Appendix 3 – Watercycle and Flood Management Strategy

RYDALMERE DEVELOPMENT PRECINCT

WATERCYCLE & FLOOD MANAGEMENT STRATEGY REPORT

Initial Investigation

SUSTAINABLE CERTIFICATION
ISO9001:2008
AS/NZS 4801:2001
ISO 14001:2004
Endorsed
Integrated Management System

Quality
Safety
Environment

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS

Rydalmere Precinct

Watercycle & Flood Management Strategy Report

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PO Box 4366, PENRITH WESTFIELD, NSW 2750
580 High Street, PENRITH, NSW 2750
P 02 4720 3300
W www.jwprince.com.au
E jwp@jwprince.com.au

J. WYNDHAM PRINCE

CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS

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1 INTRODUCTION

This *Water Cycle & Flood Management Strategy Report* has been prepared on behalf of Property NSW to support a planning proposal to amend of the Parramatta Local Environmental Plan (PLEP) 2011 to allow for the redevelopment of surplus land in North Parramatta to create a new mixed use precinct.

The new precinct will provide a high density residential development with a diverse range of housing and retail and commercial development with the opportunity for research and education related employment in close proximity to existing and planned public transport nodes. The proposal will allow for the provision of up to 3,000 dwellings and approximately 40,000m^2 of retail and commercial floor space.

The proposal will also deliver community facilities, a significant public open space network and a new public domain to meet the needs of the new community.

1.1 Background

Comprising two adjoining land parcels, the Ageing, Disability and Home Care (ADHC) facility at 266 Victoria Road, North Parramatta and the former Macquarie Boys High School (MBHS) at 26 Kissing Point Road, the Site encompasses approximately 19.4ha in the City of Parramatta LGA. The MBHS was closed by the Department of Education in 2008 and the Site has been vacant since that time. The ADHC facility is still in operation, however, the Site will be vacated by mid-2017.

Property NSW on behalf of Family and Community Services (FACS) and Department of Education (DE) have been charged with responsibility of divesting the Site.

The Site is located north of Rydalmere train station, on the north eastern corner of James Ruse Drive and Victoria Road intersection, bounded to the north by Kissing Point Road and Vineyard Creek. The Site is a 5 - 10 minute walk from Rydalmere Train station, with the potential for improvements in connectivity to further enhance accessibility. The University of Western Sydney's North Parramatta and Parramatta campuses lie to the west and south of the Site offering the potential for synergies between education, research and employment.

The divestment and redevelopment of the Site offers opportunities to:

- Provide a significant urban infill opportunity within the City of Parramatta LGA aligning with the broader Government objectives and the Sydney Metropolitan strategy to increase and accelerate housing supply
- Optimise the Site's strategic location relative to the proposed Western Sydney Light Rail network in terms of increasing density along public transport corridors
- Support FACS and DE's commitment to recycling of capital investment in new and expanded facilities to meet the needs of the community

In line with the above and to provide certainty of housing supply to the market, job creation and development of underutilised assets, Property NSW has developed a concept plan to guide the redevelopment of the Site. The concept plan seeks to satisfy the NSW Government's priorities for the precinct:

- Create a sustainable community with access to employment and education opportunities, community facilities and a high quality of life
- Improve connectivity between the Site and its surrounds in terms of transport, pedestrian and cycling networks and the open space network
- Create a high quality public domain that is legible and activates the precinct

- Enhance the riparian corridor along the boundary of the Site with the potential to deliver the missing link in the Vineyard Creek Corridor and to support the development of Sydney's Green Grid

To realise the vision for the Site articulated in the concept plan, an amendment to the Parramatta Local Environmental Plan (PLEP) 2011 to allow for the redevelopment of surplus land in Parramatta to create a new mixed use precinct.

1.2 Objective

This report details the procedures used and presents the results of investigations undertaken by J. Wyndham Prince in developing a *Water Cycle and Flood Management Strategy* that incorporates the principles of Water Sensitive Urban Design (WSUD) to integrate with and inform the planning process for the Rydalmere Development Precinct.

The objective of this investigation is to identify all stormwater and flood management issues to be considered in the future development of the site consistent based on proposed concept plan to support the rezoning process. These investigations will assess flooding along Vineyard Creek and make recommendations on an appropriate evacuation strategy. The size of location of stormwater devices will also be identified to ensure that the quantity and quality of stormwater leaving the site satisfies statutory requirements.

At this stage, the size and location of devices are located based on empirical methods and best engineering practice. It is noted that further development of the *Water Cycle & Flood Management Strategy* may be required as a condition of the Gateway determination. This assessment would include detailed modelling within both MUSIC (Water Quality) and XP-RAFTS (hydrologic).

This investigation addresses engineering considerations, whilst placing a strong focus on conserving and enhancing the bio-diversity, ecological health and positive water quality benefits in the nearby existing riparian corridors and downstream sensitive areas.

This "initial" investigation includes the following specific tasks:

- Liaise with the Parramatta City Council (Council) to determine their specific requirements for development of the Site.
- Investigate a range of stormwater management and water sensitive urban design measures which may be suitable for the Site. Make recommendations to implement the most appropriate treatment devices to form part of the proposed strategy for the Site.
- Develop a hydrologic analysis within XP-RAFTS to determine the peak flows along Vineyard Creek for the 5% and 1% Annual Exceedance Probability (AEP) events, together with the Probable Maximum Flood (PMF) under "Existing" conditions.
- Develop a two dimensional (2D) hydraulic flood model within TUFLOW to determine the flood extents for the 5%, 1% AEP and PMF events under "Existing" conditions.
- Make comparison of predicted flood extents against previous studies and Council records.
- Determine indicative locations / sizes of detention basins to restrict post- development flows to pre-development levels (based on Upper Parramatta River Catchment Trust (UPRCT) guidelines).
- Identify indicative locations / sizes of water quality devices to achieve Council's and the Office of Environment and Heritage (OEH) water quality targets and the Stream Erosion Index Assessment (based on empirical methods).
- Provide preliminary advice on how an appropriate flood evacuation route may be adopted within the Site.

- Prepare a Draft Water Cycle Management Concept Plan.
- Prepare a *Water Cycle and Flood Management Strategy Report* to support the rezoning for the Site, detailing the investigations, findings, calculations and design details.

2 PREVIOUS REPORTS

2.1 Council Flood Studies

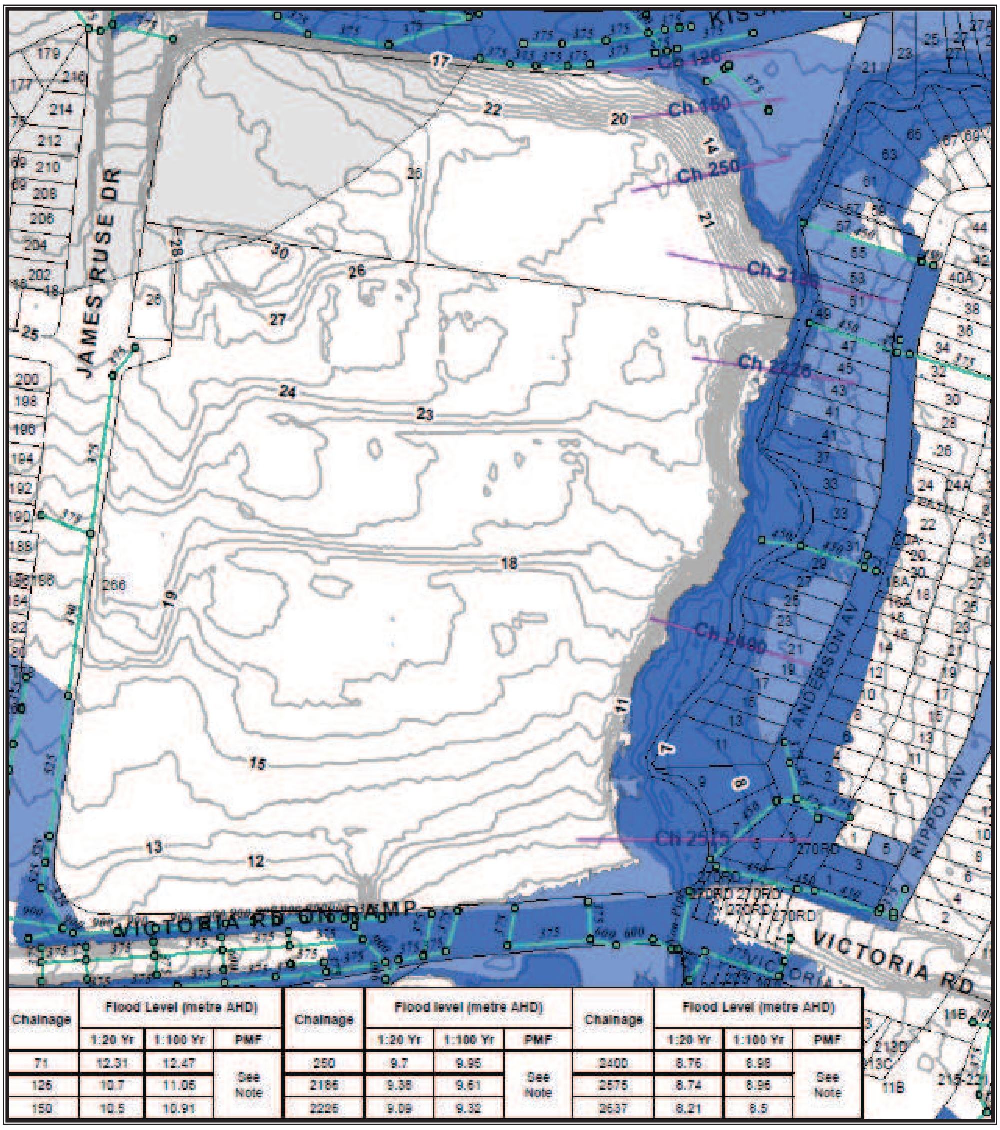
A number of previous flood studies have been undertaken (by others) in the vicinity of the Site on behalf of Council.

Council has provided a copy of the following flood maps from these studies as background information to inform this assessment:

- Vineyard Creek Sub-Catchment Management Plan (SMEC, 2004)
- Rydalmere Knowledge Precinct Flood and Development Control Study (SMEC, 2013)
- Parramatta Drainage (SKM, 1990)

Importantly, the supplied information includes predicted flood extents and heights for the 5%, 1% AEP and PMF events - which can be used for comparison / calibration for this study.

The supplied figure from Vineyard Creek Sub-Catchment Plan (SMEC, 2004) also included a series of cross sections along Vineyard Creek with predicted flood levels being reported in a series of tables across the 5%, 1% AEP and PMF events. The location of each of these cross sections are shown on Plate 2.1 below.



Chainage	Flood Level (metre AHD)			Chainage	Flood level (metre AHD)			Chainage	Flood Level (metre AHD)		
	1:20 Yr	1:100 Yr	PMF		1:20 Yr	1:100 Yr	PMF		1:20 Yr	1:100 Yr	PMF
71	12.31	12.47	See Note	250	9.7	9.95	See Note	2400	8.76	8.98	See Note
126	10.7	11.05		2186	9.38	9.61		2575	8.74	8.96	
150	10.5	10.91		2226	9.09	9.32		2637	8.21	8.5	

PLATE 2.1 – FLOOD DEPTH COMPARISON LOCATIONS (PCC, 2016)

3 THE EXISTING ENVIRONMENT

3.1 The Site

The Site is located within the Parramatta Local Government area and consists of approximately 19.4 Ha of land. It is bounded by three (3) major roads including James Ruse Drive to the west, Victoria Road to the south, Kissing Point Road to the north.

The existing site includes an existing crest towards the northern portion of the site up to approximately RL 30 m AHD. The existing terrain to the north of the crest is within the MBHS portion of the site and generally drains towards Kissing Point Road, whilst the remainder of the site grades towards Victoria Road to the south. There is upwards of 22 m level difference across the site with Victoria Road around RL 8 m AHD.

The existing FACS portion of the site is generally tiered with grass embankments which extend between each of the roadways / rows of dwellings. Existing retaining walls (extending up to around 7 m) are located along the northern and north-west boundaries of the site at the intersection of Kissing Point Road and James Ruse Drive.

An existing Caltex Oil easement bisects the eastern portion of the Site. The oil main is 0.35 m dia with previous investigations confirming that the depth is generally 1.8 – 2.7 m deep but possibly extends to 6 m in steeper locations.

Vineyard Creek runs along the eastern edge of the Site and receives a large upstream catchment which extends up to Pennants Hills Road. Vineyard Creek is a tributary of Parramatta River with its confluence located approximately 700 m to the south. The total catchment to Victoria Road is approximately 357 Ha. Refer to Plate 3.1.

Plate 3.1 – Existing Site

Vineyard Creek is a 2nd order watercourse and receives upstream flows via a number of culvert crossings under Kissing Point Road (8.5 m wide x 4.5 m high culvert and 1.5 m dia pipe). The creek runs north-south along the eastern edge of the site and drains via the existing bridge crossing under Victoria Road (4.8 m wide x 2.8 m high) into Western Sydney University Campus land to the south. Refer to Plate 3.2

Plate 3.2 – Victoria Road Bridge Crossing

Importantly, Vineyard Creek is generally set well clear of the proposed development with a level difference of up to around 14 - 15 m (from the development surface to the creek invert) in the northern portion of the site, which transitions to around 2.5 m level difference near Victoria Road. Refer to Plates 3.3 to 3.5.

Plate 3.3 – Vineyard Creek (Location 1)

Plate 3.4– Vineyard Creek (Location 2)

Plate 3.5 – Vineyard Creek (Location 3)

4 THE PROPOSED DEVELOPMENT

The proposed concept plan for the Site is shown on Plate 4.1. The development will include mixed use development with residential and retail / commercial buildings, open space / public domains, enhanced biodiversity corridor and an arterial road network.

Plate 4.1 – Proposed Concept Plan

5 DEVELOPMENT GUIDELINES, OPPORTUNITIES & CONSTRAINTS

The following guidelines were considered in developing the *Water Cycle Management and Flooding Strategy* for the Site.

5.1 Parramatta City Council DCP (2011)

The stormwater related objectives of DCP 2011 include the following:

- To minimise the quantity of stormwater run-off including changes in flow rate and duration by disconnecting impervious areas.
- To protect and enhance existing natural or constructed drainage networks including channel bed and banks by controlling the magnitude and duration of erosive flows.
- To ensure that downstream flora and fauna are protected from stormwater impacts during and post construction.
- To minimise surcharge from the existing drainage systems.
- To minimise and control nuisance flooding and to provide for the safe passage of less frequent floods.
- To ensure that on-site stormwater management measures are operated and maintained in accordance with design specifications.

The design criteria listed as follows:

- WSUD principles are to be integrated into the development through the design of stormwater drainage, on-site detention and landscaping and in the orientation of the development rather than relying on 'end of pipe' treatment devices prior to discharge.
- Operating practices and technology are to be employed to prevent contamination of stormwater.
- Development is to be sited and built to minimise disturbance of the natural drainage system.
- Impervious surfaces are to be minimised and soft landscaping and/or permeable paving used to promote infiltration and reduce stormwater run-off.
- WSUD elements should be located and configured to maximise the impervious area that is treated.
- Adequate provision is to be made for the control and disposal of stormwater run-off from the site to ensure that it has no adverse impact on Council's stormwater drainage systems, the development itself, or adjoining properties. Stormwater drainage design criteria are to be in accordance with Council's current Design and Development Guidelines.
- On-site detention (OSD) will be required as outlined in the Upper Parramatta River Catchment Trust On-Site Detention Handbook.P.8 Stormwater, including overland flows entering and discharging from the site, must be managed. The site drainage network must provide the capacity to safely convey stormwater run-off resulting from design storm events listed in Council's Design and Development Guidelines.
- Council will generally not permit the construction of stormwater drainage lines through public reserves.
- The design and location of stormwater drainage structures, such as detention and rainwater tanks, is to be integrated with the landscape design for the site. Above-ground structures are not to be visually intrusive.
- Run-off entering directly to waterways or bushland is to be treated to reduce erosion and sedimentation, nutrient and seed dispersal.

- The discharge of polluted waters from the site is not permitted. Discharges from premises of any matter, whether solid, liquid or gaseous is required to conform to the Protection of the Environment Operations Act and its Regulations, or a pollution control approval issued by the NSW Office of Environment and Heritage for Scheduled Premises.
- For developments required to prepare a WSUD strategy, those developments must achieve pollution reduction targets identified in the DCP and prepare a WSUD Strategy.
- All development must consider the WSUD measures listed in the DCP in order to achieve water quality and quantity targets.
- Pollution load reduction as defined in Table 5.1 below is to be determined preferably through the Model for Urban Stormwater Improvement Conceptualisation (MUSIC), using suitable modelling parameters for Parramatta / Western Sydney. Pollution load reduction may also be determined by an equivalent, widely accepted model or methodology.

Table 5.1 – Water Quality Targets

Pollutant	Performance Target reduction loads[1]
Gross Pollutants	90% reduction in the post development mean annual load of total gross pollutant load (greater than 5mm)
Total Suspended Solids	85% reduction in the post development mean annual load of Total Suspended Solids (TSS)
Total Phosphorus	60% reduction in the post development mean annual load of Total Phosphorus (TP)
Total Nitrogen	45% reduction in the post development mean annual load of Total Nitrogen (TN)
Hydrocarbons, motor oils, oil and grease	No visible oils for flows up to 50% of the one-year ARI peak flow specific for service stations, depots, vehicle body repair workshops, vehicle repair stations, vehicle sales or hire premises, car parks associated with retail premises, places of public worship, tourist and visitor accommodation, registered clubs and pubs

5.2 Upper Parramatta River Catchment Trust

The fourth edition of the Upper Parramatta River Catchment Trust was released in December 2005. The aim of the policy was to ensure that subsequent developments will not increase flooding or stormwater flows at any downstream locations, in all flood events up to and including 1% AEP event.

OSD is more likely to be successful than previous approaches because it addresses the fundamental reason for our present and growing urban stormwater flooding problems – loss of flood storage.

Previous revisions of the UPRCT guidelines specified a detention requirement of 470m3/Ha. The fourth edition then later adjusted the rate to be 455 m^3/ha of storage required under the amended upper Parramatta River catchment OSD policy.

For the purposes of this study, the higher rate of 470 m^3/Ha is conservatively applied.

5.3 Water Sensitive Urban Design (WSUD)

Water Sensitive Urban Design aims to minimise the hydrological impacts of urban development and maximise the multiple use benefits of a stormwater system.

Australian Runoff Quality (ARQ, 2006) identifies the objectives of WSUD to include:

- Reducing potable water demand through water efficient appliances, rainwater and grey water reuse.
- Minimising wastewater generation and treatment of wastewater to a standard suitable for effluent reuse opportunities and/or release to receiving waters.
- Treating urban stormwater to meet water quality objectives for reuse and/or discharge to surface waters.
- Preserving the natural hydrological regime of catchments.

Australian Runoff Quality also identifies WSUD as the adoption of the following planning and design approaches that integrate the following opportunities into the built form of cities and towns:

- Detention, rather than rapid conveyance of stormwater.
- Capture and use of stormwater as an alternative source of water to conserve potable water.
- Use of vegetation for filtering purposes.
- Protection of water-related environmental, recreational and cultural values.
- Localised water harvesting for various uses.

6 WATER CYCLE MANAGEMENT OPTIONS

The Water Cycle Management Strategy proposed for the Site has been prepared with consideration of the statutory requirements and guidelines listed in Section 5 of this report. The strategy focuses on mitigating the impacts of the development on the total water cycle and maximising the environmental, social and economic benefits achievable by utilising responsible and sustainable stormwater management practices.

A range of stormwater management techniques and options considered for the management of nutrients and suspended solids discharging from the site are summarised below.

Each of these management techniques were evaluated and compared with consideration of a range of environmental, social/amenity, economic, maintenance and engineering criteria.

6.1 Vegetated Swales and Buffers

Swales are formed, vegetated depressions that are used for the conveyance of stormwater runoff from impervious areas. They provide a number of functions including:

- Removing sediments by filtration through the vegetated surface.
- Reducing runoff volumes (by promoting some infiltration to the sub-soils).
- Delaying runoff peaks by reducing flow velocities.

Swales are typically linear, shallow, wide, vegetation lined channels. They are often used as an alternative to kerb and gutter along roadways but can also be used to convey stormwater flows in recreation areas and car parks.

PLATE 6.1– TYPICAL GRASSED SWALE

Comment: Once bulk earthworks are undertaken at the site, it is likely that there may be potential for areas of land within the Site which are suitable for swales and buffers (i.e < 3%). However, swales and buffers within urban residential streets are not recommended due to the large number of culvert crossings required for driveways, safety concerns, increased number of GPT’s required and significant maintenance burden for the future asset owners.

6.2 Sand Filters

Sand filters typically include a bed of filter media through which stormwater is passed to treat it prior to discharging to the downstream stormwater system. The filter media is usually sand, but can also contain sand/gravel and peat/organic mixtures. Sand filters provide a number of functions including:

- Removing fine to coarse sediments and attached pollutants by infiltration through a sand media layer.
- Delaying runoff peaks by providing retention capacity and reducing flow velocities.

Sand filters can be constructed as either small or large scale devices. Small scale units are usually located in below ground concrete pits (at residential/lot level) comprising of a preliminary sediment trap chamber with a secondary filtration chamber. Larger scale units may comprise of a preliminary sedimentation basin with a downstream sand filter basin-type arrangement.

PLATE 6.2 – TYPICAL SAND FILTER

Comment: Sand filters are generally suited to smaller catchments. They are inefficient when compared to bio-retention systems and require frequent maintenance.

6.3 Permeable Pavement

Permeable pavements, which are an alternative to typical impermeable pavements, allow runoff to percolate through hard surfaces to an underlying granular sub-base reservoir for temporary storage until the water either infiltrates into the ground or discharges to a stormwater outlet. They provide a number of functions including:

- Removing some sediments and attached pollutants by infiltration through an underlying sand/gravel media layer.
- Reducing runoff volumes (by infiltration to the sub-soils).
- Delaying runoff peaks by providing retention/detention storage capacity and reducing flow velocities.

Commercially available permeable pavements include pervious/open-graded asphalt, no fines concrete, modular concrete blocks and modular flexible block pavements.

There are two (2) main functional types of permeable pavements:

- Infiltration (or retention) systems – temporarily holding surface water for a sufficient period to allow percolation into the underlying soils.
- Detention systems – temporarily holding surface water for short periods to reduce peak flows and later releasing into the stormwater system.

PLATE 6.3 – TYPICAL PERMEABLE PAVERS

Comment: Permeable pavements are generally a more 'at source' solution and best suited as an 'on lot' approach or for small roadway catchments. Permeable pavers may possibly be considered at the development application stage for on lot treatment or for areas draining small catchment areas with low sediment loads and low vehicle weights. These systems are however prone to clogging and are not recommended for the Site.

6.4 Infiltration Trenches and Basins

Infiltration trenches temporarily hold stormwater runoff in a sub-surface trench prior to infiltrating into the surrounding soils. Infiltration trenches provide the following main functions:

- Removing sediments and attached pollutants by infiltration through the sub-soils.
- Reducing runoff volumes (by infiltration to the sub-soils).
- Delaying runoff peaks by providing detention storage capacity and reducing flow velocities.

Infiltration trenches typically comprise of a shallow, excavated trench filled with reservoir storage aggregate. The aggregate is typically gravel or cobbles but can also comprise modular plastic cells (similar to a milk crate). Runoff entering the system is stored in the void space of the aggregate material or modular cells prior to percolating into the surrounding soils. Overflow from the trench is usually to downstream drainage system. Infiltration trenches are similar in concept to infiltration basins, however trenches store runoff water below ground in a pit and tank system, whereas basins utilise above ground storage.

Comment: Infiltration trenches and basins are not appropriate for clay soils. Infiltration trenches and basins are therefore not recommended for the Site.

6.5 Bio-retention Systems

Bio-retention systems consist of a filtration bed with either gravel or sandy loam media and an extended detention zone typically from 0.1 - 0.3 m deep designed to detain and treat first flush flows from the upstream catchment. They typically take the form of an irregular bed or a linear swale and can either be co-located within detention basins or in the outer 50% of riparian corridors. The surface of the bio-retention system can be grassed or mass planted with water tolerant species. Filtration beds of bio-retention systems are typically 0.4 – 0.6 m deep.

PLATE 6.4 – TYPICAL BIORETENTION RAINGARDEN

Comment: Bio-retention systems are an effective and efficient means of treating pollutants from urban development when part of an overall treatment train approach. Bio-retention systems require a reasonable amount of maintenance during the vegetation establishment phase however reduce once established. These devices are proposed as part of the Site at selected location.

6.6 Cartridge Filtration Systems

Cartridge filtration systems are underground pollution control devices that treat first flush flows. The unit consists of a vault containing a number of cartridges each loaded with media that targets specific pollutants. Each cartridge has a maximum treatable flowrate of approximately 1-1.5 litres per second, and the unit can accommodate up to 24 cartridges providing a maximum treatable flowrate of 24-36 litres per second.

PLATE 6.5 – TYPICAL CARTRIDGE SYSTEM

Comment: Cartridge filtration systems are an efficient means of treating pollutants from urban development as they are typically located underground and therefore do not require additional landtake. As cartridge systems have a low treatable flow rate, additional 'buffer' storage is usually provided to keep the capital costs down. Cartridge filtration systems also need to be supplemented with additional treatment devices to achieve pollutant reduction targets. This requires significant height differences between the inlet to the filtration system and the discharge point from the supplementary system. It also generally results in expensive capital and ongoing maintenance costs. These devices are not currently proposed for the Site but may be considered as an alternative to bio-retention gardens in future.

6.7 Rainwater Tanks

Rainwater tanks are sealed tanks designed to contain rainwater collected from roofs.

Rainwater tanks provide the following main functions:

- Allow the reuse of collected rainwater as a substitute for mains water supply, for use for toilet flushing, laundry, or garden watering.
- When designed with additional storage capacity above the overflow, provide some on-site detention, thus reducing peak flows and reducing downstream velocities.

The water collected can be reused as a substitute for mains water supply either indoors (toilet flushing) or outdoors (garden watering). Rainwater tanks can be either above ground or underground. Above ground tanks can be placed on stands to prevent the need of installing a pump to distribute the water. Such systems are referred to as gravity systems. Pressure systems require a pump and can be either above or below ground tanks.

PLATE 6.6 – TYPICAL RAINWATER TANK

Tanks can be constructed of various materials such as ColorbondTM, galvanised iron, polymer or concrete.

Comment: Rainwater tanks are effective in removing suspended solids and a small amount of nutrient pollutants. They are also effective in reducing overall runoff volumes. The effectiveness of rainwater tanks is also increased when plumbed in for internal use. These devices are therefore proposed to be adopted at the Site. This could be wither a Precinct based approach of rainwater capture or at a finer scale with the details provided as the development proceeds.

7 PROPOSED WATER CYCLE MANAGEMENT STRATEGY

A critical consideration for the Water Cycle Management strategy for the Site is the ecological sustainability of the riparian corridor at Vineyard Creek and the downstream Parramatta River. To maintain stormwater quality at the required levels, a 'treatment train' approach is proposed where various types of pollutants are removed and flow volumes and discharge rates are managed by a number of devices acting in series. The stormwater management treatment train will consist of the following elements.

A Draft Water Cycle Management Plan is included on Figure 7.1 in Appendix C. Discussion of each of the elements are included in the following sections.

7.1 Water Efficiency

7.1.1 On Lot Treatment

- Implementation of water efficient fittings and appliances in all dwellings (dual flush toilet, AAA shower heads, water efficient taps and plumbing).
- Minimisation of impervious areas through acceptable development controls.
- The provision of rainwater tanks on each allotment, along with implementation of the above water efficient devices, will satisfy the requirements of BASIX. The connection of water tank to service internal uses will ensure any requirements are met and additional benefits are realised.

Plate 7.1– On Lot Treatment

7.2 Water Quality Measures

7.2.1 Street Level Treatments

i. Inlet Pit Filter Inserts and Gross Pollutant Traps (GPTs)

GPT devices are typically provided at the outlet to stormwater pipes. These systems operate as a primary treatment to remove litter, vegetative matter, free oils and grease and coarse sediments prior to discharge to downstream (Secondary and Tertiary) treatment devices. They can take the form of trash screens or litter control pits, pit filter inserts and wet sump gross pollutant traps.

In theory, inlet pit filter inserts have several advantages over end of pipe GPT's, such as providing a dry, at source collection of litter, vegetative matter and sediment as well as allowing for staged construction works without having to provide additional / temporary GPT units. Pit filter inserts can provide an at source mechanism for treatment of gross pollutants as development proceeds throughout the site.

Manufacturers now also offer a new range of dry GPTs as possible end of line solutions to water quality management. Such proprietary devices offer the ability for gross pollutants to be captured in a cage at high level, which enables pollutants such as litter, leaves and debris to remain dry rather than being stored in a wet sump.

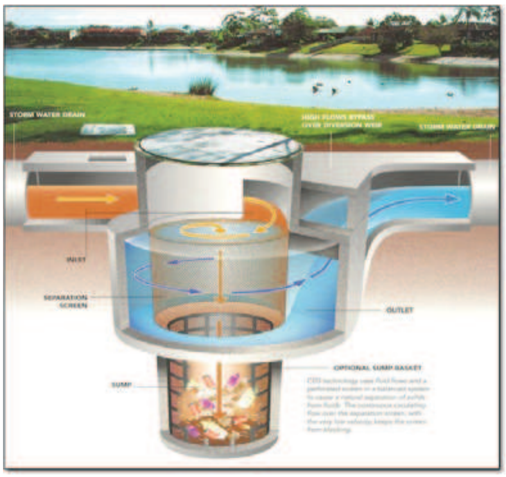


Plate 7.2– Vortex Style GPT

7.2.2 Subdivision / Development Treatment

i. Raingardens

Raingardens are large scale, non-linear bio-retention systems. At this stage, five (5) regional scale 'raingardens' are proposed to be co-located within detention basins across the Site. Each raingarden is indicatively sized to 1.5% of the receiving catchment, with sizes subject to confirmation as part of future assessment to achieve the nutrient reduction targets specified in Council guidelines.

In addition to pollutant removal, the raingardens will also attenuate first flush flows to reduce the risk of stream erosion on Vineyard Creek.

Plate 7.3 – Typical Raingarden after Plant Establishment

The strategy for the Site does not preclude the use of additional or alternate WSUD elements within the streetscape or landscape. These elements, such as swales or bio-retention systems in the medians of dual carriageways, can be considered at the development application and detailed design stages. The use of such elements would require consideration of issues such as practicality in the urban environment, sustainability, safety, maintenance and performance.

7.3 Water Quantity Measures

7.3.1 Subdivision / Development Treatment

i. Detention Basins

Peak storm flow attenuation up to the 1% AEP event is addressed through the provision of detention storage basins located within the Site.

Five (5) detention basins have strategically been located throughout the Site within landscape areas, open spaces and (wherever possible) to the east of the Caltex Oil Easement. Indicative sizes are proposed in Section 8.

At this stage, the size of basins have been determined based on UPRCT guidelines, however there may be opportunity to further optimise basin sizes using a pre-post assessment in XP-RAFTS. This has been raised with Council and is currently under consideration. Refer to Section 8 for discussion.

7.4 Construction Stage

Erosion and sediment control measures are to be implemented during the construction phase in accordance with the requirements of BCC and the guidelines set out by Urban Growth NSW (formerly Landcom) (the "Blue Book" 2004).

As the operation of "bio-retention" (raingarden) type water quality treatment systems are sensitive to the impact of sedimentation, construction phase controls should generally be maintained until the majority of site building works are complete. Alternatively, a very high level of at source control on individual allotments during the building and site landscaping works, which is regularly inspected by BCC officers, would be required.

7.5 Interim Treatment Measures

The raingarden media bed should be protected throughout the civil and housing construction phases of the development. The floor of the raingarden should be lined with either a layer of turf or a sacrificial upper media bed layer and planting that would need to be replaced upon 80% completion of housing construction.

Upon 80% completion of housing construction within the catchment, the turf or sacrificial layer can be removed, replaced and the final planting completed.

7.6 Long Term Management

Regular maintenance of the stormwater quality treatment devices is required to control weeds, remove rubbish, and monitor plant establishment and health. Some sediment build-up may occur on the surface of the raingardens and may require removal to maintain the high standard of stormwater treatment.

Proper management and maintenance of the water quality control systems will ensure long-term, functional stormwater treatment. It is strongly recommended that a site-specific Operation and Maintenance (O & M) Manual is prepared for the system. The cost of preparing this manual should be a component of the Section 94 scheme. The O & M manual will provide information on the Best Management Practices (BMP's) for the long-term operation of the treatment devices. The manual will provide site-specific management procedures for:

- Maintenance of the GPT structures including rubbish and sediment removal.
- Management of the raingarden including plant monitoring, replanting guidelines, monitoring and replacement of the filtration media and general maintenance (i.e. weed control, sediment removal).

8 HYDROLOGIC ANALYSIS

A hydrologic analysis has been undertaken using the rainfall - runoff flood routing model XP-RAFTS (Runoff and Flow Training Simulation with XP Graphical Interface) to generate peak hydrographs along Vineyard Creek for input to the hydraulic modelling (see Section 9 for further details)

8.1 Approach

Based on J. Wyndham Prince's experience in other similar Precincts, locations of detention basins have been identified for inclusion within the concept plan. At this stage, the size of detention basins have been determined in accordance with the UPRCT guidelines (refer to Figure 7.1 in Appendix C). XP-RAFTS modelling can be further updated once the concept plan is finalised.

Importantly, it is noted that the existing site is urbanised and includes a large number of impervious areas (buildings, carparks and roads). There may be opportunity for a pre-post assessment to be undertaken in XP-RAFTS as an alternative to the UPRCT guidelines, since it is not a greenfield development. The suggested alternate approach would then demonstrate pre-post peak flows for the 20%, 5% and 1% AEP events can be effectively managed for the site.

This suggested approach was raised to Council on 12 September 2016 via email and is currently under consideration.

8.2 Sub-catchments (Pre and Post Development)

Sub-catchment areas for the overall Vineyard Creek catchment was determined based on ALS data (supplied by Council) and detailed survey information within the Site. Catchment boundaries are shown on Plate 8.1.

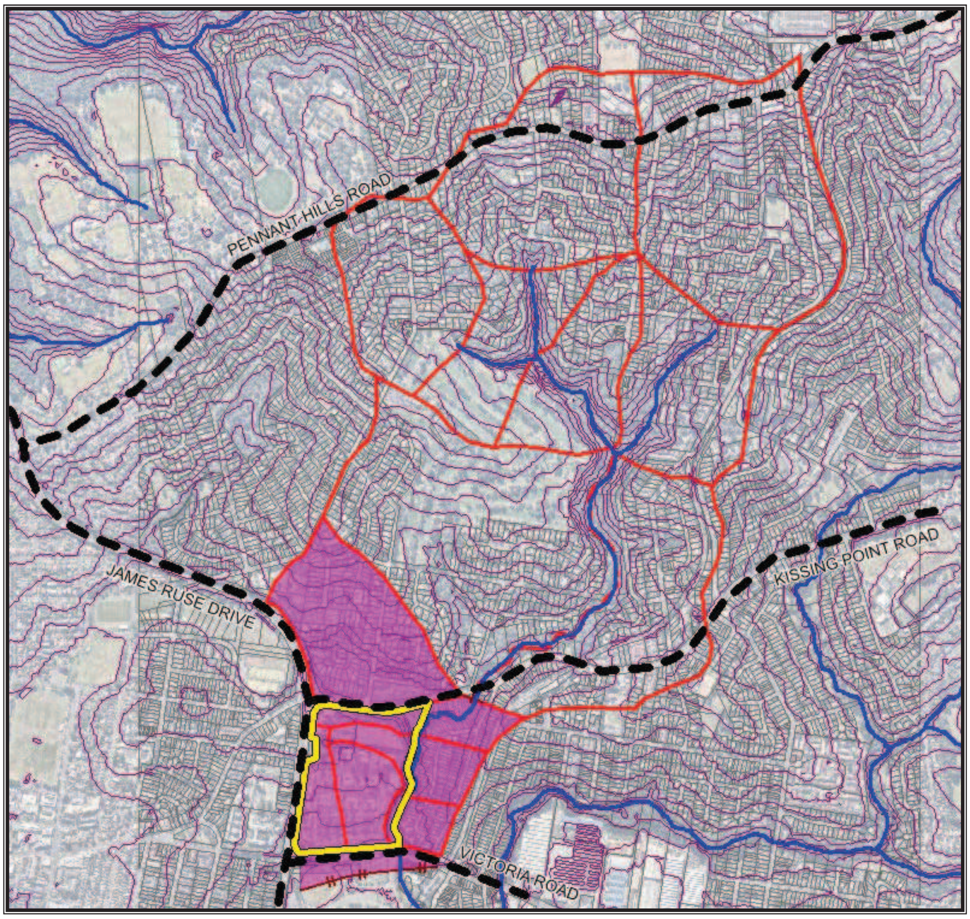


PLATE 8.1 – UPSTREAM CATCHMENT

The overall catchment is 357 Ha and has been broken into fifteen (15) sub-catchments ranging is size from 2.7 Ha to 67 Ha. Percentage Impervious, slopes, lag lengths were determined digitally based on recent aerial imagery.

For detailed of the XP-RAFTS model layout, refer to Appendix A.

8.3 Hydrology Results

Discharge estimates were derived from XP-RAFTS along Vineyard Creek for the 5% and 1% AEP events. A range of storm durations from 30 minutes to 48 hours were analysed to determine the critical storm duration for each catchment. Time lagging links were adopted with an assumed velocity of 2 m/s.

The 5% and 1% AEP and PMF peak discharges from the catchment are presented in Appendix B. The location of the comparison points are also shown on Plate 8.1, and the discharge values at these locations are listed in Table 8.1

Table 8.1 – Summary of Peak Flows – 5%, 1% Year ARI and PMF

		Peak Flow (m^3/s)		
Node	**Location**	**5%**	**1%**	**PMF**
Vineyard 1	Confluence of existing reaches upstream of Precinct	20.6	29.3	130.9
Vineyard 2	Confluence with Kissing Pond Road	41.2	54.3	243.7
Vineyard 3	Bend in Vineyard Creek. Adjacent Precinct	47.1	62.3	270.0
Vineyard 4	Adjacent to Precinct	48.6	64.3	276.5
Vineyard 5	Confluence with Victoria Road	52.1	68.1	289.0

XP-RAFTS results have determined that the 1% AEP flow along the Vineyard Creek (in the vicinity of Victoria Road) is approximately 68 m^3/s.

8.4 Indicative Detention Basins

Detention basins have strategically been located throughout the Site within landscape areas, open spaces and (wherever possible) to the east of the Caltex Oil Easement.

In accordance with UPRCT guidelines, the indicative size of detention basins have been determined based on 470 m^3 / Ha, with the basin footprint being estimated by adopting an average depth of 0.7m. A summary of these sizes is provided in Table 8.2 below.

Table 8.2 – Summary of Indicative Detention Basins

Catchment	**Area (Ha)**	**OSD Storage Requirement (m^3)**	**Approx. OSD footprint (m^2)**
Cat 1	2.92	1380	2000
Cat 2	1.44	680	1000
Cat 3	2.89	1360	1900
Cat 4/5	5.82	2740	3900
Cat 6	1.65	780	1100
Total	14.72	6940	9900

As noted in Section 8.1, there may be opportunity for a pre-post assessment to be undertaken in XP-RAFTS as an alternative to the UPRCT guidelines, since it is not a greenfield development. The suggested alternate approach would then demonstrate pre-post peak flows for the 20%, 5% and 1% AEP events.

9 FLOOD MODELLING

Flood modelling has been undertaken using *TUFLOW* (Two-Dimensional Unsteady Flow). *TUFLOW* is a computational engine that provides two-dimensional (2D) and one-dimensional (1D) solutions of the free-surface flow equations to simulate flood and tidal wave propagation (TUFLOW 2010). *TUFLOW* is specifically beneficial where the hydrodynamic behaviour in coastal waters, estuaries, rivers, floodplains and urban drainage environments have complex 2D flow patterns that would be difficult to represent using traditional 1D network models.

All flows within the watercourses and over the floodplains were modelled as 2D flows. A 2D model provides a better estimation of the effects of momentum transfer between in-bank and overbank flows and the energy losses due to meanders or bends in creeks. MapInfo, a GIS based software tool, was used for interrogating and plotting the results as well as creating the flood extents maps and the flood level difference maps.

Flood modelling for the Site has been undertaken in TUFLOW. The primary objectives include assessment of flood levels along Vineyard Creek, to demonstrate that the proposed development is well clear and to determine any potential impact on flood levels within and outside the site.

9.1 Modelling Approach

An "Existing" Conditions TUFLOW has been developed to determine flooding extents, depths and levels along Vineyard Creek and within the surrounding major roads (Victoria Road, Kissing Point Road and James Ruse Drive).

It is expected that the "Existing" flood behaviour will reflect the final flooding conditions, given the "proposed" development will include on-site detention. Notwithstanding, flood modelling for the "Developed" Scenario can be undertaken as part of the post Gateway Approval.

9.2 TUFLOW Model Set-Up and Modelling Assumptions

The *TUFLOW* model was developed to represent "Existing" conditions across the study area. Refer to Figures 9.1 and 9.2 for the *TUFLOW* model layout. The model development included the following:

- **Terrain** – The underlying digital terrain model (DTM) has been based on ALS data supplied by Council (received September 2016) across the wider catchment. Detailed survey within the boundary of the existing FACS and MBHS sites were then also supplemented within the DTM.

  A grid size of 2 m was adopted to provide an accurate definition of Vineyard Creek, the Site and surrounding catchment.
- **Downstream Boundary Conditions** – The downstream boundary condition was set as "HQ" (Height versus Flow) at the discharge location of the model. The location of the outlet was selected within the Western Sydney University site which is approximately 85 m downstream of the Victoria Road bridge crossing.
- **Flows and Upstream Boundary Conditions -** Flow hydrographs were applied to represent flows entering the model from upstream catchments and local catchments within the model. Flow hydrographs from the upstream catchments were applied as QT (Flow vs Time) inputs into the model. All local catchments within the model were applied as "Source Area" (SA) layers.

  The location of the upstream inlet was selected just to the east of the bend in Vineyard Creek and just downstream of the culvert crossing under Kissing Point Road. This location is approximately 300 m from the Site.
- **Pipe Network** – A 1D network was adopted to represent solely the major stormwater infrastructure. This includes the existing 1.5 m pipe crossing under Kissing Point Road and the Victoria Road bridge crossing (4.8 m wide x 2.8 m high).

For the purposes of this assessment, the 1D network has however conservatively excluded all other existing pit and pipe networks within surrounding areas (Victoria Road, Kissing Point Road and James Ruse Drive).

- **Material Roughness -** Material roughness factors were applied within the site based on review of aerial imagery. Refer to Appendix B for further details.

9.3 Flood Result Mapping

Flood extent mapping has been completed for the 5 %, 1 % AEP and PMF events under "Existing" Conditions. The following maps have been provided to demonstrate flood extents, depths and heights.

- Figure 9.3 – 5% AEP Flood Depth
- Figure 9.4 – 1% AEP Flood Depth
- Figure 9.5 – PMF Flood Depth

Results generally show that the proposed development areas are well clear of flooding along Vineyard Creek across the range of AEP events due to the large level difference from the development to the invert of the creek. Further discussion is provided in Section 9.5.

9.4 Comparison against Previous Studies

A number of previous flood studies have been undertaken (by others) in the vicinity of the Site on behalf of Council.

Council has provided a copy of the following flood maps from these studies as background information to inform this assessment:

- Vineyard Creek Sub-Catchment Management Plan (SMEC, 2004)
- Rydalmere Knowledge Precinct Flood and Development Control Study (SMEC, 2013)
- Parramatta Drainage (SKM, 1990)

Importantly, the supplied information includes predicted flood extents and heights for the 5%, 1% AEP and PMF events - which can be used for comparison / calibration against the current TUFLOW assessment results.

The supplied figure from Vineyard Creek Sub-Catchment Plan (SMEC, 2004) also included a series of cross sections along Vineyard Creek with predicted flood levels being reported in a series of tables across the 5%, 1% AEP and PMF events. The location of each of these cross sections are shown on Plate 9.1 below.

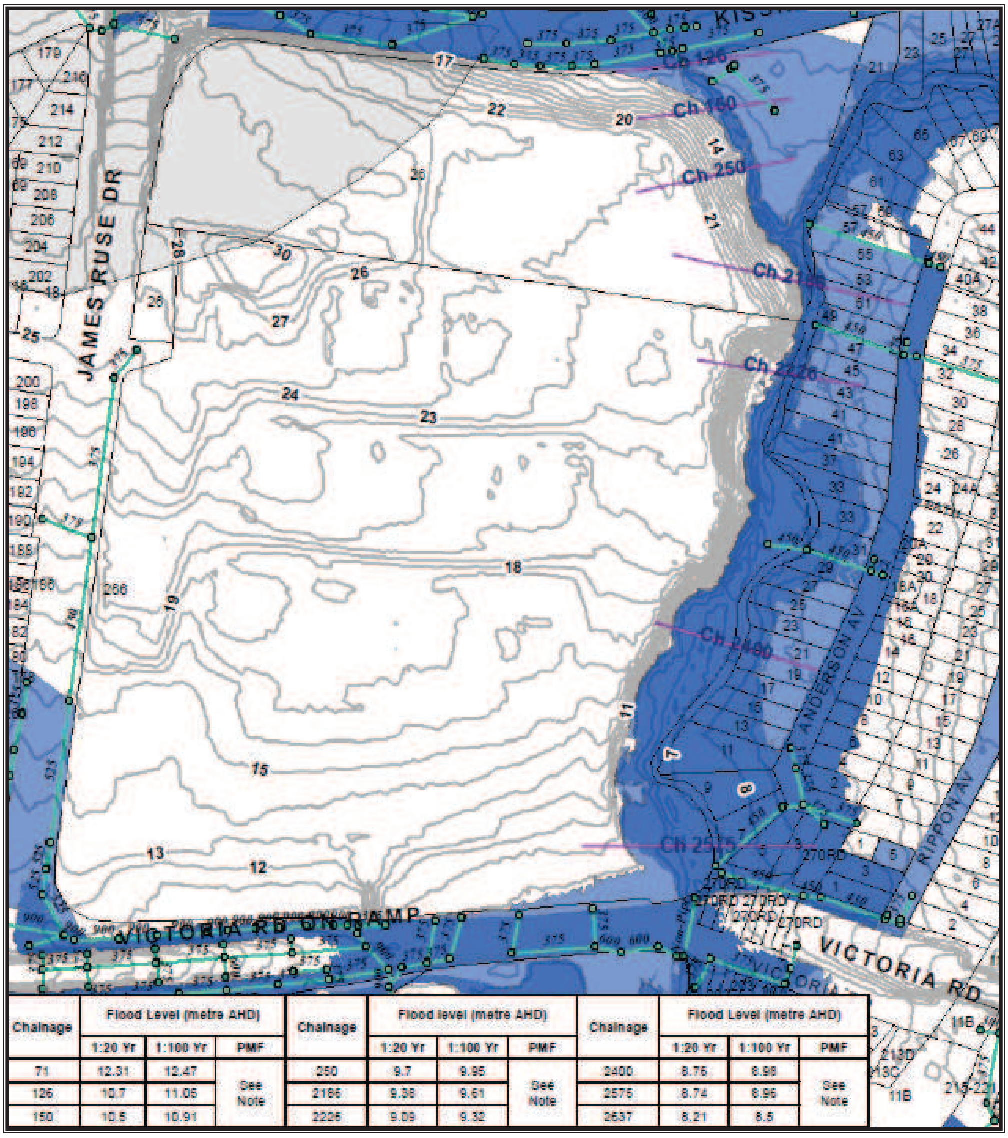


PLATE 9.1 – FLOOD DEPTH COMPARISON LOCATIONS

A visual comparison of flood extents for the 5%, 1% AEP and PMF extents has been made between Council's supplied flood maps and this study. Refer to Figures 9.3 and 9.5. The results show relatively similar flood extents across each of the modelled events. Importantly, both results show the proposed development areas to be well clear of floodwaters.

In addition to flooding extents, a comparison of flood levels at each of the cross sections along Vineyard Creek has been made between Council's supplied flood maps and the TUFLOW assessment in this study. Refer to Tables 9.1 to 9.3.

Table 9.1- Comparison of 5% AEP Results

		5% AEP		
Chainage	Ground Level	Council	JWP	Diff (m)
150	9.06	10.50	10.80	-0.30
250	8.92	9.70	10.33	-0.63
2186	6.39	9.38	10.02	-0.64
2226	6.19	9.09	9.61	-0.52
2400	6.06	8.76	8.92	-0.16
2575	5.77	8.74	8.81	-0.07

Table 9.2- Comparison of 1% AEP Results

	1% AEP		
Chainage	**Council**	**JWP**	**Diff (m)**
150	10.91	10.84	0.07
250	9.96	10.58	-0.62
2186	9.61	10.30	-0.69
2226	9.32	9.84	-0.52
2400	8.98	9.18	-0.20
2575	8.96	9.07	-0.11

Table 9.3- Comparison of PMF Results

	PMF		
Chainage	**Council**	**JWP**	**Diff (m)**
150	-	12.62	-
250	-	12.58	-
2186	12.40	12.18	0.22
2226	11.70	11.48	0.22
2400	10.51	10.50	0.01
2575	10.25	10.20	0.05

Results demonstrate a relatively good comparison between the previous Council flood studies and the current Rydalmere Assessment. Generally, those flood levels just to the north of Victoria Road (Ch 2400 to Ch2575) are within 0.1 – 0.2 m of previous studies. Importantly, the current J. Wyndham Prince assessment is slightly higher which is conservative.

Those cross sections further to the north generally have a larger difference in flood levels from those reported in the previous flood studies (in the order of 0.5 – 0.7m). Similarly however, the current J. Wyndham Prince assessment levels are higher which is conservative. Given the level difference from the invert of Vineyard Creek up to the development pad ranges up to 14 - 15 m, the assessment is therefore considered fit for purpose.

9.5 Discussion of Results

Flood mapping results clearly demonstrate that the proposed development area is well clear of flooding along Vineyard Creek across the full range of flood events. This is due to the high embankment edge which ranges in height up to 14 – 15 m from the creek invert.

A small portion of the Site is partially affected by flooding during the 1% AEP and PMF events in the south – east corner (near the vehicular entry to Victoria Road). This flooding extent is however observed to also occur across Victoria Road - rather than as a result of the proposed development. The proposed basin and road formation in this area will need to consider flooding in this area to ensure there are no adverse flood impacts. It is also noted that there are two (2) other vehicular entries to James Ruse Drive and Kissing Point Road which are well clear of inundation during extreme events. Thus flood free access in this location is not considered to be critical.

Importantly, the proposed concept plan has restricted the edge of the development to be alongside the Caltex Oil easement (which is around 10 -50 m away from the edge of the embankment edge). Given there is generally no proposed encroachment upon the flooding extents and the development will adopt on-site detention, it is therefore expected that there will be no change in flood impact surrounding the site.

10 FLOOD EVACUATION STRATEGY

The safe evacuation of people from flood affected areas during a PMF event is a key consideration of the Water Cycle Management and Flooding Strategy in the planning of any Precinct. Generally, flood evacuation routes need to be identified to ensure a "continuous rising grade" can be maintained to a level above the PMF for all evacuees and connections to the designated regional evacuation routes.

The need to consider flood evacuation was initially identified by Council within the workshop, where it was raised that previous flood studies have shown several surrounding roads to be inundated during the PMF event.

Figure 9.5 demonstrates this flooding during the PMF across Victoria Road and Kissing Point Road.

Importantly however, flood modelling results show that the proposed development area is almost entirely located above / clear of the PMF level (except for a small portion and the south – eastern corner where the Site adjoins Victoria Road). The need to evacuate is therefore not recommended nor is considered necessary given the Site would actually act as a potential safe haven.

Notwithstanding, the proposed concept plan includes the reconstruction of the existing entry / exit road to James Ruse Drive just to the south of the existing driveway. This entry / exit will provide direct emergency vehicle access to James Ruse Drive and to the M4 (which is approximately 2.4 km to the south). Refer to Plate 10.1 for PMF extents and key locations.

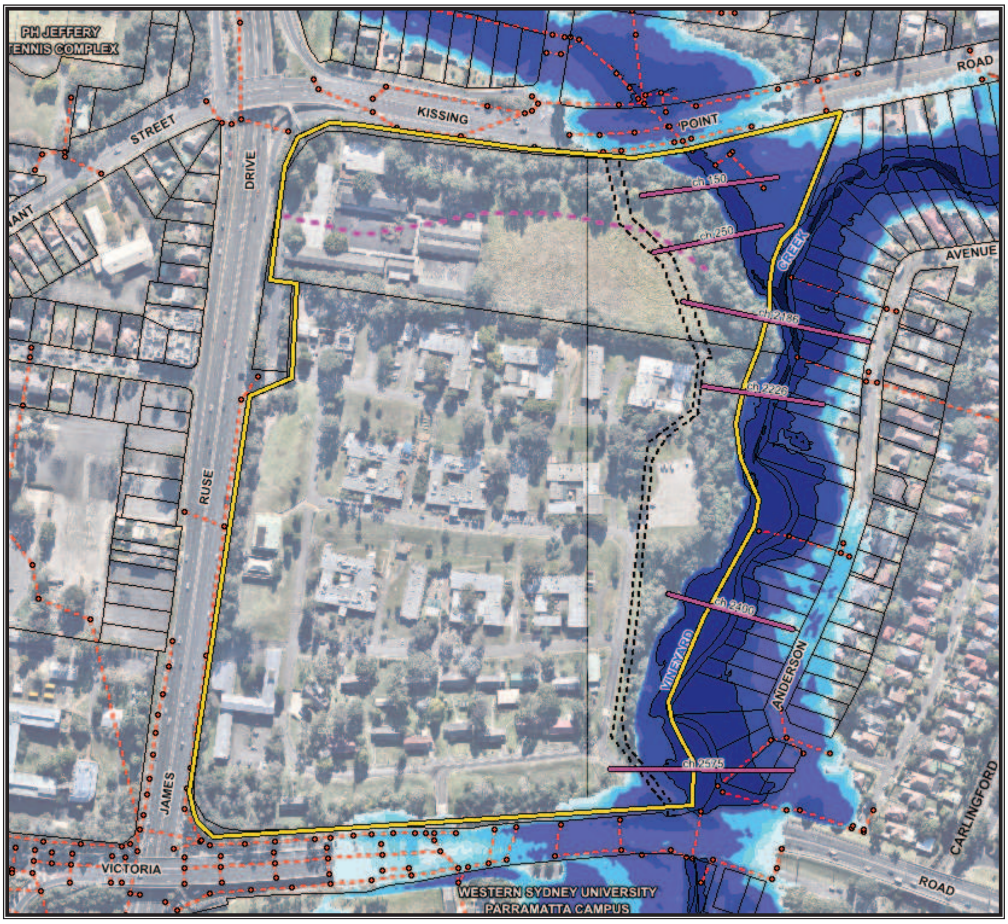


PLATE 10.1 – FLOOD EVACUATION STRATEGY

Several detention basins are proposed to be located throughout the Site. The detailed design of these basins will be undertaken in future to ensure that the surrounding roads are not cut off during the 1% AEP event.

11 WATER QUALITY

A "treatment train" of water quality devices is proposed for the Site in order to satisfy Council guidelines.

As discussed in Section 6 and 7, this "treatment train" will include on-lot treatment, rainwater tanks, gross pollutant traps and bio-retention raingardens.

This *Water Cycle Management and Flooding Strategy* provides recommendations on indicative water quality locations / sizes to inform the development of the concept plan. Once the planning proposal has been endorsed, more detailed water quality modelling may be required within MUSIC software to support the proposal moving forward.

11.1 Catchments

Sub-catchments have been determined based on the concept plan with consideration of proposed roads, open spaces and building layouts. The Site is split into six (6) distinct catchments, five (5) of which drain towards Victoria Road.

The sub-catchments range in size from 1.44 Ha to 5.82 Ha. Refer to Table 11.1 and Figure 7.1.

11.1.1 Bio-Retention Systems (Raingardens)

Bio-retention raingarden filtration systems are proposed to be co-located within each of the detention basins throughout the Site. All basins are located off-line to Vineyard Creek and are positioned throughout the development either in landscape, open space areas and wherever possible to the east of the Caltex Oil Easement.

The constraints associated with the Caltex Oil easement are recognised, however given the nature of the steep terrain across the site it is expected that a pipe crossing into the raingarden / basin could be constructed at practical locations (given grade will likely not be an issued).

It is also noted that there has been some previous liaison with Caltex (by others) regarding potential service crossings and a clear set of criteria has been provided which will inform the detailed design of each device.

The media beds of bio-retention systems ware typically 0.4 – 0.6 m deep with an average particle size of 0.5 mm and a hydraulic conductivity of 100 mm/hr. with a minimum depth of storage above the media of 300 mm. A discharge control structure can be configured (during the Development Application process) to promote extended detention times as required.

It is assumed that flows in excess of the 3 month ARI storm event will bypass the raingardens. It is also assumed that trash and gross sediments will be effectively removed prior to entering the raingardens by the proposed GPT units. In order to reduce the ongoing maintenance requirements for the raingardens, the GPTs should be selected on the basis that they intercept, as a minimum, 90% of the sediment loads greater than 0.15 mm diameter.

Treatment in raingardens is attained by detaining flows to promote sedimentation, direct filtration of particulate matter and nutrient stripping by bio-films which establish on the surface of the media bed and within the gravel layer. The organic sandy loam bed and plant system minimises evaporation losses and the raingarden will be constructed with an impermeable barrier to prevent seepage losses and to avoid groundwater salinity impacts.

11.1.2 Indicative Sizes and Locations

A conceptual sketch of the Site with indicative water quality locations / sizes is presented in Figure 9.1 in Appendix C to inform the development of the concept plan.

Based on J. Wyndham Prince's experience in other Precincts and general engineering practice, the indicative sizes of the "filter area" of raingardens is assumed at 1.5% of the catchment which drains to them. Since the terrain and extent of water quality measures is indicative, an allowance of 20% has been made for the earthworks to estimate the required landtake. The indicative sizes are listed in Table 11.1.

Table 11.1 – Indicative sizes of Bio-Retention Systems

Catchment	Total Treated Catchment Area (Ha)	Filter Area Size (m^2)	Land Take Size (m^2)
Cat 1	2.92	440	528
Cat 2	1.44	220	264
Cat 3	2.89	440	528
Cat 4/5	5.82	880	1056
Cat 6	1.65	250	300
Total	**14.72**	**2230**	**2676**

At this stage, it is expected that retaining walls will likely be required to enable the construction of the co-located raingarden / detention basins. This is due to the flat nature of the devices and the relatively large level differences across the Site. It is recommended that a bulk earthworks strategy be undertaken to minimise the impact.

Sizes are indicative only at this stage and are subject to confirmation from the detailed MUSIC modelling. Concepts could be developed as part of the concept plan as required.

12 SUMMARY & CONCLUSION

The "initial" *Water Cycle Management and Flooding Strategy* investigation has been prepared to identify all stormwater and flood management issues to be considered in the development of the concept plan. The strategy has been prepared in consideration at the statutory requirements and industry best practice for stormwater management in this catchment.

The "initial" *Water Cycle Management Strategy* consists of a treatment train consisting of on lot treatment, street level treatment and subdivision / development treatment measures. The structural elements proposed for the development consist of:

- Proprietary GPT units at each stormwater discharge point.
- Five (5) detention basins with an approximate total volume 6,940m^3
- Five (5) bio-retention raingardens which are co-located at detention basins with a total filter area of approximately 2,230 m^2

Indicative sizes of water quantity and water quality devices are presented on Figure 7.1 in Appendix C to inform the concept plan.

Water Quantity (Basin Sizing)

Detention basins have strategically been located throughout the Site within landscape areas, open spaces and (wherever possible) to the east of the Caltex Oil Easement.

In accordance with UPRCT guidelines, the indicative size of detention basins have been determined based on 470 m^3 / Ha, with the area estimated by adopting an average depth of 0.7m.

There may be opportunity for a pre-post assessment to be undertaken in XP-RAFTS as an alternative to the UPRCT guidelines, since it is not a greenfield development. The suggested alternate approach would then demonstrate pre-post peak flows for the 20%, 5% and 1% AEP events.

Water Quality

The provision of the proposed water quality treatment devices within the development will ensure that the post development stormwater discharges will meet Council and OEH's water quality objectives for the Site.

Based on J. Wyndham Prince's experience in other Precincts and general engineering practice, the indicative sizes of the "filter area" of raingardens is assumed at 1.5% of the catchment which drains to them. Since the terrain and extent of water quality measures is indicative, an allowance of 20% has been made for the earthworks to estimate the required landtake.

At this stage, it is expected that retaining walls may be required to enable the construction of the co-located raingarden / detention basins. This is due to the flat nature of the devices and the relatively large level differences across the Site. It is recommended that a bulk earthworks strategy be undertaken to minimise the impact.

Sizes are indicative only at this stage and are subject to confirmation from detailed MUSIC modelling.

Flood Modelling

Flood mapping results clearly demonstrate that the proposed Site is well clear of flooding along Vineyard Creek across the full range of flood events. This is due to the high embankment edge which ranges in height up to 14 - 15 m from the creek invert.

A small portion of the Site is partially affected by flooding during the 1% AEP and PMF events in the south – east corner (near the vehicular entry to Victoria Road). This flooding extent is however observed to also occur across Victoria Road - rather than as a result of the proposed development. The proposed basin and road formation in this area will need to consider flooding in this area to ensure there are no adverse flood impacts. It is also noted that there are two (2) other vehicular entries to James Ruse Drive and Kissing Point Road which are well clear of inundation during extreme events. Thus flood free access in this location is not considered to be critical.

Importantly, the proposed concept plan has restricted the edge of the development to be alongside the Caltex Oil easement (which is around 10 -50 m away from the edge of the embankment edge). Given there is generally no proposed encroachment upon the flooding extents and the Site will adopt on-site detention, it is therefore expected that the proposed development will not affect flooding results.

Flood Evacuation

Flood modelling results show that the proposed development area is almost entirely located above / clear of the PMF level (except for a small portion and the south – eastern corner where the Site adjoins Victoria Road). The need to evacuate is therefore not recommended nor is considered necessary given the Site would actually act as a potential safe haven.

Notwithstanding, the proposed concept plan includes the reconstruction of the existing entry / exit road to James Ruse Drive just to the south of the existing driveway. This entry / exit will provide direct emergency vehicle access to James Ruse Drive and to the M4 (which is approximately 2.4 km to the south).

The investigations completed as part of this study are considered to be fit for purpose and demonstrate that the Water Cycle and Flood Management is not a constraint to the future development of the Site.

13 REFERENCES

- BMT WBM Pty Ltd (2008). TUFLOW User Manual
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APPENDIX A – XP-RAFTS PARAMATERS

Rainfall Data & XP-Rafts Parameters – Local Hydrologic Model

The rainfall and XP-RAFTS modelling parameters for the Site includes the following:

B.1 PERN

The PERN (n) values and losses adopted for the catchments in the XP-RAFTS modelling are listed in Table B.1.

Table B.1 – XP-RAFTS Pern Values

Parameter	Catchment Condition	Value
Pern (n)	**Rural Pervious**	**0.05**
	Urban Pervious	**0.025**
	Urban Impervious	**0.015**

B.2 Loss Parameters

The loss parameters adopted in XP-RAFTS modelling are listed in Table B.2

Table B.2 – XPRAFTS Loss Parameters

	Initial Loss	Continuing Loss
Impervious	1mm	0 mm/ hr
Pervious	15mm	2.5 mm / hr

The initial and continual loss parameters adopted for the *XP-RAFTS* model are based on experience in other similar catchments in Western Sydney.

B.3 Intensity-Frequency-Duration (I.F.D.)

The *XP-RAFTS* modelling adopted intensity-frequency-duration (IFD) data for the Site was derived from the Bureau of Meteorology (BOM) website. A summary of the rainfall intensities adopted in this study is provided in Table B.3. The critical storm durations were determined using these values for each sub-catchment.

The models used to examine the performance of the catchment utilised temporal patterns for synthetic design storms as detailed in A.R.R. (I.E Aust 1987).

Table B.3 – Adopted Rainfall Parameters

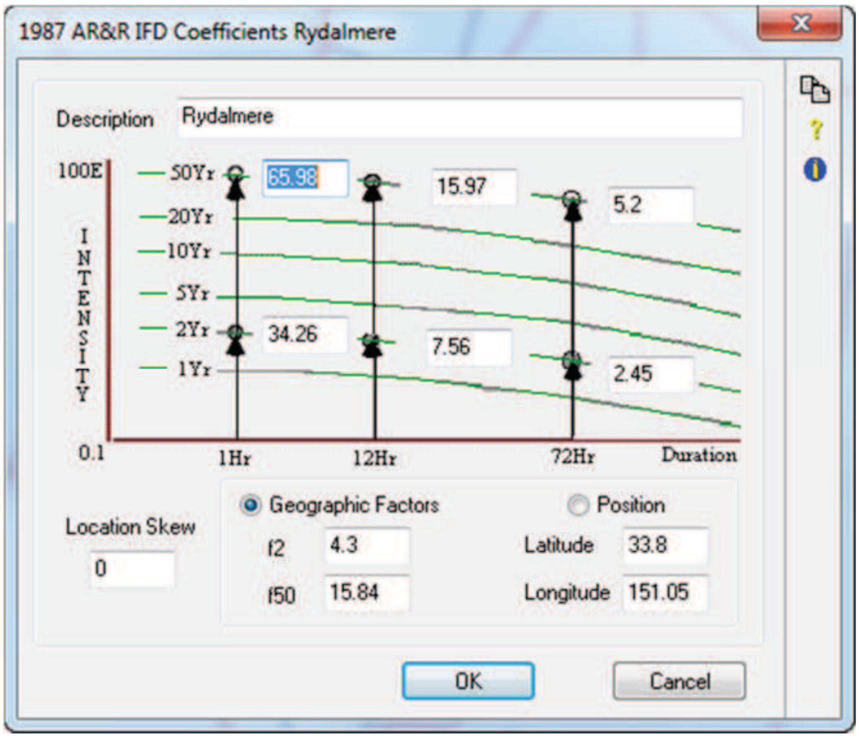


Table B.4 – XPRAFTS Catchment Summary

Catchment Name	Area (Ha)	Fraction Impervious	Slope			
			U/S Level	D/ S Level	Length	Catchment Slope
c1	5.3	50	27.6	10	470	4%
c2	2.7	30	27.6	12.7	419	4%
c3	7.0	50	30.5	8.5	518	4%
c4	7.9	50	20.8	7	296	5%
c5	4.1	70	16.8	9.1	290	3%
c6	4.7	65	25	6.9	314	6%
c7	25.4	75	52.7	13	997	4%
c8	67.2	50	69	13.3	1175	5%
c9	41.2	65	55	23.1	550	6%
c10	27.0	65	90.3	54	702	5%
c11	20.2	30	77	53.9	341	7%
c12	20.9	40	77	47	440	7%
c13	40.3	75	81	59.2	642	3%
c14	55.8	75	80.6	48.1	980	3%
c15	27.7	50	76.8	48.1	380	8%
Total	**357.4**					

Area (Ha)	
Impervious	Pervious
2.6	2.6
0.8	1.9
3.5	3.5
4.0	4.0
2.9	1.2
3.0	1.6
19.1	6.4
33.6	33.6
26.8	14.4
17.6	9.5
6.1	14.2
8.4	12.5
30.2	10.1
41.8	13.9
13.8	13.8

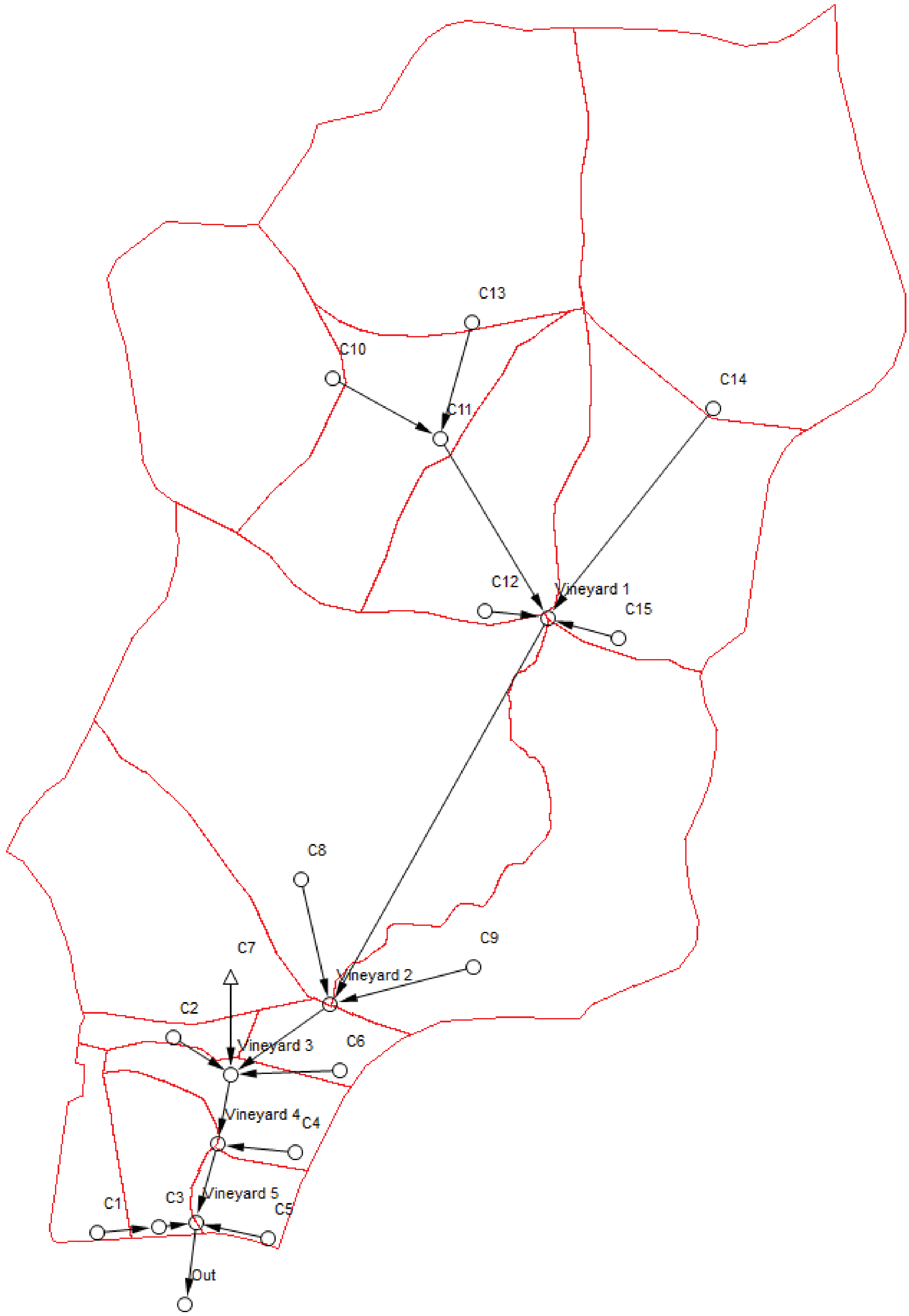


PLATE A.1 – XP RAFTS LAYOUT

APPENDIX B

APPENDIX B – TUFLOW PARAMETERS

Model Parameters

Table D.1 – TUFLOW Material Roughness

Description	Manning's "n"
Road Reserve	0.025
Light Vegetation	0.05
Heavy Vegetation	0.1
Residential Lots	0.04

APPENDIX C – FIGURES

NSW GOVERNMENT | Government Property NSW

J. WYNDHAM PRINCE

CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au

LEGEND

- Rydalmere Precinct Boundary
- Existing Oil Easement
- Potential OSD basin with inidicative size
- Potential raingarden with inidicative size
- Existing Ridgeline (Approx)
- Flow Direction Arrow
- Existing stormwater
- Proposed stormwater
- Catchment Area
- Retaining wall

Depth (m)

- 0.0 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 5.0
- 5.0 +
- 0.5 m Flood Contour

N E S W

Scale 1: 2,500 @ A3

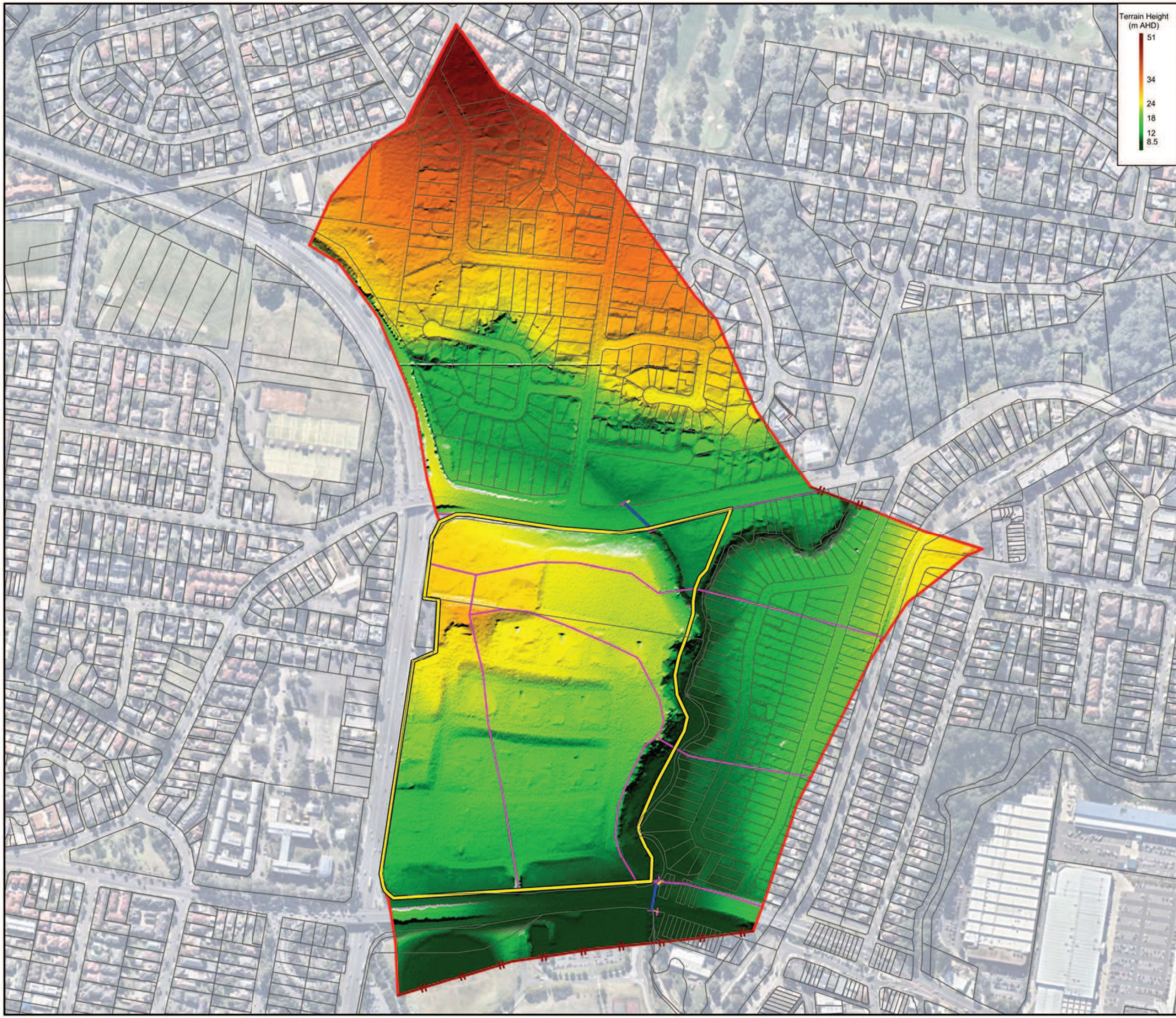
100 0 m

Figure 7.1

Rydalmere Development Precinct

Draft Water Cycle Management Plan

File Name: 110338 Figure 7.1
Date : 9/11/16
Issue : B



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J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au

LEGEND

- Plot Output Line
- TUFLOW Model Boundary
- HQ Model Outlet
- 1D Element - Pipe
- 2D SX Connection - Headwall
- SA Catchment

N W E S

Scale 1: 5000 @ A3

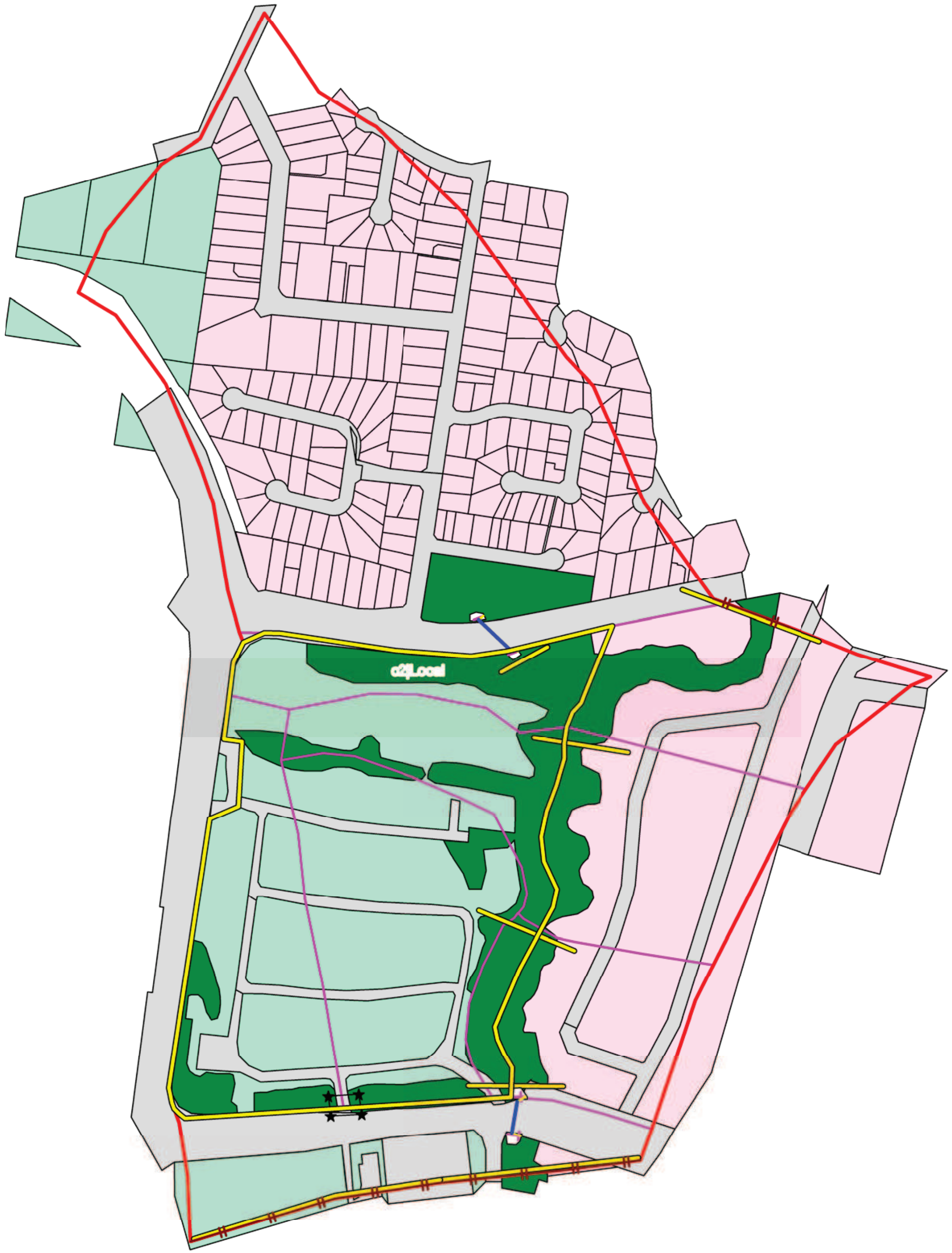
100 0 100 m

Figure 9.1

Rydalmere Development Precinct

Existing TUFLOW Terrain Map

File Name: 110338 Figure 9.1
Date : 09/11/16
Issue : A



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CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au

LEGEND

- Site Boundary
- TUFLOW Boundary
- Heavy Vegetation, n = 0.10
- Road Reserve, n = 0.025
- Residential, n = 0.04
- Light Vegetation, n=0.05
- Plot Output Line
- TUFLOW Model Boundary
- HQ Model Outlet
- 1D Element - Pipe
- 2D SX Connection - Headwall
- SA Catchment

N W E S

Scale 1: 5000 @ A3

100 0 100 m

Figure 9.2

Rydalmere Development Precinct

Existing TUFLOW Model Setup and Materials Mapping

File Name: 110338 Figure 9.2
Date : 09/11/16
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CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au

Figure 9.3

Rydalmere Development Precinct

"Existing" Scenario
Flood Depth Map
5% AEP Event

File Name: 110338 Figure 9.3
Date : 09/11/16
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CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300
F 02 4721 7638
W www.jwprince.com.au
E jwp@jwprince.com.au

LEGEND

- Rydalmere Precinct Boundary
- Existing Oil Easement
- Existing Ridgeline (Approx)
- Existing stormwater
- Cross Section

Depth (m)
- 0.0 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 5.0
- 5.0 +
- 0.5 m Flood Contour

N W E S

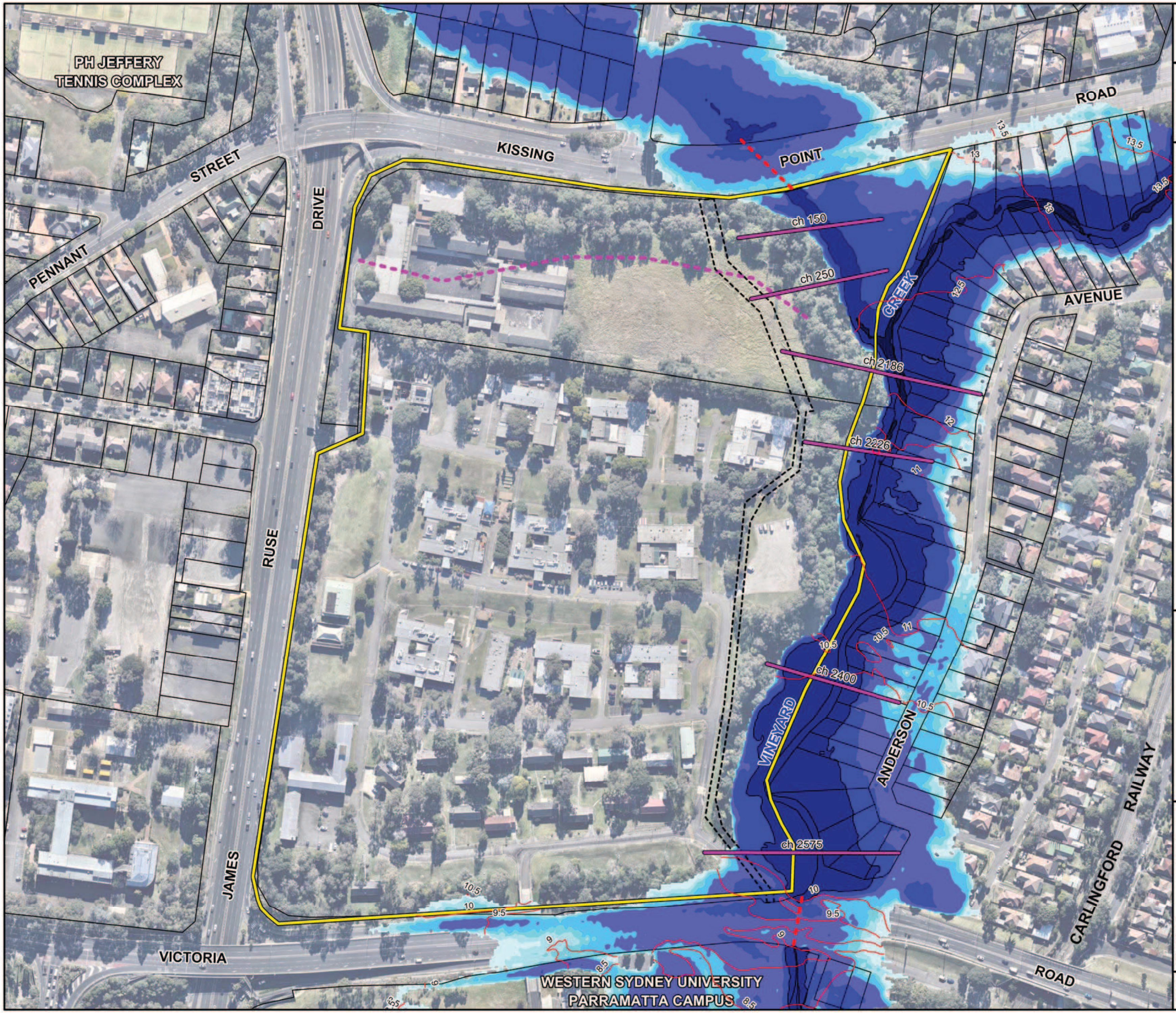
Scale 1: 2,500 @ A3

100 0 m

Figure 9.4
Rydalmere Development Precinct

"Existing" Scenario
Flood Depth Map
1% AEP Event

File Name: 110338 Figure 9.4
Date : 09/11/16
Issue : B



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J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
PO Box 4366 PENRITH WESTFIELD NSW 2750
P 02 4720 3300 W www.jwprince.com.au
F 02 4721 7638 E jwp@jwprince.com.au

LEGEND

- Rydalmere Precinct Boundary
- Existing Oil Easement
- Existing Ridgeline (Approx)
- Existing stormwater
- Cross Section

Depth (m)

- 0.0 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 5.0
- 5.0 +
- 0.5 m Flood Contour

N E S W

Scale 1: 2,500 @ A3

100 0 m

Figure 9.5

Rydalmere Development Precinct

"Existing" Scenario Flood Depth Map PMF Event

File Name: 110338 Figure 9.5
Date : 09/11/16
Issue : B