Appendix K

Hydrology and Drainage Report

Showground Station Precinct

NSW GOVERNMENT | Planning & Environment

Department of Planning & Environment

Showground Station Precinct

Hydrology & Drainage Report

REP/H001

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1 Introduction

This report has been prepared by Arup Pty Ltd (Arup) and provides an assessment of Hydrology and Drainage relating to the proposed rezoning of the Showground Station Precinct.

The Showground Station Precinct was announced by the NSW Government in August 2014. The precinct is one of number of Priority Precincts which aim to provide for more homes, jobs and improved public spaces close to transport and services. One of the key goals for Priority Precincts is to increase housing choice and affordability by delivering increased housing supply in an environmentally, socially and economically sustainable manner.

The Showground Station Precinct is located in The Hills Shire Local Government Area and covers approximately 271 hectares. The boundary of the precinct is generally based on the road boundary within a radius of 800 metres from the proposed Showground Station, which is normally considered to reflect a 10 minute walk. The boundary also takes in to account predominant land uses, built form and natural features.

The vision for the Showground Station Precinct is for a vibrant, mixed use centre comprising a mixture of offices, shops, community facilities, recreational, cultural and leisure activities, education, and a mix of housing types within walking distance of the new station.

The Showground Station Precinct is a long term project that will be delivered over the next 25 years.

2 Purpose

This report constitutes a desktop review of drainage and mainstream flooding / overland flow considerations that are important for The Showground Station Precinct (the Precinct).

This report is informed by a review of currently available existing hydrological, flooding and water sensitive urban design (WSUD) studies and policy documentation, including:

- local and site specific investigations undertaken during the assessment of the North West Rail Link (for civil and construction works);
- overland flow modelling and overland flow mapping data relevant to the Precinct (from Council's draft Urban Overland Flow Study);
- The Hills Local Environmental Plan 2012 (The Hills LEP 2012) flood provisions, and
- The Hills Development Control Plan 2012 (The Hills DCP 2012) flooding and water sensitive urban design controls.

Having undertaken the review of Council's existing instruments and hydrological / hydraulic information provided, this report further summarises and assesses stormwater quality and quantity considerations that will impact rezoning proposals for the Precinct. The assessment therefore aims to:

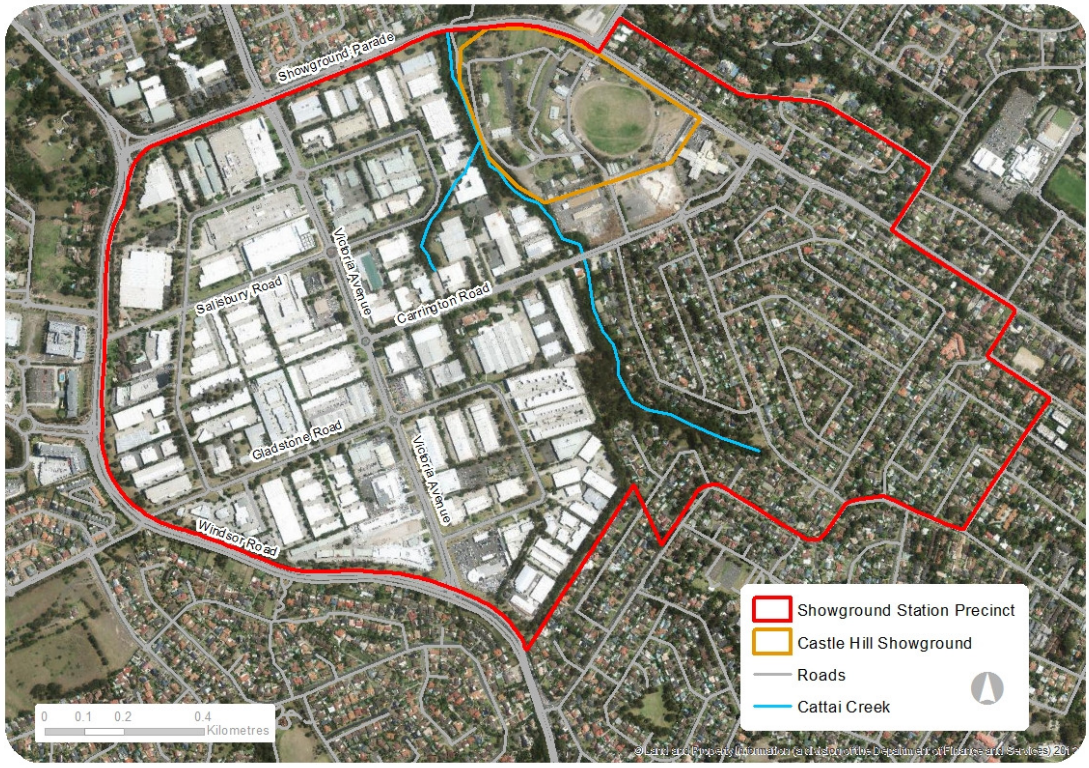
- Identify flood affected land and provide recommendations on how it should be considered in the precinct plans
- Advise on appropriate flood planning levels
- Identify any infrastructure works identified within the existing documentation required to manage flood levels
- Provide recommendations for any additional flooding or water sensitive design controls to be incorporated into Council's existing or new site-specific DCP.

3 Showground Station Precinct

3.1 Introduction

Located entirely within The Hills Local Government Area (The Hills LGA), Showground Station Precinct (the Precinct) covers approximately 271 hectares. The Precinct extends to Showground Road and slightly beyond to the north at Kathleen Avenue, Windsor Road to the west and south, and Fishburn Crescent to the south-east.

Figure 1 Showground Station Precinct Extents



3.2 Current Land Use and Runoff Potential

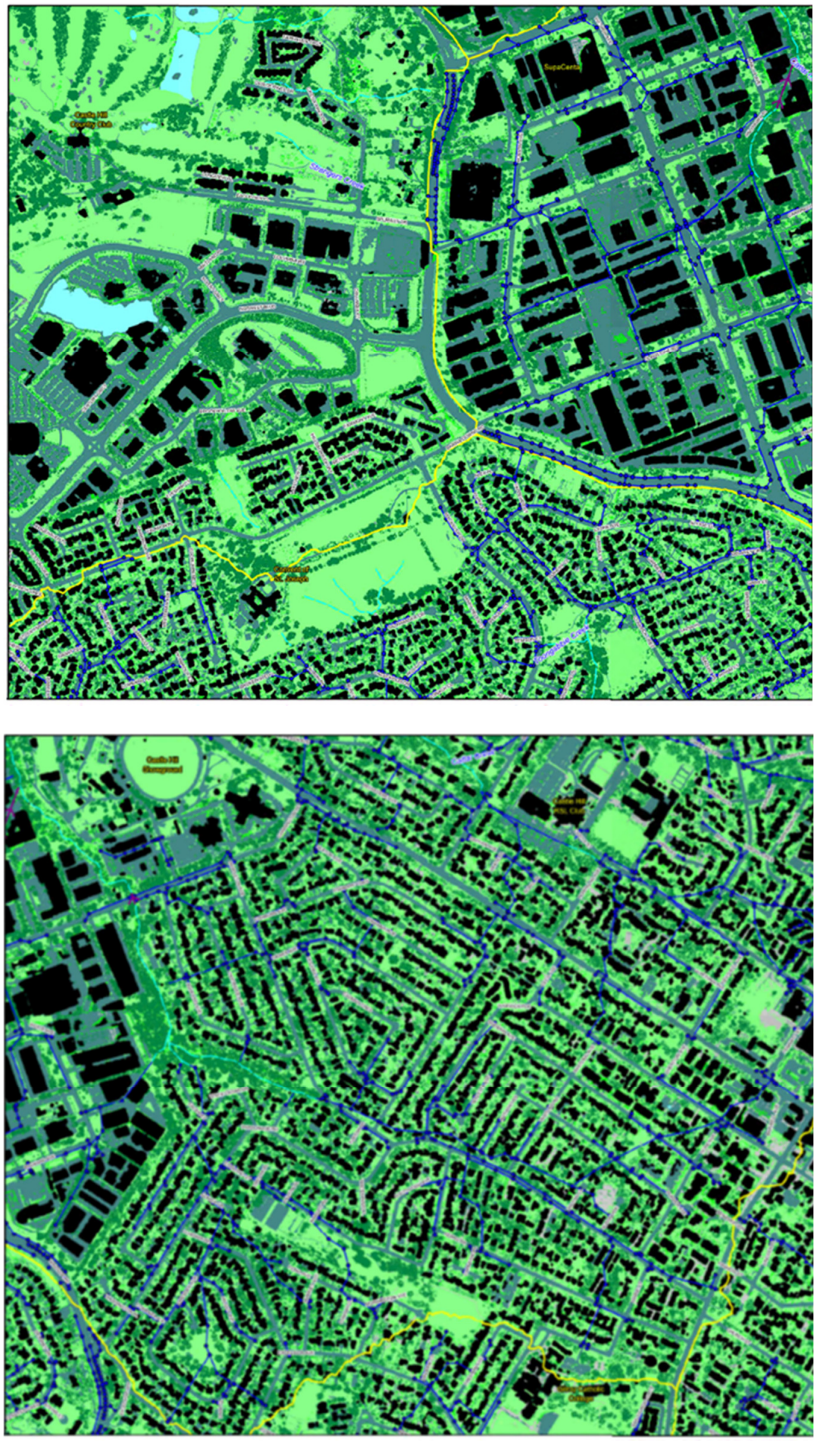
With reference to The Hills LEP 2012 land zoning map, the land use is mainly comprised of light industrial, business development and low density residential areas. The Castle Hill Showground, situated to the north-east of the site, is classified as a public recreation area along with part of Cattai Creek at Cockayne Reserve.

With respect to the potential for generation of stormwater run-off in a rainfall event, it can be seen that the light industrial and business development areas are predominantly hardstanding areas, as they consist of large building roofs and concrete surfaces / asphalt roads.

As can be seen in Figure 2 below, for the low density residential areas to the east and south east of the business district, and the Castle Hill Showground, the percentage of impermeable area (denoted in black and grey) is considerably lower.

Those areas in The Hills LEP 2012 land zoning map along Carrington Road that are currently classified as general residential and as an enterprise corridor represent the location of the proposed Showground North West Rail Link station.

Figure 2 Land Use - Surfacing Types



Source: The Hills Draft Urban Overland Flow Study

3.3 Topography

With reference to Figure 3, within the subject area, the topography ranges from 124m AHD (at the junction of Windsor Road and Showground Road) down to 64m AHD at Cattai Creek where it flows under Showground Road.

Figure 3 Topography within Subject Area

Source: Showground Structure Plan 2013. Precinct boundary has subsequently been amended.

3.4 Drainage and Watercourses

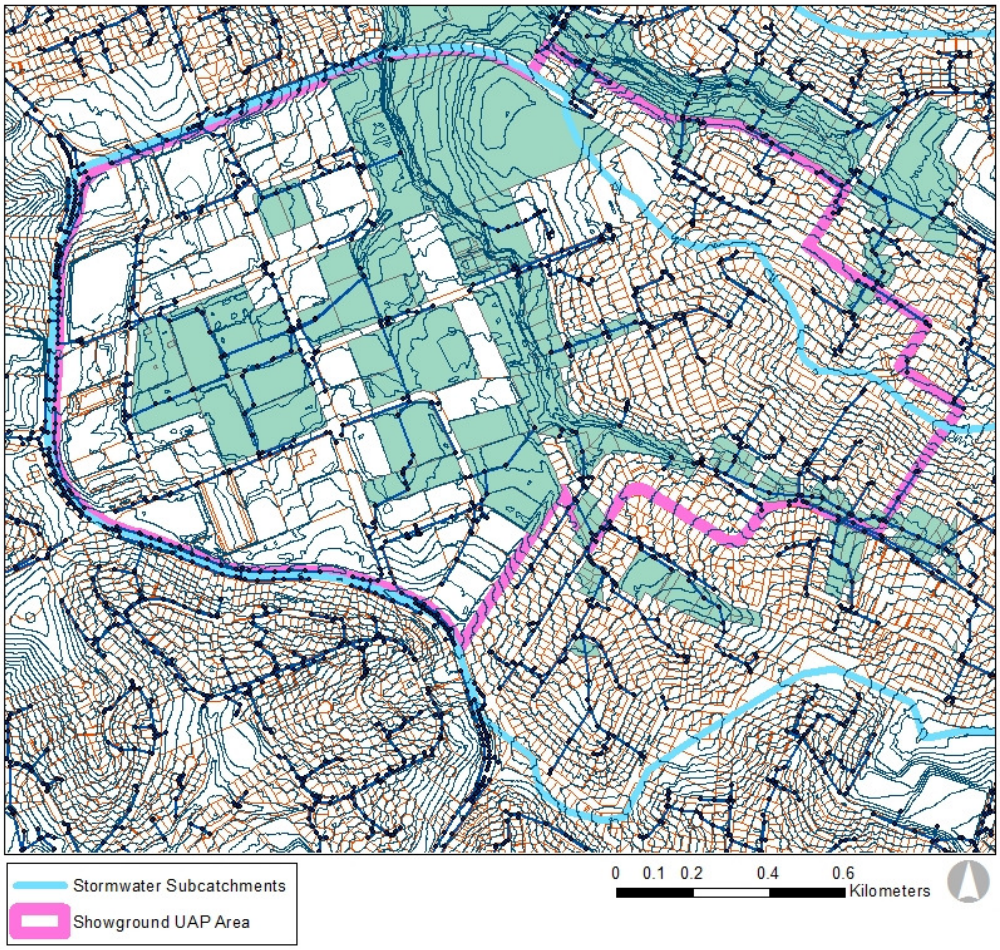
With reference to Figure 4, the Precinct extends over two subcatchments of Cattai Creek, a tributary of the Hawkesbury River. The majority of the Precinct area drains directly to Cattai Creek, which first becomes an open channel at Cockayne Reserve, and drains north (along the western boundary of Castle Hill Showground) towards Showground Road, just upstream of Fred Caterson Recreation Reserve.

A smaller portion of the Precinct to the north east drains to a tributary of Cattai Creek and becomes an open watercourse at Brittania Road. This channel joins at Fred Caterson Recreation Reserve, just to the north of the Precinct area.

As can also be seen in the drawing, there are subcatchments upstream of the Precinct extents to the south and east that drain to these tributaries. These areas are mostly comprised of low residential housing.

With reference to Figure 4, there is a considerable stormwater drainage network within this catchment which is owned and maintained by The Hills Shire Council (the Council). It is important to note that the condition of these pipes is not known.

Figure 4 Showground Station Precinct stormwater drainage network and upstream catchment



The only Sydney Water infrastructure within the catchment is for sewage and water supply. It has been noted that there is a Sydney Water sewer overflow into Cattai Creek near the Castle Hill Showground.

3.5 Riparian Features

Cattai Creek first becomes an open watercourse at Cockayne Reserve, where an 1800mm diameter stormwater pipe drains to this location from the upper reaches to the south east. These upper reaches are relatively steep and well developed.

From this location the creek flows northwards, past the Castle Hill Showground, where it discharges under Showground Road (the northern boundary of the Precinct) towards Fred Caterson Reserve. Along the creek itself, it appears to be heavily vegetated, with the EIS for The Showground NWRL station stating that this gives the potential to generate large amounts of debris in flood waters. It will therefore be important that any future flood modelling undertaken for this area addresses this issue through consideration of appropriate blockage scenarios.

4 Current Council Policy Documents

Proposed developments are currently subject to Council's DCP (2012) and LEP (2012). The "Design Guidelines for Subdivision Developments (Aug 2009)" provides engineering guidelines for the subdivision and development of land, and also prescribes the on-site stormwater detention requirements for a property.

Below is an outline of those sections of the above documents most relevant to the Precinct in relation to drainage, overland flows, and Water Sensitive Urban Design (WSUD).

4.1 LEP 2012

Clause 7.3 of the LEP outlines Council's flood planning requirements. The clause applies to all land at or below the flood planning level, which is defined in this clause as the 1:100 year ARI (average recurrence interval) flood plus 0.5m freeboard. The clause uses terminology consistent with NSW Floodplain Development Manual (2005) to allow accurate definition.

The clause states that *"Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:*

(a) is compatible with the flood hazard of the land; and
(b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and
(c) incorporates appropriate measures to manage risk to life from flood, and
(d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and
(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding."

4.2 DCP 2012

The DCP 2012 applies to all land within The Hills LGA, and aims to provide a comprehensive document that contains all development controls, standards and provisions that apply to land in The Hills LGA. This DCP also ensures that development incorporates the principles of Ecologically Sustainable Development (ESD).

Along with the LEP 2012, this document provides advice and outlines the objectives of stormwater management for various areas.

4.2.1 DCP Part B

The DCP provides different objectives for stormwater management depending on land use type. For those land use types currently within the LEP 2012 for the subject site, the range of objectives for stormwater management are as follows:

- B2 – Residential Areas

The objectives for stormwater management in residential areas are:

- To provide for the disposal of stormwater from the site in efficient and environmentally sensible ways in accordance with Council's ESD Objective 3.
- To control stormwater and to ensure that developments do not increase downstream drainage flows or adversely impact adjoining or downstream properties.
- To ensure the integrity of watercourses is protected and enhanced in accordance with Council's ESD Objective 4.
- To provide for on-site detention of stormwater.
- To encourage the reuse of stormwater

- B6 – Business Areas

For those cadastral lots within the Precinct that are classified as a business zone in accordance with the LEP, the objectives for stormwater management are as listed below:

- To ensure that commercial/retail development does not impact on the water quality of adjacent properties or creeks in accordance with Council's ESD Objective 2.
- To ensure that development does not increase downstream flooding.
- To encourage reuse, recycling and harvesting of stormwater to reduce wastage of water in accordance with Council's ESD Objective 2.
- To encourage the re-use of stormwater for the irrigation of landscaped areas, particularly during establishment periods in accordance with Council's ESD Objective 2.
- To provide for the disposal of stormwater from the site in efficient, equitable and environmentally sensible ways.

- B7 – Industrial Areas

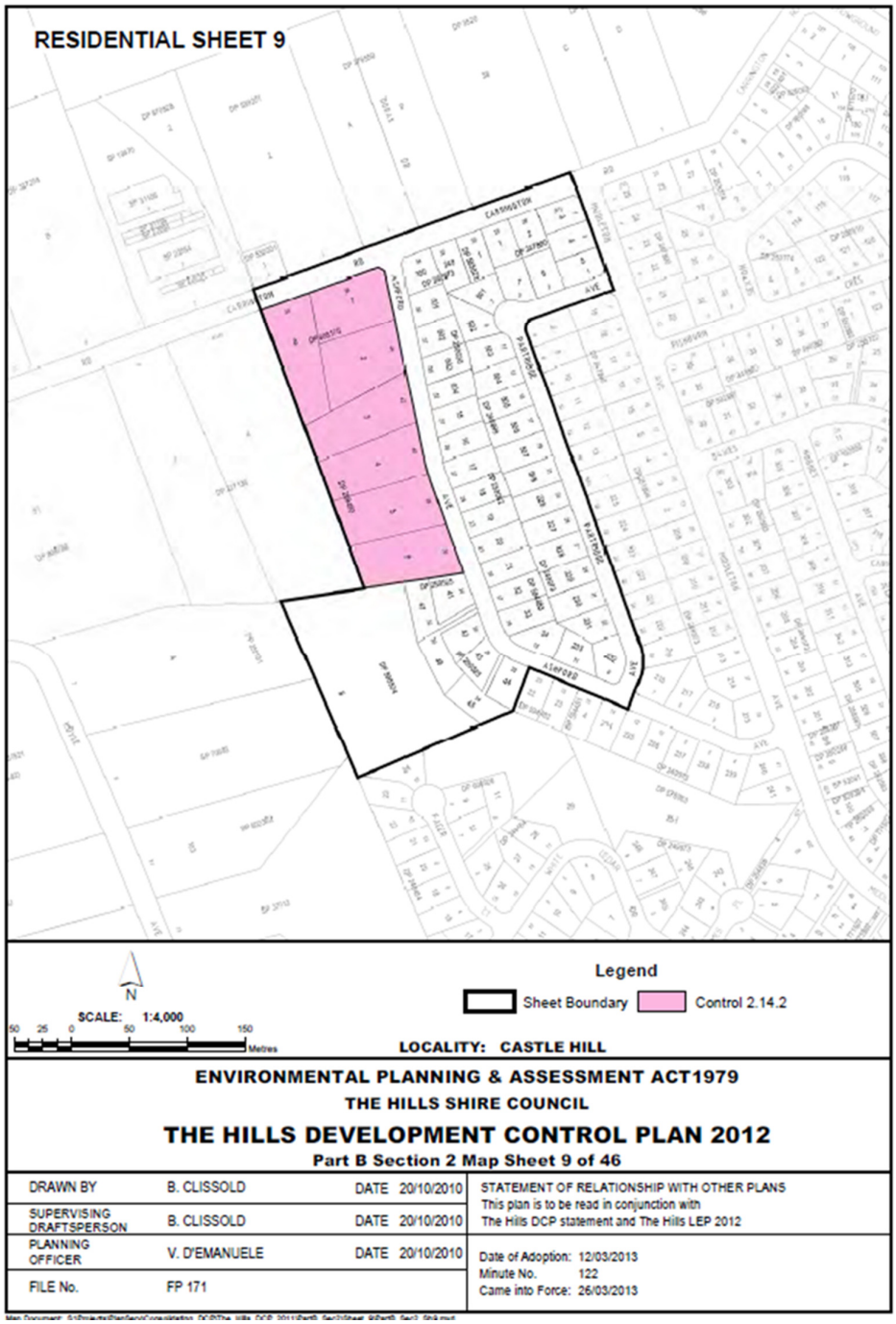
For those cadastral lots within the Precinct that are classified as a light industrial in accordance with the LEP, the objectives for stormwater management are as listed below:

- To ensure that industrial development does not impact on the water quality of adjacent properties or creeks.
- To provide for the disposal of stormwater from the site in efficient, equitable and environmentally sensible ways.
- To encourage the re-use of stormwater for the irrigation of landscaped areas, particularly during establishment periods.

4.2.2 Site Specific Objectives and Development Controls

There is one site within the Precinct which has specific development controls, as shown below, which has a maximum site coverage of 30%, compared to the normal 60%. As Cattai Creek runs through these cadastral lots, it is assumed that this reduction is to meet the objective of DCP Section 2.14.2 to "avoid the creation of drainage and runoff problems, through minimising the amount of impervious area in accordance with Councils' ESD Objective 3". Future planning for this site will need to consider and investigate further these constraints.

Figure 5 Specific Development Controls – Carrington Road / Ashford Avenue



4.2.3 Flood Controlled Land

Part C6 of the DCP provides advice on those lots that are classified as flood controlled land (i.e. land to which a flood related development control applies). The aim of this section of the DCP is to provide development controls to guide the management of flood risks associated with development by:

- Increasing public awareness of the hazard and extent of land affected by all potential floods, including floods greater than the 100 year average recurrence interval (ARI) flood and to ensure essential services and land uses are planned in recognition of all potential floods.
- Informing the community of Council's policy for the use and development of flood controlled land.
- Managing the risk to human life and damage to property caused by flooding through controlling development on land affected by potential floods.
- Minimising the potential impact of development and other activity upon the amenity, aesthetic, recreational and ecological value of the waterway corridors and the surrounding environment.

4.2.3.1 Flood Planning Levels

Part C6 of the DCP is the section that also provides guidance on how to apply appropriate flood planning levels for new developments. Section 1.6 outlines that *"a range of flood planning levels (FPL) may apply depending on the type of land use and the part of the development in consideration. In principle, a higher FPL will apply to land uses considered more sensitive to flood hazards or which may be critical to emergency management operations or the recovery of the community after a flood event".*

Part C6 includes overarching development controls relating to ensuring the development does not increase flood effects to other properties.

In addition, four potential Flood Planning Levels are defined as shown in Table 1 below.

Table 1 Flood Planning References and Levels (DCP Part C6 Table 1)

Flood Planning Levels Reference	Flood Planning Level
FPL 1	20 year ARI
FPL 2	100 Year ARI
FPL3	100 Year ARI +0.5m Freeboard
FPL 4	PMF

These flood planning levels are then applied to six land use categories, as summarised in Table 2. Key flooding controls only have been included as the DCP provides detailed descriptions.

Table 2 Flood Planning Levels by Land Use Category

Land Use Category	Key Flood Planning Level Controls
Critical Uses and Facilities	Not suitable on flood affected land up to FPL 4
Sensitive Uses and Facilities	No development in floodway, flowpath or high hazard area up to FPL4 Habitable Floors: FPL4 Non habitable Floors: FPL3* Open car parks: as high as practical, minimum FPL1 Enclosed car parks (<20 vehicles): FPL 2 Enclosed car parks (>20 vehicles): FPL 3
Residential	No development in floodway, flowpath or high hazard area up to FPL2* Habitable Floors: FPL3 Non habitable Floors: FPL3 (preferred) FPL1 (minimum)* Open car parks: as high as practical, minimum FPL1 Enclosed car parks (<20 vehicles): FPL 2 Enclosed car parks (>20 vehicles): FPL 3
Commercial or Industrial	No development in floodway, flowpath or high hazard area up to FPL2* Habitable Floors: FPL3 Non habitable Floors: FPL3 (preferred) FPL1 (minimum)* Open car parks: as high as practical, minimum FPL1 Enclosed car parks (<20 vehicles): FPL 2 Enclosed car parks (>20 vehicles): FPL 3
Recreation or Non-urban Uses	No development in floodway, flowpath or high hazard area up to FPL2* All floor levels: FPL1* Open car parks: as high as practical
Concessional Development	No development in floodway, flowpath or high hazard area up to FPL2* New habitable floor levels: FPL3* Open car parks: no lower than design floor level or ground level*

* Unless justified by a site specific assessment

The existing development comprises predominantly residential, commercial or industrial and recreation land uses. Based on the table above, a flood planning level of 100 year ARI + 500mm freeboard would generally be applicable to new habitable flood levels.

4.2.4 Water Sensitive Urban Design

Appendix B of the DCP supplements the existing DCP 2012 requirements to provide WSUD in light industrial areas, and prescribes that two WSUD measures are to be selected from the following:

- M1 – Low Impact Building Design
- M2 – Low Impact Landscape Design
- M3 – Porous Paving
- M4 – Rainwater Utilisation – toilet, hot water

- M5 – On-site infiltration system
- M6 – Stormwater Treatment System
- M7 – Infiltration or Retention System
- M8 – Stormwater Utilisation – irrigation

4.3 Design Guidelines Subdivision / Developments

Other than the LEP 2012 and DCP 2012, the Design Guidelines Subdivision / Developments provides *"engineering guidelines for the subdivision and development of land and to facilitate the efficient processing of engineering plan submissions for subdivisions and developments"*.

Within these guidelines, Section 4 outlines the requirements for stormwater drainage design within the LGA. Some sections of note within this drainage guideline that are particularly applicable to the Precinct are as follows:

- Section 4.22: On-Site Stormwater Detention
- Section 4.25: Water Sensitive Urban Design

The Design Guidelines also state that all new development proposals are to incorporate Water Sensitive Urban Design (WSUD), with the aim being to provide "sustainable and integrated management of land and water resources, incorporating best practice stormwater management, water conservation and environmental protection measures."

4.3.1 On-Site Stormwater Detention

The Hills LGA drains to two main catchments, the Upper Parramatta River Catchment and the Hawkesbury River Catchment. As the Precinct, and Cattai Creek, are subcatchments of the Hawkesbury River, the on-site stormwater detention (OSD) requirements applicable to the Precinct are as follows.

- *"…where a proposed development drains to the Hawkesbury River Catchment OSD will be required."*
- *The Permissible Site Discharge (PSD) and Site Storage Volume (SSV) requirements shall be derived from Table 4.14 for that portion of the Hawkesbury River Catchment area that falls within the Shire.*

Site Slope	***PSD (l/s/ha)***	***SSV (m^3/ha)***
Greater than 15%	*136*	*298*
Between 10% and 15%	*115*	*336*
Between 6% and 10%	*104*	*362*
Between 3% and 6%	*92*	*396*
Between 0% and 3%	*87*	*412*

Table 4.14 - PSD and SSV Requirements for the Hawkesbury River Catchment

Section 4.22 of the OSD guidelines state that sites within catchment areas draining to an existing approved detention system are exempted from the requirement for on-site detention. It is understood that this exemption typically applies to new release areas, but would also be applicable should a centralised OSD strategy be feasible for the Precinct.

4.3.2 Water Sensitive Urban Design

The section of the guidelines states that the *"objective of Water Sensitive Urban Design (WSUD) is for a post development water cycle to replicate or improve upon the pre-development water cycle through the use of design techniques to reduce development impact on receiving waters.*

The guideline requires all proposals subject to a Development Application process to incorporate WSUD measures, and that those measures be designed with ongoing operation and maintenance in mind. A number of WSUD measures are recommended for consideration, including rainwater tanks, stormwater treatment devices, biofiltration, bioretention, detention basins, swales, porous paving/surfaces, wetlands and gross pollutant traps. The guideline requires WSUD measures to be designed and constructed in accordance with:

- Water Sensitive Urban Design Technical Guidelines for Western Sydney (NSW Government Stormwater Trust and UPRCT, May 2004); and
- Australian Runoff Quality (Engineers Australia 2005)

It is worth noting that neither the LEP 2012, DCP 2012, nor any other LGA-wide Hills Shire Council guideline appears to give a "target-based" approach for the reduction in stormwater pollutant generation, although this is however included in Table 2.7 of the Water Sensitive Urban Design, Technical Guidelines for Western Sydney which is referred to in the Council DCP. The targets in the Technical Guidelines for Western Sydney apply to "medium-scale developments" generally defined as those greater than 2,500m^2 total area.

Additionally, Hills Shire Council have included "target-based" water quality performance objectives within the North Kellyville DCP 2014 and Box Hill/Box Hill Industrial Precinct DCP 2014. The targets have been determined by the NSW Office of Environment and Heritage (OEH). A comparison of the targets from the Technical Guidelines for Western Sydney and the recent Hills Shire Council specific precinct DCP's is provided in Table 3 below.

Table 3 Comparison of Stormwater Quality Performance Objectives

Pollutant	WSUD Technical Guidelines for Western Sydney	North Kellyville and Box Hill/Box Hill Industrial Precinct DCP's
Litter	70% of average annual litter load (greater than 5mm)	90% of average annual litter load (greater than 5mm)
Coarse Sediment	80% of average annual load for particles 0.5mm or less	85% of annual average load
Fine Particles	50% of average annual load for particles 0.1mm or less	-
Total Phosphorous	45% reduction in the post development mean annual load of Total Phosphorous	65% reduction in the post development mean annual load of Total Phosphorous
Total Nitrogen	45% reduction in the post development mean annual load of Total Nitrogen	45% reduction in the post development mean annual load of Total Nitrogen
Hydrocarbons, oil and grease	90% of average pollutant load.	-

It is understood through consultation with Hills Shire Council that developers are to demonstrate compliance with the pollutant reduction targets above through industry standard MUSIC water quality modelling (or equivalent) and that this is undertaken upon the submission of the Preliminary Engineering Drainage Plans in a Development Application. Requirements for MUSIC modelling are explicitly stated within the submission are not explicit within Council's plans and policy documents North Kellyville DCP 2014 and Box Hill/Box Hill Industrial Precinct DCP 2014, but not within the general DCP 2012.

4.4 Identification of Flood Affected Land

The Council have an existing hierarchy of flood information, which varies in detail across The Hills LGA. Part of this information consists of flood control lot mapping (i.e. land to which a flood related development control applies), which has been supplied by the Council for the purposes of this study.

The following mapping illustrates properties (shaded green) within the Precinct and associated upstream catchment that are currently classified by Council as "Flood Control Lots" (i.e., lots subject to a flood-related development control). While development on these land parcels may be constrained, development is not prohibited.

Figure 6 Existing Flood Control Lot Mapping

Source: The Hills DCP 2012

Upon finalisation and adoption of the Urban Overland Flow Study, that this Flood Control Lot mapping may be reviewed by Council. An overview of the Urban Overland Flow Study is provided in Section 6.

5 Previous Hydrological & Hydraulic Studies / Existing Information

Arup have undertaken a desktop review of the information that has been provided to date by Council and the Department of Planning and Environment (the Department). This information has taken the form of guidelines, reports, and GIS information to date. The following sections summarise the initial findings of this review, and will be updated before the final submission if further information is received.

5.1 The Hills Shire Council Studies

It is understood that reports relating to the stormwater drainage catchment for the Precinct are as follows:

- Urban Overland Flowpath Mapping Project (2010)
- Cattai Ridge Road XP-RAFTS model
- The draft Urban Overland Flow Study Project (ongoing): discussed in Section 6 of this report.

5.1.1 Urban Overland Flowpath Mapping Project (2010)

An overview of the Urban Overland Flowpath Mapping Project (2010) has been provided in the current draft Urban Overland Flow Study.

As such, the Urban Overland Flowpath Mapping Project *"…was prepared to identify land across the urban areas of the LGA that may be traversed by an overland flowpath. In doing so, the study was designed to assist Council in defining land that should be subject to a flood related development control (i.e., flood control lots).*

The flow path start (i.e., initiation) points were defined using the following criteria:

- *Peak 100 Year ARI Discharge > 0.9 m_3/s; or*
- *Peak 100 Year ARI Discharge > 0.4 m_3/s and the terrain is 'incised' (i.e., channelised).*

Peak 100 year ARI discharges were estimated for each DEM cell using relationships that related discharge to the contributing catchment area and upstream impervious proportion.

The resulting flow path alignments were verified relative to lots that were previously identified by Council as flood controlled land. The alignments were also verified against lots where flood and drainage complaints had previously been received.

The outcomes of the study determined that the mapped flow paths provided a reasonable representation of the start location and alignment of urban overland flow paths across the LGA. However, the study does not provide any indication of the potential depth, extent and velocity of water along these flow paths."

5.1.2 Cattai Ridge Road XP-RAFTS Model

An overview of the Cattai Ridge Road XP-RAFTS model has been provided in the current draft Urban Overland Flow Study. The XP-RAFTS model of the Cattai Creek catchment "*was originally developed as part of a proposed upgrade of the McClymonts Road causeway crossing to accommodate a fish passage. The model was subsequently extended further downstream to Cattai Ridge Road by Council.*

The model extension was completed as part of the proposed replacement of the Cattai Ridge Road crossing of Cattai Creek.

*The upper sections of the XP-RAFTS model are contained within Drainage Catchment 4…" (*the area pertaining to the catchment of the Precinct).

"Accordingly, the design discharge estimates generated by the XP-RAFTS model across this section of the catchment could be used to assist in the verification of the hydrology.." [for the current Urban Overland Flow Study].

Although the XP-RAFTS model was used to inform the current Urban Overland Flow Study used this XP-RAFTS model, the current study supersedes any information contained within this earlier study.

5.2 Other Council Flood Information

Other than the existing and previous hydrological / hydraulic studies that have been undertaken on behalf of Council, it is understood that Council also possess supplementary information related for the Hills LGA in relation to flooding, which include:

- Flood complaints database
- Historic Flood photographs

It is understood that this supplementary information has been used in the draft Urban Overland Flow Study.

5.3 Existing On Site Detention storage provisions

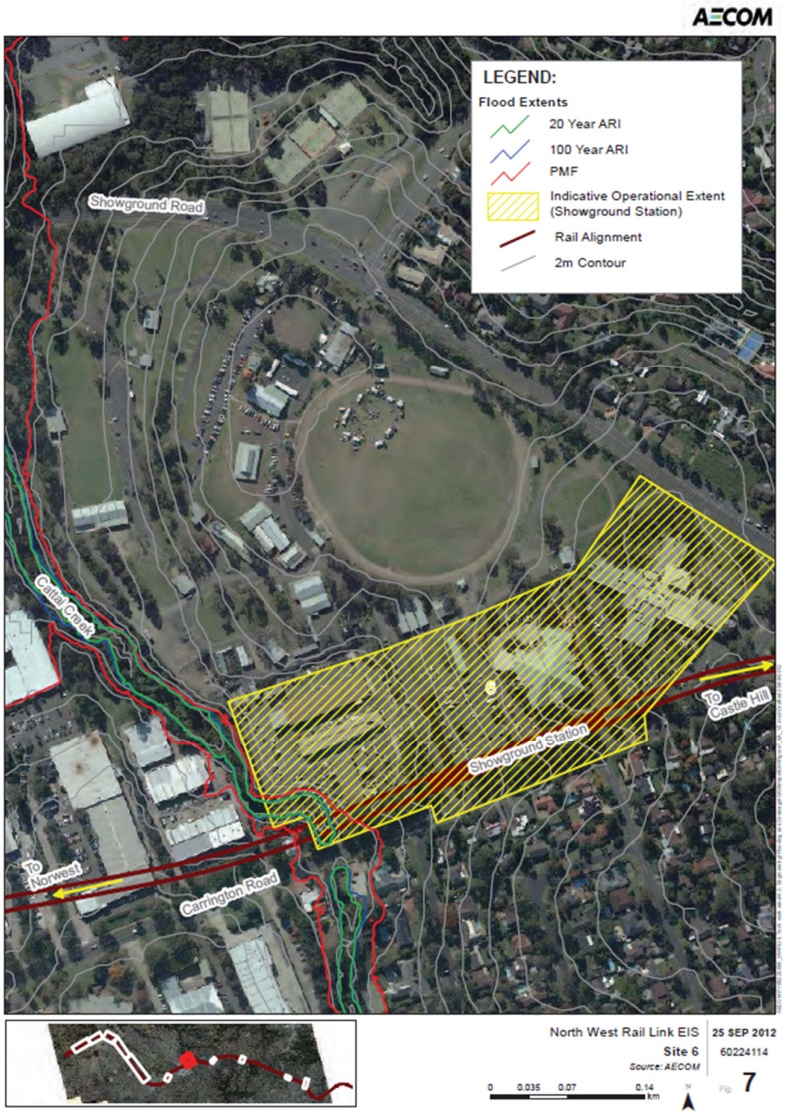
Other than the supplementary flood information, it is understood that Council also possess information in relation to those existing properties that have OSD storage installed within the lot, although much of the existing development pre-dates the commencement of Council's OSD policy (1991). This information was requested from Council but not received within the time constraints of this project.

5.4 Information prepared by Others

With regards to information or studies that have been undertaken by those other than Council, the most relevant hydraulic study that has been undertaken was as part of the Showground NWRL Station EIS, by AECOM on behalf of Department of Transport for NSW (TfNSW).

This work concentrated on Cattai Creek, as anecdotal evidence suggests that part of the Carrington Road area has been subject to flooding from Cattai Creek in the past. The study involved 1D modelling in HEC-RAS for a limited area of Cattai Creek only, and as such, the study does not consider flooding caused from overland flow. It does not therefore identify the flood risk to all properties within the Precinct, nor is it directly comparable to the more detailed studies being undertaken by Council. As can be seen in Figure 7, the land either side of the creek is at risk of flooding as expected, but it is mainly confined to existing open space areas in the LEP 2012 mapping.

Figure 7 Flood extents of Cattai Creek around Showground NWRL Station



Source: Showground NWRL Statin EIS (Aecom on behalf of TfNSW).

5.5 Water Quality

Other than the high level information provided as part of the EIS in relation to water quality, there is little available information in relation to pollutant generation within the catchment, or the current ecological / water quality health of Cattai Creek. It is noted that a Sydney Water sewer overflow spills into Cattai Creek from the industrial estate. Information in relation to the spill volume or frequency however is not known.

6 The Hills Shire Council Urban Overland Flow Study (Draft)

As discussed previously, Council have commissioned Catchment Simulation Solutions to undertake an overland flow study for a 68km2 area, primarily the older, existing urban areas of the LGA, to determine those cadastral lots that will be affected.

Council have advised that the overland flow results from this 1d/2d TUFLOW model are considered to be the most accurate information that will be available for the Precinct. As such, Arup assume that this takes precedence over all previous studies undertaken by or on behalf of Council or others.

At the time of completion Showground Urban Activation Precinct study, this project was still in progress. The draft Urban Overland Flow Study (Revision 1, October 2014) has been provided by Council for assessment. This section outlines the objectives of the report, the key features of the hydraulic model, and the main report findings.

6.1.1 Aims of The Hills Urban Overland Flow Study

The objectives of the Urban Overland Flow Study outlined by Council for the project included the following:

- Define flooding behaviour across the study area for existing topographic and development conditions;
- Produce information on flood levels, flood depths, flow velocities and discharges for the 10 year, 20 year and 100year ARI design floods;
- Use the results of the design flood simulations to define the variation in flood hazard across the study area for each design flood;
- Use the results of the design flood simulations to define the variation in hydraulic categories across the study area for each design flood;
- Identify properties within the study area where a flood related development control applies; and
- Document the outcomes of the study in a comprehensive report

In order to meet the above study objectives, the study included a review of available hydrological / hydraulic information, the compliation of a TUFLOW flood model to simulate historical flood events, verification of the historic flood information, and use of the verified TUFLOW model to derive design events for the 10 year, 20 year and 100 year ARI.

The study was not required to consider climate change.

6.1.2 Definition of Overland Flow

The report states that *"…the TUFLOW models were used to simulate design flood behaviour for the 10, 20 and 100 year ARI floods. The results of the TUFLOW simulations were subsequently "filtered" to identify those areas across each catchment where the depth and velocity of overland flows may present a*

significant hazard to people and/or cause damage to private and public properties."

All overland flow paths show areas where the depth and/or velocity of overland flows are sufficient to cause a potential risk to personal safety and/or damage to property during the nominated flood event. For the purposes of the overland flow results mapping provided in Figure 8 through Figure 11, overland flows that meet any of the criteria listed in Table 4 below have been mapped.

Table 4 Adopted Depth & Velocity Criteria for presentation of Overland Flow Results

Criteria	**Depth (m)**		**Velocity (m/s)**		**Velocity x Depth (m^2/s)**
Instability of Children	>=0.5	OR	>=3.0	OR	>0.4
Mobilisation of vehicles (floating)	>=0.3	AND	>=0.0	AND	>0.3
Mobilisation of vehicles (sliding)	>=0.1	AND	>=3.0		
Overtopping of gutters/inundation of private/public property	>=0.17	AND			>0.4
	>=0.3	AND	>0.0		

Source: The Hills Draft Urban Overland Flow Study

6.1.3 Blockage Factors

It is important to note that these overland flow results are based on stormwater system inlets and culvert inlets using the following blockage factors (which are typical current guidance within available literature):

- "On grade" stormwater pits = 20% blockage
- "Sag" stormwater pits = 50% blockage
- Culverts with height < 3 metres or width < 5 metres = 20% blockage
- Culverts with height > 3 metres and width > 5 metres = 10% blockage

6.1.4 Draft Overland Flow Results

As planning for the Precinct will need to consider 100yr ARI overland flows, this review concentrates on those results. However, 10 yr and 20 yr ARI mapping has been included and discussed in this section in relation to potential drainage network infrastructure constraints.

6.1.4.1 10 Year and 20 Year ARI Results

Figure 8 (a and b) and Figure 9 (a and b) illustrate the 10 year ARI and 20 year ARI overland flow paths respectively (as defined in Table 4 above), extracted from the Hills Draft Urban Overland Flow Study.

Areas where overland flows are present in the 10 year ARI event indicate areas where Council's current stormwater drainage design standard is unlikely to be currently being met. These areas indicate opportunities for improvement in performance during the redevelopment of the Precinct.

With reference to Figure 8 (a), it can be seen that within the industrial and commercial estate, overland flows are evident in the 10 Year ARI event along the low lying areas in the natural topography, with one major and one minor overland flow paths from the Creek through to Victoria Avenue. Flow depths for these overland flow routes are typically less than 0.5m, with the primary overland flow path near to the bend of Salisbury Avenue indicating depths of 1.0m in limited areas.

The 20 year ARI results for the industrial and commercial estate (Figure 9a) indicate only limited increases in depths and extents of overland flows along the same flow lines as the 10 year ARI.

Within the residential estate to the south and east of the Creek, there are also two main overland flow paths that drain through existing residential blocks to Cockayne Reserve. Again there is very little difference in depth and extent of overland flow between the 1 in 10 year ARI and 1 in 20 year ARI, with flow depths in these flow paths ranging from 0.1m to between 0.5m and 1.0m.

The network of east-west streets within the precinct typically follows crest lines in the local topography rather than sag lines. Upgrading drainage infrastructure within the existing streets may therefore have limited potential in relieving flooding along the overland flow paths.

6.1.4.2 100 Year ARI Results

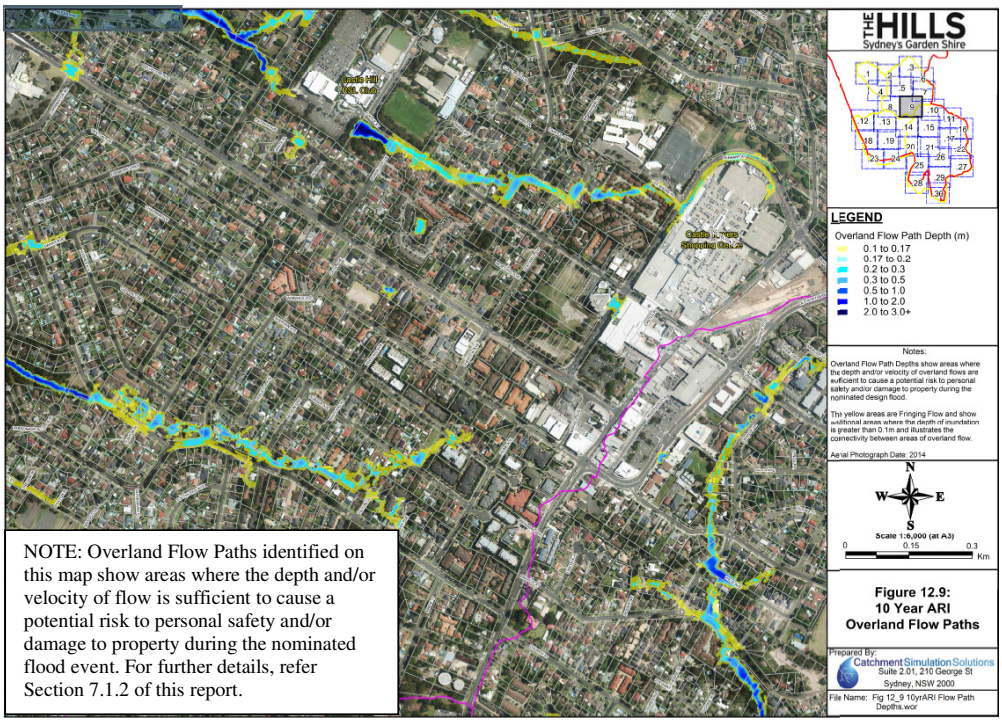
With reference to Figure 10 (a and b), it can be seen that within the industrial / commercial estate, overland flows follow similar lines to the 10 year and 20 year ARI events. Flow depths for these overland flow routes appear to range from 0.1m, to approximately 0.5m to 1.0m in limited areas.

Within the residential estate to the south east of the business area, overland flows also follow similar lines to the 10 year and 20 year ARI events. Again, the flow depths in these flow paths appear to range from 0.1m to between 0.5m and 1.0m.

While there is an increase in overland flow path extent between the minor (10 year/20year) and major (100 year) events, the increase is relatively minor.

Figure 8 10 Year ARI Overland Flow Paths

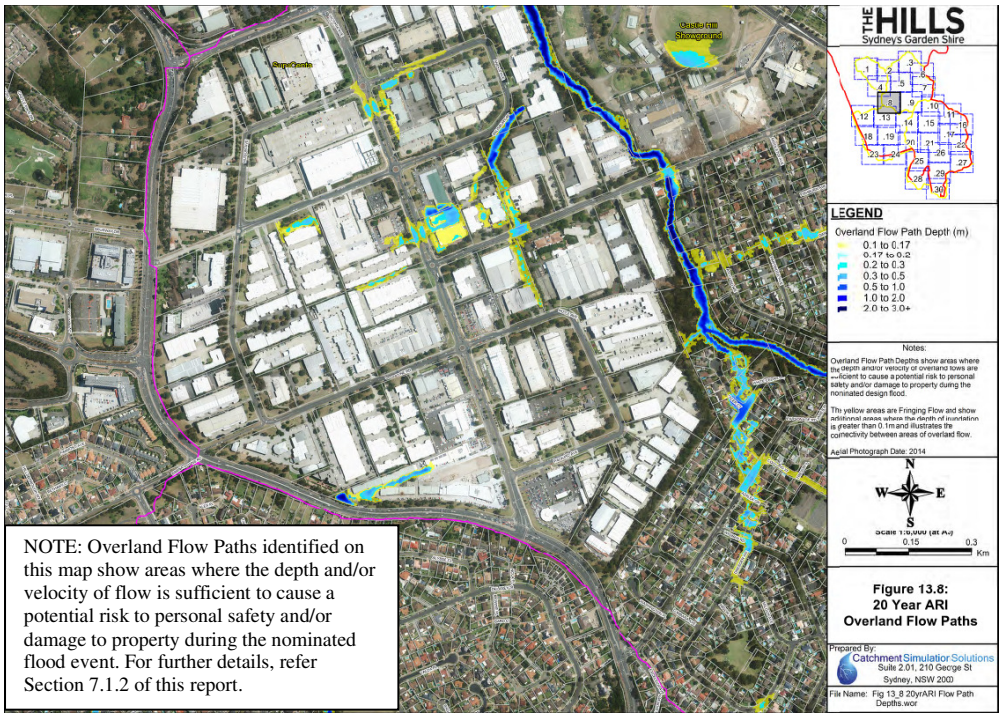
NOTE: Overland Flow Paths identified on this map show areas where the depth and/or velocity of flow is sufficient to cause a potential risk to personal safety and/or damage to property during the nominated flood event. For further details, refer Section 7.1.2 of this report.



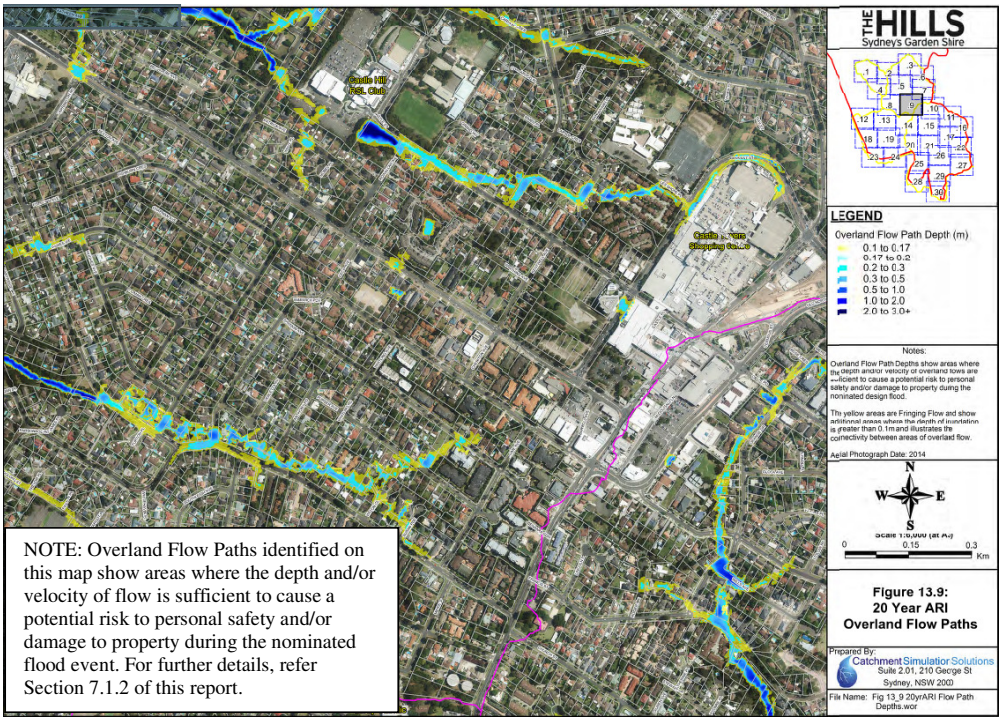
NOTE: Overland Flow Paths identified on this map show areas where the depth and/or velocity of flow is sufficient to cause a potential risk to personal safety and/or damage to property during the nominated flood event. For further details, refer Section 7.1.2 of this report.

Figures extracted from The Hills Draft Urban Overland Flow Study

Figure 9 20 Year ARI Overland Flow Paths



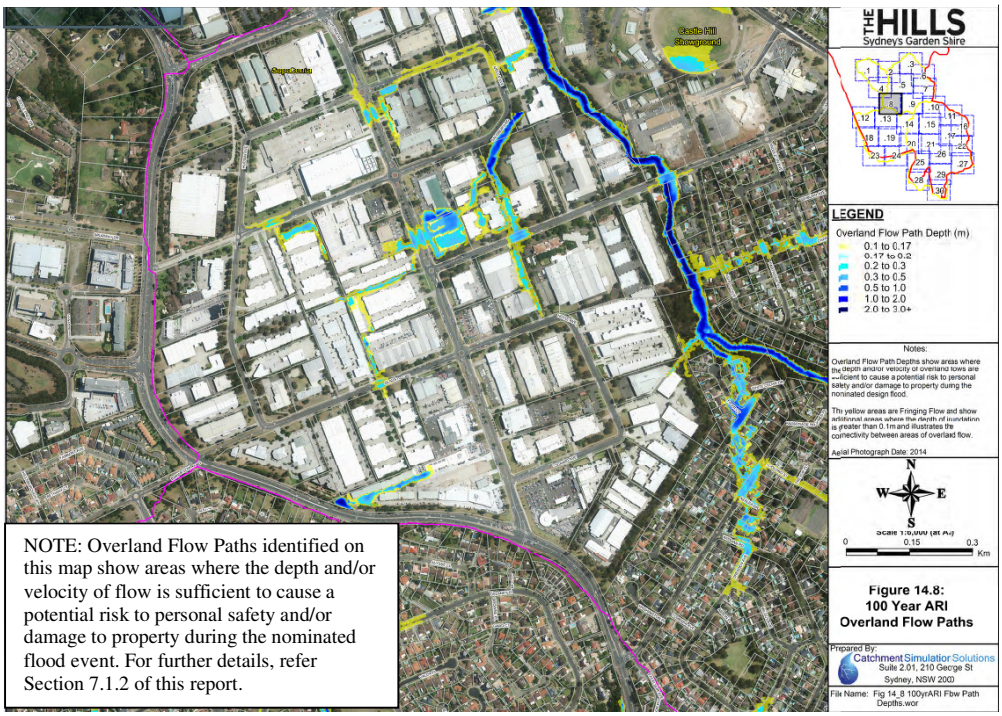
NOTE: Overland Flow Paths identified on this map show areas where the depth and/or velocity of flow is sufficient to cause a potential risk to personal safety and/or damage to property during the nominated flood event. For further details, refer Section 7.1.2 of this report.



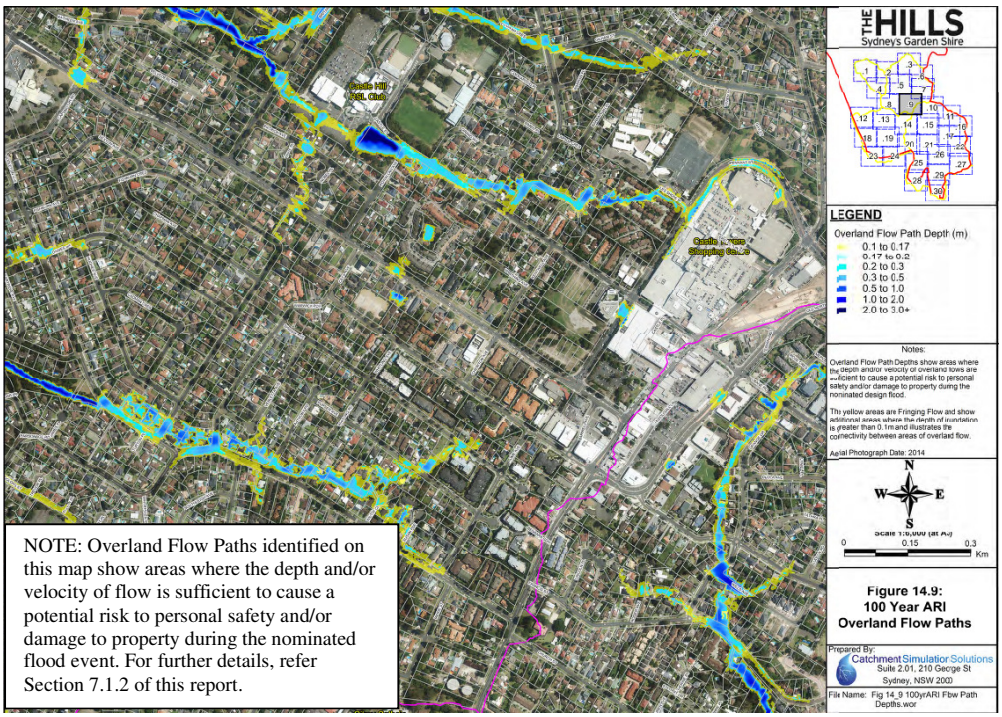
NOTE: Overland Flow Paths identified on this map show areas where the depth and/or velocity of flow is sufficient to cause a potential risk to personal safety and/or damage to property during the nominated flood event. For further details, refer Section 7.1.2 of this report.

Figures extracted from The Hills Draft Urban Overland Flow Study

Figure 10 100 Year ARI Overland Flow Paths



NOTE: Overland Flow Paths identified on this map show areas where the depth and/or velocity of flow is sufficient to cause a potential risk to personal safety and/or damage to property during the nominated flood event. For further details, refer Section 7.1.2 of this report.



NOTE: Overland Flow Paths identified on this map show areas where the depth and/or velocity of flow is sufficient to cause a potential risk to personal safety and/or damage to property during the nominated flood event. For further details, refer Section 7.1.2 of this report.

Figures extracted from The Hills Draft Urban Overland Flow Study

6.1.5 Blockage Assessment

An important element of the study is that it also has undertaken a sensitivity analysis on blockage of the stormwater system and its main culverts (zero blockage and severe). “Severe” blockage has been assessed as being:

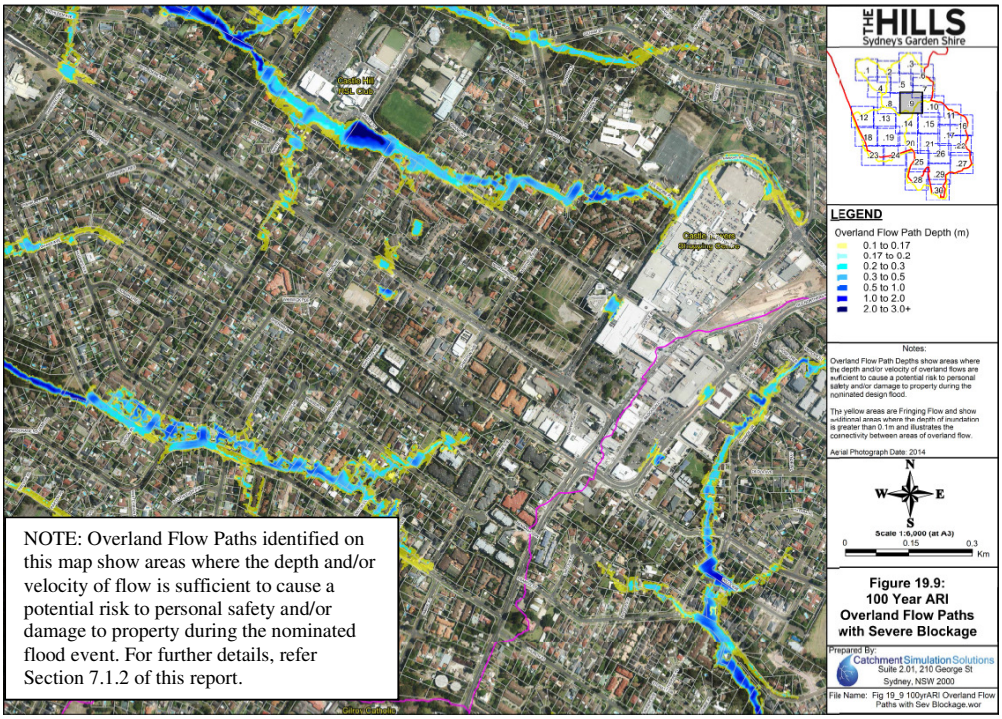
- 100% blockage of “On grade” stormwater pits
- 100% blockage of “Sag” stormwater pits = 50% blockage
- 100% blockage of Culverts with height < 3 metres or width < 5 metres
- 25% blockage of Culverts with height > 3 metres and width > 5 metres

Figure 11 (a and b) shows the effect of what is considered as a severe blockage to the stormwater system.

As would be expected, the extents of the overland flow paths are greater, affecting more cadastral lots than previous. The flow depths also appear to be deeper in some of these areas.

Figure 11 100 Year ARI Overland Flow Paths - Severe Blockage Scenario

NOTE: Overland Flow Paths identified on this map show areas where the depth and/or velocity of flow is sufficient to cause a potential risk to personal safety and/or damage to property during the nominated flood event. For further details, refer Section 7.1.2 of this report.



NOTE: Overland Flow Paths identified on this map show areas where the depth and/or velocity of flow is sufficient to cause a potential risk to personal safety and/or damage to property during the nominated flood event. For further details, refer Section 7.1.2 of this report.

Figures extracted from The Hills Draft Urban Overland Flow Study

7 Flooding Baseline for the Showground Station Urban Activation Precinct

7.1 Comparison of Flooding and Overland Flow Results

As it is understood that Council will use the information from the Urban Overland Flow Study to inform potential changes to their Flood Controlled Land mapping, a preliminary assessment of draft Overland Flow Results from the study against the existing mapping has been undertaken.

For this preliminary assessment, the flood control lot map was compared to the design 100yr ARI overland flow mapping.

The review has shown that there are more areas currently on the flood control lot mapping than appear to experience overland flows according to the new study. As such, Council may review their existing Flood Controlled Land mapping accordingly.

7.2 Recommendation

Given the time constraints of this project, it is recommended that the Precinct Structure Plan is developed in accordance with the existing flood control lot mapping and relevant flood planning levels, although the draft Overland Flow Study results have been used to inform the planning of the Precinct.

It is recommended that the Plan be reviewed once the results of the Overland Flow Study are adopted by Council.

8 Proposed Precinct Plan

With reference to the proposed LEP zoning map below, the main elements of the plan for the Showground Station UAP area are:

- Construction of new roads – These are proposed across all areas within the commercial/industrial area to the west of Cattai Creek, a new road over Cattai Creek, and further new roads within the residential areas to the east of the site and within the Castle Hill Showground area.
- Re-classification of lands to west of Cattai Creek – The proposed LEP re-zoning allows for the inclusion of an Enterprise Corridor (B6) and General Residential (R1). It also allows for increased heights of buildings within this area for existing light industrial areas.
- Re-classification of the existing Showground Area to Public Recreation (RE1) and a Local Centre (B2), which includes the NWRL Showground Railway Station.
- Re-classification of the residential area density to the east and south east to medium density (R3) and high density (R4)

Figure 12 Proposed LEP Land Zoning Map

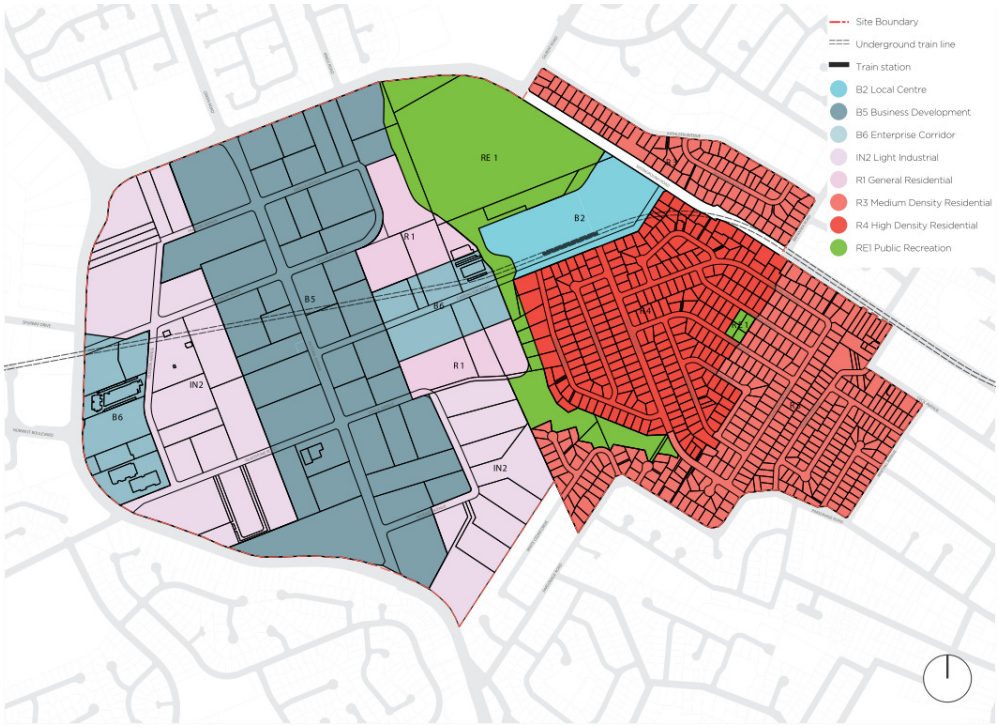
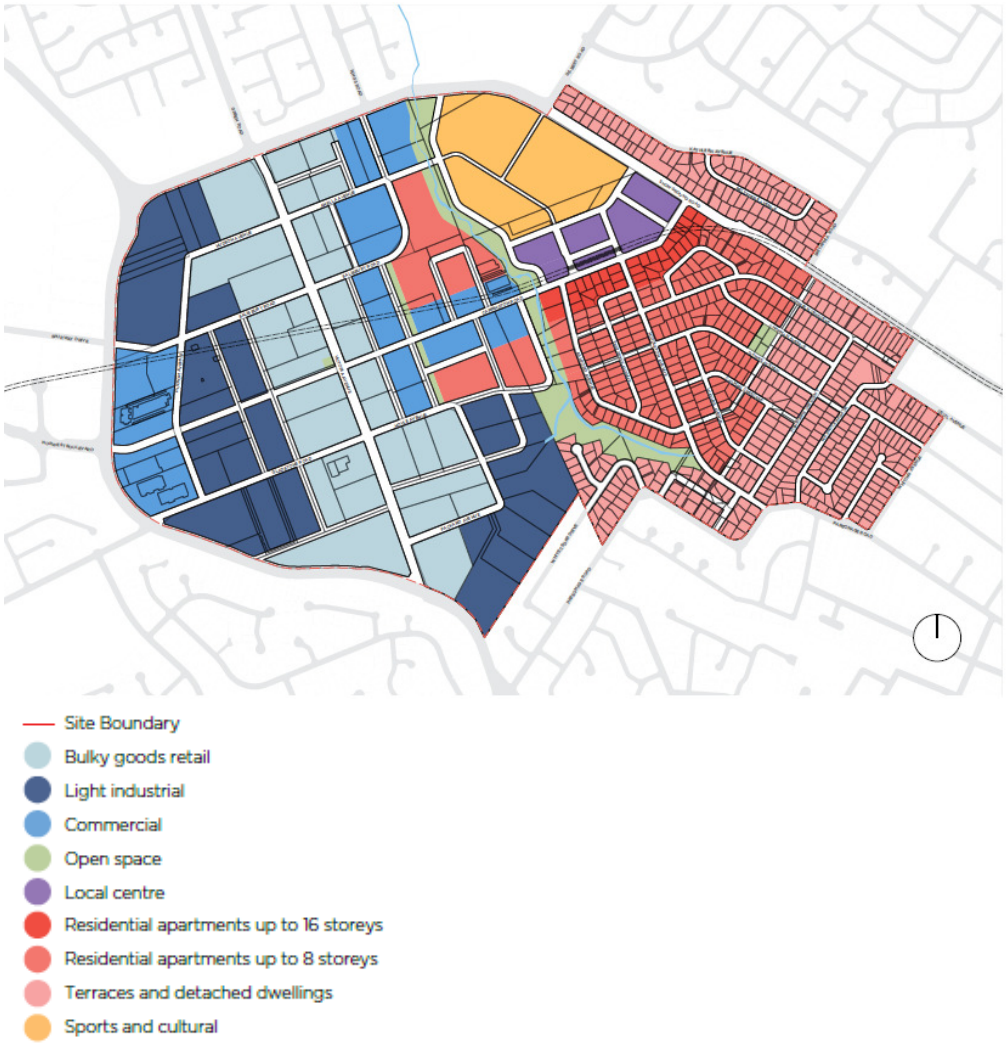


Figure 13 Proposed Precinct Plan - Land Uses



9 Precinct Plan Review

Having established the existing policies and guidelines for development within The Hills LGA, and reviewed the most current overland flow information, the following opportunities or constraints have been identified for the Precinct Plan with regards to flood mitigation/management, stormwater management and water quality treatment.

Flood mitigation/management infrastructure is discussed holistically for the precinct, whereas discussion on stormwater management and water quality treatment has been separated into the discrete elements of the Precinct Plan outlined in Section 8.

9.1 Flood mitigation/management infrastructure

Having reviewed the reports as listed in Sections 5 and 6, there do not appear to be any previously identified recommendations for flood mitigation/management infrastructure on a large scale within the Precinct or upstream.

Having reviewed the Precinct and the upstream catchment, there appears to be limited open space available for the potential provision of precinct-scale overland flow mitigation infrastructure solutions, which could typically include options such as retarding basins and channel modifications.

Although there are not many opportunities upstream of the catchment to provide large scale solutions, the provision of on-the-lot solutions (such as rainwater tanks) should be investigated to assist with the reduction of surface water run-off for more frequent events. An incentive for the installation of rainwater tanks on existing properties could be provided. It is assumed that any redeveloped residential property will be required to install these through BASIX requirements. The recent North Kellyville DCP 2014 and Box Hill/Box Hill Industrial Precinct DCP 2014 mandated that "All buildings must install rainwater tanks to meet a portion of supply such as outdoor use and toilets. All residential dwellings are required to provide a (minimum) 3,000 litre (3 KL) rainwater tank as part of the WSUD strategy, and such tank is to be connected for use in toilet flushing and external uses." It should be noted that rainwater tanks are not recommended as a solution for significant rainfall events that will cause overland flooding.

Within the Precinct itself, as there will be significant redevelopment expected, there are potential opportunities to address the overland flow issues, as illustrated in the mapping shown in this report. For each road that is to be developed, additional stormwater infrastructure will need to be constructed. Should this be undertaken in a holistic manner in accordance with the existing OSD policy, it may assist in reducing the overland flows that exists within the area.

9.2 Stormwater Management and Water Quality Treatment

9.2.1 Overall Commentary

Although the Precinct should result in considerable redevelopment and opportunities to improve the stormwater management for the catchment, it is

anticipated that this redevelopment will generally be implemented in piecemeal fashion over a medium to long term period. As such, it will be difficult for Council to implement a large scheme that will result in an immediate improvement to overland flow or water quality issues.

With that being the case, it may be more advisable to implement any changes through the revision of the LEP and DCP, and to mitigate any known risks with regards to overland flows until the point that the catchment has been redeveloped to the extent that there is a reduction in peak flows.

As a considerable area within the extents of the Precinct may be re-developed, OSD implementation would be likely to have a positive impact on the current overland flow results as discussed, and subsequent benefit to flood mitigation within Cattai Creek. This could be investigated as an option in a potential future flood/overland flow modelling study by Council, that would examine the effects of the new development.

Other than further hydraulic modelling being undertaken to determine the effects of the Precinct development, a general Stormwater Masterplan for the Precinct could be undertaken to determine the other benefits that may be associated to sustainable stormwater management, such as stormwater harvesting and re-use for example.

There may be opportunities for improvement in the riparian corridor, such as examining the spill performance and spill frequency of the existing Sydney Water overflow that discharges to Cattai Creek. Redevelopment of the area to the west of Cattai Creek may identify any unknown stormwater connections and reduce the frequency of when this overflow discharges

Further opportunities for improvement to the riparian corridor, such as geomorphological improvements, could be made through the widespread implementation of rainwater tanks on private properties.

9.2.2 New Roads

The introduction of new roads will likely open up new routes for overland flow around the precinct, potentially reducing flood impacts to lots. The development of these roads may also increase surface water run-off within the Precinct Area, which should be mitigated through on site detention.

Should these new roads, along with the increase in density of the area, result in additional traffic, this will likely introduce additional water quality loadings (motor oils/hydrocarbons) to the area that would need to be addressed. As discussed above, road upgrades are anticipated to be delivered in a staged manner, accompanying adjacent developments, which makes integration of WSUD elements challenging. However, there is potential for raingardens/bioretention tree pits to be introduced (supplementing, rather than replacing the typical minor drainage network) to treat local flows from the road corridor.

9.2.3 Commercial/Industrial Area West of Cattai Creek

As described above, the introduction of new roads within this area may cause changes to the overland flow routes. With regards to the newly proposed B6 Enterprise Corridor and R1 General Residential, these appear to be within the 100

year ARI overland flow paths for the catchment, and are currently classified as flood control lots. It is assumed that additional measures will need to be undertaken to address the potential overland flows through these areas, and that Flood Planning Levels will be set to 100 year ARI plus 500mm freeboard in line with Part C6 of the DCP.

With regards to water quality and pollutant generation within the area, the reduction in light industrial areas may result in the reduction of some current pollution loading, particularly if WSUD elements are introduced to the area through its redevelopment.

9.2.4 Showground

Having assessed the available overland flow mapping for this area, it does not appear that there are considerable existing overland flow problems. The redevelopment of this part of the Precinct however, which could include an increase in impermeable area, may result in additional surface run-off compared to the existing situation. The introduction of more people and vehicles to the area, since it is proposed to be a local centre as part of the Precinct rezoning, is likely to generate additional pollutant loadings.

Although the proposed re-zoning may increase the surface water run-off and water quality pollutant generation, this area has significant opportunites for stormwater management and WSUD given that it is likely to be developed in a more holistic manner and within a shorter time frame than other parts of the precinct. There should be ample opportunities available to not only manage these increases, but to develop in a sustainable manner that should result in improving the existing situation.

A holistic stormwater management plan could be derived for this specific area, and given that this is to become a new local centre and potential showcase to entice further redevelopment within the area, it should be investigated whether this could become a Green Star community area.

The large available open space area would be likely to provide sufficient scope to introduce WSUD and detention for a wider catchment than simply the Showground's local catchment alone. However, the position of the Showground area close to the top of the catchment and to the north of Cattai Creek means that there is limited potential to use this area to treat and/or detain stormwater flows from the rest of the precinct

9.2.5 Existing residential area

For the existing residential area to the east/south-east of the site, the Precinct Plan proposes an increase in density (to medium and high density housing), with the introduction of new roads. These density increases may result in the increase in impermeable areas, and therefore in an increase in surface water run-off. Mandating OSD in these areas should be considered to not only eliminate the potential increase in run-off, but to reduce it in comparison with the existing conditions.

It is noted that the proposed new road, a continuation of Dawes Avenue to the west towards Cattai Creek, would assist with the conveyance of overland flows

towards the creek. The construction of this road would require the demolition of existing properties that appear to be affected by overland flow.

As with other areas within the proposed precinct, the increase in density will most likely result in an increase in water quality pollutant loadings that will need to be addressed also, through on-lot WSUD measures.

10 Future Planning Controls

It is understood that The Hills Shire Council are currently in the process of revisiting the LEP and DCP for the whole Local Government Area, and that therefore there may be changes in relation to the management of stormwater, overland flows and water quality.

In determining potential future planning controls that could be incorporated into Hills Shire Council's DCP, it is acknowledged that it is important to achieve the best outcome for the community and the environment, whilst not impinging on the financial viability of redevelopment due to overly restrictive measures. As such, Arup have assessed the merit of the existing controls/guidelines.

The recent North Kellyville DCP 2014 and Box Hill/Box Hill Industrial Precinct DCP 2014 contain a number of stormwater quantity, quality and flooding provisions that are either not included or not as clearly articulated in the current DCP 2012, and these provide a good basis for future DCP provisions for the Precinct.

10.1 OSD Policy

As discussed earlier in this report, the existing OSD policy is set to the requirements of the Hawkesbury River Catchment OSD policy. It is assumed that the benefits that this current policy provides would therefore be mandated as a minimum should there be a change in the OSD policy. In examining the existing policy however, should the redevelopment of the Precinct result in the widespread implementation and construction of OSD tanks, the overland flows should reduce considerably. An example of this is the light industrial / commercial area to the west of Cattai Creek within the Precinct. The excerpt below is from the current Overland Flow Study (Drainage Catchment 4 Flow Locations), and shows flow measurement lines from which piped and overland flows have been extracted from the TUFLOW model for the 10 year, 20 year and 100 year design ARI events.

Figure 14 Flow Measurement Lines - Overland Flow Study

Figures extracted from The Hills Draft Urban Overland Flow Study

The corresponding Table 4 in the report provides the breakdown as follows:

ID	Location	Peak Discharge (m^3/s)								
		10 Year ARI			20 Year ARI			100 Year ARI		
		Pipe	Overland	Total	Pipe	Overland	Total	Pipe	Overland	Total
40	Whitling Ave	4.77	4.86	9.63	4.96	6.65	11.6	4.77	10.3	15.1
41	DS Middleton Ave	4.83	8.51	13.3	5.07	12.0	17.1	5.56	15.9	21.5
42	White Cedar Dr	2.15	7.89	10.0	2.82	10.7	13.5	2.46	14.5	17.0
43	DS Carrington Rd	0.00	23.8	23.8	0.00	30.7	30.7	0.00	43.1	43.1
44	Victoria Av	7.22	1.63	8.85	8.78	2.53	11.3	9.86	4.94	14.8
45	Castle St/Grand Wy	3.24	7.44	10.7	3.53	9.48	13.0	3.72	13.6	17.3
46	Britannia Rd X Bounty Ave	2.56	4.22	6.78	2.80	5.19	7.99	3.12	7.41	10.5

Figures extracted from The Hills Draft Urban Overland Flow Study

Should there be little or no existing OSD within the area, the application of widespread OSD through redevelopment upstream of the flow check line at Victoria Avenue should result in considerable flow reductions.

Assuming that only two thirds (52 ha approx.) of the upstream catchment from this flow check line had OSD implemented in the future, the peak flow for the 100yr ARI for this whole area would be reduced to 4.5 m^3/s, which is a considerable reduction pro-rata wise of the equivalent total of 9.8 m^3/s for the 100 year ARI event. This estimation was on the basis that a Permissible Site Discharge

of 87 l/s/ha, in line with the Hawkesbury River Catchment OSD Policy, would be implemented.

10.2 WSUD

There is an opportunity to provide more up-to-date and binding WSUD consideration within Council's LEP and/or DCP, consistent across all types of development, including areas under 2,500m^2 in size. The existing 'target-based' pollutant reductions that are recommended in the Technical Guidelines for Western Sydney could be incorporated within the actual DCP, and demonstration of how these targets have been addressed by mandated as a DA submission requirement. The target values could be increased to match those included within the North Kellyville DCP 2014 and Box Hill/Box Hill Industrial Precinct DCP 2014, as provided in Table 3 of this report. Inclusion of a target for oils and greases is also recommended. As an example, Parramatta City Council's DCP requires no visible oils for flows up to 50% of the one-year ARI peak flow specific for particular development types.

10.3 Draft Controls

10.3.1 Objectives

a. To adopt best practice techniques for stormwater quality management.

b. To minimise flooding and reduce the effects of stormwater pollution on Cattai Creek.

c. To ensure that land is appropriate to managing and minimising risks from flooding.

d. To ensure an integrated approach to water management through the use of water sensitive urban design (WSUD) principles.

10.3.2 Controls

1. A comprehensive Stormwater Management Plan/Master Plan is to be prepared for the Precinct prior to approval of first development within the B2 zone. The Master Plan is to ensure the sustainable stormwater management within the Precinct and is to include consideration of various of sustainable practices including stormwater management, rainwater harvesting and re-use and water conservation.
2. All Stormwater drainage designs are to comply with the most up to date revision of Council's "Design Guidelines".
3. WSUD is to be adopted throughout all development, incorporating water quality management and attenuation of runoff to acceptable levels following development.
4. The following stormwater management objectives are to be achieved for all development within the Precinct:
   - 90% reduction in the post-development average annual gross pollutant load

- 85% reduction in the post-development average annual total suspended solids (TSS) load
- 65% reduction in the post-development average annual total phosphorus (TP) load
- 45% reduction in the post-development average annual total nitrogen (TN) load

5. For developments generating oils and grease, the additional objective of no visible oils for flows up to 50% of the one-year ARI peak flow shall be achieved.
6. Design or new road corridors shall incorporate WSUD elements including raingardens/bioswales/bioretention tree pits to supplement the typical minor drainage network to treat local flows from the road corridor. Design and construction of these elements shall allow for ease of ongoing maintenance and for pedestrian crossings at appropriate locations.
7. WSUD infrastructure elements are to be designed and constructed in accordance following publications:
   - Australian Runoff Quality (Engineers Australia 2005)
   - Water Sensitive Urban Design Technical Guidelines for Western Sydney (NSW Government Stormwater Trust and UPRCT, May 2004).
8. Water quality modelling to support development proposals within the Precincts shall utilise MUSIC Version 5 or later and adopt modelling parameters in line with the most up to date version of the NSW Music Modelling Guidelines (CMA).
9. To minimise the impact of stormwater on the health and amenity of Cattai Creek, stormwater is to be retained on development sites by:
   - collecting and storing water from roofs and hard surfaces
   - maximising porous surfaces and deep soil zones
   - draining paved surfaces to adjacent vegetation
10. All buildings must install rainwater tanks to meet a portion of supply such as outdoor use and toilets. All residential dwellings are required to provide a (minimum) 3,000 litre (3 KL) rainwater tank, and such tank is to be connected for use in toilet flushing and external uses. Larger tanks than the requirement are permitted.
11. Each rainwater tank is to be provided with potable water trickle top-up with a back flow prevention device, complying with Sydney Water requirements.
12. On-site detention is to be provided in accordance with Section 4.22 of Council's Design Guidelines Subdivision / Developments.
13. Within the Showground Precinct, Flood planning levels for new development shall comply with the requirements of Council's DCP (2012) Section C6.
14. Development is to comply with the flood risk management provisions of Council's DCP 2102 Section C6.
15. All landscaping is to be compatible with flood risk and not impede overland stormwater flows.

16. All vegetation species and structures, including paths, walls and fences, are to be able to withstand temporary flood inundation in any areas designated as detention basins.
17. During the construction phase of development, the relevant Stormwater Management Objectives for New Development as set out in the most up to date revision of "Managing Urban Stormwater: Soils and Construction" (NSW Department of Housing) must be complied with in full.
18. Erosion and sediment control measures are to be implemented and regularly maintained on site, while sediment trapping measures are to be located at all points where stormwater runoff can enter inlets to stormwater systems, or where runoff may leave the construction site.