Schofields Precinct

Water Cycle Management Strategy Report Incorporating Water Sensitive Urban Design Techniques

POST EXHIBITION REPORT




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SCHOFIELDS PRECINCT

WATER CYCLE MANAGEMENT STRATEGY INCORPORATING WATER SENSITIVE URBAN DESIGN TECHNIQUES

- DOCUMENT CONTROL SHEET -

Issue No.	Amendment	Prepared By & Date	Checked By and Date	Approved By and Date
A	Preliminary Draft for Discussion	DG (22-12-10)	PM (22-12-10)	
B	Draft Exhibition Issue	DG (13-7-11)	DG (13-7-11)	
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D				

Flood levels presented in this report are suitable for planning purposes only

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1. EXECUTIVE SUMMARY

1.1. Project Objective

J. Wyndham Prince Pty Ltd in close consultation with the Department of Planning and Infrastructure and Blacktown City Council have prepared a Water Cycle Management Strategy Incorporating Water Sensitive Urban Design Techniques to integrate with the Master Planning process for the Schofields Precinct, Schofields. The strategy has been prepared to conform with statutory requirements and industry best practice for stormwater management in this catchment. Sufficient detail is provided to integrate with and support the Development Planning process for the release area and to identify the size and cost of Section 94 components relating to Stormwater Management in the release area.

The overall water cycle management objectives for the release area were identified as:

***Environmental* –** Provision of appropriately designed, functional water quality facilities, salinity management, retention of existing trees, habitat revegetation and ecosystem enhancement; limitation of downstream discharge peaks and velocities; soft bioengineering treatments to reflect natural stream functions; ecologically sustainable; adopt principles of total catchment management and water sensitive urban design; conform with statutory water quality requirements; maintenance of environmental flows and inundation patterns in creeks and wetlands.

***Urban Amenity* –** Provision of a water cycle management strategy that identifies and controls limits of flood affectation; provision of aesthetic design forms that enhance urban amenity and address proposed adjacent land uses (residential, recreational and transport); views into and out of drainage corridors (security, public safety, amenity); water quality (visual amenity and public health).

***Engineering Considerations* –** Effective management and control of peak discharges, discharge velocities, and flood levels above pre-development and ecologically sustainable levels; industry best practice technical analysis of catchment hydrology and system hydraulic performance, soft sustainable bioengineering treatments, delineation of flood extents and identification of flood risk and appropriate public safety measures to deal with the identified risks (flood evacuation).

Economics - provision of a cost effective, functional trunk drainage system that optimises performance, keeps maintenance costs and requirements to an acceptable level, keeps land take to a minimum, provides maximum value for expenditure of public monies and focuses on ecological sustainability.

1.2. Statutory Requirements

The recommendations contained in the following guidelines have also been considered in the master planning process.

- Growth Centres Development Code 2006
- Blacktown City Council Growth Centre Precincts Development Control Plan 2009
- Blacktown City Council Engineering Guide for Development 2005
- Blacktown City Council DCP (2006) Part R (Water Sensitive Urban Design and Integrated Water Cycle Management)

- Department of Environment, Climate Change and Water Technical Guidelines

1.3. Methodology

The water cycle master planning process has involved considerable consultation and a number of Workshops have been undertaken to receive input from stakeholders. This consultation has included:

- Blacktown City Council
- Department of Planning and Infrastructure
- New South Wales Office of Water (By Specialist Riparian Consultant)

The investigation included the following technical tasks:

Hydrology	Review of previous hydrologic studies undertaken by others and undertake additional detailed hydrological analyses of the catchments, determine the magnitude of a range of storm flows.
Hydraulics	Review of previous hydraulic studies undertaken by others and additional hydraulic analysis of watercourses and retention basin strategies to determine peak flood levels, velocities, flow widths and flood extents.
Water Quality Modelling	Undertake a detailed water quality analysis for the release area to determine post development pollutant loads and evaluate the performance of proposed water quality treatment techniques.
Options/Treatment Techniques	Identify and evaluate a range of suitable treatment techniques to address water quality and water quantity objectives.
Preferred Treatment	Determine size, location, cost, maintenance and performance of preferred treatment techniques.

1.4. Proposed Water Cycle Strategy

A range of structural stormwater management techniques and options were considered for their suitability in managing the discharge of peak flows (water quantity) and pollutants (water quality) for the Schofields Precinct. These are summarised as follows:

Water Quantity: Regional (end of line) and Local (on lot) Detention Basins (Wet, Dry), Below ground storage tanks (public and private).

Water Quality: A range of lot based, street level and subdivision scale treatments including vegetated swales and filter strips, sand filters, bioretention systems, permeable pavements, infiltration trenches and basins, wetlands and rainwater tanks.

Each of these management techniques were evaluated and compared with consideration of a range of Environmental, Social/Amenity, Economic, Maintenance and Engineering criteria. Several of the management techniques were identified as either unsuitable for the Schofields Precinct or inefficient when compared to alternate techniques. Other management techniques, while not included in the strategy below, were identified as being suitable for further consideration at the development application and detailed design stages.

The strategy proposed as being most suitable for the Schofields Precinct is a combination of options including:

Water Quality

A treatment train consisting of:

On Lot Treatments

- Appropriate waterwise landscaping practices that have regard to the soil characteristics on site (including resident education, native but not drought tolerant species to prevent drying out of the soils, mulch, micro-irrigation).
- 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.
- BASIX compliant water tanks.
- An appropriate level of on lot treatment measures within all land uses other than low density residential to achieve the minimum target pollution reductions.

Street Level Treatments

- Proprietary gross pollutant traps.

Subdivision / Development Treatments

- Large scale bioretention systems (Raingardens and swales) generally located within the public reserves and adjacent to the riparian corridors.

Water Quantity

- Combination of both off line and on line detention storage for larger flows (2 and 100 year ARI) located adjacent to and within riparian corridors.
- Limiting the post development stream forming flow duration so that it is no more than 3 – 5 times that of the pre-development stream forming flow duration.
- Stormwater harvesting for reuse on sportsfields, parks and other public areas wherever possible.

A general arrangement plan indicating proposed locations for the water quality and water quantity treatments for the Schofields Precinct is included in Figure 4. The strategy for the Precinct does not preclude the use of additional or alternate WSUD elements within the streetscape or landscape. These elements, such as swales or bioretention systems in the medians of dual carriageways or other suitable locations, can be considered at the development application and detailed design stages.

1.5. Conclusion

The water cycle management strategy for the developed site provides a basis for the detailed design and development of the site to ensure that the following objectives for stormwater management and site discharge are achieved:

Environmental Existing stands of vegetation within the trunk drainage corridor retained where possible; existing water bodies with ecological value retained; downstream and in-channel frequent discharge peaks and velocities limited to lessen scouring, siltation and flora and fauna impacts; water quality elements proposed to remove gross pollutants and nutrients from the urban catchments; lessens the impact on ecological health and biodiversity within the riparian corridors.

Urban Amenity Limits of flood 1% affectation have been defined and future development can conform with requirements for freeboard and public safety; quality passive recreational amenity can be provided for the incoming community.

Engineering Considerations Peak discharges of frequently occurring storms, peak velocities and flood levels controlled to conform with Council’s technical requirements; water quality elements provided to conform with performance and maintenance requirements.

Economics The water cycle management strategy is functional; delivers the required technical performance; lessens environmental degradation and pressure on downstream ecosystems and infrastructure; and provides for a ‘soft’ sustainable solution for stormwater management within the release area.

The water cycle management concept is illustrated on Figure 4.

2. INTRODUCTION

The Schofields Precinct is located in the suburb of Schofields and is a Precinct of the North West Growth Centres. The Precinct consists of approximately 465 hectares of land falling within the Blacktown Local Government Area.

The Department of Planning and Infrastructure has engaged JWP to prepare a Water Cycle Management Strategy to inform the precinct planning process and support the rezoning process for the Precinct.

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

The objective of this investigation is to identify the stormwater issues to be taken into account in the development application, detailed design and development of the Schofields Precinct, to identify appropriate options and locations for the control of the quantity and quality of stormwater leaving the site, and to identify the land areas required to implement the recommended options. The outcomes identified by the investigation will then be incorporated into the Section 94 processes and Contributions Plan. Additionally, a flood impact assessment and evacuation strategy was completed for the Precinct.

The investigation addresses engineering considerations whilst placing a strong focus on conserving and enhancing the bio-diversity, ecological health and positive water quality benefits within the existing riparian corridors to provide an integrated natural resource for the incoming residents.

The investigation involved the following specific tasks:

- Liaise with the Department of Planning and Infrastructure and Blacktown City Council to determine their specific requirements for development of the Precinct.
- Investigate a range of stormwater management and water sensitive urban design measures suitable for the site. Liaise with the Department of Planning and Infrastructure and Blacktown City Council and identify the most appropriate strategy for the Schofields Precinct.
- Undertake a hydrologic analysis to determine the peak 2, 100 and 500 year ARI and PMF post development flows for use in the hydraulic model.
- Undertake a flood impact assessment and develop an evacuation strategy for the site.
- Undertake a water quality analysis and determine the minimum treatment device areas required to achieve Blacktown City Council's and the Department of Environment and Climate Change's water quality targets.
- Undertake a stream erosion index assessment to ensure that the post development stream forming flow duration is no greater than 3 – 5 times the pre-development duration.
- Prepare preliminary engineering concept designs for any measures required to achieve the water quality and quantity objectives.

- Develop cost estimates for the works suitable to inform a contributions plan for the Precinct.

- Prepare a Water Cycle Management Concept Plan.

- Prepare a Water Cycle Management and Water Sensitive Urban Design Strategy Report to support the rezoning for the Schofields Precinct, detailing the investigations, findings, calculations and design details.

3. POST EXHIBITION AMENDMENTS

The Schofields Precinct Indicative Layout Plan (ILP) and supporting documentation was exhibited in September 2011. The Department of Planning and Infrastructure received submissions from various land owners and government authorities. As a result of the submissions, as well as refinement of the masterplanning and design processes, some changes were made to the Water Cycle Management Strategy. The main changes to the strategy are described below.

3.1. Relocation of the Sports Fields

One of the main changes from the exhibited ILP was the relocation of the sports fields. The sports fields were previously located between the primary school and the Burdekin Road extension. In order to maximise the residential development potential of the Precinct, the fields have been moved west into land that was previously identified as being flood affected. Blacktown Council's serviceability criteria for the fields was that they were to be flood free in events up to the 50 year ARI. Due to the flat, wide nature of the floodplain in this area, there is only a very small difference in the 50 and 100 year ARI flood levels. As such, the fields were located above the 100 year ARI flood level. It was considered more appropriate to relocate the sports fields closer to Eastern Creek and put the additional residential development where the sports fields were previously, as the area closer to Eastern Creek is more adversely affected by extreme storm events.

As the sports fields required filling in the floodplain to achieve the level of serviceability required, some compensatory storage was necessary to ensure no adverse impacts on landowners adjoining the Precinct. Excavation in the floodplain adjacent to the sports fields and Basin 6 (see further discussion below in Section 3.2) was undertaken to provide this compensatory storage. It is envisaged that this excavated area will have a dual use as a wetland that would enhance biodiversity in the location and also provide additional water quality benefit. It is noted that the Schofields Precinct would not rely on the wetland to achieve the required water quality targets. It is intended that the outlet from Basin 6 would discharge to the wetland system. Basin 6 conveys flows from approximately 650 hectares of catchment upstream of the Schofields Precinct. The proposed wetland would therefore provide a significant regional water quality benefit.

Flood modelling was undertaken to ensure that filling for the sports fields and the compensatory storage did not result in adverse impacts on flood levels outside the Precinct boundary.

3.2. Relocation of Basin 6 and the Connecting Drainage Channels

Similar to the sports fields, Basin 6 was also relocated for the post exhibition study to maximise the potential extent of residential development within the Precinct. The channels connecting to Basin 6 were also realigned as required. Basin 6 was relocated west from its previous location to an area identified as flood affected. While the basin is partially located below the 100 year ARI flood extents, the necessary storage volume required to restrict peak flows is contained above the 100 year flood level. Although floodwater from Eastern Creek can inundate Basin 6 through 'backing up' of the lower level 'base flow' outlet, the basin embankment still creates an impediment to flows. Flood modelling was undertaken to ensure that the location of Basin 6 and the compensatory flood storage described above in Section 3.1 results in no adverse impact on land adjacent to the Precinct.

The main channel (Channel 5) that conveys flows originating from the two significant upstream catchments at the south-east of the Precinct has been reconfigured. The previous channel was not designed to convey flows that currently bisect the Nirimba site. For the purpose of the exhibition strategy it was assumed that the current drainage arrangements within the Nirimba site would remain or would be addressed at a later date.

The post exhibition channel capacity has been increased to allow flows entering and generated from the Nirimba site to be conveyed to Basin 6 and Eastern Creek. The main portion of the proposed channel straddles the boundary of the Nirimba and Defence sites.

3.3. Landform Within the Crownland Development Land

The landform utilised in the post development flood model within the Crownland Development owned site (see Figure 1) was amended to include site regrading that is part of an approved development application. The landform was provided by Crownland Developments and includes areas of filling for development and excavation to provide compensatory storage.

3.4. Realignment of Channel Within the Dairy Corp Land

The channel conveying flows through the Dairy Corp land (Channel 2) has been slightly realigned to better suit the existing landform and to fit with the revised indicative layout within this area of the Precinct.

3.5. Flood Evacuation

A detailed Flood Evacuation Assessment was undertaken by Molino Stewart for the final ILP. The recommendations from this strategy are summarised in Section 8.9 and a copy of the report is included in Attachment E.

4. THE EXISTING ENVIRONMENT

4.1. The Site

The Schofields Precinct, which totals approximately 465 hectares, is located immediately west of the Blacktown – Richmond rail line between Quakers Hill Parkway and the M7 Motorway to the south and West Parade to the north. Eastern Creek forms the western boundary of the Precinct.

The Schofields Precinct site currently consists of the Nirimba Education Precinct and rural land holdings to the south. The Department of Defence and Dairy Corp own separate significant portions of the central region, while the northern portions consist of rural and residential areas and Hebe Farm. The various land holdings are shown on Figure 1.

The majority of the defence land portion of the precinct has been cleared and consists mainly of grasslands. A small amount of bushland exists around the drainage channels and there is extensive vegetation within the Eastern Creek riparian corridor. Three disused runways and two buildings remain on the defence site.

The Dairy Corp land consists almost entirely of grasslands with only a small number of scattered trees on the site and dense vegetation along the Eastern Creek riparian corridor. A series of farm dams exist within the gully leading to Eastern Creek.

Land to the north of the Dairy Corp site and south of the Nirimba education precinct consist of urban residential development and rural properties.

The location of the Schofields Precinct is indicated in Plate 1 below and is shown in more detail in Figure 1.

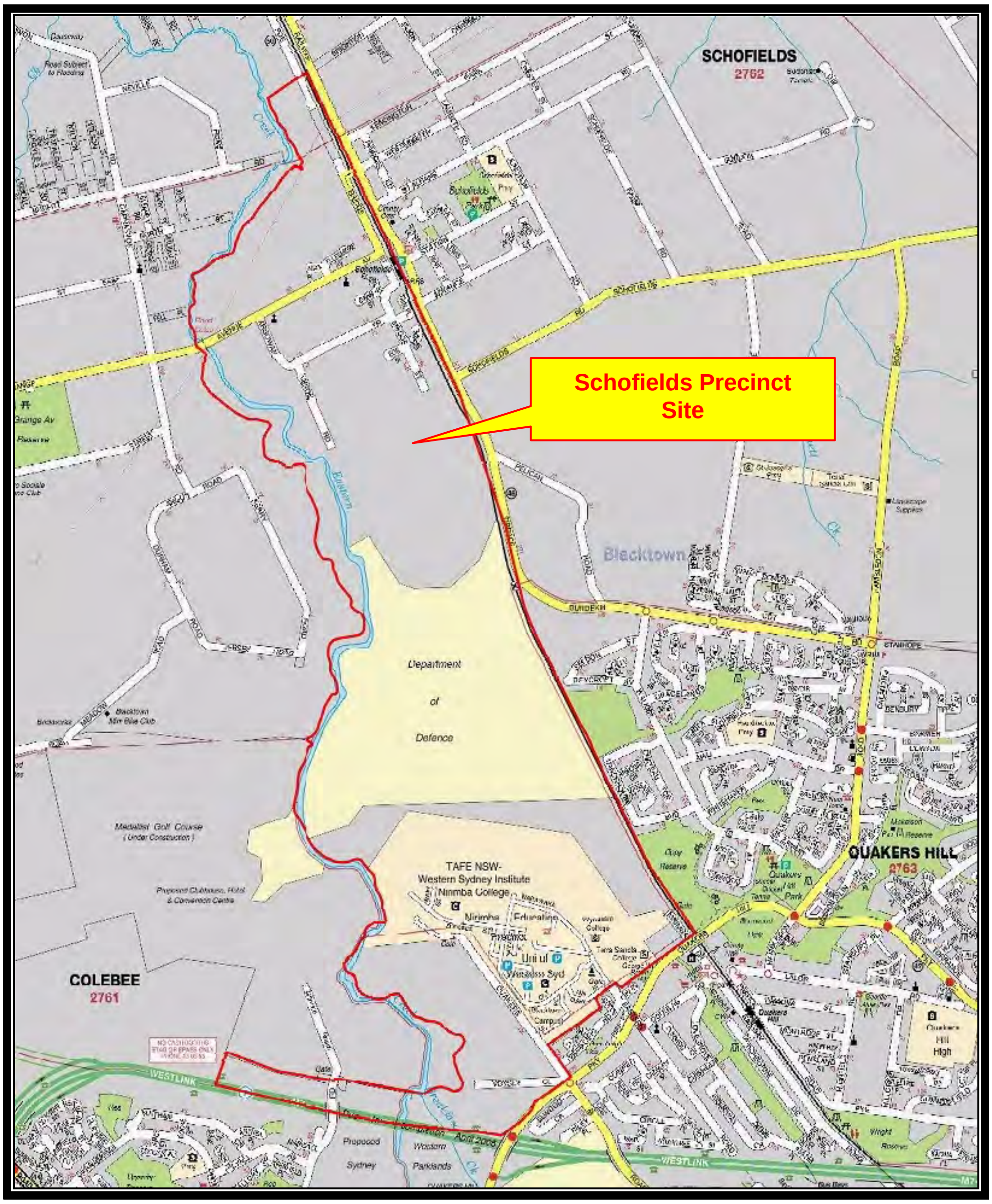


Plate 1: Location of the Schofields Precinct Development Site

4.2. Existing Drainage Configuration

The Schofields Precinct site is located directly adjacent to Eastern Creek. The entire site either drains directly to Eastern Creek or to it via minor tributaries.

A number of significant catchments are located upstream of the site and discharge to the Schofields site along the southern and eastern boundaries. The extent of the upstream catchments are shown on Plate 2.

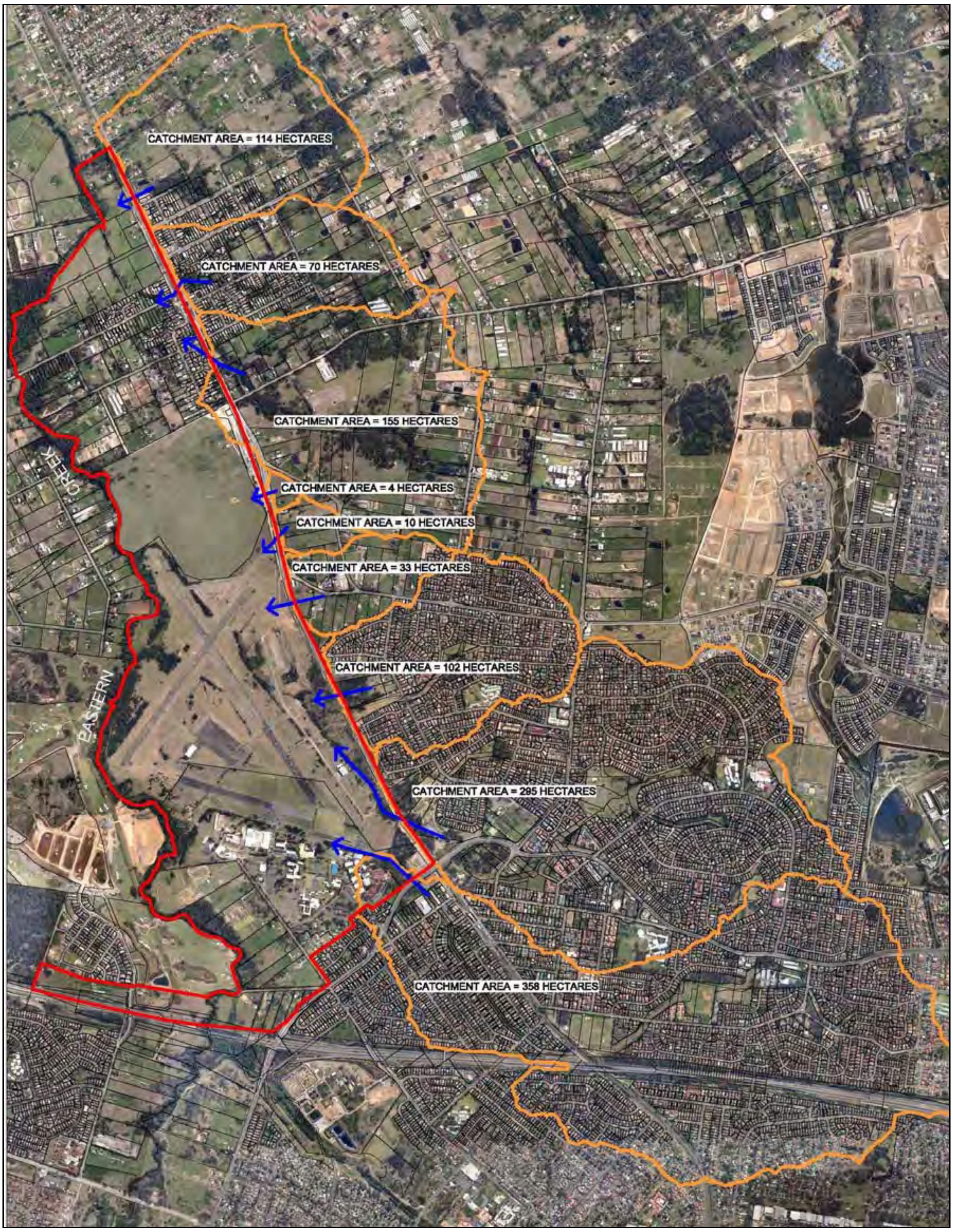


Plate 2: Extent of Upstream Catchments to the Schofields Precinct Site

A number of drainage channels have been created on the Defence site, presumably to divert the old creek lines away from the runways. A number of culverts link the drainage channels under the runways. A drainage channel has also been constructed adjacent to the northern extents of the Nirimba Education Centre.

A small portion of the south western corner of the site drains to Eastern Creek via the "Stonecutters" site to the north. The remainder of the Schofields site south of the Nirimba

Education precinct drains directly to Eastern Creek. Land within the Defence and Dairy Corp sites drain directly to Eastern Creek through a number of existing channels. Part of the existing urban and rural land to the north of the site drain directly to Eastern Creek while a portion of this area drains to Eastern Creek via a tributary.

The existing drainage configuration and flow directions within the Schofields site is shown on Plate 3. The existing drainage catchments are shown on Figure 2.

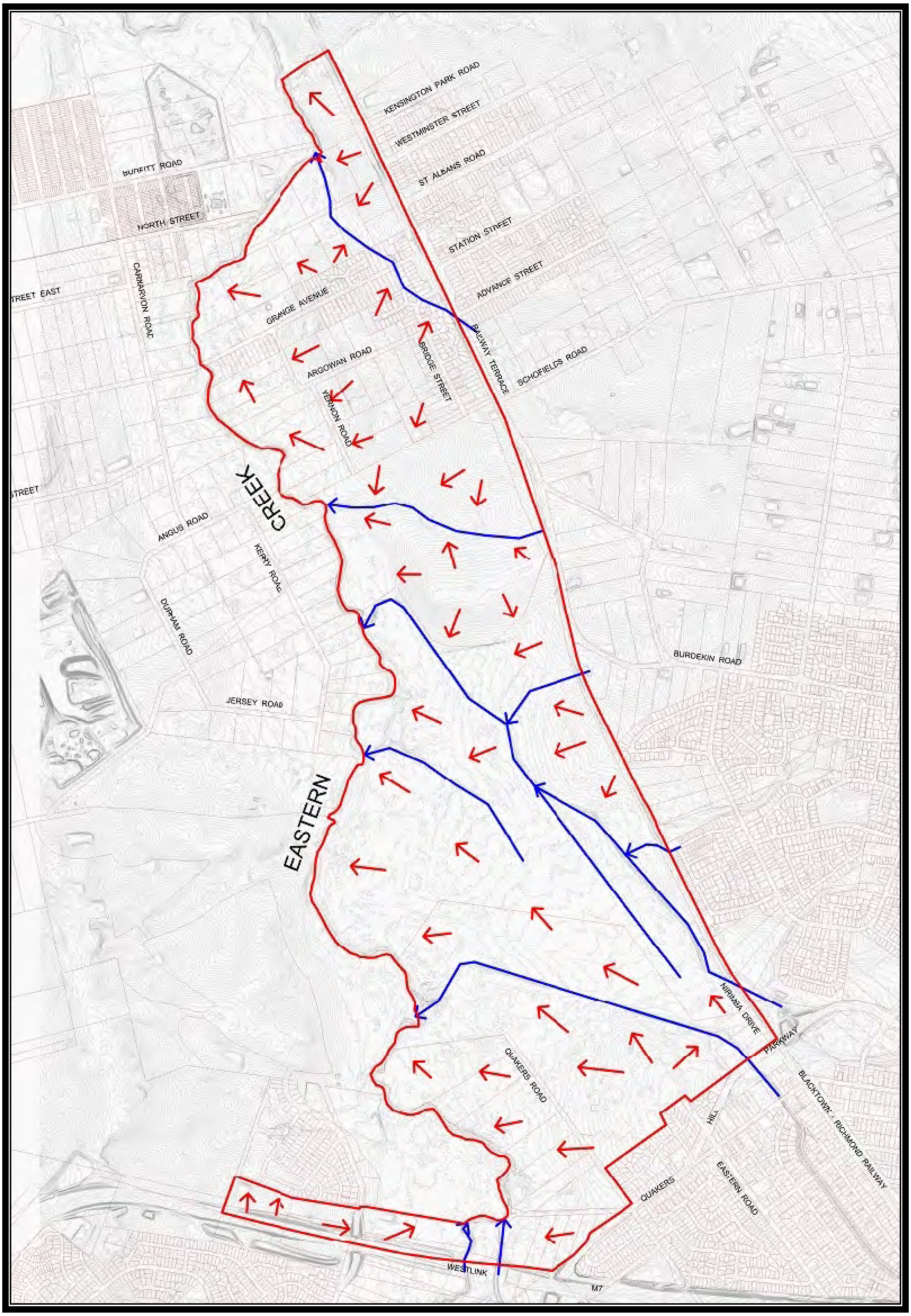


Plate 3: Direction of Flows Under Existing Conditions

4.3. The Proposed Development

As part of the Precinct Planning process, an Indicative Layout Plan (ILP) has been prepared identifying the various land uses proposed for the site. The land use for the site includes low, medium and high density residential, environmental living, schools, community facilities, riparian corridor, parks and drainage. The ILP is included in Attachment A.

With an overall area of approximately 465 hectares, the Schofields Precinct development will involve the creation of up to approximately 2950 residential allotments, the construction of 11 detention basins, 20 water quality raingardens and swales and the construction and dedication of new roads. The quantity and quality management elements will be constructed adjacent to either the Eastern Creek riparian corridor or the proposed drainage structures within the Precinct.

The proposed Schofields Precinct development is shown below in Plate 4.

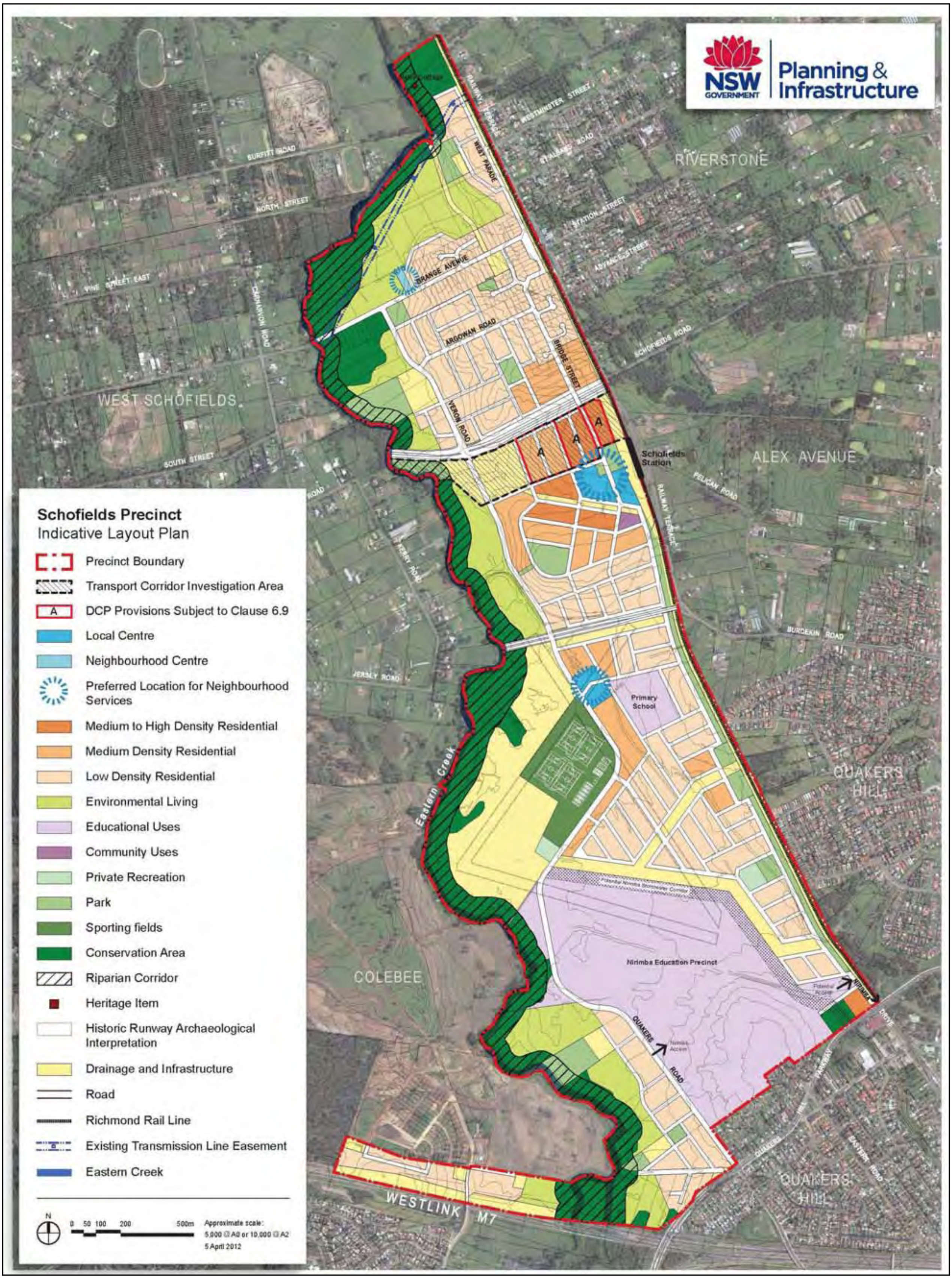


Plate 4 – Proposed Schofields Precinct Indicative Layout Plan

5. DEVELOPMENT GUIDELINES, OPPORTUNITIES AND CONSTRAINTS

The following guidelines were considered in developing the Water Cycle Management and WSUD strategy.

5.1. Growth Centres Development Code

The Growth Centres Development Code (Ref. 1) identifies the following matters for consideration with regard to Water Sensitive Urban Design and stormwater management:

- Stormwater management strategies should be based on the objectives and principles of Water Sensitive Urban Design. They should promote water reuse and maximise potable water conservation;
- Existing waterways and riparian zones should be conserved and enhanced where possible;
- Stormwater management strategies should be developed and implemented in a manner which considers and addresses potential salinity hazards;
- Stormwater management strategies should be adopted by the ILP to maximise efficient use of land and facilitate adequate allocation of land for stormwater management purposes;
- The ILP should be planned, designed and undertaken in a manner which allows for appropriate control of erosion and sediment pollution;
- A treatment train approach should be used, incorporating structural stormwater treatment measures at the primary, secondary and tertiary levels as necessary to comply with the stormwater management targets;
- The design of stormwater management systems should be integrated with the planning of road layout and design, given the potential benefits of incorporating suitable WSUD elements into road corridors;
- Stormwater reuse, retention and detention strategies should be used to minimise changes to the hydrological (or flow) regime of receiving waterways;
- Urban stormwater should not be discharged to areas of native bushland unless such discharge cannot be avoided. High levels of stormwater treatment and flow retention or detention should be implemented where such a discharge occurs to limit soil erosion and weed growth within areas of native vegetation;
- Management of stormwater should be considered on a subcatchment basis to employ source control techniques in preference to highly centralised ‘end-of-pipe’ treatment measures wherever practicable;
- Trunk drainage routes and dual carriageways should be aligned where possible, to allow use of centre medians for WSUD drainage systems;
- WSUD drainage systems may be incorporated into other roads and streets, where practicable and compatible with other design issues, including safety requirements of the relevant Road Authority;

- Any development within the 1:100 ARI flood level and the PMF should be designed to provide for emergency access;
- Critical infrastructure, such as major roads and rail, are to be located above the 1:100 flood level wherever possible;
- Evacuation routes that continually rise from residential properties to higher land should be provided.

5.2. Blacktown City Council Growth Centre Precincts Development Control Plan

The Blacktown City Council Growth Centre Precincts DCP (Ref. 2) identifies the following objectives with regard to flooding and water cycle management:

- to manage the flow of stormwater from urban parts of the Precinct to replicate, as closely as possible, pre-development flows.
- to define the flood constraints and standards applicable to urban development in the Precinct.
- to minimise the potential of flooding impacts on development.

5.3. Office of Environment and Heritage (OEH)

The Office of Environment and Heritage (OEH) (formerly the Department of Environment, Climate Change and Water) has set guidelines for stormwater quality from urban developments in their Interim Recommended Parameters for Stormwater Modelling – North-West and South-West Growth Centres (Ref. 3). This document nominates quantitative post construction phase stormwater management objectives for the reduction of various pollutants for a range of new developments. The retention criteria for the site are nominated as follows:

Total Phosphorous	65% retention of average annual load
Total Nitrogen	45% retention of average annual load
Suspended Solids	85% of average annual load for particles 0.5 mm or less
Gross Pollutants	90% retention of material greater than 5mm

The OEH guidelines also nominate a ‘stream erosion index’ target of 3.0 – 5.0, where the stream erosion index is defined as the post-development duration of flows greater than the ‘stream-forming flow’ divided by natural duration of flows greater than the ‘stream-forming flow’. For the purposes of these objectives, the ‘stream forming flow’ is defined as 50% of the 2-year flow rate estimated for the catchment under natural conditions (Ref. 3).

5.4. Blacktown City Council DCP 2006 Part R (Water Sensitive Urban Design and Integrated Water Cycle Management)

Although the Water Sensitive Urban Design and Integrated Water Cycle Management DCP is not the governing document for the Growth Centres Precincts, it has been considered in preparation of the Schofields Water Cycle Management Strategy.

Blacktown City Council's Water Sensitive Urban Design and Integrated Water Cycle Management DCP (Ref. 4) aims to:

- Protect and enhance natural river systems and their associated ecosystems and ecological processes.
- Maintain, protect and/or rehabilitate modified watercourses and their associated ecosystems and ecological processes towards a natural state.
- Minimise potable water demand and wastewater generation.
- Match the post development runoff to the pre development or natural water runoff regime as closely as possible.
- Mitigate the impacts of development on water quality and quantity.
- Mitigate the impacts of development on groundwater, particularly in saline groundwater environments.
- Ensure any changes to the existing groundwater regime do not adversely impact upon adjoining properties.
- Integrate water cycle management measures into the landscape and urban design to maximise amenity.
- Minimise the potential impacts of development and other activity on the aesthetic, recreational and ecological values of receiving waters.
- Minimise soil erosion and sedimentation resulting from site disturbing activities.
- Ensure the principles of ecologically sustainable development are applied in consideration of economic, social and environmental values in water cycle management.

The development controls applicable to the Schofields Precinct development to achieve the above objectives have been identified as:

5.4.1. Waterfront Lands

- The deemed watercourse classifications and additional waterfront lands controls shall be in accordance with the Waterfront Lands Strategy developed for that Development Application.

5.4.2. Water Conservation

- New residential dwellings, including a residential component within a mixed use building and serviced apartments intended to, or capable of being strata titled, are to demonstrate compliance with State Environmental Planning Policy – Building Sustainability Index (BASIX).
- In industrial and commercial developments dual reticulation for non potable uses such as toilet flushing, laundry, irrigation and cooling towers must be installed.

- For any water use within public open space (e.g. irrigation, water features, open water bodies / pools) an alternative water source must be identified to meet at least 80% of all demand.

5.4.3. Stormwater (Water Quality and Waterway Stability)

- 90% reduction in the post development average annual gross pollutant (>5mm) load.
- 85% reduction in the post development average annual load of Total Suspended Solids (TSS) load.
- 65% reduction in the post development average annual load of Total Phosphorus (TP) load.
- 45% reduction in the post development average annual load of Total Nitrogen (TN) load.
- 90% reduction in the post development average annual load of Total Hydrocarbons load.
- The post development duration of stream forming flows shall be no greater than 3.5 times the pre development duration of stream forming flows with a stretch target of 1.
- Minimisation of impervious areas that are directly connected to the stormwater system.

5.5. New South Wales Office of Water (NOW) Requirements

A separate Riparian and Aquatic Assessment was incorporated in the Schofields Biodiversity Assessment Report (Ref. 5) completed by Eco-Logical Australia, which included liaison and a field inspection with NOW. As a result of the investigation, Eastern Creek has been confirmed as a Category 1 stream. A number of the un-named tributaries to Eastern Creek within the site have also been classified as Category 2 and 3 water courses.

The existing water course within the defence land site is thought to have been redirected over time to allow for construction of the runways. It is proposed to realign this water course as part of the development to more accurately reflect what is thought to be the original alignment.

The existing water course locations and categories, as mapped by Eco-Logical Australia, are included in Attachment B.

5.6. Salinity

Salinity is the accumulation of mineral salts in the soil, groundwater and surface waters. Dry land salinity results when these soluble salts are transported to the surface by rising water table. The groundwater itself can also cause soluble salts to migrate under the ground surface and emerge as saline seepage in low lying areas. Salinity can lead to vegetation loss, weed invasion, soil structure decline and in some cases structural damage to buildings.

5.6.1. Salinity and Groundwater Control Measures

Groundwater **recharge** and **discharge** can both result in rising water tables and saline groundwater seepage. A Land Capability, Salinity and Contamination Assessment was undertaken by WSP Environmental and Energy (Ref. 6) to investigate and make recommendations on salinity and groundwater for the Schofields Precinct. The study found that:

- Additional development specific geotechnical studies should be undertaken in the future, particularly for areas where filling in areas of the floodplain is proposed.
- Surface soils at the channel locations were typically non-saline, while the subsoils were typically non-saline to moderately saline.
- Surface soils located outside the vicinity of the channels were typically non-saline to a depth of 0.5 metres. Deeper sub-surface soils were generally slightly saline to moderately saline.
- The moderate to high salinity concentrations in groundwater indicate that there is a potential for an increase of salinity impacts in the upper soil profile should changes to the hydrological cycle result in an increase of the groundwater table.
- Surface soils are generally non-sodic to sodic and sub-surface soils are classified as highly sodic.

Salinity management measures should be implemented for the Schofields Precinct development in accordance with the recommendations outlined in the WSP report and the WSROC Western Sydney Salinity Code of Practice (Ref. 7).

5.7. 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 (Ref. 8) 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.

5.8. Stormwater Management Objectives

5.8.1. Overall Objectives

The overall site stormwater management objectives were identified as follows:

Environmental	Provision of appropriately designed, functional water quality facilities, limitation of downstream discharge peaks and velocities and maintenance of existing downstream water quality. Maintenance of environmental flows to ecosystems downstream of the site.
Urban Amenity	Provision of a water cycle management strategy that identifies and controls limits of flood affectation and provision of aesthetic design forms that enhance amenity.
Engineering Considerations	Effective management and control of peak discharges, discharge velocities, site detention, and water quality; industry best practice technical analysis of catchment hydrology and system hydraulic performance.
Economics	Provision of a cost effective, functional site drainage system that optimises performance, provides maximum value for expenditure and keeps on-going maintenance requirements to a minimum.

5.8.2. Specific Development Objectives

In accordance with the principles of Ecologically Sustainable Development (ESD), the area needs to be designed, developed and maintained in accordance with the following stormwater management objectives:

- Preserve the ecological integrity of the identified riparian zones.
- Restrict development to above the 1% AEP flood level.
- Incorporate water sensitive urban design principles within the development.
- Ensure post-development water quality complies with Council's and the OEH's requirements.

- Provision of a sustainable aquatic environment that preserves the potential for creating habitat for locally indigenous flora and fauna.
- Minimise Council's maintenance requirements for open space, litter control structures and nutrient and sediment removal devices.
- Enhance the biodiversity, ecological health and positive water quality benefits within the Eastern Creek corridor to provide an integrated natural resource for the incoming residents.

5.9. Opportunities

In the design of any urban drainage scheme it is desirable to build on the naturally occurring physical and environmental assets of the site to maximise the quality of the ultimate living environment. In particular water should be recognised as an important resource that can enhance and bring a focus to areas accessible to the whole community.

For the Schofields Precinct site there are major opportunities to:

- Maintain, rehabilitate and enhance the Eastern Creek riparian corridor and other riparian corridors within the Precinct;
- Maximise habitat retention along the riparian corridor to provide sustainable aquatic and terrestrial ecosystems;
- Integrate open space areas and riparian corridors;
- Incorporate water reuse schemes to irrigate public reserves and proposed playing fields wherever possible.

5.10. Constraints

The constraints to be considered in the preparation of a drainage strategy for this site include:

- Steep site topography within certain areas of the site may require special treatment to reduce scour and erosion.
- Flows from significant upstream catchments are to be conveyed through the site.
- Areas of non-certified land have been identified within the site where development is restricted.
- Water quality and quantity objectives will require allocation of land for stormwater control structures.
- Existing site soil salinity and groundwater salinity constraints.
- Water use activities that can cause unnatural charging of groundwater and create rising watertables (e.g. over-irrigation of public areas, sports fields, private lawns and private gardens).

- Significant areas of the site are below the regional (RL 26.4) and local PMF flood levels. Evacuation and flood safety in the area will be important considerations.

- Due to the flat nature of the majority of the site and being on the edge of the floodplain, a significant amount of fill is expected. The flat terrain requires careful design and filling shall be kept to the minimum amount required.

6. WATER CYCLE MANAGEMENT STRATEGY CONCEPT

The Water Cycle Management Strategy proposed for the Schofields Precinct development has been prepared with consideration of the statutory requirements and guidelines listed in Section 4 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.

6.1. Water Quality Management Options

A range of stormwater management techniques and options considered for the management of nutrients and suspended solids discharging from the site are summarised as follows:

6.1.1. 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); and
- 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.

Comment: The grade of the land within certain portions of the Schofields Precinct is suitable for swales and buffers (< 3%), in particular within the Defence land. 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 requirements. Swales and buffers may possibly be considered at development application stage as one off elements within central medians on collector roads or other similar locations where the above issues are not applicable.

6.1.2. Sand Filters

Sand filters typically comprise of a bed of filter medium 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; and
- 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.

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

6.1.3. 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); and
- 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 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; and
- detention systems – temporarily holding surface water for short periods to reduce peak flows and later releasing into the stormwater system.

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.

6.1.4. Infiltration Trenches and Basins

Infiltration trenches temporarily hold stormwater runoff within 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); and

- 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 of 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 within a pit and tank system, whereas basins utilise above ground storage.

Comment: Infiltration trenches and basins are not appropriate for clay soils or where there is potential for salinity issues. Infiltration trenches and basins are therefore not recommended for the Schofields site.

6.1.5. Constructed Wetlands

Constructed wetlands can take the form of either a surface or sub surface system.

Surface Conventional wetlands.

Sub Surface Gravel filled shallow wetland.

Wetlands are shallow water body systems, densely vegetated with emergent aquatic macrophytes. Wetlands are effective in trapping suspended solids, as well as chemical and biological uptake of pollutants.

Comment: Wetlands are effective in removing sediment and nutrient loads typically generated from urban development. They do however require a large footprint area in relation to the catchment size. Wetlands also require a significant amount of maintenance. They are susceptible to algal blooms and require recirculation systems. Consideration of public safety measures are also required due to permanent deep water areas.

6.1.6. 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 100-300 mm 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 are located within the verge area of a road reserve or extend within the bushland corridors or other open space areas. 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 0.6 metres deep.

Comment: Bio-retention systems are an effective and efficient means of treating pollutants from urban developments when part of an overall treatment train. Bio-retention systems require a reasonable amount of maintenance during the vegetation establishment phase.

6.1.7. Cartridge Filtration Systems

Cartridge filtration systems are underground pollution control devices that treats first flush flows. The units 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 litre per second, and the unit can accommodate up to 24 cartridges providing a maximum treatable flowrate of 24 litres per second.

Comment: Cartridge filtration systems are an efficient means of treating pollutants from urban developments 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.

6.1.8. 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; and
- it may be permissible to use rainwater tanks for internal hot water supply.

The water collected can be reused as a substitute for mains water supply either indoors (toilet flushing and laundry) 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.

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.

Each of these management techniques were evaluated and compared with consideration of a range of Environmental, Social/Amenity, Economic, Maintenance and Engineering criteria.

6.2. Proposed Stormwater Control Strategy

The stormwater management strategy proposed for the site focuses on minimising 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 critical consideration is the ecological sustainability of the Eastern Creek Riparian corridor adjacent to the site. To maintain stormwater quality at the required levels, a “treatment train” approach is proposed where various types of pollutants are removed by a number of devices acting in series. The stormwater management treatment train will consist of the following elements.

WATER EFFICIENCY

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 and plumbing in of the water tank for internal uses will ensure any requirements are met and additional benefits are realised.

WATER QUALITY

On Lot Treatment for all Industrial, Commercial, Medium / High Density Development

For all development other than low density residential and public Council roads, water quality treatment is to be provided on site through community title or a similar appropriately managed scheme. The on lot treatment train is to be designed so that it achieves the pollutant load target reductions identified by OEH for the Growth Centres and Blacktown City Council, as outlined in Section 5. Discharges from the on lot treatment system can be directed to the public street drainage or trunk drainage systems.

Configuration and design of the on lot treatment train would be undertaken at the development application and detailed design stages of the development.

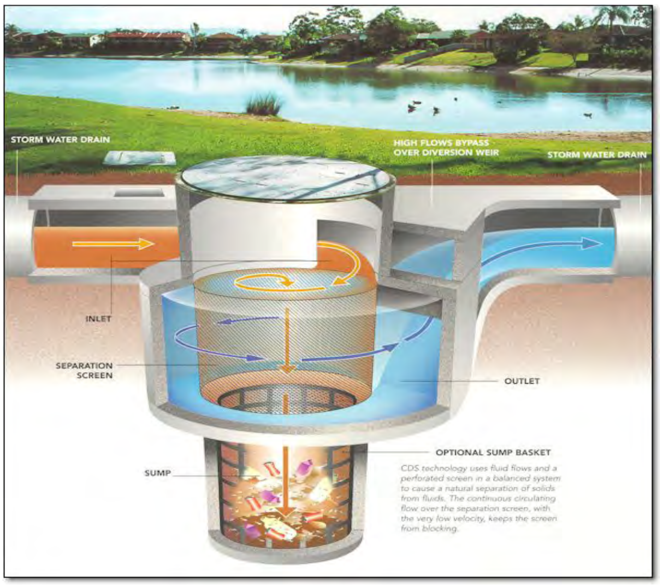
Street Level Treatments

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 a downstream (Secondary and Tertiary) treatment devices. They can take the form of trash screens or litter control pits, filter pit 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. This is particularly relevant for portions of the Schofields Precinct due to the fragmented ownership and the likely stagnated nature of future development. Pit filter inserts would provide an at source mechanism for treatment of gross pollutants as development proceeds throughout the site.

In practice, Blacktown Council have found that inlet pit filter inserts result in a reasonable maintenance burden, particularly through access for cleaning and damage / vandalism. Council have advised that they may be willing to consider pit inserts in low density residential areas where on street parking is unlikely or not permitted and where additional primary / secondary treatment measures are provided downstream in case of pit insert failure. Council's preference for the Schofields Precinct is for end of line proprietary GPT's.



The form and configuration of GPT's

can be further considered at development application and detailed design stages in conjunction with the streetscape design.

Subdivision / Development Treatment

Raingardens

Twenty regional scale "raingardens" and linear bioretention swales are proposed within the development. Raingardens are large scale, non-linear bioretention systems. The raingardens / bioretention swales will be appropriately sized to achieve the nutrient reduction targets proposed in the Blacktown City Council's WSUD and IWCM DCP (Ref. 4) for the development site. These targets are consistent with the OEH targets specified for the Growth Centres. The raingardens / swales will also attenuate first flush flows to reduce the risk of stream erosion on Eastern Creek. The location of the twenty raingardens / swales are shown on Figure 4. Refer to Section 6.4 for further discussion.

The strategy for the Precinct does not preclude the use of additional or alternate WSUD elements within the streetscape or landscape. These elements, such as swales or bioretention 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, safety, maintenance and performance.

WATER QUANTITY

Subdivision / Development Treatment

Detention Basins	Peak storm flow attenuation up to the 100 year ARI event is addressed through the provision of both regional online and local offline detention storages located within the Schofields Precinct.
Stream Erosion Index	Limiting the post development stream forming flow duration so that it is no more than 3 – 5 times that of the pre-development stream forming flow duration.

Key features of the proposed strategy are as follows:

Social:

- Integration of bio-retention raingarden systems with the overall landscape strategy for the estate to create an integrated-natural resource for the incoming and wider community.
- Enhanced visual amenity (views out of and through the riparian corridor).
- Flood affectation and public safety issues identified and controlled.
- Provision of aesthetic soft design forms that enhance urban and environmental amenity.

Environmental:

- Limited downstream and in-channel discharge peaks and velocities to avoid scouring, siltation and flora and fauna impacts
- Enhanced ecological health and biodiversity within the riparian corridors.
- Provision of gross pollutant traps and bio-retention systems to achieve water quality capable of sustaining Eastern Creek aquatic ecosystems.
- Limitation of frequent wetting flows and peak velocities to avoid creek bed/bank erosion and sedimentation. Peak storm flow attenuation is addressed through provision of regional and local detention basins located within the Schofields Precinct.
- A holistic and interdisciplinary approach to the management of urban salinity, using an approach to construction, stormwater management, building and landscaping practices, consistent with the WSROC Western Sydney Salinity Code of Practice (Ref. 7) and in accordance with the recommendations by WSP Environment & Energy (Ref. 6).
- Provision of extensive deep rooted vegetation in strategic areas to intercept ground water flows and generate natural groundwater discharge processes (evapotranspiration).

- Extensive revegetation of allotments, streetscapes, and bio-retention systems to manage urban salinity and provide habitat.

- Provision of reticulated recycled water or rainwater tanks within the development to reduce reliance on potable water supplies by using recycled water as a resource.

Economic:

- Minimisation of land take consistent with the achievement of environmental and social objectives.

- Proposed water quality improvement measures that keep recurrent maintenance tasks and costs to a minimum.

The water cycle management strategy proposed for the Schofields Precinct development site is functional; delivers the required technical performance; lessens environmental degradation and pressure on downstream ecosystems and infrastructure; and provides for a 'soft' sustainable solution for stormwater management within the release area. The water cycle management concept is illustrated on Figure 4.

6.3. Litter and Sediment Control

Local drainage throughout the development should be filtered to remove litter & coarse sediment prior to discharge into the downstream drainage systems, raingardens and the riparian corridors. Devices to achieve litter and sediment control come in various forms, such as inlet pit filter inserts, cast in situ and precast gross pollutant traps as well as wet sump and self cleansing units.

We understand that Blacktown City Council's preference is to not adopt pit filter inserts on a large scale. Therefore it is proposed that Council approved proprietary gross pollutant trap structures be provided to capture litter, vegetative matter, coarse sediment prior to discharge to the downstream treatment devices. An appropriate unit should be selected such that it intercepts a minimum 90% of the sediment of size 0.15 mm and greater. It is expected that the site drainage strategy would require approximately 23 of these structures (at least one per raingarden and discharge point to the drainage reserves). Where possible, dewatering lines will be provided to each GPT unit to facilitate drainage of the sumps. These dewatering lines will be discharged to heavily vegetated sections of the raingardens, as appropriate, to provide for nutrient stripping of the supernatant water.

At the development application phase we recommend that the acceptance of pit filter inserts be reviewed by Council as an appropriate solution for the development, given the fragmented ownership within portions of the site and potential for Council to have to maintain a high number of alternate end of pipe GPT's, which would be necessary to supplement development of land holdings in the upper catchment prior to development of the fringe of Eastern Creek.

6.4. Raingarden / Bioretention System

Twenty raingardens / bioretention swales are proposed throughout the development site, located adjacent to the Eastern Creek Riparian Corridor.

The raingardens / swales consist of a relatively shallow organic sandy loam bed (0.6 m) which will be densely vegetated with native sedges and/or grasses. These devices would be designed to receive, convey and treat 3 month ARI flows from the upstream catchments.

Treatment is attained by detention of flows, direct filtration and nutrient stripping by bio-films which establish on the surface of the media bed. The organic sandy loam bed and plant system minimises evaporation losses and the raingardens / swales will be designed to prevent seepage losses and to avoid groundwater salinity impacts.

The proposed raingardens / swales servicing the development will have an extended detention zone of 300mm which will service the first flush and base flows from the urban development. The general features and configuration of the proposed raingardens / swales is detailed in Table 6.1. The filter areas of the raingardens / swales (as a percentage of the total subcatchment area) varies depending on the extent of on lot treatment within the subcatchment. The raingarden / swales configuration and areas are shown on Figure 4. A discharge control structure will be configured to promote extended detention times for the treatment flows.

The size of the raingardens / swales have been determined using MUSIC modelling (Refer to Section 9). The performance of the devices are detailed in Section 9.5 of this report. Details of the raingardens / swales are shown on Figure 4 and the attached concept design plans.

It is recommended that prior to completion of the construction and housing phases of the Precinct the raingarden / swales floor be utilised as a sedimentation control pond. The commissioning of the raingarden / swales should only occur once sediment loads in the catchment are adequately controlled, so that the risk of clogging of the media bed is acceptable (refer to Section 6.8).

Table 6.1

BIO-RETENTION RAINGARDENS
GENERAL FEATURES AND CONFIGURATION

Storage Properties	
Extended Detention Depth (m)	0.3
Seepage Loss (mm/hr)	0
Infiltration Properties	
Filter Area (m^2)	Varies
Filter Depth (m)	0.5
Filter Media Particle Diameter (mm)	0.45
Saturated Hydraulic Conductivity (mm/hr)	100
Outlet Properties	
Overflow Weir Width (m)	Varies

Maintenance requirements for the raingarden / swales would typically involve plant replacement, weed control, repair of erosion and structural damage and removal of localised sediment build-up. This would be undertaken on a quarterly basis on average.

The performance of the water quality system is described in Section 9.4.

6.5. Water Quantity Management

Water quantity management for the Schofields Precinct is achieved through provision of eleven (11) detention basins. Two of the proposed basins are online to water courses or drainage channels that convey flows from the upstream catchments. The remaining nine basins detain flows only from the Schofields Precinct site.

The performance of the water quantity management system is described in Section 7.

6.6. Construction Stage

Erosion and sediment control measures are to be implemented during the construction phase in accordance with the requirements of Blacktown City Council and the guidelines set out by Landcom (the “Blue Book” Ref. 9).

As the operation of “bio-retention” (raingarden) type water quality treatment systems are sensitive to the impact of sedimentation, these 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 Council officers, would be required.

6.7. Interim Treatment Measures

The raingarden / swales media bed should be protected throughout the civil and housing construction phases of the development. The floor of the raingarden / swales 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 90% completion of housing construction.

Upon 90% completion of housing construction within the catchment, the turf or sacrificial layer can be removed, replaced and the final planting completed.

6.8. 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 / swales 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 / swales including plant monitoring, replanting guidelines, monitoring and replacement of the filtration media and general maintenance (i.e. weed control, sediment removal).

6.9. Stormwater Monitoring Programme

A stormwater monitoring programme should be implemented to ensure the water quality raingarden / swales continue to operate as efficiently as possible. The management system should involve regular in-situ testing of the hydraulic conductivity of the media bed. The procedure recommended for testing the in-situ hydraulic conductivity has been described in detail by the Facility for Advancing Water Biofiltration (FAWB) and is reproduced as Attachment C in this report.

Should the testing show a deficiency in the hydraulic conductivity, it is recommended that the following rectification procedure be implemented:

- Determine the filtration bed level (RL) at which the hydraulic conductivity falls below the minimum recommended value.
- Remove the portion of media bed above this level and replace with material in accordance the original specification.

It is recommended that the stormwater monitoring programme be developed for the Precinct and included in the Operation and Maintenance Manual.

7. HYDROLOGIC ANALYSIS

The hydrologic analyses for this study were undertaken using the rainfall - runoff flood routing model XP-RAFTS (Runoff and Flow Training Simulation with XP Graphical Interface) (Ref. 10 & 11). The hydrologic analysis for the Schofields Precinct was undertaken to determine the size of detention basins required to restrict peak post development flows to pre development levels and also to generate peak flow rate hydrographs for input to the hydraulic model.

7.1. Previous Modelling

A number of XP-Rafts hydrologic models have previously been prepared which cover the Schofields Precinct site, the adjacent upstream catchments and the entire Eastern Creek catchment. These models were provided by Blacktown Council for use in this study and are summarised as follows:

1. Alex Avenue and Riverstone Growth Centre Precincts Existing and Ultimate Development Case Models (Eastern Creek Catchment)

2. Schofields Precinct and Quakers Hill Area Existing Development Case Model

3. Whole of Eastern Creek Catchment Model (to Garfield Road West) (Blacktown Council's current adopted hydrologic model for determining peak flows on Eastern Creek)

The whole of Eastern Creek Catchment model includes the catchments that make up the Alex Avenue, Riverstone, Schofields and Quakers Hill development. However, as the model covers the entire Eastern Creek catchment, the subcatchment breakup for these areas is very broad, with most being greater than 100 hectares. The whole of Eastern Creek catchment model was therefore utilised in this investigation, however the more detailed subcatchment breakups were substituted in the model for the Schofields site, Alex Avenue, Riverstone and Quakers Hill. This allowed sizing of the detention basins to meet the local peak flow management targets as well as assessment of peak flows on Eastern Creek.

It is noted that the whole of Eastern Creek model does not include a percentage of imperviousness representing all of the development that has occurred in the catchment as well as the numerous detention basins within the catchment. While the detention basins may restrict peak flow rates to the pre development levels, there would be differences in the timing of peak flows and also increases in volume runoff. It is understood that Blacktown Council are seeking to have the Eastern Creek hydrology and hydraulic models updated to more accurately reflect the current and future development scenarios. The hydrology study for the Eastern Creek catchment has recently been completed and is currently being reviewed by Blacktown Council. The timing for completion of the hydraulic investigation is currently uncertain.

7.2. Sub-Catchments (Post Development)

Sub-catchment areas contributing to the drainage system were determined from the Indicative Layout Plan for the site. Catchment boundaries for the developed areas contributing to the drainage system are shown on Figure 3 and the catchment details are provided in Attachment D.

7.3. Rainfall Data & XP-Rafts Parameters

Rainfall data used in the hydrologic study is consistent with Blacktown Council's Rainfall Intensity Frequency Duration data (Table 3.0 in Appendix D of Blacktown City Council's Engineering Guide for Development (Ref. 12)).

Although the pern (n) values and losses vary slightly between the various models provided by Blacktown Council, the values in each model were adopted for consistency with the investigations previously completed. Where new nodes were added to the XP-Rafts model, the parameters summarised in Table 7.1 were adopted.

Table 7.1

XP-RAFTS PARAMETERS

Parameter	Catchment Condition	Adopted Value
Pern		
	Existing Pervious	0.04
	Urban Pervious	0.025
	Urban Impervious	0.015
Losses		
Initial Loss	Pervious Catchment	15.0
Continuing Loss	Pervious Catchment	2.5
Initial Loss	Impervious Catchment	1.5
Continuing Loss	Impervious Catchment	0.0

7.4. Detention Storages

A summary of the proposed detention storages for the Schofields Precinct are shown in Table 7.2. The basin locations are shown on Figure 4.

Table 7.2

SUMMARY OF DETENTION BASIN STORAGES

Detention Basin No.	Basin Volume (m^3)
DB1	1,600
DB2	4,000
DB3	8,600
DB4	16,500
DB5	14,800
DB6	33,600
DB7	3,100
DB8	3,450
DB9	1,100
DB10	900
DB11	950

7.5. Discharge Estimates (From The Schofields Precinct)

For the Schofields Precinct planning purposes, discharge estimates were derived for the developed catchments for storms with Average Recurrence Intervals (A.R.I.'s) of 2 and 100 years along with the PMF. Additionally, the 500 year ARI storm was also assessed to determine flood extents for use in the Flood Evacuation Study. A range of storm durations from 10 minutes to 72 hours were analysed to determine the critical storm duration for each sub-catchment.

The 2 and 100 year A.R.I. and PMF peak flows at key locations within the Schofields Precinct are presented in Table 7.3. The key locations are shown on Plate 5. The XP-RAFTS modelling outputs are provided in Attachment D.

Table 7.3

SUMMARY OF PEAK 2 & 100 YEAR ARI AND PMF FLOWS AT KEY LOCATIONS WITHIN THE SCHOFIELDS PRECINCT (WITH AND WITHOUT DEVELOPMENT IN THE SCHOFIELDS PRECINCT)

Node	2 Year ARI Peak Flow (m^3/s)		100 Year ARI Peak Flow (m^3/s)		PMF Peak Flow (m^3/s)	
	Existing Conditions	With Schofields Development	Existing Conditions	With Schofields Development	Existing Conditions	With Schofields Development
JWPDum1	9.72	7.46	22.6	22.2	61.0	71.7
34 + JWPDum2	69.3	68.2	138	135	638	570
JWPDum3	0.447	0.337	1.84	1.23	6.21	7.58
36	2.93	2.40	9.66	9.34	44.3	48.4
d6	16.9	15.2	40.3	36.7	193	193
38	24.6	23.2	60.8	54.6	319	316

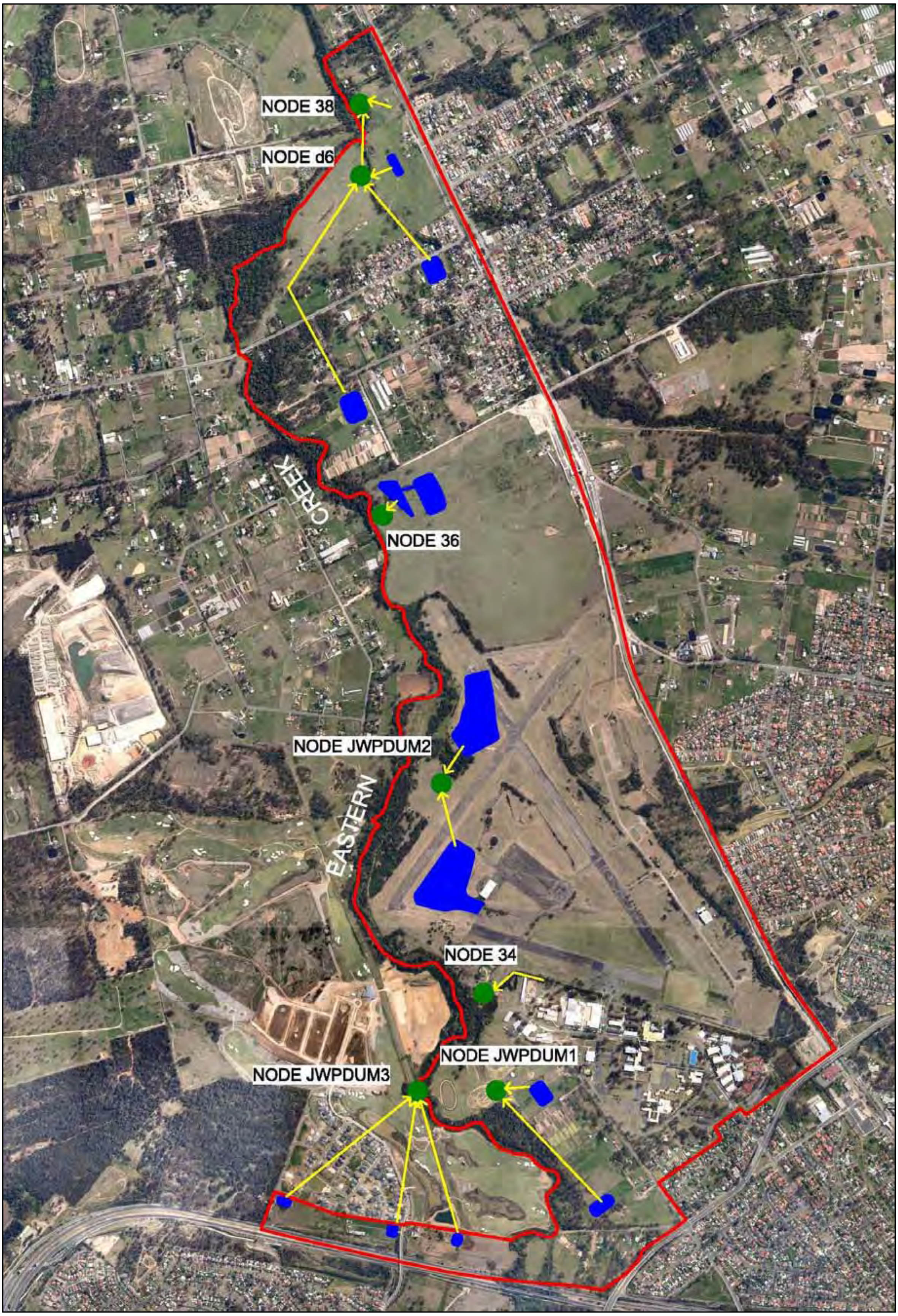


Plate 5 – XP-Rafts Node Locations Within Schofields Precinct

The XP-RAFTS modelling results presented in Table 7.3 show that the proposed detention storages within the Schofields Precinct development is adequate to restrict post development discharges to pre development levels for storm events between the 2 and 100 year ARI.

7.6. Discharge Estimates (At Eastern Creek)

The 2 and 100 year A.R.I. and PMF peak flows at key locations along Eastern Creek were also assessed for a range of storm durations from 10 minutes to 72 hours were analysed to determine the critical storm duration for each sub-catchment. The results are presented in Table 7.4. The key locations are shown on Plate 6. The XP-RAFTS modelling outputs are provided in Attachment D.

Table 7.4

SUMMARY OF PEAK 2 & 100 YEAR ARI AND PMF FLOWS AT KEY LOCATIONS ALONG EASTERN CREEK (WITH AND WITHOUT DEVELOPMENT IN THE SCHOFIELDS PRECINCT)

Node	2 Year ARI Peak Flow (m^3/s)		100 Year ARI Peak Flow (m^3/s)			PMF Peak Flow (m^3/s)		
	JWP Model Existing Conditions	JWP Model With Schofields Development	Blacktown Council Adopted Model	JWP Model Existing Conditions	JWP Model With Schofields Development	Blacktown Council Adopted Model	JWP Model Existing Conditions	JWP Model With Schofields Development
1.15	160	160	404	401	401	1641	1671	1671
33	160	160	411	397	398	1661	1682	1683
1.17	169	160	429	417	399	1714	1806	1685
35	183	181	442	453	444	1762	1982	1925
1.19	184	183	471	455	447	1905	1986	1930
37	182	181	486	454	450	1937	1998	1944
1.21	188	187	498	474	473	1974	2025	1970
39	189	187	507	484	482	1992	2047	1992
1.23	220	218	598	572	570	2401	2479	2423

Plate 6 – XP-Rafts Node Locations on Eastern Creek

The results presented in Table 7.4 show that generally the peak ultimate development discharges on Eastern Creek are less than the existing case peak discharges. This differs from some of the exhibition study results due to some changes to the hydrology model.

The existing case hydrology modelling for the Schofields Precinct also adopted the existing case Alex Avenue and Riverstone model conditions (from the model supplied by Council). The ultimate case Schofield's hydrology model adopted the ultimate case Alex Avenue and Riverstone model conditions.

Further detailed examination of the Alex Avenue and Riverstone hydrology models provided for use in the Schofields Precinct assessment was undertaken during the post exhibition study. The assessment showed that peak post development flows from these adjacent Precincts were not always less than the pre development flows, particularly for the 2 year ARI event. This resulted in the Schofields Precinct having to make up any shortfall if the ultimate case peak flows were to be less than existing flows at Eastern Creek. In order to resolve this situation, the ultimate case Alex Avenue and Riverstone hydrologic model was adopted in both the existing and ultimate case Schofields hydrologic models.

7.7. Climate Change Sensitivity Assessment

Preliminary assessments of hydrologic impacts, resulting from changes to rainfall patterns as a consequence of Climate Change, were undertaken to determine the impact of such changes on the performance of the proposed Trunk Drainage system. These assessments followed the sensitivity analysis procedures recommended in the *Impacts of Climate Change on Urban Stormwater Infrastructure in Metropolitan Sydney, Sydney Metropolitan Catchment Management Authority (January 2011)* (Ref. 13).

In summary:

- Summer runoff depths are expected to increase by a maximum of 26%.
- The 40-year 24-hour duration rainfall intensity is expected to increase by a maximum of 12%.
- The net average annual runoff is expected to fluctuate with an overall minor increase.

Consequently for the purposes of this assessment, the worst-case scenario of projected increased rainfall intensities (15% increase) and runoff depths (25% increase based on rainfall intensities increased by 15%), were adopted.

This approach has been referred to OEH for comment and has been confirmed as "a pragmatic approach to considering the impacts of Climate Change on urban drainage systems."

A discussion of the impacts of climate change on flood levels is discussed in Section 8.6.

8. FLOOD MODELLING

The 2D flood modelling of Eastern Creek and the tributaries that run through the Schofields Precinct development was undertaken using TUFLOW (Two-Dimensional Unsteady Flow) which 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 (Ref. 14). 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 creeks 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, 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 existing and ultimate case development scenarios was undertaken to determine the impact of the Schofields Precinct development on the flood levels in the creeks.

8.1. Background

An existing 1D Mike 11 model was developed by Bewsher Consulting for Eastern Creek (Ref. 15). We understand that this is Blacktown Council's current adopted flood model. For the Schofields Precinct assessment, the TUFLOW 2D model was developed as it offered the advantages of using the latest survey and roughness data and more importantly provided a better representation of flood behaviour in the floodplains. The Study Area for this flood assessment includes the section of Eastern Creek adjacent to the Schofields Precinct along with the several un-named tributaries from external upstream catchments that discharge through the site.

8.2. TUFLOW Model Set-Up and Modelling Assumptions

As with any flood modelling a number of assumptions are necessary to allow for the modelling process to proceed. Summarised below are the assumptions made within the TUFLOW model for the Schofields Precinct.

8.2.1. Digital Terrain Model (DTM)

The terrain for the Creek TUFLOW model consists of the ALS data provided by Blacktown Council. Modifications to the terrain were incorporated to reflect the proposed development in the ultimate case scenario.

A grid size of 4 m was adopted in the TUFLOW model. This grid size was found to be a reasonable balance between computing time and flooding definition.

8.2.2. Filling In The Floodplain

In order to facilitate efficient development within the Precinct it is proposed that a limited degree of filling within the flood fringe areas of the floodplain is undertaken. This limited filling would recover a portion of the site that is currently flood affected but at minor depths (generally up to approximately 300 mm). This filling is restricted to areas within the floodplain that are outside the core riparian corridor zones. The flood model has assessed the impact of the proposal to undertake this limited filling.

The required level of filling in these areas will be governed by the adjacent creeks 100 year ARI post development flood level plus 0.5m freeboard. Filling to this level will be the minimum level of fill required to allow development to proceed. Any proposal to increase filling over these levels should be supported by a flood impact assessment that considers the impacts of such filling on PMF flows and Hazards within the Precinct.

The proposed filling of the floodplain fringe is consistent with the principals outlined within the NSW Government's Floodplain Development Manual (Ref. 16).

The post exhibition flood assessment also incorporated relocation of the sporting fields to the floodplain. The sports fields were previously located between the primary school and the Burdekin Road extension. In order to maximise the residential development potential of the Precinct, the fields have been moved west into land that was previously identified as being flood affected. Blacktown Council's serviceability criteria for the fields was that they were to be flood free in events up to the 50 year ARI. Due to the flat, wide nature of the floodplain in this area, there is only a very small difference in the 50 and 100 year ARI levels. As such, the fields were located above the 100 year ARI flood level.

As the sports fields required filling in the floodplain to achieve the level of serviceability required, some compensatory storage was necessary to ensure no adverse impacts on landowners adjoining the Precinct. Excavation in the floodplain adjacent to the sports fields and Basin 6 was undertaken to provide this compensatory storage. It is envisaged that this excavated area will have a dual use as a wetland that would enhance biodiversity in the location and also provide additional water quality benefit.

Similar to the sports fields, Basin 6 was also relocated for the post exhibition study to maximise the potential extent of residential development within the Precinct. The channel connecting to Basin 6 was also realigned as required. Basin 6 was relocated west from its previous location to an area identified as flood affected. While the basin is partially located below the 100 year ARI flood extents, the necessary storage volume required to restrict peak flows is contained above the 100 year flood level. Although floodwater from Eastern Creek can inundate Basin 6 through 'backing up' of the lower level 'base flow' outlet, the basin embankment still creates an impediment to flows. Flood modelling was undertaken to ensure that the location of Basin 6 and the compensatory flood storage described above results in no adverse impact on land adjacent to the Precinct.

Building pads will need to be created in some of the environmental living zones to allow dwellings to be located above the 100 year ARI flood levels. Preliminary locations for these sites have been included in the flood modelling and should be considered further at subsequent development phases for the precinct. It is important that any dwellings within these lower lying areas be located as close as possible to the roads to allow effective evacuation in more extreme storm events.

A preliminary cut / fill grading plan has been prepared and included in Figure 26.

8.2.3. Realignment of Drainage Channels

A number of drainage channels have been constructed within the Department of Defence portion of the Precinct. It is thought that these channels were constructed to divert the old creek alignment around the runways. In order to maximise the development potential for the Precinct and also to safely convey stormwater flows up to the 100 year ARI event through the site, the channels have been realigned and widened.

The channels have generally been sized so that the maximum depth of flow in the 100 year ARI event is restricted to 1 metre with a freeboard of 0.5 metres to the top of the channel. The exception to this is for Channel 5.

The upstream catchment area to Channel 5 is approximately 653 hectares and the peak 100 year ARI flow at the upstream Schofields Precinct boundary is approximately 103 m^3/sec. With additional local flows from the Precinct, the peak 100 year ARI flow in the channel immediately upstream of Basin 6 is approximately 126 m^3/sec. Due to the magnitude of this flow rate and the flat nature of the land the channel traverses, the channel width required to convey this flow with a maximum depth of 1 metre and minimal grade would be excessively large. As agreed with Blacktown Council, the depth of flow in this channel was increased to provide a more practical overall channel width. A base flow channel was also incorporated in Channel 5. The base flow channel was modelled as being straight, however it could be designed with a meander within the base of the main channel at the DA and detailed design stages. The maximum total depth of flow in the 100 year ARI event is approximately 4 metres (including the base flow channel). The maximum depth of flow in the main channel is approximately 2 metres in the 100 year ARI event.

8.2.4. Conveyance Of Flows From Upstream Catchments

Flows from a number of upstream catchments adjacent to the Precinct need to be managed through the site. Where the upstream catchment is greater than 15 hectares, it is proposed to provide a drainage channel from the boundary of the Precinct to collect and convey the flows through the site. Where the upstream catchment area is less than 15 hectares, or where the magnitude of flow allows, it is proposed to capture and pipe the flows until the total catchment area exceeds 15 hectares, at which point an open drainage channel will be provided to convey the flows.

8.2.5. Catchment Roughness

One of the advantages of using TUFLOW for the hydraulic assessment is that different landuse can be assigned different roughness factors. For the Schofields Precinct the following roughness assumptions are summarised in Table 8.1.

Table 8.1

TUFLOW MATERIAL ROUGHNESS

Material ID	Manning "n"	Description
1	0.035	Default Floodplain
2	0.02	Roads
3	0.05	Light Vegetation
4	0.08	Medium Vegetation
5	0.1	Dense Vegetation
6	0.03	Dams With Vegetation or Short Grass
7	3	Buildings or Significant Houses
8	0.03	Open Space
9	0.015	Concrete Surfaces
10	0.1	Residential Areas
11	0.04	Farm Lots With Houses
12	0.07	Drainage Channel

8.2.6. Boundary Conditions

The boundary conditions adopted in the TUFLOW model are as follows:

- UPSTREAM – Flow hydrographs were applied as inputs at the upstream boundary of the Schofields site.
- LOCAL INFLOWS – Local inflow hydrographs were included in the model at locations representing tributaries through the Schofields Precinct site from upstream catchments.
- DOWNSTREAM – The Schofields Precinct is partially affected by the regional 100 year ARI flood event level of RL 17.3 along with the regional 5 year ARI flood event level of 11.1. Two downstream boundary condition scenarios were therefore considered and modelled, with the two different tailwater levels. It is noted that adopting the regional tailwater level of 11.1 is virtually the same as adopting normal depth of flow. Only a very small section of Eastern Creek at the northern extents of the Precinct is below RL 11.1.

8.3. Hydraulic Structures

There are a number of culverts located within the Schofields site, particularly to convey low flows under the existing runways. These culverts have only minor capacity in relation to the total peak 100 year ARI flows, however have been included in the existing case modelling. The culverts within the Nirimba site have been included in both the existing and ultimate case models.

A number of hydraulic structures will be required as part of the proposed development, primarily consisting of culverts over the proposed drainage channels and inlets and outlets to the detention basins. The culvert configurations adopted in the modelling were chosen to result in minimal restriction to the conveyance of 100 year ARI flows. Basin outlets in the modelling have generally been configured with the Stage-Discharge relationship used in the XP-Rafts hydraulic model.

8.4. Dam Break Considerations

With the recent release of new Dam Safety guidelines in June 2010, the potential need for referral of the Precinct's detention basins to the Dam Safety Committee (DSC) is now a real consideration.

In the previous release in 2005, the guideline specified that if the embankment wall of any detention/retarding basin was less then 3m in height then referral to the DSC would not normally be required. This height restriction has been removed from the 2010 guidelines and it is JWP's understanding that "all' detention storages, no matter the size of the storage or embankment height, need to be referred to the DSC for a determination of an appropriate Flood Consequence Category for each basin.

This referral should be undertaken in conjunction with a Development Application lodged with BCC for any basin construction. The PMF analysis of the flood conditions undertaken as part of this study provides an indicative "Population At Risk" (PAR) and could be used as the start point for future assessment of the likely impacts of a dam failure on the Schofields Precinct.

8.5. Flood Extent Mapping

Flood extent mapping has been completed for the 2 and 100 year ARI and PMF events under existing conditions. A series of other maps of specific ARI's have also been developed for this study as follows:

1. Depth Profile – All ARI's
2. Hazard Classification (100 year ARI and PMF only)

Under post development conditions the follow maps have been developed:

1. Depth Profile (2, 100 and 500 year ARI and PMF)
2. Hazard Classification (100 year ARI and PMF)

The above scenarios were generally mapped for the varying downstream tailwater boundary conditions, as described in Section 8.2.6. The flood depth, extent and hazard mapping is shown on Figures 5 – 23.

The peak flood levels and extents on the various water courses and drainage reserves throughout the development are generated by different storm durations for each ARI. For example, the peak flood levels on Eastern Creek generally result from longer storm durations, while peak flood levels on the side branches result from shorter duration storms. The flood extent and level mapping included in this report shows the maximums for all storm durations for each ARI.

8.6. Flood Difference Mapping

A flood difference map has been prepared which indicates the difference in 100 year ARI flood levels (with the tailwater condition of RL 11.1) between the existing case and the proposed development within the Precinct. This difference map is provided on Figure 24. The figure indicates that development of the Precinct, with the recommended controls, proposed site regarding and compensatory storage will result in some increases in flood levels within the bounds of the Precinct, which can be accommodated within the Precinct's riparian corridors and drainage reserves.

The flood modelling also indicates that there are generally no increases in 100 year ARI flood levels outside the Precinct boundary. In particular, the flood modelling did not indicate any increases in the 100 year ARI flood levels outside the Precinct boundary adjacent to the proposed sports fields and Basin 6 where the majority of the works within the existing 100 year ARI flood extents are proposed. At two isolated locations toward the southern extents of the Precinct, the flood modelling indicates very small areas where the 100 year ARI flood extents increase by less than 20 mm outside the Precinct boundary. These two areas are toward the central portion of the existing floodway.

8.7. Hazard Categories

Hazard can be considered to be a measure of the impact that floodwater may have on both people and/or property. Hazard mapping was undertaken for 100 year ARI and PMF events from the TUFLOW runs completed as part of this study.

Hazard grids are developed directly out of the TUFLOW model and have been used to produce the Hazard plans presented in this report. The floodplain has been divided into three Hazard categories (consistent with the NSW Floodplain Development Manual (Ref. 16) as follows.

1 Low Hazard

2 Transitional Hazard

3 High Hazard

Hazard maps are useful to obtain an appreciation of the relative depth and velocity of floodwater within a locality and are a critical element in determining:

- The locations of critical public infrastructure such as hospitals and aged care facilities;
- The areas in the floodplain for which public safety is "at risk"; and to
- Assist in the Flood Emergency response and Evacuation Management process.

It should be noted that during the PMF event, significant areas of the floodplain are affected by high hazard flooding and the potential impact on infrastructure within these high hazard areas needs to be considered as part of the future staging of the Precinct.

The existing case flood hazard mapping is shown on Figure 9 (100 year ARI) and Figure 11 (PMF). The ultimate case scenario flood hazard mapping is shown on Figure 17 (100 year ARI) and Figure 22 (PMF).

As the environmental living zones are located adjacent to the floodplain, it is important that any dwellings within these areas be located as close as possible to the roads for evacuation purposes in large storm events. All dwellings within the precinct are to be located above the 100 year ARI flood level.

8.8. Climate Change Impacts

The climate change flows (i.e. 15% increase in Design Rainfall Isopleths) have been used in the development of a post development post climate change hydraulic run. The resulting increase in 100 year ARI flood levels are indicated on Figure 25.

The figure indicates that generally the increases in the 100 year ARI flood levels as a result of the impact of climate change are less than 0.2 metres, which is within the component of the standard 0.5m freeboard which relates to climate variability. It is recommended however that the finished floor levels of dwellings be set at 500 mm above the climate change adjusted 100 year ARI flood level.

It is also recommended that further detailed climate change flood modelling be completed in conjunction with any future development proposals for the water management devices within the Precinct giving due consideration on the required freeboards.

8.9. Flood Evacuation Strategy

The safe evacuation of people from flood affected areas during a PMF event is a key consideration of the strategy and for the planning of the ILP. Flood evacuation need to be identified to ensure a “continuous rising grade” can be maintained to a level above the PMF for all evacuees, with connections to the designated regional evacuation routes such as Richmond and Windsor Roads.

Portions of the proposed development within the Schofields Precinct are below RL 26.4m AHD and are therefore affected by the regional Probable Maximum Flood (PMF) from the Hawkesbury Nepean River. Part of the site will also be affected by the local PMF.

A Precinct Flood Evacuation Strategy was prepared by Molino Stewart. The findings and recommendations of the strategy are summarised below and the report is included in Attachment E.

The following recommendations are made with regard to the final form of the development:

- Ensure all new roads are above the 1 in 100 flood level and that there is a rising pedestrian route (and preferably vehicular route) from every residential property to land above the regional PMF level
- Maintain the Westminster Street Bridge to allow the existing and new residences along West Parade north of Grange Avenue to evacuate without the risk of isolation.
- Construct a road linking Grange Avenue to Argowan Street along the ridgeline to enable residences along Grange Avenue and Ellesmere Avenue to evacuate south without the risk of isolation.
- Construct a pedestrian access from the park at the top of Oban Street west to the proposed road behind it to allow existing residences within the Oban Street cul de sac to evacuate west without the risk of isolation.
- Maintain the pedestrian bridge over the railway line at Bridge Street to allow the residences on Bridge Street to evacuate without risk of isolation.
- Require any development to have two storeys within the environmental living zones and any other areas where there is a risk of people being overtaken by floodwaters

when escaping local flooding. Require such buildings to be designed and constructed to remain structurally sound as a safe refuge in a local PMF.

- Ensure all residential buildings within the environmental living zones have minimum floor levels, including garage floor levels above the 1 in 100 ARI flood level and that vehicular access from the buildings to the local road is above this level.
- Maintain an alarm for the Nirimba Education Precinct that will activate at an appropriate level (probably less than 19m AHD) to trigger a timely evacuation from local flooding.

9. WATER QUALITY ANALYSIS

The water quality analysis for the post exhibition study was undertaken using the model MUSIC (Model for Urban Stormwater Improvement Conceptualisation) Version 5 (Ref. 17). This water quality modelling software was developed by the Cooperative Research Centre (CRC) for Catchment Hydrology, which is based at Monash University and was first released in July 2002. Version 5 was released in 2011.

The model provides a number of features relevant for the development:

- It is able to model the potential nutrient reduction benefits of gross pollutant traps, constructed wetlands, grass swales, bio-retention systems, sedimentation basins, infiltration systems and it incorporates mechanisms to model stormwater re-use as a treatment technique;
- It provides mechanisms to evaluate the attainment of water quality objectives;
- Allows for a Stream Erosion Index assessment.

The MUSIC modelling was undertaken to demonstrate that the water cycle management system proposed for the development will result in reductions in overall post-development pollutant loads and concentrations being discharged from the proposed development and that these discharges comply with the designated target objectives.

9.1. Catchments

Due to the number of nodes required to represent the whole of the Schofields Precinct, the site was broken up into a number of smaller subcatchments and MUSIC models were established for the proposed stormwater management system for each of these subcatchments. The extent of the catchments is shown on Figure 3 and in more detail in Attachment F. The general arrangements of the MUSIC models are also included in Attachment F.

In accordance with Blacktown City Council's WSUD and IWCM DCP (2010) (Ref. 4) an overall fraction impervious of 0.85 was adopted (new residential lot including half road) for the proposed development areas. The catchments were split into roofs, roads, other impervious area and pervious area, as appropriate to represent each post development subcatchment within the Schofields development.

The majority of urbanised areas will discharge to the water quality elements prior to discharge to Eastern Creek. Those areas bypassing the water quality elements will be compensated for by oversizing the raingardens so that the pollutant reduction targets from the overall site are achieved. All stormwater runoff from urban areas will be treated by at least a GPT prior to discharge to Eastern Creek.

For the purposes of the post exhibition assessment it is assumed that the Nirimba site will have its own local water quality devices for any development that may occur within the site. As the likely nature and extent of development within the Nirimba site is unknown at this time, no water quality modelling has been included.

The general arrangements of the MUSIC model treatment trains are included in Attachment F.

9.2. Rainfall Data

The MUSIC model is able to utilise rainfall data based on 6 minute, hourly, 6 hourly and daily time steps. A 6 minute time step was used in the analysis which was chosen in accordance with the recommendations for selecting a time step within the MUSIC Users Manual (Ref. 17).

Rainfall records for the area were provided by Blacktown City Council. The nearest rainfall station to the site with a reasonable period of 6 minute rainfall data for a suitably representative period of rainfall for the site nominated by Council was:

Station No	Location	Years of Record	Type of Data
67033	Liverpool	1967 - 1976	6 minute

It is understood that Blacktown Council have modified the data supplied by the Bureau of Meteorology for the Liverpool site to rectify a significant amount of missing data between 1974 – 1976. The mean annual rainfall in the data set supplied by Council is 857mm, while the mean annual rainfall available from the Bureau of Meteorology's long term data for the station closest to Schofields (Seven Hills) is 915mm.

The rainfall and potential evapo-transpiration data for the period analysed is included in Attachment F.

9.3. Pollutant Loading Rates

In the absence of site specific data, the soil / groundwater parameters and pollutant loading rates adopted for the natural and urban catchments of the Schofields site are based on the recommended parameters provided by the Office of Environment and Heritage for areas within Western Sydney (Ref. 3) and the Cooperative Research Centre for Catchment Hydrology (Ref. 18). The adopted parameters are presented in Tables 9.1 and 9.2. These values are consistent with those nominated in Blacktown Council's WSUD and IWCM DCP (Ref. 4) for urban areas.

Table 9.1

ADOPTED SOIL / GROUNDWATER PARAMETERS FOR THE SITE (Source: OEH Technical Note – Ref. 3)

	Units	Urban	Non-Urban
Impervious Area Parameters			
Rainfall threshold	mm/day	1.4	1.4
Pervious Area Parameters			
Soil storage capacity	mm	170	210
Initial storage	% of capacity	30	30
Field capacity	mm	70	80
Infiltration capacity coefficient - a		210	175
Infiltration capacity coefficient - b		4.7	3.1
Groundwater Properties			
Initial depth	mm	10	10
Daily recharge rate	%	50	35
Daily baseflow rate	%	4	20
Daily deep seepage rate	%	0	0

Table 9.2

ADOPTED ANNUAL POLLUTANT
EVENT MEAN CONCENTRATIONS
(Source: CRCCH – Ref. 18)

	Natural		Roofs		Roads		Remaining Urban	
Pollutant	**Base Flow (mg/L)**	**Storm Flow (mg/L)**	**Base Flow (mg/L)**	**Storm Flow (mg/L)**	**Base Flow (mg/L)**	**Storm Flow (mg/L)**	**Base Flow (mg/L)**	**Storm Flow (mg/L)**
TSS	6.03	39.8	-	20.0	-	269	15.8	141
TP	0.030	0.079	-	0.129	-	0.501	0.141	0.251
TN	0.302	0.891	-	2.00	-	2.19	1.29	2.00

9.4. Treatment Device Performance

8.4.1 Rainwater Tanks

The impacts of the use of 3000 litre rainwater tanks provided on each allotment were modelled using the “Rainwater Tank” node with the following design assumptions:

Roof Area & Area Discharging to Rainwater Tank

The average roof area was assumed to be 30% of the total developable residential area (which equates to a roof area of approximately 195m^2 on a 500m^2 lot, including half road). For the purpose of the water quality modelling, it is assumed that only half of the roof area would actually be connected to the rainwater tank. Increases in connected roof areas would result in better water quality performance.

Average Rainwater Tank Size

The average rainwater tank size adopted in the investigation was 3000 litres. Sydney Water recommends a minimum tank size of 5000 litres for residential properties, however 3000 litres was conservatively adopted for this study. Of the 3000 litres available, it is assumed that top up of the tank from the potable water main would occur once the volume of water remaining in the tank dropped below 20%. Therefore, for the volume available for stormwater storage adopted in the modelling was 2400 litres.

Average Reuse

The average reuse amount adopted in the investigation was 200 litres per household per day for toilet flushing and outdoor use. The total volumes adopted in the modelling assume a dwelling density of 15 lots / hectare. Additional reuse within the laundry has been conservatively excluded from the modelling. Previous studies undertaken (Ref. 19) into the quantity and distribution of water use within households found the following (for a household with three occupants):

- Average Annual Internal Water Usage 263 kl/yr (720 l/day)
- Water Usage for Toilet Flushing 66 kl/yr (180 l/day)
- Outdoor 112 kl/yr (310 l/day)

Therefore the average daily reuse amount for toilet flushing and outdoor use is approximately 530 litres per day. Given the continuing improvement in efficiency of water saving devices and the possible reductions in water usage since the investigations were undertaken, a reuse value of 200 litres per day was conservatively adopted in this study.

Bypassing Flows

It was assumed that flows from the roof area in excess of the 1 year ARI storm event would bypass the rainwater tanks.

8.4.2 Gross Pollutant Trap

Local drainage throughout the development should be filtered prior to discharge into the downstream drainage systems, raingardens and the riparian corridors.

8.4.3 Bioretention Raingardens & Swales

The location and size of the proposed bioretention systems is shown on Figure 4. The bioretention sizes and design assumptions that were used are presented in Table 6.1.

The expected sediment and nutrient removal performance of the raingardens was determined using the default equations and parameters provided in the MUSIC model (Ref. 17). The water quality reduction mechanisms in MUSIC are based on an exponential decay equation referred to as the k – C* curve (refer to Wong et al. – Ref. 20).

The performance parameters used in the MUSIC model are summarised in Table 9.3.

It is assumed that flows in excess of the 3 month ARI storm event will bypass the raingardens. It is noted that the bioretention swales located within Channel 5 are located above the 3 month flood levels within this channel (Refer to Attachment F for 3 month ARI flood extents. 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.

Table 9.3

MUSIC – PERFORMANCE PARAMETERS

	Bio-Retention		Rainwater Tanks	
Pollutant	**k (m/yr)**	**C* (mg/L)**	**k (m/yr)**	**C* (mg/L)**
TSS	8000	20.000	400	12.000
TP	6000	0.130	300	0.130
TN	500	1.400	40	1.400

9.5. Pollutant Load Estimates

Total annual pollutant load estimates were derived using MUSIC for the developed site incorporating the proposed water quality treatment system.

The sub-catchment treatment train and estimated annual pollutant load reductions for the local sub-catchments within the Schofields Precinct are presented in Table 9.4. The cumulative estimated annual pollutant loads and reductions for each subcatchment are presented in Table 9.4.

Table 9.4

SUMMARY OF SUBCATCHMENT TREATMENT TRAIN AND POLLUTANT LOAD REDUCTIONS (LOCAL SUB-CATCHMENTS)

Node	Catchment Area	Raingarden	Raingarden	Gross Pollutants	Total Suspended Solids	Total Phosphorus	Total Nitrogen
	Ha	% Catchment	m²	%	%	%	%
WQA	3.80	1.1	425	99.2	90.3	65.4	57.7
WQ1	4.65	1.1	500	99.2	90.1	65.4	56.9
WQB	1.98	1.1	225	99.2	90.1	65.8	57.9
WQC	1.93	1.2	225	99.3	90.7	65.8	58.1
WQ2	11.32	1.1	1300	99.1	89.4	65.4	57.5
WQ2-MD	1.00	-	-	100	85.0	65.0	45.0
WQD	4.11	1.1	450	99.3	90.1	65.3	57.1
WQ3	15.60	1.1	1700	99	89.3	65.0	57.3
WQ4	33.52	1.3	4500	98.2	88.1	65.2	58.0
WQ4-MD	11.81	-	-	100	85.0	65.0	45.0
WQ5A	17.30	1.2	2150	98.7	89.4	65.1	57.4
WQ5A-MD	4.01	-	-	100	85.0	65.0	45.0
WQ5B	17.99	1.1	1950	98.9	89.5	65.1	57.1
WQ6A	19.41	1.2	2400	98.6	89.1	65.0	57.5
WQ6A-MD	3.24	-	-	100	85.0	65.0	45.0
WQ6B	13.71	1.1	1550	99.2	90.2	65.2	56.9
WQ6B-MD	0.92	-	-	100	85.0	65.0	45.0
WQ6C	10.73	1.2	1250	98.9	89.9	65.0	57.2
WQ6D	2.37	1.1	260	99.3	90.0	65.0	56.7
WQ7	5.46	1.4	750	99.4	91.9	67.9	61.4
WQ7-BC	0.32	-	-	98.2	50.6	6.80	9.70
WQ8	9.68	1.1	1050	99.3	90.2	65.4	57.0
WQE	2.23	1.1	250	99.3	90.3	65.6	57.6
WQ9	2.67	1.1	300	99.3	90.1	65.8	57.8
WQ10	2.48	1.1	275	99.3	90.0	65.7	57.5
WQ11	2.55	1.1	275	99.3	90.1	65.5	57.0

9.6. Discussion of Modelling

The performance of the proposed water quality management strategy for the Schofields development site obtained from the MUSIC models, as summarised in Table 9.4, shows that the various treatment trains proposed will meet the requirements specified within the Growth Centre Development Code (Ref. 1), OEH's water quality objectives (Ref. 3) and Blacktown City Council's guidelines (Ref. 4).

10. WATERWAY STABILITY MANAGEMENT AND STREAM EROSION INDEX

10.1. Introduction

The former Department of Environment, Climate Change and Water (now the Office of Environment and Heritage (OEH)), Blacktown City Council and the Sydney Metropolitan Catchment Management Authority (SMCMA) have recently released draft guidelines (Ref. 3, 4 and 21) outlining techniques to address the risk of stream erosion from the urbanisation of catchments.

Stream erosion is assessed using a measure of the increase in the relative frequency in flows from the site greater than the identified "stream forming flow" resulting from urbanisation of the catchment. This measure is referred to as the Stream Erosion Index. The stream erosion index assessment is considered to be an appropriate means of assessing and addressing the impacts of urbanisation on the frequency of regular flows to the riparian corridor.

The stream erosion index is defined by the Department of Environment and Climate Change as the post development duration of flows greater than the 'stream forming flow' divided by natural duration of flows greater than the 'stream forming flow'. The 'stream forming flow' is defined as 50% of the 2 year ARI flow rate estimated for the catchment under natural conditions for cohesive bed and banks, 25% of the 2 year flow rate for moderately cohesive bed and banks and 10% of the 2 year flow rate for cohesion less bed and banks. The OEH guidelines recommend a stream erosion index of between 3.5 – 5, while Council's WSUD and IWCM DCP recommends an index of no greater than 3.5.

10.2. Modelling

The MUSIC models developed for the Schofields Precinct were utilised to determine the stream erosion index at each discharge point from the Precinct.

Similarly, as for the water quality assessment, the catchment was split into nodes representing the roofs, roads, other impervious area and pervious areas, with a total impervious area of 85%, consistent with the water quality modelling described in Section 9. The nodes representing the various water quality elements were incorporated in the model, again consistent with the water quality modelling.

The generic treatment nodes used to model the on lot treatment within the areas other than low density residential in the water quality model were modified and incorporated into a treatment train consisting of a rainwater tank, gross pollutant trap and bio-retention systems in the Stream Erosion Index model. The generic nodes used in the water quality model do not model the flow reduction that will occur from a rainwater tank and bio-retention system, which is likely to be the treatment method adopted within the lots, and would therefore provide too high an estimate of the Stream Erosion Index. The treatment trains within the areas designated for on lot treatment were sized to meet the minimum pollutant reduction targets.

Generic nodes were added to the end of each subcatchment treatment train to model the flow transfer and calculate the annual volume of flow above the critical flow for both the pre and post development cases, using the method outlined in the SMCMA Draft NSW MUSIC Modelling Guidelines (Ref. 21).

The pre and post development scenarios were modelled in MUSIC as it allows a continuous simulation assessment and easy extraction of the flows and durations. A Forest node with 0% impervious was adopted to represent the pre development case.

10.3. Stream Forming Flow and Stream Erosion Index

The 2 year ARI flow for each subcatchment was determined using Probabilistic Rational Method calculations. From this the stream forming flows were determined. The Stream Erosion Index was determined for a stream forming flow of both 25% and 50% of the 2 year ARI flow were determined using the methodology outlined in the draft SMCMA guidelines (Ref. 21) and are summarised in Table 9.1 and 9.2 below.

Ten years of six minute rainfall data was used in the simulation. The rainfall data described in Section 9.2 was adopted for the assessment.

The results of the stream erosion index assessment are summarised in Tables 10.1 (for the case where the Stream Forming Flow is 50% of the 2 year ARI flow) and 10.2 (for the case where the Stream Forming Flow is 25% of the 2 year ARI flow) below.

It is noted that the results showing the Stream Erosion Index for the case where the Stream Forming Flow is 25% of the 2 year ARI are presented for information only.

Table 10.1

STREAM EROSION INDEX
(WHERE STREAM FORMING FLOW IS 50% OF 2 YEAR ARI)

Catchment	Area (ha)	Pre Dev 2 Year ARI Flow (m^3/sec)	50% of 2 Year ARI (m^3/sec)	Pre Dev Outflow (ML/yr)	Post Dev Outflow (ML/yr)	SEI
WQ1	3.79	0.275	0.138	0.44	1.74	4.00
WQ2	4.64	0.325	0.163	0.55	2.22	4.03
WQ3	1.93	0.156	0.078	0.20	0.78	3.96
WQ4	1.98	0.160	0.080	0.20	0.81	3.98
WQ5	12.3	0.722	0.361	1.71	6.84	4.00
WQ6	4.11	0.294	0.147	0.48	2.00	4.17
WQ7	15.6	0.875	0.438	2.26	8.92	3.95
WQ8	45.3	2.06	1.030	7.73	28.4	3.67
WQ9-10	39.3	1.84	0.92	6.56	25.5	3.89
WQ11-14	50.4	2.24	1.12	8.73	37.8	4.33
WQ15	5.78	0.389	0.195	0.71	2.57	3.61
WQ16-17	11.91	0.704	0.352	1.65	6.74	4.08
WQ18	2.55	0.198	0.099	0.27	1.11	4.07
WQ19	2.48	0.193	0.097	0.26	1.08	4.09
WQ20	2.67	0.205	0.103	0.29	1.15	3.99

Table 10.2

**STREAM EROSION INDEX
(WHERE STREAM FORMING FLOW IS 25% OF 2 YEAR ARI)**

Catchment	Area (ha)	Pre Dev 2 Year ARI Flow (m^3/sec)	25% of 2 Year ARI (m^3/sec)	Pre Dev Outflow (ML/yr)	Post Dev Outflow (ML/yr)	SEI
WQ1	3.79	0.275	0.069	0.75	3.26	4.36
WQ2	4.64	0.325	0.081	0.94	4.16	4.43
WQ3	1.93	0.156	0.039	0.36	1.51	4.23
WQ4	1.98	0.160	0.040	0.37	1.56	4.26
WQ5	12.3	0.722	0.181	2.73	12.2	4.47
WQ6	4.11	0.294	0.074	0.82	3.69	4.52
WQ7	15.6	0.875	0.219	3.55	16.0	4.51
WQ8	45.3	2.06	0.515	11.40	50.0	4.39
WQ9-10	39.3	1.84	0.460	9.76	44.7	4.58
WQ11-14	50.4	2.24	0.560	12.80	62.3	4.87
WQ15	5.78	0.389	0.097	1.20	4.73	3.94
WQ16-17	11.91	0.704	0.176	2.64	12.00	4.55
WQ18	2.55	0.198	0.050	0.48	2.11	4.39
WQ19	2.48	0.193	0.048	0.47	2.07	4.39
WQ20	2.67	0.205	0.051	0.51	2.21	4.32

10.4. Discussion of Modelling

The results of the modelling as summarised in Table 10.1 shows that:

- For the case where the Stream Forming Flow is 50% of the 2 year ARI flow, the Stream Erosion Index ranges between 3.61 and 4.33 for the developed subcatchments for the 11 years of rainfall data assessed, which is within the targets outlined by OEH.

The results of the modelling as summarised in Table 10.2 shows that:

- For the case where the Stream Forming Flow is 25% of the 2 year ARI flow, the Stream Erosion Index ranges between 3.94 and 4.87 for the developed subcatchments for the 11 years of rainfall data assessed, which are within the targets outlined by OEH.

The provision of WSUD elements within the Schofields Precinct development will assist in minimising the impact of urbanisation on the waterway stability of Eastern Creek.

11. DETAILED CONCEPT DESIGNS

Detailed concept designs were prepared for each of the proposed combined detention / water quality basins, individual water quality basins and the drainage reserves. Estimates of quantities and preliminary cost estimates were also prepared for each of the basins and drainage reserves. This information will assist Blacktown City Council in the preparation of the Section 94 plan for the development.

The basins have been designed to achieve a reasonable balance of cut and fill for each individual element wherever possible, as preferred by Blacktown Council. However due to the flat nature of the site, levels have been kept as low as possible to minimise the carry on effect of then having to lift the development to suit basin and channel levels. As it stands, the development will still require a significant amount of fill to allow it to drain to the basins and to maintain grade within the drainage reserves.

The detailed concept designs and estimate of quantities for the detention basins, water quality raingarden devices and drainage channels are included in Attachment G.

11.1. Preliminary Construction Cost Estimates

A summary of the costs associated with the construction of the detention basins, raingardens and the drainage reserves are presented in a simplified form in Table 11.1. A more detailed breakdown of the Estimate of Quantities and the associated construction estimate for each basin and drainage reserve is provided in Attachment G.

Table 11.1

SUMMARY OF DETENTION BASINS, RAINGARDEN AND DRAINAGE RESERVE CHANNEL CONSTRUCTION COSTS

NO.	ITEM	AMOUNT Exc GST$
1	BASIN 1	$679,100.00
2	BASIN 2	$1,720,875.00
3	BASIN 3	$1,554,600.00
4	BASIN 4	$3,466,000.00
5	BASIN 5	$4,799,150.00
6	BASIN 6	$3,726,475.00
7	BASIN 7	$1,085,350.00
8	BASIN 8	$1,051,350.00
9	BASIN 9	$602,950.00
10	BASIN 10	$583,725.00
11	BASIN 11	$518,475.00
	COMBINED BASINS / RAINGARDENS SUB-TOTAL	**$19,788,050.00**
12	RAINGARDEN A	$371,137.50
13	RAINGARDEN B	$183,837.50
14	RAINGARDEN C	$211,237.50
15	RAINGARDEN D	$264,775.00
16	RAINGARDEN E	$184,275.00
	RAINGARDENS SUB-TOTAL	**$1,215,262.50**
18	CHANNEL 1	Existing
19	CHANNEL 2	$3,119,000.00
20	CHANNEL 3	$952,000.00
21	CHANNEL 4	$1,140,000.00
22	CHANNEL 5 (INCLUDES BIORETENTION SWALES 6A-6D)	$13,081,000.00
	CHANNELS SUBTOTAL	**$18,292,000.00**
	STORMWATER & DRAINAGE SECTION 94 TOTAL ESTIMATE	**$39,295,312.50**

12. SUMMARY & CONCLUSION

The Water Cycle Management Strategy for the Schofields Precinct has been prepared to inform the precinct planning process and support the rezoning process for the site. The strategy has been prepared to conform with the statutory requirements and industry best practice for stormwater management in this catchment.

The 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 consists of:

- Proprietary GPT units at each stormwater discharge point.
- Twenty proposed bio-retention raingardens / swales of total area 21,785m^2.
- Eleven proposed detention basins of approximate total volume 88,600m^3.
- Four proposed drainage reserve channels.

The value of the stormwater management elements proposed for the precinct is estimated to be approximately $39.2 million (excluding land acquisition).

Three hydrologic models were provided by Blacktown Council and combined for use in the investigation. The whole of Eastern Creek catchment model was updated with more detailed information within and to the west of the Schofields Precinct from recent work in other Growth Centre areas.

The hydrology modelling undertaken generally shows that ultimate development case peak discharges locally from the Precinct and on Eastern Creek can be managed to existing levels. It is noted that in most cases the ultimate case peak 100 year ARI flows are less than those in Council's currently adopted hydrologic model.

A comparison of flood model results for the Eastern Creek catchment with and without development in the Schofields Precinct shows that urbanisation will generally not result in increases in flood levels adjacent to the Precinct. The flood difference mapping undertaken shows very minor increases (less than 20 mm) outside the Precinct boundary in two very small isolated locations. The areas where these very minor increases occur are restricted to the central areas of the floodplain.

Provision of the proposed water quality treatment devices within the development will ensure that the post development stormwater discharges will meet Blacktown Council's and the Office of Environment and Heritage's water quality objectives for the Schofields Precinct development.

The provision of WSUD elements within the Schofields Precinct development will assist in minimising the impact of urbanisation on the waterway stability of Eastern Creek and comply with the Department of Environment, Climate Change and Water Stream Erosion Index and water quality targets.

The proposed Water Cycle Management Strategy for the developed site provides a basis for the detailed design and development of the site to ensure that the environmental, urban amenity, engineering and economic objectives for stormwater management and site discharge are achieved.

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