrial facilities where 35% is associated with irrigation (0.5 ML/NHa/yr) and 15% is associated with toilet flushing (0.525 kL/NHa/d).

Data centres and other high-water users would increase total water demands to 10 kL/NHa/day which is associated with demand for higher quality non potable water.

### 5.1.1 Irrigation

Irrigation demands associated with additional landscaping and vegetated set back areas on the lot will be higher for parkland industrial typologies where landscaping accounts for 14 to 18% of the lot and streetscape (0.8 ML/NHa/yr) and irrigation rates of 4.5 ML/Ha/yr are adopted. Irrigation water is likely to be sourced from a mix of water sources and the volumes of irrigation have been confirmed through a detailed land capability assessment.

Active transport routes, vegetated trunk drainage channels and public open space can feasibly be irrigated at 4.5 ML/Ha/yr according to a detailed land capability assessment study undertaken for the Aerotropolis (Aurecon, 2020).

### 5.1.2 Urban Cooling

Misting and evaporative cooling is an emerging method for reducing ambient temperatures inside and outside of buildings (notionally 4.5 ML/NHa/yr) which is promoted by the Low Carbon Living CRC (2017) as an urban cooling strategy to reduce the impacts of extreme heat and as a means of reducing stormwater runoff volumes. Water sources would be high quality where there is a risk of human contact and ingestion, but stormwater from ground surfaces could be utilised to mist rooftops for building.

Wastewater loads 2.4 to 4.8 kL/NHa/day are adopted for lower and upper range of employment lands respectively.

- Potable – 1.75 kL/NHa/d to 3.5 kL/NHa/d
- Non potable daily – 0.525 kL/NHa/d to 1.05 kL/NHa/d
- Lot irrigation – 0.5 to 0.8 ML/NHa/yr
- Public open space irrigation – 0.5 ML/NHa/yr

## 5.2 Drinking Water Servicing

### Existing drinking water servicing:

The Precinct is currently supplied via the Cecil Park reduced supply zone. There is very limited capacity in this system to supply the first stages of development.

Sydney Water is planning for staged delivery of drinking water assets across the Western Sydney Aerotropolis Growth Area (WSAGA) in line with DPIE growth forecasts. This will enable flexible servicing for interim and staged delivery to meet anticipated development timeframes.

### Interim drinking water servicing:

Interim servicing is required via extension of the Erskine Park elevated supply zone and the Cecil Park supply zone (via WP0184C).

Some pockets of the Precinct may require a booster pumping station, and this will be dependent on the staging and timing of the development, detailed hydraulic modelling and finished surface levels.

Upon completion of the Precinct rezoning and DPIE precinct planning, Sydney Water can finalise the servicing scheme plan interim servicing.

### Ultimate drinking water servicing:

Sydney Water's strategic servicing of the Precinct is linked to the draft Western Sydney Regional Master Plan and draft WSAGA Sub Regional plan. Ultimate drinking water supply for the precinct will be via the Cecil Park water supply zone, with utilisation of interim servicing links to adjoining supply zones for operational flexibility and reliability.

Upon completion of the Precinct rezoning and DPIE precinct planning, Sydney Water can finalise servicing the scheme plan for ultimate servicing.

## 5.3 Wastewater Servicing

### Existing wastewater servicing:

The eastern catchment of the Precinct drains by gravity to the St Marys wastewater system. This system has capacity to service the eastern catchment via a wastewater main extension. The eastern catchment can permanently drain to the St Marys system.

The western catchment is currently not serviced.

Sydney Water is planning for staged delivery of wastewater assets across the Western Sydney Aerotropolis Growth Area (WSAGA) in line with DPIE growth forecasts. This will enable flexible servicing for interim and staged delivery to meet anticipated development timeframes.

### Interim wastewater servicing:

Sydney Water's interim wastewater servicing scheme for the western catchment of the Precinct is for a permanent wastewater pumping station (WWPS) and deep gravity trunk mains to service the catchment. The western catchment can be pumped via an temporary pressure main to the St Marys wastewater system up to about 2026. The timescale for delivery of this work is dependent on growth demand within the Precinct, final rezoning and precinct planning. This interim solution is based on anticipated staged employment demand pre 2026 and connection will need to be managed to ensure capacity within the St Marys wastewater system.

**Ultimate wastewater servicing:**

Sydney Water's strategic servicing of the Precinct is linked to the draft Western Sydney Regional Master Plan and draft WSAGA Sub Regional plan. To fully service the Precinct the western catchment requires a permanent wastewater pumping station (WWPS) and deep gravity trunk mains. A new pressure main will divert flows to the proposed Upper South Creek Water Treatment Factory. The water factory first stage completion is targeted for 2025/2026. The timescale for delivery of this work is dependent on growth demand within the Precinct, final rezoning and precinct planning.

## 5.4 Stormwater Servicing

Stormwater generated within the Precinct will be conveyed by a combination of minor and major drainage elements within public roads and trunk drainage channels.

Consultation with Penrith Council has indicated a preference for on-lot stormwater controls to manage stormwater quality and quantity for industrial lands. This eliminates the need for regional stormwater detention and water quality facilities.

Detention basin controls for new development are prescribed in Section 6 while on lot WSUD controls are prescribed in Section 7 of this study.

In some cases, it will be necessary to use designated trunk drainage channels to safely convey stormwater from upstream catchments through land that is zoned as industrial. It will be cost effective to divert flows that exceed the capacity of low cost stormwater pipes into these channels. This often coincides with a notional upstream catchment of 15 Ha as shown in Appendix G. There is some flexibility in the alignment of trunk drainage due to steeper site grades, but this must be balance with the earthworks.

Stormwater quality and quantity management for runoff generated from upgraded and new local road networks will be provided through a combination of :

- Roadside biofiltration measures within the verge that can achieve pollution reductions required by Council.
- Sizing on-site stormwater detention basins on industrial lots to compensate for no flood detention basins downstream of roads.

This approach requires less land take for detention basins and water quality basins by consolidating the number of stormwater detention structures and co-locating stormwater management elements within the streetscape.

## 5.5 Recycled Water Servicing

Sydney Water has made commitments to the provision of recycled water to the Aerotropolis from the Upper South Creek advance water filtration plant which is planned for a site to the west of the Precinct.

Detailed planning is being carried out on the servicing concepts and networks that would deliver recycled water to Mamre Road and to determine the integration of stormwater recycling and recycled effluent.

# 6. Flooding

The Updated South Creek Flood Study (WorleyParsons, 2015) was completed for Penrith Council in conjunction with Liverpool, Fairfield and Blacktown Councils. The study utilises calibrated hydrologic losses and hydrodynamic modelling from the Flood Study endorsed to define flood planning levels throughout Penrith which includes the reaches of Ropes, Wianamatta South and Kemps Creek adjacent to the Precinct. These flood planning levels apply to new development at the boundaries of the Precinct.

For consistency, the hydrologic approaches adopted in the Penrith study have been adopted to generate new flood planning data within the Precinct.

Flooding constraints across the precinct and an assessment of flood impacts resulting from land use change, the channelisation of flow paths and the removal of farm dams has been assessed. This section describes the development of both the hydrologic and hydraulic models used to:

- Define flooding from the local catchments within the Precinct; and
- Determine flood impacts in the local catchments within the Wianamatta South, Kemps and Ropes Creek floodplains.

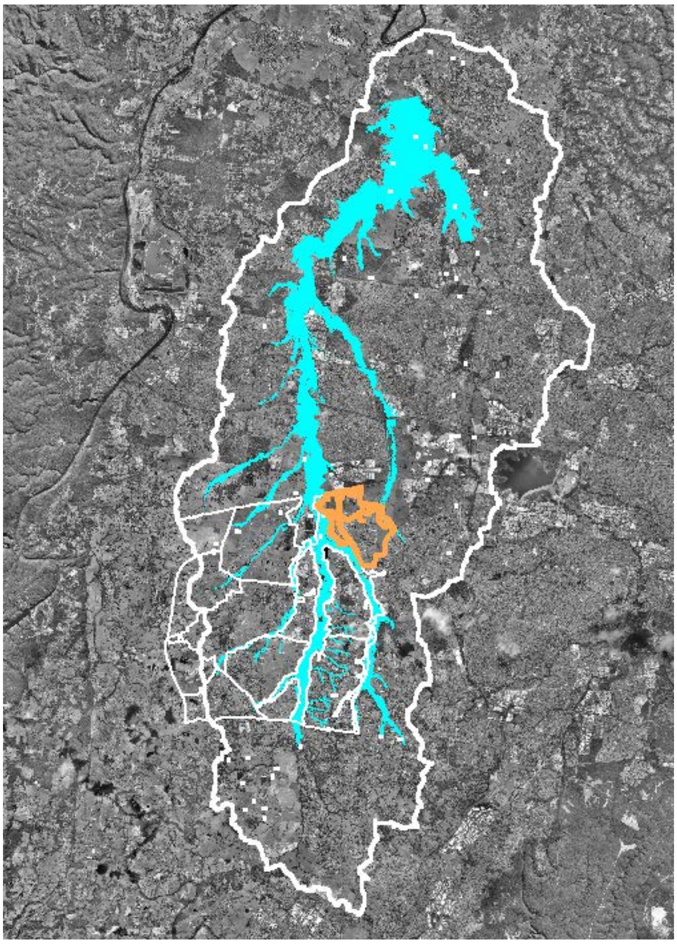


Figure 6-1 Location of Mamre Road in the context of the floodplain

## 6.1 Precinct Scale Hydrologic Model Development

A new precinct scale hydrologic model (XP-RAFTS) was used to simulate the distribution and volume of stormwater runoff generated at key locations within the Precinct under rural and post development conditions.

The model is used to simulate changes in 1% AEP flood hydrographs at the precinct boundaries. Pre and post development hydrographs are compared to the timing of regional hydrographs in the Wianamatta South and Kemps Creek hydrologic models to determine whether changes in the peak flow or timing of flows from the Precinct are likely to impact on existing flooding characteristics within the regional Wianamatta South, Kemps and Ropes floodplains.

### 6.1.1 Rainfall Data

The *Australian Rainfall and Runoff* (ARR) 1987 (ARR 1987) was adopted for floodplain management and planning in the Penrith LGA and has been adopted in this study for consistency and through consultation with the Western Sydney Planning Partnership Flood and Stormwater Management Technical Working Group.

Intensity frequency duration data adopted for the precinct was cross checked against values for Mount Vernon as adopted in the Penrith South Creek Flood Study update.

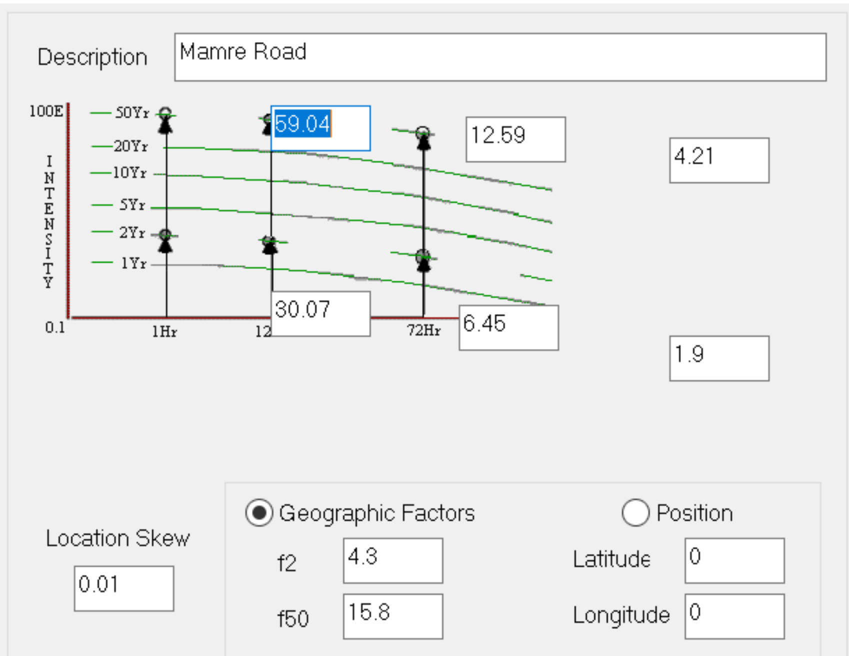



Figure 6-2 IFD parameters adopted in RAFTS modelling

### 6.1.2 Probable Maximum Precipitation

The Probable Maximum Precipitation (PMP) was calculated using *The Estimation of Probable Precipitation in Australia: Generalised Short Duration Method* (GSDM) (BoM 2003). This method is valid for catchments up to 1000 km$^2$ and storms up to 6 hours in duration. XP-RAFTS uses this method to produce PMP hyetographs based on the catchment's location, elevation, terrain roughness and moisture adjustment factor.

### 6.1.3 Sub-catchment Areas

Catchment boundaries were discretised using contours generated from LiDAR survey, topographic survey and survey of stormwater drainage systems through the upper and lower catchment areas. Additionally, catchments were discretised to represent areas of consistent land use, catchment slope, consideration of hydraulic controls, and size. Catchment mapping is shown in Figure A-6.

Changes in local sub catchment boundaries are likely following regrading of the Precinct for industrial land uses however changes to the Ropes or Wianamatta South Creek catchments will not be significant and have not been considered here.

Minimum sub catchment areas of 15 Ha were adopted to reflect the notional catchment size at which stormwater networks would generally be considered as trunk drainage systems.

#### Industrial Condition

The model structure was modified to represent local precinct roads and lots as separate nodes. This allows the simulation of on-lot flood detention basins to test how the detention strategy delivers compensatory flood detention for downstream roads that do not have a designated detention basin.

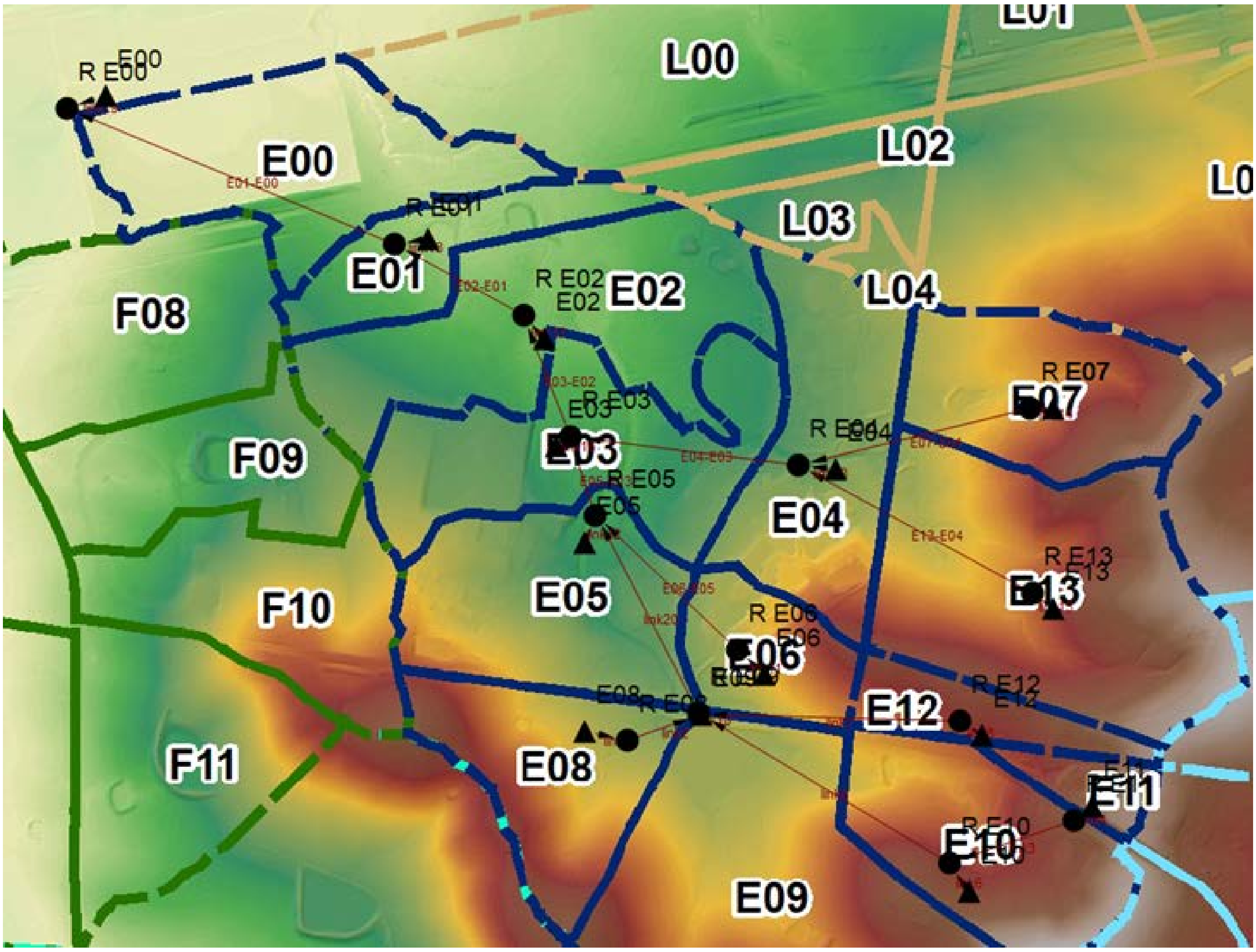



Figure 6-3 RAFTS model structure showing OSD and roads as separate nodes

### 6.1.4 Catchment Imperviousness

#### Rural Condition

Impervious land uses were delineated according to observed land use in aerial imagery for the existing scenario and based on rezoned land use for the developed scenario. Catchments with impervious surfaces were modelled as a second sub-catchment in XP-RAFTS.

#### Industrial Condition

In accordance with the urban form outlined in Section 4.2.1, a net total imperviousness rate of 80% was adopted for the IL2 lands accounting for:

- Industrial lots – 90% total imperviousness
- New roads (representing 7% of the catchment) – 80% total imperviousness
- Drainage reserves and riparian corridors – 10% total imperviousness

### 6.1.5 Catchment Roughness

Catchment roughness values were adopted as follows to be consistent with guidance:

- Rural lands and turf/vegetated areas– 0.04; and
- Developed areas with directly connected formal drainage – 0.02.

### 6.1.6 Slope

Average catchment grades were determined taking the streamflow lines from the highest part of the catchment to the catchment outlet. Rural catchment slopes were calculated using the equal area method from LiDAR survey.

New roads across the industrial precinct were modelled at existing sub catchment slopes while industrial lots are assumed to have a grade of 2% in accordance with typical practice.

### 6.1.7 Losses

Rainfall losses were adopted from the 1990 South Creek flood study which calibrated the hydrologic parameters to the 1986 and 1988 flood events. These losses were also adopted by the *Updated South Creek Flood Study* (Worley Parsons, 2015) and are therefore consistent with current flood planning data sets. Initial losses of 37.5 mm and 1 mm and continuing losses of 0.9 mm/hr and 0 mm/hr were adopted for pervious and impervious areas respectively.

Post development catchment conditions are likely to include significant earthworks with potential reductions in the capacity of urban landscape to infiltrate rainfall. For urban soils, initial losses of 10 mm and continuing losses of 0.9 mm/were adopted.

### 6.1.8 Catchment Lags

Where hydrologic model results rely on the routing of flows, an average channel flow velocity of 1 m/s has been adopted. This has been validated against TUFLOW velocity mapping which shows flood flow velocities range from 0.5 to 2 m/s. In other areas, flow routing is undertaken within the TUFLOW hydraulic model.

Farm dams and road crossings were not incorporated into the XP-RAFTS model of the predeveloped or developed catchment.

Hydraulic analysis and routing has been undertaken in a combination of XP-RAFTS and TUFLOW.

## 6.2 Precinct Scale Model Results

The local XP-RAFTS model was run for the 1EY, 5% AEP, 1%AEP, 0.2% AEP and PMF events for all durations between 15 minutes to 36 hours.

Model outputs were applied to a detailed local hydraulic model of the Precinct as outlined in Section 6.5.

The section below describes the changes in peak flows and timing at the Precinct boundary and the potential implications on regional flooding.

### 6.2.1 Western Catchments

The 1% AEP 9 hour duration ARR1987 event was determined to be critical for the rural catchment draining west to Wianamatta South and Kemps Creek. Hydrologic models of Wianamatta South Creek sourced from Council show the critical storm duration in the Wianamatta South Creek floodplain as being the 36 hour event, which was verified by the *Updated South Creek Flood Study* (Worley Parsons, 2015).

Following development of the Precinct, the XP RAFTS models predict a shift in timing of peak flows from the catchment to shorter duration storm events. Peak flow rates for storms are shown in Table 5 below.

### 6.2.2 Eastern Catchments

The 1% AEP 9 hour duration ARR1987 event was determined to be critical for the rural catchment draining to Ropes Creek.

The critical storm duration in the Ropes Creek floodplain is also determined to be the 9 hour event by testing a range of storm durations in the XP-RAFTS model used in the *Updated South Creek Flood Study* (Worley Parsons, 2015).

### 6.2.3 Northern Catchments

The Northern catchments flow directly to the WaterNSW Warragamba Pipeline , remnant high ecological value forest and the Western Sydney Employment Lands.

1% AEP 9 hour duration ARR1987 event is critical for this catchment under current conditions.

### 6.2.4 Peak Flows

The peak flow summary shown below demonstrates that the peak 1% AEP flow rates from the Precinct will increase significantly for short duration storm events and by small amounts in longer duration events that are critical to flooding in Wianamatta South and Kemps creek catchments (eg. 1% AEP, 36 hour event).

Table 5 Precinct scale hydrologic model results at Precinct boundaries

| 1% AEP Flow ($m^3/s$) Storm duration | Eastern Precinct Boundary | | Northern Precinct Boundary | | Western Precinct Boundary | |
|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre | Post |
| 120 min | 74.32 | **183.08** | 19.23 | **49.01** | 28.7 | **55.12** |
| 540 min | 97.95 | **107.24** | 25.02 | **26.65** | 39.34 | **39.7** |
| 2160 min | 65.57 | **67.16** | 15.23 | **15.54** | 26.66 | **27.02** |

*Source: MR_Hydrology_D01.xp   MR_Hydrology_E01.xpLocal*

Stormwater that discharges at the precinct boundaries must flow through existing development (to the north) or private lands to the east and west and therefore the increase in peak flows represents a potential flow impact on private land that must be managed.

## 6.3 Hydrologic Impacts

### 6.3.1 Local Impacts

Peak flows from the Precinct are sensitive to changes in rainfall loses associated with increased impervious surfaces and reduced capacity for water retention. Without stormwater detention within the Precinct, peak 1% AEP flows will increase in tributaries crossing the Precinct boundary, Mamre Road itself, and existing infrastructure to the north of the Precinct including the WaterNSW Warragamba Pipeline and Western Sydney Employment Area.

### 6.3.2 Detention Requirements

While peak flows in the Wianamatta South Creek floodplain are not sensitive to the presence of on-site stormwater detention in the Precinct, it is recommended on site detention be provided within the Precinct on the basis that:

- On site stormwater detention is necessary to attenuate peak flows of stormwater crossing the northern precinct boundary into existing industrial development and the Southern precinct boundary into privately owned lands.
- On-site stormwater detention within the eastern catchments draining to Mamre Road itself preserves peak flow rates at the regional evacuation route and preserves the level of service of cross drainage structures and the flood immunity of the traffic lanes.
- On site stormwater detention avoids potential staging or timing issues of runoff from developed sites entering lands that have not been rezoned or acquired by Council for drainage

## 6.4 On-Site Stormwater Detention

A lot-based on-site stormwater detention (OSD) approach is proposed to preserve pre-development flows within the Precinct.

The approach to OSD was based on the following two guiding principles:

- To ensure that the Precinct has a negligible impact on existing flood behaviour; and
- To conserve stream stability in perennial streams.

Since the OSD would be located on individual lots within the commercial/industrial areas, runoff from the new road reserves would not be retarded and would be compensated for on the lot.

### 6.4.1 Modelling Approach

Predevelopment flow conditions were modelled using XP-RAFTS for the 50% and 1% AEP flood events using the ARR1987 rainfall data.

The models were then modified to reflect impervious rates and slopes outlined above. In accordance with general advice provided by the Planning Partnership Office, the role of water sensitive urban design has not been included in this assessment and a total imperviousness rate of 90% has been assumed for industrial lots.

Detention storages were then iteratively sized to determine the peak site storage requirement necessary to achieve the target 50% and 1% AEP discharges.

### 6.4.2 Detention Strategy

It is recommended that each industrial lot implements on-site stormwater detention as prescribed by Table 6.

Table 6 OSD requirements on industrial lots within Mamre Road Precinct

| Zone | 50% AEP SSR ($m^3$/ha) | 50% AEP PSD (l/s/ha) | 1% AEP SSR inclusive of 50% AEP SSR ($m^3$/ha) | 1% AEP PSD (l/s/ha) |
|---|---|---|---|---|
| East Catchments draining towards Ropes Creek | 190 | 40 | 393 | 150 |
| North Catchment draining towards WaterNSW Warragamba Pipeline | 190 | 40 | 393 | 150 |
| West Catchments draining towards Ropes Creek | 190 | 40 | 393 | 150 |

Demonstration of the effectiveness of the OSD approach for the Northern Catchment is shown below which indicates that there is a net 15% reduction in peak flows to correct for the effect of channelizing overland flow paths, which has been shown to increase flows rates (Appendix C) . This plot includes the peak critical hydrograph in Wianamatta South Creek that is associated with the 36-hour duration storm event which is provided here for reference to demonstrate the impact of the OSD on flows contributing to the floodplain at the time of the peak in the Wianamatta South Creek hydrograph.

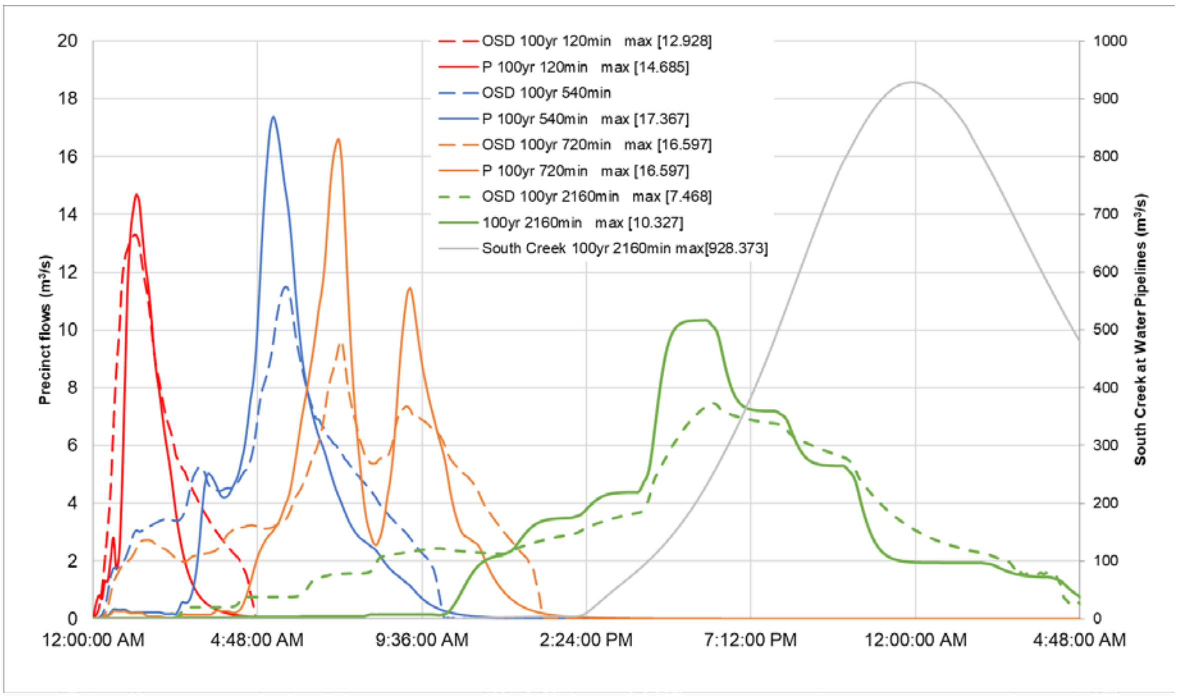



Figure 6-4 Performance of OSD basins for Northern catchments

## 6.5 Precinct Scale Hydraulic Model Development

A new precinct scale hydraulic model (TUFLOW) was used to quantify overland flow characteristics across the Precinct under rural and post development conditions and test the effectiveness and hydraulic impact of channelizing overland flows across through the Precinct to improve developable land outcomes.

Version 2018-03-AE (Single Precision) HPC module of TUFLOW was used for this project.

### 6.5.1 Existing Site Model Terrain, Model Extent and Grid Size

The terrain adopted in the TUFLOW model was created using a layered approach to add details where required from the sources of terrain made available during the model development process. Land and Property Information (LPI) NSW LiDAR dataset flown between 16 July 2019 to 18 July 2019 formed the basis for the model topography.

Design TINs obtained from Transport for NSW (TfNSW) were used to represent the strategic design for the Mamre Road upgrade. It is noted that this is a strategic design and may be revised by TFNSW in the future.

Several terrain modifications were made to realistically represent pre-developed site conditions in the model. These included:

- various road crests and kerbs were enforced in the terrain to ensure their potential hydraulic impact is captured
- the centreline of selected gullies and other small channels were enforced in the model topography to ensure appropriate representation of overland flow paths

- layered flow constrictions we applied to represent the two WaterNSW Warragamba Pipeline which were not captured in the LiDAR.

### 6.5.2 Post Development Model Terrain, Model Extent and Grid Size

The developed scenario proposes that trunk drainage corridors be provided to manage minor and major drainage from catchments exceeding 15 ha or where management of flood hazard necessitates. Terrain modification for the developed scenario included:

- the removal of all farm dams
- preserving 20 m wide overland flow paths to convey flood waters where riparian corridors don't exist
- providing low flow channels with 1 EY capacity treated with macrophytes, rip rap and rock drop structures as necessary with 4 m wide access tracks including all weather surface for maintenance vehicles and active cycle path.

The model extent is shown in Figure A-6 and Figure A-7 and includes the downstream watercourses of Kemps Creek, Wianamatta South Creek and Ropes Creek. The selected grid cell size provides a balance between the required resolution of model results with the computation time. A cell size of 3 m by 3 m has been adopted.

### 6.5.3 Culverts

Transverse culverts under Mamre Road, Aldington Road and Bakers Lane have been included in the model and are shown in Figure A-6 and Figure A-7 for pre-developed and developed scenarios respectively.

For the developed scenario, several culverts were upgraded to accommodate an upgrade to Mamre Road, Abbots Road, Aldington Road and Bakers Lane. Previous modelling from the TfNSW flood investigation (Lyall and Associates, 2017) have been adopted for Mamre Road.

### 6.5.4 Boundary Conditions

The internal source boundaries were applied as hydrographs from the XP-RAFTS model developed as part of this study (refer to Section 6.1). The delineated sub-catchments in the XP-RAFTS model were used as source area polygons, which were refined along the length of the Mamre Road and upstream of Aldington Way and Bakers Lane to ensure appropriate application of flows to the models.

The increase in impervious areas across the Precinct is predicted to generate peak flows that are more than double the existing peak flows requiring on-site stormwater detention to maintain peak discharges at road crossings, as has been assumed in the *Mamre Road Flooding and Drainage Investigation* (Lyall and Associates, 2017).

For the purposes of assessing flood risk across the Precinct, the existing rural peak flows were adopted as it was assumed each development site will preserve existing peak flood flows through on-site stormwater detention. On-site stormwater detention requirements for the Precinct are provided in Section 6.4.2.

For pre-developed conditions, initial water levels in dams have been set to represent full conditions to simulate peak flood levels for the Precinct.

### 6.5.5 Hydraulic Roughness

Hydraulic roughness in the 2D model domain is applied using GIS layers which define the extent of unique land uses. In the 1D model domain the adopted roughness value is applied to each element/conduit as one of its attributes. The Manning's "n" values adopted for the study area, including flow paths are shown in Table 7. The spatially-varying roughness values for the model are shown in Figure A-6 and Figure A-7 for pre-developed and developed conditions respectively.

Table 7 Adopted hydraulic roughness coefficients

| Land use | Adopted roughness value |
|---|---|
| Concrete pipes | 0.012 |
| Roads and hardstand | 0.02 |
| Grassed floodplain with sparse trees | 0.05 |
| Floodplain with dense trees | 0.12 |
| Vegetated riparian corridors | 0.08 |
| Rural residential / Environmental Living | 0.06 |
| Grassed floodways through industrial lands | 0.05 |

## 6.6 Flood Mapping

Flood mapping for the Precinct is shown in Figure A-9 to Figure  A-30 in Appendix A  .

- Figure A-9 to Figure A-17 respectively show the 5% AEP, 1% AEP and 0.2% AEP peak flood depth, velocity and provisional hazard for pre-developed conditions within the precinct.
- Figure A-18 to Figure A-30 respectively show the 5% AEP, 1% AEP and 0.2% AEP peak flood depth, velocity and provisional hazard for developed conditions within the precinct.
- Flood impacts outside of the precinct for two OSD scenarios are shown in Figure A-27 and Figure A-28. These show relative flood level difference for the 1% AEP event in the local floodplain without OSD on lots (Figure A-27), and with OSD on lots in the northern catchments only (Figure A-28).

### 6.6.1 Existing Flood Conditions Within the Precinct

Flooding associated with several unnamed tributaries across the Precinct have been mapped including the extents of modified agricultural drainage and diversions as well as transverse culverts at road crossings. Farm dams are prevalent across the Precinct and are assumed to be full at the onset of a design storm. The farm dams were assumed to behave like a bucket full of water whereby any water that enters the full bucket would immediately spill downstream.

Flood waters within the existing depressions are shallow and wide with velocities ranging from 0.1 to 1 m/s due to the poorly defined flow paths which have the effect of detaining flood flows and providing flood storage.

Flooding between Ropes Creek and Aldington Road creates a wide flow path within areas rezoned industrial which will constrain safe development of land on the western bank of Ropes Creek. The separation of Ropes Creek and its tributaries creates a "flood island" effect where two watercourses run parallel to each other which may present unsafe conditions for flood evacuation.

Flood water is shown to overtop Mamre Road, Abbotts Road, Aldington Road and Bakers Lane at several locations. At the WaterNSW Warragamba Pipeline overland flow crosses beneath the pipes despite there being several transverse culverts.

High hazard conditions are those creating danger to persons and emergency staff and potential damage to buildings. Low hazard may be possible for trucks to traverse if necessary, however would still provide difficulty for abled bodied persons to wade through safely (DIPN, 2015). Hazard categories can be calculated by the depth velocity product, the hazard calculated for this assessment is based on the Provisional Hydraulic Hazard Categories as per the *Floodplain Development Manual*, refer to Figure 6-5 (DIPN, 2015).

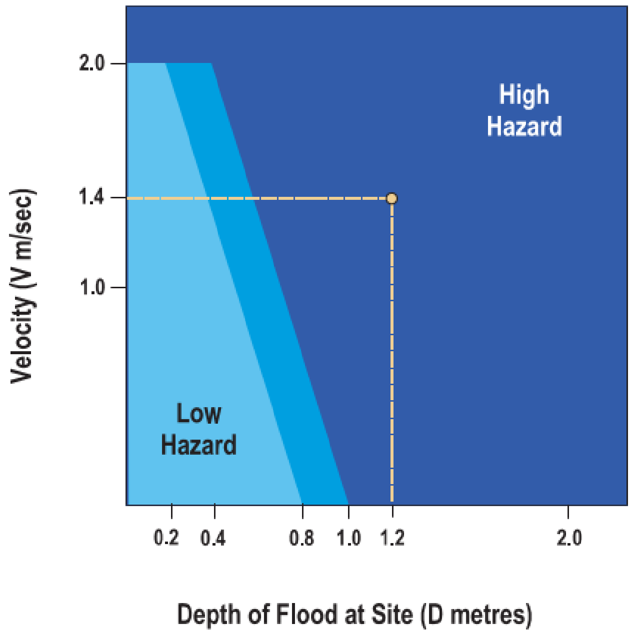



Figure 6-5 Provisional hydraulic hazard categories (DIPN, 2015)

Figure A-15 to Figure A-17 shows that areas of high hazard are mainly contained to farm dams due to their high depths. Most flow paths exhibit low hazard with some localised areas showing intermediate hazard.

The shallow but wide extent of flood waters may present a nuisance to development however it is expected to be manageable through the introduction of defined naturalised channels and the removal of farm dams. As outlined in Section 6.5.1, preliminary terrain modifications have been tested to control the flow paths within riparian corridors where possible and to limit hazard outside of roads and future workplaces.

### 6.6.2 Changes in Flood Behaviour Within the Developed Precinct

For most flow paths draining across the Precinct, 20 m wide grass lined channels are proposed to contain flood hazard in designated floodway zones (refer to Section 6.10), rather than allow flood conditions to form across private land or along roads. Channels presented in Figure 6-6 have been included in the precinct flood models and the results show that high hazard conditions form with flood waters reaching depths of up to 1 m and velocities of up to 2 m/s. It is therefore more appropriate that these types of channels be included where flooding is predicted, and no riparian corridor has been designated.

Channelizing flows across the precinct is shown to increase the potential site discharge. Where existing peak 1% AEP discharges are preserved entering the trunk drainage channels, the peak flow rate will increase by 20% due to increased conveyance and reduced flood storage associated with channelization.

The relative difference in flood levels between the pre-development and the future scenarios shows that these differences are largely contained within the precinct boundary. Areas that are no longer inundated are the result of the channelisation of flows and removal of farm dams. Due to the channelisation of flows most stream reaches experience a flood level reduction of less than 0.5 m. This can be attributed to the relative difference in the underlying terrain rather than a reduction in flow or volume.

Increases in excess of 0.1 m are observed upstream of Mamre Road at crossings XD22, XD26, XD28, XD30 and XD31. The proposed upgrade of Mamre Road raises the road preventing flow from overtopping and thereby constricting flows to the transverse culverts.

The effect of chanellising flood peak flow rates at selected locations are summarised in Table 16 and Table 7 in Appendix C.

The results show that channelizing flows may have an increase in flow rates at some boundaries to the Precinct which requires offsetting via on-site stormwater detention as described above in Section 6.4.

### 6.6.3 WaterNSW Pipelines

The WaterNSW Warragamba Pipeline along the northern boundary of the site are critical infrastructure that require protection from erosion and scour at the four locations where local stormwater generated from the Precinct crosses into the easement.

The 5% AEP flood produces very similar flow velocities in both pre-developed and developed scenarios. Similarly, 1% AEP velocities are not significantly different between existing and developed conditions.

While the duration of peak velocities may increase with increased flow durations associated with developed conditions in the catchment, the proposed Parkland mitigation strategy will result in twice the volume of stormwater runoff rather than four times the stormwater runoff which would be expected under business as usual stormwater management.

## 6.7 Evacuation

Hydraulic modelling demonstrates that the existing culvert capacity at Aldington Road and Bakers Lane is likely to be insufficient to provide 1% AEP flood immunity to those local roads. The culvert crossings are located in the sag points and it is likely that both the road and the culverts will require upgrades to provide safe passage and acceptable freeboard in a 1% AEP event within the local catchments. As part of road upgrades, the road profile will most likely require raising to provide for new services in the road corridor to cross the culverts with sufficient cover.

Notional culvert upgrades for existing roads have been provided in Table 8 to inform contribution plans. Note that no culverts have been modelled on the Ropes Creek tributary.

Table 8 Notional Road Culverts Upgrades in Existing Local Streets

| | Bakers Lane BA01 | Aldington Road AL01 | Aldington Road AL02 | Aldington Road AL03 | Aldington Road AL04 |
|---|---|---|---|---|---|
| Length (m) | 24 | 32 | 16 | 13 | 22 |
| Invert U/S (mAHD) | 53.67 | 78.07 | 71.09 | 51.23 | 74.46 |
| Invert D/S (mAHD) | 53.48 | 77.21 | 70.8 | 51.07 | 73.96 |
| Grade (%) | 1% | 3% | 2% | 1% | 2% |
| Height (m) | 0.9 | - | - | 1.52 | - |
| Width / Diameter (m) | 1.8 | 0.45 | 0.45 | 1.52 | 0.3 |
| Number of cells | 3 | 1 | 1 | 3 | 1 |

Lots within the eastern Precinct can access Aldington Road which steadily rises away from flood waters to land above the PMF. Vehicular evacuation is therefore possible.

Lots within the western Precinct can access Mamre Road which steadily rises away from flood waters to the South.

## 6.8 Upgrades to Existing Culverts

The *Mamre Road Flooding and Drainage Investigation Study* for RMS (now TfNSW) found that the majority of Mamre Road culverts (transverse drainage structures) within the Precinct have less capacity than required to convey the existing 10% AEP event. It is noted that the hydrology and road design adopted is likely to be revised at the next stage of planning and design by TfNSW and culverts may require a different capacity as a result of peak flow rates being revised should the ARR 2019 hydrologic methods be adopted.

The culverts may also require larger capacity than proposed if the Mamre Road is determined to be a regional flood evacuation route. This would require a 0.2% AEP flood immunity. Table 14 and Table 15 in Appendix B show the existing and developed culverts modelled for the Precinct.

## 6.9 Flood Impacts in Wianamatta South, Kemps and Ropes Creek Floodplains

Areas to the west of Mamre Road are outside of the 1% AEP flood extent but lie within the PMF extent. An assessment has been provided to show the potential impacts of flood events rarer than the 1% AEP event.

The results show an increase in level ranging from 0.01 m to 0.05 m within the PMF extent. This impact is relatively minor for such an extreme flood event and represents the upper limit of flood impacts to surrounding development. On this basis the potential flood impacts associated with filling the Precinct to the east of Mamre Road is considered acceptable and unlikely to have an impact on flood levels adjacent to the site.

The south eastern edge of the Precinct is affected by low hazard flooding. Industrial development in this location must provide overland flow paths that will not worsen flooding on existing housing to the south of the Precinct.

## 6.10 Trunk Drainage Channels

Flood mapping shows extensive flooding under pre-developed conditions that can be managed through the provision of 20 m wide overland flow paths to convey flood waters towards riparian corridors. Trunk drainage channels are proposed to convey overland flow paths downstream of notional 15 ha catchments:

- confine 1% AEP flood flows to designated flow paths rather than through private lands
- avoid the need for box culverts or stormwater pipes larger than 1200mm
- prevent unsafe conditions forming on steep local roads

Trunk drainage channels have been notionally located along existing low points but there may be efficiencies in realigning some reaches to achieve better industrial lot configurations.

The typical 20 m wide channel is shown in Figure 6-6 and includes:

- low flow channels with 1 EY capacity treated with macrophytes, rip rap and rock drop structures as necessary
- 4 m wide access track including all weather surface for maintenance vehicles and active cycle path.

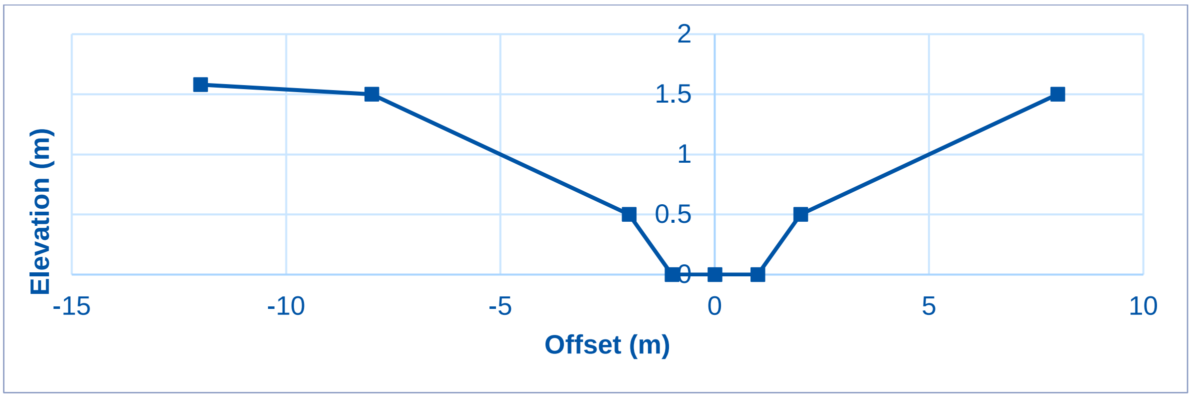



Figure 6-6 Overland flow path geometry

## 6.11 New Culverts for Local and Estate Roads

The provision of new public roads that cross riparian channels area will require new culverts sized appropriately to provide flood evacuation. Culvert locations have not been decided at this time. Hydrologic and hydraulic models developed in this study may be used to assist in the design of those structures.

# 7. Stormwater Management for Waterway Health

Stormwater quality management and potable water saving objectives that apply to the Precinct are provided in the Mamre Road DCP which also adopts Penrith Council's Water Sensitive Urban Design (WSUD) Policy and a new stormwater volume target developed by applying the *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions* (OEH, 2017).

New development will be required to demonstrate how the stormwater volume reduction and stormwater quality objectives are achieved. A demonstration is provided below on how the stormwater volume objective is achieved and how new development can:

1. Satisfy the objective of the SEPP can to avoid impacts on
   a) water quality or quantity in waterways
   b) the natural flow regime including groundwater flows
   c) the aquatic environment and riparian land (including aquatic and riparian species, communities, populations and habitats), and
   d) the stability of the bed, banks and shore of a waterway
2. Deliver existing Council stormwater management objectives
3. Achieve potable water savings
4. Apply stormwater management that is consistent with the outcomes of the Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions

## 7.1 Risk Based Stormwater Management Objectives

The Western City District Plan places an emphasis on the protection and restoration of Wianamatta South Creek, and this establishes the need for new stormwater infrastructure to work towards the Government's water quality and flow objectives for Wianamatta South Creek and its tributaries (blue grid).

The Department of Planning, Infrastructure and Environment is developing new stormwater management objectives through the application of steps of the Risk Based Framework. These objectives are locally specific which aim to protect and improve the biodiversity and health of the Wianamatta South Creek in the context of development across the entire catchment.

These objectives have been adopted in the Mamre Road DCP for consistency with the District Plan and DPIE policy in applying the Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions which also applies to state significant development.

The following sections present an interpretation of how the Risk Based Framework approach informs the development of stormwater management responses for industrial development in the Mamre Road precinct and how those stormwater management responses work towards the protection and improvement of downstream Wianamatta South Creek as outlined in the SEPP Clause.

## 7.2 Context

### 7.2.1 Waterway Values

Existing data has been used to define waterway values including High Ecological Value (HEV) mapping provided by DPIE which includes groundwater dependent ecosystems in the downstream reaches of the creek network. High Ecological Mapping is provided in Figure 7-1. This work also importantly recognises the cultural, spiritual and practical values of waterways for First Nation Peoples.

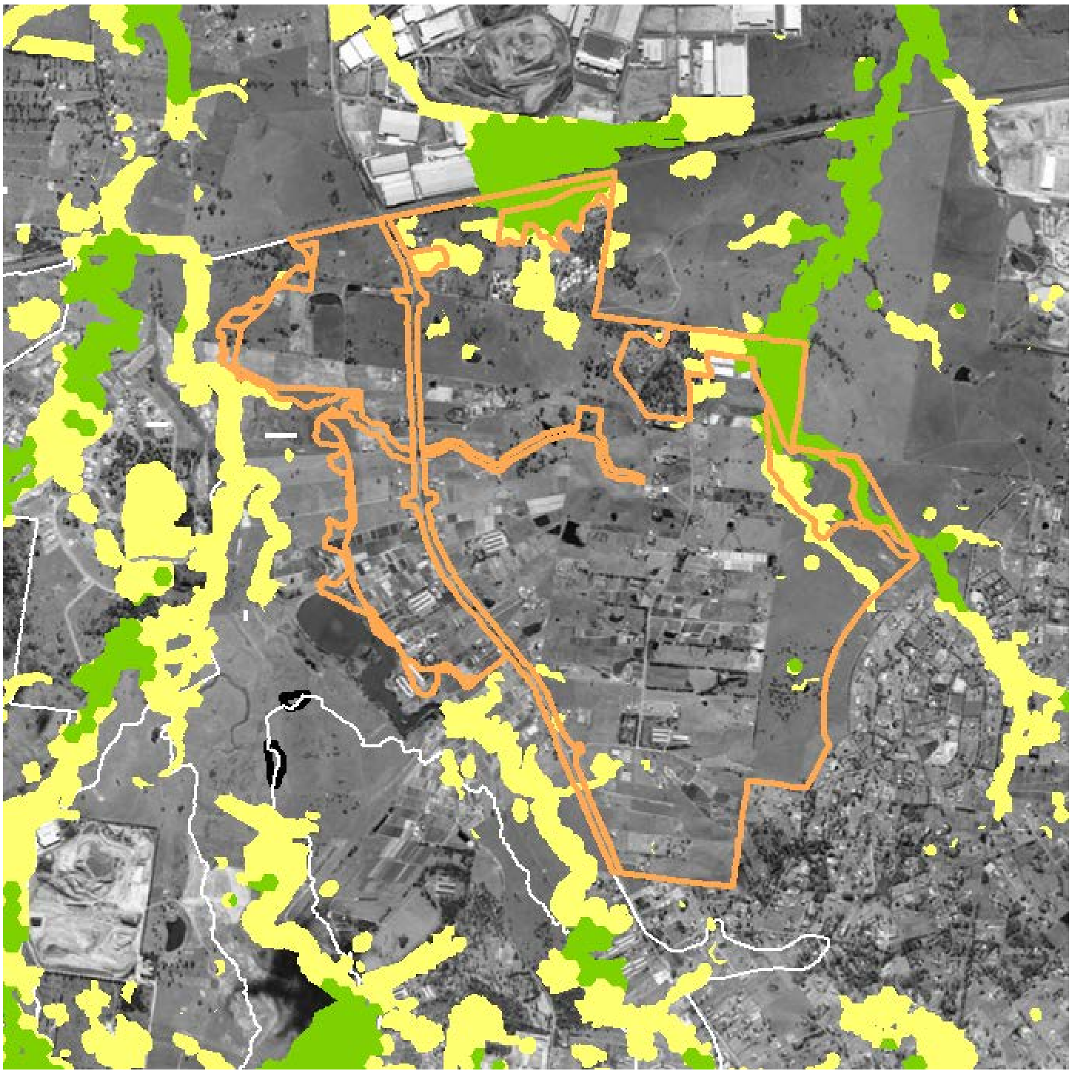


Figure 7-1 Local HEV mapping showing protect (green) and improve (yellow) value areas

HEV mapping has been supplemented with fishing and bat surveys carried out along Wianamatta South Creek reaches (Tippler, 2020). While limited in scope, the presence of these species indicates that current conditions (2019) are supporting viable populations of aquatic and terrestrial apex predators. It also suggests that the existing condition of those reaches are supporting other elements of their habitat including terrestrial and aquatic native vegetation, prey species, favourable hydrologic regimes and instream refuge.

### 7.2.2 Existing Urban Impacts

There are many reaches of Wianamatta South Creek that are in a degraded state as a result of altered land use. Waterway condition mapping of the urban catchments in the northern section of the catchment indicate the potential trajectory of waterways that receive increased runoff rates from highly impervious urban development.

Urban catchments that contain reaches of waterways in good condition can indicate an acceptable level of hydrologic change can be tolerated by a waterway without widespread loss of ecologic value.

### 7.2.3 Waterway Management Objectives

Notwithstanding the impacted condition of sections of the Wianamatta South Creek, the Western District Plan identifies the regional waterways of South, Kemps and Ropes Creeks as significant landscape features and identifies the protection and improvement of South Creek as a priority action W12 (GSC, 2018). The Western Sydney City Deal Commitments to Liveability and Environment, also lists “restore and protect” the Wianamatta South Creek blue-grid as one of the City Deal’s commitments to protecting and preserving environmental assets and parkland character. This is also implied in the HEV mapping, outlined above, which establishes ‘protect’ and ‘improve’ objectives for areas of the Wianamatta South Creek and its tributaries.

### 7.2.4 Establish Numerical Metrics

Emerging evidence shows that protecting natural stream flows and water quality plays a significant role in supporting biodiversity. Figure 7-2 presents the links between

- human values for South Creek
- terrestrial and aquatic biodiversity
- creek flows and
- instream water quality.

On this basis, establishing a target of unchanged baseline hydrology of would deliver on the objective of protecting and improving the environmental assets and parkland character of Wianamatta South Creek and its tributaries.

An increase in the flow rates or change in baseline hydrology may be acceptable where changes to in-stream flow volume, flow velocity, frequency of overbank flooding and frequency of seasonal pulse flows do not impact on downstream values.

The Mamre Road DCP adopts interim objectives for flow for Wianamatta-South Creek established by DPIE (EES) by applying the Risk Based Framework. A stormwater runoff objective of 1.9 megalitres (ML) per hectare per annum, measured at any legal discharge point or estate boundary.

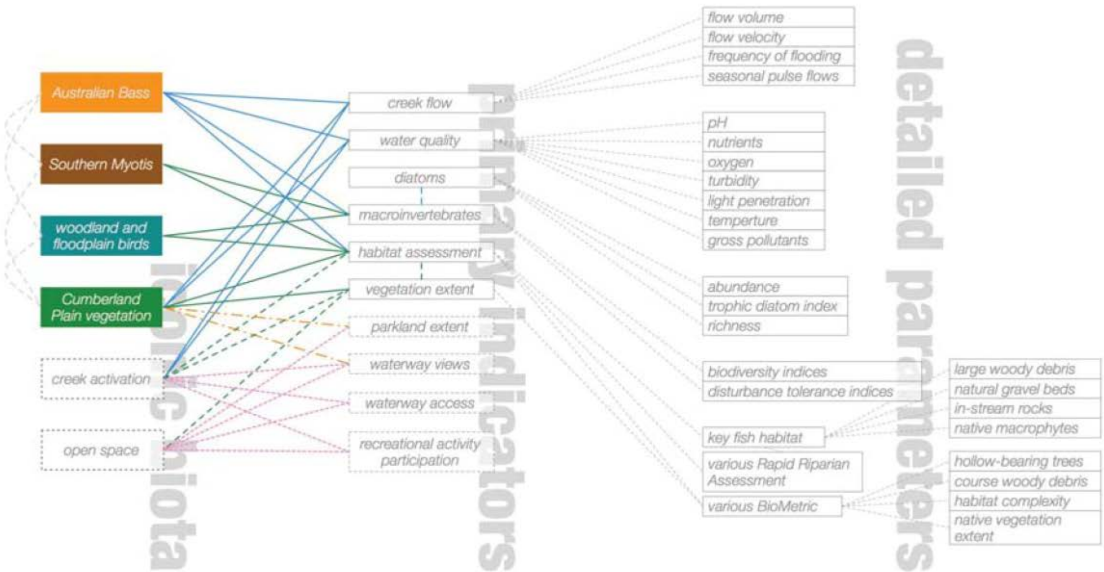



Figure 7-2 Links between waterway values, hydrology and water quality (Source: Tippler et al)

### Baseline Hydrology

Stream flow gauges across the upper and mid catchment provide the best measures of baseline hydrology for the catchment. The available data is limited but eight flow gauges provide a valuable basis for calibrating and validating a catchment wide hydrologic model developed by Sydney Water using eWater Source software.

The gauges themselves also provide a means for defining baseline hydrology.

Sydney Water has developed an approach to summarise the geomorphic conditions of a waterway known as the Urban Streamflow Impact Assessment. This approach defines the hydrology and hydraulics of baseline and future development scenarios using a combination of 9 common metrics that describe the frequency, magnitude and duration of flow events that support the current instream and floodplain habitat.

The USIA metrics are effectively a tabulated summary or description of a flow duration curve. The USIA Development report is attached for reference.

## 7.2.5 Scale of Risk

There is a need to consider the impacts of the Precinct on the blue grid in the context of the cumulative impacts from new development in the neighbouring Aerotropolis and the rapidly urbanising upper and lower South Creek catchment.

Desktop modelling exercises and evidence from urban areas in the lower catchments indicates that there is a significant risk of new development altering the natural hydrologic regime of the blue grid and impacting the biodiversity and human uses of South Creek.

Figure 7-3 shows the potential change in urban development across the catchment to accommodate population forecasts to the 2056 planning horizon. This mapping is being updated by precinct planning across the Western Sydney Aerotropolis and South West Growth Centre.

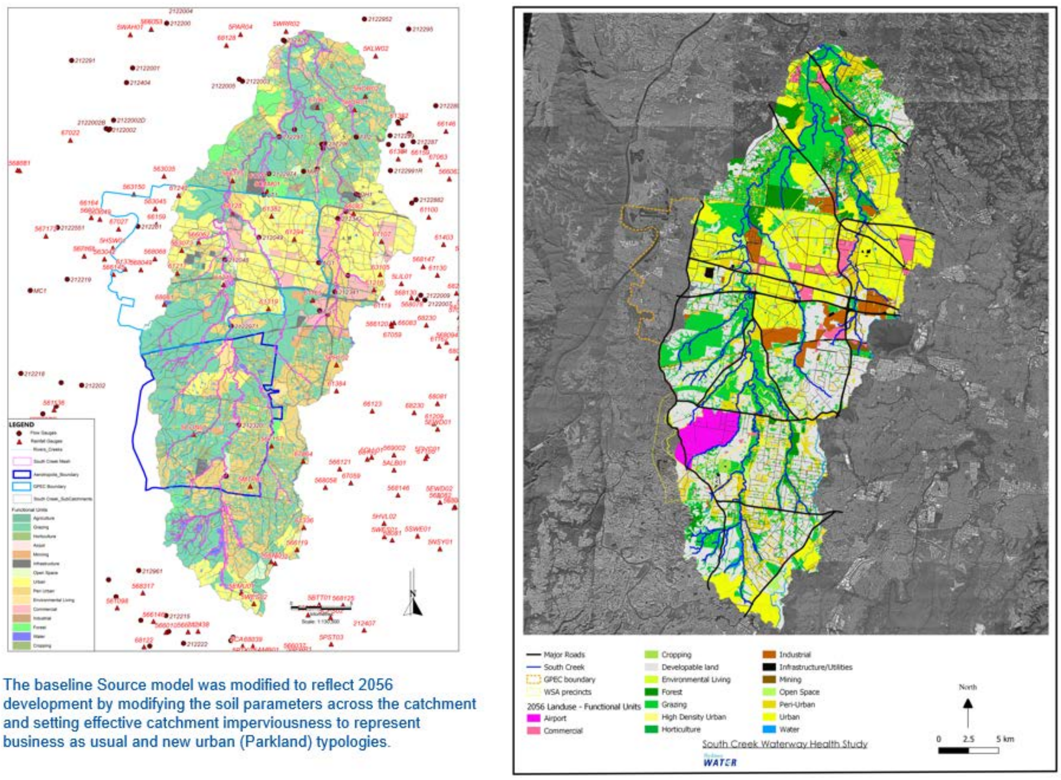



Figure 7-3 Quantifying the land use changes across the catchment

### 7.2.6 Changes in Hydrologic Cycle

Water balance modelling has been carried out to demonstrate the potential change in stormwater runoff volumes resulting from development in the Precinct. This is summarised in Table 9 below.

Table 9 Summary comparison of hydrology before and after Precinct development (1 ha basis)

| 1 ha Basis (ML/yr) | Baseline Rural Conditions (Sydney Water Source model) | Industrial + Business as Usual Approach (MUSIC model) | Industrial + Parkland Approach (MUSIC model) |
|---|---|---|---|
| Rainfall | 6.8 | 6.8 | 6.8 |
| *Industrial runoff* | | | |
| *Roof runoff* | | *3.4* | *3.0* |
| *Pavements runoff* | | *1.7* | *1.7* |
| *Road runoff* | | *0.3* | *0.3* |
| *Pervious runoff* | | *0.1* | *0.1* |
| **Total stream flow (Surface + base flow)** | **0.6 for Tributaries<br>0.9 for South Creek** | **5.5** | **5.1** |

**Source: (X567156 - solution - V2 - DF.sqz) (X567156 - BAU - DF.sqz)*

The Precinct represents a small fraction of the Wianamatta South Creek catchment, however the scale of the Precinct in the context of the Aerotropolis is significant. To Wianamatta protect South Creek from the cumulative impacts of forecast development within the Wianamatta South Creek catchment, every Precinct must contribute equally to the mitigation of stormwater impacts to deliver the objectives of the SEPP

## 7.3 Effects Based Assessment

The following sections provide a brief assessment of the potential changes to the new development on the natural flow regime as indicated by:

1. Flow volume - mean annual runoff volume as measured by ML/Ha/yr
2. Seasonal pulses – as shown by flow duration curves
3. Water quality – as indicated by stormwater pollution reduction

### 7.3.1 Stormwater Management Scenarios

Two stormwater management scenarios are tested below that provide book ends to the level of stormwater servicing for new development in the context of the Parkland City. These are summarised as:

1. **Business as usual** or current approach to achieving stormwater pollution reduction targets within current DCPs (Figure 7-4)
2. **Parkland approach** which provides an ideal level of stormwater volume and flow management to ensure a low risk of change or cumulative impacts from urban development on the Wianamatta South Creek blue grid (Figure 7-5)

The Government endorsed stormwater management approach may lie in between these two scenarios. A strategic impact assessment is provided in Section 8.4 to assist in the selection of an agreed level of service and expenditure on stormwater management.

MUSIC models of each scenario have been developed to enable rapid testing of combinations of stormwater measures or stormwater treatment trains. Screenshots of model structure are provided in Figure 7-4 and Figure 7-5 for BAU and Parkland strategies respectively.

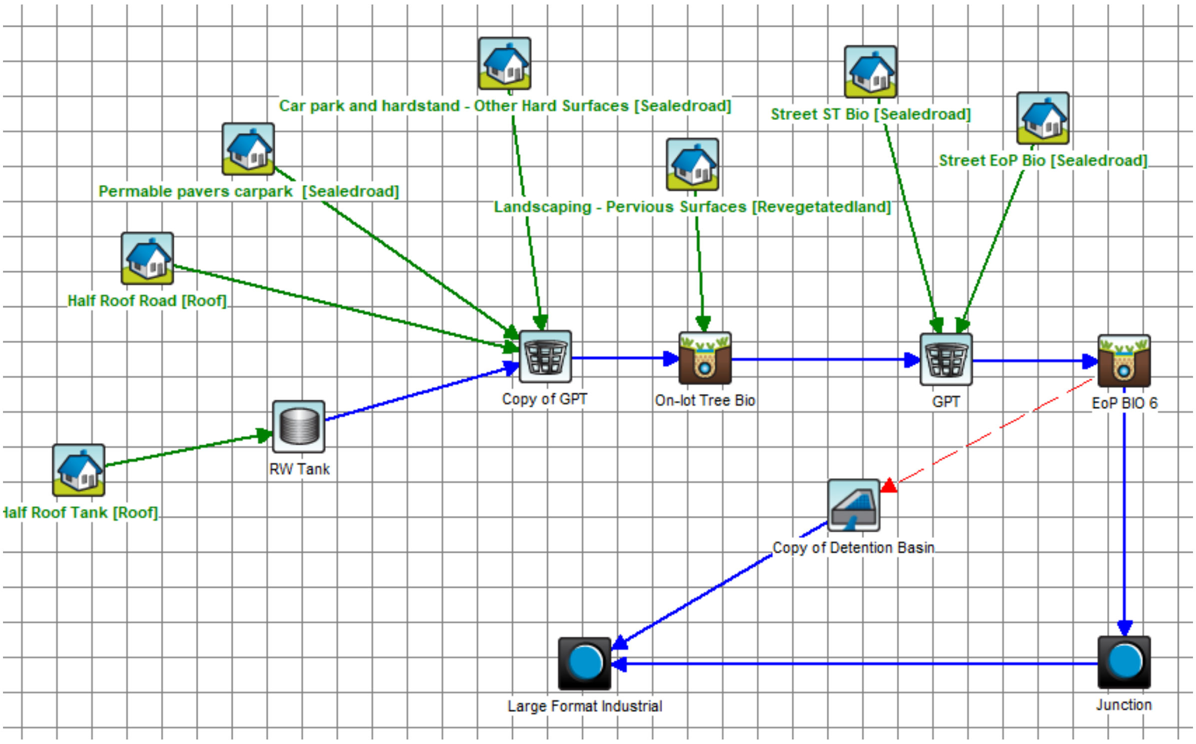




Figure 7-4 Business as Usual approach to stormwater management from industrial development sites

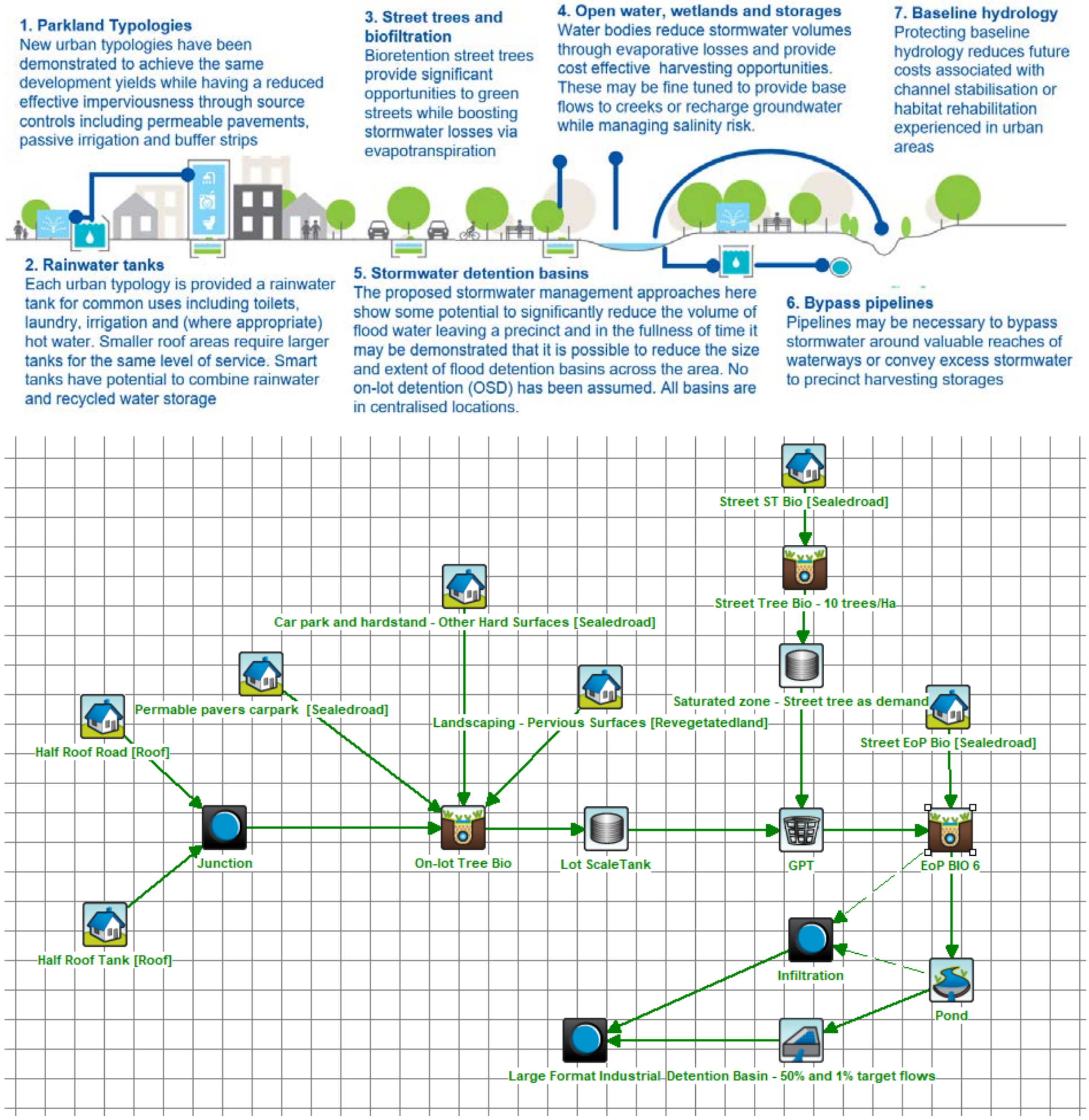



Figure 7-5 Parkland approach to stormwater management from industrial development sites

## A note on salinity and soils

Salinity risks mapping of the region shows that over irrigation and concentrated infiltration of stormwater may result in urban salinity impacts. In developing a stormwater management plan, any new developments must address how salinity issues are to be avoided through:

1. Establishment and maintaining vegetation over unpaved areas
2. Appropriate irrigation rates for the local soils and site vegetation
3. Provision of lining on WSUD measures or sub surface drainage to mitigate infiltrating excess water

### 7.3.2 Stormwater Water Balance

Table 10 provides a stormwater balance from MUSIC modelling software and illustrates how stormwater runoff volumes are increased by industrial development. Baseline surface runoff volumes (mean annual runoff volumes) have been estimated from calibrated catchment model (*ewater Source*) of the South Creek blue grid.

Surface runoff for 1st and 2nd order waterways less as ephemeral waterways tend to receive less contribution from groundwater. This is only significant for 1st and 2nd order waterways that contain areas of high ecological value. Engineered or re-aligned waterways could convey additional volumes without ecological consequence.

Table 10 Summary comparison of hydrology before and after Precinct development (1 ha basis)

| 1 ha Basis (ML/yr) | Baseline / Rural Conditions (eWater Source model) | Industrial Business as Usual Approach (MUSIC model) | Industrial Parkland Approach (MUSIC model) |
|---|---|---|---|
| ***Sources of stormwater runoff*** | | | |
| *Rural / Pervious areas* | 0.8 – 0.9 | *0.1* | *0.1* |
| *Roofs* | | *3.4* | *3.0* |
| *Industrial pavements* | | *1.7* | *1.7* |
| *New roads* | | *0.3* | *0.3* |
| ***Stormwater runoff reductions through WSUD*** | | | |
| Roof water capture for non potable demands | - | -0.5 | -0.5 |
| Re-use for greening and cooling | | | -0.7 |
| Evapotranspiration through wetlands, biofiltration and passive irrigation | - | -0.2 | -1.4 |
| Regional stormwater harvesting | | | -1.0 |
| ***Residual runoff*** | | | |
| Base Flow | 0.1* | 0.0 | 0.1 (via infiltration where appropriate) |
| Surface runoff | 0.5 (1st and 2nd order waterways) 0.8 (for higher waterways) | 4.8 | 1.3 |
| **Indicative stream flow (Surface + base flow)** | **0.6 for Tributaries 0.9 for South Creek** | **4.8** | **1.4** |

**Source: (X567156 - solution - V2 - DF.sqz) (X567156 - BAU - DF.sqz)*

This modelling shows that a business as usual approach to WSUD, where filtration is provided to manage stormwater pollution reductions only, will result in increased stormwater runoff volumes from approximately 0.9 ML/Ha/yr to 4.8 ML/Ha/yr.

Modelling also shows that by exploiting all available rainwater reuse, stormwater harvesting and irrigation and evapotranspiration opportunities (including wetlands), within the context of local salinity risk and industrial land use, the increase in annual stormwater runoff volumes can be limited to less than 2 ML/ Ha/year.

### 7.3.3 Flow Objectives

It is expected that stormwater management targets for the Precinct and Aerotropolis will include flow or stormwater volume targets. In the interim, desktop calibrated modelling is used to define baseline hydrologic characteristics of the blue grid. Where the stormwater management approach matches baseline hydrologic regimes, there is a low risk of change or damage.

The South Creek waterway health model (*eWater Source*) provides baseline hydrologic data patterns for comparison in MUSIC. The 20-year continual hydrograph (1997-2018) has been exported as a flow-duration curve (Figure 7-6) and allows for a discrete assessment of how closely the stormwater management approaches match baseline flow patterns and contribute to protecting or improving the blue grid. Three elements of the flow duration curve that relate to the natural flow regime are illustrated:

1. Zero flow periods
2. Median flow
3. Seasonal pulses (three times median flow or 'freshes').

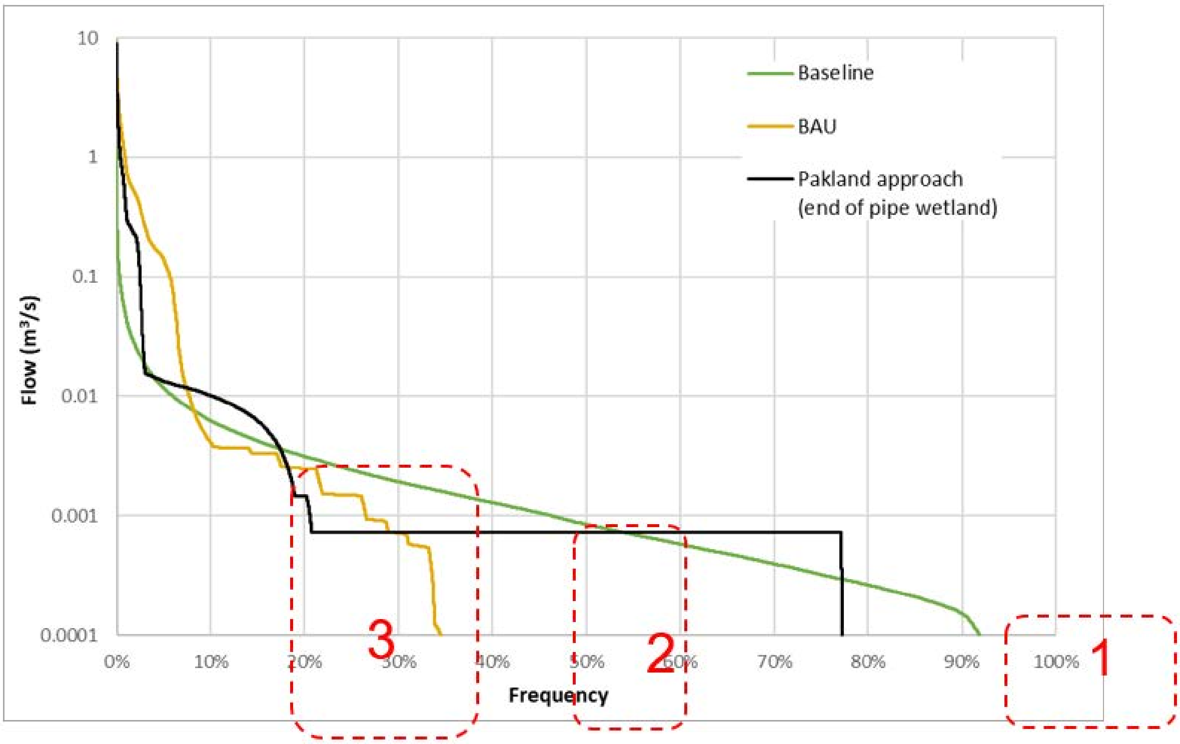



Figure 7-6 Comparison of Parkland approach and BAU approach

*Source: Flow duration curves.xls*

Figure 7-6 demonstrates how the Parkland approach can provide a much closer match to baseline hydrology than a business as usual approach with some room for further optimisation.

A critical element in this approach is through a significantly longer extended detention periods than are currently provided for under business as usual. It is recommended that site designs consider extended detention periods and may be in the order of 10 days, as opposed to 3 days for conventional wetlands or several hours in the case of hours biofiltration and detention.

### 7.3.4 Water Quality

Summary of the MUSIC model performance is presented in Table 11. The Parkland approach demonstrates that the pollution reductions approach the ideal stormwater pollution reduction targets proposed for the South West Growth Precinct which are likely to result in a minimal environmental impact.

Table 11 Comparison of BAU and Parkland stormwater pollution reductions achieved

| Parkland Industrial (per 1 ha lot) | % Reduction Achieved by BAU Measures | % Reduction Achieved by Parkland Measures |
|---|---|---|
| Flow (ML/yr) | 8.1 | 70.2 |
| Total Suspended Solids (kg/yr) | 85 | 98 |
| Total Phosphorus (kg/yr) | 65 | 91 |
| Total Nitrogen (kg/yr) | 52 | 87 |
| Gross Pollutants (kg/yr) | 100 | 100 |

### 7.3.5 Risk of Impacts

The South Creek Waterway Health hydrologic model (eWater Source) shows that between the 2011 and 2018 calibration periods, and when accounting for rainfall, the total volume of stream flow (Mean Annual Runoff Volume or MARV) at the Kemps and South Creek confluence has increased by 20% despite a relatively low increase in catchment development. Waterways in this area are showing signs of change and channel modification with an associated loss of habitat value supporting the theory of urban stream syndrome, despite the use of Water Sensitive Urban Design in new developments.

The models predict that traditional Water Sensitive Urban Design approaches (BASIX rainwater tanks, biofiltration and detention to achieve stormwater pollution reductions and the Stream Erosion Index) applied to the forecast urban growth in the catchment will likely result in double the MARV in Kemps, Ropes and South Creeks and generate more than five times the runoff volume in first and second order waterways.

Table 12 Summary of potential outcomes resulting from ideal stormwater management

| Objective | Potential Outcomes from BAU Stormwater Management Approach | Potential Outcomes from Parkland Stormwater Management Approach |
|---|---|---|
| Preserve fish habitat | Magnitude and frequency of freshes is altered<br>Median flow rates are altered<br>Baseflow rates are altered<br>Risk of change to habitat is high | Magnitude and frequency of freshes is preserved<br>Median flow rates are preserved<br>Baseflow rates are preserved<br>Risk of change to habitat is moderate to low |
| Preserve bat habitat | Open water bodies reduce, and potential habitat shrinks | Open water bodies increase potential habitat extents |
| Preserve Cumberland Plain Vegetation | Flow conditions may increase erosion of creek channels and undercut Cumberland plain vegetation | Impact is unlikely and not significant based on comparison to lower catchment conditions. May be beneficial to species requiring wetter environment ie Carex, Juncus etc |
| Preserve Groundwater dependent ecosystems | Reduction in baseflow and there is a moderate risk of impact on groundwater dependent ecosystems | Baseflow contributions from the precinct are preserved and there is a low risk of impact to groundwater dependent ecosystems if all precincts provide a similar |
| Preserve woodland bird habitat | Vegetation unlikely to be impacted therefore unlikely to impact woodland birds | Vegetation unlikely to be impacted therefore unlikely to impact woodland birds. |
| Preserve floodplain bird habitat | Potential loss or change in extent of shallow pools and backwaters due to potential increased depth and widening of flow path may reduce floodplain feeding habitats and refugia | No change in extent of shallow pools and backwaters or floodplain feeding habitats and refugia. |
| Preserve channel condition | Likely impact based on downstream sites: Potential risk of erosion, loss of channel form, pools and backwaters. Some scour protection and bed protection is likely to be required in the future | Low risk of impact: Potential risk of erosion, loss of channel form, pools and backwaters. Limited scour protection and bed protection is likely to be required in the future. |

## 7.4 Strategic Impact Assessment

A range of stormwater management approaches are provided in Table 13 which demonstrate how a site design could be developed that achieves stormwater volume reduction targets. Detail is also provided to assist in its interpretation.

Where it is required that new development achieve a residual stormwater discharge of 1.9 ML/Ha/year site designers can assemble a range of measures that reduce the runoff from site imperviousness values presented in Section 4.2.

Table 13 Assessment of stormwater volume reduction for WSUD elements

| Element | Description | Volume Stormwater Reduced (ML/yr) | $ / ML of Stormwater Reduced* |
|---|---|---|---|
| **Potable water offsetting**<br>**(BAU)**<br>**(Parkland)** | Collect roof water from maximum number of down pipes<br>Notional tank volume – 30kL/site<br>Irrigation demands – 0.5ML/NHa/yr<br>Water demands – 0.525 kL/NHa/day | 0.5<br>(60% of demand supplied) | **$10K** |
| **Urban cooling for stormwater reduction**<br>**(Parkland)** | Collect filtered water from rooves and hardstand areas<br>Notional tank volume – 80kL/NHa<br>Irrigation demands - 2.3ML/NHa/yr (may include roof misting to encourage evaporation and cool internal spaces) or apply 4.5 ML/ha of irrigated areas/yr to at least 50% of the site including roof area<br>Water demands – 0.525 kL/NHa/dr | 0.8 (excludes potable water offsetting above) | **$10K** |
| **On lot permeable pavements and stormwater buffer strips**<br>**(Parkland)** | Disconnect pavements and reduce effective imperviousness of sites<br>0.16 Ha of permeable pavements / Ha or development | 0.6 | **$34K** |
| **On lot water quality measures**<br>**(BAU)**<br>**(Parkland)** | Achieve Penrith Council stormwater pollution reductions prior to discharge to Council network.<br>TSS- 85%, TP – 65% TN-45% | 0.0 if un-vegetated<br>0.1 if biofiltration | **$30K** |
| **Biofiltration street trees**<br>**(Parkland)** | Provide equivalent of 10 trees / ha with soil volume to accommodate 8m diameter canopy mature trees<br>Pits and ‘wicking beds’ provide passive irrigation beneath ground level. Location coordinated with stormwater pits to maximise road catchments<br>Extended detention – 100mm<br>Surface area – 6 $m^2$/ tree (or 60$m^2$/ha)<br>Saturated zone/wicking depth – 300mm<br>Tree water demand – 18kL/yr | 0.2 | **$20K** |
| **End of pipe filtration for road runoff filtration**<br>**(BAU)**<br>**(Parkland)** | GPT’s and biofiltration to achieve Penrith Council stormwater pollution reductions prior to stormwater from Council’s network discharging to creeks.<br>GP – 90% TSS- 85%, TP – 65% TN-45%<br>Can be configured to provide creek baseflow via infiltration to alluvium where appropriate<br>Infiltration at riparian corridor edge using 450mm deep saturated zone. Discharge 0.1 ML/ha/yr to groundwater<br>Treated water discharges to open water bodies. Nutrient loads to open water are minimised to reduce algal risk. | 0.1 | **$10K** |

| Element | Description | Volume Stormwater Reduced (ML/yr) | $ / ML of Stormwater Reduced* |
|---|---|---|---|
| **Open water and wetlands within flood detention basins or the floodplain**<br><br>**(Parkland)** | Combined macrophyte and open water zones to provide amenity facilitate evaporation and store water for reuse.<br>Fulfil the proposed stormwater filtration function of the South Creek corridor.<br>Wetland footprint – minimum 8% of catchment<br>Average macrophyte zone depth – 300mm<br>Average open water zone depth – 1200mm<br>Extended detention depth – 500mm<br>Retention time in wetland EDD – 10 days<br><br>Irrigation water extraction – 0.5 ML/ha/yr to public open space (RE1 and RE2), blue green grid and grassed overland flow path / swales within the Precinct<br><br>Irrigation rate – 0.7 ML/ha/yr or 2.3 ML/d | 0.5 (evap)<br><br>0.5 (extraction) | **$5.5K** |
| **Regional harvesting of filtered stormwater** | Collection of filtered stormwater and transfer to advanced water recycling facility or potable water supply | 1.5 | **Not costed** |

Note that the costs presented in Table 13 do not include tipping costs, contamination management or land acquisition cost. These costs are indicative only and are based on rates from similar projects that do not represent all the potential constraints and construction issues within the Precinct. These costs are provided as an order of magnitude cost only and should not be relied upon for the purposes of budgeting. The reader is encouraged to undertake their own opinion of costs for all measures presented above.

The results show the following elements are required for standard industrial development to achieve the flow volume targets:

1. Open water bodies and wetlands are highly cost effective but have a maintenance implication when applied to each lot and promote a wildlife attraction risk that must be addressed through detailed design.
2. Rainwater tanks are a cost-effective approach and provide a potable water saving that has not been included in this assessment
3. Biofiltration is not a cost-effective method of reducing stormwater volumes but contributes to low maintenance water bodies and algal risk reduction
4. Biofiltration street trees are an expensive approach due to costs associated with forming a soil void for tree roots within the road verge, however they provide a high amenity and cool outcome to the Precinct. Rows of trees will play an important method of managing lateral groundwater movement and salinity risk.

It should be noted that there is a limit to the effectiveness of the WSUD measures listed above and they cannot necessary achieve a linear increase in effectiveness by increasing footprint. It is likely that a range of stormwater measures will be required as outlined above. There is however some flexibility in the way that developments achieve the stormwater volume reductions specified in the DCP, which is a target that has been developed by applying the Risk Based Framework and is therefore consistent with applying that same objective for state significant developments.

This demonstrates that the full range of WSUD measures in Table 13 can achieve the volume reduction objective for a notional (order of magnitude) cost of $120,000/Ha while business as usual approaches to stormwater management will achieve a notional residual discharge of 4.4 to 5 ML/Ha/yr and cost $50,000/Ha to implement.

The incremental difference in development costs are significant however which does not closely retain or maintain the baseline runoff volumes and therefore falls short of achieving stormwater management targets.

Ideally, the above costs could be included in an economic impact assessment including urban cooling benefits, aesthetic outcomes, avoided costs in waterway rehabilitation (eg. rip rap) and preservation of cultural values.

## 7.5 Regional wetland facilities

It is noted that the most cost-effective way to achieve stormwater volume load reductions is via open water bodies and these have a maintenance implication for developers and a wildlife risk.

Through master planning of the Wianamatta South Creek precinct, it will be possible to integrate regional wetlands and waterbodies and offset the need for wetlands and open water to be distributed through the Precinct on private lands.

This centralised management of water is preferable as it provides a more appropriate scale of WSUD assets for more cost-effective maintenance and management outcomes.

The timing of this may require that those waterbodies are delivered after development has commenced in the catchment and it is recommended that those waterbodies are not implemented until at least 80% of the catchment is developed. There may be an opportunity to collect developer contributions for those water bodies at a later time, but it is unlikely that a contributions plan can be put together to facilitate the construction of open water.

# 8. Conclusion

The Mamre Road industrial precinct represents a significant change in land use within the Wianamatta South and Ropes Creek catchments.

**Riparian Corridors**

A riparian corridor strategy has been developed that preserves valuable waterfront lands across the Precinct.

**Integrated Water Cycle Management**

Sydney Water has made commitments to the provision of recycled water to the Aerotropolis from the Upper South Creek advance water filtration plant which is planned for a site to the west of the Precinct.

Detailed planning is being carried out on the servicing concepts and networks that would deliver recycled water to Mamre Road and to determine the integration of stormwater recycling and recycled effluent.

Stormwater harvesting will provide an important pathway to delivering the objectives of the SEPP Clause L33 relating the preservation of the natural flow regime.

**Flooding**

Regional flood impacts are managed by the location of industrial development being set back from the 1% AEP flood extents which has eliminated the potential for filling of lots to impact on the 1% AEP flood behaviour adjacent to the Precinct.

Hydrologic and hydraulic modelling demonstrates that Precinct scale flooding can be managed by providing trunk drainage channels for catchments notionally 15 Ha and greater (refer to Appendix G). The channelization of overland flow paths will improve development yields and contain higher flood hazard conditions within designated flow paths. A notional outline of trunk drainage alignment pattern has been demonstrated in the Precinct hydraulic (*TUFLOW*) model. The channels have been modelled to follow the natural low points but may be realigned to further improve development yields. This approach has been demonstrated to increase peak flow rates by 20% which is to be offset by on-site stormwater detention.

On-site stormwater detention basins/tanks on industrial lots have been sized to ensure no increase in peak flow rates at the Precinct boundary, WaterNSW pipelines, RMS Mamre Road culverts, existing downstream development and private lands outside the Precinct. The basins are sized to offset free discharge from new local roads and channelisation of overland flow paths within trunk drainage corridors. Under this approach, no detention is required for new roads and no temporary detention is required making the staging of development simpler.

On-site stormwater detention for lots draining West of the Precinct could potentially be eliminated however the increase in peak flow needs to be accounted for in the design of cross-drainage structures associated with the RMS Mamre Road upgrade and interim arrangements are needed with downstream landholders in the Wianamatta South Creek precinct who’s land has not been acquired or included in the Precinct. On-site stormwater detention is necessary for lots draining to the North as it has been demonstrated the increased peak flows resulting from development would worsen existing flooding in the Western Sydney Employment Area and could potentially worsen any existing erosion in the vicinity of the pipelines themselves.

**Waterway Health**

The Mamre Road DCP adopts interim objectives for flow for Wianamatta-South Creek established by DPIE (EES) by applying the Risk Based Framework. A stormwater runoff objective of 1.9 megalitres (ML) per hectare per annum, measured at any legal discharge point or estate boundary.

This objective is more onerous to achieve than to simply apply stormwater pollution reduction and stream erosion index targets expressed in existing DCPs.

A range of stormwater measures are provided with demonstrated cost effectiveness to assist in the development of stormwater management plans for new development. This allows for consideration of the most cost-effective way to achieve the waterway health objectives for the Wianamatta South Creek. Stormwater balance modelling shows that open water bodies are cost effective means of reducing stormwater runoff volumes and preserving baseline hydrology characteristics. To be truly cost effective, it is recommended that these features be in the floodplain where there is no net loss of developable area, floodplain storage and conveyance. To realise this, waterbodies must be integrated into the master planning for the Wianamatta South Creek precinct and within flood prone lands zoned as Private Recreation to the East of the Precinct. The timing of this may require that those waterbodies are delivered after development has commenced in the catchment, however it is recommended that those waterbodies are not implemented until as least 80% of the catchment is developed.

The approaches presented do not promote infiltration of stormwater or high irrigation rates in unsuitable areas. Salinity mapping of the region shows that over irrigation and concentrated infiltration of stormwater may result in urban salinity impacts. In developing a stormwater management plan, any new developments must address how salinity issues are to be avoided through:

1. Establishment and maintaining vegetation over unpaved areas
2. Appropriate irrigation rates for the local soils and site vegetation
3. Provision of lining on WSUD measures or sub surface drainage to mitigate infiltrating excess water

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NSW Soil Conservation Service, 1990, Soil Landscapes of the Wollongong-Port Hacking 1:100,000 Sheet map and report

# Appendix A  Figures

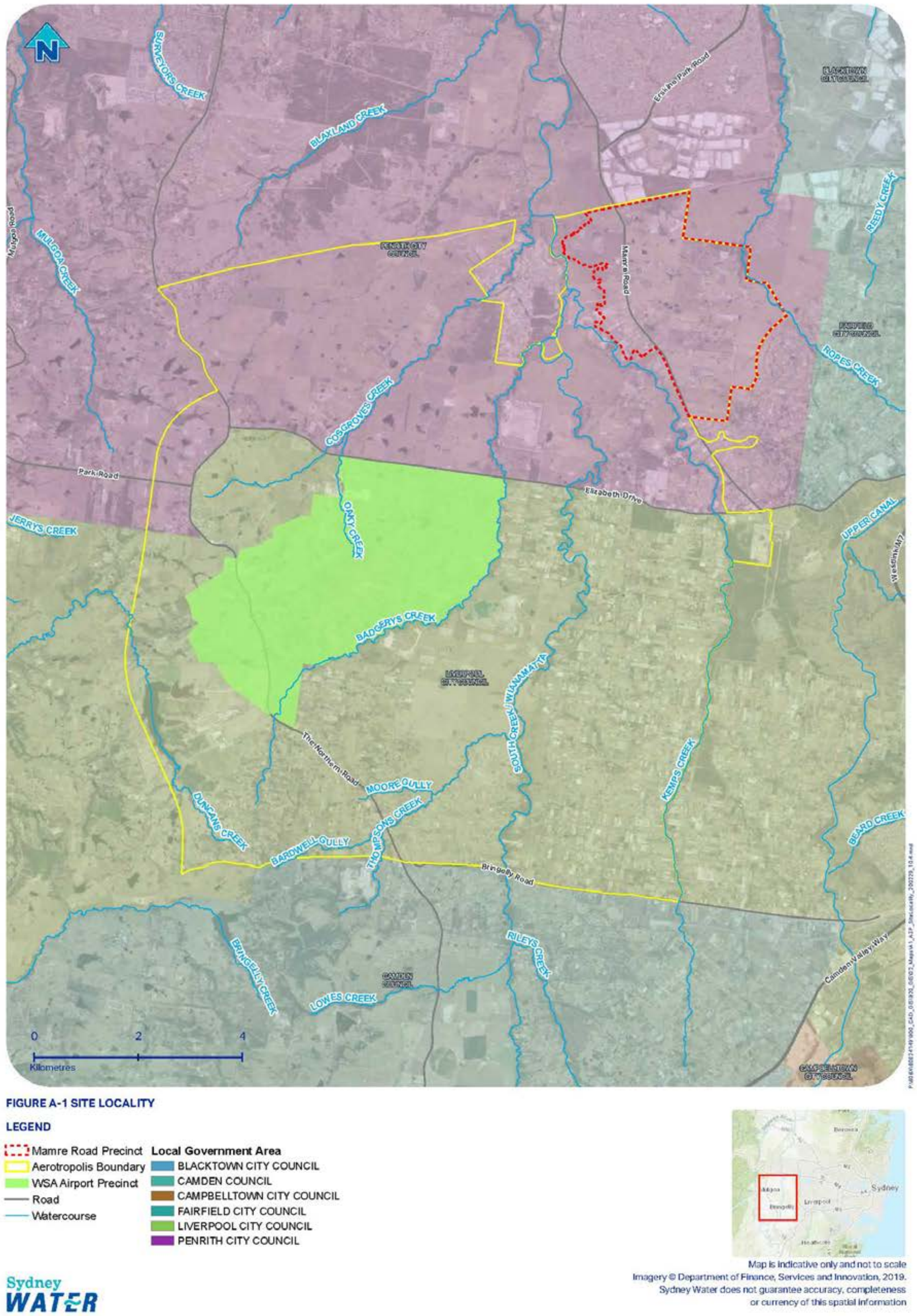


Figure A-1 Site Locality

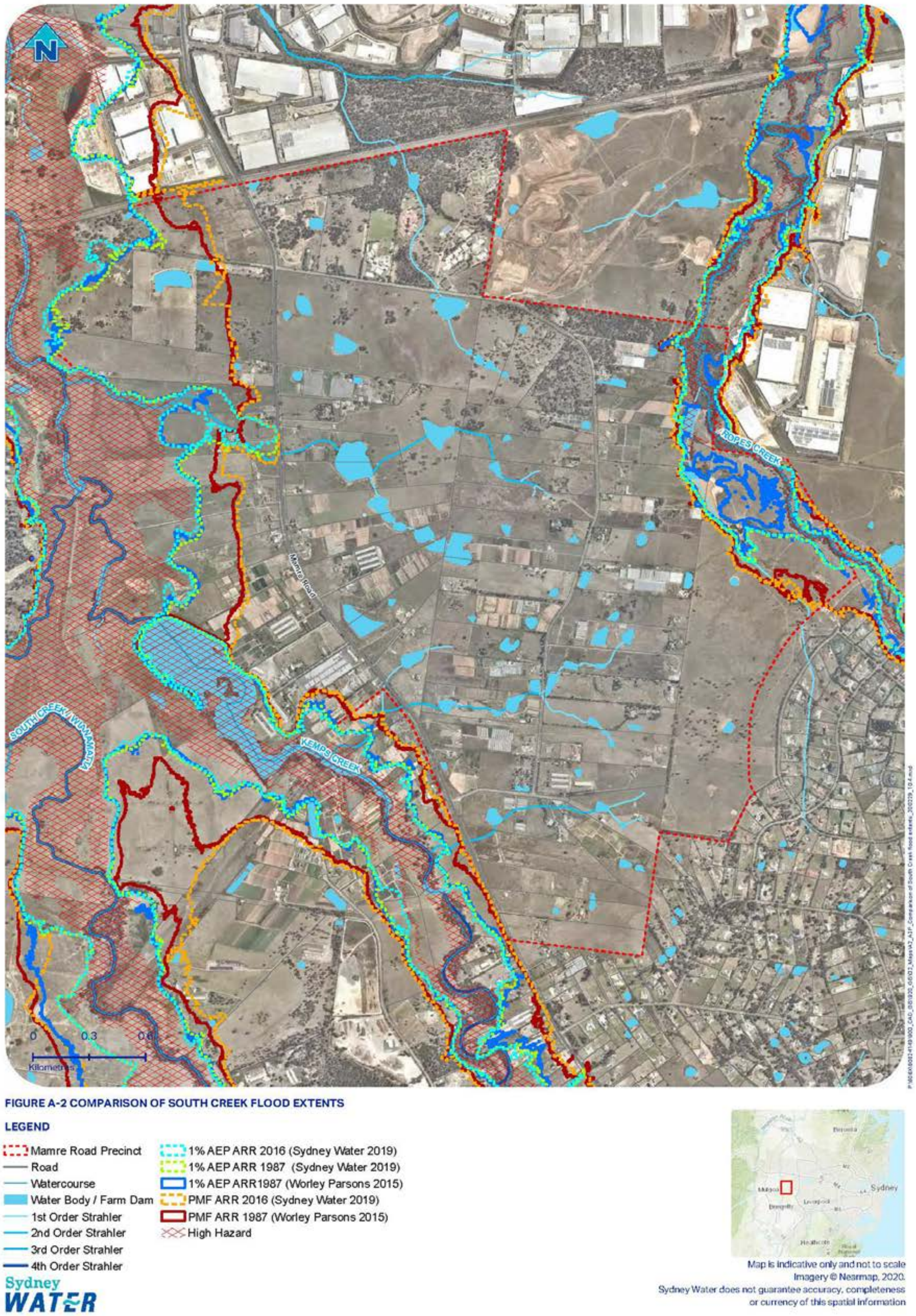


Figure A-2 Comparison of South Creek flood extents

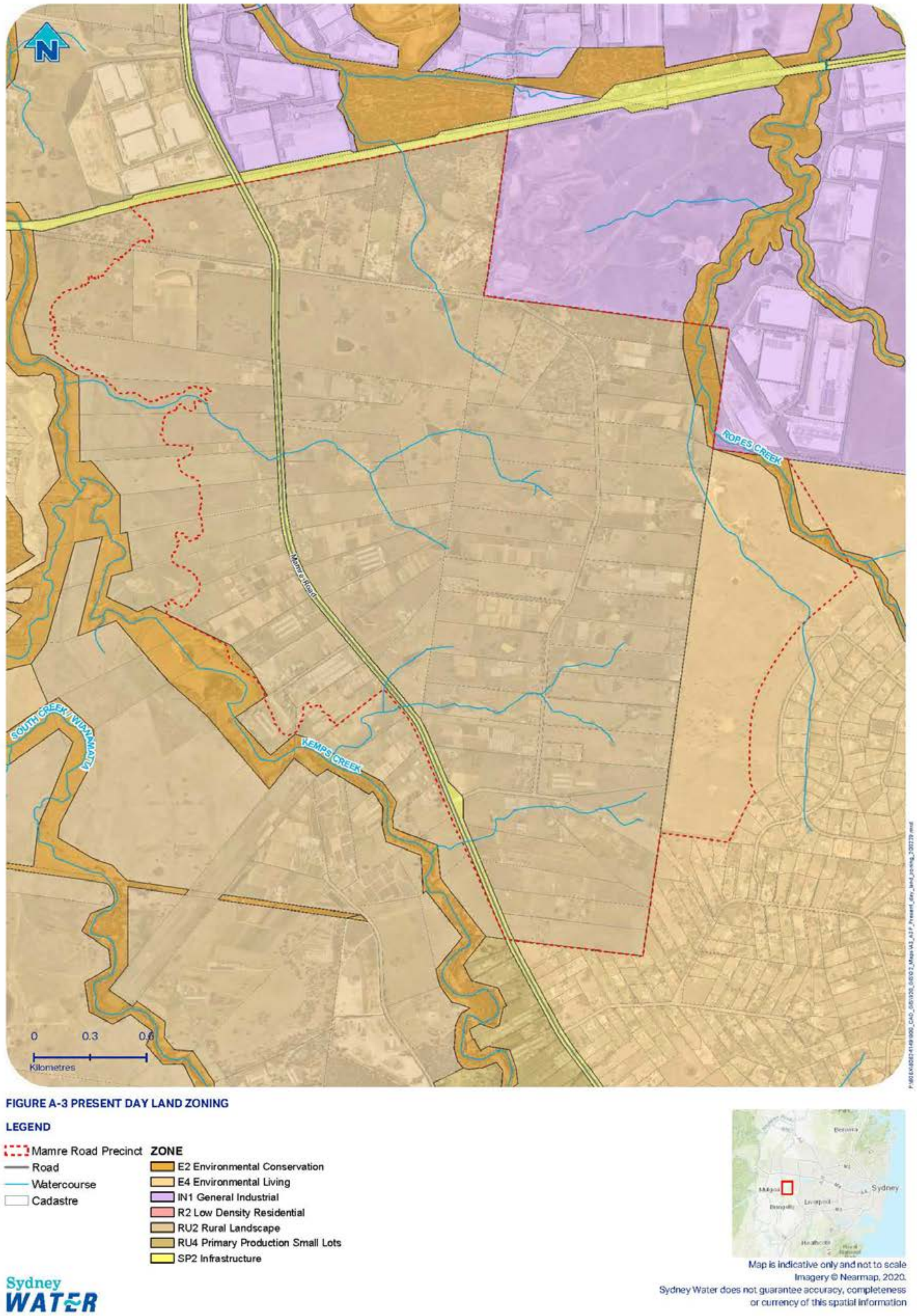


Figure A-3 Previous land zoning

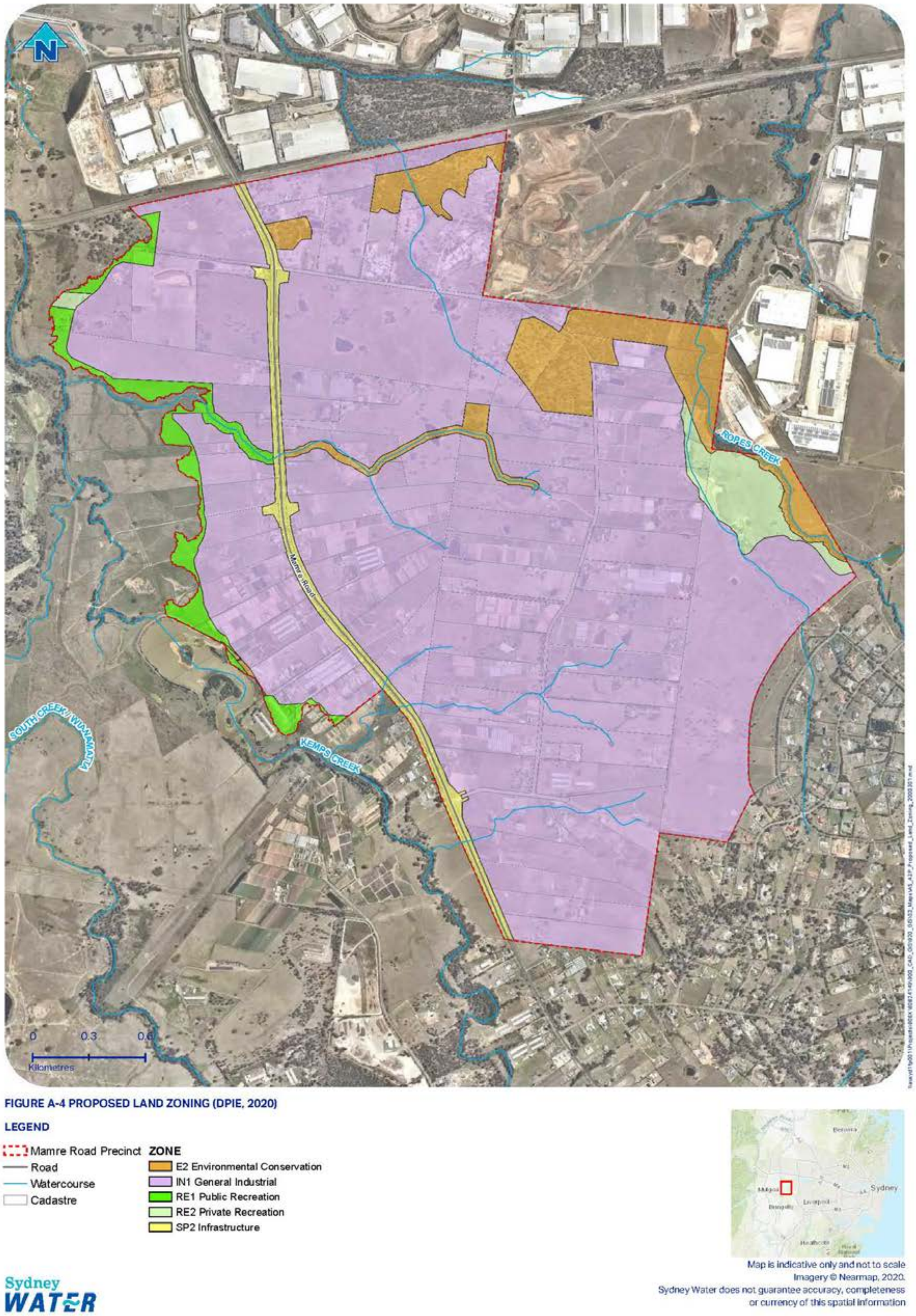


Figure A-4 Land zoning

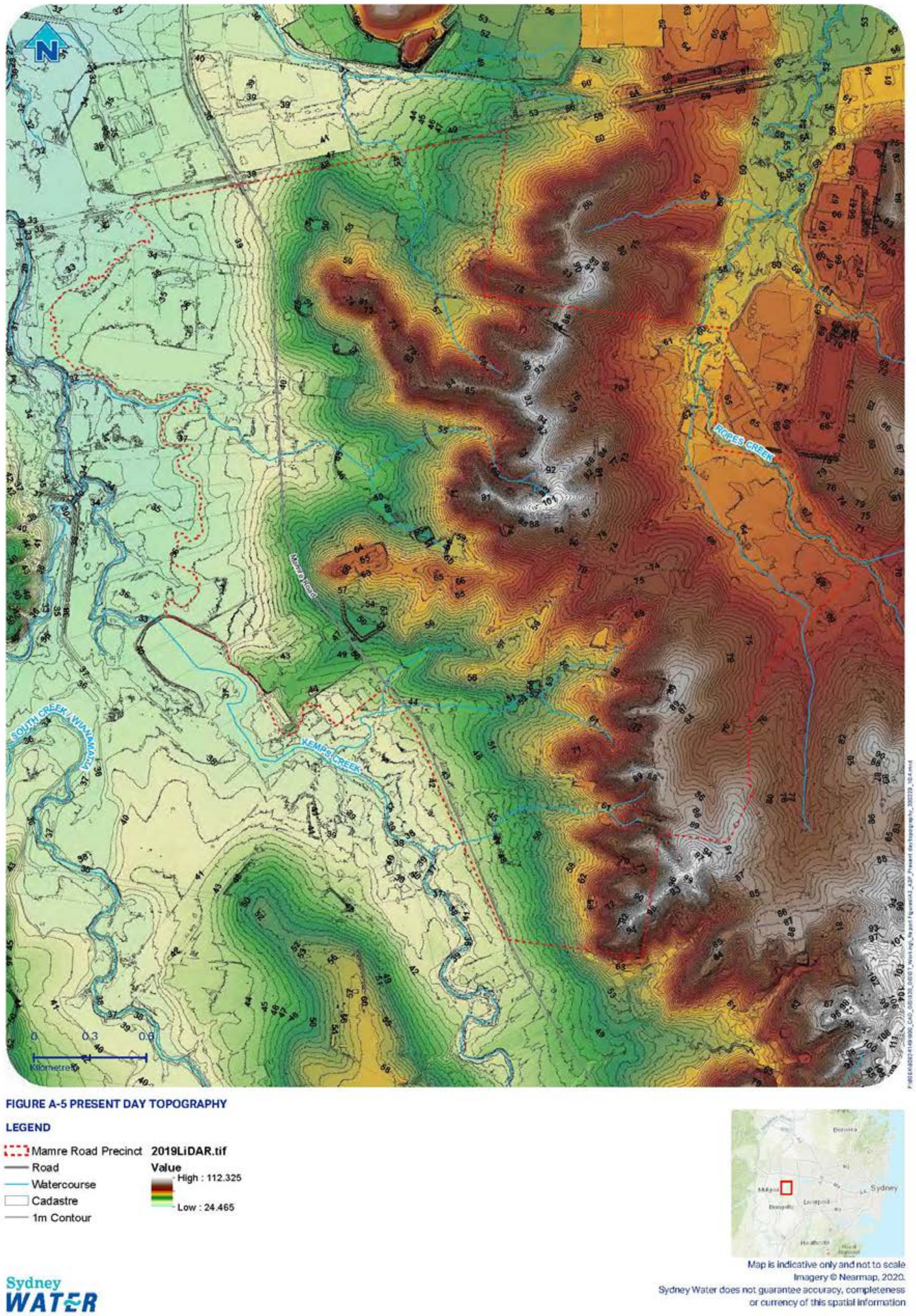


Figure A-5 Present day topography

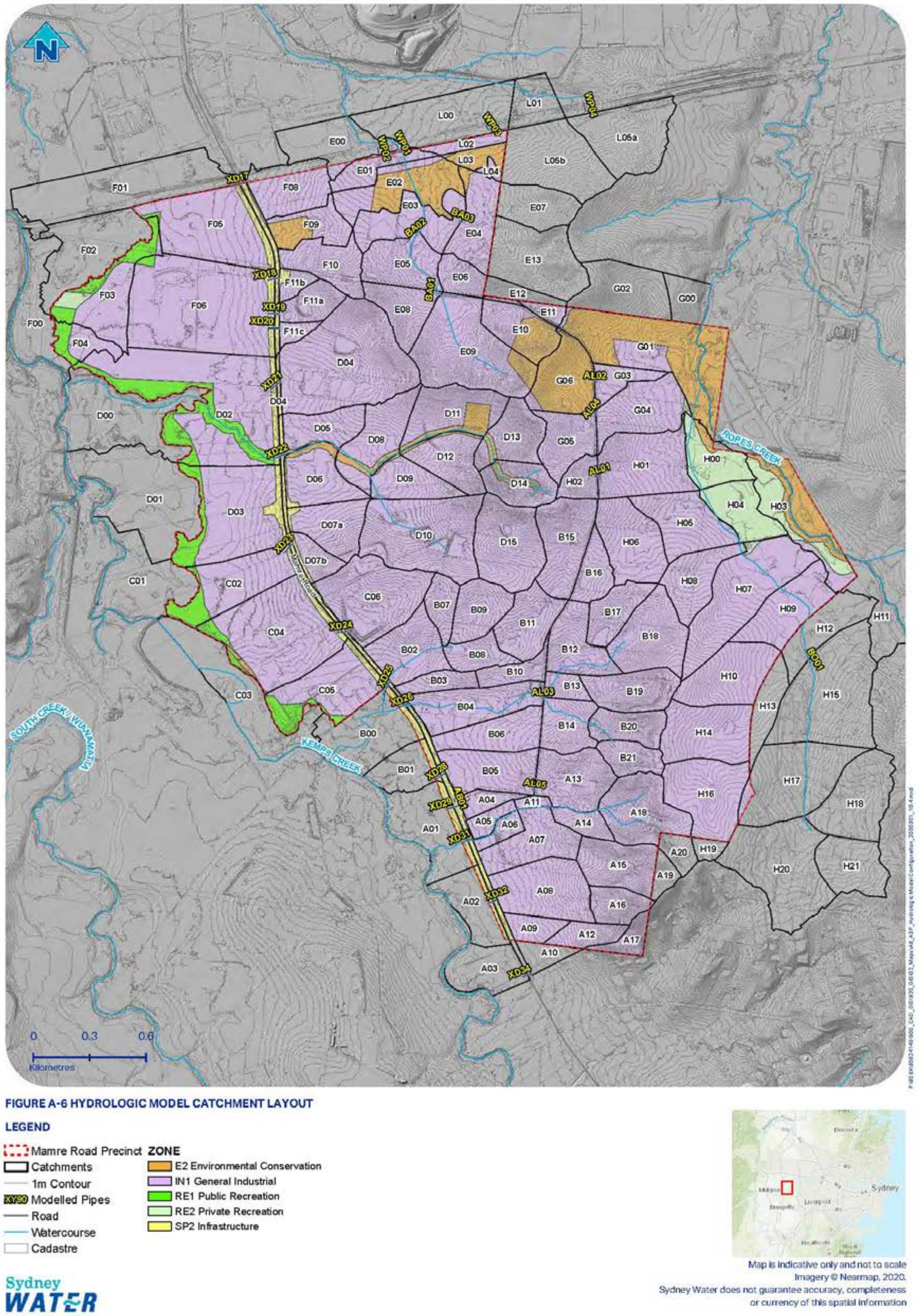


Figure A-6 Hydrologic model catchment layout

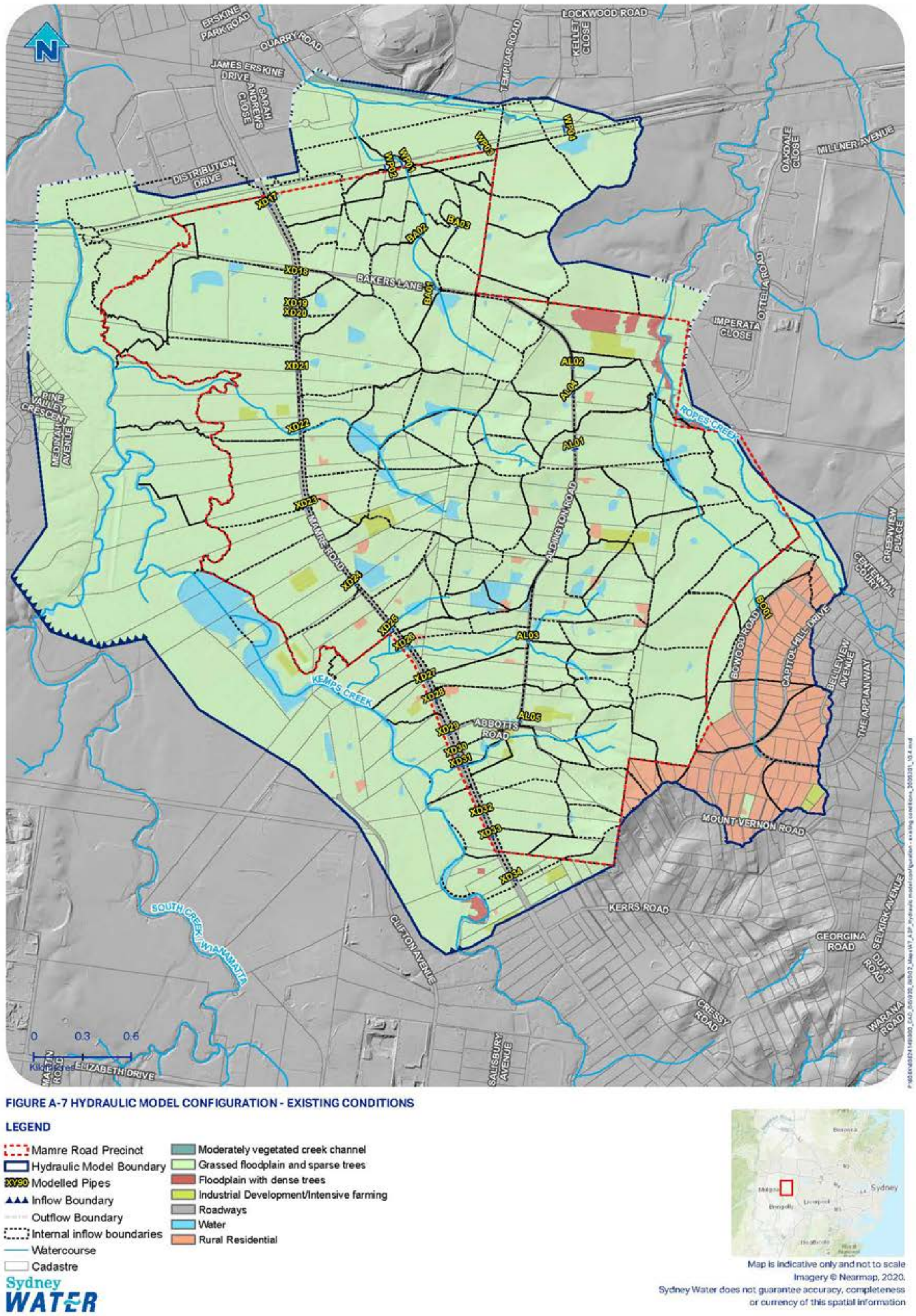


Figure A-7 Hydraulic model configuration - existing conditions

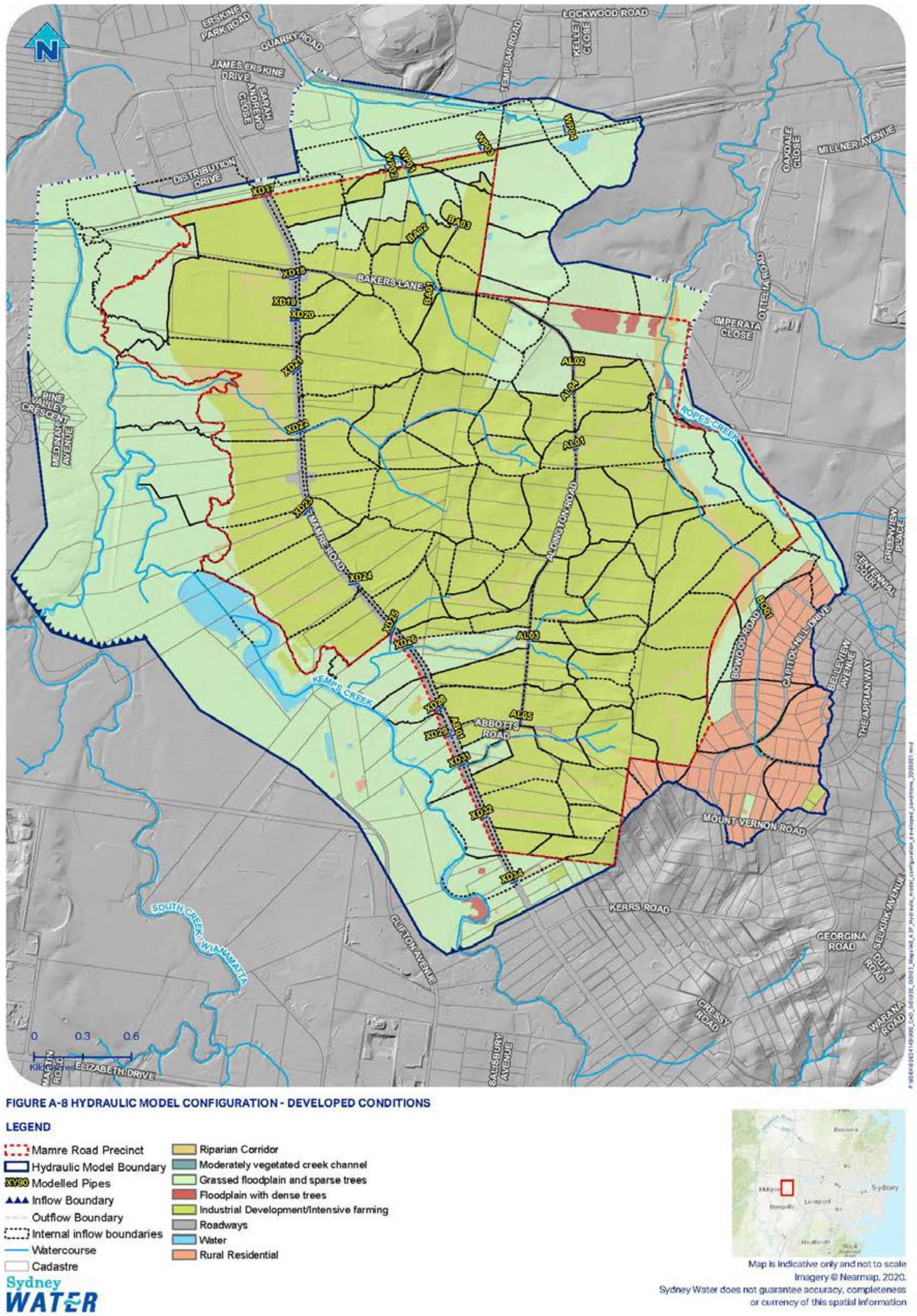


Figure A-8 Hydraulic model configuration - developed conditions

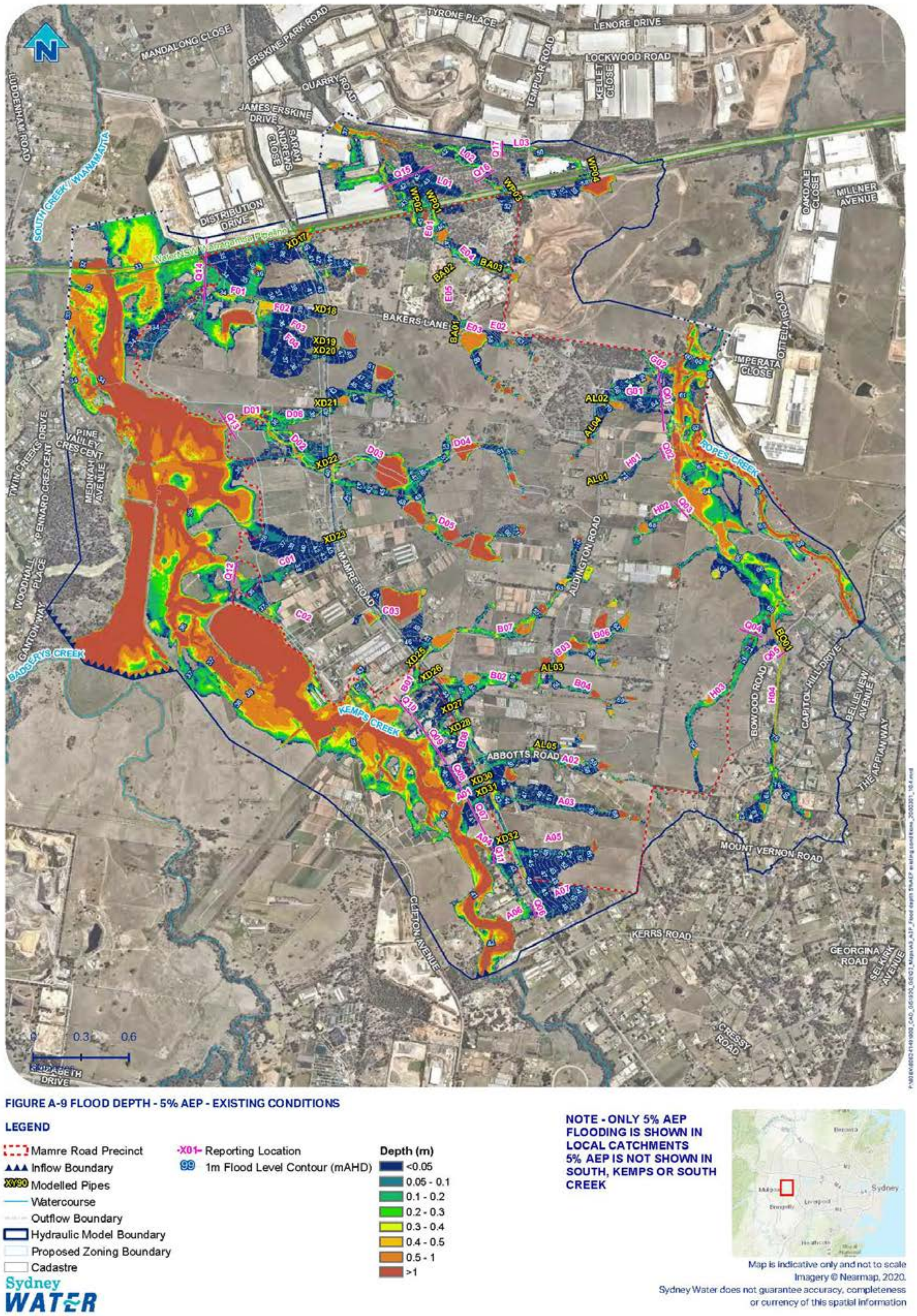


Figure A-9 Flood depth - 5% AEP - existing conditions

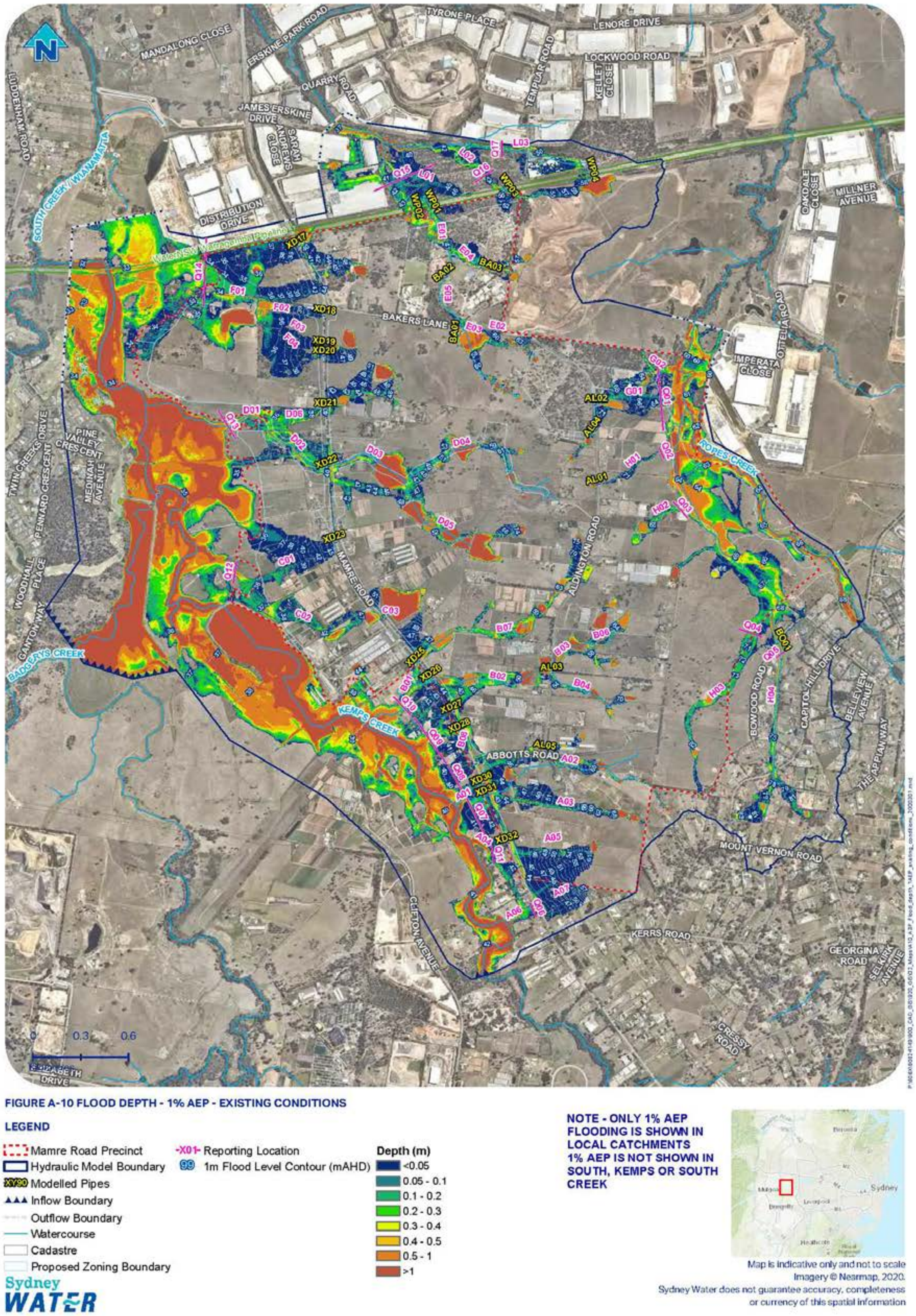


Figure A-10 Flood depth - 1% AEP - existing conditions

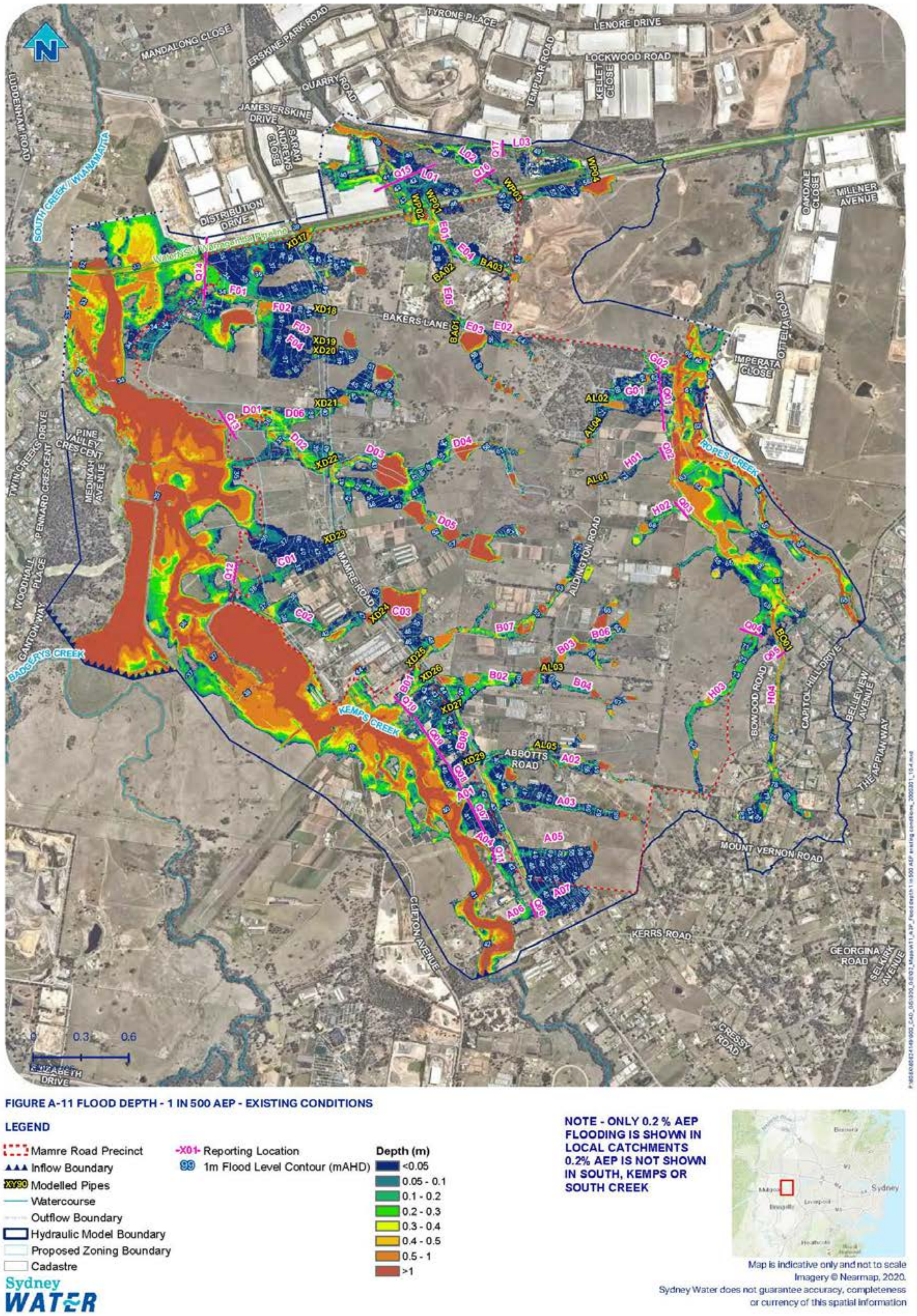


Figure A-11 Flood depth – 0.2% AEP - existing conditions

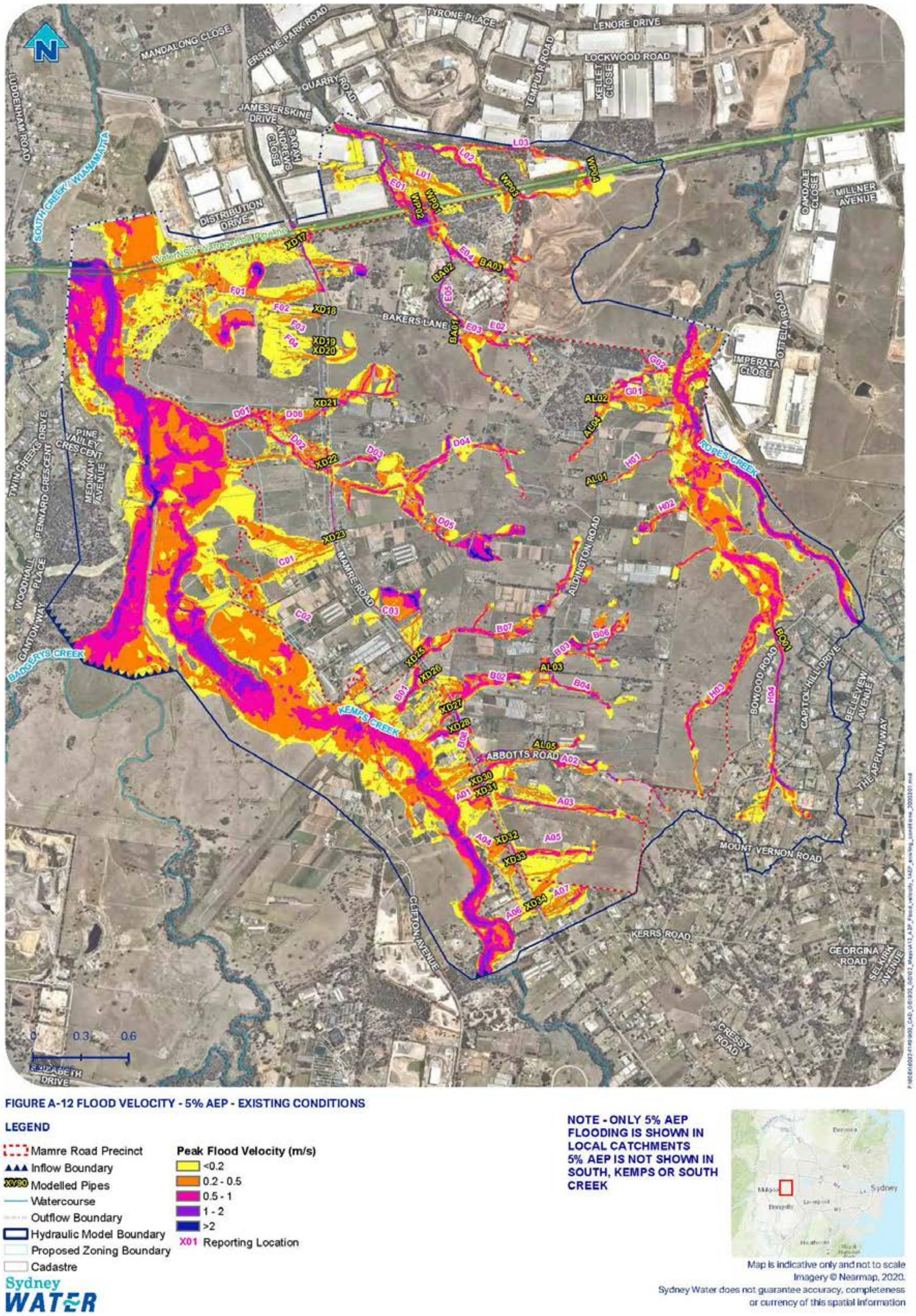


Figure A-12 Flood velocity - 5% AEP - existing conditions

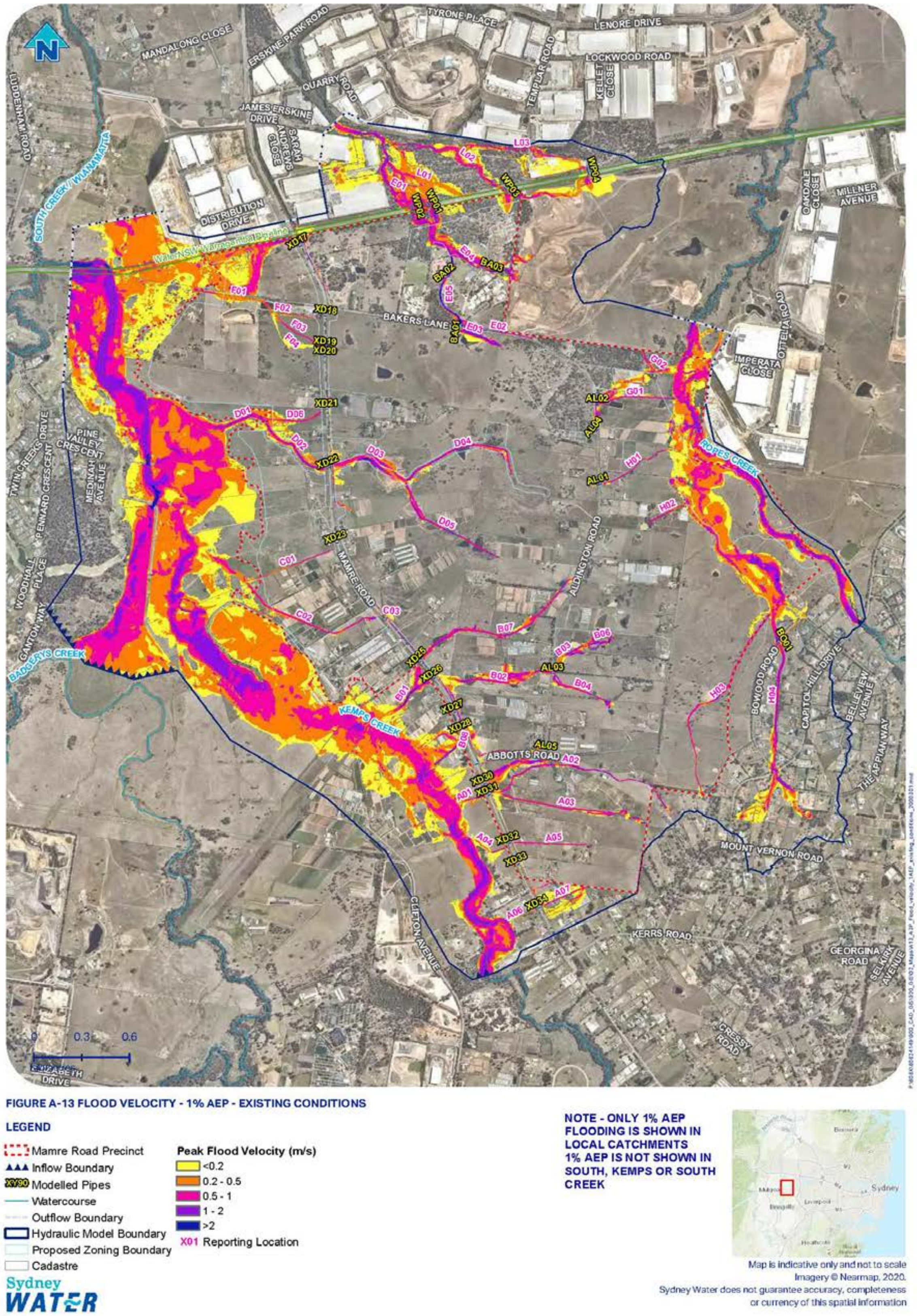


Figure A-13 Flood velocity - 1% AEP - existing conditions

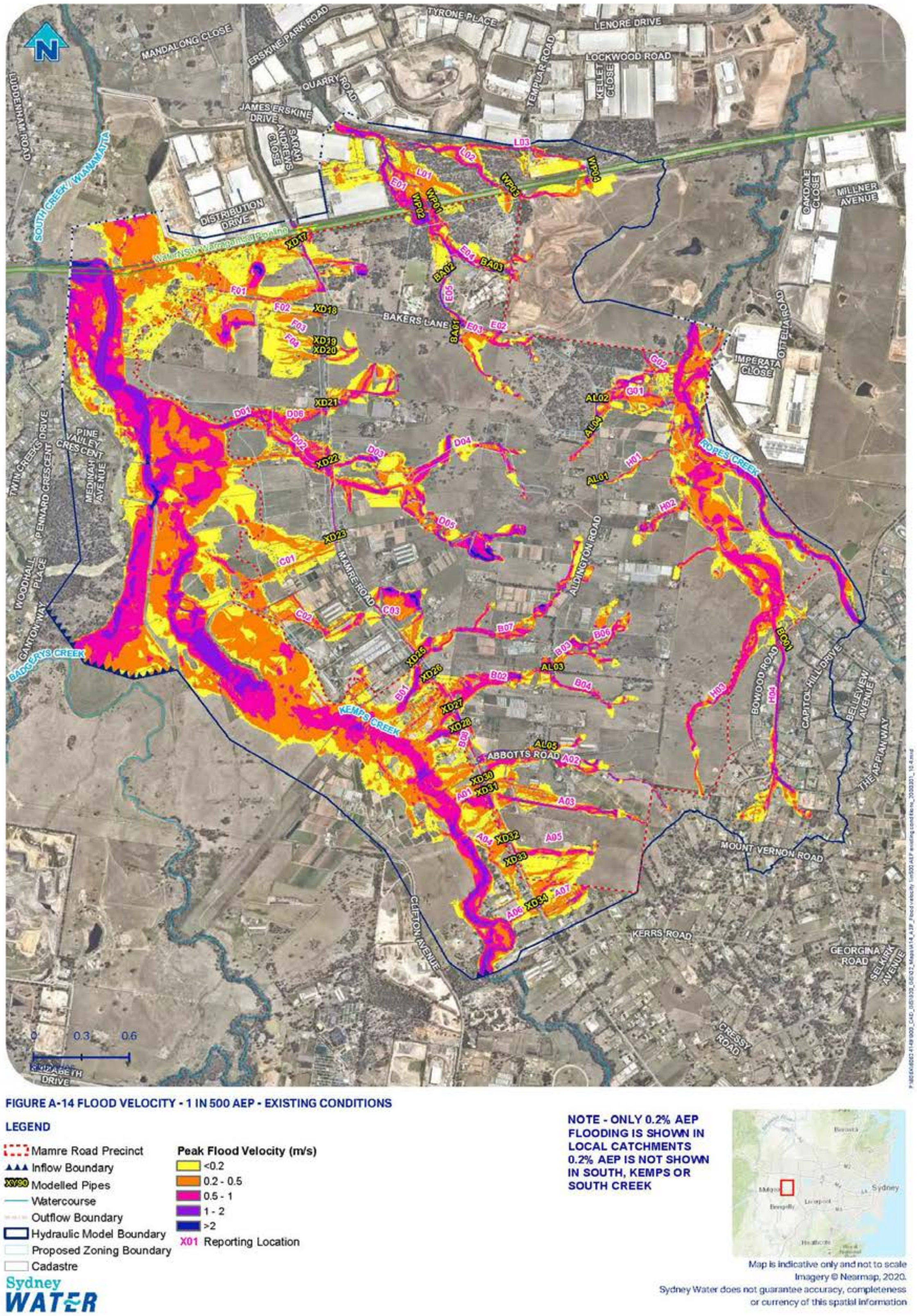


Figure A-14 Flood velocity – 0.2% AEP - existing conditions

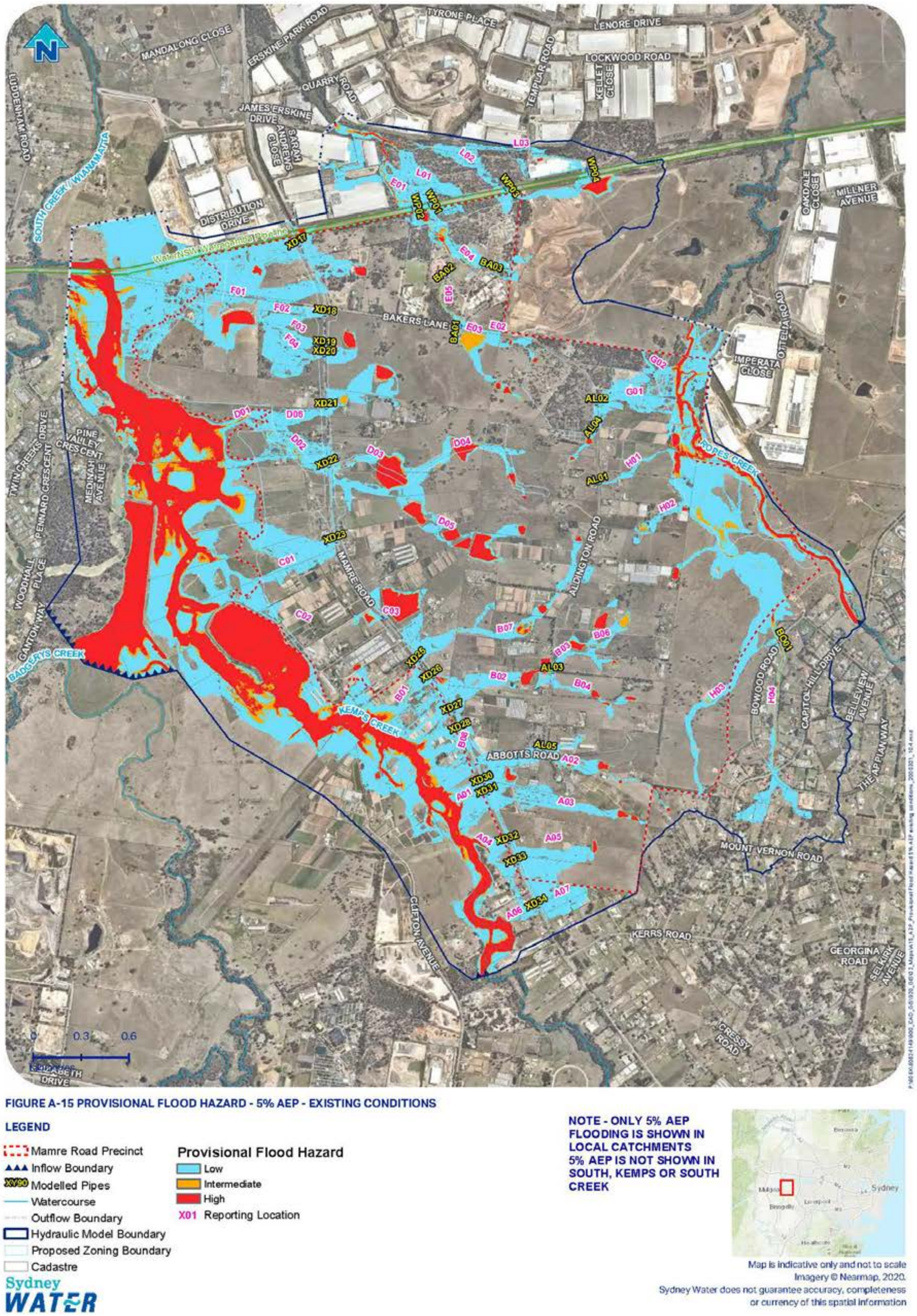


Figure A-15 Provisional flood hazard - 5% AEP - existing conditions

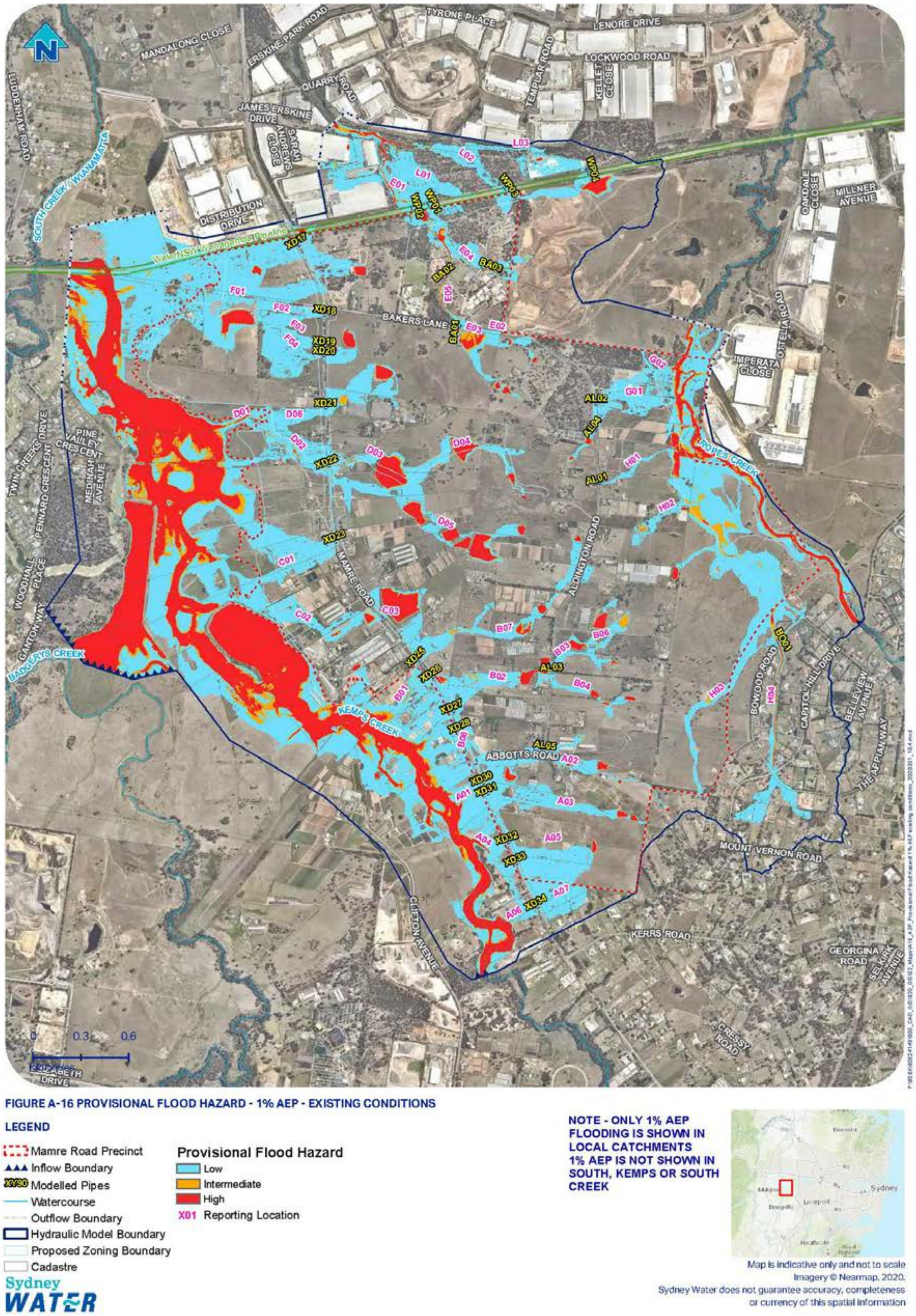


Figure A-16 Provisional flood hazard - 1% AEP - existing conditions

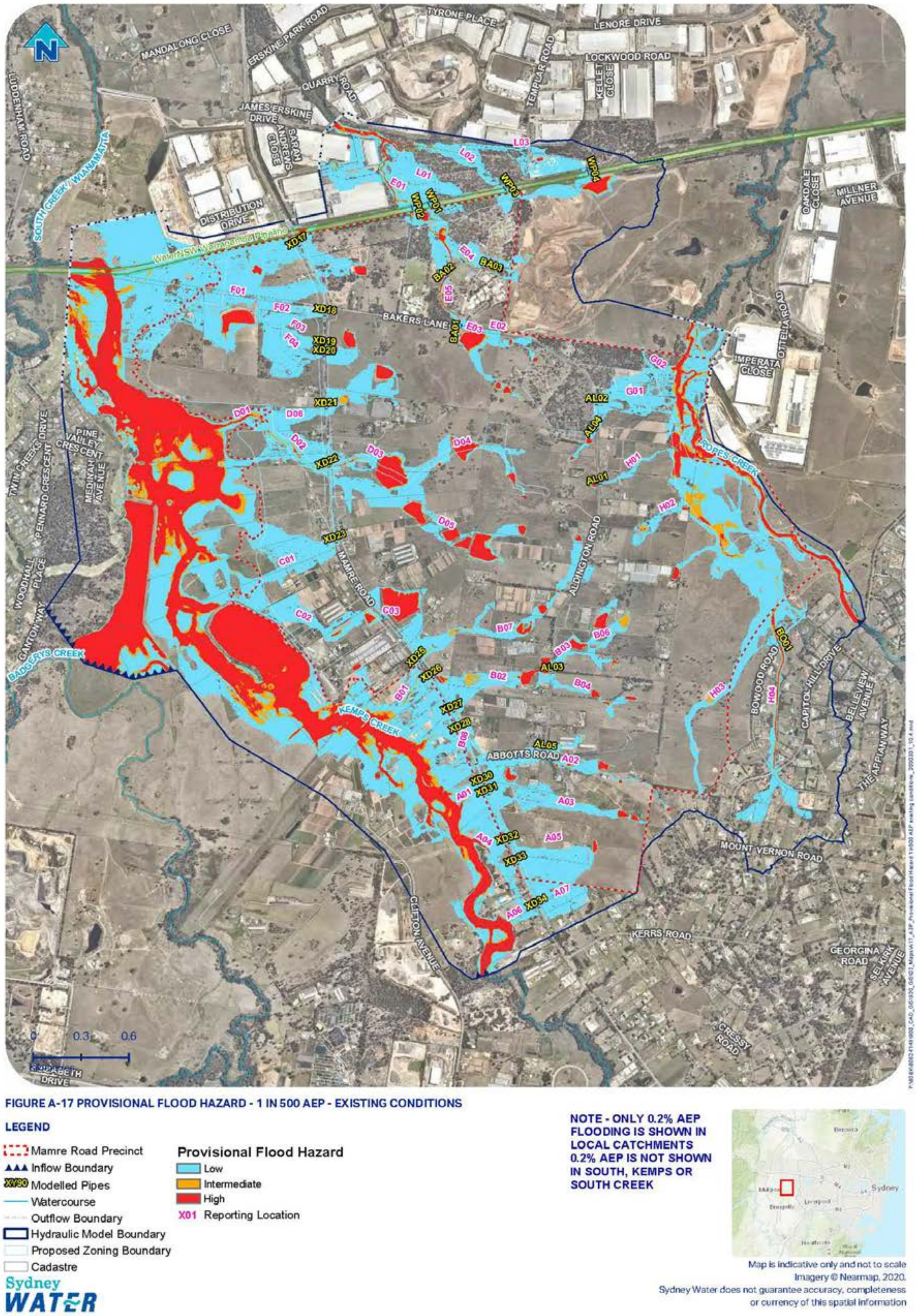


Figure A-17 Provisional flood hazard – 0.2% AEP - existing conditions

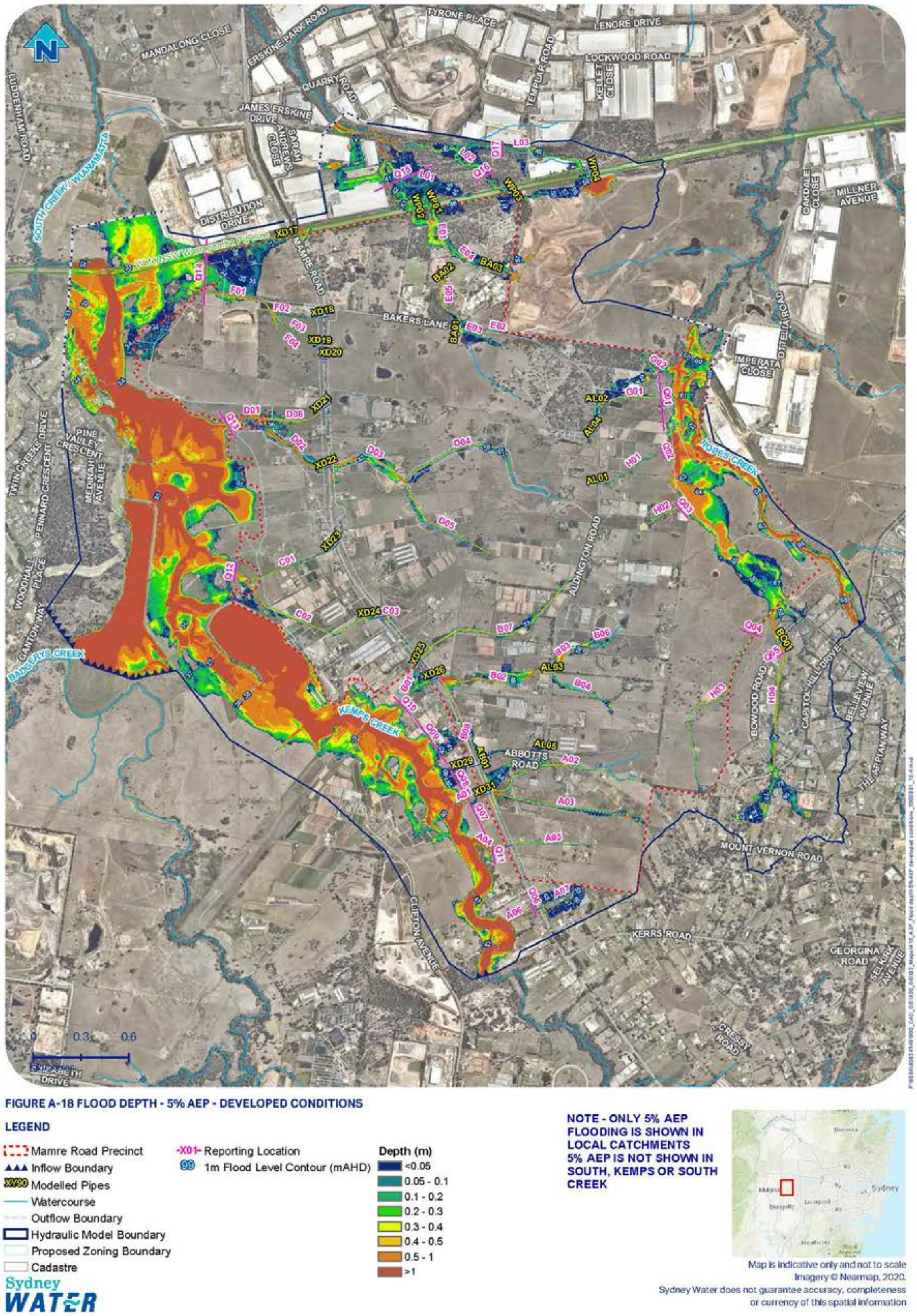


Figure A-18 Flood depth - 5% AEP - developed conditions

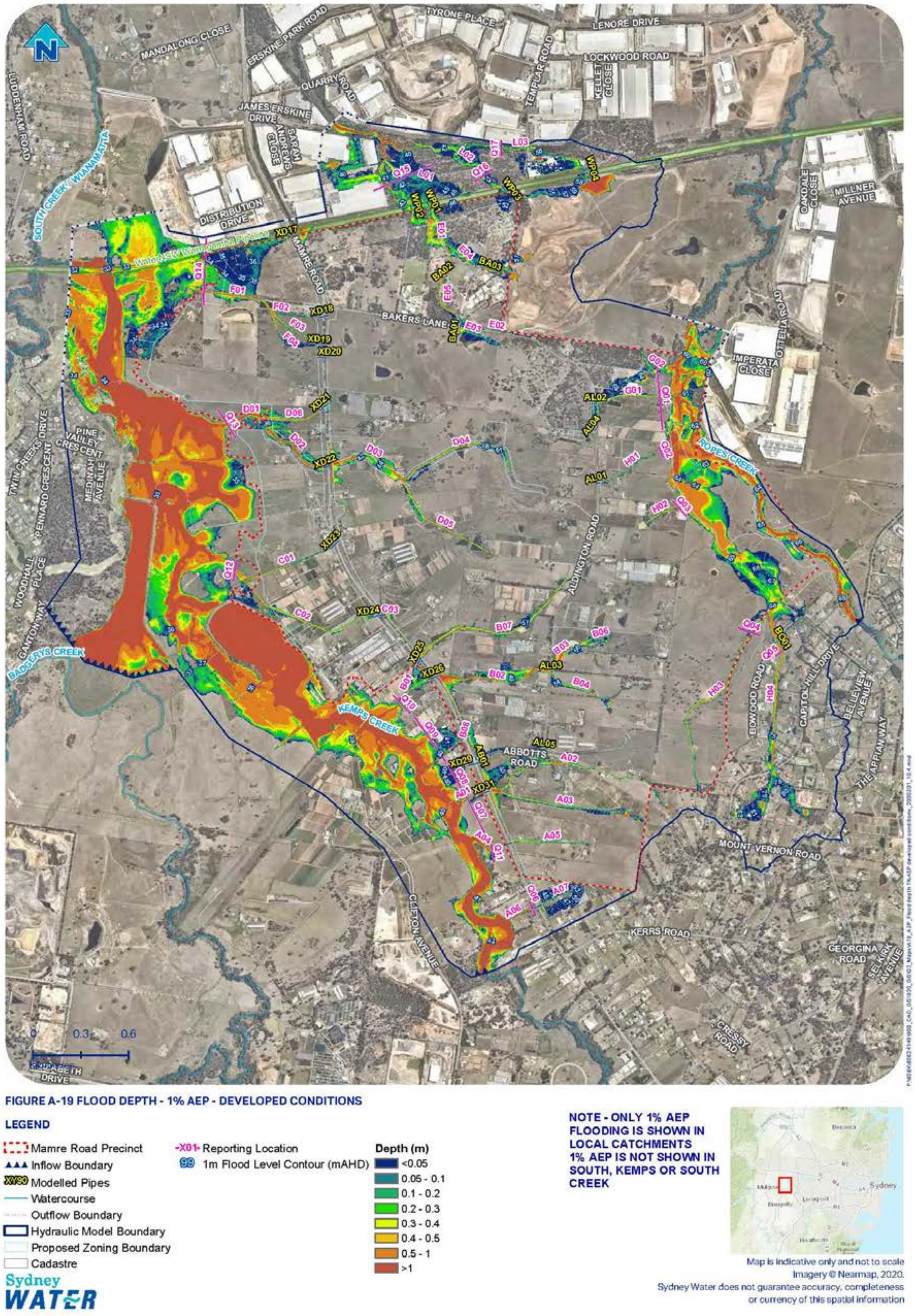


Figure A-19 Flood depth - 1% AEP - developed conditions

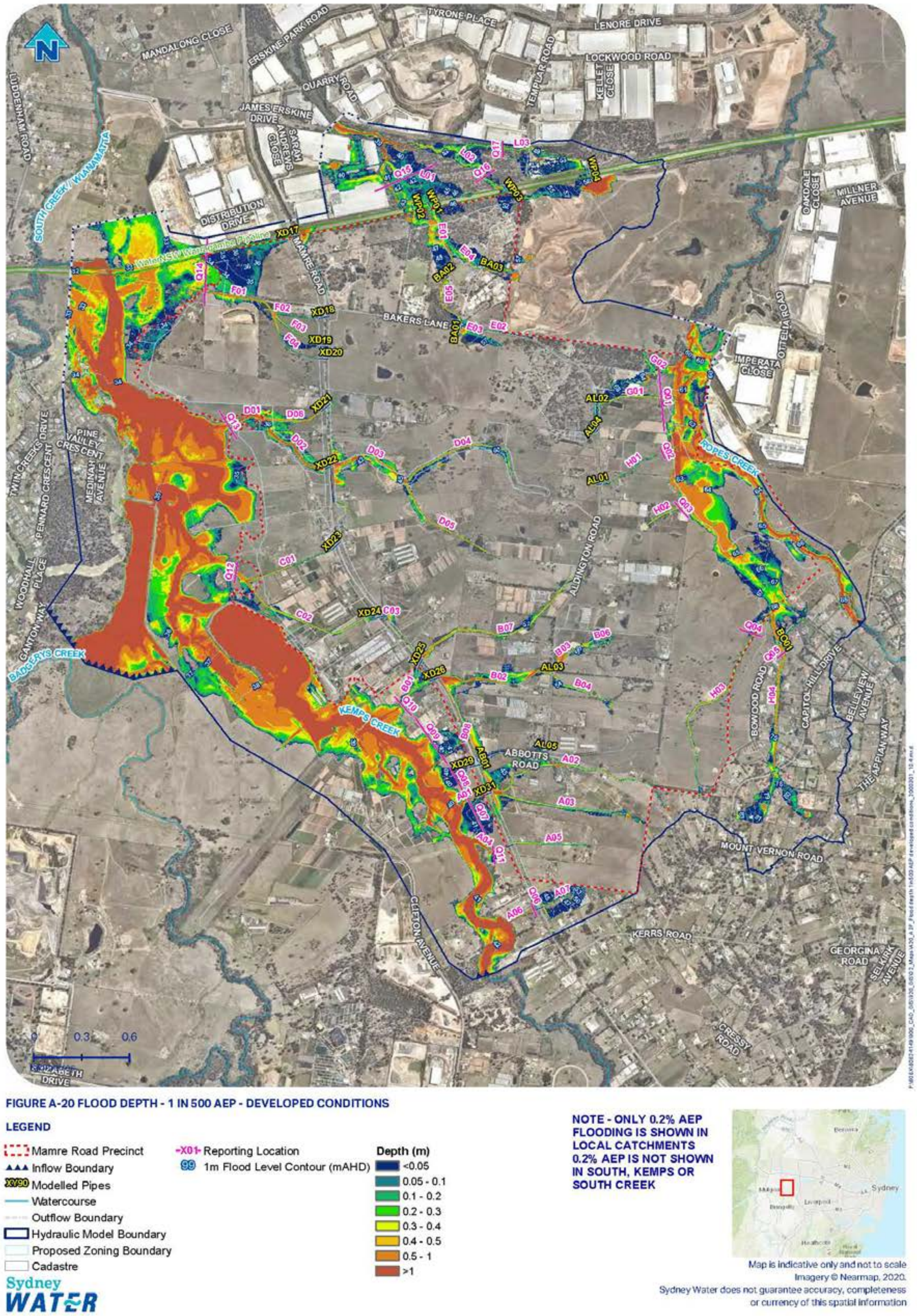


Figure A-20 Flood depth – 0.2% AEP - developed conditions

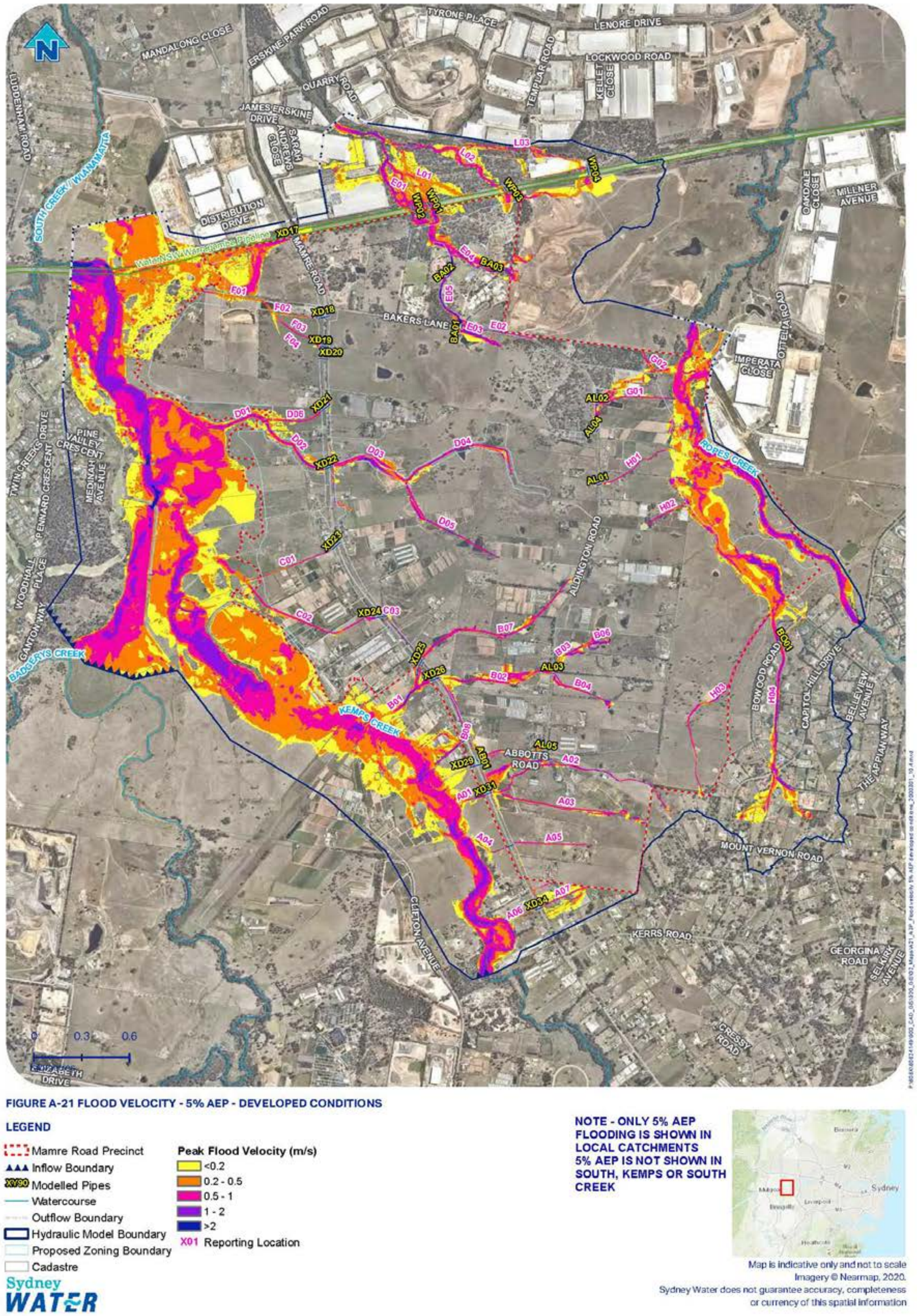


Figure A-21 Flood velocity - 5% AEP - developed conditions

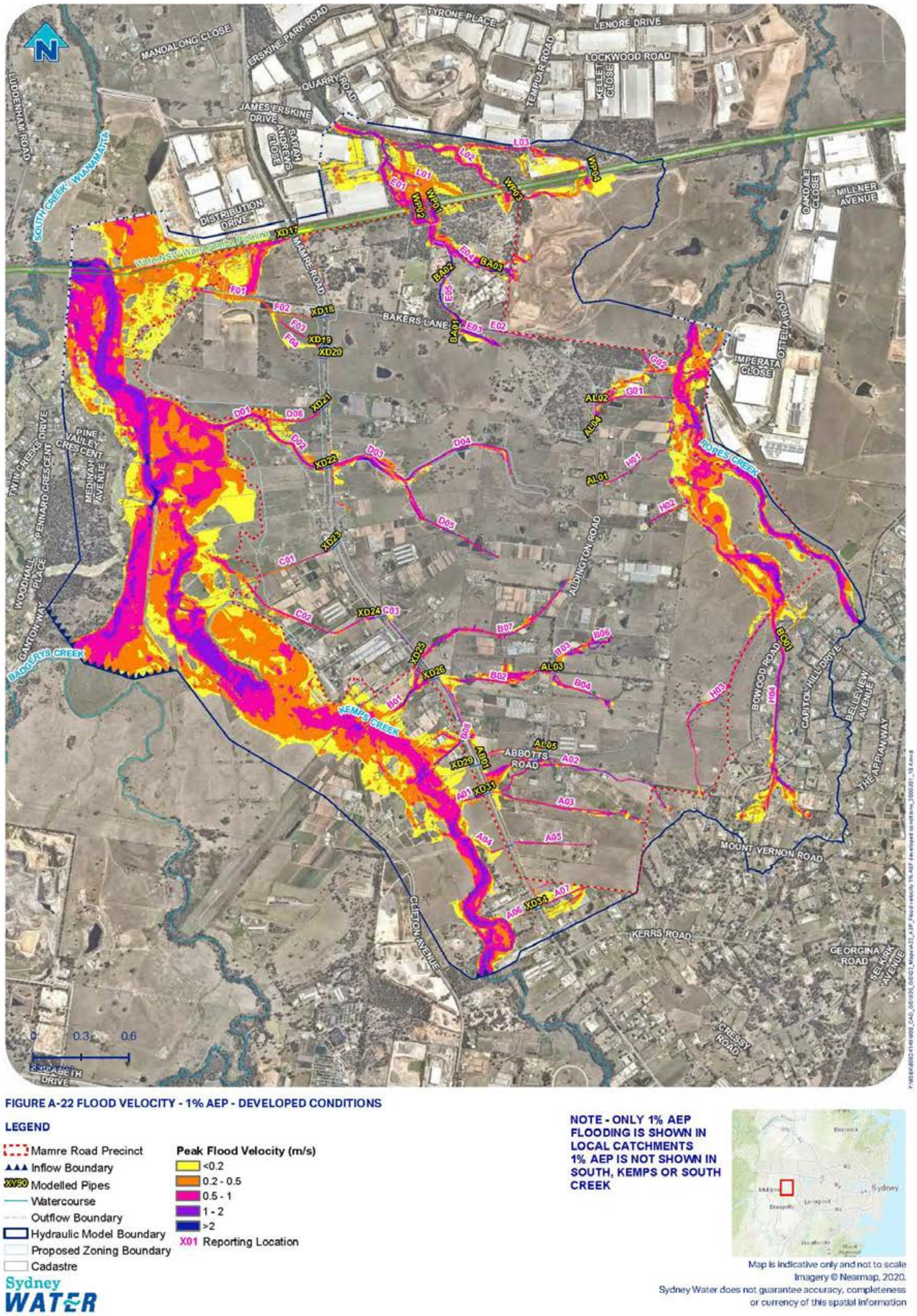


Figure A-22 Flood velocity - 1% AEP - developed conditions

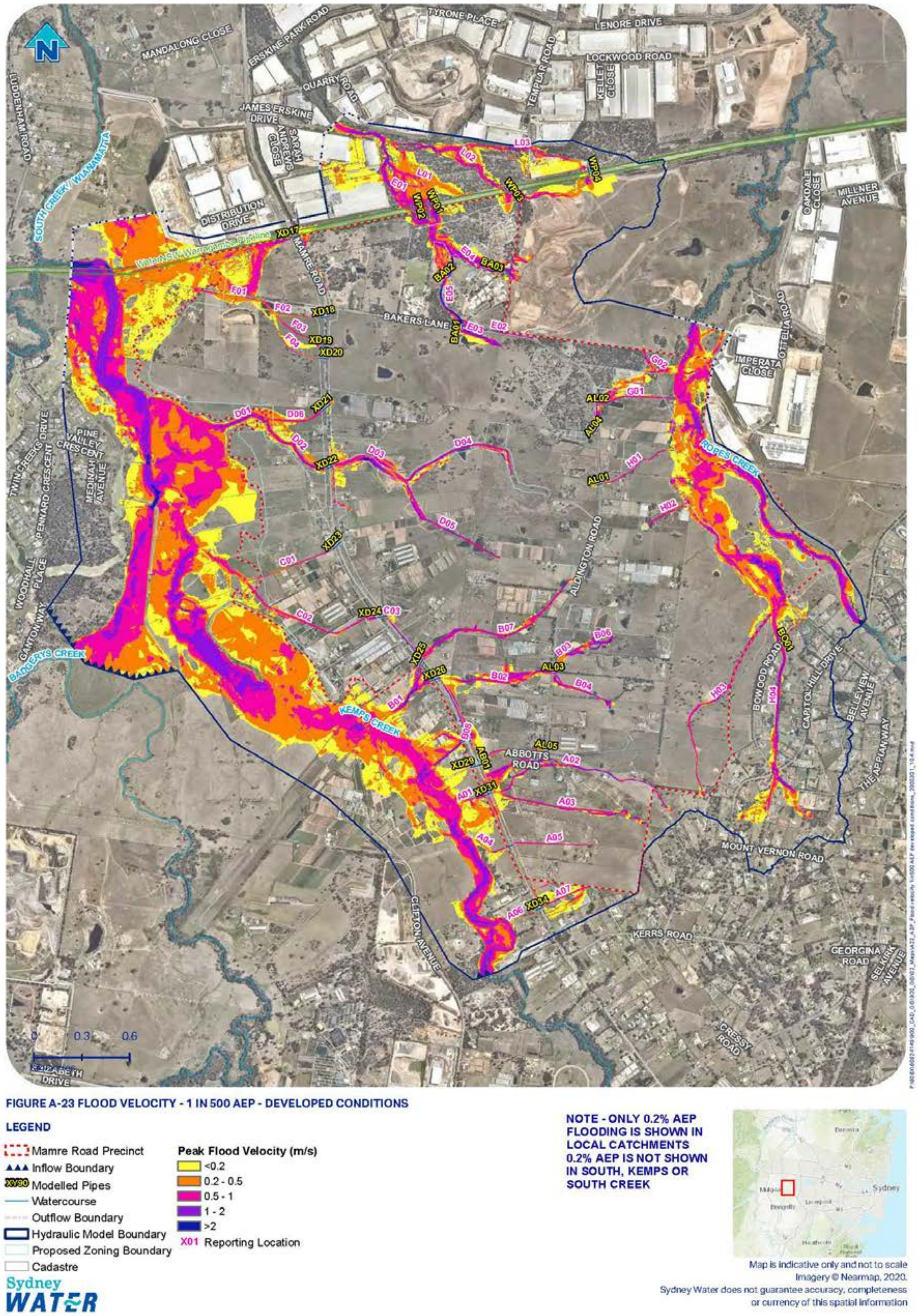


Figure A-23 Flood velocity – 0.2% AEP - developed conditions

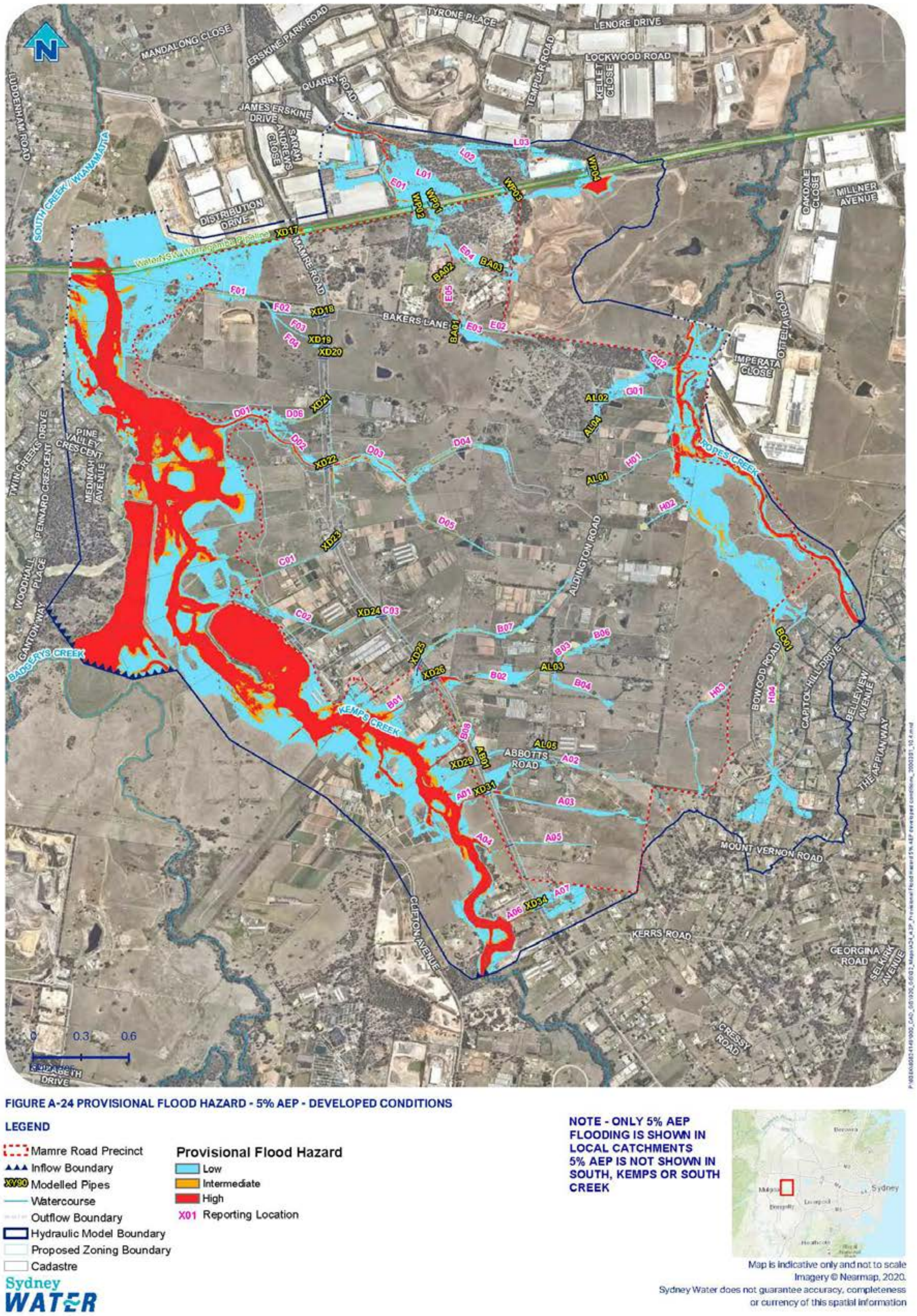


Figure A-24 Provisional flood hazard - 5% AEP - developed conditions

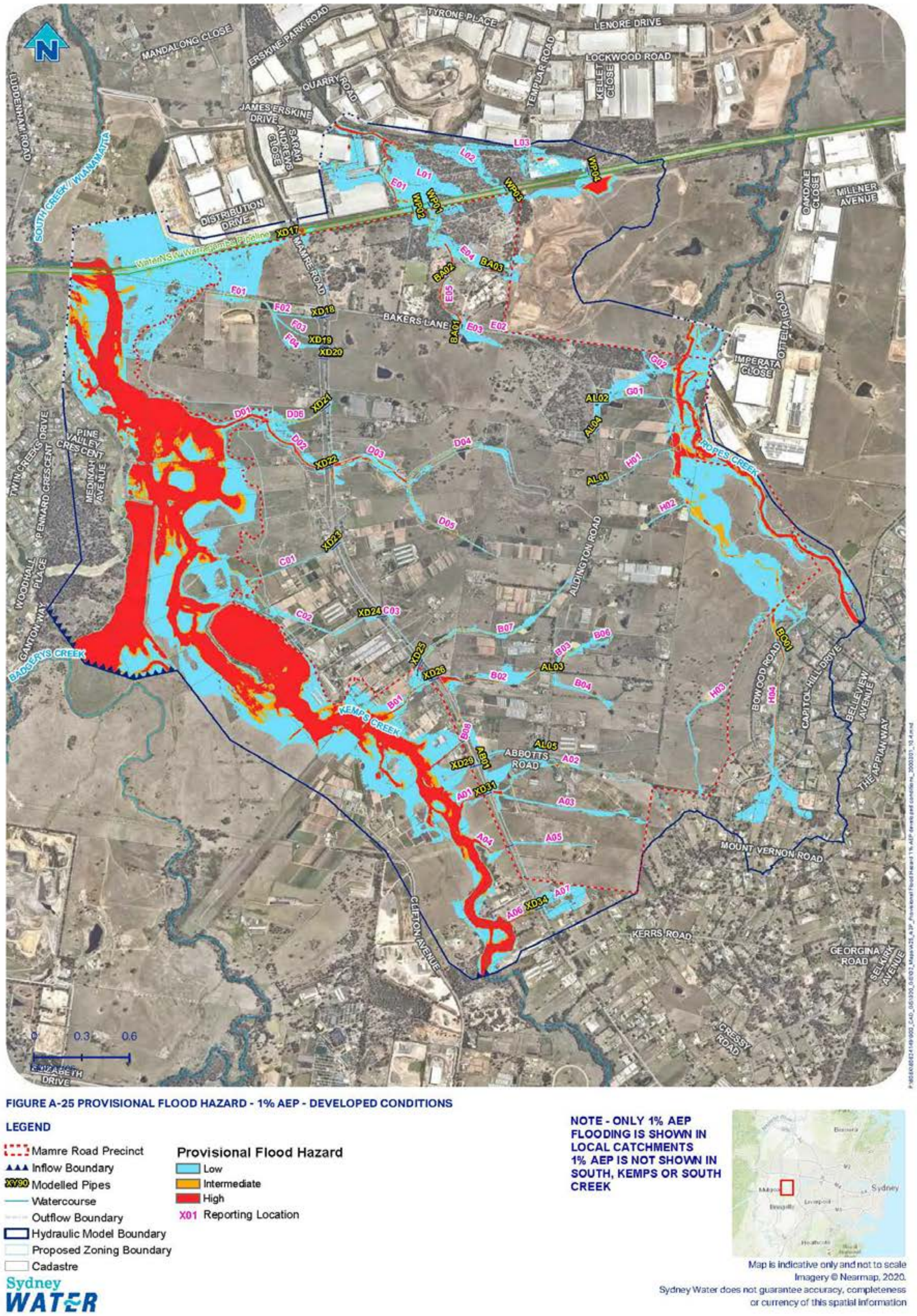


Figure A-25 Provisional flood hazard - 1% AEP - developed conditions

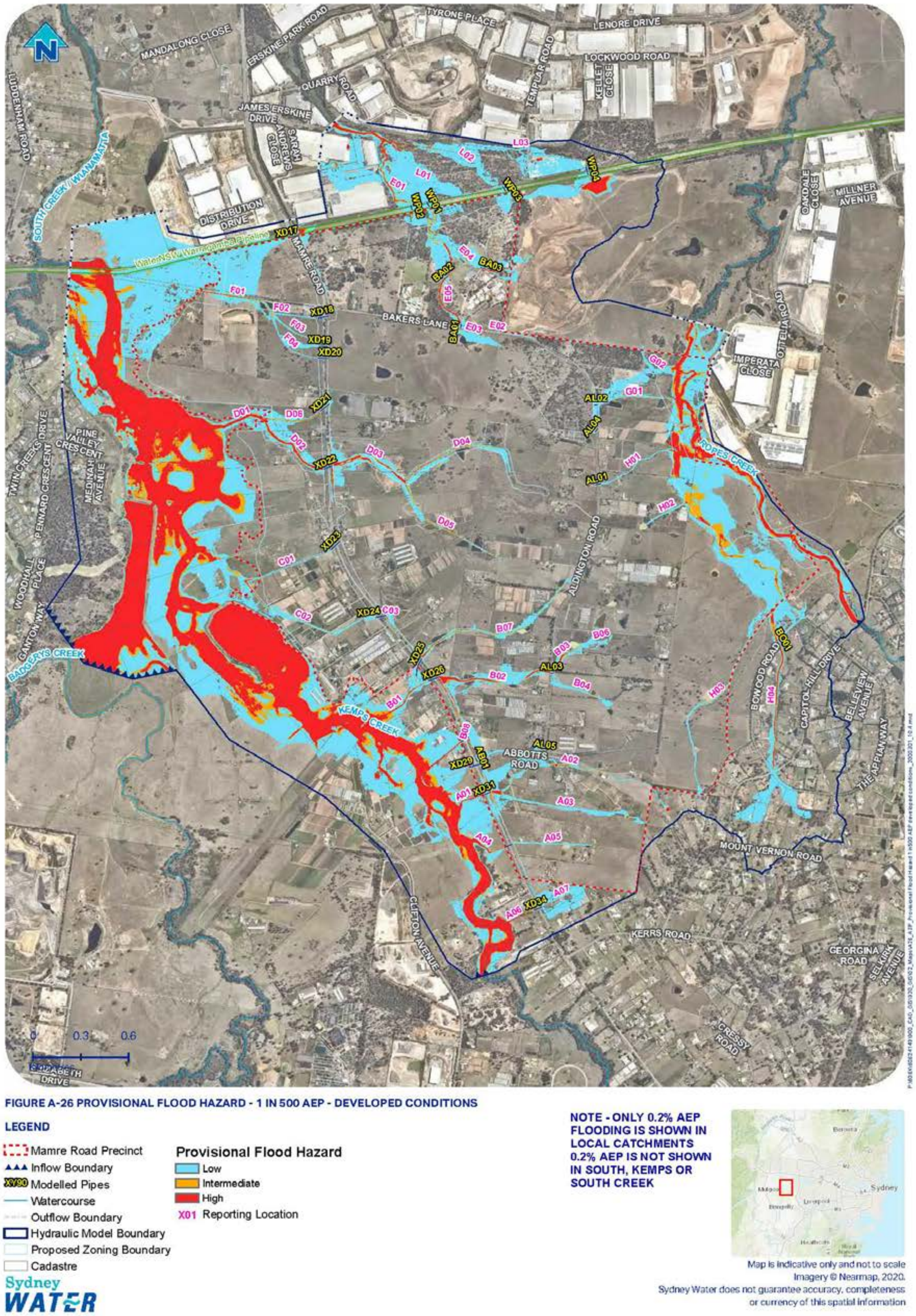


Figure A-26 Provisional flood hazard – 0.2% AEP - developed conditions

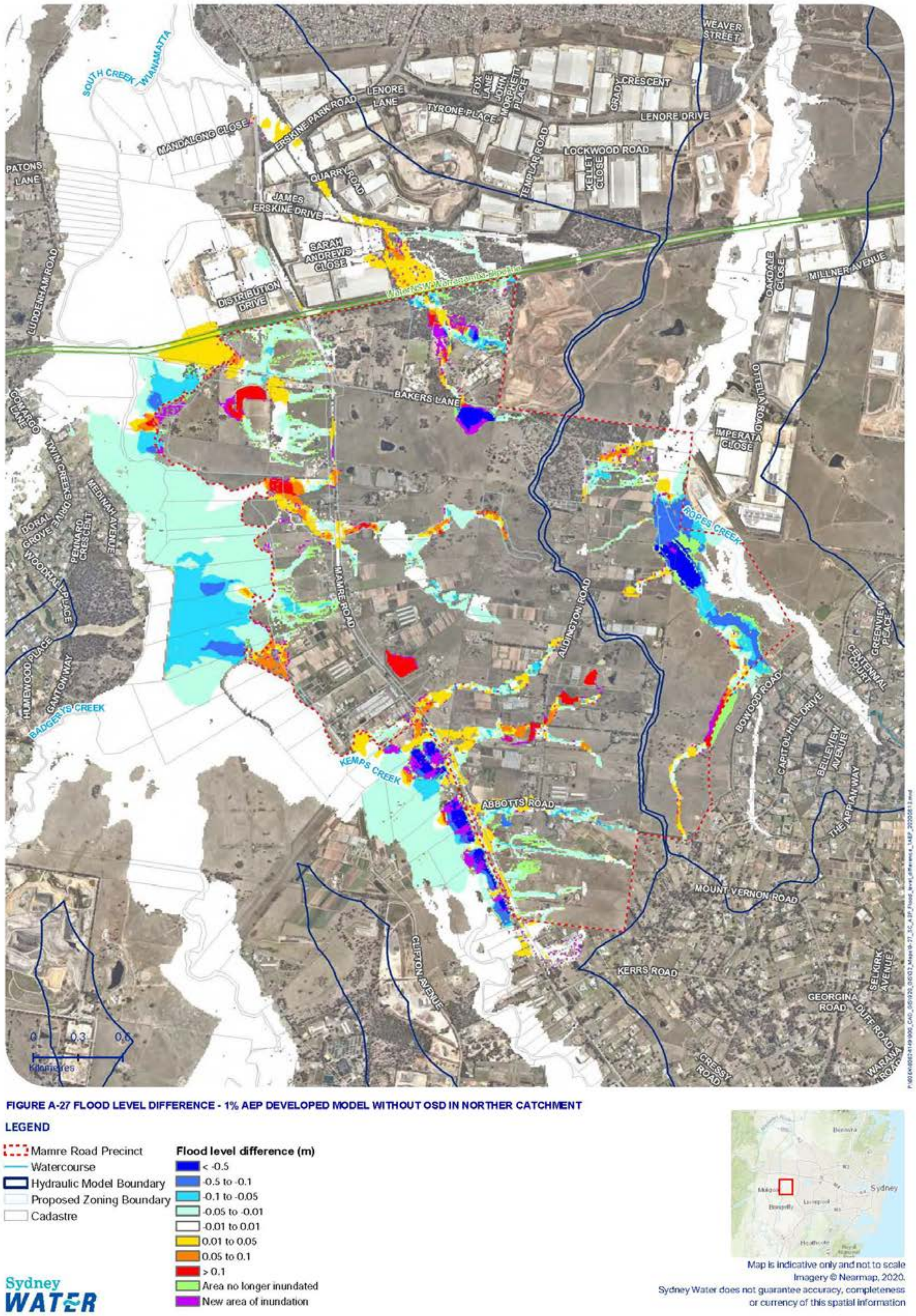


Figure A-27 Flood level difference – 1% AEP developed model without OSD in Northern Catchment

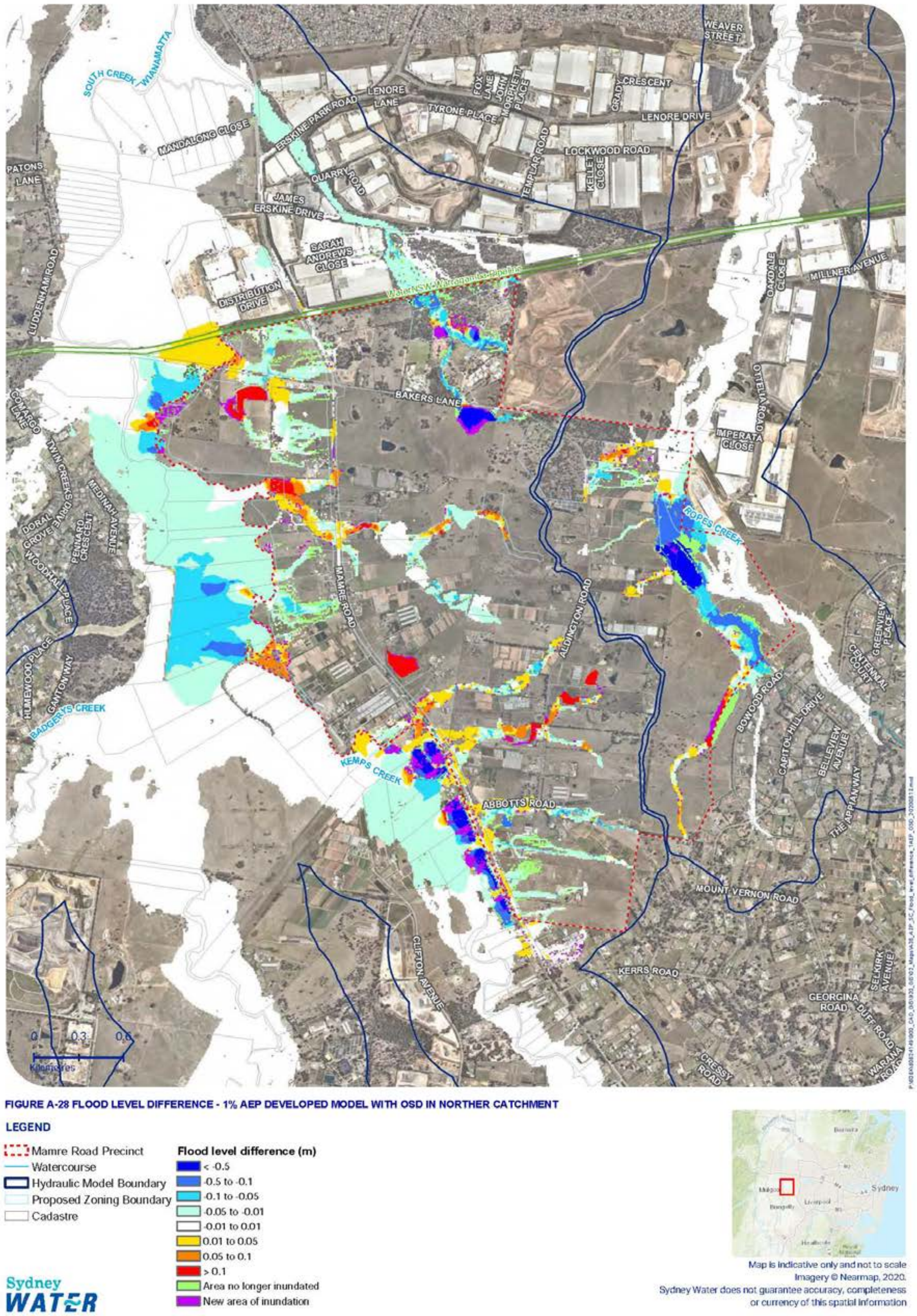


Figure A-28 Flood level difference - 1% AEP developed model with OSD in Northern Catchment

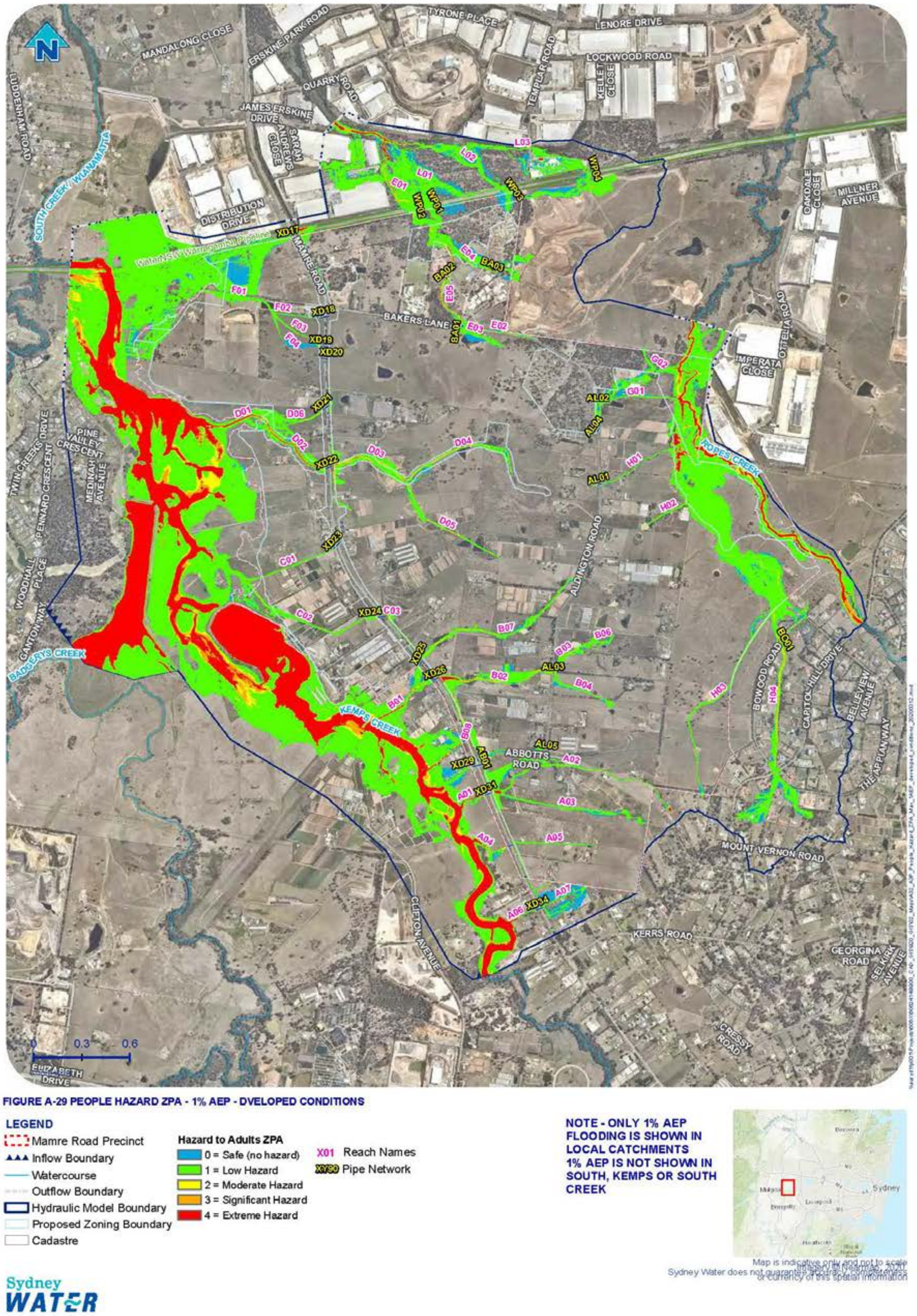


Figure A-29 People hazard ZPA – 1% AEP developed conditions

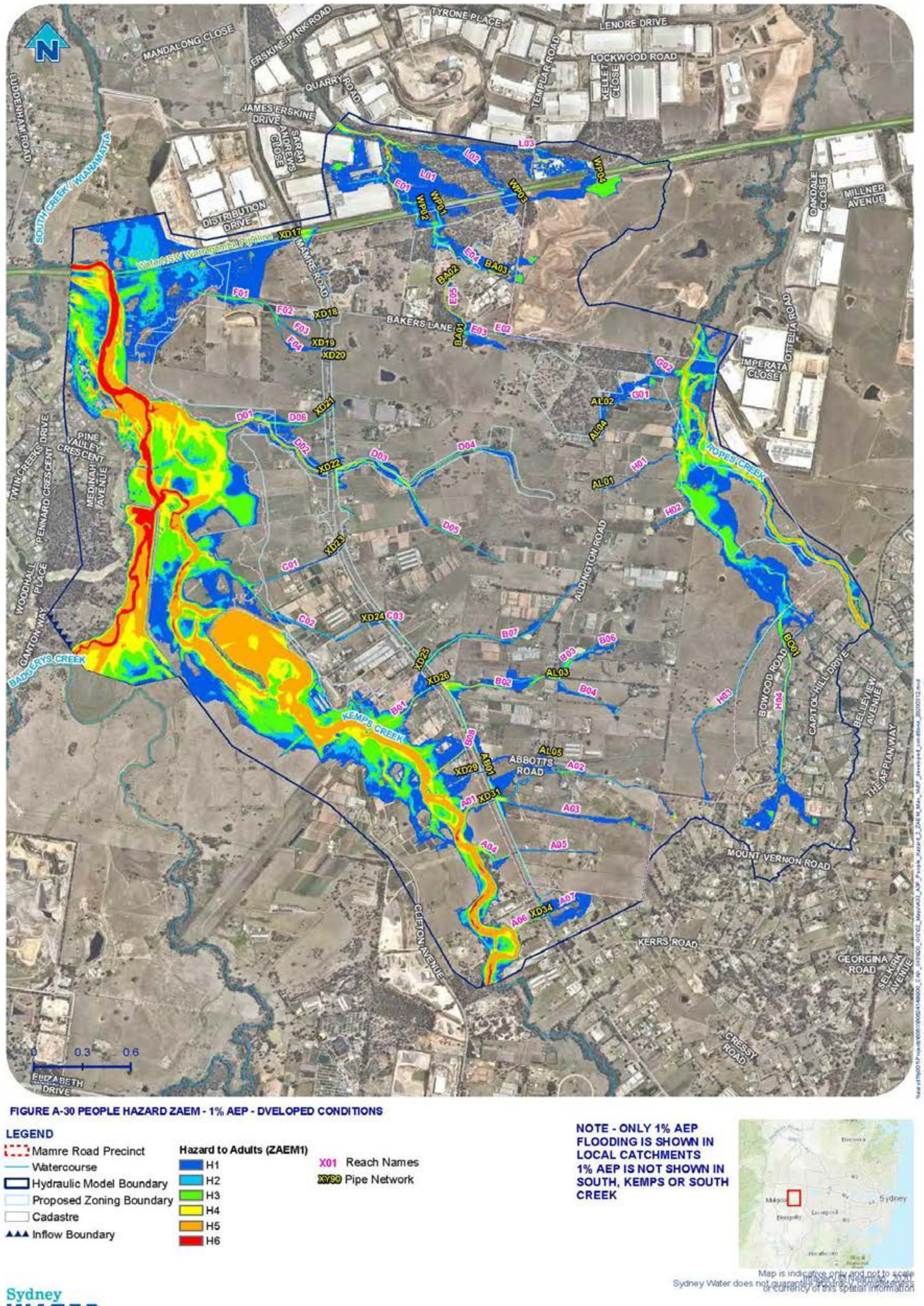


Figure A-30 People hazard ZAEM – 1% AEP developed conditions

## Water Servicing

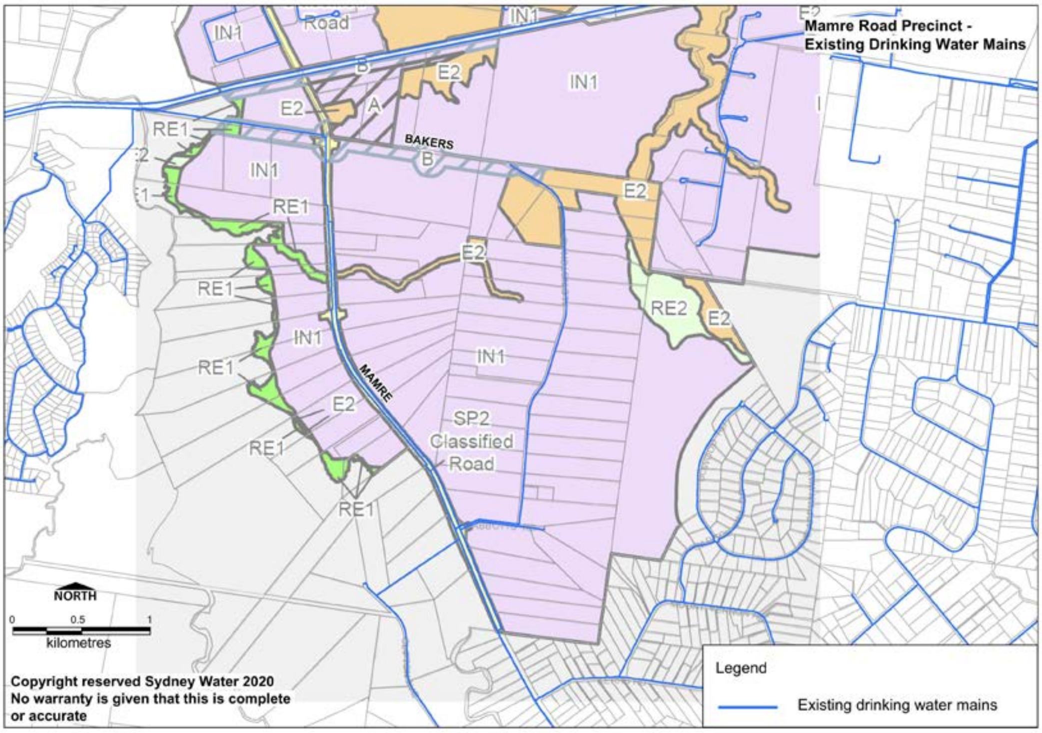


Figure A-31 Mamre Road Existing Drinking Water

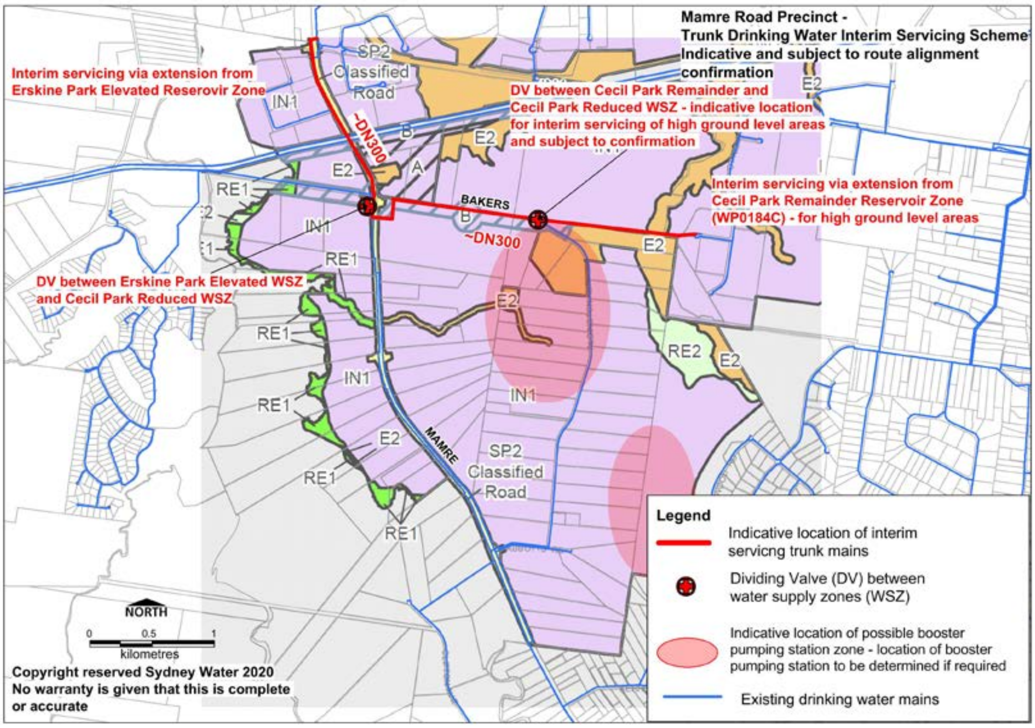


Figure A-32 Mamre Road Interim Drinking Water

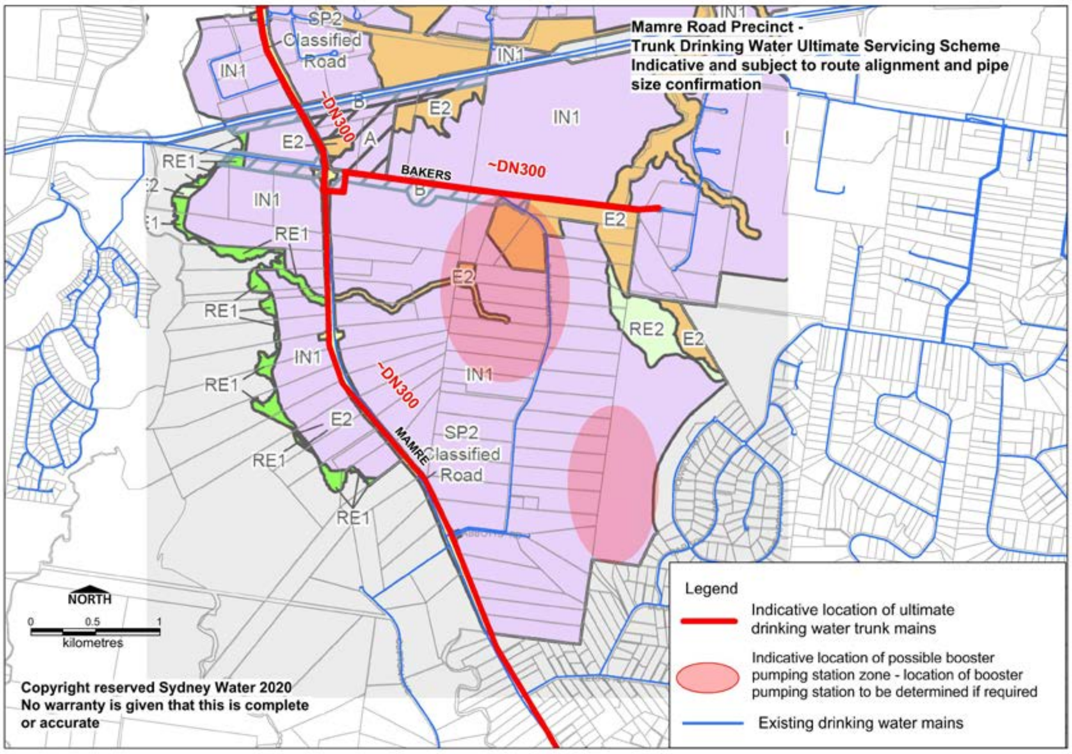


Figure A-33 Mamre Road Ultimate Drinking Water

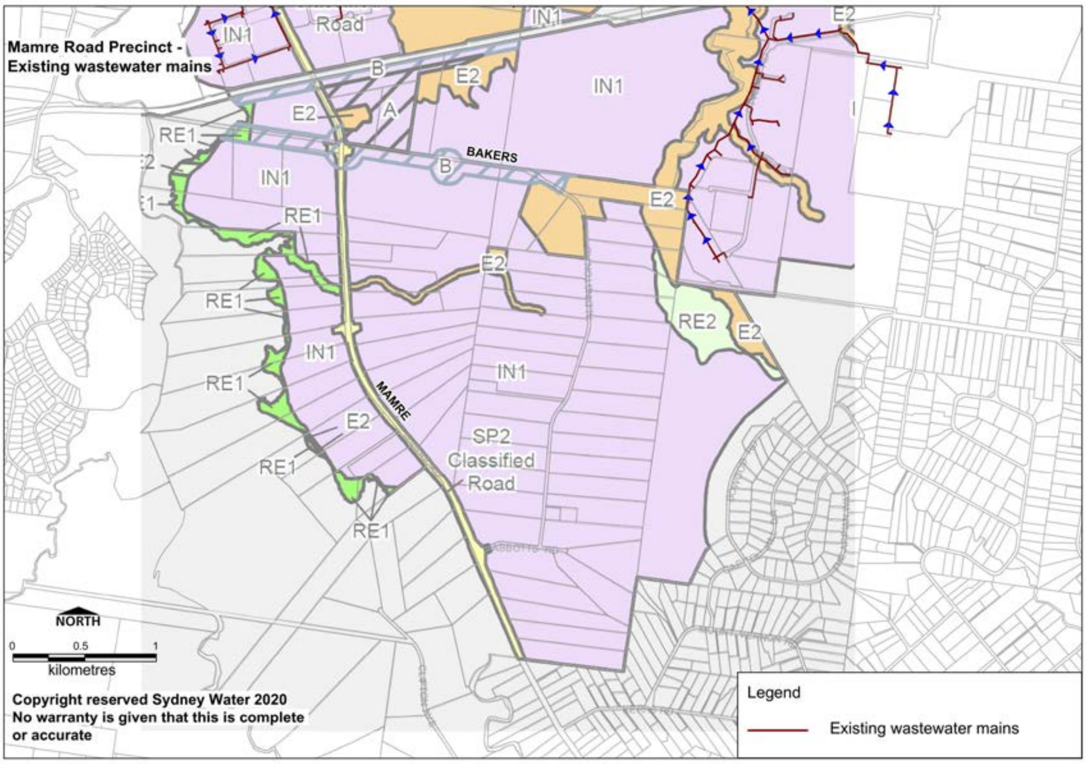


Figure A-34 Mamre Road Existing Waste Water

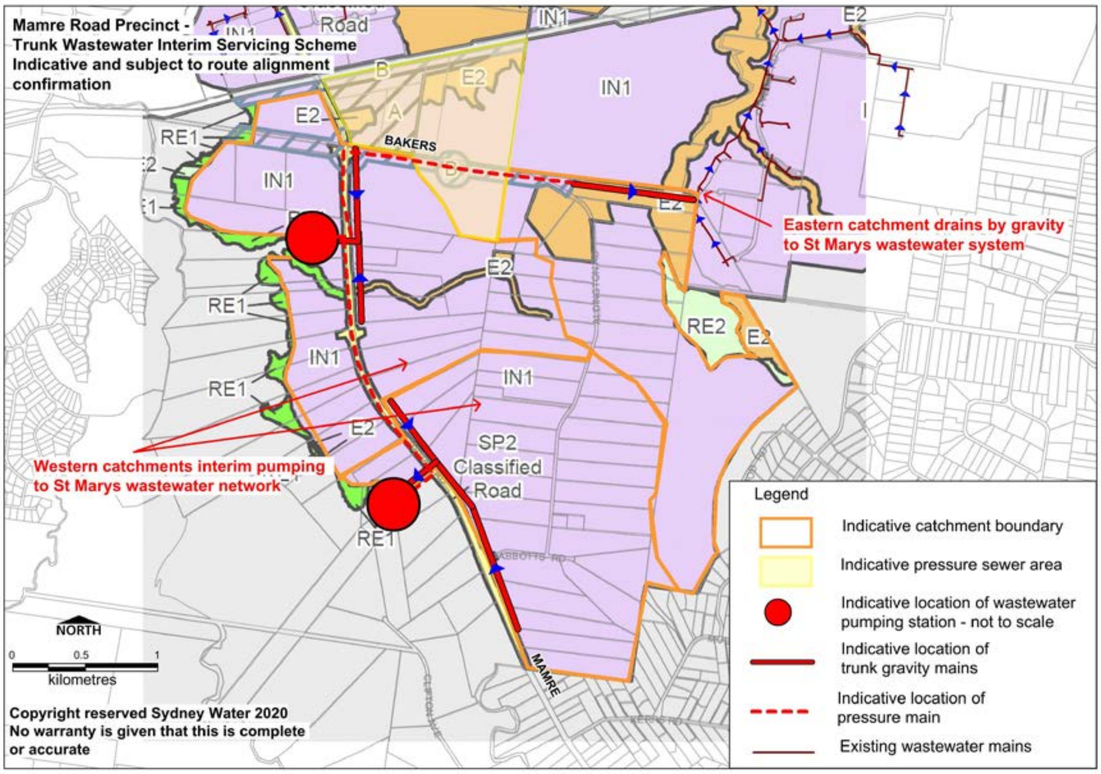


Figure A-35 Mamre Road Interim Waste Water

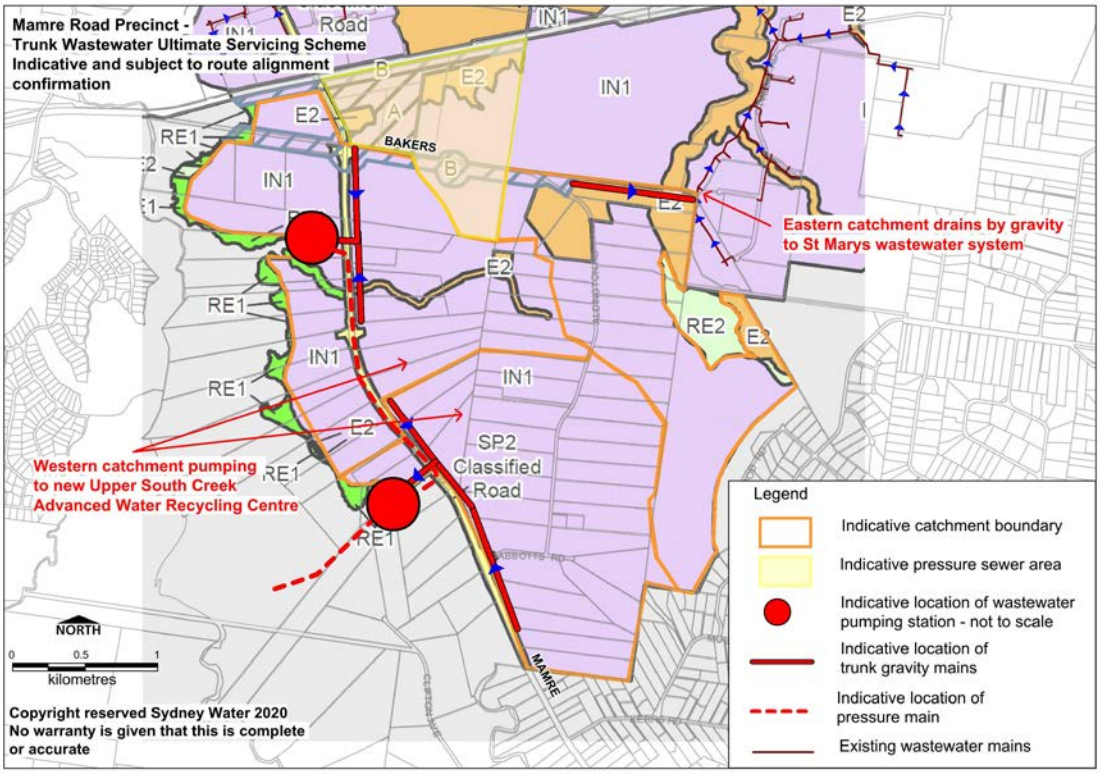


Figure A-36 Mamre Road Ultimate Wastewater

# Appendix B Adopted Culvert Sizes

Table 14 Existing Mamre Road Precinct culverts

| Culvert Name | Dimension / Type (m) | Upstream Invert (mAHD) | Downstream Invert (mAHD) | Note |
|---|---|---|---|---|
| AB01 | 3x0.6 RCP | 42.39 | 42.3 | Assumed elevation based on available survey data and aerial imagery |
| AL01 | 1x0.3 RCP | 78.07 | 77.21 | Assumed elevation based on available survey data and aerial imagery |
| AL02 | 1x0.3 RCP | 71.09 | 69.91 | Assumed elevation based on available survey data and aerial imagery |
| AL03 | 2x0.6 RCP | 51.93 | 51.8 | Assumed elevation based on available survey data and aerial imagery |
| AL04 | 1x0.3 RCP | 74.46 | 73.96 | Assumed elevation based on available survey data and aerial imagery |
| AL05 | 2x0.3 RCP | 49.96 | 49.73 | Assumed elevation based on available survey data and aerial imagery |
| BA01 | 1x0.6 RCP | 53.63 | 53.04 | Assumed elevation based on available survey data and aerial imagery |
| BA02 | 3x1.8x0.6 RCBC | 48.23 | 48.02 | Assumed elevation based on available survey data and aerial imagery |
| BA03 | 2x0.525 RCP | 51 | 50.8 | Assumed elevation based on available survey data and aerial imagery |
| BO01 | 3x1.8x0.6 RCBC | 68.07 | 68 | Assumed elevation based on available survey data and aerial imagery |
| WP01 | 1x0.6 RCP | 43.89 | 43.78 | Assumed elevation based on available survey data and aerial imagery |
| WP02 | 1x0.6 RCP | 43.33 | 43.21 | Assumed elevation based on available survey data and aerial imagery |
| WP03 | 1x0.6 RCP | 48.51 | 48.25 | Assumed elevation based on available survey data and aerial imagery |
| WP04 | 1x0.6 RCP | 54 | 51.6 | Assumed elevation based on available survey data and aerial imagery |
| XD17 | 1x0.45 RCP | 39 | 38.88 | From L&A flooding investigation |

| Culvert Name | Dimension / Type (m) | Upstream Invert (mAHD) | Downstream Invert (mAHD) | Note |
|---|---|---|---|---|
| XD18 | 1x0.525 RCP | 44.07 | 43.56 | From L&A flooding investigation |
| XD19 | 1x0.525 RCP | 42.88 | 42.597 | From L&A flooding investigation |
| XD20 | 1x0.525 RCP | 42.63 | 42.41 | From L&A flooding investigation |
| XD21 | 2x0.6 RCP | 38.95 | 38.9 | From L&A flooding investigation |
| XD22 | 3x1.8x0.6 RCBC | 39.58 | 39.2 | From L&A flooding investigation |
| XD23 | 2x0.45 RCP | 46.9 | 46.84 | From L&A flooding investigation |
| XD24 | 2x0.6 RCP | 47.77 | 47.72 | From L&A flooding investigation |
| XD25 | 3x1.8x0.6 RCBC | 43.34 | 43.28 | From L&A flooding investigation |
| XD26 | 4x1.05 RCP | 42.76 | 42.48 | From L&A flooding investigation |
| XD27 | 3x0.45 RCP | 43.14 | 42.95 | From L&A flooding investigation |
| XD28 | 4x0.375 RCP | 41.88 | 41.67 | From L&A flooding investigation |
| XD29 | 2x0.6 RCP | 42.25 | 42.04 | From L&A flooding investigation |
| XD30 | 2x0.6 RCP | 42 | 41.8 | From L&A flooding investigation |
| XD31 | 2x0.525 RCP | 42.38 | 42.31 | From L&A flooding investigation |
| XD32 | 3x0.525 RCP | 42.56 | 42.46 | From L&A flooding investigation |
| XD33 | 2x0.6 RCP | 42.72 | 42.52 | From L&A flooding investigation |
| XD34 | 3x0.6 RCP | 42.52 | 42.43 | From L&A flooding investigation |

Table 15 Developed Mamre Road Precinct culverts

| Culvert Name | Dimension / Type (m) | Upstream Invert (mAHD) | Downstream Invert (mAHD) | Note |
|---|---|---|---|---|
| AB01 | 3x0.6 RCP | 42.39 | 42.3 | Assumed elevation based on available survey data |

| Culvert Name | Dimension / Type (m) | Upstream Invert (mAHD) | Downstream Invert (mAHD) | Note |
|---|---|---|---|---|
| AL01 | 1x0.3 RCP | 78.07 | 77.21 | Assumed elevation based on available survey data |
| AL02 | 1x0.3 RCP | 71.09 | 69.91 | Assumed elevation based on available survey data |
| AL03 | 3x1.52x1.52 RCBC | 51.23 | 51.07 | Assumed elevation based on available survey data |
| AL04 | 1x0.3 RCP | 74.46 | 73.96 | Assumed elevation based on available survey data |
| AL05 | 2x0.3 RCP | 49.96 | 49.73 | Assumed elevation based on available survey data |
| BA01 | 3x1.8x0.9 RCBC | 53.67 | 53.48 | Assumed elevation based on available survey data |
| BA02 | 3x1.8x0.6 RCBC | 48.23 | 48.02 | Assumed elevation based on available survey data |
| BA03 | 2x0.525 RCP | 51 | 50.8 | Assumed elevation based on available survey data |
| BO01 | 3x1.8x0.6 RCBC | 68.07 | 68 | Assumed elevation based on available survey data |
| WP01 | 1x0.6 RCP | 43.89 | 43.78 | Assumed elevation based on available survey data |
| WP02 | 1x0.6 RCP | 43.33 | 43.21 | Assumed elevation based on available survey data |
| WP03 | 1x0.6 RCP | 48.51 | 48.25 | Assumed elevation based on available survey data |
| WP04 | 1x0.6 RCP | 54 | 51.6 | Assumed elevation based on available survey data |
| XD17 | 1x1.65 RCP | 38.15 | 37.78 | From L&A flooding investigation |
| XD18 | 1x0.825 RCP | 43.09 | 42.62 | From L&A flooding investigation |
| XD19 | 1x0.75 RCP | 42.23 | 41.98 | From L&A flooding investigation |
| XD20 | 1x0.6 RCP | 42.02 | 41.75 | From L&A flooding investigation |
| XD21 | 3x1.05 RCP | 38.6 | 38 | From L&A flooding investigation |
| XD22 | 3x2.7x0.9 RCBC | 39.06 | 38.8 | From L&A flooding investigation |
| XD23 | 1x0.9 RCP | 45.69 | 45.4 | From L&A flooding investigation |
| XD24 | 1x0.825 RCP | 46.91 | 46.6 | From L&A flooding investigation |
| XD25 | 3x1.5x0.9 RCBC | 42.87 | 42.6 | From L&A flooding investigation |
| XD25b | 1x0.375 RCP | 42.64 | 41.95 | From L&A flooding investigation |
| XD26 | 2x0.9 RCP | 42.6 | 42.1 | From L&A flooding investigation |
| XD28 | 3x1.5x0.9 RCBC | 41.67 | 41.1 | From L&A flooding investigation |
| XD29 | 1x0.9 RCP | 41.93 | 41.59 | From L&A flooding investigation |
| XD31 | 3x1.2x0.75 RCBC | 41.6 | 40.8 | From L&A flooding investigation |
| XD32 | 1x2.4x0.9 RCBC | 41.64 | 41.1 | From L&A flooding investigation |

| Culvert Name | Dimension / Type (m) | Upstream Invert (mAHD) | Downstream Invert (mAHD) | Note |
|---|---|---|---|---|
| XD34 | 3x2.4x0.9 RCBC | 42.46 | 42.2 | From L&A flooding investigation |

# Appendix C Peak Flow Rates

Table 16 Existing scenario peak flow rate ($m^3/s$)

| Reporting Location | 1EY | 5% AEP | 1% AEP | | 0.2% AEP | PMF |
|---|---|---|---|---|---|---|
| Q01 | 0.7 | 4.2 | 5.0 | **5.3** | 6.4 | 61.0 |
| Q02 | 0.2 | 0.5 | 0.5 | **0.5** | 0.5 | 9.9 |
| Q03 | 0.3 | 1.5 | 1.9 | **2.1** | 2.4 | 19.7 |
| Q04 | 1.0 | 4.3 | 5.5 | **5.3** | 7.1 | 46.7 |
| Q05 | 1.8 | 7.5 | 9.7 | **9.8** | 12.2 | 80.3 |
| Q06 | 0.4 | 1.2 | 1.5 | **1.4** | 1.8 | 10.7 |
| Q07 | 0.3 | 3.0 | 6.5 | **6.7** | 9.9 | 69.7 |
| Q08 | 0.3 | 1.0 | 1.1 | **0.1** | 1.3 | 19.7 |
| Q09 | 0.8 | 6.1 | 8.7 | **8.7** | 12.1 | 77.9 |
| Q10 | 0.7 | 5.5 | 8.7 | **11.8** | 11.5 | 81.4 |
| Q11 | 0.3 | 1.4 | 1.8 | **3.3** | 2.3 | 22.6 |
| Q12 | 0.7 | 3.4 | 4.3 | **6.5** | 5.6 | 36.8 |
| Q13 | 1.5 | 8.7 | 12.3 | **20.3** | 20.8 | 140.2 |
| Q14 | 1.5 | 4.0 | 6.1 | **10.5** | 8.0 | 55.0 |
| Q15 | 2.4 | 11.6 | 15.9 | **17.5** | 20.1 | 145.7 |
| Q16 | 0.7 | 2.6 | 3.3 | **3.2** | 4.2 | 27.6 |
| Q17 | 0.5 | 1.1 | 1.6 | **2.0** | 2.2 | 16.7 |

Table 17 Developed scenario peak flow rates ($m^3/s$)

| Reporting Location | 1EY | 5% AEP | 1% AEP | 0.2% AEP | PMF |
|---|---|---|---|---|---|
| Q01 | 1.0 | 4.1 | 5.3 | 6.8 | 59.3 |
| Q02 | 0.2 | 0.5 | 0.5 | 0.6 | 10.6 |
| Q03 | 0.4 | 1.7 | 2.1 | 2.6 | 20.3 |
| Q04 | 1.0 | 4.2 | 5.3 | 6.8 | 44.9 |
| Q05 | 1.8 | 7.7 | 9.8 | 12.3 | 79.2 |
| Q06 | 0.3 | 1.1 | 1.4 | 1.6 | 10.7 |
| Q07 | 1.7 | 6.2 | 6.7 | 8.6 | 108.2 |
| Q08 | 0.1 | 0.1 | 0.1 | 0.1 | 9.2 |
| Q09 | 0.5 | 6.0 | 8.7 | 11.3 | 45.0 |
| Q10 | 4.2 | 9.7 | 11.8 | 14.6 | 87.4 |
| Q11 | 0.6 | 2.7 | 3.3 | 4.3 | 16.7 |
| Q12 | 1.4 | 5.2 | 6.5 | 7.8 | 40.3 |
| Q13 | 4.5 | 16.7 | 20.3 | 24.8 | 129.0 |
| Q14 | 1.9 | 8.0 | 10.5 | 12.7 | 64.6 |
| Q15 | 3.4 | 14.2 | 17.5 | 21.4 | 152.6 |
| Q16 | 0.7 | 2.5 | 3.2 | 4.0 | 25.9 |
| Q17 | 0.5 | 1.6 | 2.0 | 2.7 | 20.5 |

# Appendix D Summary of Adopted Parameters

An overview of the adopted design criteria and parameters for the urban form, hydrologic and hydraulic investigations are summarised in the Table below.

| Item | Standard/Source | Adopted | Comment |
|---|---|---|---|
| **Urban Form** | | | |
| Standard Industrial Lots | Blacktown Council WSUD Guidelines | 90% impervious (as a percentage of the total lot)<br>- 51% roof<br>- 29% hardstand<br>- 10% car park<br>- 10% landscape | Sanity checked against GIS mapping for Erskine Park north of the Precinct |
| New parkland Industrial Lots | Architectus *Urban Form and Water Management* | 68% impervious<br>- 51% roof<br>- 12% hardstand<br>- 5% car park<br>- 17% permeable pavement<br>- 15% landscape | |
| Standard Business campus | | 80% impervious<br>- 25% roof<br>- 15% paving<br>- 40% car park and service road<br>- 20% landscape | |
| New parkland Business campus | Architectus *Urban Form and Water Management* | 60% impervious<br>- 25% roof<br>- 15% paving<br>- 20% car park and service road<br>- 20% permeable pavement<br>- 20% landscape | |
| Standard Dedicated public roads | PCC DCP2014 Part C10 | 7% of precinct is roads<br>60% impervious<br>- 78% pavements<br>- 12% landscape | As measured from Altis SSDA |
| New parkland Dedicated public roads | Mamre Road land holder investigation | 7% | |
| Grades | Association of Consulting Structural Engineers – Hail Loading on Rooves | Roof Grade >3%<br><br>Pavements ~1% | Roof slopes below 3 degrees are at significant risk of hail ponding and failure |
| | | | |

| | | | |
|---|---|---|---|
| **Hydrology** | | | |
| Pipe Drainage Network (Minor) | Design Guidelines for Engineering Works on Subdivisions and Developments, 1997 | 5% Annual Exceedance Probability | Minor drainage network capacity |
| Trunk Drainage Network (Major) | Design Guidelines for Engineering Works on Subdivisions and Developments, 1997 | 1% Annual Exceedance Probability | Flows exceeding minor drainage network capacity overflow to streets |
| ARR1987 Design Rainfall | Australian Rainfall and Runoff | ARR1987 for rainfall on grid<br>ARR2019 for hydrologic – hydraulic modelling | Losses adopted from 2015 Worley Parsons XP RAFTS model |
| Rural Rainfall Losses | As endorsed by DPIE/OEH for new rezoning studies | **Node 9.06**<br>Existing IL = 37.1mm<br>Existing CL = 0.91 mm/h<br>**Node 1.17**<br>Existing IL = 33.9mm<br>Existing CL = 0.91 mm/h | Taken from 2015 Worley Parsons XP RAFTS layers (node |
| Urban Rainfall Losses | As endorsed by DPIE/OEH for new rezoning studies | Pervious IL = 10mm<br>Pervious CL = 2.5mm/h<br>Imperv. IL = 1.0 mm<br>Imperv. CL = 0.0 mm/h | Applied in flood modelling |
| Pervious Catchment Roughness (PERN) | | Rural or landscaped 0.04<br>Urban impervious 0.02 | |
| **Hydraulics** | | | |
| Flood impact | Recommended criteria under Draft South Creek Floodplain Risk Management Study | Peak flood levels not increased by more than 0.02 m (20 mm) outside of the development site | Represents a change from the current DCP which allows 100mm increase in flood afflux outside the Precinct which is not accepted as best practice<br>. |
| **Flood and Overland Flow** | | | |
| Appropriate Safety Criteria for People | Stormwater Drainage Specifications for Building Developments | Max. Depth x Velocity = $0.4m^2s^{-1}$<br>Max. Depth = 0.8m<br>Max. Velocity = $2.0ms^{-1}$ | |
| Manning's Coefficient | | Lots/Road/Paved Areas Only = 0.02<br>Rural = 0.04<br>South Creek in-bank areas = 0.06 to 0.08 | Consistent with *Mamre Road Flooding and Drainage Investigation* |

| | | |
|---|---|---|
| | | South Creek over-bank areas = 0.045 to 0.10<br>Allotments = 0.10<br>Detention basin = 0.06 |
| Onsite Stormwater Detention | | |
| Outlet control | Stormwater Drainage Specifications for Building Developments | 1% AEP flood level at the discharge point<br>Submerged outlets not approved |
| OSD for industrial lots | | On-site detention to match 50% and 1% AEP pre dev flow rates via 2-stage outlets |
| OSD for roads | | Council controlled basins where possible with on-lot measures to compensate for the shortfall |
| **Treatment Train Details** | | |
| Floodway | | Inverts – match existing<br>Base width – Varies<br>Side batter – 1(V):4(H)<br>Mannings – 0.06 |
| Site set backs | | 20m on each boundary<br>10m as |
| Rainwater tanks | | At least 80 ML/Ha |
| Biofiltration street trees | Wianamatta Street Tree | Annual water demand – 18.25kL/tree |
| Detention basing | | Online if 2nd Order<br>Side batter – 1(V):6(H) |

# Appendix E  Riparian Corridor Management Plan

# Appendix F Vegetated Trunk Drainage Sizing

## Factors Considered for the Commencement of Naturalised Trunk Drainage within the Aerotropolis Precincts.

Naturalised trunk drainage has increasingly become a part of greenfield development. It is often adopted when considering the safe and economic conveyance of overland flows (often referred to as pluvial flows). This discussion paper will consider controlling influences such as existing creeks, catchment size and safety when choosing the point to initiate trunk drainage. The economics are not considered, in this paper, as there are many individual issues that will control the economics of a pluvial system.

The rainfall data used is based on Bureau of Meteorology (BOM), from ARR Hub, for areas adjacent to South Creek within the Aerotropolis precincts. The charts produced have utilised this data in a "smoothed" format to provide an indication of appropriate trunk drainage initiation point and will require appropriate hydrologic and hydraulic modelling to produce formalised designs. The conclusions drawn from this data will be generally appropriate for areas in western Sydney but may not be suitable for areas with greater or lesser rainfall.

### Natural Constraints

Pluvial flows innately follow the depressions in the topography and in a natural or rural landscape, this can be quite dendritic. Urban development tends to tame these flow paths to suit the efficacy of the urban landscape. This urban taming needs to be considered carefully, and if well thought out will utilise the form of the landscape to its advantage in locating pluvial drainage systems. This may be an iterative process but locating roads, paths and parkland in the natural depressions can greatly assist in safely directing excess flows to the trunk drainage system.

A major constraint that needs to be taken into account is the existing stream structure and the Strahler Order of these streams. This information can be obtained through the Natural Resources Access Regulator (NRAR) or from 1:25,000 topographic maps that indicate the appropriate stream categorisation. Generally, streams of Strahler Order 2 and above will require protection while Order 1 streams can often be realigned with an appropriate Controlled Activity approval. Trunk drainage systems will often commence at, or upstream of the Order 1 streams, with the use of naturalised channels enhancing the stream structure and contributing to the parklands objectives of the Aerotropolis.

### Flowpath Safety

Location of flowpaths and trunk drainage channels should consider the safety of people, vehicles and structures whilst complying with the approval authorities' requirements. Australian Rainfall and Runoff 2019 (ARR 2019) provides guidelines for safe flows by relating hazard ratings to flow velocities and depth. Councils will often have a gutter flow width that is related to the design standard of the street stormwater drainage system. Typically, the street systems are designed to either a 5% or 10% AEP while the pluvial overland flows are considered to the 1% AEP standard. Although the design standard for these systems are set, there needs to be an understanding of the hazard from flows greater than the standard with an allowance for safe failure of these systems.

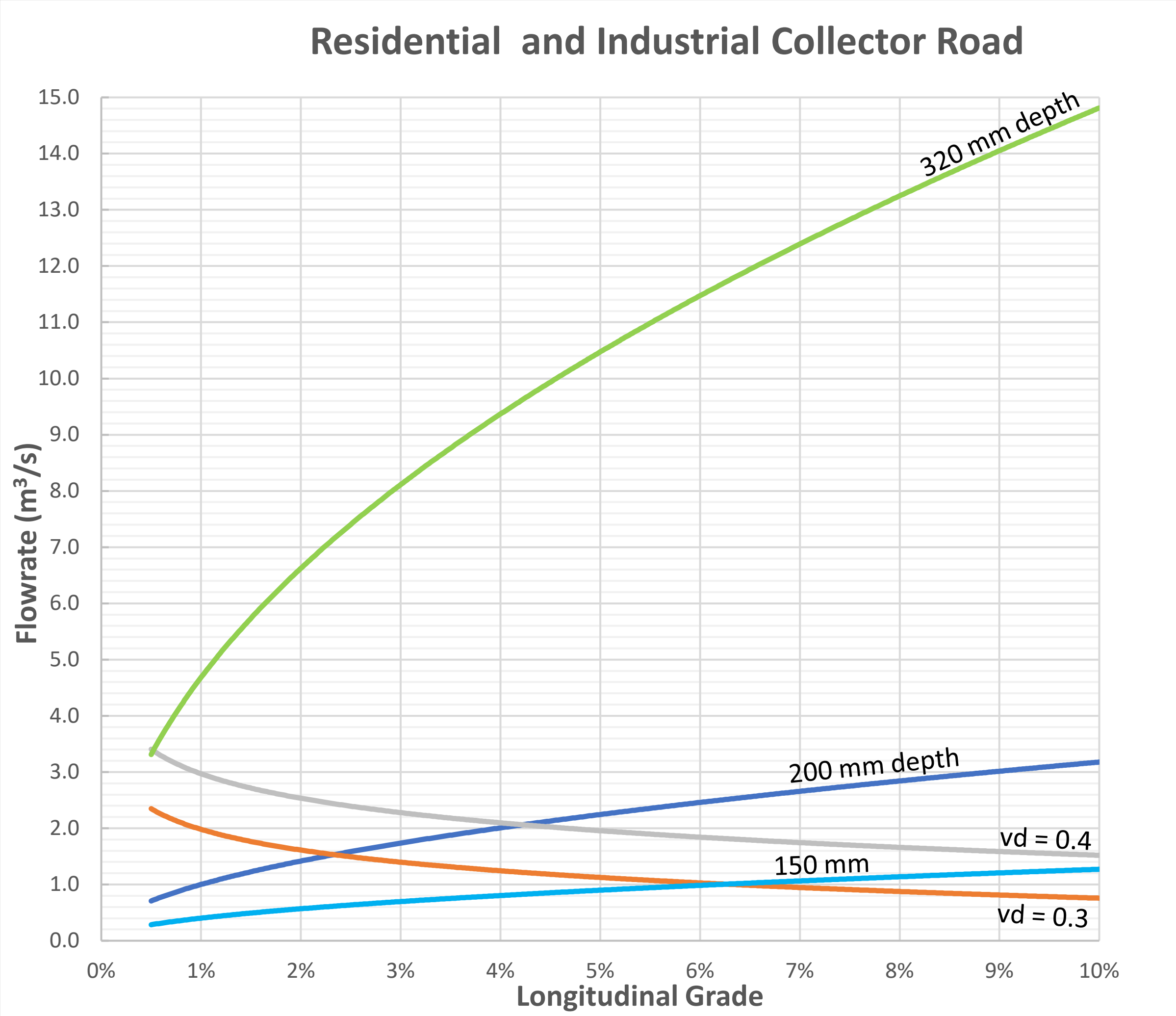


Figure 1 - Flow capacity for full carriageway width flow

ARR 2019 (Book 9 Ck 5 Sect 5.6.2) suggests a maximum street flow depth of 200 mm and a velocity depth product of 0.3 $m^2/s$ for parked vehicles and 0.4 $m^2/s$ for pedestrians. This is shown in Figure 1 and is related to typical residential and industrial collector road profiles.

This figure is indicative of the potential full width flowrates for collector roads as shown in Figure 2 and Figure 3. The 320 mm depth is about the maximum depth that can be achieved in these sections while keeping flows in the road reserve. These flows are above those that can be safely conveyed under the ARR 2019 guidelines, but this curve can be of assistance to assess fail safe solutions for flows greater than the design standards. Other considerations would include whether the vehicle access to a property is lower than the standard kerb height and the potential 200 mm depth of flow. The 150 mm depth curve has been included to show typical “gutter full” situations.

These curves were produced using Mannings formula with a slight increase in the typical Mannings ‘n’ to allow for the potential of parked vehicles and increased vegetation in line with the parkland’s objectives.  These should be seen as a tool to establish a starting point for investigation and design  To accurately assess the hazards in a design case the peak flow from the upstream catchment should be hydraulically modelled in the proposed road cross-section and assessment made of the topography adjacent to the road reserve to ensure that flows will be contained as intended.

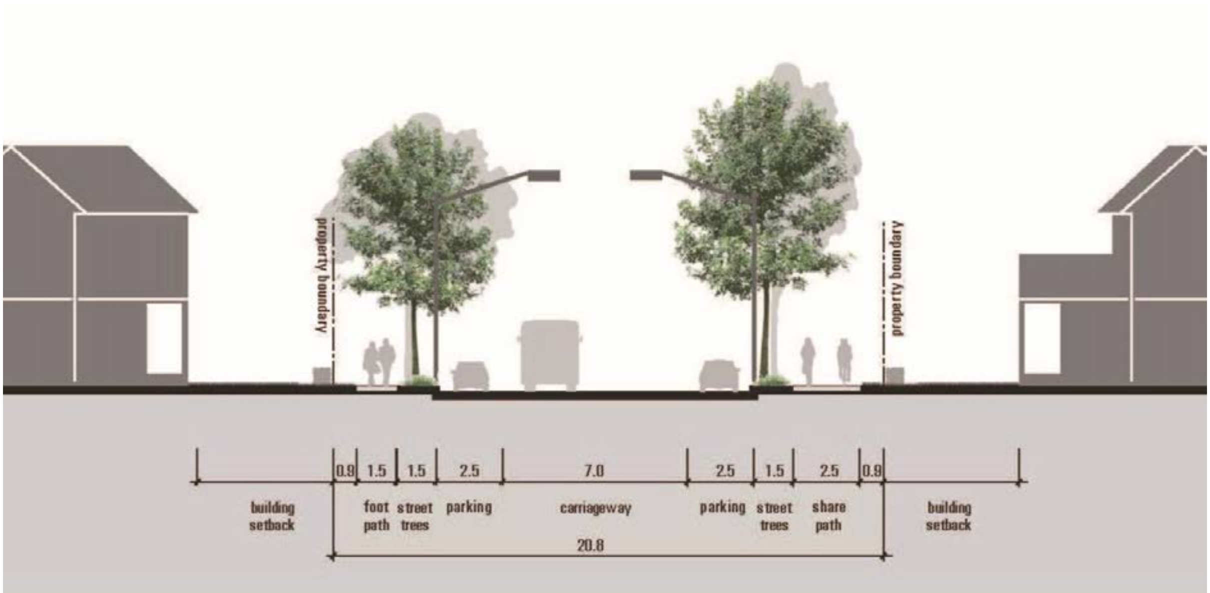


Figure 2 - Example of Residential Collector Road

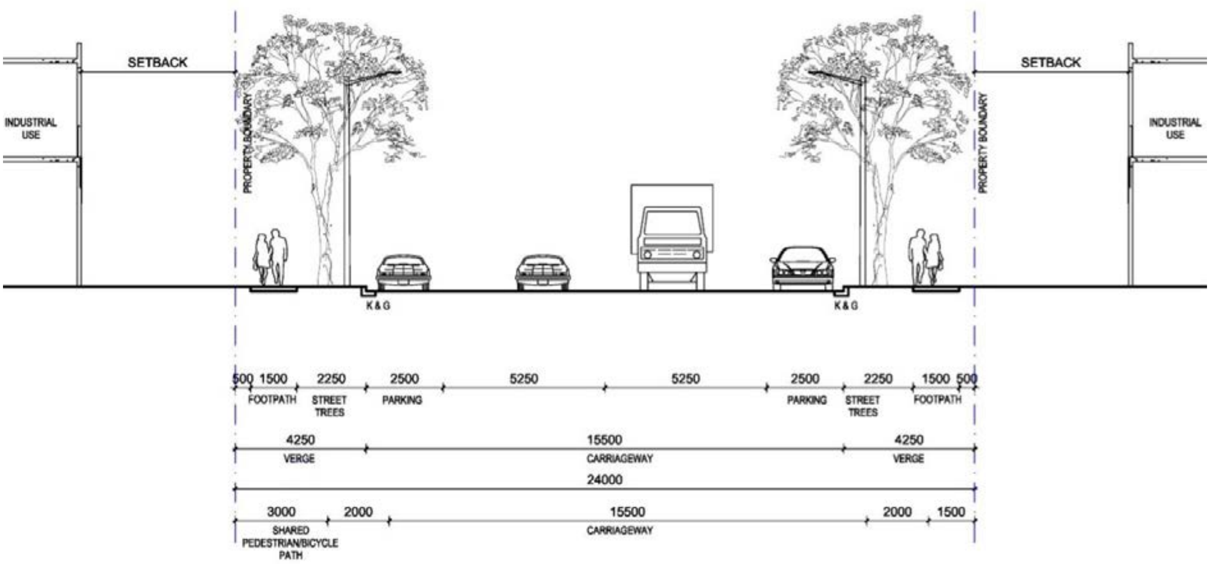


Figure 3 - Example of Industrial Collector Road

## Catchment Flows

The flows presented in the Figures 4, 5 and 6 were modelled using the RORB hydrologic model, considering catchment sizes of 10ha, 15ha, 20ha and 25ha. Each catchment was assessed with a range of imperviousness from 0% to 100%.

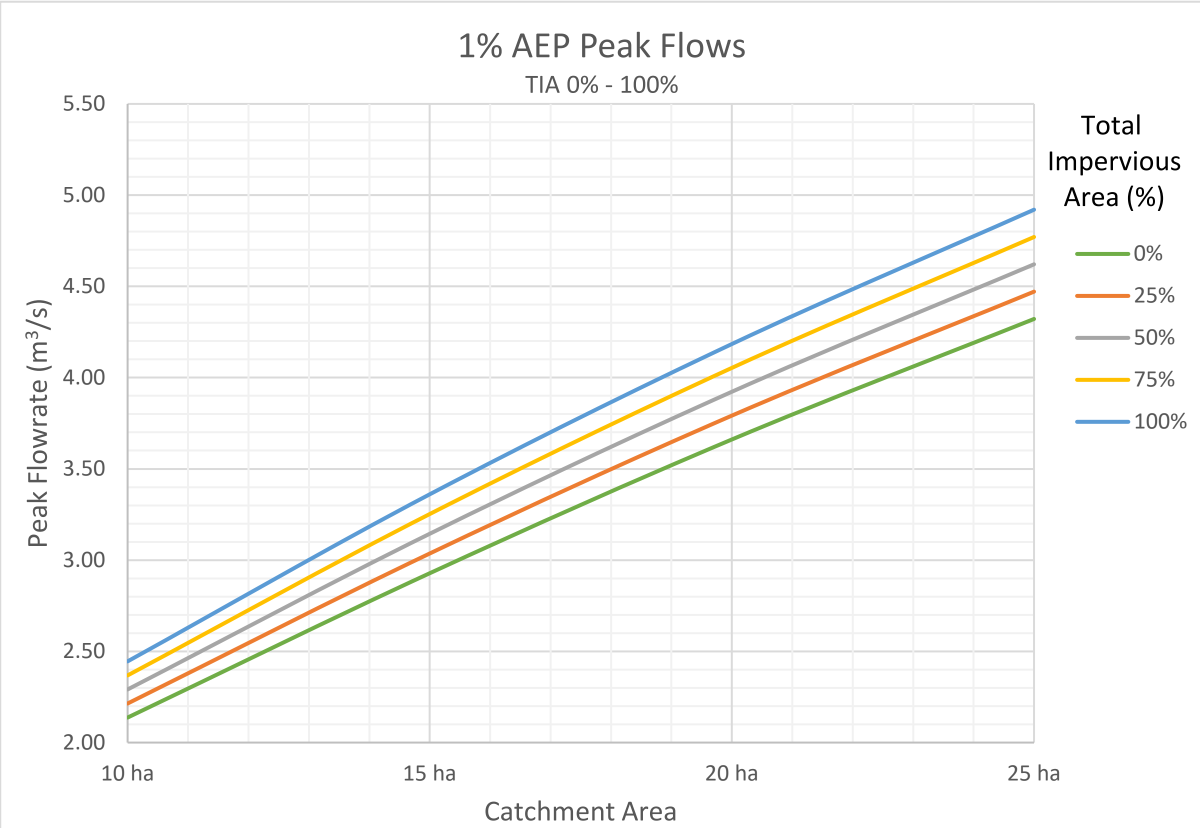


Figure 4 - Peak 1% AEP Flows for Varying TIA

The peak flow from a catchment will vary depending on the total impervious area (TIA) and the effective impervious area (EIA). The principles for this are described in ARR 2019 and for modelling purposes EIA was considered to be 66.6% of TIA.

Figure 4 shows the peak 1% AEP flowrate for the four catchment areas with a range of imperviousness from 0% to 100%. This range was shown for completeness, but the parklands objectives suggest that the imperviousness will be more mid-range and less than current business-as-usual. The modelling makes no assessment of possible site retention/detention of stormwater but is a raw discharge flowrate. These curves can be refined if DPIE-EES guidelines suggest stormwater flows are retained onsite but will be dependent on what design standards are adopted for any retention.

Figures 5 and 6 show the potential flowrates within the road sections with a reduction for flows conveyed in the street drainage system. Typically, the street drainage systems will have a 5% or 10% AEP design standard. Figure 5 shows the 1% AEP flowrate minus the 10% AEP flow and Figure 6 shows the 1% AEP flowrate minus the 5% AEP flow. Design standards for the roadway drainage are available from the local council and may also include allowances for blockage of pit and pipe systems.

An alternative to conveying pluvial flows through the roads and stormwater drainage is the possibility for flowpaths within large lots. This may be an approach suitable for large industrial developments but will require an assessment of the flows and how they can be conveyed in a safe manner to a trunk drainage or creek system. These pluvial flowpaths should be designed considering the guidelines in ARR 2019 and the approval authority requirements.

**Discussion**

From Figure 1 it can be seen that, depending on the road grade the safe flow rates vary between 0.76 $m^3/s$ to 1.53 $m^3/s$ using the ARR 2019 guidelines. It also indicates that maximum gutter full flows will range between 0.4 $m^3/s$ and 1.2 $m^3/s$. Also, from the Figures 5 and 6 it can be seen that, for street drainage systems designed to convey 5% AEP flows, trunk drainage should commence when about 10 – 16 ha of catchment contribute flows. While for 10% AEP drainage systems the commencement point for trunk drainage is about 10 – 12.5 ha. This assists in providing safe conveyance of pluvial flows through urban streets

As mentioned previously these are raw numbers that may be influenced by various factors relating to development and on-lot stormwater treatment but give a generalised point to initiate trunk drainage.

Other factors to consider are the location of roads and where they cross topographical depressions. Parklands can influence the placement of trunk drainage as well as the potential location for stormwater quality/quantity basins. All these parts of urban infrastructure can give good initiation points to commence trunk drainage and terminate the street drainage system. Naturalised channels have an advantage for the Aerotropolis precincts as they will assist in the parklands objectives by providing green infrastructure as well as assisting evapotranspiration and cooling the landscape.

**Conclusion**

The information provided in the charts are an indicative tool for concept assessment and in no way replace detailed investigation and design. While the issues controlling the initiation of trunk drainage are varied, a maximum point of commencement can be seen to be about where 15 ha of catchment contribute flows and the street drainage system is designed for a 5% AEP peak flowrate. This drops to 12 ha of contributing catchment where the street drainage system is designed for a 10% AEP peak flowrate.

Adopting a 5% AEP design standard for street drainage conveying significant pluvial flows may be seen as an acceptable way of considering the initiation point for trunk drainage.

This is suitable as a general planning tool and does not replace detailed investigation and design.

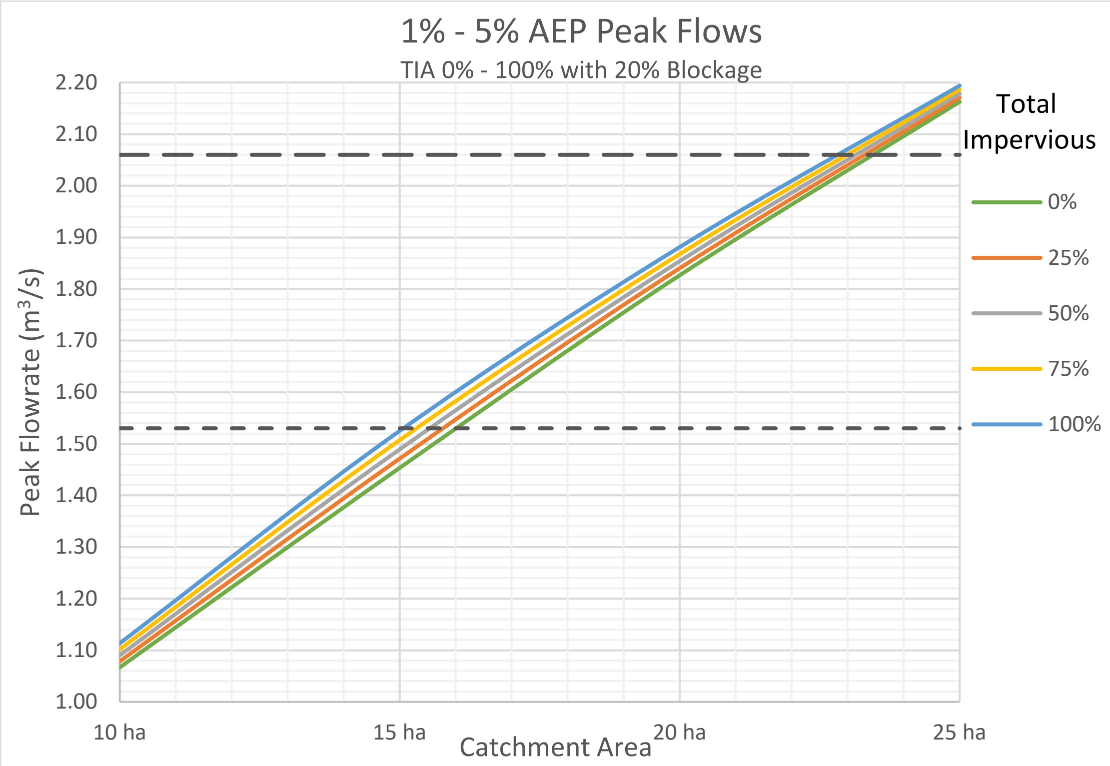


Figure 5 - 1% AEP Street Flows Reduced by 10% AEP Street Drainage

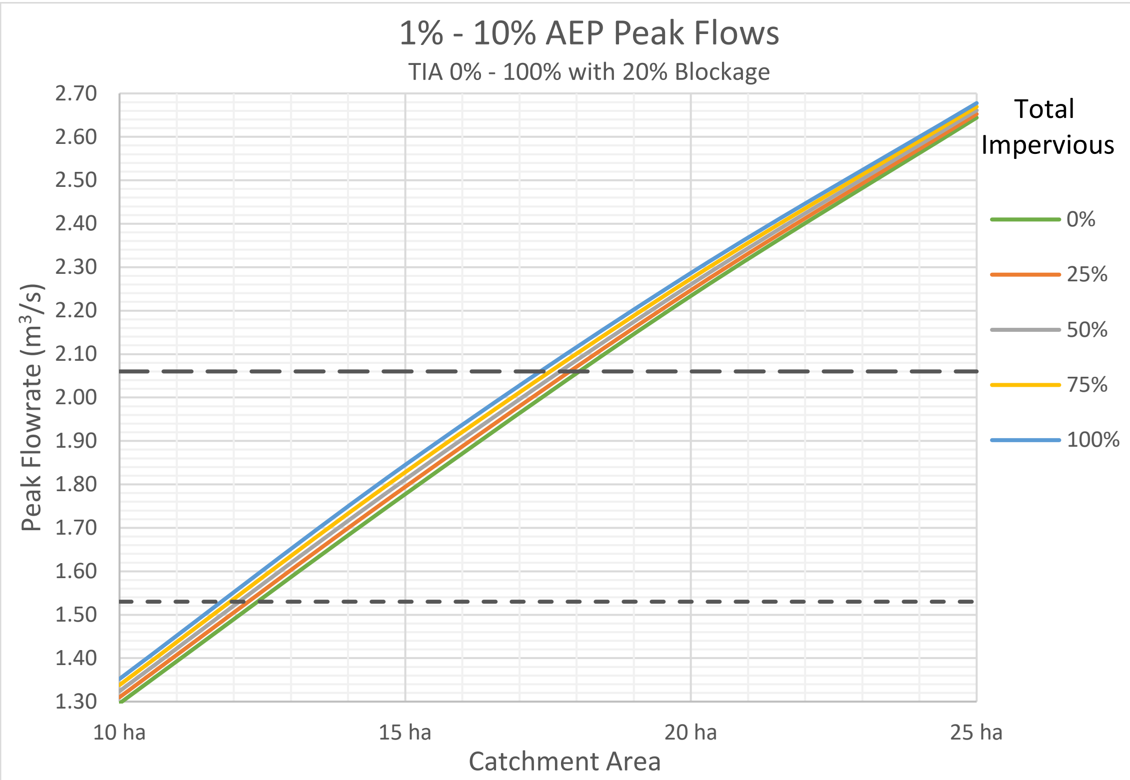


Figure 6 - 1% AEP Street Flows Reduced by 5% AEP Street Drainage