5.2 DEVELOPED CONDITIONS (NO DETENTION)

A brief description of the proposed development and layout within Googong Creek is provided in Section 2.2. This section describes the flood conditions for Googong Creek after to the development of Googong New Town, with the assumption of no detention. This section provides descriptions of the hydrologic and hydraulic calculations used to develop the flood extents maps.

5.2.1 Developed Conditions Hydrologic Modelling

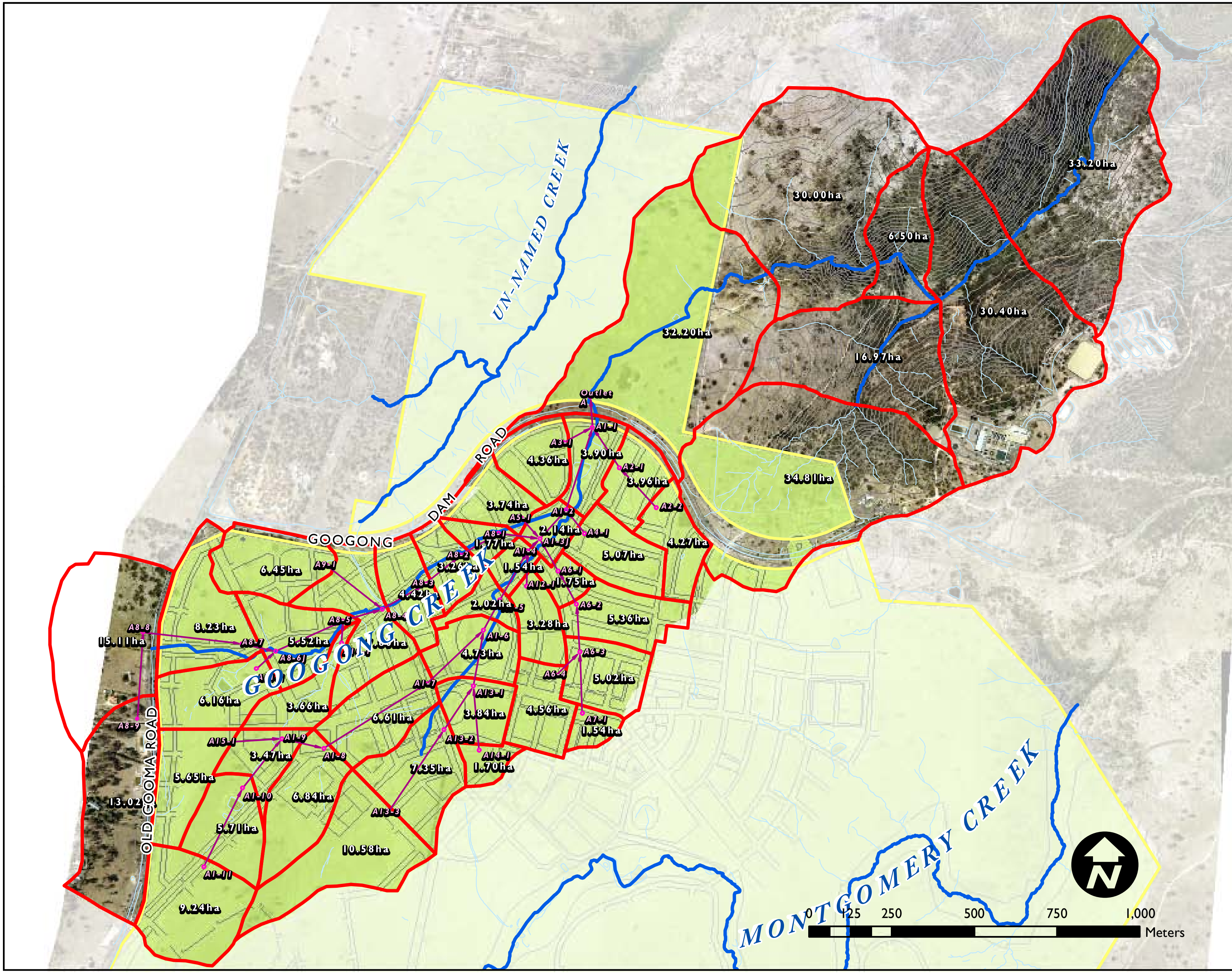
An XP-RAFTS hydrologic model has been developed for Googong Creek in the developed state with no detention. This model uses the parameters specified in ACT Planning and Land Authorities' *Water Sensitive Urban Design General Code* (March, 2008) outlined in Table 1. The layout of the model is presented in Figure 7, with data input into the models and results provided in Appendix B..

Flows were calculated for storms ranging from 15 minutes to 6 hours for the 100 year, 50 year, 20 year, 10 year, 5 year, 2 year, 18 month, 1 year, 9 month, 6 month and 3 month average recurrence intervals. Peak flows for selected ARIs relevant to those in guidelines and criteria (from Table 1), are presented in Table 3.

Table 3 Developed Conditions (No Detention) Peak Flows

Node	*Peak Flow (m^3/s)*				
	100 year	*10 year*	*5 year*	*1 year*	*3 month*
Old Cooma Road (A8-8)	2.37	1.08	0.80	0.30	0.10
Basin 4 location (A8-5)	7.01	4.65	3.99	2.25	1.14
Mini Common (A1-3J)	35.54	22.42	19.51	11.14	5.70
Outlet	38.40	24.00	20.79	11.83	6.03

The results in Table 3 indicate that development within Googong Creek catchment, assuming no detention, would more than double flows for the 100 year peak event and increase flows for the 3 month peak event by an order of magnitude. The decrease in flows for developed conditions at Basin 4 location is due to the increased flow from the developed catchments flowing out of the system earlier than the peak flows for the upstream catchment due to the effects of urbanisation.



BROWN CONSULTING

LEGEND

- CADASTRE
- CONTOUR 5m
- CREEK
- WATERCOURSES
- SITE BOUNDARY
- <all other values>

Project
GOOGONG CREEK CATCHMENT STORMWATER

Drawing Title
DEVELOPED CONDITION XP RAFTS MODEL

Scale	1:15000 @ A4
Drawn	TWC
Checked	TWC
Job No.	X07008
Drawing No.	FIGURE 5

FIGURE 7

5.3 CLIMATE CHANGE

The CSIRO technical paper *Climate Change in Australia – Technical Report 2007* states:

> *"Climate model simulations project that in the future there will be changes in the incidence of many types of extreme weather events, including an increase in extreme rainfall events, due to human influences on the atmosphere (IPCC 2007). There is evidence of increases in extreme rainfall events in at least some regions in recent decades. However, there is as yet no conclusive evidence that these increases are necessarily linked to increasing greenhouse gas concentrations."*

Engineers Australia has not issued any modifications to the procedures for estimating extreme rainfall events outlined in *Australian Rainfall and Runoff – A Guide to Flood Estimation,* 1987 (ARR, 1987). Suitable freeboard allowed for in the design is the only quantifiable safety factor that can be used to compensate for uncertainties relating to climate change.

The CSIRO climate change predictions contained in the *Climate Change in Australia – Technical Report 2007* for eastern Australia show a net increase in annual precipitation, with decreases seasonally in winter and spring. By 2030 the average projected change in annual precipitation is expected to be between two and five percent, with a slight summer increase. Looking further ahead to 2050 and 2070, the predictions become larger and more influenced by the different emissions scenarios used for modelling. A best estimate for 2050 is a five to seven and a half percent reduction in mean annual rainfall, decreasing to around two percent for 2070. Modelling of extreme rainfall events presented in Table 2 of *Climate Change in the Murrumbidgee Catchment* prepared for the New South Wales Government by the CSIRO in 2006 shows an increase in extreme rainfall of 7% by 2030 and 5% by 2070. Extreme rainfall is defined as the 1-day 40-year rainfall event.

Presently no high-resolution climate impact modelling has been carried out for the ACT and Googong area and as such the more general predictions are to be taken as estimates only of future climatic conditions. Regional precipitation variations can be quite sensitive to small differences in air circulation, terrain and other processes. This is evident from the large natural variability of precipitation in South Eastern Australia, in particular for this site, located in the rain shadow between the Snowy Mountains and Kybean Range.

In the absence of high-resolution climate impact modelling it is not possible to make definitive statements on the potential changes in the extreme events over and above the broad, catchment scale predictions in the CSIRO modelling. As a result of this uncertainty, we have undertaken a broad-scale analysis of the impacts of climate change on extreme rainfall events by adjusting rainfall intensities of

49.31 mm/hour for the peak storm event 60 minute within the XP-RAFTS hydrologic model by 5% (to 51.78 mm/hour) and 10% (to 54.21 mm/hour). The effect of this increase in rainfall intensities on flows is presented in Tables 4 and 5.

Table 4 Existing Condition Peak Flows (Climate Change Increases)

Node	***100-year 60 minute Peak Flow** (m³/s)*		
	existing intensity *	***+5% intensity***	***+10% intensity***
Old Cooma Road (A1-2)	2.41	2.60	2.81
Basin 4 location (A1-5)	7.35	7.95	8.54
Mini Common (A1-8J)	14.18	15.29	16.39
Outlet	14.86	15.99	17.12

* results previously presented in Table 2

Table 5 Developed Conditions (No Detention) Peak Flows (Climate Change Increases)

Node	***100-year 60 minute Peak Flow** (m³/s)*		
	existing intensity	***+5% intensity***	***+10% intensity***
Old Cooma Road (A8-8)	2.37	2.56	2.77
Basin 4 location (A8-5)	6.39	6.75	7.14
Mini Common (A1-3J)	28.87	30.53	32.21
Outlet	32.12	33.97	35.83

* results are not those presented in Table 3 as the peak storm is not the 60 minute event in that case

The results in Tables 4 and 5 indicate that increases in rainfall intensity will cause proportionally higher increases in flow, particularly for the undeveloped catchment. This is due to the flow from a catchment only being generated after saturation of initial storage in the soil and ponding in other surface features. Increasing the rainfall over and above the saturation and ponding points, which stay constant, directly increases the proportion of total rainfall becoming runoff.

6 STORMWATER MANAGEMENT

This section outlines general philosophy of the stormwater management system in Googong Creek. The section provides calculations demonstrating that the stormwater features will manage stormwater quantity and operate within the requirements outlined in Section 4.

6.1 TRUNK STORMWATER DRAINAGE

The concept stormwater management plan is shown in Figure 7. As discussed in Section 5, the site has been divided into several sub-catchments.

Runoff from lots is generally run in a northerly direction towards the Googong Dam Road and conveyed centrally through the site via Ponds located within the Googong Club Common recreation area. The peak flow rate discharged from the site is not to exceed the existing pre-development rate from the site. On-Site Detention requirements are detailed in Section 5.

6.1.1 Performance Targets

Performance Targets as required for storm water quantity are as outlined in Table D5.3 of Queanbeyan City Council Development Design Specification D5 –Stormwater Drainage Design, summarised in Table 1 in Section 4. The design objective for the site was to provide detention in addition to storm water quality treatment, such that flows can be attenuated to meet the objectives outlined in the code.

SWALES	$Q(m^3/s)$	TOP WIDTH(m)	BOTTOM WIDTH (m)	DEPTH (m)	'n'
A	3.5	8.2	1.0	0.60	0.035
B	4.6	10.0	1.0	0.75	0.035
C	5.0	11.0	2.0	0.75	0.035
D	6.6	11.6	2.0	0.80	0.035
E	6.9	11.9	2.3	0.80	0.035
F	7.3	12.2	2.6	0.8	0.035
G	22.4	31.0	21.6	0.8	0.050
H	10.5	14.7	5.1	0.8	0.35

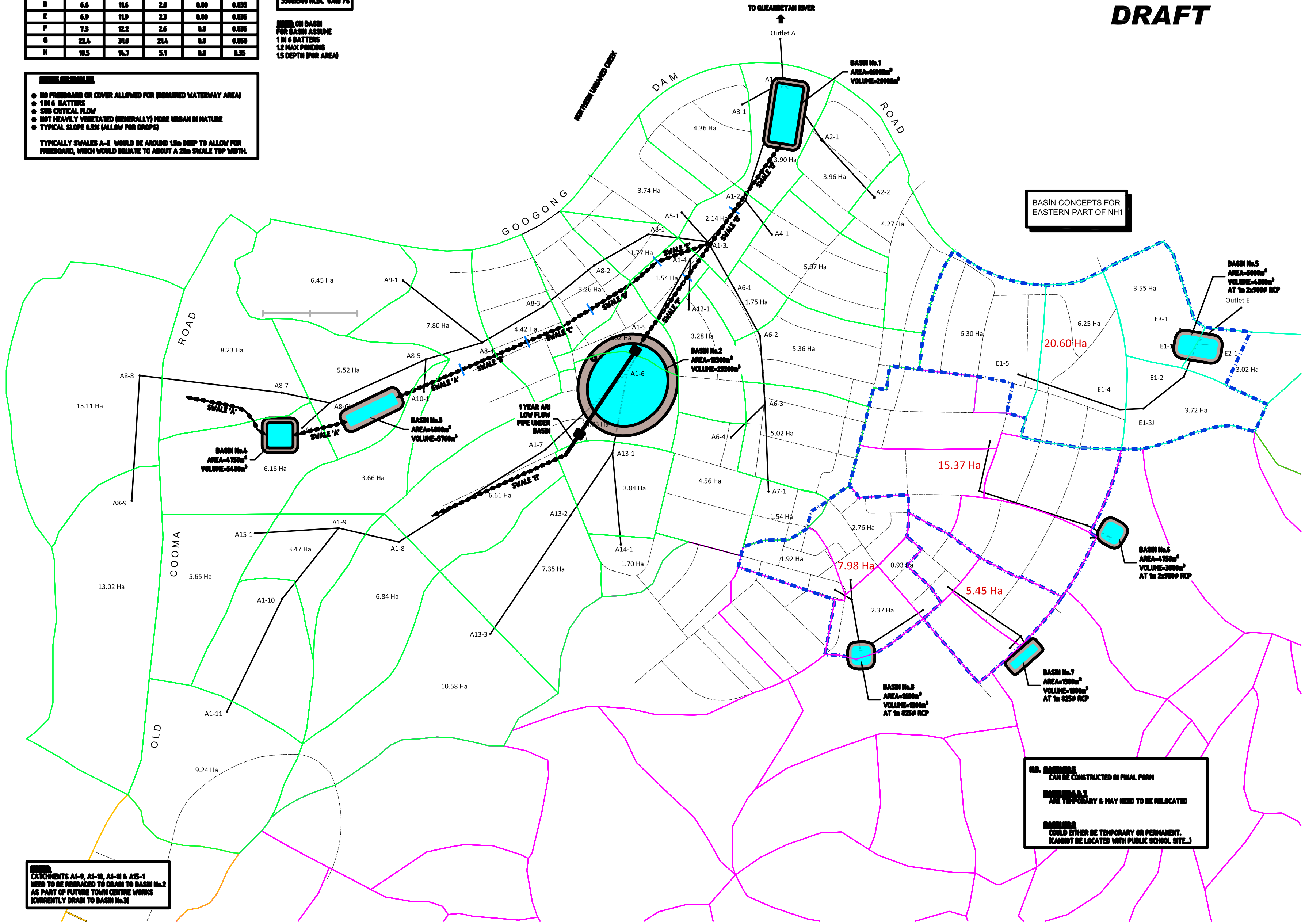
NOTES ON SWALES
- NO FREEBOARD OR COVER ALLOWED FOR (REQUIRED WATERWAY AREA)
- 1 IN 6 BATTERS
- SUB CRITICAL FLOW
- NOT HEAVILY VEGETATED (GENERALLY) MORE URBAN IN NATURE
- TYPICAL SLOPE 0.5% (ALLOW FOR DROPS)

TYPICALLY SWALES A–E WOULD BE AROUND 1.5m DEEP TO ALLOW FOR FREEBOARD, WHICH WOULD EQUATE TO ABOUT A 20m SWALE TOP WIDTH.

FOR CULVERTS UNDER ROADS (ASSUME INLET CONTROL AND 1.2m MAX PONDING)

1800x900 RCBC $3.5m^3/s$
2400x900 RCBC $4.6m^3/s$
3000x900 RCBC $5.0m^3/s$
3300x900 RCBC $6.6m^3/s$

NOTES ON BASIN
FOR BASIN ASSUME
1 IN 6 BATTERS
1.2 MAX PONDING
1.5 DEPTH (FOR AREA)



0 40 80 120 160 200 240 280 320 360 400
SCALE 1:4000 (A1) SCALE 1:8000 (A3)

Status
PRELIMINARY

Details

Issue	Amendment	Date
A	INTERNAL REVIEW	23/09/08
B	DRAFT	10/11/08
C	EASTERN CATCHMENT PLAN ADDED	27/11/08

BROWN
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Sydney Canberra Brisbane Melbourne Singapore

Project
GOOGONG NEW TOWN

Drawing Title
TRUNK STORMWATER DRAINAGE CONCEPT PLAN FOR NEIGHBOURHOOD 1 AND TOWN CENTRE

Scale	1:4000
Drawn	KT
Checked	RP
Job No	X07008.02
Drawing Number	FIGURE 8

Issue C

6.2 MINOR FLOW MANAGEMENT

The design criteria for open channels are outlined in Section D5.13 of Queanbeyan City Council – Development Design Specification D5 Stormwater Drainage Design.

Runoff from the development area for storms up to the 10 year ARI will be directed to a pipe system from the lots, in accordance with Section D5.04.5 of Queanbeyan City Council – Development Design Specification D5 Stormwater Drainage Design. The pipe system will discharge into the community detention system within Googong Creek, discussed in Section 6.4.

The road drainage system will also be connected to the central trunk drainage system with the combined flow discharging in the stormwater control basins. Flow from these basins will discharge from the site into Googong Creek to the north via the existing culvert under Googong Dam Road.

Details of the drainage systems are shown in the stormwater concept layout plan provided in Figure 7.

6.3 MAJOR FLOW MANAGEMENT

Major flows are considered those flows in excess of the 5 year ARI for residential lots and the 10 year ARI peak flow for commercial lots. Major flows from the development will be directed by overland flow paths using the roads and swales.

A series of swales, following existing natural drainage lines will direct flow from lots and roads to detention basins and eventually to the outlet at Googong Dam Road. The base of the swales will be excavated to the design level or to underlying rock where appropriate. In accordance with Section D5.13 of Queanbeyan City Council – Development Design Specification D5 Stormwater Drainage Design, the channel is to have minimum batters of 1 in 4 and the base of the channel to have a minimum cross slope of 1 in 20. The batters will be protected by freeform rock armouring where required. Stability of the rock armouring will be accordance with the methodology in Section D5.06.9 of Design Specification D5 and on Hydraulic Design of Flood Control Channels, Engineer Manual published by the US Army Corps of Engineers. The dimensions of the swales presented on Figure 7 are provided in Table 6

Table 6 Dimensions of Swales for Site Drainage

Swale	*Base Width (m)*	*Top Width (m)*	*Depth (m)*	*Q (m^3/s)*
A	1.0	8.2	0.6	3.5
B	1.0	10.0	0.75	4.6
C	2.0	11.0	0.75	5.8
D	2.0	11.6	0.8	6.6
E	2.3	11.9	0.8	6.9
F	2.6	12.2	0.8	7.3
G	21.4	31.0	0.8	22.4
H	5.1	14.7	0.8	10.5

The design criteria for major flow structures are outlined in Section D5.14 of Design Specification D5. All major structures in urban areas are to be designed for the 100 year ARI storm event without increasing flooding upstream or downstream. The minimum grades referred to in Section D5.13 are also required for the major flow channel.

6.4 DETENTION BASINS

Detention areas and stormwater harvesting will be used to limit post-development changes in flow rate and flow duration for the protection of receiving environments. This will provide protection of the terrestrial and aquatic environments of the Googong Creek floodplain and will limit the impacts of urban development on channel bed and bank erosion.

The concept stormwater layout for Googong Creek incorporates four basins located on-line within the existing creek line and tributaries. As outlined in the design criteria in Table 1 from Design Specification D5.15., the maximum batter slope of the sides of the basins is 1 in 6 and the maximum ponded depth is 1.2 metres. Dimensions of the four detention basins are provided in Table 7.

Table 7 Dimensions of Detention Basins

Basin and Node	*Area (m^2)*	*Volume (m^3)*
Basin 1 (A1-1)	16,000	20,900
Basin 2 (A8-5)	18,300	23,200
Basin 3 (A1-6)	4,800	5,760
Basin 4 (A8-6J)	4,750	5,400

Descriptions of the four detention basins shown in Figure 7 and Table 7 are:

- **Detention Basin 1** – is located at the downstream end of this stage of development, immediately upstream of Googong Dam Road. This basin takes flow from Basins 2 and 3, and provides detention for Stage 1 of the development, shown on Figure 3
- **Detention Basin 2** – is located in the recreation oval in Stage 2 of the development. This basin incorporates a low flow pipe, sized to accommodate the 1 year ARI peak flow and a surcharge pit to allow flows above the 1 year event to spill into the basin. The basin floor will be utilised as a sporting oval, with grades of 1 to 92 along the axis of the football fields. Basin 2 receives flow from Neighbourhood 1A West and Stage 2 of the development. The basin discharges to Swale F, which flows to Basin 1.
- **Detention Basin 3** – is located in the western area of the development. Basin 3 received flow from Basin 4 via Swale A and discharges to Basin 1 via Swales B, C, D, E, F and G.
- **Detention Basin 4** – is located at the western edge of the development and takes flow from upstream of Old Cooma Road. The basin discharges to Basin 3 through Swale A.

6.4.1 Modelling of Detention

Modelling of the detention systems with developed catchment conditions for the site has been undertaken using the *XP-RAFTS* hydrological package. The catchment plans those used in the modelling in Section 5.2.1, with data input into the models and results provided in Appendix B. The results are presented in Table 8.

Table 8 Developed Conditions (With Detention) Peak Flows

Node	*Peak Flow (m³/s)*				
	100 year	*10 year*	*5 year*	*1 year*	*3 month*
Old Cooma Road (A8-8)	2.41	1.12	0.84	0.33	0.17
Basin 4 location (A8-5)	3.58	1.85	1.52	0.62	0.22
Mini Common (A1-3J)	20.88	15.70	14.38	9.44	4.84
Outlet	13.81	8.65	8.12	4.26	1.64

The results in Table 8 indicate that the detention basins operate within the requirements of Queanbeyan City Council, outlined in Table 1 at the outlet of the developed area at Googong Dam Road.

6.4.2 Effects of Climate Change Flow Increases on Detention Structures

A broad-scale analysis of the impacts of climate change on detention structures was undertaken using the same methodology outlined in Section 5.3. Rainfall intensities for the 100 year 60 minute rainfall event were adjusting within the *XP-RAFTS* hydrologic model by +5% and +10%. The effect of this increase in rainfall intensities on peak basin water depth and storage volume is presented in Table 9.

Table 9 Effect of Climate Change Flow Increases on Detention Structures

Basin	*100 year 60 minute event*					
	existing intensity		*+5% intensity*		*+10% intensity*	
	Storage Volume (m^3)	*Water Depth (m)*	*Storage Volume (m^3)*	*Water Depth (m)*	*Storage Volume (m^3)*	*Water Depth (m)*
Basin 1 (A1-1)	22,180	1.26	32,015	1.30	23,580	1.33
Basin 2(A8-5)	8,320	0.45	10,327	0.56	11,527	0.62
Basin 3 (A1-6)	4,397	1.20	4,562	1.24	4,709	1.27
Basin 4(A8-6J)	3,788	1.14	4,103	1.21	4,242	1.24

The results in Table 9 indicate that increases in rainfall intensity will cause proportionally higher increases in the volume of water in storage. This is due to the flow from a catchment only being generated after saturation of initial storage in the soil and ponding in other surface features. Increasing the rainfall over and above the saturation and ponding points, which stay constant, directly increases the proportion of total rainfall becoming runoff.

The results also indicate that due to basin geometry, increases in rainfall intensity do not result in proportionally higher increases in water depth within the basins.

7 STORMWATER QUALITY AND TREATMENT

This section outlines way the water sensitive urban design (WSUD) features and the stormwater features described for each creek in Section 6 will operate and manage stormwater quality. The stormwater management system proposed within Googong Creek Catchment has been designed to improve stormwater quality, provide stabile waterways as well as supplying passive irrigation of vegetation. Gross Pollutant Traps (GPTs) and bioretention systems will be used to treat stormwater.

7.1 STORMWATER TREATMENT AND PERFORMANCE TARGET DESIGN CRITERIA

The proposed treatment system has been designed such that the development site is capable of reducing export loads to the requirements as outlined in Table D7.2 of Queanbeyan City Council *Development Design Specification D7 – Erosion Control and Stormwater Management*. These reduction rates have been provided in Table 1 in Section 4. The percentage reduction is the proportion of pollutant exported from the developed site with the proposed treatment system compared to an urban catchment with no water quality controls.

Due to uncertainties in climate change predictions and the reliance on historical data, no analysis or modelling of the effects of climate change on stormwater treatment measures and water quality has been undertaken as part of this report. It is not anticipated that climate change would cause variations in rainfall patterns outside the range for which treatment measures are effective.

7.2 STORMWATER TREATMENT STRATEGY

Development within the Googong Creek catchment will incorporate the following WSUD design features within roadways:

- Flush or castellated kerbs on roads at open space to allow road runoff to remain as overland flow
- Road runoff directed to blisters at intersections set below road surface, planted with trees
- Rain gardens in centres of street
- Indented parking bays at urban centres
- Major roads such as Googong Ave to have castellated kerb

Stormwater quality will be addressed through bioretention systems at the urban/open space interface. Where grade, cost or available treatment area is limited, wetlands or bioretention systems can be integrated with end of catchment detention areas.

Landscaped areas will be configured to optimise passive irrigation (allowing for breaks in kerbs, appropriate set down of the planted surface, paths graded to drain to landscaped areas, scour protection at the edge of the landscaped bed).

The required bioretention treatment area is approximately 1 - 2% of the impervious catchment area. The required treatment area is reduced where rainwater tanks on individual houses and premises are used. Bioretention systems (configured as street trees or rain gardens) will treat road runoff and runoff from lots. The lot drainage can be directed to the kerb or to bioretention systems (not directly to the stormwater drainage).

The proposed water quality treatment strategy is to provide communal treatment of stormwater within the Googong Mini Common, located in-line along Googong Creek, upstream of the Googong Dam Road embankment, shown on Figure 9.


GOOGONG DAM ROAD
CULVERT
PLAY
0 5 15 30 50m

The stormwater treatment strategy for each individual lot is subject to the future development and lot layout. The suitability of various treatment methods is subject to the nature of development and configuration of various structures on the site. For purposes of concept design, a typical arrangement for a 5,000m^2 lot and a 10,000 m^2 lot has been provided by adopting a combined bioretention/ detention basin on each site. The bioretention features within the Googong Mini Common are proposed as the primary treatment and each bioretention basin is to have pre-treatment by means of a trash rack or GPT. A general description of each component of the treatment system is given below.

7.2.1 Gross Pollutant Traps (GPT's)

Gross pollutant traps are typically placed in-line with the drainage system prior to discharge into a bioretention basin to capture litter, debris, coarse sediment, oils and greases. While the pollutant capture efficiency of various traps may vary, as a conservative measure for modelling purposes the GPT is assumed that the GPT will be capable of removing of the annual load:

- Gross Pollutants 90%
- Suspended Sediments 0%
- Total Phosphorous 0%
- Total Nitrogen 0%

It is proposed to install GPT upstream of the Googong Mini-Common for litter control. A discussion of the GPT in the *MUSIC* water quality modelling and performance in the overall treatment train is discussed in Section 7.3.

7.2.2 Bioretention Basins

Bioretention basins will be utilised to perform the majority of the water treatment from the site. Bioretention basins consist of shallow areas over most of their surface area to incorporate macrophytes for nutrient uptake.

The bioretention basins have been conceptually designed on the basis of a 0.4m deep filter medium with a maximum depth of ponding of 0.55m and a 48 hour drawdown. The minimum required bioretention basin surface area with the modelled pollutant removal performance is discussed in Section 7.3.

Suitable wetland macrophyte species for the bioretention basin, would include species such as; *baumea articulata*, *carex appressa*, *cyperus difformis, cyperus polystachyos, eleocharis sphacelata*, *eleocharis cylindrostachys, cyperus flaccidus, juncus prisatocarpus, juncus remotiflourus, juncus usitatus, lomandra longifolia,* *phragmites australis and phragmites lanuginosum.* All these species exhibit good nutrient removal rates and are hardy. Landscape drawings will be provided at Project Plan stage to detail the actual species mix to be used in the basin.

The bioretention basin filter media will be installed as the last stage of the development as outlined in Queanbeyan City Council Specification D7:30, in order to prevent the filter from being clogged prematurely from construction run off.

7.2.3 Ponds

Small wetlands with sections of open water, as opposed to large ponds, are will be located at the edge of the open space area shown on Figure 9. These small ponds will be aligned with piped outlets of the roads and catchment drainage network. The ponds will be perched above the main drainage line corridor of Googong Creek, offline from the main drainage pathway. This provides protection from the impacts of construction (sediment deposition, flow scouring, etc) for development upstream, as construction staging is planned for downstream areas first. The size of open water bodies will be sized for their urban catchments in order to allow inflow from rainfall to naturally ensure adequate turnover for safe algal threshold. These ponds will be designed to ensure 20 percentile residence time does not exceed 30 days. If larger water bodies are developed during the detailed design, the systems will have to be pumped to recirculate the water through dedicated treatment wetlands.

7.2.4 Street Trees

Best practice targets for pollutant reduction met through streetscape bioretention systems. Street trees will be incorporated into the road design. Street trees will be passively irrigated by allowing for breaks in kerbs, appropriate setdown, paths graded to drain to landscaped areas and scour protection at the edge of the landscaped bed).

7.2.5 Swales

A series of swales, following existing natural drainage lines will direct flow from lots and roads to detention basins and eventually to the outlet at Googong Dam Road. The use of Swales is discussed in detail in Section 6.3, with swale dimensions given in Table 6.

Swales will be planted with Monaro grasslands where appropriate for hydrology and scour protection. Planting will focus on re-establishing the grassland species of the Monaro landscape within broad waterway corridor, with some trees planted beyond the waterway channel

7.3 *MUSIC* WATER QUALITY MODELLING

The performance of the proposed water quality treatment strategy has been modelled using the *MUSIC* water quality model (Version 3.0). The parameters adopted for *MUSIC* modelling are as recommended in Appendix B of the *ACT Planning and Land Authorities Water Sensitive Urban Design General Code* (March, 2008) and are provided in Appendix C.

A series of *MUSIC* models has been developed to establish the treatment targets required to compensate for development within Googong Creek catchment. A model of the existing catchment, based on rural land use, was developed to set baseline pollutant export conditions. This existing condition model is discussed in Section 7.3.1. A model of developed catchment with no water sensitive urban design treatment features was developed to calculate pollutant export loads from the site. This developed with no treatment is discussed in Section 7.3.2. Models were developed for various treatment options the catchment, including rainwater tanks and roadside swales along with bioretention were modelled. . Input parameters into the *MUSIC* models were:

- **Lot Layout** - UD1104 rev H, dated 24.06.09 (in Appendix A)
- **Rainfall** – Queanbeyan Bowling Club (070072) for the period 1967 - 2007
- **Evaporation** – Canberra monthly averages within MUSIC (from the Bureau of Meteorology)
- **Basin dimensions** – Googong Creek - from 12D model dated Dec 08 – permanent water volume in Basins 3 and 4 is the total runoff from the 3 month 90 min ARI event
- **Bioretention and swales** – from the drawing "Trunk Stormwater Drainage Concept Plan for Neighbourhood 1 and Town Centre" X07008.02.SK01 Issue C (see Figure 8)
- **Wetland dimensions** – from drawing dated 16 Dec 08 (C8006/DE/SW)
- **Catchment areas and impervious areas** – from XP-RAFTS modelling for the project
- **Catchment break up** – from Roberts Day – Yield Analysis Table 24 June 09 (in Appendix A)
- **Runoff parameters and pollutant concentrations** – ACT Planning and Land Authorities Water Sensitive Urban Design General Code Appendix B (March, 2008).

Pollutant removal targets are provided in Table 1, taken from Queanbeyan City Council *Development Design Specification D7 – Erosion Control and Stormwater Management*. The cases modelled are as follows –

CASE 0: Existing Case – Section 7.3.1
CASE 1: Developed Case Without Treatment (No WSUD) – Section 7.3.2
CASE 2: Developed Case With Treatment (WSUD) – Section 7.3.3

The developed option with WSUD was modelled incorporating the use of recycled water from the Googong wastewater treatment plant as environmental flow in Googong Creek, outlined in Section 8.1.

7.3.1 Existing Catchment MUSIC Model - Case 0

A *MUSIC* model of the catchment in the pre-developed (current, rural, degraded) state was created to calculate the existing pollutant export loads. Catchment delineations were those used for the *XP-RAFTS* modelling, outlined in Section 5.1.1, with the model layout presented in Figure 10.

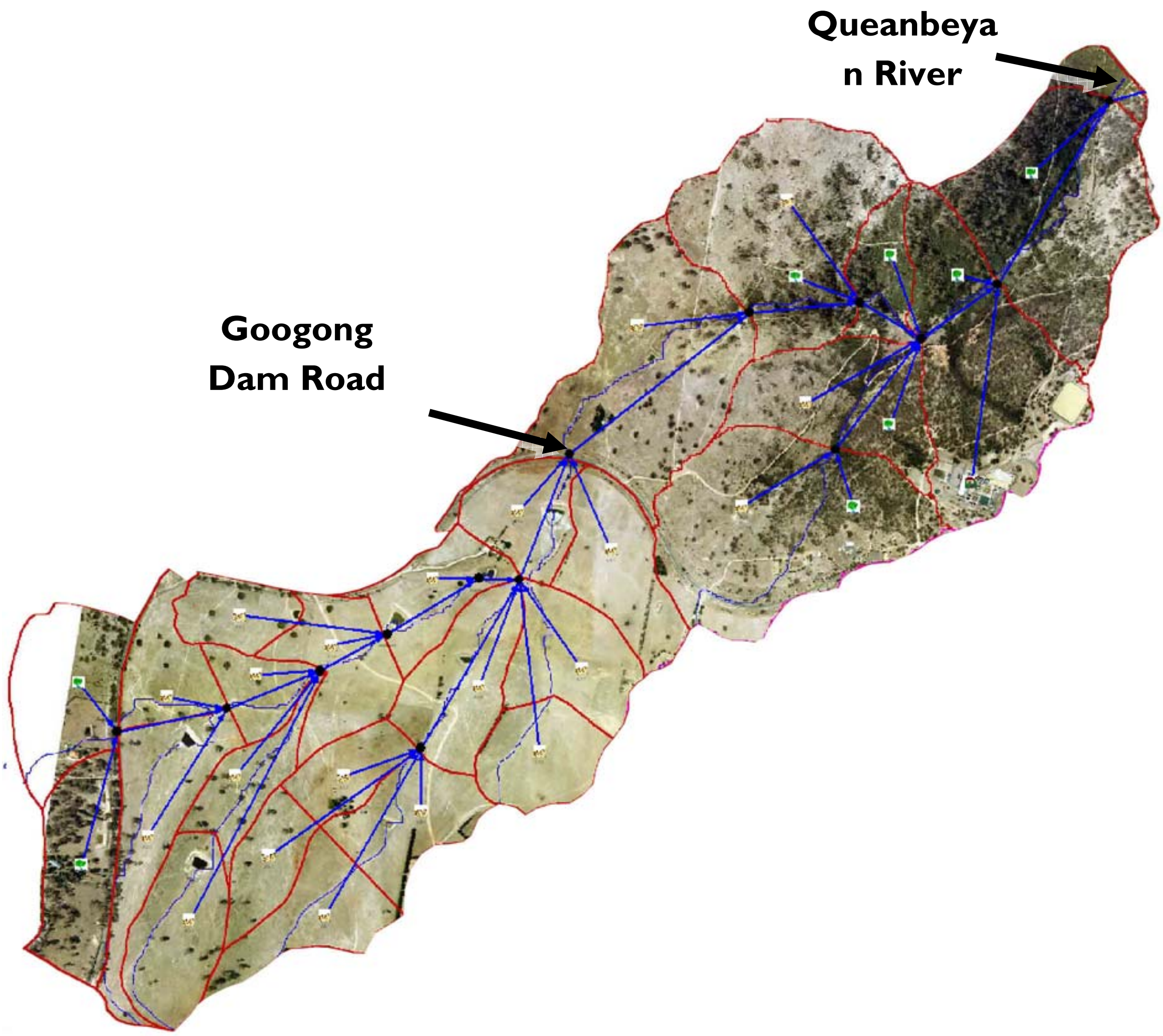

Figure 10 Existing Catchment *MUSIC* Model

Un-developed catchments in this case, and subsequent cases, were modelled as agricultural catchment nodes for the upper, grassland sub-catchments and as forested catchment nodes for the lower, steeper, more vegetated sub-catchments.

The results of the existing catchment *MUSIC* model are presented in Table 10, with results of average annual pollutant load reported at two locations; the downstream end of the development area at Googong Dam Road, and at the confluence of Googong Creek with Queanbeyan River.

Table 10 Existing Catchment Pollutant Export rates

Pollutant	*Pollutant Load* At Googong Dam Road *(kg/year)*	Removal Rate (%)	*Pollutant Load* At Queanbeyan River *(kg/year)*
TSS	37,800	-	64,300
TP	43	-	72
TN	738	-	1193
Gross Pollutants	1,950	-	4,750
Annual Flow Volume (ML/year)	179	-	329

The results in Table 10 indicate that in the undeveloped state, the catchment upstream of Googong Dam Road accounts for over half of the annual pollutant load for total suspended solids, and nutrients, and under half the gross pollutant exported from the catchment. This is due to the untreated loads coming from the Cook and Talpa properties on the northern side of Googong Dam Road. The area of these properties is as large as the site itself and generates loads of a similar magnitude to that of the site.

There has been no instream modelling of pollutant removal downstream of the site.

7.3.2 Developed Catchment MUSIC Model (No WSUD) - Case 1

A *MUSIC* model was for the developed catchment was built with no water sensitive urban design (WSUD) features included to manage water quality. This model was created in order to determine pollutant export rates from the urbanised catchment and measure their effects at the confluence with the Queanbeyan River. Catchment delineations were those used for the *XP-RAFTS* modelling, outlined in Section 5.2.1, with the model layout presented in Figure 11.

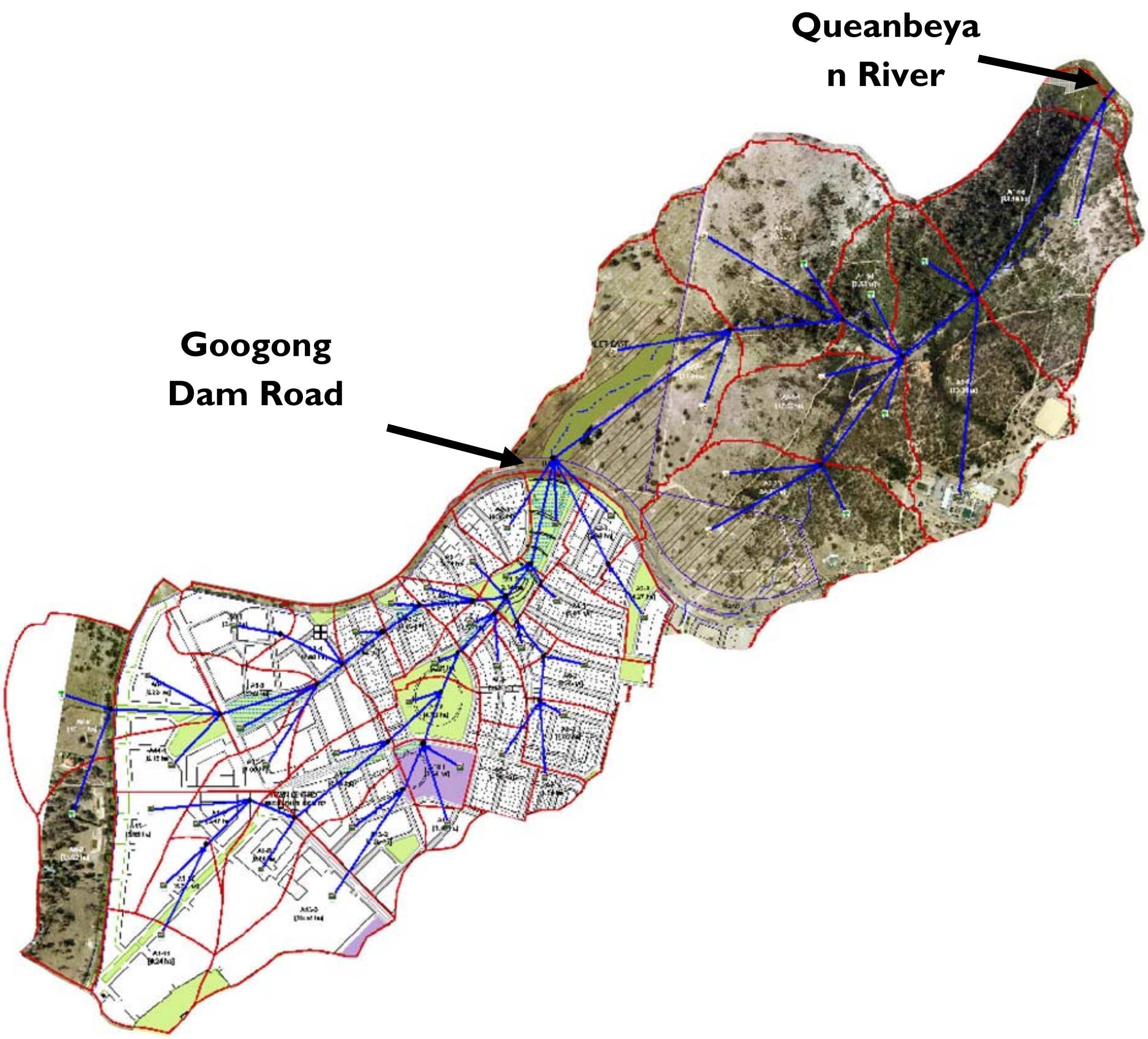

Figure 11 Developed Catchment *MUSIC* Model (No WSUD)

Un-developed catchments were modelled as in the existing catchment model, with developed catchments impervious percentages measured from Roberts Day – Yield Analysis Table dated 24 June 09 and the drawing (UD1104 rev H, dated 24.06.09).

The results of the *MUSIC* model of the developed catchment with no WSUD features are presented in Table 11. Results of average annual pollutant load reported at two locations; the downstream end of the development area at Googong Dam Road, and at the confluence of Googong Creek with Queanbeyan River.

Table 11 Developed Catchment (No WSUD) Pollutant Export rates

Pollutant	*Pollutant Load at Googong Dam Road (kg/year)*	*Removal Rate (%)*	*Pollutant Load at Queanbeyan River (kg/year)*
TSS	171,000	0%	202,000
TP	150	0%	184
TN	2,030	0%	2,580
Gross Pollutants	24,800	0%	29,200
Annual Flow Volume (ML/year)	680	0%	851

The results in Table 11 indicate that in the developed state with no WSUD, the catchment upstream of Googong Dam Road would account for approximately 80-90% of the annual pollutant load for total suspended solids, nutrients and gross pollutant at the confluence with the Queanbeyan River.

7.3.3 Developed Catchment MUSIC Modelling Options - Case 2

A *MUSIC* model was for the developed catchment was built that included the water sensitive urban design (WSUD) features included in drawing UD1104 rev H, dated 24.06.09, Trunk Stormwater Drainage Concept Plan for Neighbourhood 1 and Town Centre" X07008.02.SK01 Issue C with Wetland dimensions from drawing dated 16 Dec 08 (C8006/DE/SW). This model was created in order to determine the effects of these measures to manage water quality and reduce pollutant export rates from the urbanised catchment upstream of Googong Dam road and also to measure their effects at the confluence with the Queanbeyan River. Catchment delineations were those used for the XP-RAFTS modelling, outlined in Section 5.2.1, with the model layout presented in Figure 12.

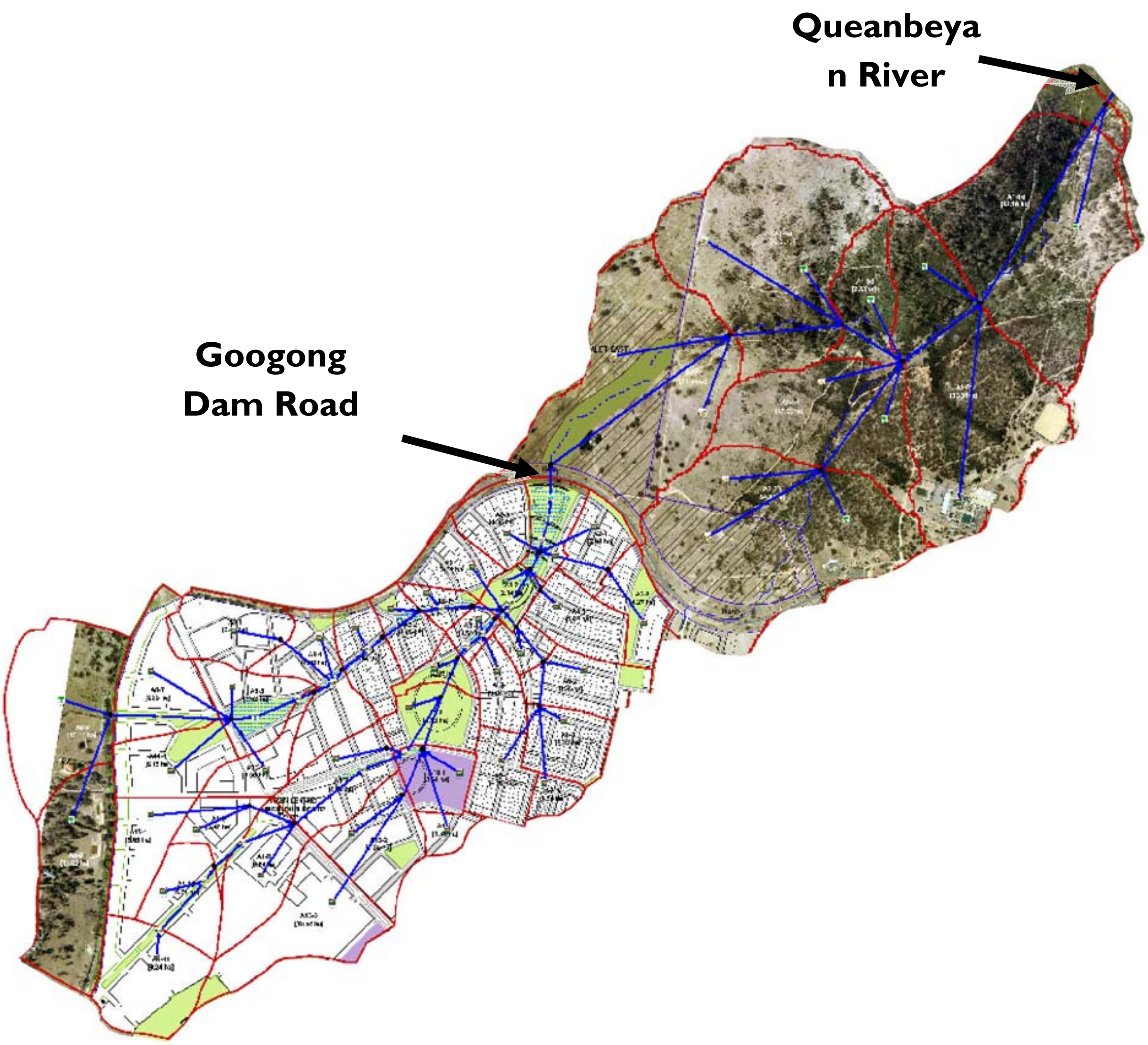

Figure 12 Developed Catchment *MUSIC* Model (WSUD)

Developed and un-developed catchments were modelled as in the models discussed in Sections 7.3.1 and 7.3.2.

The results of the *MUSIC* model of the developed catchment incorporating WSUD features are presented in Table 12. Results of average annual pollutant load reported at two locations; the downstream end of the development area at Googong Dam Road, and at the confluence of Googong Creek with Queanbeyan River, along with pollutant removal rates for the developed catchment upstream of Googong Dam Road.

Table 12 Developed Catchment (WSUD) Pollutant Export rates

Pollutant	*Pollutant Load at Googong Dam Road (kg/year)*	*Removal Rate (%)*	*Pollutant Load at Queanbeyan River (kg/year)*
TSS	7,540	95.6%	39,200
TP	52	65.1%	87
TN	765	62.3%	1,310
Gross Pollutants	0	100.0%	4,390
Annual Flow Volume (ML/year)	614	9.7%	784

The results in Table 12 indicate that the WSUD features presented on in Trunk Stormwater Drainage Concept Plan for Neighbourhood 1 and Town Centre" X07008.02.SK01 Issue C and Wetland dimensions from drawing dated 16 Dec 08 (C8006/DE/SW) would allow the proposed development to meet the pollutant removal targets set in the Googong New Town DCP within Googong Creek.

Comparison of these results with those presented in Table 10 indicate that exported pollutant loads at the Queanbeyan River from the developed catchment with WSUD would be 60-80% of those for the existing catchment for total suspended solids and total phosphorous, slightly higher for total nitrogen and about 90% of the gross pollutants.

8 INTEGRATED WATER MANAGEMENT

This section outlines the integration of stormwater treatment measures with the water quality measures outlined in MWH (Montgomery Watson Harza Pty Ltd) *Googong Design Assumptions for Potable and Recycled Water System*. This section also outlines how the WSUD measures meet the requirements of the Googong Water Cycle Project EA

8.1 PERFORMANCE TARGETS

The performance targets required in the *ACT Planning and land Authorities Industrial Zones Development Code* (March, 2008) is outlined below

> *Evidence is provided that shows the development achieves a minimum 40% reduction in mains water consumption compared to an equivalent development constructed in 2003 using the ACTPLA on-line assessment tool or the NSW BASIX tool. The 40% target is to be met without any reliance on landscaping measures to reduce consumption.*

The achievement of water conservation measures as required for Water Sensitive Urban Design (WSUD) is requires the implementation of water demand management measures at each individual lot These measures include applying water efficient fittings and fixtures, Water efficient mechanical plant, Water efficient landscaping and rainwater capture, storage and use. The use of rain water tanks are to be encouraged on the lots and utilisation of rainwater would generally be used for reuse in toilet flushing, landscape irrigation and general wash down. Although use of rainwater tanks has not been modelled as part of the quantity or quality studies, adoption of rainwater tanks would contribute to the attenuation requirements for water quality and quantity on individual lots.

The adoption of these strategies will depend on the nature of development to be occupies by each individual lot and will be the responsibility of each individual lot to achieve the performance targets required by the ACT Planning and Land Authorities *Water Sensitive Urban Design General Code* (March, 2008). The development of each lot will be subject to individual future applications.

8.1 MUSIC Water Quality Modelling (including Recycled Water)

The performance of the proposed water quality treatment strategy has been modelled using the *MUSIC* water quality model (Version 3.0). The parameters adopted for *MUSIC* modelling are as recommended in Appendix B of the ACT Planning and Land Authorities *Water Sensitive Urban Design General Code* (March, 2008) and are provided in Appendix C.

A series of *MUSIC* models has been developed to establish the treatment targets required to compensate for development within Googong Creek catchment. A model of the existing catchment, based on rural land use, was developed to set baseline pollutant export conditions. This existing condition model is discussed in Section 7.3.1. A model of developed catchment with no water sensitive urban design treatment features was developed to calculate pollutant export loads from the site. This developed with no treatment is discussed in Section 7.3.2. Models were developed for various treatment options the catchment, including rainwater tanks and roadside swales along with bioretention were modelled. These options were modelled along with the use of recycled water from the Googong wastewater treatment plant as environmental flow in Googong Creek. Data used in Section 7.3 was used in this modelling, along with additional data from the following sources:

- **Time series data** on the discharge of recycled water from the WRP supplied from *WATNET* modelling undertaken by MWH dated 29 Oct 09
- **Pollutant Concentrations in recycled water**
    - **TSS** – 5.0 mg/L
    - **TN** – 10 mg/l
    - **TP** – 0.2 mg/L
- **Rainwater Tank volume** – 65.6 m^3/ha (based on lot layout and lot yield of 12.81 lots/ha calculated from Roberts Day – Yield Analysis Table dated 24 June 09 and the drawing (UD1104 rev H, dated 24.06.09)
- **Rainwater tank daily demand** of 2.88kL/ha/day, determined by MWH *WATNET* modelling

CASE 3: Developed Case With Treatment (WSUD) + Water Recycling Plant Discharging into Basin 1 – Section 8.1.1
CASE 4: Developed Case With Adjusted Treatment (WSUD) to meet targets + Water Recycling Plant Discharging into Basin 1– Section 8.1.2
CASE 5: Developed Case With Treatment (WSUD) + Water Recycling Plant Discharging into Basin 1 + Rainwater Tanks– Section 8.1.3

CASE 6: Developed Case With Treatment (WSUD) + Water Recycling Plant Discharging into Basin 4 – Section 8.1.4

CASE 7: Developed Case With Treatment (WSUD) + Water Recycling Plant Discharging into Basin 4 + Rainwater Tanks – Section 8.1.5

8.1.1 Recycled Water MUSIC Model (Insertion at downstream basin) - Case 3

The developed catchment with WSUD model discussed in Section 7.3.3 was adjusted to incorporate the insertion of the discharge of recycled water from the WRP supplied by MWH dated 29 Oct 09 at the downstream basin (Detention Basin 1 discussed in Section 6.4), immediately upstream of Googong Dam Road.

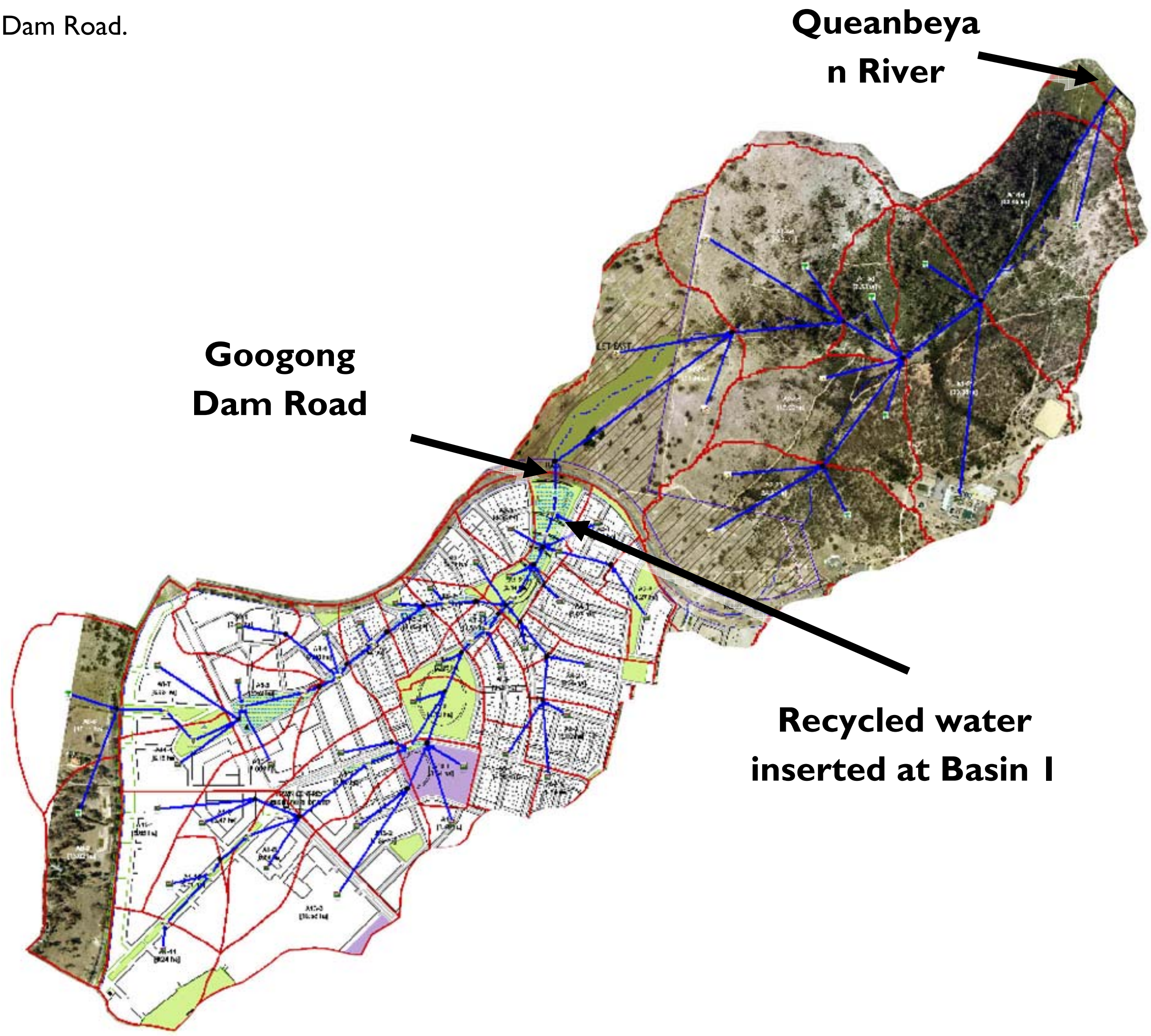

Figure 13 Developed Catchment *MUSIC* Model (WSUD Recycled at Basin 1)

The results of the *MUSIC* modelling for Googong Creek catchment with excess recycled water discharged into the system at Basin 1 are reported in Table 13 at the downstream end of the development Googong Dam Road, and at the confluence with the Queanbeyan River.

Table 13 Developed Catchment (WSUD, Recycled water inserted at downstream basin) Pollutant Export rates

Pollutant	*Pollutant Load at Googong Dam Road (kg/year)*	*Removal Rate (%)*	*Pollutant Load at Queanbeyan River (kg/year)*
TSS	9,000	94.7%	40,600
TP	64	64.2%	98
TN	1,250	63.5%	1,800
Gross Pollutants	0	100.0%	4,390
Annual Flow Volume (ML/year)	753	8.1	923

The results in Table 13 indicate that the treatment system does not meet the removal targets at Googong Dam Road for nutrient removal. To meet this requirement the bioretention basin within the Googong Mini-Common would need to be increased in size.

The pollutant load at the confluence with the Queanbeyan River is lower than the existing catchment rate for total suspended solids and gross pollutants, but higher for nutrients.

8.1.2 Recycled Water MUSIC Model (Insertion at downstream basin) – Revised Bioretention - Case 4

The results in Section 8.1.1, the treatment system proposed in Trunk Stormwater Drainage Concept Plan for Neighbourhood 1 and Town Centre" X07008.02.SK01 Issue C incorporating wetland dimensions from drawing dated 16 Dec 08 (C8006/DE/SW) does not meet the removal targets at Googong Dam Road for nutrient removal. To meet this requirement the bioretention basin within the Googong Mini-Common was increased in size in the *MUSIC* model from 3000m^2 to 3500m^2. The model layout is presented in Figure 14.

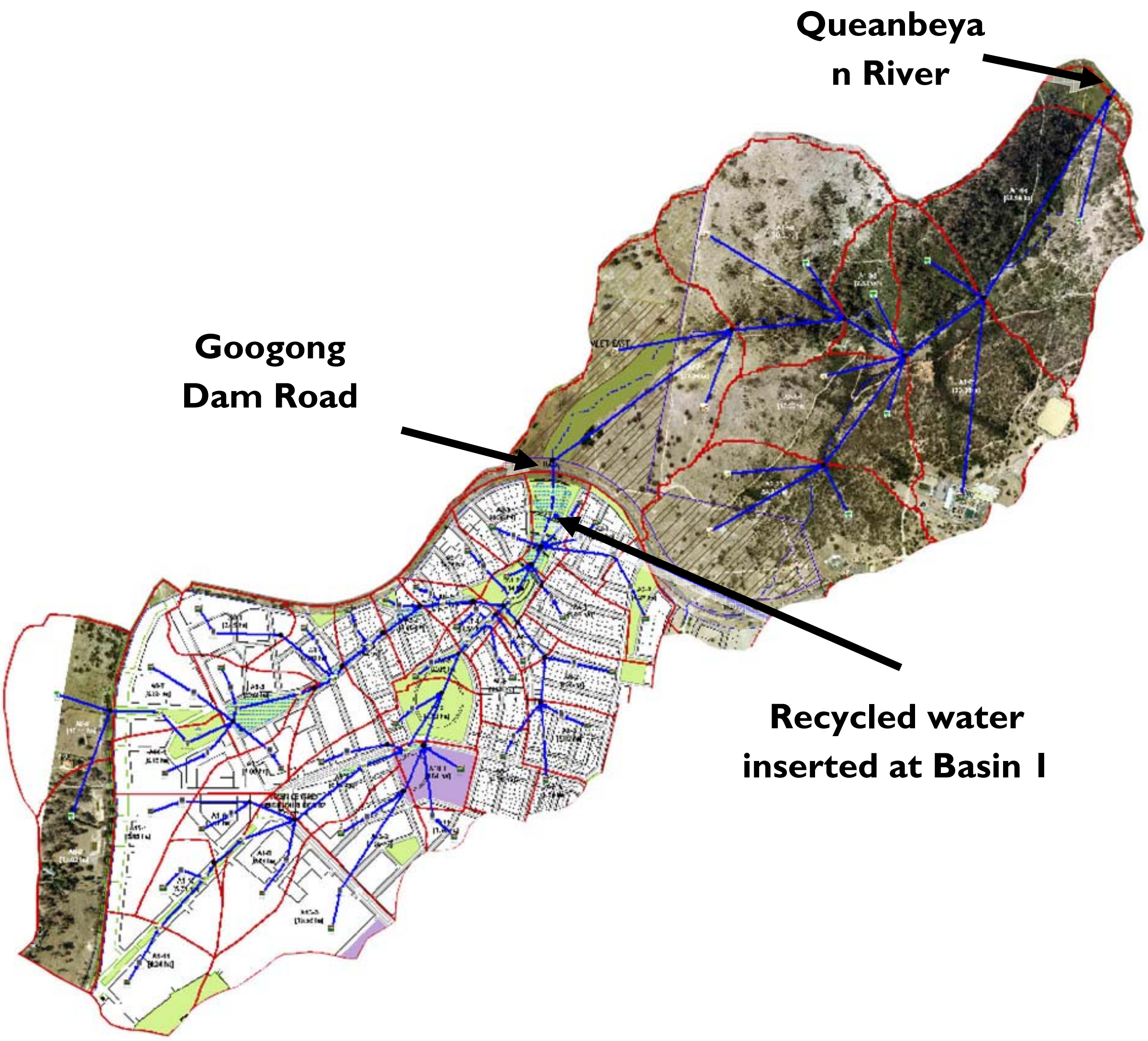

Figure 14 Developed Catchment *MUSIC* Model (WSUD Recycled at Basin 1 – Revised Bioretention)

The results of the *MUSIC* modelling for Googong Creek catchment with excess recycled water discharged into the system at a revised Basin 1 are reported in Table 14 at the downstream end of the development Googong Dam Road, and at the confluence with the Queanbeyan River.

Table 14 Developed Catchment (WSUD Recycled at Basin 1 – Revised Bioretention) Pollutant Export rates

Pollutant	*Pollutant Load at Googong Dam Road (kg/year)*	*Removal Rate (%)*	*Pollutant Load at Queanbeyan River (kg/year)*
TSS	8,670	94.9%	40,300
TP	62	65.1%	96
TN	1,220	64.3%	1,770
Gross Pollutants	0	100.0%	4,390
Annual Flow Volume (ML/year)	753	8.1%	923

The results in Table 14 indicate that the treatment system proposed in Trunk Stormwater Drainage Concept Plan for Neighbourhood 1 and Town Centre" X07008.02.SK01 Issue C incorporating wetland dimensions from drawing dated 16 Dec 08 (C8006/DE/SW) with an upgraded Basin 1 from 3000m^2 to 3500m^2 to meets the removal targets at Googong Dam Road for nutrient removal.

The pollutant load at the confluence with the Queanbeyan River is lower than the existing catchment rate for total suspended solids and gross pollutants, but higher for nutrients.

8.1.3 Recycled Water MUSIC Model with Rainwater Tanks (Insertion at downstream basin) - Case 5

The *MUSIC* model developed in Section 8.1.2 incorporating the upgraded Basin 1 required to meet the water quality targets was adjusted to incorporate rainwater tanks on each dwelling. Rainwater Tank volume rate per hectare used in the model was calculated as 65.6 m^3/ha. This was based on lot layout and lot yield of 12.81 lots/ha calculated from Roberts Day – Yield Analysis Table dated 24 June 09 and the drawing (UD1104 rev H, dated 24.06.09). This volumetric rate was used for developed catchment area only. The rainwater tank daily demand of used in the MWH modelling was converted to a volumetric rate per hectare per day of 2.88kL/ha/day. The layout of the *MUSIC* model is presented in Figure 15.

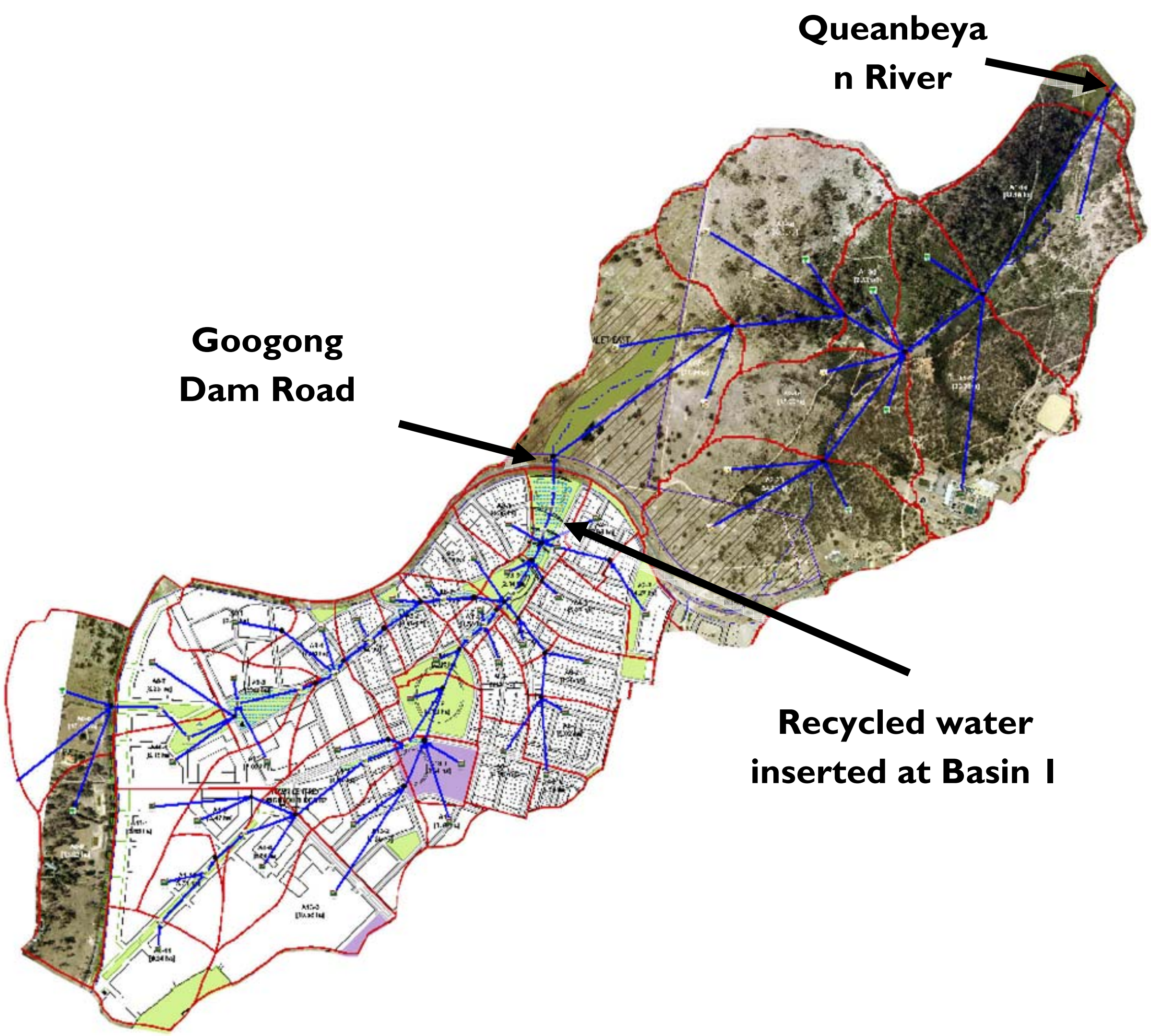

Figure 15 Developed Catchment *MUSIC* Model (WSUD Recycled at Basin 1 – Revised Bioretention with Rainwater Tanks)

The results of the *MUSIC* modelling for Googong Creek catchment with excess recycled water discharged into the system at a revised Basin 1 incorporating the effect of rainwater tanks on each dwelling are reported in Table 15 at the downstream end of the development Googong Dam Road, and at the confluence with the Queanbeyan River.

Table 15 Developed Catchment (WSUD Recycled at Basin 1 – Revised Bioretention with Rainwater Tanks) Pollutant Export rates

Pollutant	*Pollutant Load at Googong Dam Road (kg/year)*	*Removal Rate (%)*	*Pollutant Load at Queanbeyan River (kg/year)*
TSS	8,510	95.1%	40,100
TP	65	69.8%	99
TN	1,810	66.2%	2,360
Gross Pollutants	0	100.0%	4,390
Annual Flow Volume (ML/year)	808	20.2%	978

The results in Table 15 indicate that the treatment system proposed in Section 8.1.2 with the inclusion of rainwater tanks would meet the removal targets at Googong Dam Road for nutrient removal.

The pollutant load at the confluence with the Queanbeyan River is lower than the existing catchment rate for total suspended solids and gross pollutants, but is higher for nutrients.

8.1.4 Recycled Water MUSIC Model (Insertion at upstream basin) – Revised Bioretention - Case 6

The model developed in Section 8.1.2 was modified to incorporate the insertion of the discharge of recycled water from the WRP supplied by MWH dated 29 Oct 09 at the upstream end of Googong Creek, into Detention Basin 4, discussed in Section 6.4. The layout of the *MUSIC* model is presented in Figure 16.

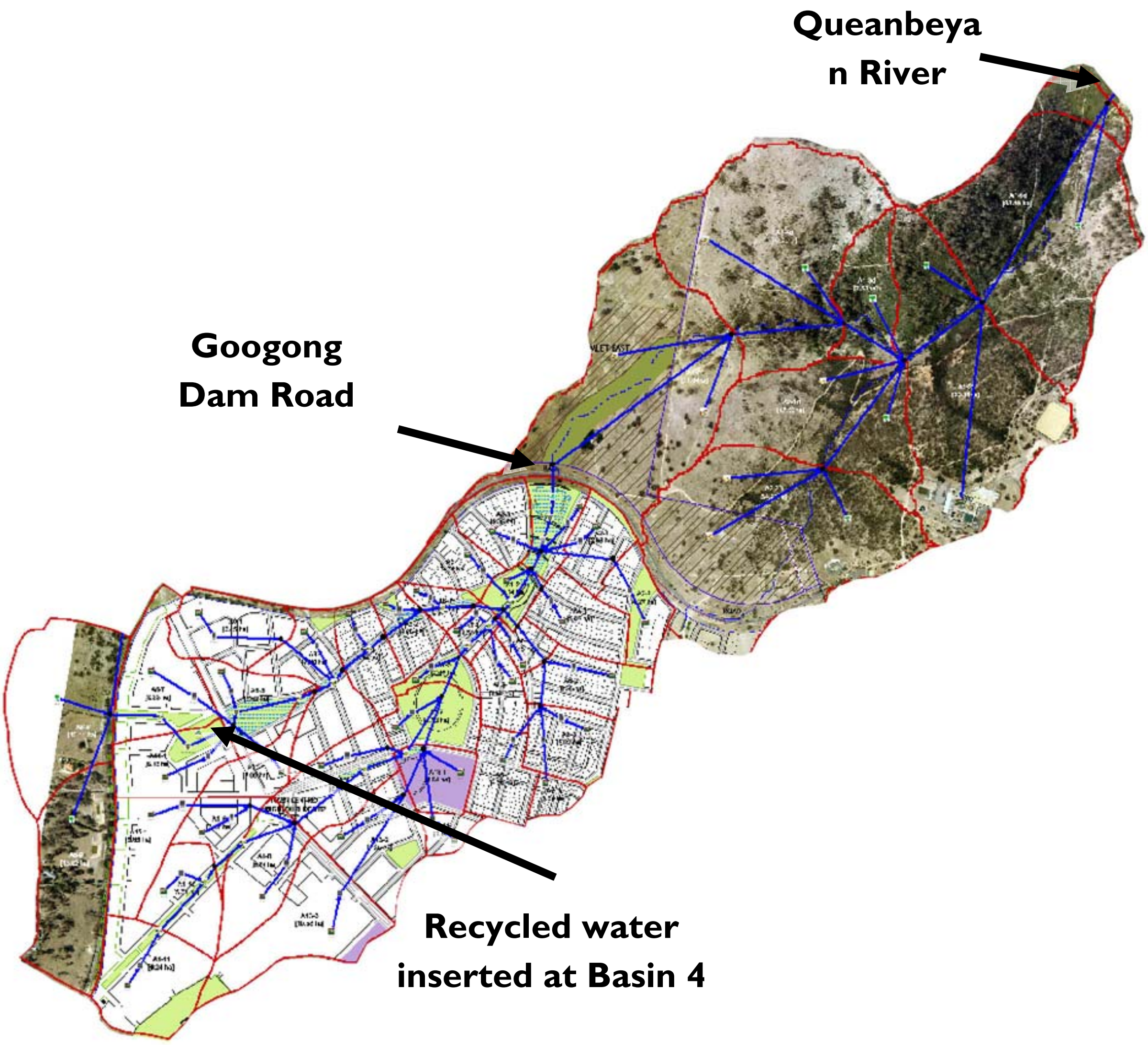

Figure 16 Developed Catchment *MUSIC* Model (WSUD Recycled at Basin 4 – Revised Bioretention)

The results of the *MUSIC* modelling for Googong Creek catchment with excess recycled water discharged into the system at Basin 4 are reported in Table 16 at the downstream end of the development Googong Dam Road, and at the confluence with the Queanbeyan River.

Table 16 Developed Catchment (WSUD (Recycled Water Insertion at upstream basin)) Pollutant Export rates

Pollutant	*Pollutant Load at Googong Dam Road (kg/year)*	*Removal Rate (%)*	*Pollutant Load at Queanbeyan River (kg/year)*
TSS	8,430	95.1%	40,100
TP	62	65.2%	96
TN	856	75.0%	1,400
Gross Pollutants	0	100.0%	4,390
Annual Flow Volume (ML/year)	770	6.1%	940

The results in Table 16 indicate that the treatment system proposed in Figure 16, with the insertion of recycled water from the WRP at the upstream end of Googong Creek at Basin 4 would meet the removal targets at Googong Dam Road for nutrient removal.

The pollutant load at the confluence with the Queanbeyan River is lower than the existing catchment rate for total suspended solids and gross pollutants, but is higher for nutrients.

8.1.5 Recycled Water MUSIC Model with Rainwater Tanks (Insertion at upstream basin) - Case 7

The model developed in Section 8.1.4, incorporating the insertion of recycled water at the upstream end of Googong Creek was modified to incorporate rainwater tanks on each dwelling. Rainwater tank parameters are the same as those used in Section 8.1.3. The layout of the *MUSIC* model is presented in Figure 17.

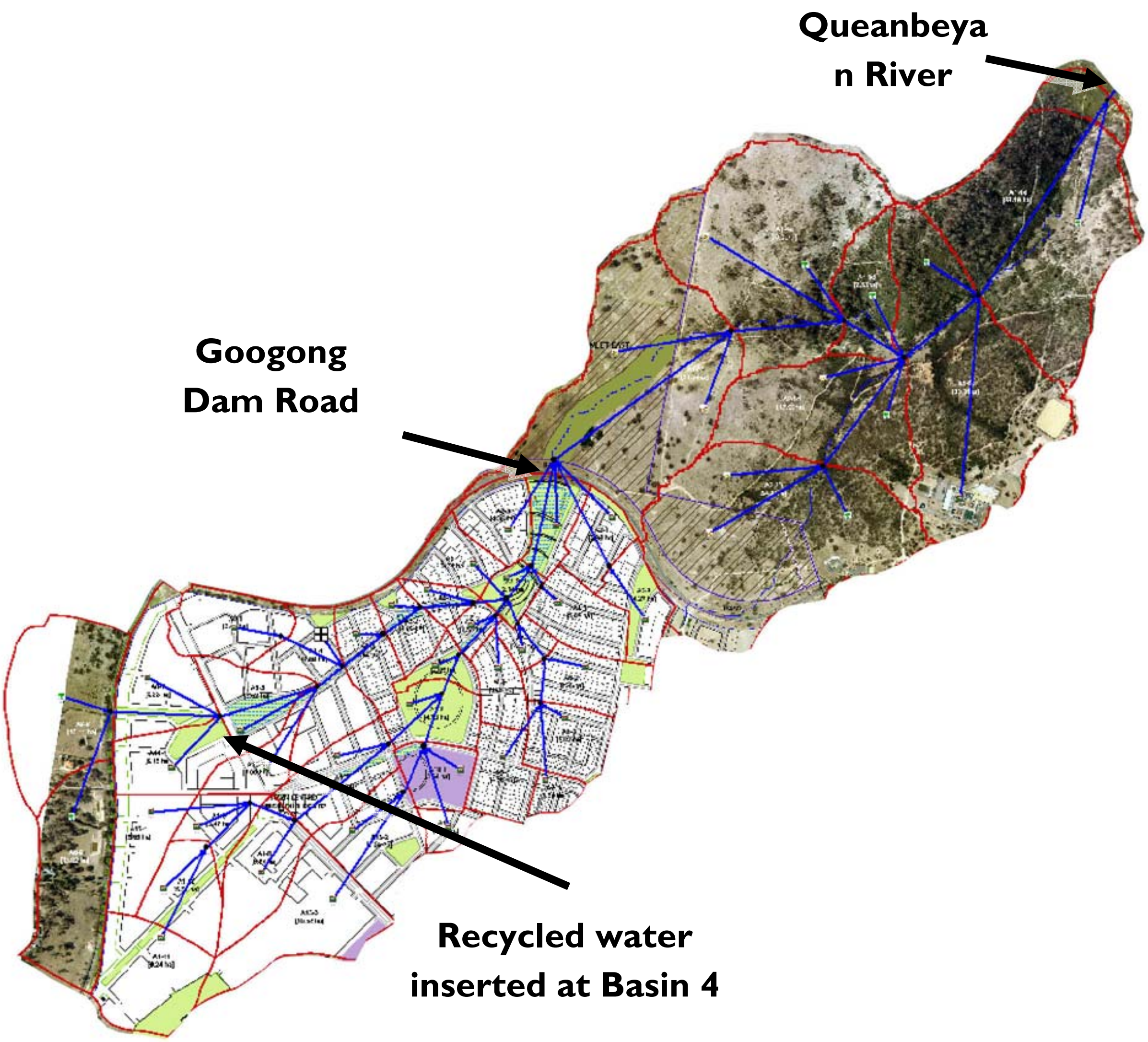

Figure 17 Developed Catchment *MUSIC* Model (WSUD Recycled at Basin 4 – Revised Bioretention with Rainwater Tanks)

The results of the *MUSIC* modelling for Googong Creek catchment with excess recycled water discharged into the system at Basin 4, incorporating the effect of rainwater tanks on each dwelling are reported in Table 17 at the downstream end of the development Googong Dam Road, and at the confluence with the Queanbeyan River.

Table 17 Developed Catchment (WSUD with Rainwater Tanks (Recycled Water Insertion at upstream basin)) Pollutant Export rates

Pollutant	*Pollutant Load at Googong Dam Road (kg/year)*	*Removal Rate (%)*	*Pollutant Load at Queanbeyan River (kg/year)*
TSS	8,540	95.0%	40,200
TP	64	70.4%	98
TN	820	84.7%	1,370
Gross Pollutants	0	100.0%	4,390
Annual Flow Volume (ML/year)	808	20.2	978

The results in Table 17 indicate that the treatment system proposed in Figure 17, with the insertion of recycled water from the WRP at the upstream end of Googong Creek at Basin 4, with the inclusion of rainwater tanks would meet the removal targets at Googong Dam Road for nutrient removal.

The pollutant load at the confluence with the Queanbeyan River is lower than the existing catchment rate for total suspended solids and gross pollutants, but is higher for nutrients.

8.1.6 MUSIC Modelling Results and Conclusion

The results of the *MUSIC* modelling outlined in this letter report indicate that the design meets the stormwater water quality objectives. The calculations indicate that the design presented on Trunk Stormwater Drainage Concept Plan for Neighbourhood 1 and Town Centre" X07008.02.SK01 Issue C (with the modification of Basin 1, increased from 3000m^2 to 3500m^2) achieves the pollutant removal targets in the Queanbeyan City Council Development *Design Specification D7 – Erosion Control and Stormwater Management* with the inclusion of recycled water from the Googong Water Recycling Plant.

9 SOIL & WATER MANAGEMENT DURING CONSTRUCTION

A Soil and Water Management Plan (SWMP) will be prepared and implemented to minimise potential impacts on hydrology and water quality during the construction period. This plan will incorporate the design and installation of erosion controls in accordance with the requirements of *Queanbeyan City Council Development Design Specification D7 – Erosion Control and Stormwater Management* and the *Managing Urban Stormwater: Soils and Construction* published by Landcom (colloquially known as the *"Blue Book"*).

The plan will include the following:

- At the vegetation clearing stage, cleared vegetation will be mulched and spread over disturbed area to provide a natural erosion barrier
- Prior to commencement of earthworks, a range of measures will be put in place including:
    - Construction of cut-off drains to prevent clean water from upstream of the corridor flowing onto and eroding disturbed areas
    - The diversion of site discharge points to erosion control measures such as silt fences and sedimentation basins in order to control dirty water areas
    - The stabilisation of exposed areas as soon as practical following the construction of each section of works
- Controls outside the specific work area would be put in place including:
    - Refuelling of plant an machinery within bunded areas or off site in appropriate locations
    - Minimisation of disturbed areas so that the potential export of sediment is minimised
    - The establishment and maintenance of stabilised construction compounds to reduce the overall disturbance area for the Project.
- Temporary sediment basins will be constructed to capture water and sediment before it can leave the site or enter the receiving water bodies. Conceptual design of the temporary sediment basins will be included in the SWMP and follow the methodology outlined in the "*Blue Book*" with the following features:
    - Sediment basins are to be located at points near where dirty water would discharge to receiving waters or leave the site
    - Basins are to be designed for Type F/D soils, as outlined in Section 6.3.4 of the Blue Book, in accordance with the soil type classifications shown on Figure 3.
    - The minimum depth of the basins will be 0.6 metres with an average depth of 1 metre.

A surface water quality monitoring program for the construction period will be developed to monitor water quality upstream and downstream of the construction areas. Construction period monitoring will be carried out periodically and after rainfall events as part of the assessment of the operation of water quality mitigation measures. Monitoring during the construction phase of the project would examine the following indicators:

- pH
- Electrical conductivity
- Turbidity
- Dissolved oxygen