Goulburn Mulwaree Council

Report for Marulan Township Development

Marulan Stormwater Master Plan

December 2005

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Appendices

1. Introduction

1.1 Background

Goulburn Mulwaree Council engaged GHD to undertake the development of a stormwater master plan for the future development of Marulan as shown on the "Greater Marulan Structure Plan" November 2003 in Appendix A.

The Mulwaree Shire Council "Settlement Strategy", November 2003 (Ref 3), indicated that the shire has sustained steady population growth. A number of issues account for this growth including the improved accessibility to Sydney through the construction of the M5 and further development of the Western Sydney Orbital Route.

Due to the increasing shortage of urban and rural land within the Sydney Region, the more affordable and available land within the Shire is seen as a major attraction.

It is for the above reasons that Marulan is being promoted as an alternative for both urban development and business opportunities. However, the ability to cater for any significant increase in development will be highly dependant upon the availability of services to the area.

1.2 General

The areas proposed for development as part of the settlement strategy include Sector A (Zone 1(b)), Sector D, Sector F and the parcel of land Zoned 1(b) within Sector B. These are the areas that have been considered in this stormwater master plan.

Sector A consists of approximately 335 ha of both general rural and rural urban zones. Of this area, only zone 1(b) land (approximately 60 ha), is being considered for further development.

The existing village of Marulan is included in Sector F. While there is a considerable amount of development within Sector F, there are still a number of locations where further development could occur. The settlement strategy indicates areas for future residential development as well as nominating designated business areas.

Zone 1(b) within Sector B has also been nominated for future residential and industrial development. This area of approximately 90 ha (based on information provided by Patterson Britton), will be comprised of a mixture of urban residential and future industrial expansion.

The majority of stormwater from each of the above sectors contributes to a watercourse that flows into the Wollondilly River Catchment with some runoff being directed into the Bungonia Creek catchment.

Sector D is located on the eastern side of the highway and is currently zoned for residential-urban expansion. Current plans indicate that this area of approximately 290 ha will have mixed land uses ranging from high density to rural residential and will also include some commercial areas.

2. Regulatory Requirements

2.1 General

Both the Bungonia Creek and Wollondilly Creek catchments are drinking water catchments of the Sydney Catchment Authority (SCA). Consequently, due to the location of the development area, there are two main regulatory authorities that would be involved in the decision process for any proposed development. These include both Goulburn Mulwaree Council (GMC) and the SCA.

A ridge heading approximately northeast bisects the township between both the Wollondilly River catchment and the Bungonia Creek catchment. Figure 1 indicates the major catchment boundaries.

2.2 Goulburn Mulwaree Council Requirements

The Marulan Urban Stormwater Management Plan (MUSMP), which outlines a number of key issues for consideration with any new development. These key issues include, but are not limited to the following:

- Water-sensitive urban design principles are to be incorporated into any new development;
- Management of both stormwater quantity and quality should be at or near the source;
- "Natural" channel designs, rather than constructed floodways, should be incorporated where appropriate;
- Peak flows from the development should not exceed pre-development flows for all storm events from the 1 year to 100 year average recurrence interval (ARI);
- Protect and maintain natural wetlands, watercourses and riparian corridors; and
- Maximise the use of vegetated flow paths.

The document also includes a number of more specific issues in regards to both stormwater quantity and quality. For stormwater quantity, the following are the noted key items:

- Impervious areas connected to the drainage system to be minimised;
- Re-use of stormwater is to be maximised;
- Use of vegetated flow paths to be maximised;
- Use of at source infiltration to be used where appropriate;
- Alterations to natural flow paths, discharge points and volumes to be minimised;
- No increase in bank-full flows as a result of development;
- Multiple use of stormwater facilities; and
- Impact of stormwater discharge on urban bushland areas to be minimised.

For stormwater quality, the following retention criteria are nominated for development sites:

- Coarse sediment – 80% retention of average annual load for particles ≤ 0.5mm;
- Fine particles – 50% retention of average annual load for particles ≤ 0.1mm;
- Total phosphorous – 45% retention of average annual load;
- Total Nitrogen – 45% retention of average annual load;

- Gross pollutants – 90% retention of average annual load > 5mm; and
- Hydrocarbons, motor fuels, oils and grease – 90% retention of average annual load.

2.3 Sydney Catchment Authority

The Sydney Catchment Authority (SCA) must assess any proposed development that falls within the Sydney water supply area. Discussions with SCA indicated that they are required to undertake the assessment in accordance with SEPP 58, in particular, Clause 10.

This clause indicates the following must be considered:

- Whether the development or activity will have a neutral or beneficial effect on the water quality of rivers, streams or groundwater in the hydrological catchment, including during periods of wet weather;
- Whether the water quality management practices proposed to be completed as part of the development or activity are sustainable over the long term; and
- Whether the development or activity is compatible with relevant environmental objectives and water quality standards established by the Government for the hydrological catchment.

2.4 Summary

From 2.2 and 2.3 it can be seen that GMC assesses the effectiveness of the water quality measures based on a % reduction of load basis, while the SCA requires a more holistic approach to any proposed treatment.

Since the SCA is the controlling authority in relation to water quality for the larger portion of the development area, the assessment of any water quality measures will be in accordance with the SCA requirements.

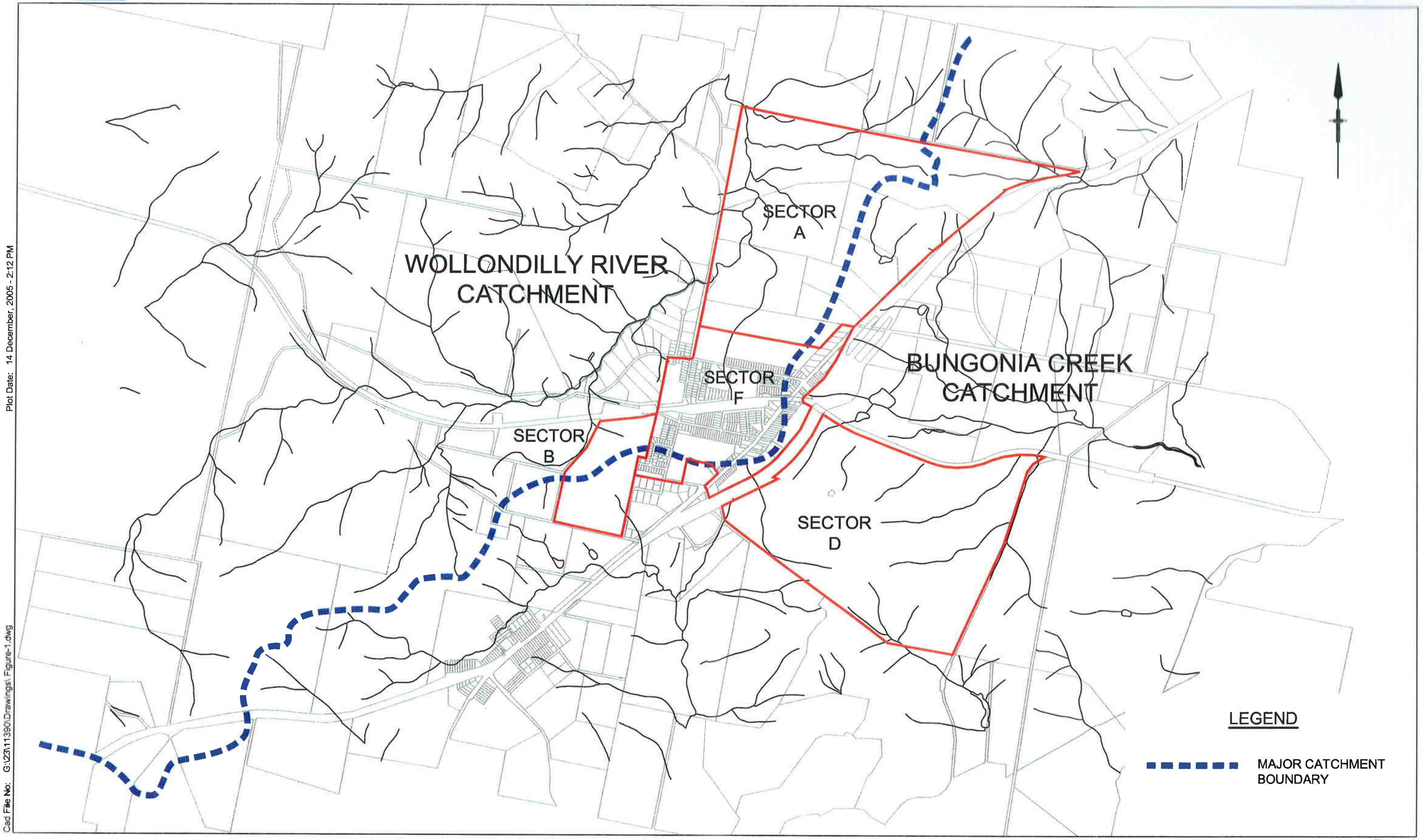

Figure 1
Major Catchments

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3. Peak Discharge Controls

As indicated in Section 2, there is a requirement by both GMC and SCA that any development will not have a negative impact of the downstream system. GMC specifically nominate in the Marulan Urban Stormwater Management Plan, that "*Generally no increase in the 1 in 5 year and 1 in 100 year probability peak flows*".

On that basis, an analysis was undertaken to determine the impact, of various levels of development, on the peak discharge flows followed by a comparison with the existing peak flows. This information was then used to size on-site detention for the development area.

3.1 Methodology

3.1.1 General

In order to establish the peak flows in both pre development and post development conditions, a RAFTS-XP model was established. Figure 2 shows the catchment boundaries established for the area.

As part of the process of establishing a RAFTS-XP model, appropriate soil loss models need to be determined. Previous studies (STORM Consulting Pty Ltd) in the Goulburn area have used 5mm initial and 1mm/hr continuing loss for pervious areas and 1mm initial and 0mm/hr continuing loss for impervious areas.

Reference was made to soil maps of Australia that are on the internet web site www.canri.nsw.gov.au (the Community Access to National Resources). This web site contains the National Resource Atlas, which was used to view the soil maps of the area. The soil surrounding and including Marulan has been classified as "*soil capable of general cultivation*". For this reason, it is concluded that a higher loss model is more applicable to this area than the model used in the previous studies described above.

For most of the pervious areas, a loss model that assumes an initial loss of 15mm with a continuing loss of 2.5mm/hr was applied. For impervious areas the losses are 1.5mm initial and 0.5mm/hr continuing.

A sensitivity check was made to compare the peak flows generated for the proposed and previous loss models and the results are shown on Table 1.

Table 1 Comparison of Peak Flows for Alternative Loss Models

	Lower Loss model (Pervious IL=5;CL=1 Impervious IL=1;CL=0 10% impervious)			Higher Loss model (Pervious IL=15;CL=2.5 Impervious IL=1.5;CL=0.5 10% impervious)			% Comparison (Disch. Higher Loss Model/ Lower Loss Model)		
Node	Q1	Q10	Q100	Q1	Q10	Q100	Q1	Q10	Q100
2	26.9	69.6	120.4	11.8	52.0	98.0	44%	75%	81%
5	29.3	76.0	129.8	13.1	56.8	106.7	45%	75%	82%
10	30.7	79.4	134.8	13.7	59.4	111.8	45%	75%	83%
17	32.3	84.0	143.0	14.2	62.3	118.8	44%	74%	83%

Table 1 indicates the peak flow at the nominated node points for a range of storm events with both the lower loss model and higher loss model. The table then compares these peak flow rates and the percentages given have been calculated as higher model/lower model flows.

From the table it can be seen that for the 1-year event, the flows generated from the higher loss model are significantly lower than those generated for the lower loss model (less than half). However, for both the 10-year and 100 year events, the difference in peak flow is much less.

Overall, it is considered that the soil loss values in the higher loss model more reasonably represent the conditions of the area and this modelling has been adopted for the project and all the subsequent analysis described below.

3.1.2 On-site or Single Structure Detention

There are two means by which on-site detention can be achieved: either on individual properties or as a single structure that would serve the development as a whole.

While it is preferable to deal with the detention of runoff "at source", this is not always the most practical solution. In some cases, it may not be possible to provide the required on-site detention on individual properties and hence a single structure at the catchment outlet may be required.

Another situation in which on-site detention may not be practical is where there is rural residential development. While the use of rainwater tanks is likely to be included, the practicality of including other on-site detention features would need to be considered as part of the development process.

For these reasons, detention basin sizes have been determined for the catchments that have been nominated for further development that is discussed in Section 3.2.3.

3.1.3 Permissible Site Discharge

A RAFTS-XP model was established for a unit area of 1 hectare to enable simulation of progressive development of a 1-hectare site. This model firstly simulated the existing conditions of the area and was then progressively 'developed'. The existing conditions for the site were nominated as 10% impervious with an average slope of 5% and a Manning's roughness of 0.05.

A number of storm durations were modelled ranging from 10 minutes through to the 4.5 hours, with a routing increment of 1 minute. This wide range was chosen to ensure that the critical storm duration was determined for each development case.

Increasing the percentage impervious of the area in 10% increments simulated the process of 'developing' the unit area. It also involved the inclusion of the impervious Manning's roughness of 0.015. It was also assumed that between 100% and 70% of any lot would drain to the on-site detention system. The remaining catchment area will drain directly to the conventional stormwater system.

To ensure compliance with the Council requirement of no increase in flows as a result of development, the permissible discharge from the on-site detention system in addition to the runoff from the remaining catchment area are not to exceed the existing conditions peak flow.

3.1.4 On-site Detention

The detention volumes required for each level of development have been determined for each development area as it is the storage volume available that will dictate the ability to achieve the permissible site discharge. If insufficient detention is provided, it is not possible to reduce the permissible site discharge to the prescribed level.

3.2 Results

Permissible site discharge and site storage requirements have been determined to reduce the developed 100-year ARI flows back to predevelopment 100-year flows. The results that are presented in the following tables are for guidance only.

Consideration should be given to the performance of these systems in smaller events. The outlet from the on-site detention system must be sized to ensure that the peak flows for the smaller storm events are also not increased as a result of the development.

Sizing of the detention basins has also been undertaken for the 100 year ARI storm event. As for an on-site detention system, the size and configuration of the outlet should be determined to ensure that peak flows from smaller events do not exceed the predevelopment level.

Table 2 shows both the current level of development and expected level of development based on information supplied for each catchment area.

Table 2 Level of Expected Development

Catchment	% Impervious Pre Development	% Impervious Post Development
3	25	50
6	25	50
7	10	50
8	10	50
20	10	50
21	10	40
22	10	30
23	10	20
24	10	30
25	10	30
26	10	30
27	10	40
28	10	40
29	10	40

The existing conditions RAFTS-XP model was altered to reflect these various levels of development based on the above.

3.2.1 Permissible Site Discharge

Table 3 indicates the permissible site discharge for a range of development levels (% impervious) and contribution to the on-site detention system based on RAFTS-XP model runs with the test case unit 1 hectare area (refer 3.1.3). These results are for the 100 year ARI storm event.

Table 3 Permissible Site Discharge (l/s/hectare)

	Percentage of Development Area Draining to OSD System			
% Impervious	**100**	**90**	**80**	**70**
10	250	225	195	170
20	250	220	195	170
50	·250	215	185	155
70	250	210	170	135
90	250	205	155	105

An example of the application of the above table is:

For an area with 80% draining to the on-site detention system and 70% of the area is impervious, the permissible site discharge from Table 3 would be 170 l/s/hectare. If the area of the lot was 1,000 sqm, the permissible site discharge from this lot would be (1,000/10,000) x 170 = 17 l/s.

Table 3 prescribes the allowable site discharge assuming the development of individual lots. It does not cater for the increase in runoff from roadway areas within the development. The increase in runoff from these roadway areas could be catered for either in a detention basin at the outlet of the drainage system or by over-restricting the discharge from the lots.

3.2.2 On-Site Detention

As for the permissible site discharges, RAFTS-XP model runs with the test case unit 1-hectare area were used to determine the volume of detention required for the unit hectare area for the nominated range of contribution areas and development levels (% impervious). These are presented in Table 4. These results are for the 100-year ARI storm event.

Table 4 Site Storage Requirements (m^3/hectare)

	Percentage of Development Area Draining to OSD System			
% Impervious	**100**	**90**	**80**	**70**
10	0	45	90	135
20	10	60	95	140
50	50	120	170	215
70	170	235	300	350
90	300	365	440	530

For the same area with 80% draining to the on-site detention system and 70% of the area being developed, the on-site detention requirement would be (1,000/10,000) x 300 = 30 m^3.

3.2.3 Single Structure Detention

The catchments in each of the development areas shown on Figure 1 which will require detention are 1, 1a, 3, 6, 7, 20, 21, 22, 23, 24, 25, 26, 27, 28 and 29 as shown on Figure 2. If the on-site detention controls specified above are not applied on the individual properties, detention basins would be required at the discharge point of the catchments.

GHD

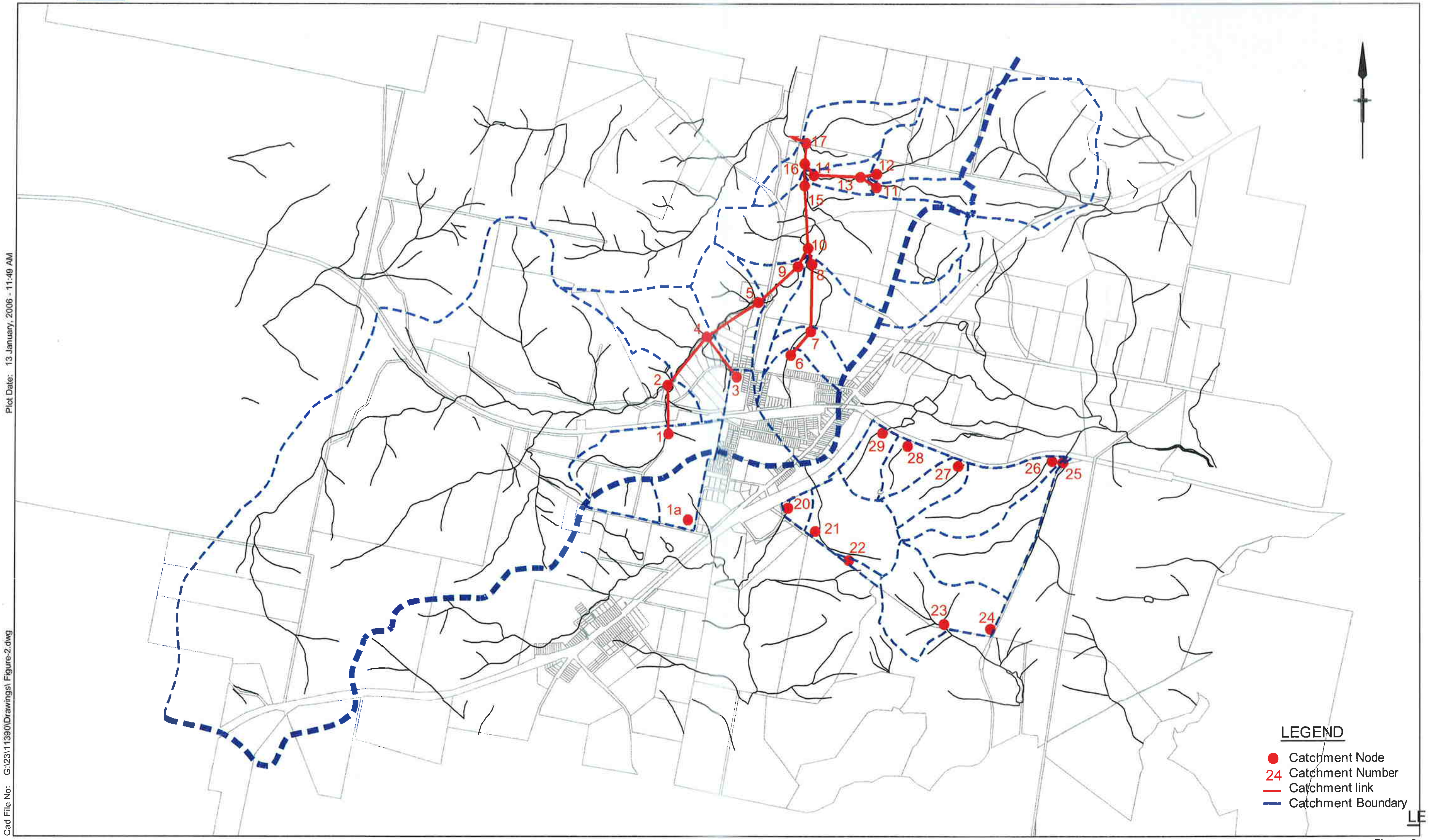


Figure 2
Detailed Catchment Plan

Table 5 indicates the predevelopment and post development flow for the catchments being developed. It also indicates the required storage to offset this increase and a preliminary footprint area for a single detention basin at the discharge point for each of these catchments.

Table 5 Detention Basin Sizing

Catchment	Q100 Pre (m^3/s)	Q100 Post (m^3/s)	Storage (m^3)	Internal Base area (m x m)
3	4.37	5.32	860	10 x 20
7	18.48	27.25	4,985	26 x 52
20	1.21	1.83	1,120	13 x 26
21	9.97	12.64	14,420	63 x 126
22	0.96	1.13	310	5 x 10
23	10.06	11.46	7,560	44 x 88
24	3.87	4.42	990	12 x 24
25	9.76	12.35	13,990	62 x 124
26	19.53	24.25	25,490	86 x 172
27	3.81	4.84	1,860	18 x 36
28	4.32	5.42	1,980	20 x 40
29	4.74	5.77	3,710	29 x 58

Each of the basins has a weir level 1.5m above the invert of the basin, embankment height 2.0m above the invert and 1 in 6 internal batter slopes. The outlet configuration for the basins nominated above has not been determined. This will be part of the concept design process and will be highly dependant upon the final development of the catchment and the method of applying the detention throughout the catchments.

A landscape buffer zone surrounding the detention basin should also be included in the concept layout for these structures.

3.3 Summary

As part of the development process, it would be necessary to nominate which method of detention was to be applied to each catchment. Where feasible, it is recommended that on-site detention be incorporated onto individual lots. This would allow treatment at the source of the runoff rather than allowing for the increased runoff to be transported further downstream.

The benefit of applying this principle 'at source' is the reduction in capital cost of the downstream drainage system. By limiting the discharge from each allotment to the predevelopment level, the size of the conventional road stormwater system can be reduced.

In the event that it is not possible to incorporate on-site detention, the use of detention basins just upstream of the catchment outlet, would be required. This would reduce the discharge from the catchment back to a predevelopment level.

The advantages and disadvantages of each means of detention would need to be considered in conjunction with both Council and the developer in order to determine the most suitable result.

4. Major Flow Path Assessment

Figure 3 shows the creeks and major trunk drainage tributaries considered in the analysis described below.

Sectors A, B and F (Figure 1) are located to the west of the highway and contribute to the Joarimin Creek catchment. Joarimin Creek in turn, contributes to the Wollondilly River catchment. To ensure that the Sydney Catchment Authority requirement of no negative impact is achieved, the existing flows within Joarimin Creek need to be maintained.

This section of the report outlines the treatment of flows through the trunk drainage system of Joarimin Creek.

Also considered in this section of the report is the formalisation of other natural tributaries throughout the development areas.

4.1 Methodology

4.1.1 Joarimin Creek

To ensure that there is no negative impact on the downstream system as a direct result of any of the proposed developments, the predevelopment peak flows through Joarimin Creek were determined.

The RAFTS-XP model established for the investigations described in Section 3 was further examined to determine the peak flow at critical locations along the existing creek.

To ensure that development does not encroach on the flow path of the trunk drainage system, the cross sectional area required to cater for the 100 year ARI peak flow rates was also determined at the same locations.

Preliminary discussions were also held with Department of Infrastructure Planning and Natural Resources (now Dept of Natural Resources, (DNR)) in order to establish what interest, if any, they may have in this system. These discussions indicated that there was no special interest in the area, however some setback from the riparian zone may be required. For this study, a 40m setback from the top of embankment has been assumed to be the limit of DNR's interest. This should be further investigated as part of the development process.

4.1.2 Trunk Drainage Tributaries

A number of existing tributaries have been assessed for the expected level of development in the contributing catchment. This assessment was undertaken for the 100 year ARI event and trapezoidal channel dimensions to cater for these flows were determined.

The channel profile and cross section for each tributary has been based on containing the 100 year ARI flows and ensuring that a maximum velocity*depth product of 0.6 was maintained.

4.2 Results

4.2.1 Joarimin Creek

Table 6 indicates the predevelopment flow rates, which are to be maintained as the post-development flows at a number of node locations along Joarimin Creek and the depth of flow required in a trapezoidal channel with a 5m wide base and 1 in 6 batter slopes.

Table 6 Trunk Drainage Peak Flows

Node	Q1 Peak Flow	Q10 Peak Flow	Q100 Peak Flow	Depth of Q100 Flow
2	11.8	52.0	98.0	1.65
5	13.1	56.8	106.7	1.70
10	13.7	59.4	111.8	1.75
17	14.2	62.3	118.8	1.80

The top width of flow ranges from 24.8m to 26.6m. If DNR require a setback of 40m either side of the channel, development would not be allowed to occur within this area.

From the supplied information in regards to Sectors A, B and F (Figure 1), it does not appear that there is any proposed development within the land noted as being of possible interest to DNR.

4.2.2 Trunk Drainage Tributaries

Table 7 indicates the required design cross-section dimensions for each tributary. These cross sections have been determined based on the existing longitudinal slopes and the requirement that the velocity*depth product does not exceed 0.6. Values greater than 0.6 may result in a compromise of public safety.

If the resulting cross section widths are considered to be too great, it may be possible to reduce the base width by incorporating rock protection of the invert to increase the roughness along the channel. As part of the detail design process for each development, the developer may consider other means by which to reduce the land take for these overland flow paths.

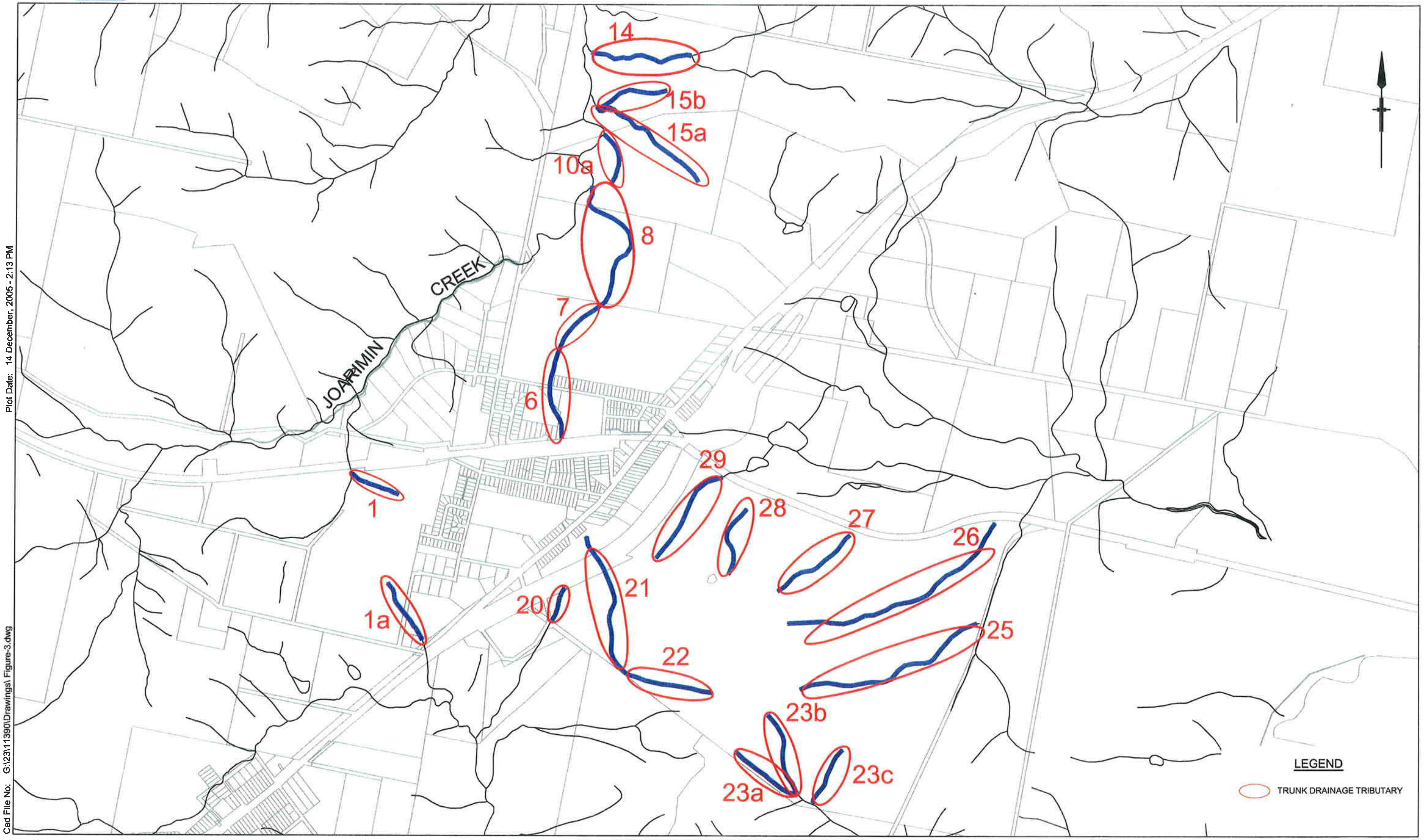


Figure 3
Trunk Drainage Tributaries

Table 7 Trunk Drainage Tributaries

Tributary	Q100 Flow (m^3/s)	Slope (%)	Base Width (m)	Flow Depth (mm)	Top Flow Width (m)
1	3.2	1	3	440	8.5
1a	5.4	1	7	420	12.0
6	11.9	4.5	18	260	21.1
7	14.7	5	24	250	27.0
8	19.0	5	30	260	33.0
10	5.2	5	7	260	10.1
14	20.9	1.5	32	360	36.3
15a	6.8	2.5	10	310	13.7
15b	2.6	2.5	3	320	6.8
20	2.9	2	3	360	7.3
21	7.9	5	12	250	15.0
22	6.1	7	9	230	11.8
23a	3.2	6.5	4	250	7.0
23b	4.6	6.5	7	230	9.8
23c	1.9	6.5	2	250	5.0
25	12.4	4	20	260	23.1
26	10.4	4.5	16	260	19.1
27	6.0	6	9	240	11.9
28	4.8	6	7	240	9.9
29	6.3	6	9	250	12.0
30a	4.4	2.5	6	310	9.7
30b	2.5	2.5	2	350	6.2

To meet the Sydney Catchment Authority requirement of no negative impact on the downstream system, the existing peak flow rates must be maintained along Joarimin Creek. These flow rates have been nominated in Table 6 above for a range of storm events.

The depth of flow in a nominated trapezoidal cross section has also been nominated.

With the inclusion of detention structures, either on-site detention or detention basins, the reduction of post development flow rates back to predevelopment level, can be achieved.

To aid in the reduction of any degradation of Joarimin Creek, it is also recommended that some remediation and bank protection works be carried out. While an engineered cross section has been nominated to ensure sufficient capacity within the creek is achieved, it is recommended that the final shaping of the creek be as 'natural' as possible.

The proposed profile of the creek would include variations in batter slope and base width and also allow for meandering and the incorporation of pools and riffles. This would aid in the reduction of flow velocities and assist in the removal of fine sediment and the reduction in bank erosion.

4.3 Proposed Infrastructure Upgrade Works

The proposed infrastructure upgrade works are described below and shown on the master plan drawing, Figure 4. The estimate cost of these works is shown in Section 7.2, Table 13 .

4.3.1 Basins 1 and 1A

These basins are associated with the Tailored Properties development and the construction of these is responsibility of the developer of this partion of land.

4.3.2 Basin 3A

Basin 3A is located on public land immediately upstream of the 950 diameter culvert under the railway line. It is designed to reduce the stormwater discharge from the existing development on the west side of the township and south of the railway line as well as the 102 lot Portland Avenue development to the predevelopment flows. The basin has also been sized so that the 100 year flow will pass through the existing culvert under the railway line.

The developer for Portland Avenue will be required to make a Section 64 contribution to the cost of construction of the basin as shown in Table 13.

4.3.3 Channel 3 - Railway line to Basin 3

The 49 lot subdivision on the west side of Stony Creek Road (N-S) is transected by the existing natural drainage channel from the culvert under the railway line to Joramin Creek. The developer of this subdivision is responsible for construction of the drainage channel through the subdivision to Basin 3.

4.3.4 Basin 3

Basin 3 adjacent to Maclura Drive is designed to reduce the stormwater discharge from the 49 lot subdivision on the west side of Stony Creek Road (N-S) as well as a small amount of runoff the subdivision on the east side of Stony Creek Road (N-S) to the predevelopment flows. The construction of this basin is the responsibility of the developer of the 49 lot subdivision.

4.3.5 Channel 6 - Railway line to Brayton St

This channel formalises the existing drainage channel through the open space and serves the existing development south of the railway line and the development between the railway line and Brayton Street (E-W). The upgrade works would be fully funded by Council. The size of the channel could be reduced if a basin was consrtucted on the south side of the 900 culvert under the railway line. However it seems that the only land available for a basin is owned by the railway and therfore it may not be possible to constuct a basin in his location.

4.3.6 Channel 6 - Brayton St to Basin 6

It has been assunmed that the flow in the upstream channel will pass under Brayton Street (E-W) without restriction and flow into Basin 6. The cost of this channel should be proportioned between the existing development on the north side of Brayton Street and the developer of Sub-sector F1. The costs have been proportion in this manner because the construction of the channel is not necessary unless Sub-sector F1 is developed.

4.3.7 Basin 6

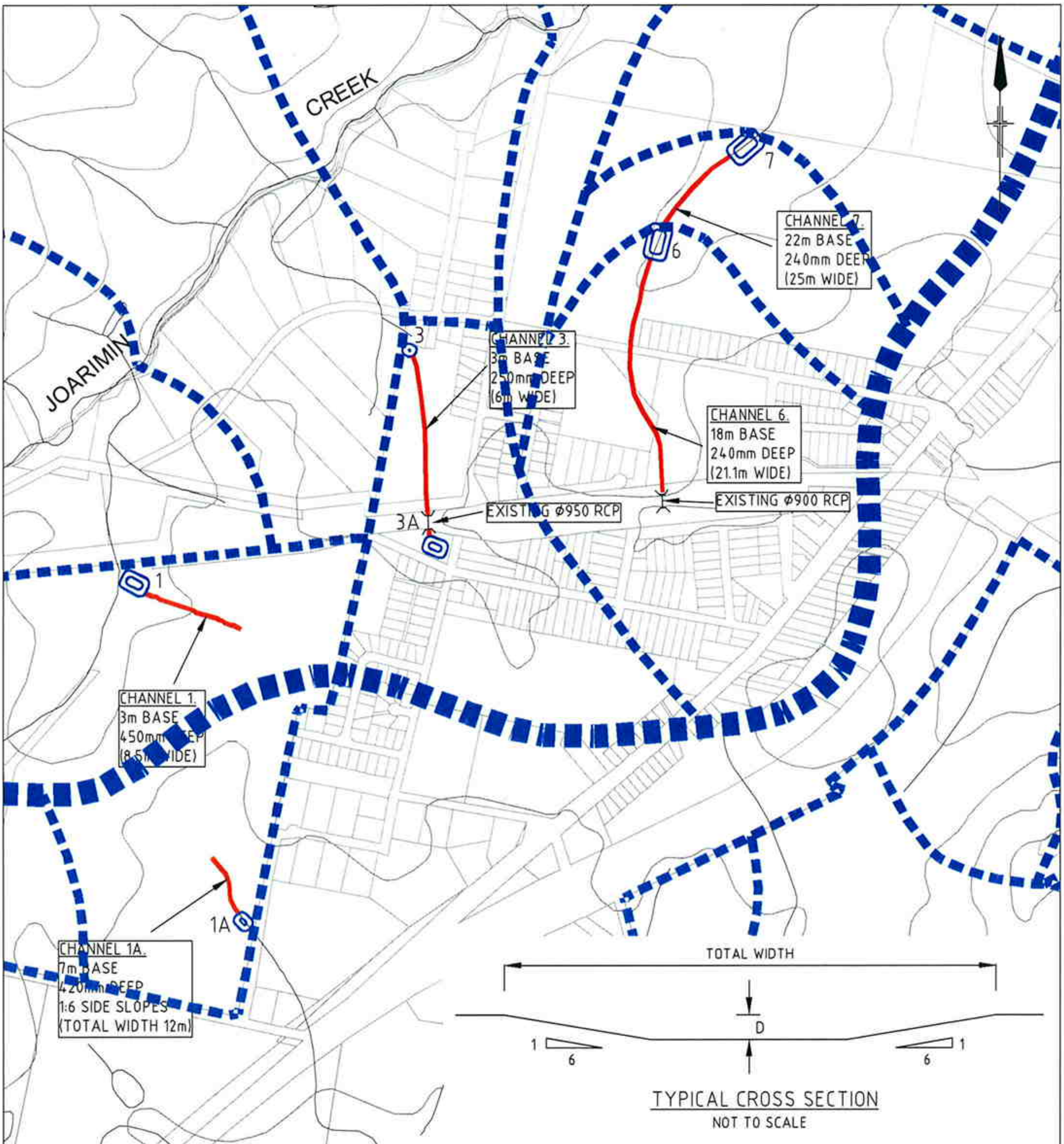
Basin 6 at the northern boundary of Sub-sector F1 is designed to reduce the stormwater discharge from the catchment upstream of this point to the predevelopment flows. The costs of this basin should be proportioned between the existing development on the north side of Brayton Street and the developer of Sub-sector F1. The costs have been proportion in this manner because the construction of the basin is not necessary unless Sub-sector F1 is developed.

4.3.8 Channel 7 - Basin 6 to Basin 7

Because Basin 6 controls the flow in the existing drainage channel through this development Sector A to Joramin Creek, the developer of Zones 1(b) and 2(v) in Sector A will be responsible for the construction of this channel.

4.3.9 Basin 7

Basin 7 is designed to reduce the stormwater discharge from the development in Zones 1(b) and 2(v) in Sector A to the predevelopment flows in the natural drainage channel downstream form the basin to Joraminn Creek. The developer will be responsible for the construction of this basin.



BASIN	MIN. SURFACE AREA (m^2)	STORAGE VOLUME (m^3)
1	2520	2830
1A	1280	1165
3	810	640
3A	1975	2210
6	2820	3340
7	1730	1825

5. Water Quality

5.1 Introduction

Marulan falls within the Sydney Catchment Authority (SCA) area. As a result, any development within this area must comply with the SCA planning principles. The SCA DRAFT document "Sustaining the Catchments", indicates that the basis of these principles is to ensure that there is a "neutral or beneficial effect on water quality".

According to this document, "a neutral or beneficial effect on water quality is demonstrated if one or all of the following factors can be achieved:

- A development has no identifiable impact on water quality;
- Any impacts can be treated or removed through approved systems;
- The impact can be contained within the development site;
- The development maintains the status quo or improves water quality leaving the site; or
- Where any of the above is not possible, the impacts can be managed using an approved pollution offset.

5.2 Methodology

In order to assess the impact of any future development, it is firstly necessary to establish the basis from which the effects of the development would be measured. The pollutant loading in the runoff for the current land uses needs to be determined.

MUSIC (the Model for Urban Stormwater Improvement Conceptualisation) is considered to be the most suitable planning tool currently available for this type of analysis. This model is able to simulate the catchment type and generate an annual pollutant loading for Total Suspended Solids (TSS), Total Phosphorous (TP), Total Nitrogen (TN) and Gross Pollutants (GP).

By then amending the existing conditions model to reflect the expected level of development, a revised annual pollutant loading can then be established. The revised loading can then be used to determine the required treatment method, if any, to offset the effects of the proposed development.

This investigation and report nominates target pollutant reduction levels for different types of development and outlines the benefits of a number of treatment methods. However, the report does not prescribe the use of any particular method. It is considered that each developer will be able to choose the treatment method most suitable to the individual sites.

5.3 Existing Conditions

The existing conditions in the development area were assessed. It was considered that for Sector D (Figure 1), to the east of the highway, that the current conditions were consistent with the MUSIC source node type 'agricultural'. The level of percentage impervious for the existing land use was nominated as 10%, which allowed for a number of rocky areas at, or near, the surface.

Similarly:

- For Sector A, the only area under consideration was zone 1(b). It was also considered to have a current land type of agricultural and the initial percentage impervious was also nominated as 10%.
- Sector B, zone 1(b) was also nominated as agricultural with an initial 10% impervious.

Sector F contains the existing village urban area as well as areas nominated for further development. The existing village area was nominated in the MUSIC model as 'urban' with an initial percentage impervious of 25% to cater for the varying levels of development through the catchments.

In order to satisfy the requirement that the post development pollutant loadings do not exceed the pre-development loadings, the existing conditions of the site were examined. The following section outlines the steps taken and assumptions made as part of this process.

5.4 Evaluation of Sectors A, B and F

Sector A and major parts of Sectors B and F are in the catchment of Joarimin Creek which flows into the Wollondilly River within the Sydney Catchment.

Each development area has been considered separately with the discharge point from each of the areas being directed into Joarimin Creek. For a number of the proposed development areas, preliminary layouts have been obtained however; there are areas where it is still unclear as to what the final development may include.

Consequently, a unit area of 1 ha has been nominated for the quantitative investigation. This was done for both the 'urban' and 'agricultural' source nodes. The modelling of these nodes were then progressively developed in order to determine what level of retention was required for the pollutant loadings for the range of development levels.

Based on this analysis, it is considered that for any future development, the required level of retention required can be selected based on the level of development. This approach will also allow the developer to incorporate the most appropriate water quality measures.

5.5 Sector D

Sector D was also analysed based on a unit area of 1 ha. The current proposal for the development of this area indicates that there will be a wide range in the density of the development. Some of the nominated areas include medium density residential housing while other areas are rural residential.

Again, the modelling of the unit area was progressively developed to allow for the simulation of a range of development levels and the required retention levels were determined.

5.6 Required Retention Rates

As part of the development process, the land use would change. The following criteria for % imperviousness were adopted for all areas:

- agricultural — 10% impervious;
- rural residential — 20 to 30% impervious;
- urban residential — 40 to 70% impervious; and
- commercial — 80 to 90% impervious.

The default source nodes within MUSIC are limited to forest, agricultural and urban. Consequently, for both the rural residential and commercial development levels, a user defined source node definition was required.

There is a lack of MUSIC input data available for different land uses in the project area, and consequently other sources were considered. Brisbane City Council has done extensive monitoring of the quality of runoff over the past ten years. This has lead to the development of pollutant concentrations and export relationships for a variety of land uses for the Brisbane area. This research has resulted in the most extensive range of available information in regards to water quality modelling currently available.

A comparison was made between the default MUSIC parameters and the parameters adopted by Brisbane City Council (BCC) for agricultural land. It was found that there was little difference between the two and hence the following BCC parameters for rural residential and commercial were also adopted for this analysis.

Table 8 and Table 9 show the recommended pollutant retention rates for land that is currently classified as agricultural or urban land use respectively.

Table 8 % Required Pollutant Retention for Agricultural Land Use

% Impervious	TSS	TP	TN	GP
10 (existing)	0	0	0	0
20	60	0	20	55
30	65	15	50	70
40	65	55	65	75
50	70	60	65	80
60	80	65	70	80
70	80	70	75	85
80	80	80	85	85
90	85	85	85	85

Table 9 % Required Pollutant Retention for Urban Development

% Impervious	TSS	TP	TN	GP
25 (existing)	0	0	0	0
30	30	15	25	15
40	35	40	45	35
50	50	45	50	45
60	65	55	55	50
70	65	60	65	55
80	70	75	75	60
90	70`	80	75	60

5.7 Discussion

5.7.1 Required Retention Rates for Current Agricultural Land Use Areas

Table 8 shows the required retention rates for the nominated pollutants for areas currently considered to be agricultural.

From Table 8 above, it can be seen that for an increase in the percentage of impervious area, there is a required increase in the percentage retention rate for each of the nominated pollutants.

Sediment from development is generated in two ways. Firstly, as part of the development process: the higher the level of development, the greater the area of disturbance. This leads to higher levels of generated suspended solids. Secondly, once the development is completed, there continues to be an increased level of suspended solids generation due to the increase in vehicular traffic. By default, it is assumed that more intense development generates higher traffic volumes. Sediment attached to vehicles on the underside of the chassis and on tyres, is deposited onto hardstand areas. During a runoff event, it is then transported through the drainage system.

Consequently, for suspended solids, there is an immediate increase in generation as a direct result of development and there is a continuing gradual increase in the required level of retention with increasing levels of development.

The increase in the generation of total phosphorous with development is not significant until the level of development results in the change in land use from rural residential to urban. This is because total phosphorous generation rates for urban areas allow for the inclusion of sewage overflows, which then discharge into the drainage system. At this point there is a marked increase in the retention rate. There is then a continuous gradual increase in the required retention rate with further increases in intensity of development.

Fertilising of lawns and gardens as well as the increase in animal habitation has an impact on the level of total nitrogen generated. With increasing urban development there is an increase in the density of vegetation, and taking into account the maintenance of lawns in the residential areas, there is an increase in the level of nitrogen in the soil.

The transportation of sediment results in conveyance of attached nutrients off the development site and into the drainage system.

Increased levels of development also result in increased quantities of gross pollutants or litter. Gross pollutants are considered to be items that could be captured by a 5mm mesh. Organic matter accounts for approximately 65% of gross pollutants. This is reflected in the required retention rates nominated in Table 8.

5.7.2 Required Retention Rates for Existing Urban Development Areas

Table 9 indicates the required retention rates for the nominated pollutants for areas currently considered to be urban. As discussed in Section 5.7.1, there is a required increase in the retention rate for each pollutant with increasing levels of development.

5.8 Water Quality Treatment Measures

A number of water quality treatment measures would be suitable for these development areas. The following sections outline some of these and also indicate the performance levels of each of these measures.

5.8.1 Vegetated Swales

Vegetated swales perform a number of functions. They are able to not only convey but to detain and treat stormwater runoff. The vegetation within the swale assists in the removal of sediment and suspended soils which in turn aids in the reduction of phosphorous and nitrogen reaching the downstream system.

The incorporation of swales within a development area also assists in the treatment of hydrocarbons, oil and grease generated off roadways areas. Current water sensitive urban design standards incorporate grassed swales into the road design in place of concrete kerb and gutter.

Swales are most effective if the road layout is such that it follows the natural contours. This allows a reasonably flat grade, between 1 and 5%, which will increase both the infiltration time and the time of concentration to the discharge point.

Another advantage of incorporating swales into the road design is the reduction in capital cost. There is a reduction in the amount of stormwater pipe required and depending on the shaping of the swale, only driveway crossings will require short culverts for the conveyance of the stormwater runoff.

5.8.2 Bioretention

The combination of vegetated swales with an underlying infiltration trench forms the basis for a bioretention system. Compared to conventional drainage components, the hydraulic control of the swale on the stormwater runoff allows a longer attenuation time, which in turn allows for more of the runoff to percolate through into the filter material of the infiltration trench.

Effectiveness of the filter material is highly dependent upon its hydraulic conductivity. Due to a longer detention time, a lower conductivity will result in a higher the rate of pollutant removal.

As with vegetated swales, this system can be incorporated into the road design and may also be considered to improve the aesthetics of the area by allowing for a higher level of planting

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5.8.3 Wetlands

Wetlands are an effective, end of pipe treatment measure for the removal of both suspended solids as well as soluble pollutants. They incorporate an extended detention zone which assists in the settlement of suspended solids while the macrophyte zone around the edge of the pond aids in the removal of the soluble nutrients.

5.9 Summary

The following table has be derived from information contained in the NSW EPA document "Managing Urban Stormwater – Treatment Techniques" and may be used as a quick reference on the effectiveness of a number of treatment measures in the removal of pollutants. This reference table is indicative only and further investigations as to the applicability of each measure should be undertaken as part of the development application and detail design processes.

Table 10 Effectiveness of Water Quality Measures for Different Pollutants

Pollutant	High	Medium	Low
Gross Pollutants	CDS Unit	GPT	Trash Rack
Coarse Sediment	CDS Unit	Minor GPT	Trash Rack
Medium Sediment	Wetland	CDS Unit	OSD System
Fine Sediment		Wetland	Swale
Nutrients		Wetland	Swale
Heavy Metals		Wetland	Swale
Oil and Grease		Wetland, CDS Unit	Swale

6. Rainwater Tanks

The incorporation of rainwater tanks into new developments has a number of benefits. These include the ability to reduce the frequency and volume of stormwater runoff from the development site as well as allowing the capture of stormwater for re-use. Re-use of stormwater, as part of water sensitive urban design, reduces the demand on the potable water system. In the current regulatory climate of water conservation and sustainability, any reduction of demand on this system is considered to be advantageous.

6.1 Current Policy

GMC currently have a rainwater tank policy which states: "to reduce the dependency on the public water supply system, new release areas in Goulburn have been required to provide rainwater tanks for all new dwellings". This mandatory requirement specifies that:

- "Tanks shall have a minimum capacity of 10,000 litres; and
- Rainwater tank supply being connected to the hot water service, laundry and toilet facilities with a top up connection into the tank from the reticulated system. Tank supply may also be used for landscape and garden irrigation."

While the tank is designed to capture runoff from the roof system, it is still necessary to allow for the first flush runoff to bypass the tank. This will ensure that dust, debris and other contaminants do not enter the tank and result in health issues. Regular maintenance is also required to ensure the quality of the water. This maintenance should be conducted in accordance with the National Environmental Health Forum document "Guidance on the Use of Rainwater Tanks".

The GMC policy has been incorporated into the proposed development areas at Marulan and an analysis of the effectiveness of these tanks was undertaken as described below.

The ability of the nominated 10,000 litre tanks to capture runoff from a number of roof sizes was examined as well as the ability of these tanks to cater for the predicted daily demands.

6.2 Methodology

In order to determine tank performance, the expected daily demand for each dwelling firstly needed to be established. This was done using the ACT Water Efficiency Calculator, which is available on the web site www.thinkwater.act.gov.au. By nominating the fixture types throughout a household, the daily demand for each area is able to be determined.

For this development, each building will need to conform to the BASIX requirement of a 40% reduction in potable water consumption. The means by which the water usage is reduced in accordance with BASIX include the following:

- Landscaping that requires less water;
- Wastewater re-use for gardens;
- Rainwater tanks for use in gardens, toilet and/or laundry; and
- Water-saving fixtures including dual flush toilets.

Further information in regards to the BASIX requirements and recommendations for reduction in potable water consumption can be found on the Department of Infrastructure, Planning and Natural Resources web site www.basix.nsw.gov.au.

Two scenarios were examined in the rating of the tank performance. Firstly, in line with the above policy, a daily demand for internal house usage only was determined and estimated at 300 litres per household per day. The second scenario included some outside watering and increased the daily demand to approximately 800 litres per household per day.

The model was adjusted to cater for a range of roof areas (allowing for variations in the development type), allowed for full roof area contribution and incorporated a 10,000-litre tank for each house. The number of days for which the tank was able to provide the required water demand and the number of days when spillages occurred were determined.

6.3 Results

Table 11 presents the results for a 10,000-litre rain tank, a total demand of 300 litres per household per day and application of the rainwater tank policy. Between 60 and 85% of the annual water supply could be serviced by the tank depending on the house roof area. The remainder of the required daily demand for the specified mandatory uses would be supplied through a top up from the reticulated water system.

Table 11 Rainwater Tank Performance for 300 litres per household per day demand

Roof Area (sqm)	% Supply per year	No. of spills per year
200	60	7
300	76	12
500	83	25
700	85	33

Based on Canberra rainfall being typical for the region,

Table 12 indicates that for a total daily demand of 800 litres per day, between 20% and 54% of the individual household annual water supply could be satisfied by rainwater tanks depending on the roof area. The remainder would be sourced from the potable water system.

Table 12 Rainwater Tank Performance for 800 litres per household per day demand

Roof Area (sqm)	% Supply per year	No. of spills per year
200	20	0
300	30	3
500	47	10
700	54	14

Based on Canberra rainfall being typical for the region,

From the above tables, it can also be seen that for larger roof areas, there is an increase in the number of spills to the stormwater drainage system per year. For no rainwater tank, the number of discharges into the stormwater system per year is approximately 70.

With consideration given to all of the above issues, it can be concluded that the inclusion of a 10,000-litre tank with each house will reduce the demand on the potable water system as well as reducing the number of stormwater discharges from the roof area for each site. This would aid in the reduction of the impact of the development on the downstream flows.

A further advantage of the incorporation of these rainwater tanks is that the MUSIC modelling indicated a reduction on the pollutant loadings as a result of their inclusion.

7. Costs

7.1 General

The budget cost estimates presented in this section are based on extrapolation of recent similar project pricing, budget quotes for some equipment items, industry unit rates and GHD experience. The budget estimates are based on incomplete design and other information and are not warranted by GHD. The accuracy of these estimates is not expected to be better than about ± 25% for the scope of work described in this report. A detailed design is recommended if a more reliable estimate is required. The cost estimates include construction contingency, project management, design fees, development application, environmental assessment and GST. The cost estimates exclude the collection system servicing each lot in the proposed developments.

7.2 Section 64 Developers Contribution

The capital costs of the stormwater system and the proportioning of the costs to determine the Section 64 contributions from developers is detailed in Table 13.

Table 13 Section 64 Contributions

Item	Capital Costs	Stage 1								Stage 2								Stage 3	
		Existing development[1] (Sector F4, F5 & F6)		Stony Ck Rd Subdivision (West)		Portland Avenue (Sector F2)		Betley Park[2]		Tailored Properties[2]		Sector F1		Sector F3[2]		Sector F4[3] (undeveloped northern portion		Sector A, Zone 1(b)	
		Area	s64 charge	Area	s64 charge	Area	s64 charge	Area	s64 charge	Area	s64 charge	Area	s64 charge	Area	s64 charge	Area	s64 charge	Area	s64 charge
Basin 3A	$194,893	12.8	$109,896		$0	9.9	$84,998		$0		$0		$0		$0		$0		$0
Channel 3 - Railway line to Maclura Dr	$206,793	7.3	$119,809	5.3	$86,984		$0		$0		$0		$0		$0		$0		$0
Basin 3	$154,297	7.3	$89,394	5.3	$64,903		$0		$0		$0		$0		$0		$0		$0
Channel 6 - Railway line to Brayton St	$265,758	46	$265,758		$0		$0		$0		$0		$0		$0		$0		$0
Channel - Brayton St to Basin 6	$278,514	1	$70,155		$0		$0		$0		$0	2.97	$208,359		$0		$0		$0
Basin 6	$224,144	1	$56,459		$0		$0		$0		$0	2.97	$167,684		$0		$0		$0
Channel 7 - Basin 6 to Basin 7	$293,885		$0		$0		$0		$0		$0		$0		$0		$0	23.9	$293,885
Basin 7	$186,104		$0		$0		$0		$0		$0		$0		$0		$0	23.9	$186,104
Total s64 charges	$1,804,389		$711,471		$151,887		$84,998		$0		$0		$376,043		$0		$0		$479,989
No of Lots					49		102						104						600
Cost Per lot			N/A		$3,100		$833						$3,616						$800

Notes:

1. Existing Development charges would be recovered through Council Rate charges.
2. Developments with no charges indicates that the developer is soley responsible for controling the stormwater discharge to pre-development flows before it leaves the developed area.
3. Sector F4 has been subdivided and therefore Council is responsible for the provision of stormwater services.
4. Argyle Park on the east side of the Hume Highway is not included in the table. Note 2 applies to this development.

9. References

1. ANZECC (1992) Australian Water Quality Guidelines for Fresh and Marine Waters, National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council.
2. Goulburn Mulwaree Council (2004) Rainwater Tanks – New Development Policy.
3. Mulwaree Shire Council, Settlement Strategy, November 2003, Retrieved 8 August 2005 from Goulburn Mulwaree Council Web site: http://goulburn.local-e.nsw.gov.au/planning/1281/1323.html.
4. NSW EPA (1997) Managing Urban Stormwater - Treatment Techniques.
5. Brisbane City Council (2003) Guidelines for Pollutant Export Modelling in Brisbane Version 7 – Draft.
6. Connell Wagner (2003) Infrastructure Services Report, Proposed Rezoning of Land at Marulan for Urban and Rural Residential Purposes Lot 203 DP 870194.
7. Argyle Park Developments (2005) Argyle Park, Urban Design and Ecological Fit.
8. Mike George Planning Pty Ltd (2005) Supplement to Environmental Study, Proposed Rezoning of Land at Marulan for Urban Purposes.
9. WBM (2003) Stormwater Treatment Framework and Stormwater Quality Improvement Device Guidelines.
10. National Environmental Health Form Monograph (1998) Guidance on the Use of Rainwater Tanks.

8. Recommendations

Based on the investigations, it is recommended that each development should submit a Water Management Plan as part of the Development Application. This Water Management Plan should indicate how each of the items discussed in this report are to be addressed for the individual development.

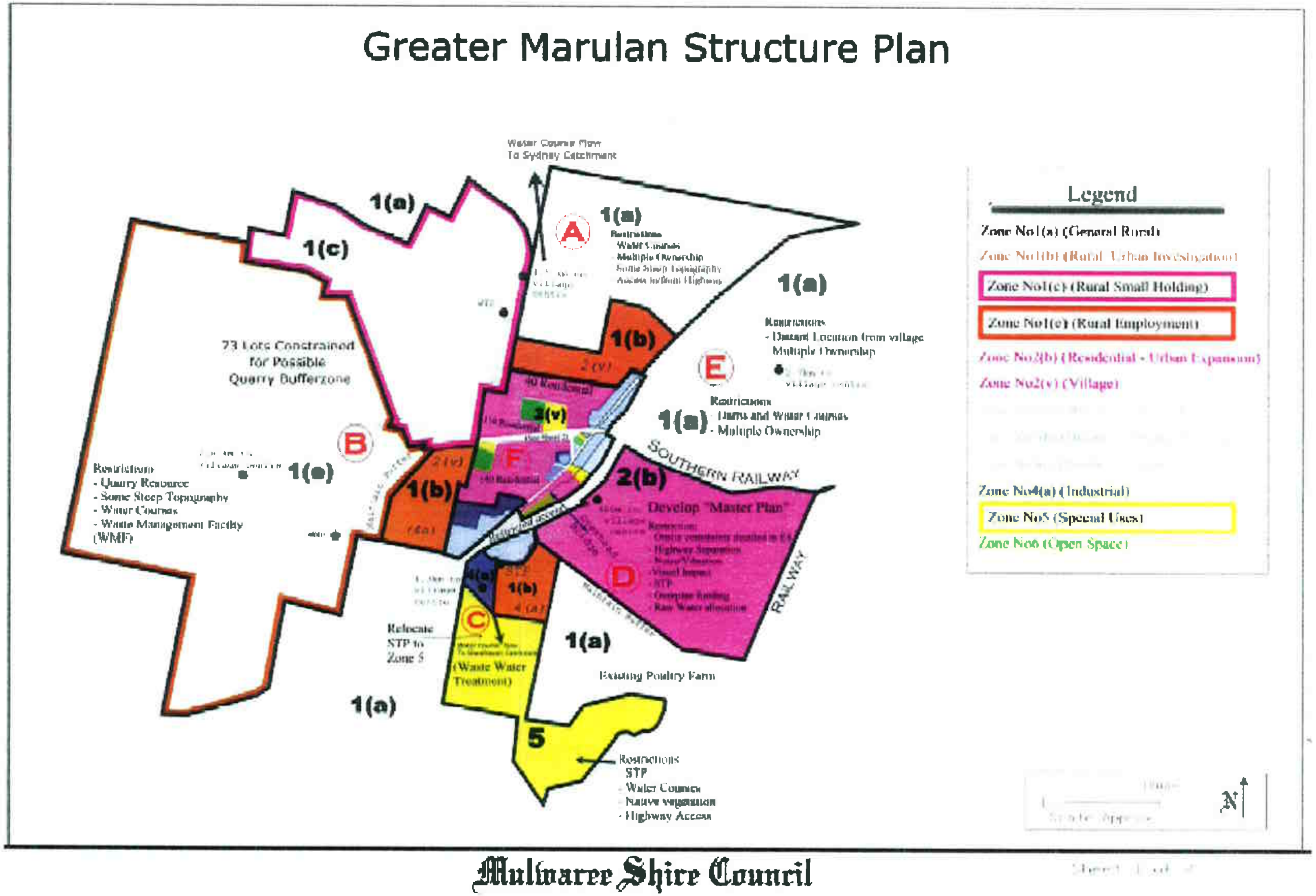
The issues, which should be specifically addressed, are:

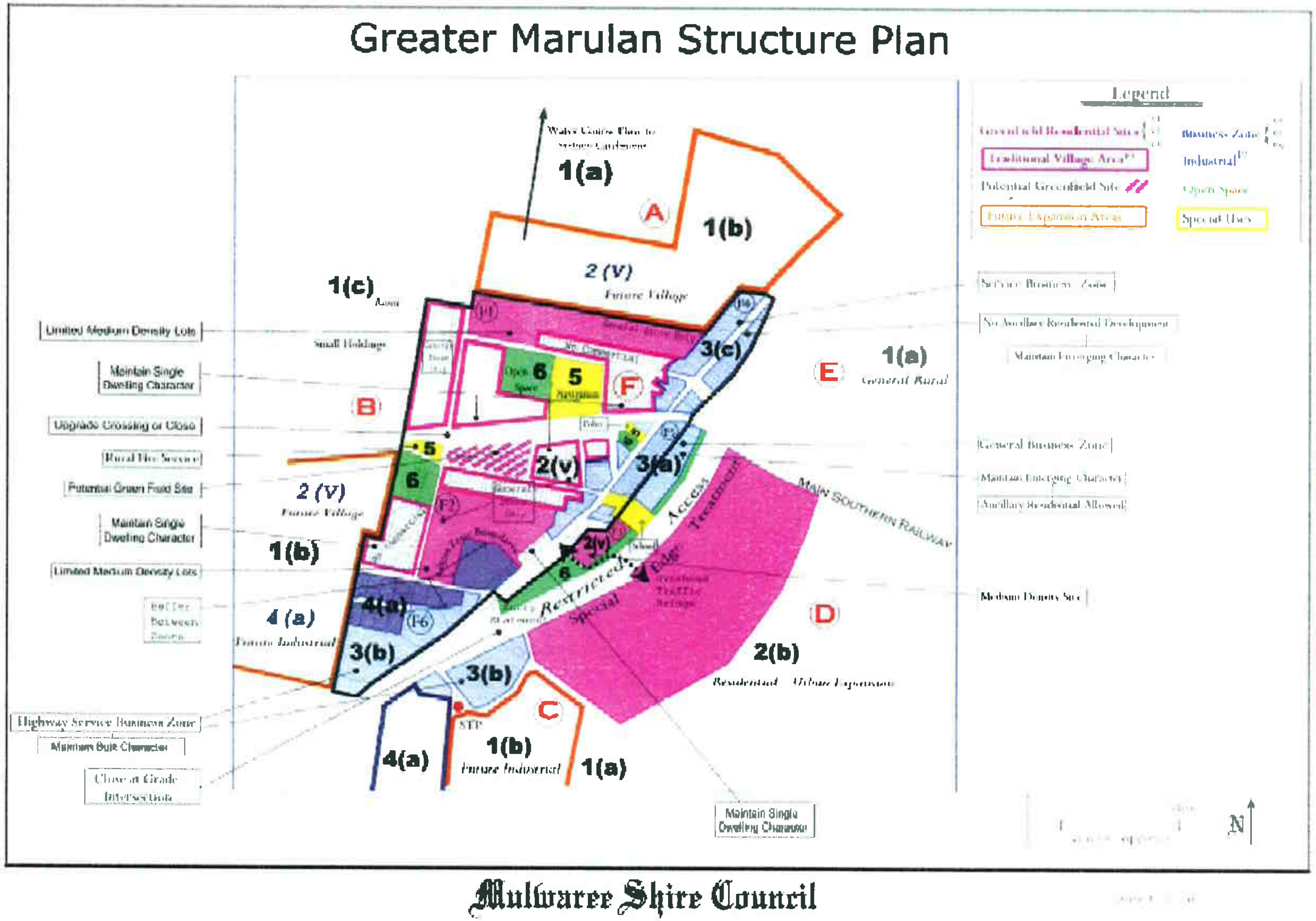
- Determination of the preferred stormwater detention treatment method for the development; and
- Determination of the stormwater treatment train for runoff quality and nominated features to be included in the development;

It is also recommended that the Council's existing Rainwater Tank Policy be applied to all developments.

Appendix A

Greater Marulan Structure Plans


Greater Marulan Structure Plan
Water Course Flow To Sydney Catchment
Legend
Zone No1(a) (General Rural)
Zone No1(c) (Rural Small Holding)
Zone No1(e) (Rural Employment)
Zone No2(b) (Residential - Urban Expansion)
Zone No2(v) (Village)
Zone No4(a) (Industrial)
Zone No5 (Special Uses)
Zone No6 (Open Space)
1(a)
1(c)
1(b)
1(e)
2(b)
2(v)
4(a)
5
A
B
C
D
E
F
73 Lots Constrained for Possible Quarry Bufferzone
Restrictions
- Quarry Resource
- Some Steep Topography
- Water Courses
- Waste Management Facility (WMF)
Restrictions
- Distant Location from village
Multiple Ownership
Restrictions
- Dams and Water Courses
- Multiple Ownership
SOUTHERN RAILWAY
RAILWAY
Develop "Master Plan"
Relocate STP to Zone 5
(Waste Water Treatment)
Existing Poultry Farm
Restrictions
STP
- Water Courses
- Native vegetation
- Highway Access
N
Mulwaree Shire Council


Greater Marulan Structure Plan
Legend
Traditional Village Area
Potential Greenfield Site
Future Expansion Areas
Business Zone
Industrial
Open Space
Special Uses
1(a)
1(b)
1(c)
2 (V)
Future Village
2(v)
2(b)
3(a)
3(b)
3(c)
4(a)
4 (a)
Future Industrial
General Rural
Residential
Small Holdings
Access
Restricted
Special
Edge
MAIN SOUTHERN RAILWAY
STP
Limited Medium Density Lots
Maintain Single Dwelling Character
Upgrade Crossing or Close
Rural Fire Service
Potential Green Field Site
Highway Service Business Zone
Maintain Bulk Character
Close at Grade Intersection
Service Business Zone
General Business Zone
Ancillary Residential Allowed
Medium Density Site
Mulwaree Shire Council

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