Transport
Roads & Maritime
Services

APPENDIX J

Campbelltown Road MR177

Flooding and drainage investigation (part 1)

RMS 2013

FLOODING AND DRAINAGE INVESTIGATION

CAMPBELLTOWN ROAD UPGRADE – CAMDEN VALLEY WAY TO BROOKS ROAD

VOLUME 1 – MAIN REPORT

March 2013

FINAL REPORT

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ABBREVIATIONS

AHD	Australian Height Datum
ALS	Airborne Laser Scanning (type of aerial survey)
ARI	Average Recurrence Interval (years)
ARR	Australian Rainfall and Runoff, 1998 Edition
CCC	Campbelltown City Council
DP	Deposited Plan
DRC	Design Road Chainage
GPT	Gross Pollutant Trap
LCC	Liverpool City Council
LESCA	Local Erosion and Sediment Control Area
PRM	Probabilistic Rational Method
RCBC	Reinforced Concrete Box Culvert
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
SWRL	South West Rail Link

S1 SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

An investigation was carried out by Lyall & Associates Consulting Water Engineers on behalf of Roads and Maritime Services (RMS) to assess requirements for the control of stormwater runoff along the 5.4 km length of Campbelltown Road between Camden Valley Way and Brooks Road. This report deals with issues relating to both the construction and operational phases of the road upgrade project.

Table S1 over summarises requirements for upgrading existing cross drainage structures along the length of the proposed road upgrade, whilst **Table S2** over presents the findings and recommendations of the investigation carried out into a preferred pavement drainage strategy for the road upgrade works.

Figures 6.1, **6.2** (**A** and **B**), **6.13**, **6.14** and **6.15** (bound in **Volume 2** of the report) show the layout of the cross and pavement drainage lines comprising the recommended drainage strategy for the Campbelltown Road upgrade and should be referred to when reading **Tables S1** and **S2**.

The key findings of the investigation as they relate to **present day conditions** were as follows:

- The hydrologic standard of existing cross drainage located along the length of the road corridor varies substantially, with surcharging of the existing road expected to occur for average recurrence intervals (ARI's) ranging between about 2 and 100 years.
- Insufficient information was available at the time of writing to determine the hydrologic standard of existing cross drainage located along the section of Campbelltown Road which runs from Glenfield Road to Beech Road. It will be necessary for RMS to undertake detailed survey of drainage infrastructure located along this section of Campbelltown Road prior to commencing detail design of the road upgrade.

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

<u>Cross Drainage</u>

- The measures recommended in **Table S1** would improve the level of flood immunity afforded to the new section of road <u>west</u> of Beech Road to a minimum 100 year ARI standard. They would also minimise the adverse flood-related impacts of the road upgrade works on existing development and the existing drainage lines into which the new pavement drainage system will discharge.
- It will be necessary for RMS to undertake further hydraulic analyses during detail design to confirm that the capacity of existing cross drainage structures <u>east</u> of Beech Road, should they be retained and extended as part of the road upgrade, will provide Campbelltown Road with a level of flood immunity of at least 100 year ARI.
- At the location where Campbelltown Road crosses the main arm of Maxwells Creek, it is recommended that the existing three cell box culvert be replaced by a new bridge with a 20 m long clear span centred over the existing road culverts.
- Due to the widening of Campbelltown Road, it will be necessary to re-align a short reach of Maxwells Creek north (downstream) of the road corridor. The present investigation showed that the creek works will not increase scour potential in the receiving reach of Maxwells Creek, beyond the limit of works. However, it is recommended that scour protection measures in the form of dumped rock riprap be incorporated in the design of the bridge and creek re-alignment works where turbulence in the flow could cause scour (refer **Figure 6.2B** for extent of creek re-alignment and scour protection works).

- Whilst Campbelltown City Council were consulted as part of this present investigation, it is recommended that the designers of the road upgrade liaise further with Council to confirm that future development upstream of Campbelltown Road will not be permitted to increase peak flows arriving at the road corridor boundary.

Pavement Drainage

- RMS' desired 20 year ARI hydrologic standard for the new pavement drainage system is achievable along the new section of road west of Beech Road.
- Preliminary investigations also indicate that the same hydrologic standard can be achieved east of Beech Road, although more detailed investigations will need to be undertaken during detail design with the benefit of additional survey.

Residual Property Impacts

- The measures recommended in **Table S1** and **S2** would minimise the adverse flood-related impacts of the road upgrade works on existing development and the existing drainage lines into which the new cross and pavement drainage systems will discharge.
- Residual impacts relate primarily to the creation of drainage easements within a number of properties adjoining the widened road corridor, with peak flow rates in receiving drainage lines located adjacent to existing development generally subject to only minor increases as a result of the proposed road upgrade works.
- A summary of residual drainage-related property impacts should the recommended drainage strategy be implemented by RMS are contained in **Table 9.1**.

The key findings and recommendations 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 8.1** to **8.5** show the locations where a series of smaller temporary sediment sumps could be built to control runoff from disturbed areas during construction. The location of the sumps was determined based on a review of the available contour data and an assessment of the likely location where runoff from the road corridor will discharge to receiving drainage lines during the construction phase of the project.

TABLE S1
SUMMARY OF CROSS DRAINAGE REQUIREMENTS
CAMPBELLTOWN ROAD UPGRADE

Location	Sequential Cross Drainage Counter	Design Road Chainage	Existing Pipe/Culvert Dimensions (mm)	Peak Flow Estimate (1): 100 year ARI Present Day (m^3/s)	Peak Flow Estimate (1): 100 year ARI + Climate Change (m^3/s)	Upgrade Requirements	U/S Invert Level (m AHD)	D/S Invert Level (m AHD)	Length (m)	Slope (%)	Minimum Road Level: C/W Adjacent to Inlet (m AHD)	Minimum Road Level: Central Median (m AHD)	Minimum Road Level: C/W Adjacent to Outlet (m AHD)	Approximate Minimum Cover over New Cross Drainage: C/W Adjacent to Inlet (m)	Approximate Minimum Cover over New Cross Drainage: Central Median (m)	Approximate Minimum Cover over New Cross Drainage: C/W Adjacent to Outlet (m)	Critical Level for Overtopping New Road (m AHD)	Freeboard to Road Level: 100 year ARI Present Day (m)	Freeboard to Road Level: 100 year ARI Climate Change (m)	Comments
70 m south of Glenfield Road	X1	380	unknown	3.9	4.3	Unable to be Determined														• Detailed survey required along the existing cross drainage structure to support hydraulic analyses required to determine the current hydrologic standard of Campbelltown Road. • Further assessment required during detail design to establish upgrade requirements. Analyses to extend downstream of Campbelltown Road along the existing trunk drainage line that runs along Parkers Farm Place to Maxwells Creek. • Designers to liaise with CCC to confirm that future development upstream of the road corridor will not be permitted to increase peak flows arriving at Campbelltown Road.
Immediately south of Parkers Farm Place	X2	560	1 off 1350 RCP	3.3	3.6	Extend existing 1 off 1350 RCP														• Detailed survey required along the existing cross drainage structures to support hydraulic analyses necessary to confirm 100 year ARI hydrologic standard of Campbelltown Road. • Existing 1500 RCP along northern kerbline of road to be reconstructed over approximately 90 m where it connects existing cross drainage structures to the trunk drainage line along Parkers Farm Place. • Hydraulic analyses required during detail design to confirm upgrade requirements. Analyses to extend downstream of Campbelltown Road along the existing trunk drainage line that runs along Parkers Farm Place to Maxwells Creek. Analyses to also extend upstream of Campbelltown Road to assess the performance of existing piped drainage systems and stormwater detention basin within Panorama Estate, and ensure that the road upgrade does not increase peak flood levels along the upstream side of the road corridor.
80 m south of Parkers Farm Place	X3	630	2 off 750 RCP's	5.6	6.2	Extend existing 2 off 750 RCP's														
150 m south of Beech Road	X4	1200	4 off 600 RCP's	6.3	6.9	3 off 1200 RCP's	41.0	40.6	42	1.0	43.4	n/a	43.8	1.1	n/a	1.8	43.0	0.3	0.2	• Critical level of 43.0 m AHD represents edge of trafficable lane along southern (upstream) side of existing ramp to Hume Highway (levels assumed unchanged along this ramp). • Debris control structure to be installed at inlet of upgraded cross drainage structure to reduce risk of blockage. • Connect upgraded cross drainage to existing piped drainage system on northern (downstream) side of road corridor at new junction pit. • Survey required to confirm details of existing piped drainage system between proposed connection point immediately north of road corridor and Maxwells Creek.

(1) Peak flows used for sizing upgraded cross drainage structures are based on the present day level of development in the upstream catchment, unless otherwise noted under "Comments" column.

TABLE S1 (CONT'D)
SUMMARY OF CROSS DRAINAGE REQUIREMENTS
CAMPBELLTOWN ROAD UPGRADE

Location	Sequential Cross Drainage Counter	Design Road Chainage	Existing Pipe/Culvert Dimensions (mm)	Peak Flow Estimate (1)		Upgrade Requirements	U/S Invert Level	D/S Invert Level	Length	Slope	Minimum Road Level			Approximate Minimum Cover over New Cross Drainage			Critical Level for Overtopping New Road	Freeboard to Road Level		Comments
				100 year ARI Present Day	100 year ARI + Climate Change						C/W Adjacent to Inlet	Central Median	C/W Adjacent to Outlet	C/W Adjacent to Inlet	Central Median	C/W Adjacent to Outlet		100 year ARI Present Day	100 year ARI Climate Change	
				(m^3/s)	(m^3/s)		(m AHD)	(m AHD)	(m)	(%)	(m AHD)	(m AHD)	(m AHD)	(m)	(m)	(m)	(m AHD)	(m)	(m)	
Southbound ramp to Hume Highway	X5	1270	1 off 375 RCP	0.20	0.22	1 off 450 RCP	41.6	41.4	28.0	0.5	43.2	n/a	43.0	1.2	n/a	1.0	43.3	1.2	1.1	• Critical level of 43.3 m AHD represents surface level at new grated inlet pit on northern side of ramp. • New inlet pit to be sized to prevent bypass flows across the pavement and incorporating a blockage factor of at least 20% (assuming on-grade pit). • Discharge upgraded cross drainage to new drainage channel extending east along southern side of Campbelltown Road to inlet of Cross Drainage Structure X4 at DRC 1200. Channel will extend outside existing road corridor into Lot 1 in DP 270152.
Immediately west of Hume Highway	X6	1640	1 off 1050 RCP	3.9	4.3	Extend existing 1 off 1050 RCP														• Concept design not sufficiently advanced to determine length of pipe required to accommodate road widening. • Detail design to assess the impact of the extension on hydraulic capacity of the structure.
Immediately west of Ingleburn Gardens Drive	X7	2110	1 off 2400 x 600 RCBC	1.4	1.5	Extend existing 1 off 2400 x 600 RCBC	42.06	41.8	50	0.5	44.3	n/a	44.0	1.5	n/a	1.3	43.8	0.4	0.2	• Critical level of 43.8 m AHD represents top of embankment around existing water quality ponds fronting the road corridor. • Alternatively, extend existing cross drainage using 2 off 1050 RCP's. Minimum cover of 1.0 m is still achievable for this configuration based on advice from RMS with regard to feasible design road levels. • New junction pit required in median of upgraded road to connect existing and new cross drainage structures. • Potential blockage at existing inlet within water quality pond has not been considered by this present investigation. • Discharge to existing drainage line that runs north from road corridor to main arm of Maxwells Creek.
Maxwells Creek	X8	2300	3 off 2700 x 1200 RCBC's	34.3	37.7	New 20 m long bridge											43.8	0.3	0.2	• Critical level of 43.8 m AHD represents top of embankment around existing water quality ponds fronting the road corridor in Ingleburn Gardens Estate. • Adopted waterway opening comprises 12 m base width and 1V:1.5H spill-through abutments. • Approx. 0.6 m clearance available between peak 100 year ARI water level on upstream side of road corridor and bridge soffit level, assuming 1 m deck thickness. ➢ Creek realignment works required over approximately 85 m along Maxwells Creek where it runs immediately downstream (north) of the road corridor.

(1) Peak flows used for sizing upgraded cross drainage structures are based on the present day level of development in the upstream catchment, unless otherwise noted under "Comments" column.

TABLE S1 (CONT'D)
SUMMARY OF CROSS DRAINAGE REQUIREMENTS
CAMPBELLTOWN ROAD UPGRADE

Location	Sequential Cross Drainage Counter	Design Road Chainage	Existing Pipe/Culvert Dimensions (mm)	Peak Flow Estimate (1): 100 year ARI Present Day (m^3/s)	Peak Flow Estimate (1): 100 year ARI + Climate Change (m^3/s)	Upgrade Requirements	U/S Invert Level (m AHD)	D/S Invert Level (m AHD)	Length (m)	Slope (%)	Minimum Road Level: C/W Adjacent to Inlet (m AHD)	Minimum Road Level: Central Median (m AHD)	Minimum Road Level: C/W Adjacent to Outlet (m AHD)	Approximate Minimum Cover over New Cross Drainage: C/W Adjacent to Inlet (m)	Approximate Minimum Cover over New Cross Drainage: Central Median (m)	Approximate Minimum Cover over New Cross Drainage: C/W Adjacent to Outlet (m)	Critical Level for Overtopping New Road (m AHD)	Freeboard to Road Level: 100 year ARI Present Day (m)	Freeboard to Road Level: 100 year ARI Climate Change (m)	Comments
270 m east of Zouch Road	X9	3900	1 off 375 RCP	0.73	0.80	2 off 600 RCP's	75.3	74.7	47.0	1.3	77.3	n/a	76.5	1.4	n/a	1.0	77.4	1.1	1.0	• Critical level of 77.4 m AHD represents approximate minimum level along back of footpath on northern (upstream) side of upgraded road. • Upgraded cross drainage sized to cater for future uncontrolled development in upstream catchment. • Upgraded cross drainage structure will cater for 50% blockage. • Construct drop inlet for new cross drainage on northern side of upgraded road. • Construct drainage channel at outlet extending south to new subdivision drainage system. Depth at cross drainage outlet is approximately 1.6 m to achieve minimum cover of 1.0 m with current design road levels. RMS to liaise with Landcom regarding design and location of channel works.
Immediately east of Blomfield Road	X10	4720	1 off 600 RCP	No Cross Drainage Required																• Design road levels are below natural surface levels along upslope (eastern) side of road corridor. • Runoff from upslope catchment to be controlled along eastern side of road corridor with catch drain located along top of cut batter. • Introduce upslope runoff into new pavement drainage at location of existing driveways.
150 m east of Denham Court Road	X11	4940	1 off 525 RCP	No Cross Drainage Required																• Design road levels are below natural surface levels along upslope (eastern) side of road corridor. • Runoff from upslope catchment to be controlled along eastern side of road corridor with catch drain located along top of cut batter. • Introduce upslope runoff into new pavement drainage at location of existing driveways.

(1) Peak flows used for sizing upgraded cross drainage structures are based on the present day level of development in the upstream catchment, unless otherwise noted under "Comments" column.

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TABLE S2
RECOMMENDED PAVEMENT DRAINAGE STRATEGY

Section	Key Findings and Recommendations
Camden Valley Way to Hume Highway	➢ **Figure 6.1** summarises the pavement drainage strategy where Campbelltown Road runs between Camden Valley Way at **DRC 0** and the Hume Highway at **DRC 1600**. It is recommended that the pavement drainage system be discharged at two locations along this length of Campbelltown Road, on the northern side of the road corridor (refer locations marked **P1** and **P2** on **Figure 6.1**). ➢ It is recommended that runoff from two small catchments located to the south of Camden Valley Way on either side of Campbelltown Road is incorporated into the upgraded pavement drainage system. ➢ <u>Outlet at **DRC 550** (refer location **P1** on **Figure 6.1**)</u> The first outlet of the upgraded pavement drainage system would discharge to the existing trunk drainage line that runs north-west from the road corridor along the northern side of Parkers Farm Place at **DRC 550**. The hydrologic standard of the existing trunk drainage line will be slightly reduced as a result of the road upgrade works, because minor widening of Campbelltown Road will increase peak flows discharging from the road corridor. For the 100 year ARI event, the increase in peak flow is around 2% (refer location **P1.1** on **Figure 6.1**). For smaller events, the increase in peak flows is larger, up to a maximum of 5% for the 2 year ARI. However, the existing trunk drainage line has sufficient capacity to convey flows generated by storm events slightly larger than 20 year ARI. [For larger events, surcharge into the surrounding street network will occur with overland flows conveyed along Parkers Farm Place to Maxwells Creek.] On this basis, the provision of an upgraded pavement drainage system within the road corridor to cater for events up to 20 year ARI would be achievable. More detailed analyses will be required during detailed design to confirm that hydraulic conditions within the trunk drainage line will not cause a backwater that leads to surcharge within the road corridor for events up to 20 year ARI. Runoff from the upgraded pavement drainage system will discharge to Maxwells Creek via an existing gross pollutant trap (GPT) located at the western end of Parkers Farm Place. Lack of available space within the road corridor near the intersection of Campbelltown Road and Parkers Farm Place provides limited opportunity to incorporate additional water quality controls or spill containment measures along this length of upgraded road. The nature of the existing road drainage system in this area, which combines runoff from upslope catchments with runoff generated within the road corridor, also limits opportunities to implement measures to target runoff generated by road pavement in isolation. ➢ <u>Outlet at **DRC 1200** (refer location **P2** on **Figure 6.1**)</u> The second outlet would discharge to the existing trunk drainage line that runs north-west from the road corridor through **Lot 200** in **DP 1090110** at **DRC 1200**. The hydrologic standard of the existing trunk drainage line will be slightly reduced as a result of the road upgrade works, because minor widening of Campbelltown Road will increase peak flows discharging from the road corridor. For the 100 year ARI event, the increase in peak flow is around 1% (refer location **P2.1** on **Figure 6.1**). For smaller events, the increase in peak flows is larger, up to a maximum of 14% for the 2 year ARI. However, the existing trunk drainage line has sufficient capacity to convey flows generated by storm events up to and including 100 year ARI. On this basis, the provision of an upgraded pavement drainage system within the road corridor to cater for events up to 20 year ARI would be achievable. It is recommended that more detailed analyses are undertaken during detailed design to confirm that hydraulic conditions within the trunk drainage line will not cause a backwater that leads to surcharge within the road corridor for events up to 20 year ARI. Runoff from the upgraded pavement drainage system will discharge to Maxwells Creek via an existing GPT located on the northern side of Creekside Place. Lack of available space within the road corridor at this location will require in-line control measures to be incorporated into the adjacent sections of new pavement drainage should RMS wish to cater for potential spills along this length of Campbelltown Road. Alternatively, it may be possible to locate these measures in land immediately north of the road corridor (i.e. in **Lot 200** in **DP 1090110**), however this would require acquisition of additional land on which to locate these measures and construct a suitable vehicular access track for maintenance purposes.

Note that at each outlet of the pavement drainage system (and also cross drainage) it will be necessary to incorporate appropriate energy dissipation and scour protection measures.

TABLE S2 (CONT'D)
RECOMMENDED PAVEMENT DRAINAGE STRATEGY

Section	Key Findings and Recommendations
Hume Highway to South West Rail Link Overpass	➢ **Figure 6.2A** summarises the pavement drainage strategy where Campbelltown Road runs between the Hume Highway at **DRC 1600** and the SWRL overpass at **DRC 2500**. It is recommended that the pavement drainage system be discharged into two receiving drainage lines along this length of Campbelltown Road, on the northern side of the road corridor (refer locations marked **P3**, **P4** and **P5** on **Figure 6.2A)**. Note that all works proposed along the northern side of Campbelltown Road between the Hume Highway and the SWRL overpass would be located outside the existing road corridor in land that has been set aside as a Regional Park within the framework of the Edmondson Park Precinct. ➢ Outlets at **DRC 2040** (refer locations **P3** and **P4** on **Figure 6.2A**) The first and second outlets would discharge directly to the existing drainage line that runs to the north of the road corridor opposite Ingleburn Gardens Drive near **DRC 2040**. These outlets would drain the length of road corridor between the proposed crest over the Hume Highway at **DRC 1600** and the next outlet to the west at **DRC 2300** (refer below). The upgraded cross drainage structure at **DRC 2110** would also discharge into the existing drainage line at this location. Peak flows along the existing drainage line immediately downstream of the combined outlets will be increased over the full range of storm events by between 32% and 48% (refer location **P4.1** on **Figure 6.2A**). It will be necessary to incorporate appropriate energy dissipation and scour protection measures at the location of the new piped outlets. An area measuring approximately 5 m by 5 m would be required at the toe of the widened road embankment in order to construct these measures. It is recommended that RMS obtain an easement over this area to enable future maintenance works at the outlets (e.g. removal of built-up sediment and debris) to be undertaken as required. Note that it will be necessary to shift the sag in the road profile approximately 110 m west from its present location to around **DRC 2040** in order to outlet the pavement drainage system at this location whilst achieving a minimum cover of 1.0 m to finished road levels. It is understood that preliminary investigation by RMS shows this change in road profile to be feasible. Peak flows in Maxwells Creek downstream of the existing drainage line will not be increased significantly as a result of the road upgrade works due to the large size of the upstream catchment at this location, with a maximum increase of 1% for all events between 2 and 100 year ARI (refer location **P4.2** on **Figure 6.2A**). ➢ Outlet at **DRC 2300** (refer location **P5** on **Figure 6.2A**) The third outlet would discharge to the northern (downstream) side of the new bridge over Maxwells Creek at **DRC 2300**. This outlet would drain the length of road corridor between **DRC 2300** and the next outlet to the west at **DRC 3100** (see next section below). It is recommended that the pavement drainage system outlet is located on the western side of the new bridge. Peak flows in Maxwells Creek downstream of the new pavement drainage outlet will not be increased significantly as a result of the road upgrade works due to the large size of the upstream catchment at this location. For example, peak flows immediately downstream of Campbelltown Road will be increased by around 2% for the 2 year ARI event, with impacts less than 1% for events between 5 and 100 year ARI (refer location **P5.1** on **Figure 6.2A**). Note that further improvement in the quality of stormwater runoff discharging to Maxwells Creek could be made by locating a new vegetated swale along the northern side of the road corridor between the SWRL overpass at **DRC 2500** and Maxwells Creek at **DRC 2300**, discharging to Maxwells Creek at the new bridge structure. The new pavement drainage system along this length of the road corridor could be discharged at a number of locations along this length of road corridor to maximise potential water quality improvements. However, construction of the swale at the toe of the widened road embankment would require additional clearing of existing vegetation within the Regional Park (refer next dot point below). ➢ Given the two receiving drainage lines downstream (north) of Campbelltown Road where it runs between the Hume Highway and the SWRL overpass are located within the Regional Park, it would be desirable to incorporate provision for gross pollutant removal and spill containment at the proposed outlets of the new pavement drainage system (i.e. at **P3**, **P4** and **P5**). Additional land would need to be acquired at the toe of the widened road embankment to construct these measures, and provision for vehicular access off the northbound carriageway of the upgraded road would also be required for maintenance purposes. A minimum additional corridor width of 5 m from the embankment toe would be required, extending approximately 30 m along the length of the road from each outlet in order to construct a containment area of sufficient volume to capture up to 25 m^3 of spill material. However, RMS has indicated that the footprint of the upgraded road should be reduced as far as practicable in this area, to minimise the extent of clearing required within the Regional Park. It is also understood that several potential archaeological deposits have been located along the northern side of the road corridor within the Regional Park, which may be impacted by the additional footprint required to locate these water quality improvement measures.

Note that at each outlet of the pavement drainage system (and also cross drainage) it will be necessary to incorporate appropriate energy dissipation and scour protection measures.

TABLE S2 (CONT'D)
RECOMMENDED PAVEMENT DRAINAGE STRATEGY

Section	Key Findings and Recommendations
South West Rail Link Overpass to Zouch Road	➢ **Figures 6.13** and **6.14** summarise the pavement drainage strategy where Campbelltown Road runs between the SWRL overpass at **DRC 2500** and the proposed crest in the upgraded road west of Zouch Road at **DRC 4440**. It is recommended that the pavement drainage system be discharged at three locations along this length of Campbelltown Road, on the southern side of the road corridor (refer locations marked **P6** and **P7** on **Figure 6.13**, and **P8** on **Figure 6.14**). ➢ It is recommended that runoff from a small catchment located on the northern side of Campbelltown Road immediately west of the SWRL is incorporated into the new pavement drainage system. ➢ Outlets at **DRC 2800** and **DRC 3100** (refer locations **P6** and **P7** on **Figure 6.13**) Between the SWRL overpass and Zouch Road there is no requirement for upgraded cross drainage because the road corridor is located along a natural ridgeline. However, it is recommended that outlets to the new pavement drainage system be provided on the southern side of Campbelltown Road at the location of future intersections with East Town Centre Road at **DRC 2800** (location **P6**) and Croatia Avenue at **DRC 3100** (location **P7**). At both locations, runoff from the pavement drainage system would be piped to the south along the eastern side of future road corridors, and discharge into a natural drainage line. This drainage line forms part of a riparian corridor that will be preserved and enhanced by Landcom for its Edmondson Park South development. **Appendix D** contains a plan showing the water cycle management strategy developed by Landcom for Edmondson Park South, which shows the location of the riparian corridor (denoted **Corridor A**). Measures for improvement of water quality for the stormwater generated within the development will also be incorporated into the future riparian corridor. Whilst peak flows immediately downstream (south) of Campbelltown Road would be increased as a result of the road upgrade works (refer locations **P6.1** and **P7.1** on **Figure 6.13**), these flows would be controlled by the newly constructed piped drainage systems. Peak flows within the future riparian corridor to the south of Campbelltown Road would also be increased as a result of the road upgrade works (refer locations **P7.2** and **P7.3** on **Figure 6.13**). However, Landcom has advised that planning for the future subdivision in this part of Edmondson Park South has made allowance to cater for the upgrade of Campbelltown Road. The conceptual arrangement for these new pavement drainage outlets and associated piped drainage systems has been discussed and agreed with Landcom. However, RMS will need to liaise further with Landcom during detailed design of the road upgrade to confirm the most appropriate alignment for the new piped drainage systems along East Town Centre Road and Croatia Avenue. ➢ Outlet at **DRC 3900** (refer locations **P8** on **Figure 6.14**) The third outlet along the length of Campbelltown Road between the SWRL overpass and Zouch Road would discharge to the southern (downstream) side of the upgraded cross drainage structure at **DRC 3900**. This outlet would drain the length of road corridor between proposed crests at **DRC 3800** and **DRC 4440**. It is recommended that the combined outlet discharge into a new grass lined drainage channel and low flow piped drainage system extending approximately 160 m to the south around the western side of Mont Saint Quentin Oval and connecting to the future drainage system of Landcom's subdivision in this area. The conceptual arrangement for this new drainage channel has been discussed and agreed with Landcom. However, RMS will need to liaise further with Landcom during detailed design of the road upgrade to confirm the proposed location and treatment of these channel works. Note that detailed design of the channel works may also need to take into account potential heritage-related impacts to the Mont Saint Quentin Oval curtilage. Whilst peak flows immediately downstream (south) of Campbelltown Road would be increased as a result of the road upgrade works (refer location **P8.1** on **Figure 6.14**), these flows would be controlled within the newly constructed drainage system. It is further noted that Landcom has advised that the future subdivision drainage system in this area has been sized to cater for the upgrade of Campbelltown Road. ➢ It is recommended that runoff from a small catchment located on the northern side of Campbelltown Road immediately west of Zouch Road is incorporated into the new pavement drainage system. ➢ It is understood that the water cycle management strategy developed for Edmondson Park South incorporates a range of land use planning measures, treatment measures and preservation of existing riparian corridors designed to effectively manage the quality of stormwater generated within the development, with allowance for runoff generated on new and upgraded roads in the surrounding road network (including Campbelltown Road) to drain through these treatment measures and riparian corridors. On this basis, there is no need for additional water quality improvement measures to be incorporated into design of the road upgrade works.

Note that at each outlet of the pavement drainage system (and also cross drainage) it will be necessary to incorporate appropriate energy dissipation and scour protection measures.

TABLE S2 (CONT'D)
RECOMMENDED PAVEMENT DRAINAGE STRATEGY

Section	Key Findings and Recommendations
Zouch Road to Brooks Road	➢ **Figure 6.15** summarises the pavement drainage strategy where Campbelltown Road runs between the proposed crest west of Zouch Road at **DRC 4400** and Denham Court Road at **DRC 5100**. It is recommended that runoff from upslope catchments along the eastern side of the upgraded road be introduced into the new pavement drainage system along this length of Campbelltown Road, with combined runoff from the pavement drainage system discharged at one, possibly two locations on the western side of the road corridor at **DRC 4720** and **DRC 4920**. Note that at each outlet of the pavement drainage system (and also cross drainage) it will be necessary to incorporate appropriate energy dissipation and scour protection measures. ➢ <u>Outlet at **DRC 4720** (refer location **P9** on **Figure 6.15**)</u> The existing cross drainage structure at **DRC 4720** discharges into a piped drainage system that conveys runoff to the tributary arm of Cabramatta Creek through **Lots 27** and **28** in **DP 1443**, approximately 200 m to the north-west of Campbelltown Road. The proposed outlet at location **P9** would discharge to the western (downstream) side of the road corridor at **DRC 4720**. Nominally, this outlet would drain the length of road corridor between the proposed crest at **DRC 4400** and **DRC 4720**, although options for directing runoff to this location from the west have also been assessed as part of this present investigation (refer discussion below on possible outlet at **DRC 4920**). Peak flows immediately downstream of the widened road corridor will be increased over the full range of storm events (refer location **P9.1** on **Figure 6.15**). For example, for the 100 year ARI event the increase in peak flow is about 70%. For smaller events, the increase in peak flows is greater (up to around 110% for the 2 year ARI). As this will lead to a reduction in the hydrologic standard of the existing piped drainage system through **Lots 27** and **28** in **DP 1443**, it will be necessary for it to be upgraded over its full length between the road corridor and the existing creek. Based on preliminary assessment, a single 1050 RCP will be required to control runoff at this location for all events up to and including the 100 year ARI. RMS would need to gain permission from the landowner to carry out these works, and also obtain an easement (approximately 4 m wide) over the length of pipeline (approximately 200 m) outside the road corridor. It is recommended that the new piped drainage system is located along the southern boundary of **Lot 27** in **DP 1443** to minimise property impacts associated with these works. It will also be necessary to incorporate appropriate energy dissipation and scour protection measures at the creek outlet. ➢ <u>Outlet at **DRC 4920** (refer location **P10** on **Figure 6.15**)</u> The existing cross drainage structure at **DRC 4940** discharges across a grassed paddock within **Lot 21** in **DP 1443**. This drainage line feeds into a tributary arm of Cabramatta Creek approximately 70 m north of the road corridor. The tributary arm then runs generally north in the form of a grassed swale through the western portion of **Lot 1** in **DP 630181**, which contains the Denham Court Caravan Park. Based on preliminary assessment, a single 1200 RCP would be required to convey runoff discharging from the new pavement drainage system at **DRC 4920** to the existing creek. In order to minimise property impacts associated with these works, the preferred location of the new piped drainage system is along the northern boundary of **Lot 21** in **DP 1443**. RMS would need to gain permission from the landowner to carry out these works, and also obtain an easement (approximately 4 m wide) over the length of pipeline outside the road corridor. Preliminary assessment of the impact of the road upgrade on peak flows downstream of Campbelltown Road assumed that a new pavement drainage outlet at **DRC 4920** would drain the length of road corridor between **DRC 4720** and **DRC 5260**, with the grading of a new pavement drainage system matching the prevailing grade of the road towards the proposed sag at **DRC 4960**. This assessment showed that peak flows immediately downstream of the road corridor would be increased over the full range of storm events (refer location **P10.1** on **Figure 6.15**). For the 100 year ARI event, the increase in peak flow would be around 7%. For smaller events, the increase in peak flows would be greater (For example, up to around 37% for the 2 year ARI). The preliminary assessment also showed that peak flows further downstream of the road corridor along the tributary arm of Cabramatta Creek where it runs through **Lot 1** in **DP 630181** as a grassed swale (refer location **P10.2** on **Figure 6.15**) would be increased over the full range of storm events. For the 100 year ARI event the increase in peak flow would be around 5%, whilst for smaller events the increase in peak flows would be greater (For example, up to around 16% for the 2 year ARI). Hydraulic modelling along the grass-lined swale through **Lot 1** in **DP 630181** showed that the increase in peak flows as a result of the road upgrade would translate into an increase in peak flood levels of between 20 and 30 mm for events up to 100 year ARI. Review of natural surface levels adjacent to the grassed swale indicates that a number of existing residences on its right (eastern) overbank may be subject to above-floor level inundation under present day conditions. This situation would likely be exacerbated by the road upgrade. The discharge of runoff from the road corridor west (upstream) of the **Lot 1** in **DP 630181** would also increase the frequency that flows are experienced in the grassed swale, which may lead to maintenance difficulties for the property owner. It is therefore recommended that RMS consider the following two options which are aimed at reducing the impact the road upgrade will have on drainage and flooding conditions in **Lot 1** in **DP 630181**. • **Option 1** would involve directing runoff from the length of upgraded road corridor between **DRC 4400** and **DRC 4720** to the outlet at **P9** (refer above) and between **DRC 4720** and **DRC 5260** to the outlet at **P10**. **Figure 6.15** shows the layout of a pavement drainage system which reflects this option. In addition to constructing a single 1200 RCP along the northern boundary of **Lot 21** in **DP 1443**, it would also be necessary to construct a low flow piped drainage system beneath the invert of the existing grassed swale in **Lot 1** in **DP 630181**. The low flow piped drainage system would mitigate the impacts of the road upgrade by reducing the rate (and frequency) of flow conveyed by the grassed swale to no greater than present day conditions. RMS would need to obtain an easement over the low flow piped drainage system where it runs through **Lot 1** in **DP 630181** for maintenance purposes. It is recommended that as part of the works comprising **Option 1**, that the low flow section of creek downstream of the new piped outlet be rehabilitated (refer **Figure 6.15** for extent). • **Option 2** would involve directing runoff from the length of road corridor between **DRC 4720** to **DRC 5260** to the outlet at **P9**, thus removing the need for an outlet at **DRC 4920**. This would require routing the pavement drainage system to the north against the prevailing grade of the road. As a result, the depth of the proposed piped drainage system on the western side of the upgraded road at **P9** would be greater than 4 m. [RMS advised that it is not feasible to shift the sag in the road closer to **P9**, thus reducing the depth of the pipeline. However, the larger diameter pipes could be located along the superelevated northbound carriageway, which would assist in minimising the depth of the pavement drainage system]. Preliminary assessment indicates that it would be necessary to provide 2 off 1200 mm diameter pipes downstream of location **P9** in order to accommodate the additional flow from the road corridor. Whilst **Option 2** would remove the need to construct and obtain easements over piped drainage lines in **Lot 21** in **DP 1443** and **Lot 1** in **DP 630181**, the installation of large diameter pipe(s) at depths exceeding 4 m may not be feasible given constraints such as trenching costs and impacts on utilities. As further information is required in order to properly assess each option (e.g. there would be a need to undertake a geotechnical investigation to determine the characteristics of the insitu material along the line of the deep trench and to also gather details on existing/ proposed utilities), the determination of the preferred option will need to form part of the detail design for the road upgrade project.

TABLE S2 (CONT'D)
RECOMMENDED PAVEMENT DRAINAGE STRATEGY

Section	Key Findings and Recommendations
Zouch Road to Brooks Road (continued)	➢ The relatively steep terrain between the road corridor and the tributary arm of Cabramatta Creek precludes consideration of swales for water quality improvement along the length of road corridor between the proposed crest west of Zouch Road at **DRC 4400** and Denham Court Road at **DRC 5100**. The nature of the proposed road drainage system in this area, which will combine runoff from upslope catchments with runoff generated within the road corridor, also limits opportunities to implement measures that could target road runoff in isolation. In order to target gross pollutants, trash racks could be installed at the new pipe outlets along the tributary arm of Cabramatta Creek. Whilst vehicular access to maintain the trash racks would be possible along the new piped drainage system easements, a vehicular ramp from the new northbound carriageway would need to be constructed to provide access to the easements. Alternatively, GPT's could be installed on the western side of the road corridor at the proposed outlet locations near **DRC 4720** and **DRC 4920** (marked **P9** and **P10**, respectively, on **Figure 6.15**). However additional land would need to be acquired at the toe of the widened road embankment to install these devices. Provision for vehicular access off the northbound carriageway of the upgraded road would also be required to facilitate maintenance of the devices. Note also that GPT's would need to be sized to cater for flows which discharge to the new pavement drainage system from upslope areas. ➢ To the south of Denham Court Road, the proposed road upgrade works will transition back to tie in to the existing two lane carriageway. **Figure 6.15** shows the length of transition works extending south to Brooks Road. It is recommended that runoff controlled by short lengths of new kerb and gutter south of Denham Court Road be directed into existing roadside table drains on either side of Campbelltown Road.

Note that at each outlet of the pavement drainage system (and also cross drainage) it will be necessary to incorporate appropriate energy dissipation and scour protection measures.

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1 INTRODUCTION

1.1 Background

Roads and Maritime Services (RMS) is currently developing a concept design for the planned upgrade of the 5.4 km length of Campbelltown Road between Camden Valley Way, Casula and Brooks Road, Denham Court.

The objective of this present investigation was to undertake an assessment of drainage requirements associated with the road upgrade, and to prepare preliminary designs for cross and pavement drainage systems that will be required as part of the upgrade works. This work will inform further development of the concept road design and preparation of an environmental assessment for the upgrade works.

Figure 1.1 shows the location of Campbelltown Road and a number of major landmarks within the study area that are referenced in this report. The study area broadly comprised the existing drainage lines, and contributing catchment areas, that cross Campbelltown Road along the 5.4 km length of the proposed road upgrade. Investigations were extended downstream of the road corridor along each drainage line a sufficient distance to establish the likely impact of the road upgrade works on existing drainage arrangements, and to develop suitable mitigation strategies to minimise any adverse impacts as far as practicable.

Catchment modelling using the DRAINS rainfall-runoff software was undertaken to define peak flood flows arriving at the road corridor at the various cross drainage sites. The DRAINS model was also used to investigate the impact that widening the road and upgrading existing cross drainage will have on peak flows in existing drainage lines downstream of Campbelltown Road, and to assist in the development of a strategy for discharging runoff from the upgraded roadway to these receiving drainage lines.

Existing cross drainage systems along the length of the road upgrade were hydraulically assessed to firstly define the hydrologic standard of the existing carriageway. Further hydraulic analysis was then undertaken to assess requirements for the future upgrade of cross drainage along the route.

The study included a detailed hydraulic investigation to determine the nature of flooding under both pre- and post-road upgrade conditions where Campbelltown Road crosses Maxwells Creek, a tributary of the Georges River, due to the complex nature of flooding patterns in this area. Requirements for the upgrade of existing cross drainage at this location aimed at minimising the impact of the road upgrade on flood behaviour were also assessed.

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.
- Review of previous studies and available data along the route of the proposed road upgrade works.

- Liaison with Campbelltown City Council (CCC) regarding relevant requirements for future development upstream of Campbelltown Road.
- Liaison with Liverpool City Council (LCC) and Landcom regarding relevant requirements for discharge of runoff from new pavement drainage systems into existing drainage lines and watercourses downstream of Campbelltown Road.
- Hydrologic analysis of catchments upstream of the road corridor to determine peak flow rates approaching existing cross drainage along the route. 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 could be determined along the receiving drainage lines.
- Hydraulic analyses of existing cross drainage structures along Campbelltown Road to determine the current hydrologic standard of these crossings. Further hydraulic analyses were then undertaken to assess requirements for the future upgrade of these cross drainage structures. The potential impact of future development and climate change on peak flows was taken into consideration for the sizing of all cross drainage along Campbelltown Road.
- Develop a strategy for discharging runoff from the new pavement drainage system aimed at mitigating the impacts of the road upgrade works on existing development. In developing the strategy, the impact of the road upgrade works on both nuisance and major flooding were taken into account. Opportunities for the treatment of stormwater runoff captured by the new pavement drainage system, and for the provision of spill containment measures, were also assessed.

  Following agreement with RMS regarding the proposed pavement drainage strategy, a concept layout for the new pavement drainage system was also developed to show the indicative location of inlet pits and piped drainage lines that will be required to capture and convey runoff from the ultimate six-lane configuration of Campbelltown Road to receiving drainage lines.
- Assess requirements for temporary sediment retention basins which may be needed along the length of the proposed road upgrade works to treat runoff from the road corridor during the construction phase of the project.

1.3 Outline of Report

Section 2 of this report gives a brief description of the catchments which presently contribute runoff to existing cross drainage along Campbelltown Road. Two existing pavement drainage lines that control runoff along the length of Campbelltown Road between Camden Valley Way and the Hume Highway are also described.

Section 3 summarises the results of the assessment of peak design flood flows at the locations of existing cross drainage along the length of Campbelltown Road that will be upgraded.

Section 4 deals with the findings of an investigation which was carried out to assess the hydrologic standard of existing cross drainage along the Campbelltown Road corridor. A detailed description of flooding characteristics at the location where Maxwells Creek crosses the road corridor is also contained in this section of the report.

Section 5 provides a brief description of the proposed road upgrade works.

Section 6 sets out the key criteria which were adopted for sizing cross drainage along Campbelltown Road, and presents the findings of the investigation into its upgrade. Note that **Table S1** in **Section S1** summarises the findings and recommendations of the investigation at each location where cross drainage will be required.

Section 7 provides a summary of the approach adopted in developing a pavement drainage strategy for Campbelltown Road as part of this present investigation. Note that **Table S2** in **Section S1** presents the findings and recommendations of the investigation carried out into a preferred pavement drainage strategy for the road upgrade works.

Section 8 outlines the findings of a preliminary assessment of measures which will be required to control runoff from the road corridor during the construction phase of the project. Preliminary advice in relation to the locations where the implementation of temporary sediment sumps would assist in this regard is also contained in this section of the report.

Section 9 provides a summary of residual drainage-related property impacts should the recommended drainage strategy be implemented.

Section 10 contains a list of references used during the course of the investigation.

Volume 2 of the report contains all referenced figures and appendices.

Appendix A contains a series of photographs that show the condition of the existing drainage lines that will receive runoff from the new pavement drainage system for the upgrade of Campbelltown Road. **Appendix B** contains a plan showing details of the existing piped drainage system under Campbelltown Road in the vicinity of Parkers Farm Place. **Appendix C** contains a plan showing the extent of works that are currently under construction as part of Stage 6 of the Ingleburn Gardens Estate development, which lies immediately upstream (north) of Campbelltown Road. **Appendix D** contains a plan showing the proposed water cycle management strategy developed by Landcom for its Edmondson Park South development, which lies to the south of Campbelltown Road.

1.4 Available Data

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

- Ortho-rectified 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 a number of existing cross drainage structures and piped drainage systems throughout the study area.
- Existing utilities data based on desktop review.
- Preliminary horizontal and vertical alignments for the proposed road upgrade works.
- GIS datasets including property boundary information.

The following additional information was obtained from other sources (as noted) over the course of the investigation:

- Flood study report and various survey and design information relating to the South West Rail Link (SWRL) (sourced from SMEC).
- Various engineering drawings and reports relating to development of Ingleburn Gardens Estate (sourced from Monarch Investments).
- RAFTS hydrologic model prepared in support of the Part 3A concept plan approval for Edmondson Park (South) (sourced from J. Wyndham Prince).
- Plan showing selected details of an existing stormwater detention basin within Panorama Estate and existing piped drainage under the adjacent section of Campbelltown Road (sourced from CCC).
- Various reports and plans prepared in support of the Concept Plan and Stage 1 Project Application prepared in support of Landcom's proposed development of Edmondson Park South (sourced from the Department of Planning website).

2 CATCHMENT DESCRIPTION

2.1 General

This section of the report contains a brief description of the catchments which presently contribute runoff to existing cross drainage along Campbelltown Road. Two existing pavement drainage systems that control runoff along Campbelltown Road where it runs between Camden Valley Way and the Hume Highway are also described.

For the purpose of this present discussion, the length of Campbelltown Road that will be upgraded has been divided into three sections, with each section representing a different creek system in which the existing road drainage systems are located.

The three creek systems and the approximate Design Road Chainages (DRC's) which define the catchment divides are as follows:

- Maxwells Creek System – **DRC 0** (Camden Valley Way) to **DRC 4400** (200 m south of Zouch Road).
- Cabramatta Creek System – **DRC 4400** (200 m south of Zouch Road) to **DRC 5100** (Denham Court Road).
- Cottage Creek System – south of **DRC 5100** (south of Denham Court Road).

All the above creek systems form part of the larger Georges River catchment. However, each system is described separately in the following sections of the report to assist the reader in understanding the source of flows in existing drainage lines which cross the road corridor.

Figure 2.1 shows the extent of the catchments which drain to ten existing cross drainage structures under Campbelltown Road, and one existing cross drainage structure under the southbound ramp to the Hume Highway, and should be referred to when reading the following sections of the report. **Figures 2.2** to **2.4** show further details of existing drainage arrangements along Campbelltown Road in the vicinity of these existing cross drainage structures, and should also be referred to when reading the following sections of the report.

Table 2.1 (below) provides a summary of the existing cross drainage structures under Campbelltown Road.

Appendix A contains a series of photographs showing the condition of the existing receiving drainage lines downstream of Campbelltown Road, and references to these photographs are contained in the following sections (and **Table 2.1**) where appropriate.

2.2 Maxwells Creek System

Between its intersection with Camden Valley Way and Beech Road (i.e. between **DRC 0** and **DRC 1050**), runoff from the dual carriageways of Campbelltown Road is controlled by an existing pavement drainage system. Whilst details of the kerb inlet pits and pipes controlling runoff along this length of the road corridor are not available, it is known that the system discharges into an existing trunk drainage line that runs to the north of Campbelltown Road along Parkers Farm Place (refer **Plate 1** in **Appendix A**).

TABLE 2.1
SUMMARY OF EXISTING CROSS DRAINAGE

Catchment	I.D.	Design Road Chainage	Location	Existing Cross Drainage Configuration (1)	Description of Receiving Environment (2)
Maxwells Creek	X1	380	70 m south of Glenfield Road	unknown	Discharge to piped drainage system along Parkers Farm Place, ultimately drains to Maxwells Creek (refer **Plates 1** and **2**)
	X2	560	Immediately south of Parkers Farm Place	1 off 1350 RCP	
	X3	630	80 m south of Parkers Farm Place	2 off 750 RCP's	
	X4	1200	150 m south of Beech Road	4 off 600 RCP's	Discharge to piped drainage system through Lot 200 in DP 1090110, ultimately drains to Maxwells Creek (refer **Plate 3**)
	X5	1270	Hume Highway ramp	1 off 375 RCP	Discharge to upstream (southern) side of road, then to inlet of X4 at DRC 1200
	X6	1640	Immediately west of Hume Highway	1 off 1050 RCP	Discharge to drainage line that feeds in to Maxwells Creek (refer **Plate 4**)
	X7	2110	Immediately west of Ingleburn Gardens Drive	1 off 2400 x 600 RCBC	Discharge to drainage line that feeds in to Maxwells Creek (refer **Plate 5**)
	X8	2300	Maxwells Creek	3 off 2700 x 1200 RCBC's	Maxwells Creek (refer **Plates 7 and 8**)
	X9	3900	270 m east of Zouch Road	1 off 375 RCP	Discharge to informal drainage line adjacent to Mont Saint Quentin Oval (refer **Plate 9**)
Cabramatta Creek	X10	4720	Immediately east of Blomfield Road	1 off 600 RCP	Discharge to piped drainage system, ultimately drains to Cabramatta Creek (refer **Plate 10**)
	X11	4940	150 m east of Denham Court Road	1 off 525 RCP	Discharge to informal drainage line across grassed area adjacent to existing residence (refer **Plate 11**)

(1) RCP – reinforced concrete pipe, RCBC – reinforced concrete box culvert.
(2) Refer **Appendix A** for plates.

The trunk drainage line comprises a single 1800 mm diameter reinforced concrete pipe (RCP) where it runs immediately west of Campbelltown Road, increasing in size to 2100 mm diameter west of Beech Road before discharging into Maxwells Creek at the western end of Parkers Farm Place (refer **Plate 2** in **Appendix A**). A gross pollutant trap (GPT) is located at the outlet of the trunk drainage line, with vehicular access for maintenance purposes available via a concrete ramp from Parkers Farm Place.

Figure 2.2 shows the alignment of the trunk drainage line where it runs along the northern side of Parkers Farm Place, the location of the existing GPT, as well as the extent of the existing pavement drainage system along Campbelltown Road that contributes runoff to this line.

Runoff from upslope areas along the southern side of Campbelltown Road is also conveyed to the existing trunk drainage line in Parkers Farm Place via three existing cross drainage systems that cross the road corridor at **DRC 380**, **DRC 560** and **DRC 630**.

Runoff from a 9.9 ha catchment on the northern side of Glenfield Road is conveyed under the road by a pipe of unknown size, which continues south along the upstream (eastern) side of Campbelltown Road to around **DRC 380**. At this location a second inlet controls runoff from a 1.2 ha catchment along the eastern side of the road corridor, before the piped drainage system crosses under Campbelltown Road. The piped drainage system then continues south under the western kerbline of Campbelltown Road where it accepts runoff from the road corridor via a number of kerb inlet pits, before connecting into the existing trunk drainage line in Parkers Farm Place.

Panorama Estate is drained internally by a piped drainage system, which discharges across Campbelltown Road at the following two locations:

- At **DRC 560**, a single 1350 RCP conveys runoff from the northern portion of the Estate across the road corridor. A small area north of the Estate is also drained to this cross drainage structure. The 1350 RCP discharges directly to the existing trunk drainage line in Parkers Farm Place.
- At **DRC 630**, 2 off 750 RCP's drain an existing stormwater detention basin located along the eastern side of the road corridor. This basin accepts runoff from the southern portion of the Estate. A small area south of the Estate is also drained to the 2 off 750 RCP's.

Appendix B contains a plan showing details of these two cross drainage structures sourced from CCC.

Between Beech Road and the Hume Highway (i.e. between **DRC 1050** and **DRC 1580**), runoff from the northbound carriageway of Campbelltown Road is controlled by a series of kerb inlet pits and pipes located along the northern kerbline. Whilst details of these pits and pipes are not available, it is known that this pavement drainage system discharges into an existing trunk drainage line that runs to the north of Campbelltown Road through **Lot 200** in **DP 1090110** (refer **Plate 3** in **Appendix A**). The trunk drainage line comprises a single 1800 RCP where it crosses Creekside Place, before discharging into Maxwells Creek a short distance to the north. A GPT is located at the outlet of the trunk drainage line, with vehicular access for maintenance purposes available via a concrete ramp from Creekside Place.

Figure 2.2 shows the alignment of the trunk drainage line where it runs north of Campbelltown Road, the location of the existing GPT, as well as the extent of the existing pavement drainage system along the road corridor that contributes runoff to this line.

An existing cross drainage structure at **DRC 1200** comprising 4 off 600 RCP's also discharges into the 1800 mm diameter trunk drainage line. This cross drainage controls runoff from a catchment area of approximately 22.1 ha along the southern side of Campbelltown Road.

A short distance to the west at **DRC 1270**, a single 375 RCP located under the existing southbound ramp to the Hume Highway controls runoff from a relatively small catchment located between the ramp and Campbelltown Road. This pipe discharges to the southern side of the road corridor, where runoff is conveyed east to the inlet of the cross drainage at **DRC 1200**.

Immediately west of the existing Hume Highway overbridge, an existing cross drainage system conveys runoff to the north beneath Campbelltown Road at **DRC 1640** (refer **Figure 2.3**). The system comprises a grated surface inlet pit drained by a single 1050 RCP. The catchment contributing runoff to this cross drainage structure is around 17.5 ha in area and includes a section of the Hume Highway corridor extending approximately 1 km to the south.

The cross drainage at **DRC 1640** also controls runoff from the eastern portion of the adjacent Ingleburn Gardens Estate. Plans provided by the developer (Monarch Investments) show that a piped stormwater drainage system within the Estate directs runoff to a sediment retention basin adjacent to Campbelltown Road at **DRC 1800**. It is understood that this basin will in the future be converted into a permanent dual purpose stormwater detention and water quality control basin. Site observations show that a piped drainage system currently connects the outlet of the temporary basin arrangement to the inlet pit of the cross drainage structure at **DRC 1640**.

The cross drainage structure at **DRC 1640** discharges into a small drainage channel (refer **Plate 4** in **Appendix A**) that runs generally north-west through the adjacent bushland, and joins the main arm of Maxwells Creek approximately 150 m north of Campbelltown Road.

The majority of the Ingleburn Gardens Estate, including the initial stages of residential and commercial development along Ingleburn Gardens Drive, drains to an existing water quality control basin that is located on the south-western corner of Campbelltown Road and Ingleburn Gardens Drive. The piped outlet of this basin drains to an existing cross drainage line which comprises a single 2400 mm wide by 600 mm high reinforced concrete box culvert (RCBC). This cross drainage structure is located immediately west of Ingleburn Gardens Drive at **DRC 2110**.

The cross drainage structure at **DRC 2110** discharges into a small drainage channel (refer **Plate 5** in **Appendix A**) that runs generally north through the adjacent bushland, and joins the main arm of Maxwells Creek approximately 170 m north of Campbelltown Road.

Campbelltown Road crosses the main arm of Maxwells Creek at **DRC 2300**. The creek runs generally to the north and is conveyed under the existing two lane carriageway in a three cell box culvert system, with each cell measuring 2700 mm wide by 1200 mm high.

The Maxwells Creek catchment is approximately 1.8 km^2 in area at Campbelltown Road. The catchment includes Edmondson Park South, part of the broader Edmondson Park precinct that forms part of the South West Growth Centre. At the time of writing, Stage 1 land development works had commenced in Edmondson Park South to facilitate the first stage of residential and mixed use development. **Figure 1.1** shows the extent of the Precinct as well as the approximate extent of the Stage 1 works.

The SWRL, also under construction at the time of writing, crosses the Maxwells Creek floodplain a short distance upstream (south) of Campbelltown Road. Design drawings provided by RMS show that the rail line will cross the floodplain on a new multi-span bridge structure approximately 210 m long. A new box culvert system comprising 10 off 3600 x 900 RCBC's will also be constructed to convey flow in Maxwells Creek under a new maintenance access road that will be located within the rail corridor immediately downstream (north) of the new rail bridge.

Note also that recent works have been undertaken as part of the Ingleburn Gardens Estate development, which have involved the construction of an emergency overflow channel between the existing water quality control pond (refer above) and the creek. These works have also involved widening and deepening the existing creek over a length of approximately 70 m extending upstream from the road corridor (refer **Plate 6** in **Appendix A**).

It is understood that these creek modification works have been undertaken to reduce the frequency at which floodwaters will surcharge the right (eastern) overbank of the creek and flow into the existing water quality ponds located along the Estate's Campbelltown Road frontage. **Appendix C** contains a plan showing the extent of the above-mentioned works being undertaken as part of Stage 6 of the Ingleburn Gardens Estate development.

Downstream (north) of the road corridor the overbank areas of Maxwells Creek are heavily vegetated by groundcover and trees, whilst the in-bank section of the creek contains some scattered trees and other light vegetation (refer **Plates 7** and **8** in **Appendix A**). The creek channel bends sharply to the east a short distance downstream of the road corridor, and narrows to a width of 8 – 9 m at top of bank level before continuing generally to the north-east.

Flooding conditions along the main arm of Maxwells Creek in the vicinity of Campbelltown Road, including the influence of the range of recent works described above, have been assessed as part of this present investigation, details of which are contained in **Section 4** of this report.

West of Maxwells Creek, the existing two lane carriageway climbs along a ridge line to Mont Saint Quentin Oval over a distance of approximately 1.5 km (refer **Figure 2.4**). At **DRC 3900**, a single 375 RCP drains to the south under Campbelltown Road, discharging to an informal drainage line immediately north of the oval (refer **Plate 9** in **Appendix A**). This cross drainage structure controls a catchment area of 3.8 ha along the northern side of the road corridor.

Campbelltown Road continues to climb to a crest in the road corridor located approximately 200 m south of Zouch Road at **DRC 4400**.

2.3 Cabramatta Creek System

There are two existing cross drainage structures under Campbelltown Road where it runs through the Cabramatta Creek catchment between **DRC 4400** and **DRC 5100** at Denham Court Road (refer **Figure 2.4**).

Immediately north of Blomfield Road at **DRC 4720**, a single 600 RCP conveys runoff from east to west across the road corridor, controlling a 2.3 ha catchment along the eastern side of Campbelltown Road. Whilst the outlet of this pipe was unable to be located by RMS surveyors, it is believed that the existing cross drainage system is piped through the adjacent property (i.e. **Lots 27** and **28** in **DP 1443**) and discharges into a tributary arm of Cabramatta Creek approximately 200 m to the north-west of the road corridor (refer **Plate 10** in **Appendix A**).

Further south at **DRC 4940**, a single 525 RCP also conveys runoff from east to west across Campbelltown Road, controlling a 5.6 ha catchment along the eastern side of the road corridor. This cross drainage structure discharges runoff across a grassed paddock within **Lot 21** in **DP 1443** (refer **Plate 11** in **Appendix A**).

This drainage line feeds into a tributary arm of Cabramatta Creek approximately 70 m north of the road corridor. The tributary arm then runs generally north in the form of a grassed swale through the western portion of **Lot 1** in **DP 630181**, which contains the Denham Court Caravan Park (refer **Plate 12** in **Appendix A**).

2.4 Cottage Creek System

South of Denham Court Road at **DRC 5100**, Campbelltown Road continues along a ridge line that falls to the south towards Cottage Creek. There is no cross drainage under the existing two lane carriageway for the short distance over which the proposed road upgrade works will transition back to match the existing road geometry at Brooks Road.

3 CATCHMENT HYDROLOGY

3.1 General

The assessment of runoff characteristics from the catchments which contribute flows to the network of piped and channel drainage systems along the road corridor was based on a hydrologic model developed using the DRAINS software. 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. It 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. It is applicable to both rural and developed catchments, or any combination of the two, and is therefore well suited to this present investigation.

The DRAINS model was also used to assess the impact the road upgrade works will have on peak flows in the receiving drainage lines downstream of Campbelltown Road, further details of which are presented in **Section 7**.

The extent of the various catchments that contribute flow to the existing drainage systems which cross Campbelltown Road are shown on **Figure 2.1**. Peak flows arriving at the inlet of the various existing cross drainage structures estimated using DRAINS were reviewed against alternative peak flow estimation methods, and previous flood study investigations where such information was available.

The following sections of the report contain a brief description of the adopted modelling approach and present peak flow estimates adopted for the purpose of this present investigation.

3.2 DRAINS Model Development

A number of hydrologic sub-models are available within DRAINS to simulate the conversion of rainfall to runoff. For the purpose of this present investigation, the following approach was adopted to suit the nature of the various catchments across the study area:

- The RAFTS sub-model was applied to the predominantly undeveloped catchments that presently contribute runoff to Maxwells Creek and its northern tributary.
- The ILSAX sub-model was applied to the remaining catchments within the study area that generally comprise a mix of rural and rural-residential areas, as well as a number of more heavily urbanised areas (e.g. Ingleburn Gardens and Panorama estates).

Figure 3.1 shows the layout of the various sub-catchments which comprise the DRAINS model developed for the study area. Note that the individual sub-catchments have been shaded to separately identify those areas where the RAFTS and ILSAX modelling approaches were applied.

Sub-catchment boundaries were digitised based on available contour information, which comprised (in order of accuracy, from highest to lowest) ground survey along the road corridor, ALS data and 2 m contour data.

Sub-catchment slopes used for input to the RAFTS component of the hydrologic model were derived using the vectored average slope approach, whilst the average sub-catchment slope computed using available contour data was used for input to the ILSAX component of the DRAINS model.

Aerial photography and site observations were used to assess the degree of urbanisation which is present in the study catchments.

Rainfall intensities for the 2, 5, 10, 20 and 100 year ARI events were derived using procedures outlined in Australian Rainfall and Runoff (ARR) (IEAust, 1998).

In the absence of gauged streamflow data that could otherwise be used to calibrate the DRAINS model, peak flows arriving at the road corridor were tuned as close as was practicable to peak flow estimates derived using rational method procedures consistent with guidance provided in ARR. Assessment of peak flows generated by catchments that are predominantly undeveloped was carried out using the Probabilistic Rational Method (PRM) developed for use in eastern NSW, whilst those catchments in which significant development has occurred were assessed using a more traditional deterministic rational method approach.

Adopted ILSAX model parameters comprised initial losses of 1 and 5 mm for paved and grassed areas respectively. The soil type was set equal to 3, which corresponds with a soil of comparatively high runoff potential. An antecedent moisture condition (AMC) of 3.5 was adopted for the 100 year ARI event with a value of 3 adopted for smaller events. These AMC values reflect rather wet conditions prior to the occurrence of design storm events.

Adopted RAFTS sub-model parameters comprised initial losses of 1.5 and 10 mm for paved and grassed areas, and continuing losses of zero and 2.5 mm per hour for the same, respectively.

3.3 Peak Flow Estimates for Present Day Conditions

Table 3.1 (below) gives peak flow rates generated by DRAINS for each of the catchments upstream of Campbelltown Road that contribute runoff to existing cross drainage structures along the route of the proposed road upgrade. Flows are provided for design storm events ranging between 2 and 100 year ARI.

TABLE 3.1
PEAK FLOWS AT EXISTING CROSS DRAINAGE UNDER CAMPBELLTOWN ROAD

I.D.	Design Road Chainage	Catchment Area (ha)	Peak Flows (m^3/s)[(1)]				
			2 year ARI	5 year ARI	10 year ARI	20 year ARI	100 year ARI
X1	380	11.1	0.92	1.6	1.9	2.5	4.0
X2	560	7.7	1.1	1.5	1.7	2.1	2.8
X3	630	13.3	1.9	2.7	3.1	3.7	4.9
X4	1200	22.1	1.3	2.4	3.0	3.9	6.5
X5	1270	0.5	0.05	0.09	0.10	0.13	0.20
X6	1640	17.5	1.2	1.8	2.1	2.6	3.9
X7	2110	10.2	0.92	1.4	1.7	2.1	3.2
X8	2300	178	8.0	13.8	16.3	21.2	34.3 [(2)]
X9	3900	3.8	0.25	0.43	0.54	0.70	1.2
X10	4720	2.3	0.18	0.31	0.38	0.50	0.83
X11	4940	5.6	0.45	0.78	0.96	1.3	2.1

(1) Peak flows represent local catchment flows only and do not include bypass flows from nearby cross drainage systems. Peak flows have been quoted to more than one decimal place for ease of comparison where flows are relatively small.

(2) Adopted peak 100 year ARI flow rate at Maxwells Creek crossing based on PRM estimate of 34.3 m^3/s for the purpose of this present investigation. For comparison, the peak 100 year ARI flow rate estimated by DRAINS is 29.8 m^3/s.

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4 ASSESSMENT OF PRESENT DAY FLOODING CONDITIONS

4.1 General

The assessment of present day flooding conditions was based on the peak flood flow estimates summarised in **Section 3** of this report. Hydraulic calculations utilised survey information provided by RMS where available, supplemented by ALS data along the route of Campbelltown Road. This topographic data was supported by a range of information, including both design plans and work-as-executed details, relating to previous development that has occurred in areas adjacent to the road corridor.

Table 4.1 summarises the results of the assessment of flooding carried out to estimate the capacity of the existing drainage infrastructure in terms of peak flow and the ARI of surcharging of each of the cross drainage systems under Campbelltown Road. The assessed capacity of existing cross drainage systems shown in **Table 4.1** was generally determined based on hydraulic analyses undertaken using the DRAINS model established to represent present day conditions along the road corridor (refer **Section 3**).

TABLE 4.1
CAPACITY OF EXISTING DRAINAGE INFRASTRUCTURE
UNDER CAMPBELLTOWN ROAD

I.D.	Design Road Chainage	Location	Existing Cross Drainage Configuration	Assessed Capacity (ARI)
X1	380	70 m south of Glenfield Road	unknown	Unable to be determined [(1)]
X2	560	Immediately south of Parkers Farm Place	1 off 1350 RCP	100 year [(2)]
X3	630	80 m south of Parkers Farm Place	2 off 750 RCP's	100 year [(2)]
X4	1200	150 m south of Beech Road	4 off 600 RCP's	20 – 50 year
X5	1270	Hume Highway ramp	1 off 375 RCP	20 – 50 year
X6	1640	Immediately west of Hume Highway	1 off 1050 RCP	20 – 50 year [(3)]
X7	2110	Immediately west of Ingleburn Gardens Drive	1 off 2400 x 600 RCBC	20 – 50 year
X8	2300	Maxwells Creek	3 off 2700 x 1200 RCBC's	
X9	3900	270 m east of Zouch Road	1 off 375 RCP	< 2 year
X10	4720	Immediately east of Blomfield Road	1 off 600 RCP	50 – 100 year [(4)]
X11	4940	150 m east of Denham Court Road	1 off 525 RCP	2 – 5 year

(1) Insufficient information was available to assess the present hydrologic standard of Campbelltown Road at this cross drainage system.

(2) Assessed capacity at these locations is based on information provided by Campbelltown City Council, which was not able to be verified as part of this present investigation.

(3) Note that runoff which surcharges the inlet of the existing cross drainage structure will flow along the western side of the Hume Highway under the Campbelltown Road overbridge, and therefore does not impact on Campbelltown Road.

(4) Assessment does not account for existing piped drainage system downstream of road corridor, details of which were not available for this present investigation.

At the location where Maxwells Creek crosses the road corridor at **DRC 2300**, detailed two-dimensional (in plan) hydraulic analysis was undertaken using the TUFLOW software to assess flood behaviour, due to the complex nature of flooding patterns in this area. **Sections 4.2** and **4.3** of this report provide a description of the methodology and findings of the investigation into flooding patterns along the road corridor in the vicinity of Maxwells Creek under pre-road upgrade conditions.

4.2 Maxwells Creek System

4.2.1 The TUFLOW Modelling Approach

TUFLOW is a two-dimensional hydraulic model which does not rely on a prior knowledge of the pattern of flood flows in order to set up the various fluvial and weir type linkages which describe the passage of a flood wave through the system.

The basic equations of TUFLOW involve all of the terms of the St Venant equations of unsteady flow. Consequently the model is "fully dynamic" and once tuned will provide an accurate representation of the passage of the floodwave through the drainage system in terms of extent, depth, velocity and distribution of flow.

TUFLOW solves the equations of flow at each point of a rectangular grid system which represent overland flow on the floodplain and along streets. The grid system may also be used to describe the waterway area available in the channel system. Channel systems can also be modelled as one-dimensional elements embedded in the larger two-dimensional domain which typically represents the wider floodplain. Flows are able to move between the one and two-dimensional elements of the model depending on the capacity characteristics of the drainage system being modelled.

The two-dimensional approach adopted in the present analysis was to model both the channels and floodplain as a grid. The choice of grid point spacing depends on the need to accurately represent features in the channels and on the floodplain which influence hydraulic behaviour and flow patterns (e.g. buildings, streets, changes in channel and floodplain dimensions, hydraulic structures which influence flow patterns, etc).

4.2.2 Development of TUFLOW Model

<u>Model Layout</u>

The layout of the TUFLOW model that was set up as part of this present investigation is shown on **Figure 4.1**.

An important consideration of two-dimensional modelling is how best to represent the roads, fences, buildings and other features which influence the passage of flow over the natural surface. Due to the relatively small size of the TUFLOW model, it was possible to adopt a fine grid spacing of 2 m whilst maintaining a reasonable simulation run time of around two hours.

Grid elevations were typically based on ALS data, however detailed ground survey was used in preference to ALS data where available. Ridge and gully lines were added to the model where the grid spacing was considered too coarse to accurately represent important topographic features which influence the passage of overland flow, such as levees, road centrelines and minor gullys.

TUFLOW models representing the following two scenarios were developed to assist in understanding how recent works undertaken on the floodplain of Maxwells Creek upstream of Campbelltown Road have influenced flood behaviour approaching the road corridor:

- Circa 2011 Conditions

  This scenario is representative of floodplain conditions prior to commencement of the following works that are under construction at the time of writing:

  - Construction of the SWRL.
  - Works associated with further development of Ingleburn Gardens Estate, comprising construction of an emergency overflow channel between the existing water quality pond and Maxwells Creek, and associated works within the main channel of Maxwells Creek.

- Baseline Conditions

  This scenario is representative of future floodplain conditions on completion of the above-mentioned works, but prior to the upgrade of Campbelltown Road. The scenario therefore represents a baseline for assessment of the impact that the road upgrade will have on flooding conditions along Maxwells Creek.

<u>Sources of Topographic Data</u>

Topographic data from a range of sources was relied upon to construct the TUFLOW models representing both circa 2011 and baseline conditions. This data included:

- ALS data provided by RMS to define natural surface levels on the floodplain.
- Detailed ground survey along Campbelltown Road, and extending approximately 80 m downstream (north) of the road along the in-bank area of Maxwells Creek, provided by RMS.
- Detailed ground survey along the SWRL corridor where it crosses Maxwells Creek upstream (south) of Campbelltown Road, provided by John Holland.

The following data was used to construct the TUFLOW model representing baseline conditions only (i.e. it was not used to define circa 2011 floodplain conditions):

- Details of the SWRL embankment and related bridge/culvert structures where the rail corridor crosses the floodplain of Maxwells Creek upstream of Campbelltown Road, provided by SMEC / John Holland.
- Details of Ingleburn Gardens Estate emergency overflow channel and creek modification works along Maxwells Creek between Campbelltown Road and the SWRL, provided by Monarch Investments.

Model Boundary Conditions

Upstream Boundaries

Discharge hydrographs generated by DRAINS were applied at the inflow boundaries for the TUFLOW model. These comprised both inflows applied at the external TUFLOW model boundary and internal point source inflows as shown on **Figure 4.1**.

In order to investigate flood behaviour along Maxwells Creek for an event representative of the Probable Maximum Flood, an Extreme Flood with a peak discharge equal to five times that of the 100 year ARI was also analysed in TUFLOW. The discharge hydrograph applied at each inflow boundary was factored up to generate the Extreme Flood for the purpose of this present investigation.

Downstream Boundary

The downstream boundary of the TUFLOW model was established at Camden Valley Way, which lies approximately 1.8 km downstream (north) of Campbelltown Road measured along the main arm of Maxwells Creek.

Maxwells Creek discharges under Camden Valley Way via a large multi-cell box culvert system. The TUFLOW model boundary was configured to allow free discharge from this cross drainage structure for all flood events simulated as part of this present investigation.

Hydraulic Model Parameters

The main physical parameter represented in TUFLOW is the hydraulic roughness, which is required for each of the various types of surfaces comprising the overland flow paths in the two-dimensional domain, as well as for the streams incorporated as one-dimensional elements. In addition to the energy lost by bed friction, obstructions to flow also dissipate energy by forcing water to change direction and velocity, and by forming eddies. Hydraulic modelling traditionally represents all of these effects via the surface roughness parameter known as “Manning’s n”.

Hydraulic roughness values adopted for design purposes were selected based on site inspection, past experience and values contained in the engineering literature (refer **Table 4.2**).

TABLE 4.2
“BEST ESTIMATE” OF HYDRAULIC ROUGHNESS VALUES
ADOPTED FOR TUFLOW MODELLING

Surface Treatment	Manning’s n Value
Roads/railways	0.02
Cleared sections of floodplain	0.045
Treed reaches of Maxwells Creek (including in-bank areas) and its tributaries	0.08
Fenced properties with buildings	0.1
Buildings	10

4.3 Model Results

4.3.1 Circa 2011 Floodplain Conditions

Figure 4.2 shows 100 year ARI flooding patterns representative of circa 2011 floodplain conditions in the vicinity of the Maxwells Creek crossing.

The presence of the levee bank which was once located along the right bank of Maxwells Creek immediately upstream of the road corridor would have resulted in a large portion of the 100 year ARI flow being conveyed by the 3 off 2700 x 1200 RCBC's which cross Campbelltown Road west of the Ingleburn Gardens Estate development.

The modelling undertaken as part of the present investigation shows that the existing road culverts would have conveyed a peak flow of 33 m^3/s under zero blockage conditions, with a peak flow of about 1 m^3/s shown to surcharge the right (eastern) bank of Maxwells Creek on the southern (upstream) side of the road corridor. The peak 100 year ARI flood level at the inlet of the road culverts under circa 2011 floodplain conditions would have been about RL 44.9 m AHD.

The modelling also shows that the 2400 x 600 RCBC which crosses Campbelltown Road immediately west of the Ingleburn Gardens Drive intersection would have had sufficient capacity to convey the peak 100 year ARI flow discharging from the water quality ponds located in the Ingleburn Gardens Estate development and the flow of about 1 m^3/s which is shown surcharging the road culverts on Maxwells Creek.

4.3.2 Baseline Conditions

Figure 4.3 shows 100 year ARI flooding patterns in the vicinity of the Maxwells Creek crossing following the completion of the South West Rail Link and the channel works which are presently being constructed by the developer of the Ingleburn Gardens Estate. The modelling undertaken as part of the present investigation shows that the construction of the emergency overflow channel which runs from the western end of the water quality pond in the Ingleburn Gardens Estate development to Maxwells Creek has resulted in an increase in the rate at which floodwater will surcharge the existing road culverts on Maxwells Creek.

Whereas previously the presence of the levee would have limited the peak flow surcharging the road culverts to about 1 m^3/s, its removal has increased the peak flow which will surcharge the right (eastern) bank of Maxwells Creek in a 100 year ARI flood event to about 9 m^3/s.

The relief route created by the construction of the channel works has resulted in about a 700 mm reduction in the peak 100 year ARI flood level at the inlet of the road culverts. The increase in rate of flow discharging toward the east on the southern (upstream) side of the road has also meant that the road culverts now only convey a peak flow of about 25 m^3/s in a 100 year ARI event.

The 2400 x 600 RCBC which crosses Campbelltown Road immediately west of the Ingleburn Gardens Drive intersection has insufficient capacity to convey the flow which surcharges Maxwells Creek and the water quality ponds in the Ingleburn Gardens Estate development, with the result that floodwater will now inundate Ingleburn Gardens Drive near its intersection with Campbelltown Road to a maximum depth of about 800 mm.

Floodwater which inundates the intersection will either flow in a northerly direction across Campbelltown Road or in an easterly direction along the southern side of the existing two lane carriageway. A peak flow of about 4 m^3/s will surcharge the centreline of Campbelltown Road over about a 200 m width, whilst a peak flow of about 1.3 m^3/s is shown to flow along the southern side of the road corridor where it will discharge to the inlet of the 1050 mm diameter pipe which crosses Campbelltown Road immediately west of the Hume Highway.

Figure 4.4 shows flooding patterns for an Extreme Flood in the vicinity of the Maxwells Creek crossing following the completion of the South West Rail Link and the channel works which are presently being constructed by the developer of the Ingleburn Gardens Estate.

Floodwaters would inundate Campbelltown Road over a length of approximately 450 m extending north-east from Maxwells Creek. The total peak flow across the Campbelltown Road corridor is around 180 m^3/s. A peak flow of 139 m^3/s is shown to be surcharging the centreline of the road, with the remainder conveyed under the road via the existing 3 off 2700 x 1200 RCBC's on Maxwells Creek (36 m^3/s) and the existing 2400 x 600 RCBC immediately west of Ingleburn Gardens Drive (5 m^3/s).

The maximum depth of flow over the centreline of Campbelltown Road is around 0.5 m, whilst floodwaters would inundate Ingleburn Gardens Drive near its intersection with Campbelltown Road to a maximum depth of about 1.3 m.

5 PROPOSED ROAD UPGRADE WORKS

5.1 General

The proposed road upgrade works involve widening the 5.4 km length of Campbelltown Road where it runs between Camden Valley Way and Brooks Road. The upgraded length of road corridor will ultimately provide a six lane dual carriageway configuration (i.e. three lanes in each direction) along its full length. However, initially only four lanes will be provided for the length of road south of the Hume Highway, with a wide median for the future addition of an extra lane in both directions.

The following sections provide a brief description of key elements of the proposed road upgrade works, based on the concept road design model current at May 2012.

5.2 Camden Valley Way to Hume Highway

At its northern end at **DRC 0**, the upgrade of Campbelltown Road will tie into Camden Valley Way at the Crossroads intersection. Between Camden Valley Way and Parkers Farm Place at **DRC 550** widening of Campbelltown Road will be limited to added shoulders as the existing dual carriageways each provide three lanes. Between Parkers Farm Place and Beech Road at **DRC 1040** Campbelltown Road will be upgraded to six lanes by widening into the existing central median and on both sides of the road corridor. Existing intersections at Glenfield Road (**DRC 290**), Parkers Farm Place (**DRC 550**) and Beech Road (**DRC 1040**) will be upgraded to suit the new six lane configuration. The new intersection at Beech Road will also accommodate a proposed future connection on the southern side of Campbelltown Road.

An added lane to the southbound carriageway will allow connection to the existing two lane entry ramp to the Hume Highway, with the remaining two lanes then continuing southbound over the existing Hume Highway overbridge (circa **DRC 1560**). A new bridge will be constructed on its northern side to carry the northbound carriageway of the upgraded road, with sufficient width to cater for a shared path and future three lane configuration.

The proposed vertical alignment of the road between Camden Valley Way and the Hume Highway retains the location of the two existing sags (**DRC's 620** and **1240**) in the road corridor.

5.3 Hume Highway to Brooks Road

The existing two lane carriageway between the Hume Highway and Denham Court Road will be upgraded to four lanes with a wide median for the future addition of an extra lane in both directions. Existing intersections at Ingleburn Gardens Drive (**DRC 2080**), Zouch Road (**DRC 4200**), Blomfield Road (**DRC 4740**) and Denham Court Road (**DRC 5100**) will be upgraded to suit the new six lane configuration. The initial road upgrade works will also make provision for future intersections at **DRC 2820** (East Town Centre Road), **DRC 3120** (Croatia Avenue) and **DRC 3500** (realignment of existing MacDonald Road).

At its southern end, the upgrade of Campbelltown Road will tie into the existing two lane carriageway a short distance south of Denham Court Road. The current concept road design shows this tie in extending to Brooks Road.

The proposed vertical alignment of the road between the Hume Highway and Brooks Road retains the location of the two existing sags (**DRC's 1920** and **4940**) in the road corridor. The proposed road design also introduces a minor additional sag into the vertical alignment at Mont Saint Quentin Oval near **DRC 3900**.

6 CROSS DRAINAGE REQUIREMENTS

6.1 General

Requirements for upgrading existing cross drainage along Campbelltown Road were identified as part of this present investigation, and are summarised in **Table S1** at the front of this report. The assessment of cross drainage requirements has been based on a concept road design model provided by the RMS in May 2012.

Figures 6.1, **6.2 (A and B)**, **6.13**, **6.14** and **6.15** (6 sheets in total) show the recommended cross drainage upgrade requirements along Campbelltown Road and should be referred to when reading **Table S1** and the following sections of the report. [Note that these figures also show the recommended pavement drainage strategy along the length of the proposed road upgrade.]

These figures also show the indicative location and direction for table drains that will be required to intercept and control runoff along the upslope side of Campbelltown Road. A number of more substantial drainage channels are also shown on these plans. These channels will be required to direct concentrated flows discharging from upgraded road drainage systems toward existing receiving watercourses. It should be noted that these table drains and drainage channels have not been sized but will require the road works to extend beyond the footprint of RMS's current concept road design model. This may have implications for land acquisitions and/or easements where works will extend outside the existing road corridor. It is also noted that the May 2012 concept road design model did not include the extent of cut and fill batters that will be required to tie the upgraded road formation into surrounding natural surface levels. This also has implications for land acquisition and/or easement requirements.

Section 6.2 provides a brief summary of key design considerations that were taken into account in assessing cross drainage upgrade requirements along the length of Campbelltown Road.

Sections 6.3 to **6.7** deal with the specific cross drainage upgrade requirements along the length of Campbelltown Road.

6.2 Design Considerations

6.2.1 General

The following sections provide a summary of key design parameters and assumptions made for the purpose of this present investigation. A number of recommendations are also provided to assist in future design development for the road upgrade.

As mentioned above, the assessment of cross drainage requirements has been based on a concept road design model. The designers of the Campbelltown Road upgrade will need to review the road design model supplied by RMS in light of the recommendations contained in this report to ensure the intent of the cross drainage measures is maintained in the final design of the roadworks.

Note also that it will be necessary for the designers of the road upgrade to undertake similar hydraulic model studies to confirm (or otherwise) the sizing of all cross drainage recommended in this report. RMS should make available the data which has been compiled as part of this present investigation as it will assist in developing the detail design of the cross drainage for Campbelltown Road.

6.2.2 Hydrologic Standard for the Road Upgrade

RMS's Brief required that all cross drainage structures be configured to achieve a 100 year ARI level of flood immunity to the upgraded section of Campbelltown Road. The potential impact of future climate change on peak flows was also taken into consideration when sizing upgraded cross drainage along the road corridor to cater for this hydrologic standard (refer **Section 6.2.4** below).

6.2.3 Peak Flow Estimates for Sizing Cross Drainage

Sizing of the cross drainage was generally based on peak flow estimates for a level of development consistent with present day conditions, with consideration of potential future uncontrolled development in the catchments which drain to the cross drainage only given to those catchments which are less than 10 ha in area. These relatively small catchments were deemed to be at greater risk of future development occurring without incorporation of an effective stormwater detention system. Fully developed catchment conditions (i.e. catchment conditions reflecting future development that is consistent with current land zonings) were therefore assumed for catchments up to 10 ha in area.

For the remaining upslope catchments (i.e. catchments greater than 10 ha in area), it has been assumed that measures will be incorporated into future development which will control the rate of flow discharging to the road corridor to no larger than present day conditions. It is recommended that the designers of the road upgrade liaise further with CCC to confirm that future development upstream of Campbelltown Road will not be permitted to increase peak flows arriving at the road corridor boundary.

6.2.4 Consideration of Climate Change

The weight of scientific evidence shows that climate change will have adverse impacts on sea levels and rainfall intensities. The significance of these effects on flood behaviour will vary depending on geographic location and local topographic conditions.

Climate change impacts on flood producing rainfall events show a trend for larger scale storms and resulting depths of rainfall to increase (McLuckie et al, 2005 in DECC, 2007). The impacts of climate change and associated effects on the viability of floodplain risk management options and development decisions may be significant and therefore should be taken into account in this present investigation using site specific data.

CSIRO prepared reports for the NSW Government on the impacts of climate change on rainfall intensities. In the Hawkesbury-Nepean system, the 40 year ARI, 1 day rainfall was predicted to increase by up to 10% over the period 2030 to 2070. These results suggest that the impacts of climate change in the catchments which contribute runoff to the cross drainage of Campbelltown Road will lie somewhere between present day conditions and conditions existing with a 10% increase in rainfall intensities.

For the purpose of this present investigation, design 100 year ARI peak flows for current (2012) climatic conditions were increased by 10% in order to assess the impact increases in peak flows will have on the sizing requirements for cross drainage along Campbelltown Road.

6.2.5 Minimum Cover Requirements

RMS advised that where possible, a minimum cover of 1 m was to be provided beneath each carriageway to all cross drainage structures *[Note this would allow for a 300 mm depth of cover below the base of a nominal 700 mm thick pavement]*. Cover has therefore been assessed for each cross drainage structure and is reported at both kerbline locations in **Table S1**.

It should be noted that RMS's May 2012 concept road design model did not incorporate the depressed median that will be constructed initially along much of the road corridor (i.e. the road design model currently represents the ultimate road formation with three lanes in each direction, which is crowned at the median except in locations of superelevation). The impact of reduced cover to the cross drainage as a result of constructing depressed medians will therefore need to be considered further as part of the detailed design of the road upgrade.

6.2.6 Culvert Blockage

In assessing the size requirements for new cross drainage structures, allowance was generally made for a 50% reduction in the available waterway area which may result from a partial blockage of the structure by debris or sediment. However, alternative recommendations are provided for selected locations, as described below and in **Table S1**.

6.2.7 Utilities

It should be noted that the location of underground utilities along the route of the proposed road upgrade have been determined by desktop review only. The location and depth of utilities and their impact on the cross drainage systems have therefore not been considered as part of this initial assessment of cross drainage requirements. Detailed investigations will need to be carried out during the preparation of the detailed design for Campbelltown Road in order to ensure there is no conflict between the cross drainage and either existing or proposed utilities.

6.3 Camden Valley Way to Hume Highway Upgrade Requirements

6.3.1 Cross Drainage Structure X1

Insufficient information was available at the time of writing to determine the hydrologic standard of existing Cross Drainage Structure X1. The configuration, size and precise alignment of the existing cross drainage structure where it runs between the northern side of Glenfield Road and Parkers Farm Place is unknown.

Due to the relatively minor extent of upgrade works that will be undertaken along this length of Campbelltown Road, it would be preferable to retain as much existing drainage infrastructure as possible, subject to providing the necessary level of flood immunity to the upgraded road.

Prior to commencing detail design of the road upgrade, it will be necessary for RMS to undertake detailed survey along the length of existing Cross Drainage Structure X1 in order to support hydraulic analyses required to determine its current hydrologic standard. Requirements for upgrading the existing structure (if any) can then be determined. Detailed survey will need to incorporate the two existing inlets to the drainage line, located along the northern side of Glenfield Road and along the southern side of Campbelltown Road at **DRC 380**.

It will be necessary to extend these hydraulic analyses downstream of Campbelltown Road to include the existing trunk drainage line that runs along Parkers Farm Place to Maxwells Creek, to confirm that this piped drainage line has sufficient capacity to accept combined flows from the upgraded cross and pavement drainage systems. This assessment should also confirm that hydraulic conditions within the trunk drainage line will not cause a backwater that leads to surcharge within the road corridor for events up to 100 year ARI.

The designers of the road upgrade will also need to liaise with CCC to confirm that future development upstream of the road corridor, including the future Glenfield Rise Estate to the north of Glenfield Road (refer **Figure 6.1**), will not be permitted to increase peak flows arriving at Campbelltown Road.

6.3.2 Cross Drainage Structures X2 and X3

Based on information obtained from CCC during the course of this present investigation, existing Cross Drainage Structures X2 and X3 have sufficient capacity to convey flows up to and including the 100 year ARI event. On this basis, it is recommended that the existing cross drainage structures are retained where they run beneath the existing dual carriageways of Campbelltown Road.

On the northern side of the road corridor, both cross drainage structures will need to be extended by approximately 5 m to suit the new location of the northern kerbline along Campbelltown Road. The existing 1500 RCP that connects the two cross drainage structures to the existing trunk drainage line in Parkers Farm Place will also need to be reconstructed to suit the new kerbline location, over a length of approximately 90 m. The extent of these works is shown on **Figure 6.1**.

Note that insufficient information was available at the time of writing to verify that existing Cross Drainage Structures X2 and X3 provide Campbelltown Road with a level of flood immunity of at least 100 year ARI. During detail design it will be necessary to undertake more detailed hydraulic analyses to confirm the capacity of these structures should they be retained and extended as part of the road upgrade. Detailed survey will be required along the existing cross drainage structures to support these analyses.

The hydraulic performance of the existing piped drainage systems upstream of Campbelltown Road within Panorama Estate, including the existing stormwater detention basin near **DRC 630**, will also need to be assessed to ensure that runoff approaching the road corridor is controlled for all events up to and including 100 year ARI. Detail design of the road upgrade will also need to ensure that the performance of these existing piped drainage systems is not adversely affected by the road works.

It will be necessary to extend these hydraulic analyses downstream of Campbelltown Road to include the existing trunk drainage line that runs along Parkers Farm Place to Maxwells Creek, as noted above in **Section 6.3.1**.

6.3.3 Cross Drainage Structure X4

It will be necessary to replace the existing 4 off 600 RCP's at **DRC 1200** with 3 off 1200 RCP's in order to limit the 100 year ARI peak flood level on the southern (upstream) side of the road corridor to approximately 43.0 m AHD (i.e. the level at which floodwaters will start to inundate trafficable lanes on the adjacent Hume Highway on-ramp) (refer **Figure 6.1**).

A new junction pit will be required on the northern (downstream) side of the upgraded road to connect the upgraded cross drainage structure into the existing 1800 RCP that runs to the north of the road corridor.

During detail design it will be necessary to undertake more detailed hydraulic analyses to confirm that the existing 1800 RCP has sufficient capacity to accept flows from the upgraded cross drainage in addition to the new pavement drainage system along the adjacent section of upgraded road. Additional survey will also be required to confirm details of the existing 1800 RCP over its full length between the road corridor and Maxwells Creek.

Note that 5 off 1200 RCP's (i.e. with a total waterway area of 5.6 m^2, which is more than double that of the existing 1800 RCP) would be required in order to cater for a 50% blockage scenario. However, given the downstream culvert size in this case it is considered that a more appropriate means of managing the risk of blockage would be to install a debris control structure at the inlet of the cross drainage.

6.3.4 Cross Drainage Structure X5

It is recommended that Cross Drainage Structure X5 be upgraded to a 450 RCP where it crosses the southbound on-ramp to the Hume Highway at **DRC 1270** (refer **Figure 6.1**).

The upgraded cross drainage structure will discharge into a new table drain along the southern side of the road corridor, where runoff will be conveyed to the inlet of Cross Drainage Structure X4 at **DRC 1200**. A new surface inlet pit will need to be provided in the median area to suit design road levels, with the pit sized to prevent bypass flows across the pavement and incorporating a blockage factor of at least 20% (for an on-grade pit).

6.4 Hume Highway to South West Rail Link Overpass Upgrade Requirements

6.4.1 Cross Drainage Structure X6

It will be necessary to extend Cross Drainage Structure X6 on the northern (downstream) side of the road corridor to accommodate the widened roadway (refer **Figure 6.2A** for details). At the time of writing, the concept design for Campbelltown Road was not sufficiently advanced to allow the length of pipe which will be needed to accommodate the road widening to be determined.

During detail design it will be necessary to assess the impact the provision of an additional length of 1050 mm diameter pipe will have on the hydraulic capacity of the cross drainage structure. It may be necessary to install a larger diameter pipe downstream of the existing 1050 mm diameter pipe as analyses undertaken as part of the present investigation show that stormwater will surcharge the inlet of the existing cross drainage structure and flow along the western side of the Hume Highway during a 100 year ARI event.

As discussed in **Section 6.3.2**, the upgrade of the Maxwells Creek crossing will prevent the breakout of flow which presently occurs along the southern (upstream) side of the road corridor, thus reducing the peak flow which this cross drainage system will need to convey in a 100 year ARI storm event.

6.4.2 Cross Drainage Structures X7 and X8

It is recommended that Cross Drainage Structure X7 be maintained where it crosses the southbound carriageway, and that a new length of either reinforced concrete pipe or box culvert be installed across the new northbound carriageway. A new junction pit will be required in the central median. It is noted that a single 1350 mm diameter pipe or twin 1050 mm diameter pipes would need to be installed across the northbound carriageway in order to match the waterway area of the existing 2400 x 600 RCBC.

On the northern side of the road corridor, the extended cross drainage structure should be connected into the new pavement drainage system under the northern kerbline of Campbelltown Road. The combined drainage system would then discharge to the existing drainage line on the northern side of the road corridor around **DRC 2080**. The extent of these works is shown on **Figures 6.2A** and **6.2B**.

The analyses undertaken as part of the present investigation show that the channel works presently being undertaken by the developer of the Ingleburn Gardens Estate have exacerbated flooding conditions along the road corridor east of the Maxwells Creek crossing (refer **Section 4.3** for details). The modelling shows that in a 100 year ARI event, a peak flow of about 9 m^3/s will surcharge the right (eastern) bank of Maxwells Creek, where it will inundate a section of Campbelltown Road east of Ingleburn Gardens Drive.

Whilst the channel works currently being undertaken by the developer of the Ingleburn Gardens Estate have exacerbated flooding conditions along the road corridor, it is not feasible to upgrade the cross drainage east of the Maxwells Creek crossing to accommodate the resulting increased rate of flow. Rather it is recommended that the Maxwells Creek crossing be upgraded to either a bridge or culvert arrangement with sufficient capacity to lower peak 100 year ARI flood levels on the southern (upstream) side of the road corridor to below RL 43.8 m AHD (i.e. below the elevation at which floodwater which discharges to the water quality pond located in the Ingleburn Gardens Estate development will surcharge onto the road corridor).

Analyses undertaken as part of the present investigation show that in order to reduce the peak flood level on the southern (upstream) side of the road corridor to below RL 43.8 m AHD it would be necessary to replace the existing 3 off 2700 x 1200 RCBC's with either 4 off 3600 x 1800 RCBC's (assuming zero blockage), or alternatively, a new bridge of about 20 m clear span.

Figure 6.3 shows flooding patterns in the vicinity of the Maxwells Creek crossing assuming the existing cross drainage structure is replaced with 4 off 3600 x 1800 RCBC's (with zero blockage), whilst **Figure 6.4** shows the impact this replacement option would have on flood behaviour for a storm with an ARI of 100 years. **Figure 6.5** shows flooding patterns in the vicinity of the Maxwells Creek crossing assuming the existing cross drainage structure is replaced with a bridge of 20 m clear span with a 30° skew, whilst **Figure 6.6** shows the impact this alternative replacement option would have on flood behaviour for a storm with an ARI of 100 years.

In considering an upgraded box culvert structure for the Maxwells Creek crossing, it would be prudent to cater for potential blockage of the structure. For a 50% blockage scenario, a waterway area equivalent to 8 off 3600 x 1800 RCBC's would be required to limit the peak flood level on the southern (upstream) side of the road corridor to below RL 43.8 m AHD. However, the extent of creek reshaping works required to accommodate a structure of this size would be impractically large, and is not recommended. A blockage factor less than 50% would therefore need to be accepted by RMS for an upgraded box culvert structure.

In regard to the modelling undertaken for the bridge replacement option, it was assumed that the waterway opening beneath the structure would comprise a trapezoidal section with a 12 m base width and 1(vertical):1.5(horizontal) spill-through abutments. Based on the proposed road levels contained in the concept design and assuming a 1 m deep superstructure (i.e. bridge deck plus pavement), the soffit levels of the bridge on the southern (upstream) side of the road corridor are estimated to be about RL 44.1 m AHD on the right (eastern) abutment and about RL 44.4 m AHD on the left (western) abutment.

The replacement of the existing road culverts with a bridge will reduce the peak 100 year ARI flood level on the southern (upstream) side of the road corridor by about 700 mm, from an elevation of about RL 44.2 m AHD to an elevation of about RL 43.5 m AHD. The resulting reduction in the peak 100 year ARI flood level on the southern (upstream) side of the road corridor will establish a 300 mm freeboard to the crest level of the earth embankment which runs along the northern and eastern sides of the water quality pond, therefore preventing the breakout of flow which presently occurs toward the east.

By inspection of **Figure 6.6**, the bridge option would also result in an increase in peak 100 year ARI flood levels immediately downstream (north) of Campbelltown Road, by a maximum of around 200 mm. However, the area over which peak flood levels would be increased is contained within the future Regional Park and does not impact on existing development.

Figures 6.7 and **6.8** show flooding patterns and impacts, respectively, for the bridge option for a storm with an ARI of 100 years including allowance for future climate change (i.e. with peak flows increased by 10% above present day conditions). Freeboard to the crest level of the earth embankment which runs along the northern and eastern sides of the water quality pond is reduced to approximately 200 mm for this scenario. Similar increases in peak flood levels, to a maximum of around 200 mm, are shown on **Figure 6.8** downstream (north) of Campbelltown Road under this climate change scenario.

Figures 6.9 and **6.10** show flooding patterns and impacts, respectively, for the bridge option for an Extreme Flood (i.e. with peak flows equating to five times that of the 100 year ARI event under current climate conditions). From inspection of **Figure 6.10**, the road upgrade will result in an increase in peak flood levels both upstream (south) and downstream (north) of the road corridor. Within Ingleburn Gardens Estate, the maximum increase in peak flood level to the west of Ingleburn Gardens Drive in the vicinity of the existing water quality ponds is around 150 mm. East of Ingleburn Gardens Drive, peak flood levels adjacent to existing residential and commercial development would be increased by up to 160 mm. Further east of this existing development, the increase in peak flood levels along the southern side of Campbelltown Road approaches 300 mm.

Table 6.1 summarises the advantages and disadvantages of the two cross drainage upgrade options for the Maxwells Creek crossing, noting that in both cases it will be necessary to re-align the creek channel over a length of approximately 85 m extending north (downstream) from the outlet of the existing box culvert system. **Section 6.4.3** provides further details in relation to the proposed scope and extent of creek realignment works.

Following consideration of the advantages and disadvantages set out in **Table 6.1**, it is recommended that the bridge option be incorporated into the design of Campbelltown Road upgrade at Maxwells Creek. **Table 6.2** over provides a summary of key features of both the existing and proposed cross drainage.

TABLE 6.1
ADVANTAGES AND DISADVANTAGES OF BOX CULVERT AND BRIDGE OPTIONS
MAXWELLS CREEK CROSSING

Option	Advantages	Disadvantages
Box Culvert	• Could be built with a skew angle greater than 30º, which would reduce the works required to re-align the creek on the northern (downstream) side of the road corridor.[1] • Least expensive option.	• Footprint of structure will extend beyond that of the road. • Major works required in invert of creek (e.g. reinforced concrete slab and headwalls). • The width of the creek would need to be increased on the southern (upstream) side of the road in order to accommodate the structure. • Considered to be a harder engineering solution to the bridge option. • At higher risk of experiencing a blockage during a flood than the bridge option. Culvert dimensions that are sufficiently large to cater for a 50% blockage scenario could not be practically accommodated within Maxwells Creek. • Increase in skew angle leads to difficulties with tying into emergency overflow channel from water quality pond. A staggered inlet arrangement would be required to overcome these difficulties, adding to the cost to this option. • Requires reach of Maxwells Creek north (downstream) of road corridor to be re-aligned. • Minimises fish passage opportunities.
Bridge	• Footprint of structure is limited to that of the road. • Considered to be a softer engineering solution to the box culvert option. • Maximises fish passage opportunities. • Risk of blockage by debris significantly lower than box culvert option. • Creek can be reinstated to a more natural form beneath road crossing.	• Maximum skew angle equal to 35-40º. • Most expensive option. • Requires reach of Maxwells Creek north (downstream) of road corridor to be re-aligned.

1. Note that the angle flow approaches the inlet to the box culvert system would need to be taken into account when considering increasing the skew angle beyond 30º.

TABLE 6.2
KEY FEATURES OF EXISTING AND RECOMMENDED CROSS DRAINAGE AT MAXWELLS CREEK

Description (1)	Existing Cross Drainage	Recommended Cross Drainage
Configuration	3 off 2700 x 1200 RCBC's	Single span bridge
Length (m)	18	43
Clear Span	n/a	20 m
Abutment Type	n/a	Spill-through, 1V:1.5H
Road level at eastern abutment (m AHD)	44.9	45.1
Road level at western abutment (m AHD)	45.0	45.4
Soffit level at eastern abutment (m AHD)	n/a	44.1 (2)
Soffit level at western abutment (m AHD)	n/a	44.4 (2)
Performance for 100 year ARI flood event		
Peak flood level (m AHD)	44.2	43.5
Freeboard to road level at eastern abutment (m)	0.7 (3)	1.6
Freeboard to road level at western abutment (m)	0.8 (3)	1.9
Clearance to soffit level at eastern abutment (m)	n/a	0.6 (2)
Clearance to soffit level at western abutment (m)	n/a	0.9 (2)

1. Flood level, road/soffit levels, freeboard and clearance all quoted for upstream (southern) side of road corridor.
2. Estimated soffit level and clearance based on assumed bridge superstructure (i.e. bridge deck plus pavement) depth of 1 m.
3. Note that whilst positive freeboard exists adjacent to the box culvert structure under present day conditions, Campbelltown Road is surcharged further east in the vicinity of Ingleburn Gardens Drive. Refer **Section 4.3.2** for details.

6.4.3 Realignment of Maxwells Creek

Realignment of Maxwells Creek where it runs immediately downstream (north) of Campbelltown Road will be required to accommodate the proposed road widening. The length of new creek channel required to locate the creek outside the footprint of the widened road formation extends approximately 85 m from the outlet of the existing three cell box culvert. The total length of new channel works, including the section under the new bridge structure, would be approximately 105 m. The extent of these works is shown on **Figures 6.2A** and **6.2B**.

As described in **Section 2.2**, the existing in-bank section of Maxwells Creek where it runs downstream of Campbelltown Road contains some scattered trees and other light vegetation (refer **Plates 7** and **8** in **Appendix A**). The existing creek channel bends sharply to the east a short distance downstream of the road corridor, and narrows to a width of 8 – 9 m at top of bank level (approximately 5 m at bed level) before continuing generally to the north-east.

The engineered creek cross section adopted for the purpose of this present investigation comprised a trapezoidal section with a 10 m base width and 1(vertical):2(horizontal) bank slopes (refer typical section shown on **Figure 6.2B**). The channel works would need to widen to a base width of 12 m beneath the new bridge, and narrow to a base width of about 5 m at the downstream tie-in to the existing creekline. The longitudinal grade of the new creek channel would be approximately 1.2 per cent, which closely matches the grade of the existing creek bed.

Key features of the creek realignment works would also comprise the following:

- Vegetation of the creek bed and banks with native grasses and other low groundcovers. From a hydraulic perspective, scattered shrubs and small trees would also be suitable for establishment on the creek banks.
- A rock-lined low flow channel extending along the length of the creek realignment, including beneath the new bridge structure, to concentrate frequent low flows in the creek invert.
- Appropriately sized and graded rock riprap scour protection for the new bridge abutments. The outside bend of the realigned section of creek downstream (north) of the new bridge will also need to be adequately protected with rock riprap.

Note that it would be feasible to engineer a more natural, benched creek bank along the left (northern) side of the realigned creek, and it is recommended that this is investigated further during detailed design.

Flooding events associated with morphologic activity in natural streams are those that relate to near bankfull flow conditions. In south-eastern Australia these stream-forming flows typically occur for events with a recurrence interval of around 1 to 2 years.

Figures 6.11 and **6.12** demonstrate that the proposed new bridge and creek realignment works at Maxwells Creek will have only a minor impact on flow depths and velocities both upstream (south) and downstream (north) of the road corridor for storms with ARI's of 1 and 2 years. On this basis, the risk to stream stability both upstream and downstream of the creek realignment as a result of the road upgrade is considered to be negligible.

By inspection of **Figure 6.11**, impacts on flow depths outside the footprint of the proposed works are confined to the area immediately upstream of the new bridge structure for both the 1 and 2 year ARI events (refer right hand panels). This occurs as a result of removing the backwater imposed by the existing box culvert structure, and the introduction of a more efficient waterway under the new bridge.

Figure 6.12 demonstrates that the reduction in flow depths immediately upstream of the new bridge are accompanied by a corresponding acceleration of flow through the section of channel that has recently been modified by the developer of the Ingleburn Gardens Estate (refer **Section 2.2** for further details of these recent works).

At the time of writing, the final surface treatment in the section of engineered channel immediately upstream of Campbelltown Road (i.e. the channel works recently undertaken by the developer of Ingleburn Gardens Estate – refer **Section 2.2** for details) is not known. It is recommended that during detailed design of the road upgrade works further hydraulic analyses are undertaken to assess the impact that removal of the backwater imposed by the existing box culvert system will have on the scour potential of the creek bed upstream (south) of the new bridge, to determine the need for additional scour protection measures in this area.

Figure 6.12 also shows that flow velocities in the section of Maxwells Creek immediately downstream of the realignment works would be slightly reduced for the 1 year ARI event (refer top right panel). This suggests the width of the new creek channel as modelled for the purpose of this present investigation has introduced additional storage into the creek that is sufficient to slightly attenuate flows for the smaller, more frequent flood events. However, this degree of flow attenuation and corresponding reduction in flow velocities is not evident for the 2 year ARI event (refer bottom right panel), therefore it is not recommended to reduce the width of the new channel works below that specified above.

6.5 South West Rail Link Overpass to Macdonald Road Upgrade Requirements

There are no requirements for cross drainage along the section of Campbelltown Road which runs between the South West Rail Link Overpass and Macdonald Road. Details on the strategy which is to be adopted for managing the flow of water off this section of Campbelltown Road are contained in **Chapter 7** of this report.

6.6 Macdonald Road to Zouch Road Upgrade Requirements

6.6.1 Cross Drainage Structure X9

It will be necessary to replace the existing 1 off 375 RCP at **DRC 3900** with 2 off 600 RCP's to provide a minimum 100 year ARI hydrologic standard to the upgraded road (refer **Figure 6.14**).

A new drainage channel will need to be constructed at the outlet of Cross Drainage Structure X9, extending approximately 190 m to the south around the western side of Mont Saint Quentin Oval. This channel will connect into the subdivision drainage system that is to be constructed by Landcom as part of their Edmondson Park South development. RMS will need to liaise further with Landcom during detailed design of the road upgrade regarding the design and location of the channel works.

Limiting the size of the upgraded cross drainage at **DRC 3900** to 600 mm diameter will assist in reducing the depth of the outlet channel. However, this sizing should be reviewed in conjunction with the ultimate design of the channel works downstream of the road corridor.

6.7 Zouch Road to Denham Court Road Upgrade Requirements

6.7.1 Cross Drainage Structures X10 and X11

Between **DRC 4720** and Denham Court Road, current design road levels put the widened road in cut along the upslope (eastern) side of the road corridor. It would be difficult to control and direct runoff along the upslope side of the road towards upgraded cross drainage structures at **DRC 4720** and **DRC 4940** given the presence of several access driveways which will need to be maintained as part of the road upgrade.

It is therefore recommended that existing Cross Drainage Structures X10 and X11 be removed, with runoff from the upslope catchments introduced into the new pavement drainage system along the length of road corridor between about **DRC 4440** and Denham Court Road (refer **Figure 6.15**). A series of catch drains would be required along the top of the cut batter, with inlet pits provided as required to manage flows and to suit new driveway access locations.

It is recommended that combined runoff generated on both upslope catchments and the new carriageways be discharged on the western side of the road corridor at **DRC 4760** and **DRC 4920** (refer **Figure 6.15**). Further details on the strategy which is recommended for managing the flow of water downstream (west) of the road corridor are contained in **Chapter 7** of this report.

7 PAVEMENT DRAINAGE STRATEGY

7.1 General

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

Table S2 at the front of this report presents the recommended pavement drainage strategy for the upgraded length of Campbelltown Road. **Figures 6.1**, **6.2** (**A** and **B**), **6.13**, **6.14** and **6.15** (6 sheets in total) show the recommended pavement drainage strategy along Campbelltown Road and should be referred to when reading **Table S2** and the following sections of the report.

The following sections provide relevant background information to assist the reader in understanding the basis for development of the pavement drainage strategy for Campbelltown Road.

7.2 Staging of the Road Upgrade

The following road configurations have been adopted for the purpose of estimating peak flows and assessing the impact of the road works on existing development:

- Three lanes in each direction, or two lanes with a wide median at grade:
  - Camden Valley Way to Zouch Road (between **DRC 0** and **DRC 4200**)
- Two lanes in each direction with a wide grassed median (for future widening in each direction):
  - Zouch Road to Denham Court Road (between **DRC 4200** and **DRC 5100**)

Note that staging of the road upgrade has not been considered for the purpose of this present investigation (i.e. it has been assumed that upgrade of the full length of Campbelltown Road between Camden Valley Way and Denham Court Road will be undertaken in a single stage).

It will, however, be necessary for the designers of the road upgrade to size the pavement drainage system assuming Campbelltown Road is in its ultimate six-lane configuration for the full length of road corridor between Camden Valley Way and Denham Court Road. The designers will also need to consider issues associated with the staged implementation of the upgrade when configuring the pavement drainage system, in particular to cater for depressed medians that will ultimately be converted to additional trafficable lanes.

RMS should also liaise with Landcom and LCC and request that they require future development located downstream of the road corridor to adopt the ultimate six-lane configuration when sizing receiving drainage lines.

7.3 Concept Pavement Drainage System Layout

To assist in future development of the detailed design of the road upgrade, a concept layout for the new pavement drainage system was also prepared as part of this present investigation.

Figures 6.1, **6.2** (**A** and **B**), **6.13**, **6.14** and **6.15** show the indicative location of inlet pits and piped drainage lines that will be required to capture and convey runoff from the ultimate six-lane configuration of Campbelltown Road to receiving drainage lines. **Table 7.1** provides a summary of the elements comprising the concept pavement drainage system for Campbelltown Road. The adopted hydrologic standard for the concept pavement drainage system was an ARI of 20 years, as nominated in RMS' Brief.

TABLE 7.1
SUMMARY OF ELEMENTS COMPRISING
CONCEPT PAVEMENT DRAINAGE SYSTEM (1,2)

Drainage Element	Diameter (mm) / Pit Type (3)	Total Pipe Length (m) / No. of Pits/Headwalls
Reinforced Concrete Pipe	375	5020
	450	4000
	525	780
	600	470
	675	290
Pit/Headwall	SA2	314
	SAS	13
	SF	32
	MGSG	30
	Junction	9
	Headwall	10

1. **Figures 6.1**, **6.2** (**A** and **B**), **6.13**, **6.14** and **6.15** (6 sheets in total) show the recommended pavement drainage strategy for the upgraded length of Campbelltown Road.
2. Piped drainage elements forming part of recommended cross drainage strategy are not included in the above table.
3. Refer RMS standard drawings for pit/headwall details.

7.4 Catchment Modelling

The investigation into the impact the road upgrade will have on peak flows in the receiving drainage lines downstream of Campbelltown Road was undertaken using the DRAINS software.

Section 3 provides details of the adopted approach for establishing a DRAINS model to represent present day catchment conditions. This model was adjusted to reflect post-road upgrade conditions, by incorporating upgraded cross drainage structures and sections of proposed road pavement as lumped sub-catchments.

The changes in peak flow which will result from the road upgrade works are summarised in **Table 7.2** (over) for selected locations both immediately downstream of the road corridor and further downstream in receiving drainage lines where appropriate. These locations are shown on **Figures 6.1**, **6.2A**, **6.13**, **6.14** and **6.15**, and are referenced in **Table S2** where applicable.

TABLE 7.2
SUMMARY OF PEAK FLOWS (1)

Location Identifier	Location	2 year ARI				5 year ARI				10 year ARI				20 year ARI				100 year ARI			
		Present Day	Post Road Widening	Difference (2)		Present Day	Post Road Widening	Difference (2)		Present Day	Post Road Widening	Difference (2)		Present Day	Post Road Widening	Difference (2)		Present Day	Post Road Widening	Difference (2)	
		(m^3/s)	(m^3/s)	(m^3/s)	(%)	(m^3/s)	(m^3/s)	(m^3/s)	(%)	(m^3/s)	(m^3/s)	(m^3/s)	(%)	(m^3/s)	(m^3/s)	(m^3/s)	(%)	(m^3/s)	(m^3/s)	(m^3/s)	(%)
P1.1	Combined flow in drainage line at DRC 560, immediately downstream (north) of road corridor	4.32	4.59	0.27	6%	6.31	6.58	0.27	4%	7.35	7.64	0.29	4%	9.02	9.37	0.35	4%	12.91	13.33	0.42	3%
P2.1	Combined flow in drainage line at DRC 1200, immediately downstream (north) of road corridor	1.43	1.64	0.21	15%	2.51	2.73	0.22	9%	3.16	3.30	0.15	5%	4.15	4.27	0.12	3%	6.90	7.00	0.09	1%
P4.1	Drainage line at DRC 2040, immediately downstream (north) of road corridor	0.60	0.90	0.30	50%	0.84	1.22	0.38	45%	0.97	1.38	0.41	42%	1.16	1.60	0.44	38%	1.47	2.04	0.57	39%
P4.2	Maxwells Creek, downstream of drainage line at DRC 2040	15.02	15.24	0.23	1%	25.38	25.66	0.28	1%	30.98	31.29	0.31	1%	39.96	40.26	0.30	1%	56.39	56.69	0.30	1%
P5.1	Maxwells Creek at DRC 2300	8.02	8.24	0.22	3%	13.75	13.94	0.19	1%	16.32	16.51	0.19	1%	21.16	21.26	0.11	1%	29.76	29.90	0.15	0%
P6.1	Outlet of new pavement drainage system at DRC 2800	0	0.28	0.28	100%	0	0.37	0.37	100%	0	0.41	0.41	100%	0	0.47	0.47	100%	0	0.58	0.58	100%
P7.1	Outlet of new pavement drainage system at DRC 3100	0	0.47	0.47	100%	0	0.64	0.64	100%	0	0.73	0.73	100%	0	0.87	0.87	100%	0	1.15	1.15	100%
P7.2	Future riparian corridor, downstream (south) of new outlet at DRC 3100	0.89	1.17	0.29	32%	1.55	1.85	0.30	19%	1.85	2.21	0.36	19%	2.23	2.66	0.42	19%	2.93	3.49	0.56	19%
P7.3	Future riparian corridor, downstream (south) of new outlets at DRC 2800 and 3100	1.81	2.54	0.73	40%	3.05	4.06	1.02	33%	3.89	4.98	1.09	28%	4.73	5.90	1.17	25%	6.22	7.66	1.44	23%
P8.1	Drainage line at DRC 3900, immediately downstream (south) of road corridor	0.25	0.63	0.38	151%	0.43	0.94	0.51	118%	0.54	1.10	0.56	105%	0.70	1.37	0.67	95%	1.15	2.03	0.88	76%
P9.1	Drainage line at DRC 4720, immediately downstream (west) of road corridor	0.19	0.39	0.21	113%	0.31	0.59	0.28	89%	0.38	0.70	0.32	83%	0.50	0.87	0.38	75%	0.77	1.29	0.52	68%
P10.1	Drainage line at DRC 4940, immediately downstream (west) of road corridor	0.45	0.62	0.17	37%	0.79	0.96	0.18	23%	0.96	1.16	0.20	20%	1.25	1.46	0.21	17%	2.14	2.29	0.16	7%
P10.2	Tributary Arm of Cabramatta Creek, 100 m downstream (west) of road corridor	1.04	1.22	0.17	16%	1.81	1.99	0.18	10%	2.23	2.42	0.19	9%	2.84	3.11	0.27	10%	4.89	5.13	0.24	5%
P10.3	Tributary Arm of Cabramatta Creek, downstream (north) of Denham Court Caravan Park	1.74	2.10	0.36	21%	2.96	3.39	0.43	15%	3.60	4.07	0.47	13%	4.57	5.10	0.53	12%	7.03	7.69	0.66	9%

Note:
Refer **Figures 6.1**, **6.2A**, **6.13**, **6.14** and **6.15** for reference to Location Identifier
(1) Peak flows have been quoted to more than one decimal place for comparative purposes only.
(2) Note that a positive value represents an increase in peak flows when compared to present day conditions.

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8 EROSION AND SEDIMENT CONTROL STRATEGY

8.1 General

A preliminary assessment was undertaken to determine the average annual volume of sediment which could be "washed off" disturbed areas within the road corridor if appropriate measures aren't implemented by the Contractor during the construction phase of the project. Based on the findings of this preliminary assessment, it was concluded that large scale sediment retention basins do not necessarily need to form part of the *Soil and Water Management Plan* (SWMP) (or similar) for the road upgrade project. Rather, the provision of a series of smaller temporary sediment sumps positioned at key locations along the road corridor would necessarily be sufficient to manage runoff from disturbed areas during construction.

It is recommended that the strategy presented in this section of the report be used as the starting point for the preparation of the 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.

8.2 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 "on-site" water and bypass "off-site" water through the construction site, 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 drainage lines through the site;
- separation of clean and dirty water wherever possible;
- site maintenance requirements; and
- progressive site rehabilitation.

<u>Local erosion and sediment control measures</u>

The publications entitled *"Soils and Construction – Managing Urban Stormwater"* Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008). *[Note that subsequent references to the "Blue Book" refer to both publications in a combined sense.]* allow 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), is less than 150 m^3/annum.[1]

[1] Refer Appendix A of the *Blue Book* (Landcom, 2004) for details of the RUSLE

To demonstrate that large scale sediment retention basins do not necessarily need to form part of the SWMP for the road upgrade project, the road corridor was divided into a number of discrete areas (denoted hereon as “local erosion and sediment control areas”, or LESCA’s) and the average annual soil loss from each computed by application of the RUSLE. The extent of each LESCA was derived based on a review of the available contour data and an assessment of the likely location where runoff from the road corridor will discharge to receiving drainage lines during the construction phase of the project.

Figures 8.1 to **8.5** show the extent of the LESCA’s along the route of the road upgrade, as well as the estimated average annual soil loss from each. **Table 8.1** summarises the parameters which are constant in the RUSLE for the site, whilst **Table A1** in **Annexure A** gives the average annual soil loss derived for each LESCA, as well as the RUSLE parameters which are unique to each.

TABLE 8.1
CONSTANT PARAMETERS ADOPTED FOR APPLICATION TO THE RUSLE

Parameter	Value	Comment
Rainfall Intensity for 2 year ARI, 6 hour duration design storm	10.3 mm/hr	For Claremont Meadows through which the Stage 1 works run
Rainfall Erosivity Factor (R)	2329	Based on 2 year ARI, 6 hour duration design storm
Soil/sediment Type	D D F	Blacktown Soil Landscape Luddenham Soil Landscape South Creek Soil Landscape
Soil Erodibility Factor [2] (K)	0.038 0.038 0.05	Blacktown Soil Landscape Luddenham Soil Landscape South Creek Soil Landscape
Erosion Control Practice Factor (P)	1.3	Representative of compacted and smooth surface conditions on site
Cover Factor (C)	1.0	Representative of bare earth conditions on site.

By inspection of the values given in **Table A1** in **Annexure A** (and also shown on **Figures 8.1** to **8.5**), it can be seen that the estimated average annual soil loss from each LESCA does 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 smaller scale elements:

- temporary revegetation/rehabilitation works to reduce the extent of disturbed surfaces;
- application of temporary surface treatments or blanketing on exposed earth surfaces;

[2] Values taken from Table C20 in Appendix C of Landcom, 2004

- sediment barriers and sumps, in series where necessary;
- vegetative buffer strips; and
- stabilised drainage lines incorporating rock check dams at regular intervals.

Figures 8.1 to **8.5** show the locations where temporary sediment sumps could be built to control runoff from disturbed areas during construction. The location of the sumps was determined based on a review of the available contour data and an assessment of the likely location where runoff from the road corridor will discharge to receiving drainage lines during the construction phase of the project.

Ultimate requirements for temporary sediment sumps along the length of road corridor will be dictated by final design of the road upgrade, proposed construction methods and staging plans, and site management practices.

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9 PROPERTY IMPACTS

9.1 General

Tables S1 and **S2** at the front of this report summarise the recommended drainage strategy for the upgrade of Campbelltown Road, including requirements for both cross and pavement drainage, respectively. **Figures 6.1**, **6.2** (**A** and **B**), **6.13**, **6.14** and **6.15** show the layout of the cross and pavement drainage lines comprising the recommended drainage strategy.

Table 9.1 over provides a summary of residual drainage-related property impacts should the recommended drainage strategy be implemented by RMS.

As previously mentioned, table drains will be required in a number of locations along Campbelltown Road to intercept and control runoff along the upslope side of the road corridor, and will require the road works to extend beyond the footprint of RMS's May 2012 concept road design model. This may have implications for land acquisitions and/or easements where works will extend outside the existing road corridor. The impacts outlined in **Table 9.1** do not identify the individual properties for which these table drains may have implications for land acquisition and/or easement requirements.

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TABLE 9.1
SUMMARY OF RESIDUAL PROPERTY IMPACTS FOLLOWING IMPLEMENTATION OF RECOMMENDED DRAINAGE STRATEGY

Section	Figure Ref.	Cross Drainage Identifier (1)	Pavement Drainage Outlet Identifier (1)	Summary of Drainage-Related Property Impacts
Camden Valley Way to Hume Highway	6.1	X1	n/a	➢ Requirements for upgrading the existing cross drainage structure under Glenfield Road were unable to be determined. Further assessment will be required during detailed design of the road upgrade, based on additional survey data. Whilst precise property impacts cannot be determined at this time, detailed design of the road upgrade will aim to minimise impacts by locating new or upgraded drainage infrastructure within the existing road corridor as far as practicable, and to ensure that the road upgrade will not increase peak flood levels along the upstream (northern) side of Glenfield Road.
Camden Valley Way to Hume Highway	6.1	X2 / X3	P1	➢ Impact of road upgrade on peak flows downstream of the road corridor is negligible, due to the minor nature of proposed road widening in this area.
	6.1	X4	P2	➢ Impact of road upgrade on peak flows downstream of the road corridor is negligible, due to the minor nature of proposed road widening in this area.
	6.1	X5	n/a	➢ New drainage channel to receive flows from upgraded cross drainage to be constructed along southern side of road corridor. Channel works will extend outside the existing road corridor into Lot 1 in DP 270152.
Hume Highway to South West Rail Link Overpass	6.2A	X6	n/a	➢ Existing 1 off 1050 RCP to be extended on northern side of road corridor. New pipe and tail out works into existing drainage line confined to existing road reserve. ➢ Residual impact on peak flows in receiving drainage line is negligible.
	6.2A	X7	P3 / P4	➢ New combined outlet incorporating energy dissipation and scour protection measures to be constructed for upgraded cross and pavement drainage systems. An area measuring approximately 5 x 5 m is required at the foot of the widened road embankment, within the adjacent Regional Park, to construct these measures. Easement also to be obtained over this area within the Regional Park. ➢ Residual increase in peak flows along receiving drainage line ranges between 50% for the 2 year ARI and 39% for the 100 year ARI (refer location **P4.1**). Associated minor increase in peak flood levels along receiving drainage line is confined to Regional Park.
	6.2A	X8	P5	➢ 85 m long section of Maxwells Creek to be realigned where it runs immediately downstream (north) of Campbelltown Road. The footprint of creek realignment works will extend outside the widened road corridor into the adjacent Regional Park. ➢ Impacts on flow depths and velocities along Maxwells Creek downstream of the creek realignment are minor only, and are not considered to present a risk of increased scouring or erosion. ➢ Residual impact on peak flows along main arm of Maxwells Creek immediately downstream of the road corridor is negligible for events up to and including 100 year ARI. ➢ Further investigation will be required during detailed design of the road upgrade to determine the need for scour protection measures in the section of Maxwells Creek immediately upstream (south) of the road corridor.
South West Rail Link Overpass to Macdonald Road	6.13	n/a	P6 / P7	➢ New piped drainage systems along Croatia Avenue and East Town Centre Road to be constructed to convey runoff from new pavement drainage systems to future riparian corridor within Edmondson Park South development. Final location of new drainage works along future road corridors to be confirmed in conjunction with Landcom.
Macdonald Road to Zouch Road	6.14	X9	P8	➢ New grass-lined channel and low flow piped drainage system to convey runoff from upgraded cross and pavement drainage systems to be constructed around western side of Mont Saint Quentin Oval, connecting to future Landcom subdivision drainage system. Final location of new drainage works located outside road corridor to be confirmed in conjunction with Landcom.
Zouch Road to Denham Court Road	6.15	n/a	P9	➢ Existing piped drainage system in Lot 27 in DP 1443 to be replaced by new 1 off 1050 RCP and associated easement (approx. 4 m wide). ➢ Existing creek between new piped outlet in Lot 27 in DP 1443 and existing farm dam in Lot 1 in DP 608141 to be rehabilitated.
	6.15	n/a	P10	➢ New 1 off 1200 RCP and associated easement (approx. 4 m wide) to be located along northern boundary of Lot 21 in DP 1443. ➢ New low flow piped drainage system and associated easement (approx. 4 m wide) to be located along invert of existing grassed swale in Lot 1 in DP 630181 (Denham Court Caravan Park). ➢ Existing creek between new piped outlet in Lot 1 in DP 630181 and existing farm dam in Lot 1 in DP 608141 to be rehabilitated. ➢ Residual increase in peak flows along tributary arm of Cabramatta Creek where it enters existing farm dam in Lot 1 in DP 608141 ranges between 21% for the 2 year ARI and 9% for the 100 year ARI (refer location **P10.3**).

(1) Refer **Figures 6.1**, **6.2A**, **6.13**, **6.14** and **6.15** for reference to Cross and Pavement Drainage Identifiers.

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10 REFERENCES

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ANNEXURE A

TABLE SUMMARISING ESTIMATED AVERAGE ANNUAL SOIL LOSS FROM ROAD CORRIDOR

TABLE A1
ESTIMATED AVERAGE ANNUAL SOIL LOSS FROM ROAD CORRIDOR

LESCA No.	Local Identifier	Slope Length (m)	Gradient (%)	LS Factor	Sediment Load (tonnes/ha/yr)	Area Contributing to On-site Water (ha)	Sediment Load (m^3/yr)
1	SBC_280 (1a)	58.00	1.94	0.34	39.12	0.12	3.2
	SBC_280 (1b)	55.00	1.82	0.32	36.82	0.08	1.8
	SBC_280 (2)	71.00	4.93	1.08	124.27	0.37	30.9
						Total	**35.9**
2	NBC_280	56.00	5.36	1.05	120.82	0.44	35.5
						Total	**35.5**
3	NBC_630 (1)	43.00	3.49	0.57	65.59	0.17	7.4
	NBC_630 (2)	33.00	3.03	0.43	49.48	0.41	13.5
	NBC_630 (3)	13.00	11.54	0.96	110.46	0.13	9.9
						Total	**30.8**
4	SBC_630 (1)	24.00	4.17	0.50	57.53	0.13	5.0
	SBC_630 (2)	94.00	1.60	0.34	39.12	0.30	7.9
	SBC_630 (3)	13.00	3.85	0.33	37.97	0.15	3.7
						Total	**16.5**
5	SBC_800	95.00	1.05	0.21	24.16	0.33	5.3
						Total	**5.3**
6	NBC_1020 (1)	14.00	10.71	0.92	105.86	0.08	5.9
	NBC_1020 (2)	7.00	14.29	0.80	92.05	0.16	9.7
	NBC_1020 (3)	17.00	2.94	0.30	34.52	0.55	12.5
						Total	**28.2**
7	SBC_800	80.00	1.25	0.26	29.92	0.42	8.4
						Total	**8.4**
8	SBC_1180 (1)	34.00	4.41	0.64	73.64	0.18	8.6
	SBC_1180 (2)	20.00	3.75	0.42	48.33	0.25	8.1
						Total	**16.7**

TABLE A1 (Cont'd)
ESTIMATED AVERAGE ANNUAL SOIL LOSS FROM ROAD CORRIDOR

LESCA No.	Local Identifier	Slope Length (m)	Gradient (%)	LS Factor	Sediment Load (tonnes/ha/yr)	Area Contributing to On-site Water (ha)	Sediment Load (m^3/yr)
9	NBC_1200 (1)	29.00	3.45	0.45	51.78	0.36	12.5
	NBC_1200 (2)	15.40	6.49	0.58	66.74	0.20	9
	NBC_1200 (3)	50.00	2.00	0.34	39.12	0.15	4
	NBC_1200 (4)	10.80	18.52	1.46	168.00	0.12	13.9
	NBC_1200 (5)	11.50	39.13	3.09	355.56	0.06	14.1
	NBC_1200 (6)	10.00	5.00	0.36	41.42	0.03	0.9
						Total	**54.4**
10	SBC_1220 (1)	20.00	3.75	0.42	48.33	0.29	9.3
	SBC_1220 (2)	58.00	1.72	0.31	35.67	0.17	4.1
	SBC_1220 (3)	23.00	3.26	0.39	44.88	0.16	4.6
	SBC_1220 (4)	13.40	44.78	3.87	445.31	0.05	14.4
	SBC_1220 (5)	10.00	3.75	0.29	33.37	0.03	0.6
						Total	**33.0**
11	NBC_1650 (1)	17.00	4.41	0.43	49.48	0.05	1.6
	NBC_1650 (2)	11.00	29.55	2.36	271.56	0.04	7.7
	NBC_1650 (3)	12.30	32.52	2.79	321.04	0.30	64.8
	NBC_1650 (4)	13.00	15.38	1.36	156.49	0.10	10
	NBC_1650 (5)	15.00	3.33	0.32	36.82	0.16	4
						Total	**88.1**
12	SBC_1850 (1)	31.00	1.61	0.23	26.47	0.06	1
	SBC_1850 (2)	11.00	36.36	2.81	323.34	0.04	8.5
	SBC_1850 (3)	5.70	39.47	1.76	202.52	0.06	7.5
	SBC_1850 (4)	214.00	2.10	0.64	73.64	0.37	18.4
	SBC_1850 (5)	42.00	1.19	0.19	21.86	0.37	5.4
						Total	**40.8**

TABLE A1 (Cont'd)
ESTIMATED AVERAGE ANNUAL SOIL LOSS FROM ROAD CORRIDOR

LESCA No.	Local Identifier	Slope Length (m)	Gradient (%)	LS Factor	Sediment Load (tonnes/ha/yr)	Area Contributing to On-site Water (ha)	Sediment Load (m^3/yr)
13	NBC_2000 (1)	20.00	1.25	0.16	18.41	0.19	2.4
	NBC_2000 (2)	5.60	8.93	0.40	46.03	0.08	2.3
						Total	**4.7**
14	SBC_2300	171.00	1.00	0.23	26.47	0.33	5.9
						Total	**5.9**
15	NBC_2150 (1)	16.00	3.13	0.31	35.67	0.05	1.1
	NBC_2150 (2)	9.00	1.39	0.13	14.96	0.11	1.1
	NBC_2150 (3)	21.00	4.76	0.53	60.99	0.11	4.6
	NBC_2150 (4)	10.00	25.00	1.88	216.32	0.06	8.7
						Total	**15.5**
16	NBC_2300 (1)	13.60	14.71	1.34	154.19	0.03	3.1
	NBC_2300 (2)	19.00	5.26	0.55	63.29	0.10	4.3
	NBC_2300 (3)	35.00	4.29	0.64	96.90	0.27	17.4
						Total	**24.8**
17	SBC_2320 (1)	23.40	2.14	0.27	31.07	0.14	2.8
	SBC_2320 (2)	70.00	2.86	0.58	87.81	0.17	10
						Total	**12.8**
18	SBC_2480 (1)	43.00	3.49	0.57	86.30	0.22	12.5
	SBC_2480 (2)	31.00	4.84	0.67	77.09	0.33	17.2
	SBC_2480 (3)	77.00	1.95	0.39	44.88	0.20	5.9
						Total	**35.6**
19	NBC_2550 (1)	35.00	4.29	0.63	95.38	0.14	8.8
	NBC_2550 (2)	42.00	4.76	0.78	89.75	0.27	16.1
	NBC_2550 (3)	49.00	2.04	0.34	39.12	0.28	7.4
						Total	**32.3**

TABLE A1 (Cont'd)
ESTIMATED AVERAGE ANNUAL SOIL LOSS FROM ROAD CORRIDOR

LESCA No.	Local Identifier	Slope Length (m)	Gradient (%)	LS Factor	Sediment Load (tonnes/ha/yr)	Area Contributing to On-site Water (ha)	Sediment Load (m^3/yr)
20	NBC_2850 (1)	20.00	2.50	0.29	33.37	0.31	6.8
	NBC_2850 (2)	54.00	1.85	0.32	36.82	0.26	6.5
						Total	**13.3**
21	SBC_2870 (1)	27.00	3.70	0.47	54.08	0.25	9.1
	SBC_2870 (2)	31.00	3.23	0.45	51.78	0.33	11.4
						Total	**20.5**
22	NBC_3170 (1)	80.00	1.88	0.38	43.73	0.28	8.2
	NBC_3170 (2)	97.00	3.09	0.74	85.15	0.34	19.2
	NBC_3170 (3)	19.00	2.63	0.21	24.16	0.12	1.9
						Total	**29.3**
23	SBC_3170 (1)	25.00	2.00	0.26	29.92	0.24	4.8
	SBC_3170 (2)	77.00	3.90	0.87	100.11	0.28	18.9
	SBC_3170 (3)	25.00	6.00	0.68	78.25	0.15	7.9
						Total	**31.6**
24	NBC_3520 (1)	56.00	1.00	0.18	20.71	0.24	3.4
	NBC_3520 (2)	48.00	2.08	0.35	40.27	0.28	7.5
						Total	**10.9**
25	SBC_3520 (1)	23.00	2.17	0.27	31.07	0.25	5.1
	SBC_3520 (2)	24.00	4.17	0.50	57.53	0.17	6.3
	SBC_3520 (3)	15.00	3.33	0.32	36.82	0.10	2.6
						Total	**14.0**
26	NBC_3900 (1)	18.00	2.78	0.30	34.52	0.16	3.8
	NBC_3900 (2)	8.00	3.13	0.22	25.31	0.03	0.5
						Total	**4.2**
27	SBC_3900	17.50	8.57	0.82	94.35	0.24	15.0
						Total	**15.0**

TABLE A1 (Cont'd)
ESTIMATED AVERAGE ANNUAL SOIL LOSS FROM ROAD CORRIDOR

LESCA No.	Local Identifier	Slope Length (m)	Gradient (%)	LS Factor	Sediment Load (tonnes/ha/yr)	Area Contributing to On-site Water (ha)	Sediment Load (m^3/yr)
28	NBC_3920 (1)	19.00	2.63	0.29	33.37	0.01	0.3
	NBC_3920 (2)	17.00	2.94	0.30	34.52	0.16	3.6
	NBC_3920 (3)	49.00	3.06	0.53	60.99	0.27	11.1
						Total	**15.0**
29	SBC_3920 (1)	22.00	6.82	0.76	87.45	0.21	12.3
	SBC_3920 (2)	21.00	7.14	0.77	88.60	0.25	14.9
	SBC_3920 (3)	30.00	5.00	0.68	78.25	0.20	10.7
	SBC_3920 (4)	14.00	2.68	0.26	29.92	0.05	0.9
						Total	**38.8**
30	NBC_4160 (1)	6.00	8.33	0.39	44.88	0.07	2.2
	NBC_4160 (2)	50.00	1.00	0.17	19.56	0.07	0.9
	NBC_4160 (3)	24.00	4.17	0.50	57.53	0.29	11
	NBC_4160 (4)	90.00	1.00	0.20	23.01	0.15	2.2
						Total	**16.3**
31	SBC_4440	26.00	3.85	0.48	55.23	0.31	11.5
						Total	**11.5**
32	NBC_4710 (1)	17.00	2.94	0.30	34.52	0.21	4.9
	NBC_4710 (2)	24.00	4.17	0.50	57.53	0.39	14.8
	NBC_4710 (3)	34.00	2.94	0.43	49.48	0.36	11.7
	NBC_4710 (4)	35.00	4.29	0.63	72.49	0.35	17
						Total	**48.4**
33	NBC_4940 (1)	38.00	6.58	1.03	118.52	0.74	58.8
	NBC_4940 (2)	23.00	6.52	0.52	59.83	0.13	5.1
	NBC_4940 (3)	37.00	4.05	0.61	70.19	0.71	33.3
						Total	**97.2**

TABLE A1 (Cont'd)
ESTIMATED AVERAGE ANNUAL SOIL LOSS FROM ROAD CORRIDOR

LESCA No.	Local Identifier	Slope Length (m)	Gradient (%)	LS Factor	Sediment Load (tonnes/ha/yr)	Area Contributing to On-site Water (ha)	Sediment Load (m^3/yr)
34	NBC_5100 (1)	56.00	3.57	0.67	77.09	0.34	17.3
	NBC_5100 (2)	27.00	5.56	0.71	81.70	0.16	8.7
						Total	**26.0**
35	NBC_5160	32.00	4.69	0.66	75.94	0.32	16.1
						Total	**16.1**
36	NBC_5240 (1)	16.00	12.50	1.24	142.68	0.15	14.6
	NBC_5240 (2)	21.00	1.19	0.15	17.26	0.14	1.6
						Total	**16.2**
37	NBC_5350 (1)	25.00	6.00	0.73	84.00	0.08	4.4
	NBC_5350 (2)	11.00	13.64	1.05	120.82	0.04	2.9
						Total	**7.3**
38	NBC_5430	8.00	6.25	0.38	43.73	0.05	1.3
						Total	**1.3**
39	SBC_5430	21.00	2.38	0.28	32.22	0.21	4.4
						Total	**4.4**