Appendix E Drainage investigation

DRAINAGE INVESTIGATION

SHOWGROUND ROAD UPGRADE – CARRINGTON ROAD TO OLD NORTHERN ROAD

December 2013

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File:/Reports/SGU_001_v1.3_Report.doc	Rev No: 1.3	Authors: SAB/NB

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ABBREVIATIONS

AHD	Australian Height Datum
ALS	Airborne Laser Scanning (survey data)
ARI	Average Recurrence Interval (years)
ARR	Australian Rainfall and Runoff, 1998 Edition
DRC	Design Road Chainage
GIS	Geographic Information System
LESCA	Local Erosion and Sediment Control Area
LGA	Local Government Area
RCP	Reinforced Concrete Pipe
RL	Reduced Level
RMS	NSW Roads and Maritime Services
RUSLE	Revised Universal Soil Loss Equation
SWMP	Soil and Water Management Plan
THSC	The Hills Shire Council

S1 SUMMARY OF KEY FINDINGS

An investigation was carried out by Lyall & Associates Consulting Water Engineers on behalf of the NSW Roads and Maritime Services (RMS) to assess requirements for the control of stormwater runoff along the proposed upgrade of Showground Road between Carrington Road and Old Northern Road, Castle Hill. This report deals with issues relating to both the construction and operational phases of the proposed road upgrade.

The scope of the investigation comprised the following broad tasks:

- Review and refinement of a DRAINS model provided by The Hills Shire Council for use in the present investigation.
- Development of a concept drainage arrangement for the upgraded road which has a minimum hydrologic standard of 10 year average recurrence interval (ARI).
- Assessment of the impact the road upgrade works will have on the hydrologic regime of receiving drainage lines into which the new pavement drainage system for the upgraded sections of the road will discharge.
- Development of an erosion and sediment control strategy for the construction phase of the proposed road upgrade.

The extent of the catchments which presently contribute runoff to drainage lines located within the road corridor are shown on **Figures 2.1** and **2.2**, whilst the layout of the concept drainage arrangement developed as part of the present investigation is shown on **Figure 5.1** and **5.2**.

Present Day Conditions

The key findings of the investigation in terms of present day drainage patterns along Showground Road were as follows:

- **Catchment 1** – The existing 600 mm diameter pipe which drains toward the south from the road corridor (refer Peak Flow Location Identifier F1 on **Figure 2.1**) has a hydrologic standard of greater than 100 year ARI.
- **Catchment 2A** – The existing local stormwater drainage system south of the road corridor has a hydrologic standard of about 2 year ARI. As a result, stormwater runoff which surcharges the kerb inlet pits in Cecil Avenue will discharge into the adjoining catchment (i.e. Catchment 2B), where it will flow onto Showground Road at the intersection of the two roads.

  Due to limitations in the pit inlet and pipe capacity within the road corridor (analyses indicate that ponding in the sag in Showground Road would occur on average once a year), the 750 mm diameter pipe which runs northward through the existing townhouse complex at No. 59A Castle Street (refer Peak Flow Location Identifiers F3 and F4 on **Figure 2.1**) does not flow full over the full range of storms up to 100 year ARI.
- **Catchment 2B** – The hydrologic standard of the piped drainage system which approaches Showground Road from the south is between 2-5 year ARI. The peak overland flow approaching the road corridor from the south through the adjacent residential properties is about 0.7 m^3/s for the 10 year ARI design storm event.

  The existing 900 mm diameter pipe which runs to the north of the road corridor toward Patrick Avenue (refer Peak Flow Location Identifier F7 on **Figure 2.2**) has a similar hydrologic standard, flowing full for events as frequent as 5 year ARI.

- **Catchment 2C** – Due to limitations in the pit inlet capacity within the road corridor, the existing 900 mm diameter pipe which runs toward the north through the frontage of No. 106 Showground Road (refer Peak Flow Location Identifier F9 on **Figure 2.2**) does not flow full over the full range of storms up to 100 year ARI.
- **Catchment 2D** – The existing longitudinal drainage line which runs in a westerly direction beneath the southern kerbline of Showground Road has a hydrologic standard of about 5 year ARI. The analyses also indicate that water will pond across the intersection of Showground Road and Carrington Road in events as frequent as 2 year ARI.

Post Road Upgrade Conditions – Operational Phase

The key findings of the investigation as they relate to the operational phase of the project were as follows:

- **Catchment 1** – The DRAINS model developed as part of the present investigation indicates that peak flows discharging from the road corridor to the existing 600 mm diameter pipe opposite Pennant Street (refer Peak Flow Location Identifier F1 on **Figure 5.1**) will not be increased for storms with ARI's up to 100 years.
- **Catchment 2A** – Whilst peak flows discharging to the north will be increased as a result of the road upgrade (refer Peak Flow Location Identifier F3 on **Figure 5.1**), improvements in hydraulic capacity associated with the upgrade of the existing stormwater drainage system in the road corridor means that more flow will be conveyed in the existing 750 mm diameter pipe when compared to present day conditions. As a result, there will be an overall reduction in the peak flow discharging to the north of the sag in the road corridor as overland flow.

  Whilst the hydrologic standard of the receiving drainage system is about 10 year ARI, the relatively shallow depth of two 132 kV feeder lines which run along the northern side of Showground Road west of Cheriton Avenue mean that it is not practical to install sufficient waterway area in the cross drainage to prevent surcharge of the sag in Showground Road for events larger than about 5 year ARI. It was also found that in order to drain the sag on the southern side of Showground Road, the stormwater drainage system had to be routed further west, where it could cross under the 132 kV feeder lines.

  Widths of flow along the westbound kerbline also exceed 1 m in a 10 year ARI event for the case where a new SA3 stormwater pit is provided in line with the north-south boundaries of each of the adjacent private properties (i.e. provision of one kerb inlet pit per property). Whilst the provision of additional pits along the kerb would assist in reducing widths of gutter flow, the final spacing of the inlet pits will depend on the set out of driveways and pedestrian crossings.
- **Catchment 2B** – As the hydrologic standard of the existing 900 mm diameter pipe is only about 5 year ARI, it is not possible to prevent ponding across the upgraded section of road at the location of the sag during more intense storm events (i.e. RMS' requirement to achieve a minimum 10 year ARI hydrologic standard cannot be achieved at this location).

  In order to cross under the two 132 kV feeder lines which run along the northern side of Showground Road, it will be necessary to install 2 off 675 mm diameter pipes across the new widened carriageway at the location of the sag.

Widths of flow along the westbound kerbline are greater than 1 m in a 10 year ARI event, especially where gutter flows approach the sag in the road. The provision of additional pits in this area would not necessarily assist in reducing the widths of flow in this area given that the hydrologic standard of the longitudinal drainage system is less than 10 year ARI.

It will be necessary to install a new 600 mm diameter pipe beneath the western kerbline of Rowallan Avenue extending from Showground Road to Castle Street in order to reduce the rate at which flow discharges overland through existing residential development located to the north of the road corridor at the location of the sag (refer Peak Flow Location Identifier F7 on **Figure 5.2**).

- **Catchment 2C** – Peak flows discharging from the road corridor (refer Peak Flow Location Identifier F9 on **Figure 5.2**) will be subject to minor increases over the full range of design storm events. This occurs as a result of the small increase in impervious area within the upgraded road corridor. However, the existing 900 mm diameter pipe that runs north from the road corridor at this location through No. 106 Showground Road is shown to have sufficient capacity to convey the increased rate of flow for storms with ARI's up to 100 years.
- **Catchment 2D** – Whilst the DRAINS model developed as part of the present investigation shows a minor increase in peak flows discharging overland to residential development north of the road corridor (refer Peak Flow Location Identifier F10 on **Figure 5.2**) as a result of the road upgrade for events larger than about 10 year ARI, given the limited nature of the works in this catchment it is likely that during detail design this impact will be removed.

Post Road Upgrade Conditions – Construction Phase

The key findings of the investigation as they relate to the construction phase of the project were as follows:

- Large scale sediment retention basins do not necessarily need to form part of the Soil and Water Management Plan (or similar) for the road upgrade project in order to comply with the guidelines set out in *"Soils and Construction – Managing Urban Stormwater"* Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008). Rather, it is recommended that localised erosion and sediment control measures, including temporary sediment sumps where practicable, form the basis of the erosion and sediment control strategy that will need to be developed as part of final design and/or construction documentation for the road upgrade works. **Figures 6.1** and **6.2** show the extent of land which will be disturbed during the construction phase of the project (excluding areas of existing pavement) and identifies the receiving drainage lines to which runoff from these areas will discharge.
- Measures such as temporary diversion channels and bunding will also need to be implemented during the construction phase of the project to prevent concentrated flow, which presently discharges onto the road corridor from the south, from causing scour of disturbed surfaces. The difficulty which will be faced by the contractor is that in several locations concentrated flow discharges onto the road corridor via ill-defined drainage paths (e.g. down driveways and along boundary fences). In order to minimise scour potential during the construction phase of the project, it will be necessary to carefully plan, implement and maintain measures which are aimed at intercepting this concentrated flow and diverting it toward the piped stormwater drainage system.

1 INTRODUCTION

1.1 Background

Roads and Maritime Services (RMS) is currently developing a concept design for the proposed upgrade of Showground Road between Carrington Road and Old Northern Road, Castle Hill. **Figure 1.1** shows the extent of the proposed road upgrade works, which are located wholly within The Hills Shire Council (THSC) local government area (LGA). Showground Road presently comprises a two lane single carriageway for most of its length between Carrington Road and Pennant Street. The upgrade will involve widening this section of the road to achieve a four lane divided carriageway over the full length between Carrington Road and Old Northern Road, with provision for future widening to six lanes if warranted.

The objective of the present investigation was to undertake an assessment of drainage requirements associated with the road upgrade (both during the construction and operational phases of the road upgrade), and to prepare preliminary designs for the upgrade of existing road drainage systems. This work will inform further development of the concept road design and preparation of an environmental assessment for the upgrade works.

Catchment modelling using the DRAINS rainfall-runoff software was undertaken to assess the performance of existing road drainage systems along the route of the proposed road upgrade. An existing DRAINS model provided by THSC, which was reviewed and refined as part of the present investigation, formed the basis of this assessment.

The DRAINS model was also used to investigate the impact that the road upgrade works would have on peak flows in existing drainage lines downstream of Showground Road, and to assist in the development of a strategy for discharging runoff from the upgraded road corridor to these receiving drainage lines.

1.2 Study Tasks

The study tasks were broadly as follows:

- Site inspection to ground-truth existing drainage arrangements, confirm additional survey requirements and identify relevant site constraints. A survey brief was subsequently prepared setting out additional requirements for RMS' surveyors to confirm details of various sections of existing piped drainage both within and downstream of the road corridor.
- Review of available data and current RMS concept design for the proposed road upgrade works. A review of relevant technical documentation prepared by THSC as part of an earlier concept design for the road upgrade (herein referred to as the *"2011 Concept Design"*) was also undertaken.
- Liaise with THSC to obtain relevant drainage information along Showground Road and the existing stormwater drainage lines into which the upgraded road drainage system will need to connect.
- Hydrologic analysis of catchments upstream of and along Showground Road to determine peak flow rates approaching and within the road corridor. Hydrologic modelling also included catchments which lie downstream of the road corridor so that impacts on peak

flow rates as a result of the road upgrade works could be determined along the receiving drainage lines.

- Hydraulic analysis of existing drainage systems within and downstream of the road corridor to determine the hydrologic standard of the existing two lane carriageway as well as the capacity of existing piped drainage systems which receive runoff from the road corridor.
- Develop a strategy for discharging runoff from the upgraded length of Showground Road aimed at mitigating the impacts of the road upgrade works on existing development.

  A concept layout for new and upgraded road drainage systems was developed to show the indicative location of inlet pits and piped drainage lines that will be required to capture and convey runoff from the upgraded length of Showground Road to receiving drainage lines.
- Develop a strategy to control erosion and sediment-laden runoff during construction of the road upgrade.

1.3 Outline of Report

Section 2 of this report provides a description of the catchments which presently contribute runoff to existing road drainage systems along the length of Showground Road to be upgraded. A brief description of these existing drainage systems and their receiving drainage lines is also provided.

Section 3 contains an overview of the methodology and findings of an investigation undertaken to assess peak flow rates at key locations along the length of the road upgrade works under present day conditions. A hydrologic model was developed for this purpose using the DRAINS software. This section also presents the findings of an investigation which was carried out to assess widths of flow within the road corridor, the hydrologic standard of existing transverse piped crossings of Showground Road, and the capacity of existing piped drainage systems which receive runoff from the road corridor.

Section 4 provides a brief description of the proposed road upgrade works, and in particular the proposed control of stormwater runoff from widened sections of road pavement.

Section 5 presents the recommended strategy for managing runoff along the upgraded length of Showground Road and for its discharge into receiving drainage lines. This section also deals with the impact the road upgrade works will have on drainage patterns along the length of the road corridor and receiving drainage lines, including comparison of peak flows under present day and post-upgrade conditions for design storms up to 100 year average recurrence interval (ARI) at several key locations. A summary of residual drainage-related property impacts should the recommended drainage strategy be implemented is also provided in this section.

Section 6 provides a summary of the approach to be adopted in developing an erosion and sediment control strategy for the construction phase of the road upgrade works. This includes requirements for local erosion and sediment control measures along the length of the road upgrade.

Section 7 contains a list of references used during the course of the investigation.

Appendix A contains a figure showing the extent and layout of an existing DRAINS model that was provided by THSC, which formed the starting point for further model development and refinement as part of the present investigation (refer **Section 3** for details).

1.4 Available Data

The following data were made available by RMS for this present investigation:

- Aerial photography covering the study area.
- Airborne laser scanning (ALS) survey data covering the study area.
- Detailed ground survey information along the route of the proposed road upgrade works.
- Detailed survey of existing piped drainage systems located within and adjacent to the road corridor.
- Current concept road design model for the proposed upgrade works.
- Drawings showing the indicative location of existing utilities within the road corridor.
- GIS datasets including property boundary information.

The following additional information was obtained from THSC to assist with the investigation:

- GIS datasets showing selected details of the existing stormwater drainage system along Showground Road and in surrounding catchment areas to its north and south.
- DRAINS hydrologic model for the Castle Street catchment, developed on behalf of THSC by SKM as part of the Draft Castle Hill Precinct Flood Study, 2005 (filename *"BC279_Castle_Street_Standard H M_V1.drn"*).
- Various information documenting the 2011 Concept Design for the road upgrade, including:
    - concept drainage plans; and
    - a report prepared by THSC entitled *"MR157 Showground Road Upgrade and Widening, Phase 1: 4 Lane Option, Carrington Road to Old Northern Road – Final Concept Design Report"* dated May 2011.

N

60 0 60 120 180 m

Scale: 1:6,000

Lyall & Associates

LEGEND

Showground Road Upgrade

2A Sub-Catchment Boundary and Identifier

SHOWGROUND ROAD UPGRADE
DRAINAGE INVESTIGATION

Figure 1.1

LOCATION PLAN

2 EXISTING ROAD DRAINAGE SYSTEMS

2.1 General

This section of the report contains a description of existing road drainage systems along the length of Showground Road to be upgraded, including both cross and pavement drainage systems. A brief description of the catchments which presently contribute runoff to these road drainage systems is also provided. [1]

Figure 1.1 shows the extent of five catchments which contribute runoff to existing road drainage systems along Showground Road, as well as the location of the respective receiving drainage lines and other key features along the route of the proposed road upgrade, and should be referred to when reading the following sections of the report.

Figures 2.1 and **2.2** show further details of existing road drainage systems along the length of the road corridor and should also be referred to when reading the following sections of the report.

2.2 Catchment Overview

The 1.3 km length of Showground Road to be upgraded is located within the headwaters of the Cattai Creek catchment. Cattai Creek ultimately flows into the Hawkesbury River on its right bank approximately 20 km to the north of Showground Road.

Figure 1.1 shows that a short length of the road corridor to be upgraded is located within **Catchment 1**, which drains to the south towards **Drainage Line 1**. This drainage line flows generally to the west in the form of a piped drainage system before emerging as a vegetated channel on the downstream (western) side of Middleton Avenue, Castle Hill. This channel forms the main arm of Cattai Creek.

The remainder of the road corridor is located within **Catchments 2A**, **2B**, **2C** and **2D**, which drain to the north towards **Drainage Line 2**. This drainage line also flows generally to the west in the form of a piped drainage system before emerging as a vegetated channel on the downstream (western) side of Britannia Road, Castle Hill. This channel forms a tributary arm of Cattai Creek, which joins the main arm on its right bank approximately 1.4 km further west.

Surrounding land use along the length of Showground Road to be upgraded is predominantly residential is nature, with commercial development on both sides of the road corridor at its eastern end between Pennant Street and Old Northern Road.

The prevailing terrain along the road corridor is relatively mild, with maximum longitudinal grades up to about 6 per cent, and typical grades for land adjoining the road corridor in the order of 3-6 per cent to a maximum of about 10 per cent.

[1] Note that for the purpose of this report, the locations of key features are identified by their position along Showground Road as defined by its Design Road Chainage (DRC). Note also that the discussion of road drainage systems commences at the eastern limit of the road upgrade, moving in a westerly direction (i.e. the discussion runs in the direction of decreasing DRC). This convention has also been adopted when describing the concept drainage and erosion and sediment control strategies in Sections 5 and 6 of the report, respectively.

There are no major creek crossings along this section of Showground Road as it is located relatively high in the headwaters of the Cattai Creek catchment and in close proximity to an existing ridgeline. The following section provides a more detailed description of existing road drainage systems, including a number of minor piped crossings, along the length of the proposed road upgrade works.

2.3 Existing Road Drainage Systems

The following sections provide a brief description of existing drainage systems that are located along the route of the proposed road upgrade works.

2.3.1 Catchment 1

Catchment 1 is about 1.7 ha in area and comprises mainly developed land including a 240 m long section of Showground Road extending west from Old Northern Road, as well as a small catchment which lies along the northern side of the road corridor.

The existing piped drainage system in Catchment 1 drains towards a sag in Showground Road which is located at its intersection with Pennant Street near **DRC 1340**. A 525 mm diameter pipe conveys runoff across the road corridor from north to south.

Runoff leaving the road corridor along Drainage Line 1 is controlled by a 600 mm diameter pipe, which runs south from the sag in the southern kerbline of Showground Road. Available survey data shows this pipe is located along the boundary of the **Castle Hill Baptist Church** and the adjacent **McDonald's Restaurant** (refer **Figure 2.1** for location). Stormwater which surcharges the piped drainage system will enter the Church grounds as overland flow via the existing driveway.

Site inspection shows that Drainage Line 1 continues as a piped drainage line to the south of Cecil Avenue, and runs generally west through residential areas of Castle Hill before discharging into Cattai Creek on the downstream (western) side of Middleton Avenue.

2.3.2 Catchment 2A

Catchment 2A is about 6.1 ha in area and comprises a 450 m long section of Showground Road in addition to existing residential development located along the southern side of the road corridor.

The existing piped drainage system in Catchment 2A drains towards a sag in the road corridor near **DRC 840**. A 300 mm diameter pipe and 525 mm diameter pipe located at **DRC 840** and **DRC 860**, respectively, convey stormwater under the roadway from south to north. These two piped drainage lines join immediately north of the roadway and continue to the north as twin 600 mm diameter pipes.

Runoff leaving the road corridor along Drainage Line 2A is controlled by a single 750 mm diameter pipe, which runs north through an adjacent residential townhouse complex at **No. 59A Castle Street** (refer **Figure 2.1** for location) towards Castle Street. Stormwater which surcharges the piped drainage system within the road corridor will flow overland through this townhouse complex.

Drainage Line 2A discharges into Drainage Line 2 at Castle Street, which then continues generally to the west towards Cattai Creek.

Note that a 120 m long section of the eastbound carriageway extending east from Kentwell Avenue does not form part of Catchment 2A. Rather, runoff generated on this section of carriageway is presently conveyed north along the eastern kerbline of Kentwell Avenue as overland flow.

2.3.3 Catchment 2B

Catchment 2B is about 10.7 ha in area and comprises a 410 m long section of Showground Road in addition to existing residential development located along the southern side of the road corridor.

The existing piped drainage system in Catchment 2B is comprised of two main branches. The first branch is a 375 mm diameter line that is located under the southern kerbline of Showground Road, which crosses the roadway as a 600 mm diameter pipe at the location of a sag in the road corridor near **DRC 560**. The second branch drains most of the residential catchment upstream (south) of Showground Road, and crosses the roadway as a separate 600 mm diameter pipe a short distance west of the sag point.

The two piped branches join immediately north of the roadway and continue to the north as a 900 mm diameter pipe, which controls runoff leaving the road corridor along Drainage Line 2B. Available drainage data sourced from THSC shows this pipe is located within **No. 80 Showground Road** (refer **Figure 2.2** for location). Stormwater which surcharges the piped drainage system within the road corridor will flow through this property and adjacent residential development as overland flow. Drainage Line 2B discharges into Drainage Line 2 to the north of Patrick Avenue.

Note that a 90 m long section of the eastbound carriageway extending east from Rowallan Avenue does not form part of Catchment 2B. Rather, runoff generated on this section of carriageway is presently conveyed north along the eastern kerbline of Rowallan Avenue as overland flow.

2.3.4 Catchment 2C

Catchment 2C is about 1.9 ha in area and comprises a 190 m long section of Showground Road in addition to existing residential development located along the southern side of the road corridor.

Stormwater runoff generated within Catchment 2C is controlled by a piped drainage system that crosses Showground Road as a 525 mm diameter pipe near **DRC 180**. A 600 mm diameter pipe controls runoff leaving the road corridor to the north along Drainage Line 2C. Available survey data shows this pipe is located within **No. 106 Showground Road** (refer **Figure 2.2** for location). Drainage Line 2C discharges into Drainage Line 2 to the north of Kathleen Avenue.

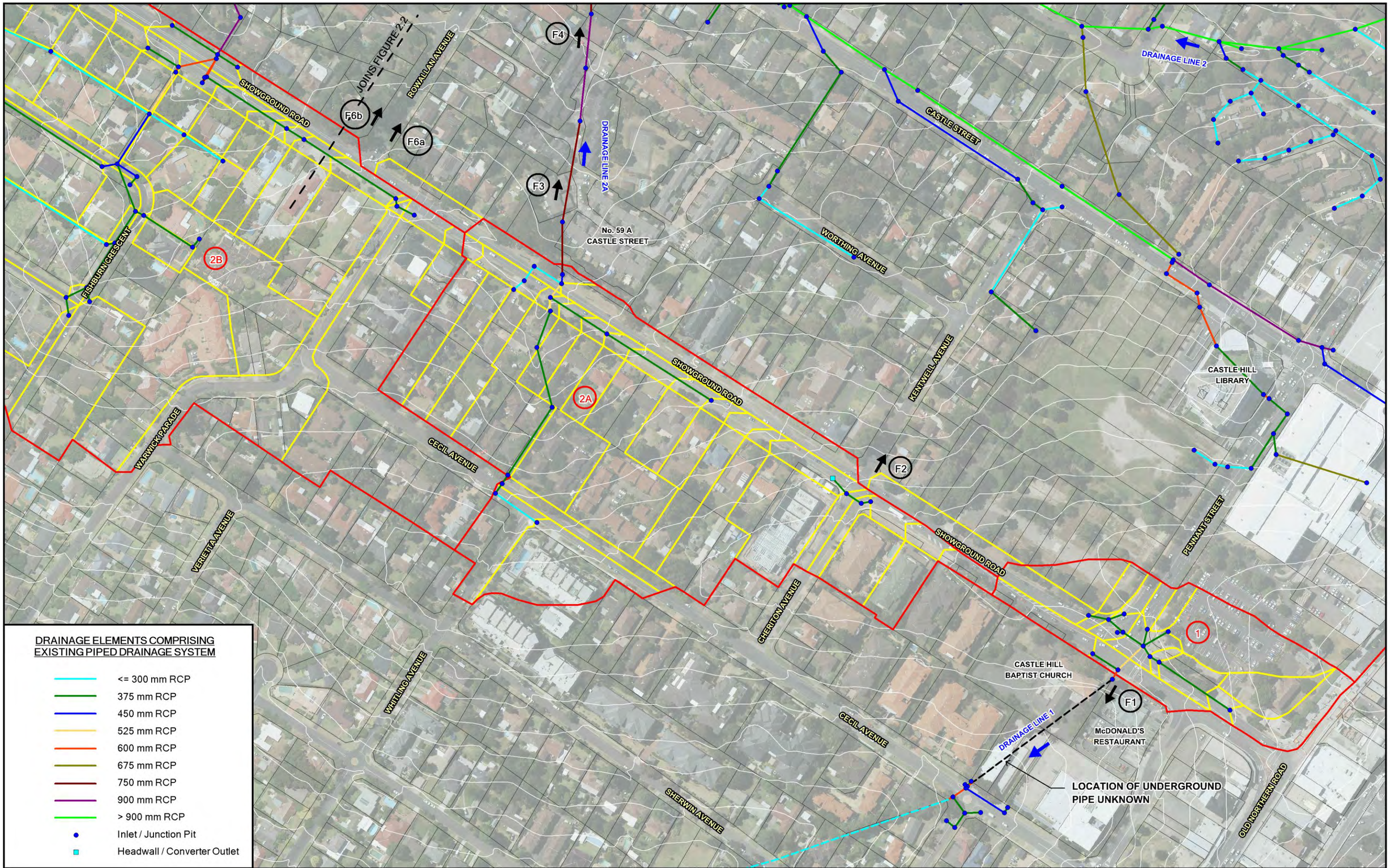
Stormwater which surcharges the existing road drainage system will flow west along the road corridor into Catchment 2D (refer next section).

2.3.5 Catchment 2D

Catchment 2D is about 5.2 ha in area and comprises a 350 m long section of Showground Road in addition to existing residential development located along the southern side of the road corridor. A portion of THSC Chambers site on the western side of Carrington Road also forms part of this catchment.

The existing piped drainage system in Catchment 2D drains towards the sag in Showground Road which is located on the western side of its intersection with Carrington Road. A 600 mm diameter pipe conveys runoff across the road corridor from south to north.

The 600 mm diameter pipe continues to the north of the road along Drainage Line 2D. Available drainage data sourced from THSC shows the pipeline to be located along the boundary between **Nos. 122** and **124 Showground Road** (refer **Figure 2.2** for location). Stormwater which surcharges the piped drainage system within the road corridor will flow through the former property as overland flow. Drainage Line 2D discharges into Drainage Line 2 to the north of Kathleen Avenue.



DRAINAGE ELEMENTS COMPRISING
EXISTING PIPED DRAINAGE SYSTEM

- <= 300 mm RCP
- 375 mm RCP
- 450 mm RCP
- 525 mm RCP
- 600 mm RCP
- 675 mm RCP
- 750 mm RCP
- 900 mm RCP
- > 900 mm RCP
- Inlet / Junction Pit
- Headwall / Converter Outlet

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Scale: 1:2,500

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LEGEND

- 2A — Catchment Boundary and Identifier
- Sub-Catchment Boundary
- F1 → Peak Flow Location and Identifier

SHOWGROUND ROAD UPGRADE
DRAINAGE INVESTIGATION

Figure 2.1

EXISTING ROAD DRAINAGE SYSTEM
OLD NORTHERN ROAD TO ROWALLAN AVENUE

DRAINAGE ELEMENTS COMPRISING
EXISTING PIPED DRAINAGE SYSTEM

- <= 300 mm RCP
- 375 mm RCP
- 450 mm RCP
- 525 mm RCP
- 600 mm RCP
- 675 mm RCP
- 750 mm RCP
- 900 mm RCP
- > 900 mm RCP
- Inlet / Junction Pit
- Headwall / Converter Outlet

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LEGEND

- 2A — Catchment Boundary and Identifier
- Sub-Catchment Boundary
- F7 → Peak Flow Location and Identifier

SHOWGROUND ROAD UPGRADE
DRAINAGE INVESTIGATION

Figure 2.2

EXISTING ROAD DRAINAGE SYSTEM
ROWALLAN AVENUE TO CARRINGTON ROAD

3 CATCHMENT HYDROLOGY – PRESENT DAY CONDITIONS

3.1 General

To enable an assessment of the impact the road upgrade works will have on the hydrologic regime of receiving drainage lines along the length of the proposed Showground Road upgrade, an event-based peak flow analysis was undertaken using the DRAINS software.

The following sections of the report contain a brief description of the adopted catchment modelling approach, as well as a summary of key model results for present day conditions.

Model results for post-upgrade conditions, and further discussion relating to the impact of the road upgrade works on peak flow rates in the receiving drainage lines, is presented in **Section 5**.

3.2 Hydrologic Model Development

DRAINS is a simulation program which converts rainfall patterns to stormwater runoff, and then routes flows through networks of piped drainage systems, culverts, storages and open channels. The software develops hydrographs and calculates hydraulic grade lines throughout the drainage network, enabling users to analyse the magnitude of overflows and stored water for established drainage systems. DRAINS was originally developed for the purpose of analysing urbanised catchments, and is therefore well suited to this present investigation.

As previously mentioned, THSC provided a DRAINS model that was developed by SKM for the Castle Street catchment as part of the Draft Castle Hill Precinct Flood Study (2005). **Appendix A** contains a figure showing the extent and layout of the Castle Street catchment DRAINS model that was developed by SKM.

Following a review of the Castle Street catchment DRAINS model, the following adjustments were made to its structure both within and upstream of Showground Road:

- Details of several pits and pipes (e.g. size and invert levels) within the road corridor were updated based on RMS' detailed survey information. Details of overflow routes (e.g. connectivity, cross section definition, slopes and critical elevations) within the road corridor were also updated based on survey information and visual inspection.
- Sub-catchment definition both upstream and within the road corridor was refined to better represent the various locations at which runoff approaches Showground Road, and to allow widths of overland flow within the road corridor to be assessed at a higher resolution. Relevant model data for these sub-catchments, including flow path characteristics in lieu of the more simplistic time of concentration calculations incorporated in the original model, was also reviewed and adjusted as necessary.
- The model was extended to include the existing road drainage catchments 1, 2C and 2D, which lie outside the extent of the Castle Street catchment that was previously investigated by SKM, 2005. Details of the existing road drainage systems in catchments 1, 2C and 2D were based on RMS' detailed survey information and visual inspection along the road corridor. Details of the existing piped drainage system extending upstream of the road corridor within catchment 2D was sourced from GIS-based stormwater asset data provided by THSC.

The structure of the existing DRAINS model along the various receiving drainage lines extending downstream of Showground Road was briefly reviewed and generally found to be suitable for application to this present investigation.

The catchment boundary shown on **Figure 1.1** (refer solid red line) illustrates the total extent of the catchment area incorporated into the adjusted DRAINS model. **Figures 2.1** and **2.2** show the extents of the existing road drainage system and associated sub-catchments along Showground Road which were modelled in DRAINS.

Adopted DRAINS model parameters comprised initial losses of 2 and 10 mm for paved and grassed areas, respectively. An antecedent moisture condition of 3 was adopted, reflecting rather wet conditions prior to the occurrence of storm events and the soil type was set equal to 3, which corresponds with a soil of comparatively high runoff potential.

Rainfall intensities for design storms ranging between 1 and 100 year ARI, and for storm durations ranging between 25 minutes and 2 hours, were derived using procedures outlined in Australian Rainfall and Runoff (ARR) (IEAust, 1998).

3.3 Hydrologic Model Results – Present Day Conditions

Table 3.1 summarises the results of an assessment of existing widths of flow along both eastbound and westbound kerblines of Showground Road for the 10 year ARI design event.

TABLE 3.1
WIDTHS OF FLOW ALONG EXISTING ROADWAY
10 YEAR ARI

Catchment	Maximum Width of Flow (m) Along Kerbline – 10 year ARI	
	Eastbound	Westbound
1	1.4	1.7
2A	2.0	5.0
2B	1.8	4.7
2C	2.0	2.8
2D	1.9	4.0

Maximum widths of flow along the westbound carriageway are shown to encroach into the adjacent trafficable lane at various locations along the length of road to be upgraded. Along the eastbound carriageway, widths of flow for design events up to 10 year ARI are generally contained within the existing wide shoulder.

The key findings of the investigation in terms of present day drainage patterns along Showground Road were as follows:

- **Catchment 1** – The existing 600 mm diameter pipe which drains toward the south from the road corridor (refer Peak Flow Location Identifier F1 on **Figure 2.1**) has a hydrologic standard of greater than 100 year ARI.

- **Catchment 2A** – The existing local stormwater drainage system south of the road corridor has a hydrologic standard of about 2 year ARI. As a result, stormwater runoff which surcharges the kerb inlet pits in Cecil Avenue will discharge into the adjoining catchment (i.e. Catchment 2B), where it will flow onto Showground Road at the intersection of the two roads.

  Due to limitations in the pit inlet and pipe capacity within the road corridor (analyses indicate that ponding in the sag in Showground Road would occur on average once per year), the 750 mm diameter pipe which runs northward through the existing townhouse complex at No. 59A Castle Street (refer Peak Flow Location Identifiers F3 and F4 on **Figure 2.1**) does not flow full over the full range of storms up to 100 year ARI.

- **Catchment 2B –** The hydrologic standard of the piped drainage system which approaches Showground Road from the south is between 2 and 5 year ARI. The peak overland flow approaching the road corridor from the south through the adjacent residential properties is about 0.7 m^3/s for the 10 year ARI design storm event.

  The existing 900 mm diameter pipe which runs to the north of the road corridor toward Patrick Avenue (refer Peak Flow Location Identifier F7 on **Figure 2.2**) has a similar hydrologic standard, flowing full for events as frequent as 5 year ARI.

- **Catchment 2C** – Due to limitation in pit inlet capacity within the road corridor, the existing 900 mm diameter pipe which runs toward the north through the frontage of No. 106 Showground Road (refer Peak Flow Location Identifier F9 on **Figure 2.2**) does not flow full over the full range of storms up to 100 year ARI.

- **Catchment 2D** – The existing longitudinal drainage line which runs in a westerly direction beneath the southern kerbline of Showground Road has a hydrologic standard of about 5 year ARI. The analyses also indicate that water will pond across the intersection of Showground Road and Carrington Road in events as frequent as 2 year ARI.

Peak rates of flow at key locations along the length of the proposed road upgrade are summarised in **Table 3.2** over for storms with ARI's of 10 and 100 years.

TABLE 3.2
PEAK FLOWS – PRESENT DAY CONDITIONS

Catchment	Location	Location Identifier (1)	Peak Flow (m^3/s)(2)			
			Piped		Overland	
			10 year ARI	100 year ARI	10 year ARI	100 year ARI
1	Discharging to Drainage Line 1 across southern boundary of road corridor via 600 mm diameter pipe.	F1	0.52	0.72	0	0
2A	Discharging north along eastern side of Kentwell Avenue.	F2	-	-	0.06	0.09
	Discharging to Drainage Line 2A across northern boundary of road corridor.	F3	0.78	0.84	0.61	1.43
	Internal to residential townhouse complex (No. 59A Castle Street) north of Showground Road along route of existing overland flow path.	F4	0.88	0.95	0.50	1.32
	Flow in Drainage Line 2, immediately downstream of confluence with Drainage Line 2A.	F5a	4.24	4.30	7.42	13.2
	Flow in Drainage Line 2 immediately west (downstream) of Rowallan Avenue.	F5b	12.0	18.1	-	-
2B	Discharging north along eastern side of Rowallan Avenue.	F6a	-	-	0.04	0.06
	Discharging north along western side of Rowallan Avenue.	F6b	-	-	0	0
	Discharging to Drainage Line 2B across northern boundary of road corridor via 900 mm diameter pipe.	F7	1.37	1.42	1.08	2.65
2C	Discharging along Drainage Line 2B where it enters residential property on northern side of Patrick Avenue.	F8	2.06	2.09	0.57	2.42
2C	Discharging to Drainage Line 2C across northern boundary of road corridor via 900 mm diameter pipe.	F9	0.42	0.52	0	0
2D	Discharging to Drainage Line 2D across northern boundary of road corridor via 600 mm diameter pipe.	F10	0.56	0.61	0.72	1.41

(1) Refer **Figures 2.1** and **2.2** for reference to Location Identifier.

(2) Peak flows quoted to more than one decimal place for ease of comparison only between relatively small flows.

4 PROPOSED ROAD UPGRADE WORKS

As mentioned, Showground Road comprises a two lane single carriageway for most of its length between Carrington Road and Pennant Street. The proposed road upgrade involves widening to provide a four lane divided carriageway for the full length between Carrington Road and Old Northern Road, as well as associated intersection upgrades and improved facilities for pedestrians and cyclists. Key features of the road upgrade include the following:

- Dual carriageways, each with two 3.5 m wide through lanes, separated by a raised concrete median.
- Two new signalised intersections, located at Kentwell Avenue / Cheriton Avenue and at Rowallan Avenue.
- Modification of the existing signalised intersection at Pennant Street.
- Introduction of bus priority measures in the eastbound direction at signalised intersections.
- Reservation for a 3.5 m wide footway on both side of the road that would contain a 2.5 m wide shared path in the northern footway and a 1.5 m wide concrete footpath in the southern footway.
- Provision for the future widening to three lanes in each direction.

In general, both the horizontal and vertical alignments of the proposed road upgrade works will closely follow that of the existing road. The current concept road design model shows that no major cuts or fills will be required.

It is understood that the existing single carriageway and adjacent shoulder areas are formed on sections of concrete slab that will be retained as part of the road upgrade works. The widened road will be formed by laying new flexible pavement and constructing new full-depth pavement sections alongside these as required. Site works are expected to commence in 2015, with all construction to be undertaken in a single stage of work.

5 RECOMMENDED DRAINAGE STRATEGY

5.1 Concept Drainage System Layout

A strategy aimed at mitigating the adverse impacts of the road upgrade works on existing development and the drainage lines into which the upgraded pavement drainage system will discharge was developed as part of the present investigation. In developing the strategy, the impact of the road upgrade works on both nuisance and major flooding was taken into account.

Figures 5.1 and **5.2** show the concept drainage strategy along Showground Road and should be referred to when reading the following sections of the report. Note that RMS will need to undertake further design development to confirm the size of pipes and number of pits required to control runoff from the upgraded sections of road, as those shown on **Figures 5.1** and **5.2** are indicative only.

5.2 Design Considerations

5.2.1 Design Development

Assessment of drainage requirements was undertaken based on a concept road design model provided by RMS in late-October 2013. However, at the time of writing it is understood that further design development is underway to refine various aspects of the concept road design. A number of design elements that will influence drainage requirements for the road upgrade (e.g. pedestrian crossings) are also yet to be determined by RMS.

As part of the detailed design process, the designers of the road upgrade works will need to review the concept road design model which is developed by RMS in light of the recommendations contained in this report to ensure the intent of the recommended drainage strategy is maintained in the final design of the roadworks.

5.2.2 Hydrologic Standard of Upgraded Stormwater Drainage System

Stormwater runoff from the widened sections of road pavement will be controlled by new or upgraded pavement drainage systems which will discharge to THSC's existing piped stormwater drainage system.

RMS advised that the desired hydrologic standard for new and upgraded road drainage systems, including transverse crossings of the road corridor, was an ARI of 10 years under present day climatic conditions. However, a key finding of this present investigation is that due to constraints imposed by existing utilities within the road corridor, as well as existing piped drainage systems into which new road drainage systems will be connected, this hydrologic standard is not achievable along the full length of the road upgrade. At the location of the sags in the road corridor within Catchments 2A and 2B, the recommended drainage strategy will provide a minimum hydrologic standard of about 5 year ARI (refer **Sections 5.3.3** and **5.3.4** for further details).

5.2.3 Future Development Upslope of the Road Corridor

For the developed catchments which lie along the upstream (southern) side of Showground Road and contribute runoff to the various piped drainage systems along the road corridor, it was assumed that measures will be incorporated into any future redevelopment which will control the rate of flow discharging to the road corridor to no larger than under present day conditions.

5.2.4 Utilities

RMS advised that the 3D utilities model for Showground Road was compiled using information obtained through the following sources:

- RMS 3D utility survey which was undertaken using radio detection equipment;
- electronically locating transponders that were installed along the alignment of two 132 kV feeder lines that are located along the northern side of Showground Road west of Cheriton Avenue;[2]
- pot-holing information compiled by Cardno; and
- available Work-As-Executed drawings.

Appendix B contains several plans and long sections which were compiled as part of the present investigation showing details of the proposed pavement drainage system where there is the potential for it to clash with existing utilities.

Appendix C contains copies of as-built plans of the recently installed 132 kV feeder line which is located along the northern side of Showground Road west of Cheriton Avenue. Note that the new feeder line appears to have been installed at a more shallow depth than indicated on the as-built drawings. The 3D utilities model provided by RMS also shows the 132 kV lines clashing with existing stormwater pipes, the inverts and sizes of which were confirmed in the field by RMS' surveyors. Given the potential for this major utility to impact the set out of the upgraded pavement drainage system, it is recommended that during detail design its depth be confirmed by means of pot-holing.

5.2.5 Maximum Allowable Widths of Flow

RMS advised that the following maximum allowable widths of flow as measured from the face of kerb were to be used when developing the concept drainage system for the road upgrade:

- 1.0 m along main carriageway;
- 1.0 m in left turn lanes adjacent to kerbline;
- 0.5 m in right turn lanes adjacent to medians;
- 0.5 m at bus bays (whether indented or not) and at pedestrian crossings; and
- 0.3 m in median lanes (not turning lanes).

Note that the above criteria are based on the future six-lane arrangement, when the currently proposed wide shoulders will be converted to trafficable lanes (i.e. the stormwater drainage

[2] Attempts by RMS to pothole to confirm the depth of the 132 kV feeder line were unsuccessful as the trench was backfilled with stabilised sand that could not be penetrated by non-destructive means.

system which is to be constructed as part of the current road upgrade must cater for the requirements of the future upgrade in terms of maximum allowable widths of flow into the future kerbside lanes).

For local roads, RMS advised that for those that have a 5.0 m lane width, then a 2.0 m width of flow is acceptable, whilst for those that have a 4.0 m lane width, then a 1.5 m maximum allowable width of flow is acceptable.

5.2.6 Potential Blockage of the Road Drainage System

The following pit blocking factors were adopted for pit spacing purposes to account for the potential reduction in inlet capacity that may occur as a result of partial blockages due to litter and other debris:

- On-grade pits – 20% blockage
- Sag pits – 50% blockage

5.3 Impact of Road Upgrade on Drainage Patterns and Recommended Measures

5.3.1 General

The DRAINS model which was used to derive peak flows under present day conditions was adjusted to reflect the changes which will occur to the surface of the road corridor as a result of the road upgrade works. The full width of the road corridor was modelled as impervious surface, which accounts for the proposed road widening as well as the introduction of shared paths along both sides of the widened road. Links within the DRAINS model were also altered to reflect changes that will occur in drainage patterns as a result of the installation of new road drainage systems along the length of the road upgrade.

Table 5.1 at the end of this chapter shows the impact the road upgrade will have on peak flows in selected locations along the receiving drainage lines downstream of Showground Road for storms with ARI's of 10 and 100 years. Note that the locations referred to in **Table 5.1** are shown on **Figures 5.1** and **5.2**. The following sections provide a summary of the proposed adjustments to existing road drainage systems and drainage-related impacts along the length of the proposed road upgrade works.

5.3.2 Catchment 1

Proposed adjustments to the existing road drainage systems along the length of Showground Road within Catchment 1 are shown on **Figure 5.1**. These reflect relatively minor works to suit the proposed eastbound left turn and splitter island arrangement at the Pennant Street intersection, and reconstruction of the existing pavement drainage line along the westbound kerbline. These new pavement drainage lines will connect into the existing piped drainage system which conveys runoff across the road corridor from north to south near **DRC 1340**.

The DRAINS model developed as part of the present investigation indicates that peak flows discharging from the road corridor to the existing 600 mm diameter pipe opposite Pennant Street (refer Peak Flow Location Identifier F1) will not be increased for storms with ARI's up to 100 years.

However, as there will be a small increase in impervious area within the upgraded road corridor, the above finding should be confirmed during detail design to ensure that existing development downstream (south) of the road corridor is not subject to increased overland flows as a result of the road upgrade works. Additional detailed survey along the existing piped drainage system that extends south between Showground Road and Cecil Avenue would be required to confirm that this piped drainage system has sufficient capacity to convey any increase in the rate of flow discharging from the road corridor.

Figures B1 and **B2** in **Appendix B** show details of the proposed crossing of major underground utilities near the intersection of Showground Road and Pennant Street.

5.3.3 Catchment 2A

Proposed adjustments to the existing road drainage systems along the length of Showground Road within Catchment 2A are shown on **Figure 5.1**. These works essentially involve the replacement of the existing piped drainage system within the road corridor with a new pavement drainage system. Existing transverse crossings of the roadway between **DRC 840** and **DRC 860** would also be replaced with a new piped crossing at **DRC 860**, connecting into the existing 750 mm diameter piped drainage line that runs north from the road corridor through the existing townhouse complex at No. 59A Castle Street.

The new pavement drainage system would extend east of Kentwell Avenue / Cheriton Avenue intersection along both carriageways, and replace the existing minor piped drainage line crossing Cheriton Avenue. **Figures B3** and **B4** in **Appendix B** show details of the proposed crossing of major underground utilities near the intersection of Showground Road and Cheriton Avenue. Pavement drainage lines would be required in the median on the western side of this intersection due to the super-elevated westbound carriageway.

Overland flows discharging north from the road corridor along the eastern kerbline of Kentwell Avenue (refer Peak Flow Location Identifier F2) will be eliminated as a result of road upgrade works. This occurs as a result of extending the new pavement drainage system within Catchment 2A along the eastbound carriageway of Showground Road towards the crest in the road corridor to the east of Kentwell Avenue.

Peak flows discharging to the north along Drainage Line 2A from the sag in the upgraded road corridor at **DRC 840** (refer Peak Flow Location Identifier F3) will be increased over the full range of design storm events. This occurs as a result of the increase in impervious area within the upgraded road corridor, as well as the additional catchment area controlled by the new pavement drainage system within Catchment 2A (i.e. the eastbound carriageway to the east of Kentwell Avenue).

Whilst peak flows discharging to the north will be increased, improvements in hydraulic capacity associated with the upgrade of the existing stormwater drainage system in the road corridor means that more flow will be conveyed in the existing 750 mm diameter pipe when compared to present day conditions. As a result, there will be an overall reduction in the peak flow discharging to the north of the sag in the road corridor as overland flow.

Whilst the hydrologic standard of the receiving drainage system is about 10 year ARI, the relatively shallow depth of the two 132 kV feeder lines which run along the northern side of Showground Road mean that it is not practical to install sufficient waterway area in the cross drainage to prevent surcharge of the sag in Showground Road for events larger than about 5 year ARI. It was also found that in order to drain the sag on the southern side of Showground Road, the stormwater drainage system had to be routed further west, where it could cross under the 132 kV feeder lines. **Figures B5** and **B6** in **Appendix B** show details of the proposed crossings of the two 132 kV feeder lines in the vicinity of the sag in Showground Road.

Widths of flow along the westbound kerbline also exceed 1 m in a 10 year ARI event for the case where a new SA3 stormwater pit is provided in line with the north-south boundaries of each of the adjacent private properties (i.e. provision of one kerb inlet pit per property). Whilst the provision of additional pits along the kerb would assist in reducing widths of gutter flow, the final spacing of the inlet pits will depend on the set out of driveways and pedestrian crossings.

5.3.4 Catchment 2B

Works within Catchment 2B will essentially involve the replacement of the existing piped drainage system within the road corridor with a new pavement drainage system.

Preliminary assessment of the impact of upgrading Showground Road would have along Drainage Line 2B, were the full extent of the new pavement drainage system to be connected to this drainage line, showed that overland flows discharging from the road corridor north of the sag at **DRC 560** would be increased, thereby affecting a number of residential properties. Whilst upgrading or duplicating the existing 900 mm diameter piped drainage line that runs north from Showground Road at this location to cater for the increased flows from the upgraded road was considered, it was not deemed practical given the proximity of existing houses and other structures (e.g. swimming pools) in this area.

Instead, it is proposed to divert runoff from the eastern portion of Catchment 2B (refer Catchment **2B-1** on **Figures 5.1** and **5.2**) away from the sag in the road corridor at **DRC 560** via a new 600 mm diameter piped drainage line extending north beneath the western kerbline of Rowallan Avenue. The new piped drainage line would discharge into Drainage Line 2 on the downstream (western) side of Rowallan Avenue where it runs in the form of an engineered channel adjacent to the southern side of Castle Street. **Figures B7** and **B8** in **Appendix B** show details of the proposed crossing of major underground utilities near the intersection of Showground Road and Rowallan Avenue.

The remainder of Catchment 2B (refer Catchment **2B-2** on **Figure 5.2**) would be drained to a new transverse crossing of the dual carriageways at **DRC 560**, connecting into the existing 900 mm piped drainage line along Drainage Line 2B. In order to cross under the two 132 kV feeder lines which run along the northern side of Showground Road, it will be necessary to install 2 off 675 mm diameter pipes across the new widened carriageway at the location of the sag. **Figures B9** and **B10** in **Appendix B** show details of the proposed crossing of major underground utilities at the location of the sag in Showground Road.

Overland flows discharging north from the road corridor along the eastern kerbline of Rowallan Avenue (refer Peak Flow Location Identifier F6) will be eliminated as a result of road upgrade works. This occurs as a result of extending the pavement drainage system within Catchment 2B-1 along the eastbound carriageway of Showground Road towards the crest in the road corridor to the east of Rowallan Avenue.

As a result of the above measures, peak flows discharging from the upgraded road corridor along Drainage Line 2B will be reduced by the road upgrade works for storms with ARI's up to 100 years.

As the hydrologic standard of the existing 900 mm diameter pipe is only about 5 year ARI, it is not possible to prevent ponding across the upgraded section of road at the location of the sag during more intense storm events (i.e. RMS' requirement to achieve a minimum 10 year ARI hydrologic standard cannot be achieved at this location).

Widths of flow along the westbound kerbline are greater than 1 m in a 10 year ARI event, especially where gutter flows approach the sag in the road. The provision of additional pits in this area would not necessarily assist in reducing the widths of flow in this area given that the hydrologic standard of the longitudinal drainage system is less than 10 year ARI.

5.3.5 Catchment 2C

Proposed adjustments to the existing road drainage systems along the length of Showground Road within Catchment 2C are shown on **Figure 5.2**. These works involve the installation of new pavement drainage lines along the proposed eastbound and westbound kerblines. It will also be necessary to replace the existing 525 mm diameter pipe which crosses Showground Road at **DRC 180**, due to its relatively shallow depth.

Peak flows discharging toward the north from the road corridor (refer Peak Flow Location Identifier F9) will be subject to minor increases over the full range of design storm events. This occurs as a result of the small increase in impervious area within the upgraded road corridor. However, the existing 900 mm diameter pipe that runs north from the road corridor at this location through No. 106 Showground Road is shown to have sufficient capacity to convey the increased rate of flow for storms with ARI's up to 100 years.

5.3.6 Catchment 2D

Works within Catchment 2D will involve the extension of the existing pavement drainage line which is located beneath the eastbound kerbline near **DRC 150**, whilst maintaining the existing pavement drainage line which is located beneath the westbound kerbline.

Whilst the DRAINS model developed as part of the present investigation shows a minor increase in peak flows discharging overland to residential development north of the road corridor (refer Peak Flow Location Identifier F10) as a result of the road upgrade for events larger than about 10 year ARI, given the limited nature of the works in this catchment is likely that during detail design this impact will be removed.

TABLE 5.1
IMPACT OF ROAD UPGRADE ON PEAK FLOWS[1]

Catchment	Location	Location Identifier [2]	Pre-Upgrade Conditions				Post-Upgrade Conditions				Difference[3]			
			Piped		Overland		Piped		Overland		Piped		Overland	
			10 year ARI	100 year ARI	10 year ARI	100 year ARI	10 year ARI	100 year ARI	10 year ARI	100 year ARI	10 year ARI	100 year ARI	10 year ARI	100 year ARI
1	Discharging to Drainage Line 1 across southern boundary of road corridor via 600 mm diameter pipe.	F1	0.52	0.72	0	0	0.52	0.68	0	0	0	-0.04	0	0
2A	Discharging north along eastern side of Kentwell Avenue.	F2	-	-	0.06	0.09	-	-	0	0	-	-	-0.06	-0.09
	Discharging to Drainage Line 2A across northern boundary of road corridor.	F3	0.78	0.84	0.61	1.43	1.37	1.54	0.03	0.96	0.59	0.70	-0.58	-0.47
	Internal to residential townhouse complex (No. 59A Castle Street) north of Showground Road along route of existing overland flow path.	F4	0.88	0.95	0.50	1.32	1.37	1.55	0	0.87	0.49	0.60	-0.50	-0.45
	Flow in Drainage Line 2, immediately downstream of confluence with Drainage Line 2A.	F5a	4.24	4.30	7.42	13.2	5.95	6.22	6.04	11.5	1.71	1.92	-1.38	-1.7
	Flow in Drainage Line 2 immediately west (downstream) of Rowallan Avenue.	F5b	12.0	18.1	-	-	12.8	19.1	-	-	0.8	1.0	-	-
2B	Discharging north along eastern side of Rowallan Avenue.	F6a	-	-	0.04	0.06	-	-	0	0	-	-	-0.04	-0.06
	Discharging north along western side of Rowallan Avenue.	F6b	-	-	0	0	0.54	0.81	0	0	-	-	0	0
	Discharging to Drainage Line 2B across northern boundary of road corridor via 900 mm diameter pipe.	F7	1.37	1.42	1.08	2.65	1.85	2.08	0	1.19	0.48	0.66	-1.08	-1.46
	Discharging along Drainage Line 2B where it enters residential property on northern side of Patrick Avenue.	F8	2.06	2.09	0.57	2.42	2.32	2.43	0.09	1.20	0.26	0.34	-0.48	-1.22
2C	Discharging to Drainage Line 2C across northern boundary of road corridor via 900 mm diameter pipe.	F9	0.42	0.52	0	0	0.43	0.62	0	0	0.01	0.10	0	0
2D	Discharging to Drainage Line 2D across northern boundary of road corridor via 600 mm diameter pipe.	F10	0.56	0.61	0.72	1.41	0.52	0.55	0.72	1.45	-0.04	-0.06	0	0.04

(1) Peak flows have been quoted to more than one decimal place for comparative purposes only.

(2) Refer **Figures 5.1** and **5.2** (and **Figures 2.1** and **2.2**) for reference to Location Identifier.

(3) Note that a positive value represents an increase in peak flow when compared to present day conditions. Orange shading indicates an increase in peak flow as a result of the road upgrade, whilst green shading indicates a reduction (or no change) in peak flow.

N

25 0 25 50 75 m

Scale: 1:2,500

Lyall & Associates

LEGEND

2A — Catchment Boundary and Identifier

F1 → — Peak Flow Location and Identifier

Existing Piped Drainage System to be Retained

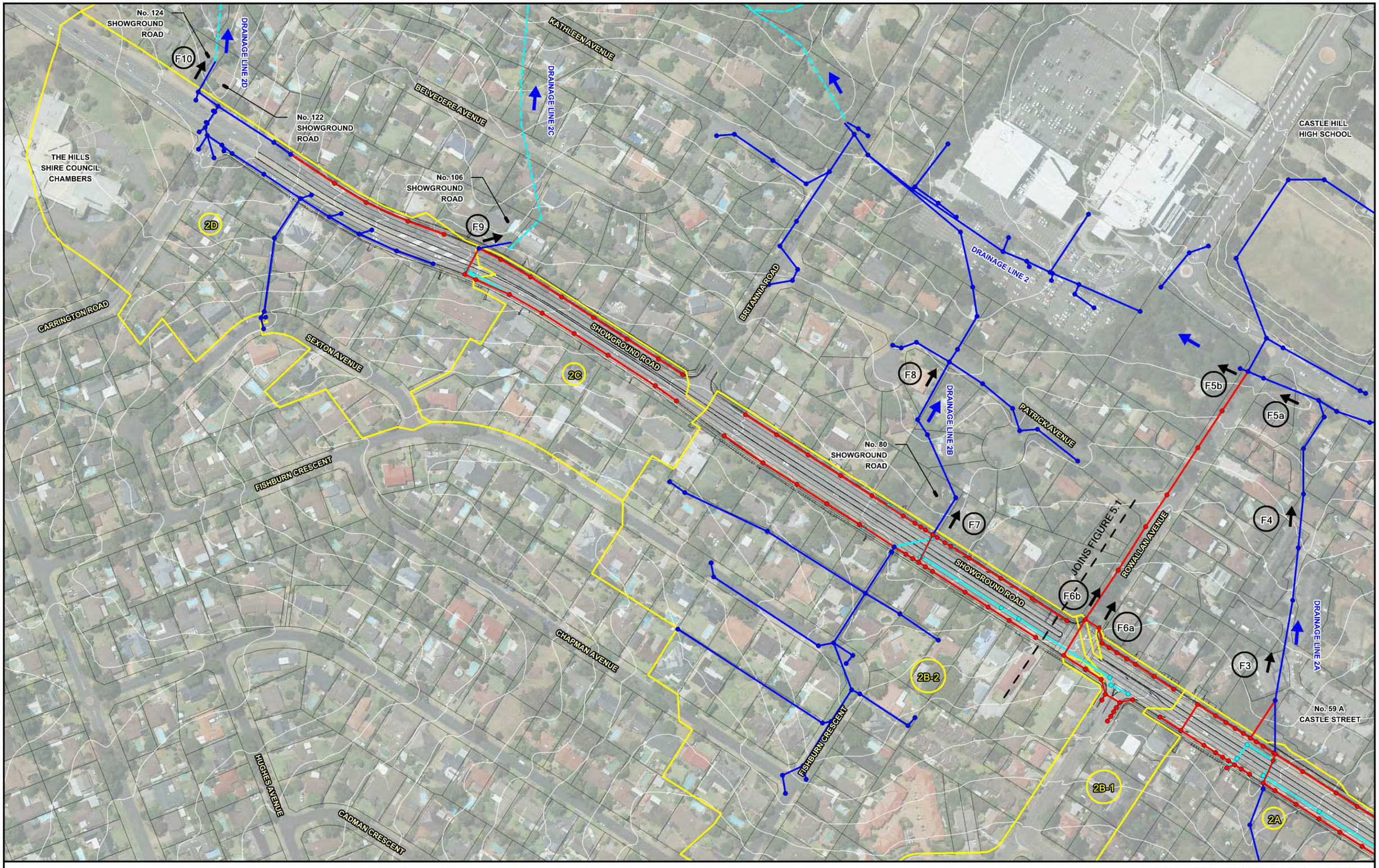
Existing Piped Drainage System to be Demolished and Removed or Alternatively Abandoned

New Piped Drainage System

SHOWGROUND ROAD UPGRADE
DRAINAGE INVESTIGATION

Figure 5.1

CONCEPT DRAINAGE STRATEGY
OLD NORTHERN ROAD TO ROWALLAN AVENUE



N

25 0 25 50 75 m

Scale: 1:2,500

Lyall & Associates

LEGEND

2C — Catchment Boundary and Identifier

F7 → — Peak Flow Location and Identifier

Existing Piped Drainage System to be Retained

Existing Piped Drainage System to be Demolished and Removed or Alternatively Abandoned

New Piped Drainage System

SHOWGROUND ROAD UPGRADE DRAINAGE INVESTIGATION

Figure 5.2

CONCEPT DRAINAGE STRATEGY
ROWALLAN AVENUE TO CARRINGTON ROAD

6 EROSION AND SEDIMENT CONTROL STRATEGY

6.1 General

A strategy aimed at mitigating the adverse impacts of the construction phase of the road upgrade on water quality in receiving drainage lines and watercourses was developed as part of this present investigation.

It is recommended that the strategy presented in this section of the report be used as a starting point for preparation of the Soil and Water Management Plan (SWMP) that will need to be developed as part of final design and/or construction documentation for the road upgrade works. However, it should be recognised that ultimate requirements for controlling erosion and sediment during construction will be dictated by final design of the road upgrade works, proposed construction methods, staging and site management practices, all of which are yet to be finalised.

The strategy has been developed based on the principles and design guidelines set out in the following documents:

- *Soils and Construction – Managing Urban Stormwater* series (herein referred to as the *"Blue Book"*), comprising:
  - Volume 1 (Landcom, 2004)
  - Volume 2D – Main Roads (DECC, 2008).
- *RMS Erosion and Sedimentation Management Procedure* (RMS, 2008).
- *RMS QA Specification G38* (RMS, 2011).

6.2 Key Elements of the Strategy

The primary principles for effective erosion and sediment control are firstly to minimise erosion, and then to capture sediment from disturbed areas where erosion cannot be prevented.

Whilst this present investigation deals primarily with the control of sediment, and the structural measures that will be required to capture "dirty" water (i.e. runoff generated on-site) and bypass "clean" water (i.e. runoff generated off-site) through the construction corridor, a range of erosion control principles will need to be incorporated into the future SWMP including:

- appropriate location and treatment of site access and stockpile sites;
- conservation of existing topsoil for later site rehabilitation;
- minimisation of disturbed areas, and stabilisation using batter blanketing, surface mulching or vegetation;
- scour protection along any temporary drainage lines through the site;
- separation of clean and dirty water wherever possible, and the diversion of clean water from upslope areas through the construction corridor;
- site maintenance requirements; and
- progressive site rehabilitation.

6.3 Local Erosion and Sediment Control Measures

The *Blue Book* allows for localised erosion and sediment control measures to be used in the absence of large scale sediment retention basins where the average annual soil loss from a disturbed area, as derived by application of the Revised Universal Soil Loss Equation (RUSLE) [3], is less than 150 m^3.

Figures 6.1 and **6.2** show the extent of land which will be disturbed during the construction phase of the project (excluding areas of existing pavement) and identifies the receiving drainage lines to which runoff from these areas will discharge. Given the relatively confined nature of the construction works (i.e. narrow sections of new pavement combined with resurfacing of existing pavement), by inspection the estimated average annual soil loss from disturbed areas will not exceed the threshold value of 150 m^3. The implementation of effective localised erosion and sediment control measures aimed at minimising the volume of sediment which is transported from disturbed areas will therefore be key to the control of sediment from the road corridor in the absence of any large scale sediment retention basins. Measures would include use of the following practices and smaller scale elements:

- staging of works to minimise the extent of disturbance at any one time;
- temporary stabilisation or revegetation/rehabilitation works to reduce the extent of disturbed surfaces;
- application of temporary surface treatments or blanketing on exposed earth surfaces;
- sediment barriers and sumps, in series where necessary;
- vegetative buffer strips; and
- stabilised drainage lines incorporating rock check dams at regular intervals.

Measures such as temporary diversion channels and bunding will also need to be implemented during the construction phase of the project to prevent concentrated flow, which presently discharges onto the road corridor from the south, from causing scour of disturbed surfaces. The difficulty which will be faced by the contractor is that in several locations concentrated flow discharges onto the road corridor via ill-defined drainage paths (e.g. down driveways and along boundary fences). In order to minimise scour potential during the construction phase of the project, it will be necessary to carefully plan, implement and maintain measures which are aimed at intercepting this concentrated flow and diverting it toward the piped stormwater drainage system.

[3] For further details of the RUSLE, refer Appendix A of Landcom, 2004.

TOTAL DISTURBED AREA - 50 m²

JOINS FIGURE 6.2

SHOWGROUND ROAD

ROWALLAN AVENUE

TOTAL DISTURBED AREA - 790 m²

DRAINAGE LINE 2A

2A

DRAINAGE LINE 2

CASTLE STREET

No. 59 A CASTLE STREET

WORTHING AVENUE

FISHBURN CRESCENT

2B

TOTAL DISTURBED AREA - 440 m²

TOTAL DISTURBED AREA - 2920 m²

SHOWGROUND ROAD

TOTAL DISTURBED AREA - 160 m²

KENTWELL AVENUE

TOTAL DISTURBED AREA - 1610 m²

CASTLE HILL LIBRARY

WARWICK PARADE

CECIL AVENUE

2A

TOTAL DISTURBED AREA - 2900 m²

VERETTA AVENUE

SHOWGROUND ROAD

TOTAL DISTURBED AREA - 1350 m²

PENNANT STREET

CHERTON AVENUE

TOTAL DISTURBED AREA - 990 m²

1

CASTLE HILL BAPTIST CHURCH

TOTAL DISTURBED AREA - 400 m²

WHITLING AVENUE

CECIL AVENUE

1

McDONALD'S RESTAURANT

DRAINAGE LINE 1

LOCATION OF UNDERGROUND PIPE UNKNOWN

SHERWIN AVENUE

OLD NORTHERN ROAD

DISTURBED AREAS

- Catchment 1
- Catchment 2A
- Catchment 2B
- Catchment Contributing to Gutter Flow in Local Roads

N

25 0 25 50 75 m

Scale: 1:2,500

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LEGEND

- Existing Piped Drainage System
- 2A — Sub-Catchment Boundary and Identifier
- 2A → Catchment Discharge Point and Identifier

Note: Areas Contributing to Gutter Flow in Local Roads Not Assigned an Identifier.

SHOWGROUND ROAD UPGRADE DRAINAGE INVESTIGATION

Figure 6.1

EXTENT OF DISTURBED AREAS
OLD NORTHERN ROAD TO ROWALLAN AVENUE

No. 124 SHOWGROUND ROAD
DRAINAGE LINE 2D
KATHLEEN AVENUE
DRAINAGE LINE 2C
BELVEDERE AVENUE
No. 122 SHOWGROUND ROAD
TOTAL DISTURBED AREA - 610 m²
THE HILLS SHIRE COUNCIL CHAMBERS
TOTAL DISTURBED AREA - 640 m²
No. 106 SHOWGROUND ROAD
CASTLE HILL HIGH SCHOOL
TOTAL DISTURBED AREA - 540 m²
DRAINAGE LINE 2
BRITANNIA ROAD
CARRINGTON ROAD
SEXTON AVENUE
SHOWGROUND ROAD
TOTAL DISTURBED AREA - 620 m²
TOTAL DISTURBED AREA - 20 m²
TOTAL DISTURBED AREA - 40 m²
TOTAL DISTURBED AREA - 1170 m²
PATRICK AVENUE
DRAINAGE LINE 2B
No. 80 SHOWGROUND ROAD
FISHBURN CRESCENT
JOINS FIGURE 6.1
ROWALLAN AVENUE
TOTAL DISTURBED AREA - 50 m²
TOTAL DISTURBED AREA - 2700 m²
SHOWGROUND ROAD
TOTAL DISTURBED AREA - 790 m²
DRAINAGE LINE 2A
CHAPMAN AVENUE
No. 59 A CASTLE STREET
FISHBURN CRESCENT
HUGHES AVENUE
CADMAN CRESCENT

DISTURBED AREAS
- Catchment 2A
- Catchment 2B
- Catchment 2C
- Catchment 2D
- Catchment Contributing to Gutter Flow in Local Roads

N
25 0 25 50 75 m
Scale: 1:2,500

Lyall & Associates

LEGEND
- Existing Piped Drainage System
- Sub-Catchment Boundary and Identifier
- Catchment Discharge Point and Identifier
  Note: Areas Contributing to Gutter Flow in Local Roads Not Assigned an Identifier.

SHOWGROUND ROAD UPGRADE DRAINAGE INVESTIGATION

Figure 6.2

EXTENT OF DISTURBED AREAS
ROWALLAN AVENUE TO CARRINGTON ROAD

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