MID-WESTERN REGIONAL COUNCIL

GULGONG STORMWATER DRAINAGE STUDY

JUNE 2009

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Job No: CJ194 File: Gulgong.doc	Date: June 2009 Rev No.: 1.1	Author: BWL Principal: BWL

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SUMMARY

The urban area of Gulgong comprises two stormwater catchments which have been denoted Catchments X and Y for the purposes of this study (**Figure 1.1**). The catchments are separated by a north-south ridge of high ground and are drained by a system comprising kerb and gutters, and sections of pipeline. In general the system is capable of controlling minor storm events up to the 5 year ARI magnitude, in conformance with accepted engineering practice.

During major storm events which surcharge the capacity of the piped drainage system, or in areas where there is no existing piped drainage, several of the streets which are aligned with the direction of flow act as overland flow paths. There are also areas in Catchment X where residential development is located on the low side of the street (Wynella, Young and Caledonian Streets) and where overland flow occurs through allotments.

Site inspection of the drainage networks in Catchments X and Y was undertaken during the course of the study to identify directions of gutter flow and clarify details shown on drawings of the existing drainage system supplied by Council. Locations where problems are experienced during major storm events due to surcharges of the stormwater system were identified by Council and from information provided by residents resulting from the issue of a Community Questionnaire at the commencement of the study.

Hydrologic models of the catchments were prepared using the DRAINS rainfall runoff program. The results of the model were used to determine the behaviour of the systems for storms ranging between 5 and 100 year ARI.

Hydraulic modelling was undertaken to assess depths and velocities of flow in several streets during major storm events. Those parameters were related to the provisional flood hazard (which is dependent on the product of velocity and depth of flow) using principles set out in Australian Rainfall and Runoff, 1998 and the Floodplain Development Manual, 2005.

Street and gutter flow in the street systems of Catchments X and Y may lead to unsafe situations along some roads during major storms. At those locations new piped drains have been sized which have a capacity sufficient to convey 20 year ARI flows. The purpose of the improvements is to reduce overland flows in the streets in the event of a 100 year ARI storm. A preliminary assessment of pipeline requirements for the two catchments, together with indicative costs and priorities for implementation are summarised in **Table S.1**. Locations of potential schemes are shown on **Figure S1**.

The investigation has been undertaken using existing sources of data mainly comprising 1 m contour plans of the catchments. Consequently, refining cost estimates and the preparation of concept designs for the schemes will require additional survey information.

It is not feasible to implement large community owned retarding basins to reduce downstream flood peaks to the capacity of the existing system due to the absence of suitable sites. Consequently, stormwater management in Gulgong will need to rely on augmentation of the existing piped stormwater system in the streets, in conjunction with drainage swales to convey overland flows through several residential allotments in Catchment X. The co-operation of the owners will be required to enable construction of the swales to proceed, as easements will need to be created for the maintenance of these flow paths.

TABLE S.1
POTENTIAL IMPROVEMENTS TO DRAINAGE SYSTEMS OF CATCHMENTS X AND Y

Catchment	Option	Description	Indicative Cost $ x 10^3	Comments	Priority
X	X1	Improvements to drainage system in Wynella Street, in conjunction with drainage swale through private property in Young Street, to reduce un-controlled overland flow.	20	The swale would formalise the existing overland flow path through private property. An easement to drain water presently exists along the line of the overland flow path. This measure has a **low priority** as flooding is not severe. Refer **Figure 4.1** for details.	**Low**
	X2	Reduction of flooding at No 7 Caledonian Street by construction of drainage swale	15	The swale would formalise the existing overland flow path, but would require the creation of an easement to drain water in order to ensure that it is kept clear and to allow maintenance by Council. This measure has a **medium priority** but requires the agreement of the land owner for implementation. Refer **Figure 4.1** for details.	**Medium**
	X3	Mayne Street	160	Piped drainage along Mayne Street from Fitzroy Street to Fisher Street to reduce uncontrolled overland flows in the street system. Continue drainage improvements in Mayne Street across Fisher Street to southern side of road.	**Low - Medium**
	X4	Robinson Street	110	Piped drainage from Fitzroy Street to Fisher Street to reduce uncontrolled overland flows in the street system.	**Low**
	X5	Wilga Road	216	Piped drainage from Fisher Street to d/s Bunderra Street to reduce uncontrolled overland flows in the street system	**Low**

TABLE S.1
POTENTIAL IMPROVEMENTS TO DRAINAGE SYSTEMS OF CATCHMENTS X AND Y
(continued)

Catchment	Option	Description	Indicative Cost $ x 10^3	Comments	Priority
Y	Y1	Moonlight Street – Bowman Street	125	The objective of this scheme is to reduce overland flows surcharging the northern gutter of Belmore Street and entering the grounds of the High School.	**Low**
	Y2	Medley Street- Rouse Street	208	The objective of this scheme is to reduce overland flows in the lower reaches of Medley and Rouse Streets and nuisance flooding at the intersection of these two streets.	**Low -**
	Y3	Herbert Street, Lynne Street to Rouse Street	171	The objective of this scheme is to reduce overland flows in the lower reaches of Herbert Street and nuisance flooding at the intersection of Herbert and Rouse Streets.	**Low**
	Y4	White Street, Bayly Street to Belmore Street	58	The objective of this scheme is to reduce the incidence of overland flows in Herbert Street and nuisance flooding at the intersection with Rouse Street.	**Low**
	Y5	Nandoura / Station Streets	560	The objective of this scheme is to reduce overland flows in Nandoura and Station Streets and nuisance flooding at Rouse Street.	**Low**
	Y6	Rouse / Station Streets	1,020	The objective of this scheme is to divert flows away from private property located to the north of Rouse Street near its intersection with Station Street.	**Low**

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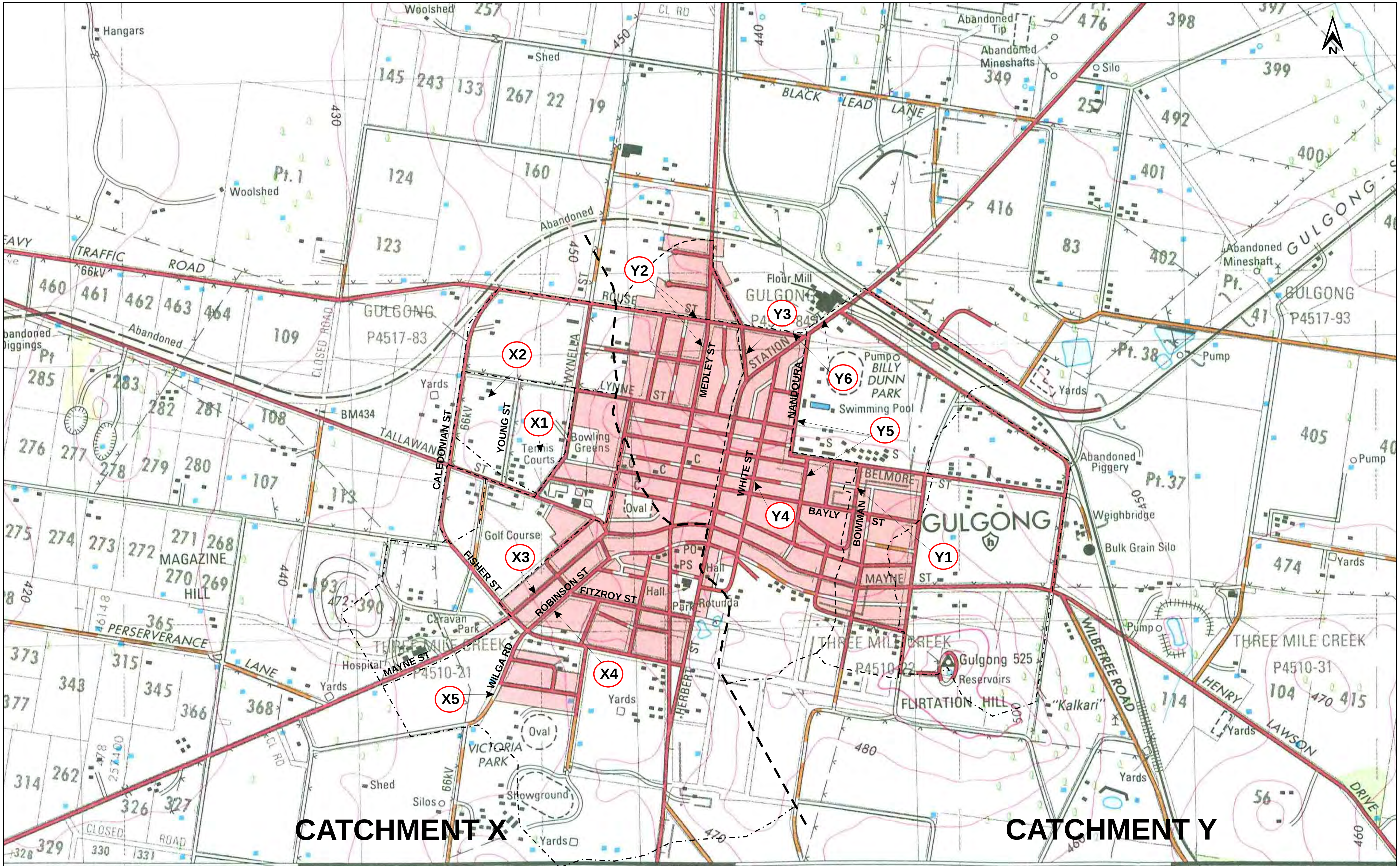

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CATCHMENT BOUNDARY

GULGONG STORMWATER DRAINAGE STUDY

Figure S1

STORMWATER DRAINAGE
IMPROVEMENT SCHEMES

1. STUDY AREA AND STORMWATER CATCHMENTS

Stormwater runoff in Gulgong is conveyed in a formalised drainage system comprising gutter and piped flow through the developed part of town which discharge to several natural drainage lines. This report deals with the system within the urban area of Gulgong.

Gulgong is located on high ground, with a ridge line dividing the town into two separate drainage catchments denoted *Catchments X* and *Y* on **Figure 1.1,** which shows the layouts of the two hydrologic models used to estimate stormwater flows in the respective catchments. The ridge extends northwards from the intersection of Fisher and Herbert Streets to Rouse / Wynella Streets.

1.1 Catchment X

Catchment X drains the street system on the western side of this line. Runoff crosses Caledonian Street at four separate locations and continues in a westerly direction across rural land. Other crossings are located at Rouse Street to the north and Wilga Road and Mayne Street to the south. The sub-catchments comprising *Catchment X* are pre-fixed with the letters F to L, on **Figure 1.1**. The total catchment area of *Catchment X* is 129 ha, including the golf course located to the south of Tallawang Street. The northern portion of the catchment is characterised by large allotments with single residences. The southern portion of the catchment is more urbanised with smaller residential allotments.

In the upper reaches of the catchment stormwater flows are conveyed within the street gutter system. In the downstream reaches of the largely residential southern portion of the catchment, insufficient inlet and pipe capacity leads to surcharging of inlet pits and road crossings during heavy rainfall events.

1.2 Catchment Y

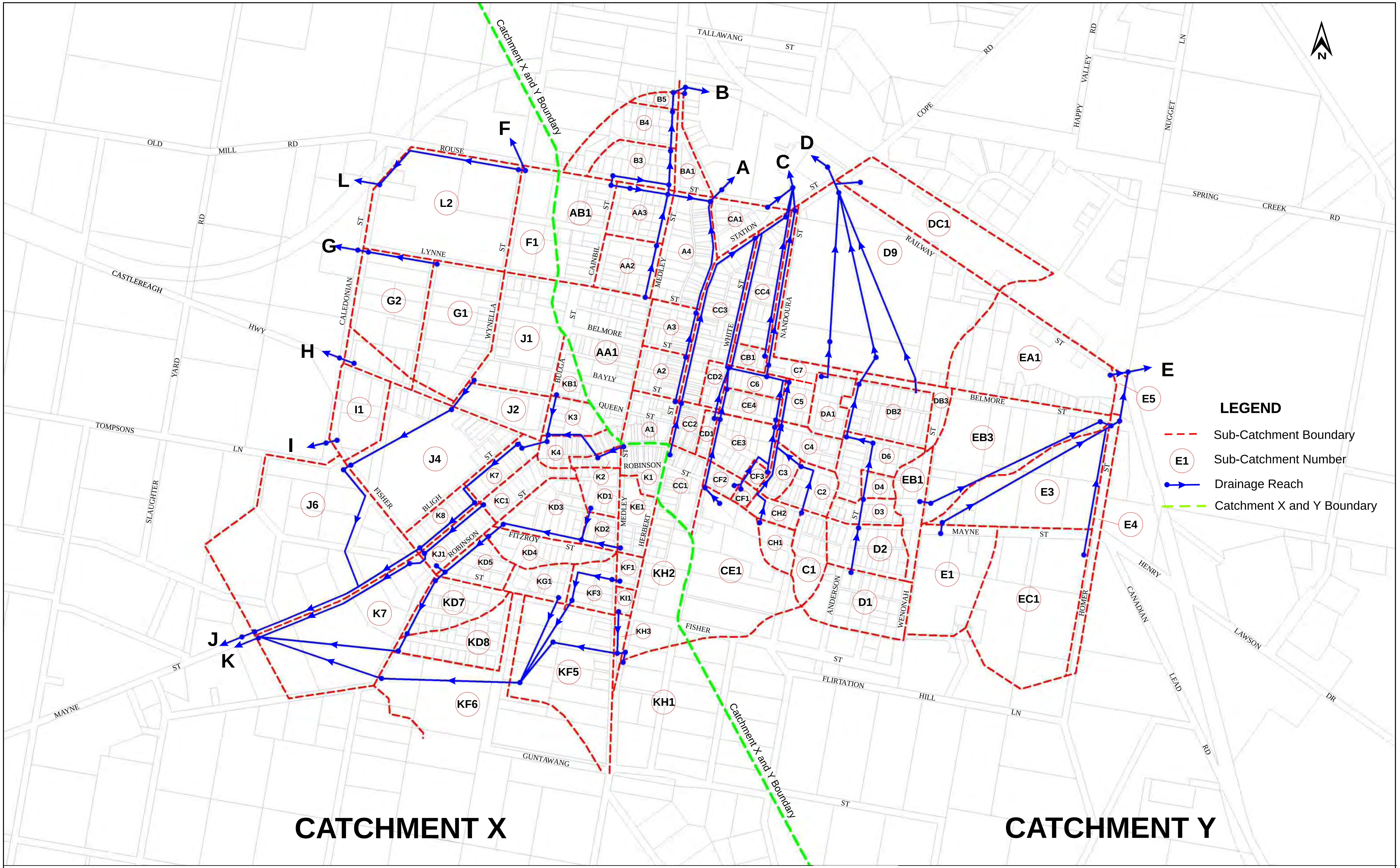
Catchment Y drains the area on the eastern side of the ridge. Runoff from the catchment on the western side of Herbert Street drains in a northerly direction mainly along Medley and Herbert Streets and crosses Rouse Street before discharging into rural lands. These areas are modelled as sub-catchments pre-fixed with the letters A and B.

Drainage from the area between Herbert and Wenonah Streets also follows a northerly route along the street system (via White, Nandoura and Bowman Streets) to Rouse and Belmore Streets. These areas are modelled as sub-catchments pre-fixed with the letters C and D.

Sub-catchments between Wenonah and Homer Streets are pre-fixed with the letter E and discharge to a culvert at the intersection of Railway and Homer Streets. The total area comprising *Catchment Y* is about 165 ha.

Catchment Y is the more urbanised of the two, with the paved area comprising 19.2 ha of its total 165 ha area. In the upper residential reaches of the catchment, stormwater flows are conveyed along roadside depressions. At several locations, for example the intersection of Moonlight and Wenonah Streets, no roadside depressions are present and during heavy rainfall nuisance flooding of several properties is experienced.

In the lower reaches of the catchment, piped drainage convey stormwater flows for the frequent storm events to open channels draining through rural lands to the north of Rouse and Station Streets. The presence of high kerb and guttering generally prevents the flooding of properties within the town for events which surcharge the pipe system. The south to north running streets provide overland flow paths. However, a concentration of overland flows at the intersections of these streets and the east west running streets (Rouse and Belmore Streets) could result in flooding problems. For example, the grounds of Gulgong High School could be flooded due to overland flows heading northwards along Bowman Street and surcharging the northern gutter of Belmore Street.



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GULGONG STORMWATER DRAINAGE STUDY

Figure 1.1

CATCHMENTS X AND Y - DRAINS MODEL LAYOUT

2. HYDROLOGIC MODELLING

2.1 Introduction

This chapter deals with the conversion of design rainfall events into peak flows within the drainage systems of *Catchments X* and *Y* for the 5, 20 and 100 year ARI events and the PMF.

Stormwater flows generated by the existing urbanised catchment were assessed using a computer-based model based on the DRAINS system. DRAINS simulates the rainfall-runoff process on natural and impervious catchments, developing flow hydrographs at each entry point in the drainage system and then routing and combining flows through the drainage network. It is capable of modelling multiple storm patterns, pit bypass flows and overland flows.

2.2 Model Setup

Figure 1.1 shows the arrangement of sub-catchments and drainage links used to model the generation and movement of flows through the drainage networks of *Catchments X* and *Y*. Pipe sizes were obtained from data on the stormwater system supplied by Mid Western Council. Pit entry capacities for input to the DRAINS models were estimated by counting the number of pits situated within each sub-catchment. Overflows from pits were directed to the next downstream reach with overland travel times calculated assuming a velocity of overland flow equal to 2 m/s.

Stormwater flowing within the road gutter system was simulated as open channel flow in a trapezoidal channel. Manning's n values of 0.012 and 0.2 were adopted for reaches of kerb and gutter and grassed swales respectively.

No historic flow data were available in the drainage system of Gulgong. The models were therefore tuned to reproduce peak flows estimated by the Rational Method, as described in Chapter 14 of Australian Rainfall and Runoff, 1998 for urbanised catchments. The tuning of *Catchment X* and *Catchment Y* is summarised below.

2.2.1 Catchment X

The model for *Catchment X* was tuned by adjusting the value of antecedent moisture condition (AMC) until the modelled flood peaks on sub-catchments K and J approximated those calculated using the Rational Method for a 100 year ARI storm event. These two sub-catchments have the highest percentage of urbanisation in *Catchment X*. The other sub-catchments are mostly rural and the Rational Method would not be appropriate for tuning the model. An AMC value of 3.3 was found to give good correspondence with the Rational Method peak discharges and was adopted for the full range of design storm events. This adopted value represents the pervious portion of the catchment in a rather wet state, and was considered appropriate for modelling purposes.

2.2.2 Catchment Y

Flows generated from DRAINS using an AMC value of 2.9 was found to give good correspondence with peak flows estimated from the Rational Method. This value was adopted for the full range of design storm events and represents the pervious portion of the catchment in a rather wet state.

2.3 Model Results

Storms of 10 to 180 minutes duration and 5, 20 and 100 year ARI were applied to both models. The results are discussed below.

2.3.1 Catchment X

Results obtained from the DRAINS model indicate that, for all reaches within the catchment, the critical storm duration is either 20 or 60 minutes. **Table 2.1** shows peak discharges for the 20 and 60-minute storms at different locations within the catchment. The four sub-catchments discharging stormwater on the western side of *Catchment X* at Caledonian Street are essentially semi-rural areas. Sub-catchments K and J which drain in a south-westerly direction to Mayne Street are partially urbanised.

TABLE 2.1
PEAK DISCHARGES CATCHMENT X
20 AND 60 MINUTE STORM DURATIONS
(m^3/s)

DRAINS Sub-catchment	5 year ARI		20 year ARI		100 year ARI	
	20 min	60 min	20 min	60 min	20 min	60 min
G at Caledonian / Lynne Street	0.039	**0.163**	0.904	**0.904**	1.69	**1.84**
H at Caledonian/Tallawang Street	0.006	**0.022**	0.086	**0.112**	0.234	**0.237**
I at Caledonian / Fisher Street	0.015	**0.046**	0.176	**0.226**	**0.472**	0.489
K&J at Mayne Street / Hospital	**3.29**	2.47	6.33	**6.72**	12.7	**12.80**
F at Wynella / Rouse Street	0.02	**0.084**	0.328	**0.401**	**0.894**	0.79
L at Caledonian Street	0.031	**0.098**	0.904	**0.904**	1.03	**1.22**

The critical storm duration is generally 60 minutes for all recurrence intervals. It is also evident that peak flows for the 5 year ARI are much smaller, as a percentage of the 100 year peak, than would be expected for more heavily urbanised catchments. For the smaller storms, a considerable portion of the total rainfall infiltrates into the largely grassed portion of the catchment and does not contribute to surface runoff.

2.3.2 Catchment Y

The peak discharges are shown on **Table 2.2**. These flows represent the discharges at the model outlets entering unlined channels draining through rural land. A storm duration of 20 minutes was the critical storm duration for all sub-catchments, except for sub-catchment E. The latter is a mainly rural catchment and has a slightly higher peak flow for the 60 minute duration and a 20 year ARI event.

The DRAINS results showed that overland flows could occur in the street system of the urbanised area. Stormwater flows originating from the southern end of the catchment drain in a northerly direction, following the grade of the street system. These flows traverse the length of the town as gutter and/or pipe flow and result in high peak discharges being experienced in the downstream reaches, ie the northern end of town.

Most existing pipes are able to convey flows produced by a 20 year ARI event. However, at some locations significant overland flows occur in the streets. These locations are discussed in the next section and potential improvements are reviewed.

TABLE 2.2
PEAK DISCHARGES CATCHMENT Y
20 MINUTE STORM DURATION
(m^3/s)

DRAINS Sub-catchment	5 year ARI	20 year ARI	100 year ARI
A d/s Herbert/Rouse St	1.65	1.81	2.48
B d/s end Medley St	0.27	0.36	1.84
C northern side of Rouse St	2.37	2.86	5.54
D d/s Station / Railway Streets	1.28	1.85	3.87
E d/s Railway / Homer Streets	0.53	1.26 (1.71)	5.13

Note: Value in ( ) is for 60 minute storm duration.

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3. HYDRAULIC MODELLING

3.1 General

Stormwater drainage which surcharges the piped drainage system at Gulgong is conveyed along the street system to the rural areas bordering the town. Hydraulic modelling was carried out to assess the depths and velocities of flow in the streets which function as overland flow paths. The hydraulic modelling used the HEC-RAS software.

The geometric models comprised cross sections of the streets derived from a one metre contour plan supplied by Council. The following streets were modelled:

- **Catchment X** – Mayne Street, extending 800 m south-west from Fitzroy Street. The average gradient to the intersection with Fisher Street is 3.2 per cent, reducing downstream of that point to 1.2 per cent.
- **Catchment Y** – Medley Street over the 560 m reach from Lynne Street to downstream of the intersection with Herbert Street. The average gradient is 1.9 per cent.
- **Catchment Y –** Herbert Street over the 750 m reach from Robinson Street to Rouse Street. The average gradient over that distance is 2.8 per cent.
- **Catchment Y –** White Street over the 730 reach from Robinson Street to Station Street. Over the first 125 m to Queen Street the gradient is over 9 per cent. Further downstream to Station the street flattens to an average grade of 2.6 per cent.
- **Catchment Y –** Nandoura Street from Queen Street to Rouse Street, a distance of 700 m. The average gradient of the street over this distance is 2.6 per cent.
- **Catchment Y –** Bowman Street/Belmore Street from Queen Street to Nandoura Street, a distance of about 500 m. The average gradient is 1.9 per cent.

3.2 Model Results

Water surface profiles were computed for the 5, 20 and 100 year ARI storms. The flows applied to the models were computed from the DRAINS modelling and represent the discharge surcharging the existing piped system.

Typical depths and velocities of flow in the street system for the 20 and 100 year ARI storms are shown in **Table 3.1**. In conjunction with an assessment of likely flood hazard in the street (which depends on velocity and depth of overland flow), these results give a guide on the priority of drainage improvements to the stormwater system.

3.3 Flood Hazard Concept

Depths and velocities of flooding in the street system were computed using the HEC-RAS model results. Section 14.5.4 (ii) of ARR, 1998 was used as a guide to assess the flood hazard. Velocity and depth of flow are related to conditions such as the safety of pedestrians and stability of vehicles. Flood prone areas are divided into low or high hazard areas on the basis of depth and velocity. For shallow depths of flow in the road system, high hazard conditions commence when the product of depth and velocity approaches 0.4 m^2/s.

In addition, depths of flow at the gutter should not exceed 200 to 250 mm to prevent entry of flow into residential allotments bordering the streets. From the above assessment, the priorities for improving the piped drainage in the street system would be as follows:

- Catchment X – Mayne Street
- Catchment Y – northern end of Nandoura Street
- Catchment Y - northern end of Herbert Street
- Catchment Y – northern end of Medley Street

For the problem areas identified from the above assessment, piped drainage improvements have been sized to convey 20 year ARI flows. The objective was to prevent overland and road flows that could lead to hazardous conditions developing from surcharges in the event of a 100 year ARI storm.

TABLE 3.1
DEPTHS AND VELOCITIES OF FLOW IN STREET SYSTEM
PRESENT DAY CONDITIONS

Location	Average Depth (mm)		Average Velocity (m/s)		Velocity x Depth (m^2/s)	
	20 year ARI	100 year ARI	20 year ARI	100 year ARI	20 year ARI	100 year ARI
Catchment X - Mayne St	480	630	1.82	2.35	0.87	1.48
Catchment Y – Medley St	170	230	0.90	1.05	0.15	0.23
Catchment Y – Herbert St	140	200	0.87	1.16	0.12	0.24
Catchment Y – White St	120	170	0.76	1.00	0.09	0.17
Catchment Y – Nandoura St	160	210	0.89	1.12	0.14	0.24
Catchment Y – Bowman St	180	250	0.54	0.74	0.10	0.19

4. DRAINAGE IMPROVEMENTS

4.1 Catchment X

4.1.1 Problem Areas Identified by Council and Community Newsletter

Figure 4.1 is a location plan of the Wynella Street, Young Street and Caledonian Street area illustrating features of the following discussion.

- *Wynella Street.* Stormwater runoff from high ground to the east flows across this street, which runs in a north to south direction, and enters residential allotments on its western side. Nuisance flooding of the allotments would occur on a regular basis as the gutter system is of low capacity and interrupted by driveways leading to residences on the downslope side of the road. The gradient of the road in the southwards direction is also quite low. Conveyance of runoff from major storm events would require a large diameter pipelines due to the flat gradient available and is not economically feasible. Council proposed the capture and conveyance of runoff in a drainage swale which would run in a westerly direction along property boundaries to Young Street. Raising footpath and driveway levels on the western side of Wynella Street was also proposed (in conjunction with the swale) to encourage the collection and southward drainage of flows along Wynella Street. The measures proposed by Council will not require an easement to be created through private property as one already exists along the line of the proposed overland flow path. This scheme is identified **X1** on **Figure S1**.

- *Caledonian Street.* Drainage problems were reported in this area from responses in the Community Newsletter. The problems are similar to those existing in Wynella Street and described above. In this case runoff originates from Young Street. Council have proposed conveyance of runoff in a drainage swale running westwards from Young Street to Caledonian Street and thence to rural areas to the west. The constraints to augmenting the capacity of the stormwater system in Young Street are similar to Wynella Street and correspondingly, the swale is considered to be an appropriate solution to the problem. This scheme is identified **X2** on **Figure S1**.

4.1.2 Pipeline Augmentation in the Streets

The extents and sizes of pipes are shown schematically in **Figure 4.2** and summarised in **Table 4.1**. The schemes have been identified with the prefix **X,** with locations also shown in **Figure S1**.

The augmentation scheme could consist of 5 new reaches of pipe totalling approximately 650 m. The new pipelines will convey flows in a south westerly direction towards rural parts of town.

Scheme X3

To the north of Fisher Street a new 525 RCP is required beneath the western gutter of Mayne Street. This pipe would connect into the existing kerb inlet pit on the north western corner of the intersection of Mayne and Fisher Streets. The existing pipes draining from this pit reduce in capacity further downstream and it would be therefore be necessary to place a short length of new 600 RCP beneath the intersection draining to the open channel along the western side of Mayne Street. This pipe would replace the existing small 300 RCP located immediately to the west of the intersection. Stormwater flowing along Mayne Street to the south of Fisher Street would be conveyed in the existing depressions on each side of the road. No detailed cross sectional data is presently available, so that the capacity of this overland flow path could not be assessed.

Schemes X4 and X5

Along Robinson Street a new 525 RCP (**Scheme X4**) with several inlet pits would collect gutter flows and direct them towards the intersection of Fisher/Mayne Streets where it would connect into the existing 1200 x 360 RCBC conveying flows beneath the intersection. A new 750 RCP would lead out of the box culvert along Wilga Road (**Scheme X5**). At Bunderra Street the increase in stormwater flows from the contributing catchment to the east require a 900 RCP to convey flows beneath Wilga Street to the west. At this point flows discharge onto rural land where they flow overland and join stormwater flowing along Mayne Street.

TABLE 4.1
DRAINAGE IMPROVEMENTS CATCHMENT X

Scheme	Location	Pipe Length (m)	Pipe Diameter (mm)	Indicative Cost ($)	Priority
X1	Wynella Street (Drainage Swale)	na	na	20,000	Medium
X2	Young-Caledonian Street (Drainage Swale)	na	na	15,000	Medium
X3	Mayne Street (to Fisher Street)	185	525	125,000	Low - Medium
	Mayne Street (crossing of Fisher Street)	40	600	35,000	
X4	Robinson Street (Fitzroy to Fisher Street)	175	525	110,000	Low
X5	Wilga Road (Fisher to Bunderra Street)	180	750	149,000	Low
	Wilga Road (d/s Bunderra Street)	65	900	67,000	

4.2 Catchment Y

4.2.1 Pipeline Augmentation in the Streets

Sections of pipeline which could be augmented are shown on **Figure 4.3** and listed in **Table 4.2**. The reductions in the depth and velocity of flow in the street system resulting from the augmentation of the existing pipe drainage system as shown on **Figure 4.3** are presented in **Table 4.3**.

Scheme Y1

Excessive gutter flows are experienced in the vicinity of Moonlight and Bowman Streets downstream of the 450 RCP draining from Menchin Lane. Presently stormwater flows are discharged into the street at Moonlight Street and follow the street system to Belmore Street where they pond at the inlet to an existing 600 RCP which conveys flows through the school grounds to the north. Flows which cannot enter the inlet to the pipe either surcharge the roadway and flow into the school grounds or continue in an easterly direction towards a second inlet pit approximately 150 m further along Belmore Street.

It is proposed to lay a new 195 m length of 525 RCP from the outlet of the existing 450 RCP to the inlet of the existing 600 RCP at Belmore Street to reduce the volume of water flowing along the roadway. The inlet capacity to the existing pipe system upstream of the new 525 RCP in Menchin Lane should also be increased to ensure pipes flow to capacity.

Schemes Y2 and Y3

Flows generated by sub-catchments in the north west sector of *Catchment Y* converge as gutter flows in the street system at the northern end of the town, leading to excessive depths of flow in middle to downstream areas of several of the streets: e.g. Medley, Herbert and Nandoura Streets.

The proposed augmentation option for this area consists of the following works:

- *New 450 RCP in Rouse Street*. The new pipe will connect into an existing 450 RCP draining the western side of Cainbil Street. At Medley Street it is proposed to abandon the short length of existing 675 RCP draining the south western corner of Rouse Street and continue the new 450 RCP across the intersection and alongside the 675 RCP to Herbert Street. The 450 RCP will connect into the pit from which the existing 675 RCP drains to an existing 900 RCP which conveys flows beneath Rouse Street and into an open channel to the north.

- *New 600 RCP in Medley Street.* The new pipe will drain flows from Worobil Street to the north. The pipe will connect into the existing 675 RCP at the intersection of Medley and Rouse Streets.

- *New 450 RCP in Herbert Street.* Approximately 360 m of pipe will be required along the western gutter of Herbert Street. Due to lack of capacity in Rouse Street, the existing 900 RCP conveying flows to the north beneath the road will surcharge. The connection of this new 450 RCP to the inlet of the 900 RCP will result in flows less than 20 year ARI surcharging the system. It is therefore necessary to continue the 450 RCP across Rouse Street parallel with the 900 RCP and discharge flows from Herbert Street directly into the open channel to the north.

A Manning's calculation was undertaken on the open channel downstream of the 900 RCP This calculation showed the channel has the capacity to convey a major flood, provided it is maintained clear of excessive vegetation.

Schemes Y4 and Y5

A significant piped drainage network exists along Nandoura Street where stormwater flows converge from a large contributing catchment. Areas exist upstream of the pipe network where gutter flows are excessive during storm events. It is proposed to both extend the pipe network into upstream reaches and lay a duplicate 750 RCP pipeline beneath the western gutter of Nandoura Street. The proposed works would entail:

- *Laying new lengths of 525 RCP beneath the eastern gutters of White and Nandoura Streets south of Belmore Street*. In White Street the pipe would lead from Bayly Street to the north of Little Bayly Street where it would connect to the existing 600 RCP which leads into Belmore Street (**Scheme Y4**). In Nandoura Street the pipe would lead from Lowe Street to Belmore Street where it would connect to an existing 600 RCP (part of **Scheme Y5**).

- *Duplicate the existing 750 RCP in Nandoura Street and abandon a short length of existing 600 RCP in Belmore Street*. Presently two 600 RCPs drain to the 750 RCP, resulting in a reduction in pipe capacity in the downstream direction. In conjunction with the capture of more gutter flow to the south, it is proposed to duplicate the 750 RCP beneath the eastern gutter of Nandoura Street, by providing a new pipe beneath the western gutter (this measure and the measures outlined below are part of **Scheme Y5**). This would effectively divide the catchment drainage on either side of the road. This augmentation scheme would require a short length of existing 600 RCP along Belmore Street to be abandoned to separate the two systems.

- *Laying a new length of 600 RCP in Station Street*. Excessive depths of flow within Station Street require a length of pipe between White and Nandoura Streets.

- *Replacement of existing 675 RCP with new 1050 RCP*. At the confluence of the new 750 and 600 RCPs, a new pipe of capacity greater than the existing 675 RCP is required. A 1050 RCP will replace the existing pipe to convey stormwater flows from the catchment to the west of Nandoura Street to the open channel to the north of Rouse Street.

- *Roadside works.* Presently stormwater flowing within the gutter systems to the south of Belmore Street flow in road side depressions. It is recommended that these depressions be either formalised, or kerb and gutter constructed in conjunction with the new pipe reaches outlined above.

A Manning's calculation was undertaken on the open channel to the north of Rouse Street. This calculation showed the channel has a capacity to convey major floods provided it is maintained clean of excessive vegetation growth.

Schemes Y6

Council has received several complaints from the owner of a property which is located along the northern side of Rouse Street near its intersection with Station Street. The owner claims that a large amount of litter is deposited on his property as a result of stormwater discharging from Council's pipe drainage system.

Whilst Council has recently installed a gross pollutant trap on the outlet of one of the pipes which discharge to his property, a drainage scheme was developed which is aimed at piping flows to a location downstream of the property. The scheme, which would involve laying a new pipe drainage system in Rouse and Station streets, would entail:

- *Laying a new length of 1050 RCP along the southern kerbline of Rouse Street between Herbert Street and Station Street*. The 1050 RCP pipe would need to cross to the northern side of Rouse Street immediately west of its intersection with Station Street.

- *Laying a new length of 2 off 1200 RCP's over a 190 m length in Station Street to a location north of the flour mill*. Survey would need to be undertaken to confirm that there is sufficient grade to allow the pipe drainage system to be self cleansing. Survey would also be required to demonstrate that the pipe drainage system could be constructed with sufficient cover. Should cover be a constraint, than a reinforced box culvert could be adopted, although this would significantly add to the overall cost of the scheme.

It should be noted that sizing of the pipes in Rouse and Station street was done based on the assumption that Schemes Y2 to Y5 will also be implemented by Council (i.e. that the drainage system in this area has a capacity of about 20 year ARI). Smaller diameter pipes could be adopted by Council should it be decide to adopt a lesser hydrologic standard for the pipe drainage system in this area.

TABLE 4.2
DRAINAGE IMPROVEMENTS CATCHMENT Y

Scheme	Location	Pipe Length (m)	Pipe Diameter (mm)	Indicative Cost ($)	Priority
Y1	Moonlight Street (Menchin Lane to Bowman Street)	55	525	125,000	Low
	Bowman Street (Moonlight Street to Belmore Street)	140	525		
Y2	Rouse Street (Cainbil Street to Medley Street)	105	450	208,000	Low
	Rouse Street (Medley Street to Herbert Street)	115	450 (parallel pipe)		
	Medley Street (Worobil Street to Rouse Street)	180	600		
Y3	Herbert Street (Lynne Street to Rouse Street)	360	450	171,000	Low
Y4	White Street (Bayly Street to Little Bayly Street)	100	525	58,000	Low
Y5	Nandoura Street (Lowe Street to Belmore Street)	190	525	560,000	Low
	Nandoura Street (Belmore Street to Station Street)	470	750 (duplicate pipe)		
	Station Street (White Street to Nandoura Street)	140	600		
	Rouse Street (Station Street to Open Channel	30	1050		
Y6	Rouse Street (Herbert Street to Station Street)	235	1050	1,020,000	Low
	Station Street (Rouse Street to north of flour mill)	190	2 off 1200		

TABLE 4.3
DEPTHS AND VELOCITIES OF FLOW IN STREET SYSTEM
POST PIPE AUGMENTATION CONDITIONS

Location	Average Depth (mm)		Average Velocity (m/s)		Velocity x Depth (m^2/s)	
	20 year ARI	100 year ARI	20 year ARI	100 year ARI	20 year ARI	100 year ARI
Catchment Y – Medley St	10 [170]	170 [230]	0.09 [0.90]	0.91 [1.05]	0.01 [0.15]	0.15 [0.23]
Catchment Y – Herbert St	60 [140]	170 [200]	0.56 [0.87]	1.02 [1.16]	0.03 [0.12]	0.17 [0.24]
Catchment Y – White St(1)	120 [120]	170 [170]	0.76 [0.76]	1.00 [1.00]	0.09 [0.09]	0.17 [0.17]
Catchment Y – Nandoura St	70 [160]	170 [210]	0.55 [0.89]	0.96 [1.12]	0.04 [0.14]	0.16 [0.24]
Catchment Y – Bowman St	10 [180]	210 [250]	0.07 [0.54]	0.61 [0.74]	0.01 [0.10]	0.13 [0.19]

Note: Numbers in [ ] correspond to present day conditions (refer **Table 3.1**).

1. Depths and velocities of flow will be reduced along White Street between Bayly Street and Little Bayly Street.

4.3 Use of Detention Storage

Drainage improvements described above cater for stormwater flows under existing conditions. It is important to ensure that flows do not increase in the future as development proceeds.

Due to the local topography and the existing pattern of development, there are no obvious sites available where large retarding basins could be implemented to provide throttling of flows on a catchment-wide basis. Detention storage will be limited to small-scale basins at the downstream end of development sites or on-site detention storage for in-fill development.

Council's existing OSD policy is aimed at ensuring that post-development flows leaving the site are no larger than under present day conditions. Developers' Consultants should be required to submit a short written report with Development Applications detailing the results of the analysis. A proforma could be provided by Council, which sets out design requirements of the policy and acts as a check list for the report.

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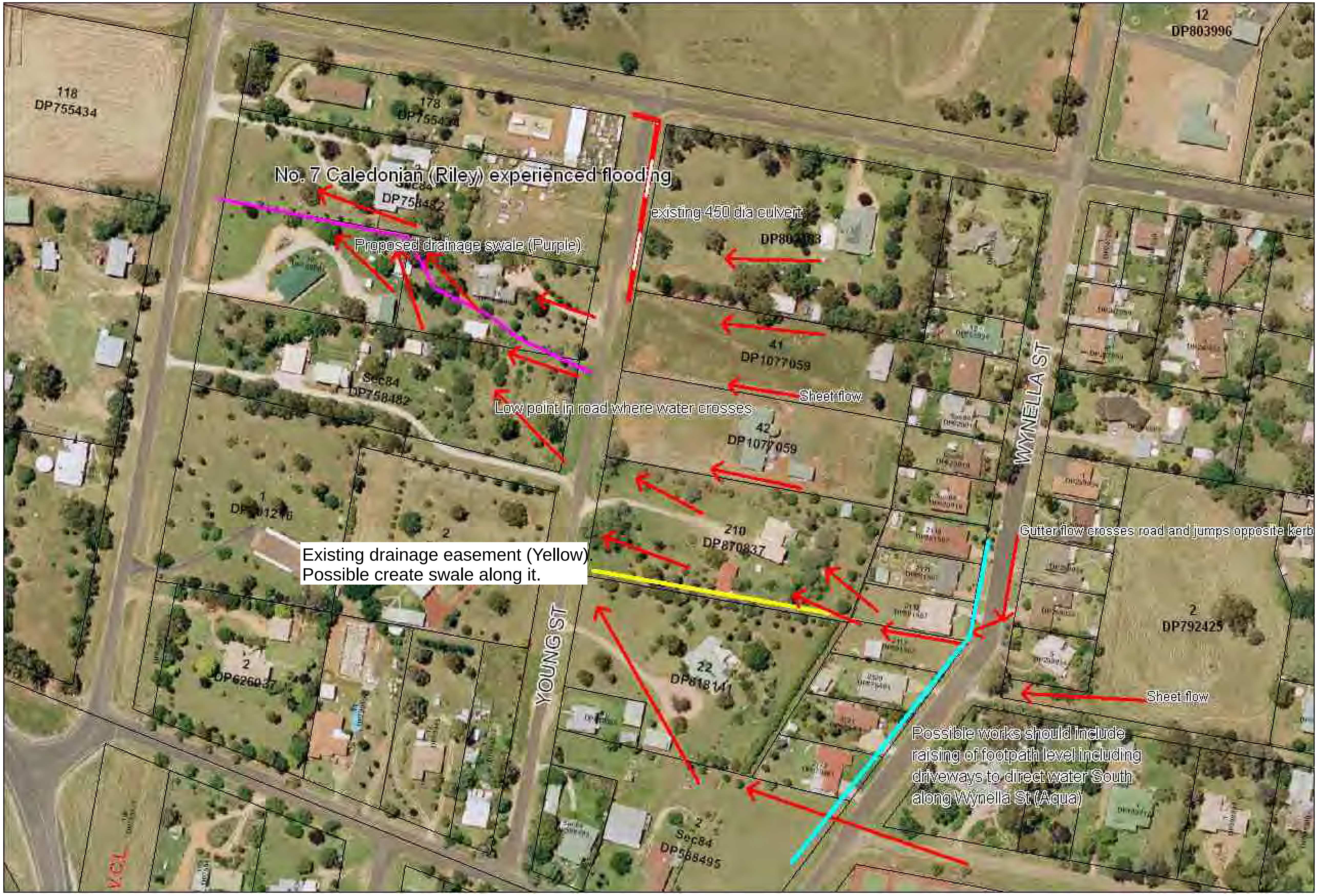
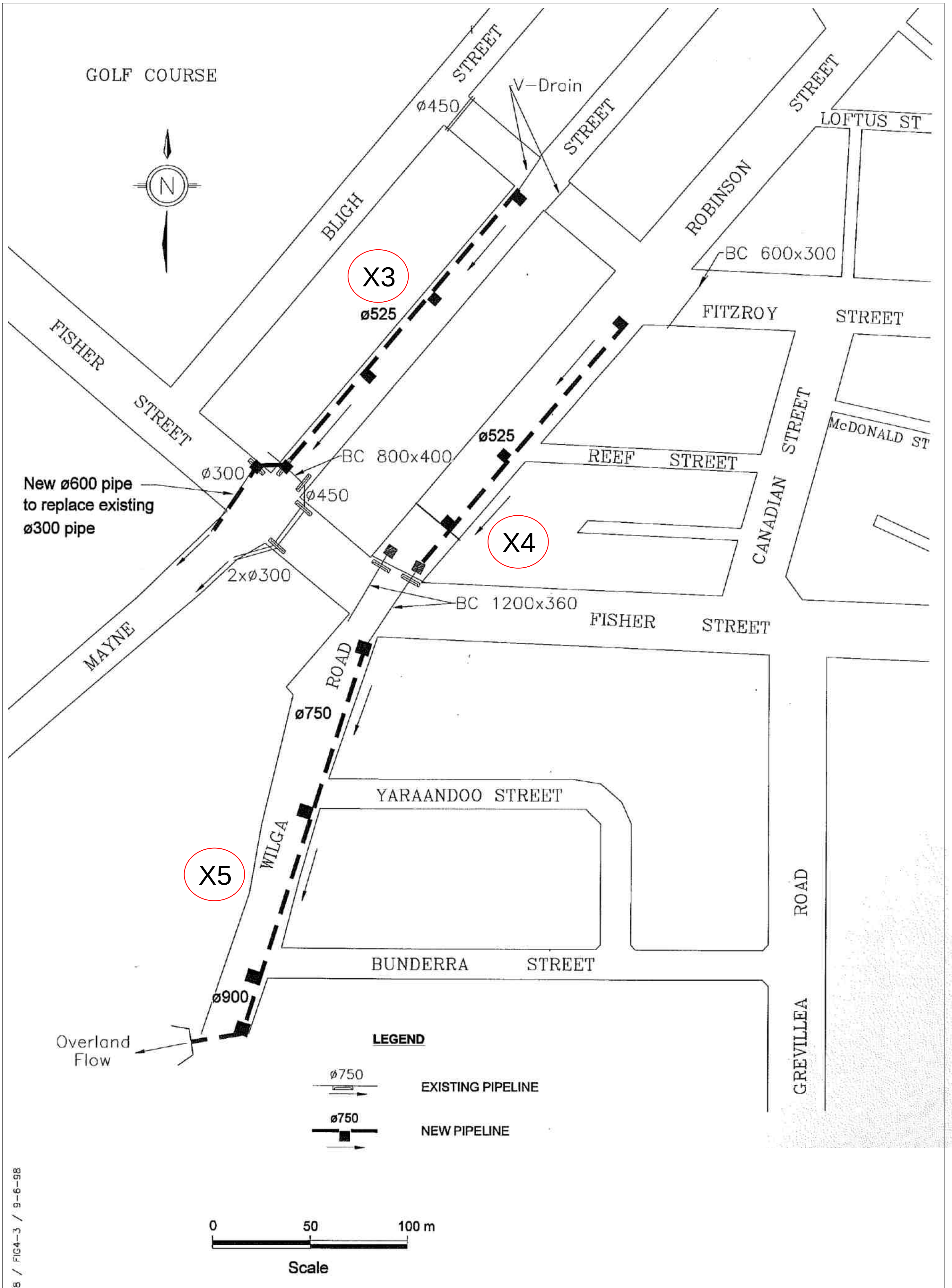


GULGONG STORMWATER DRAINAGE STUDY

Figure 4.1

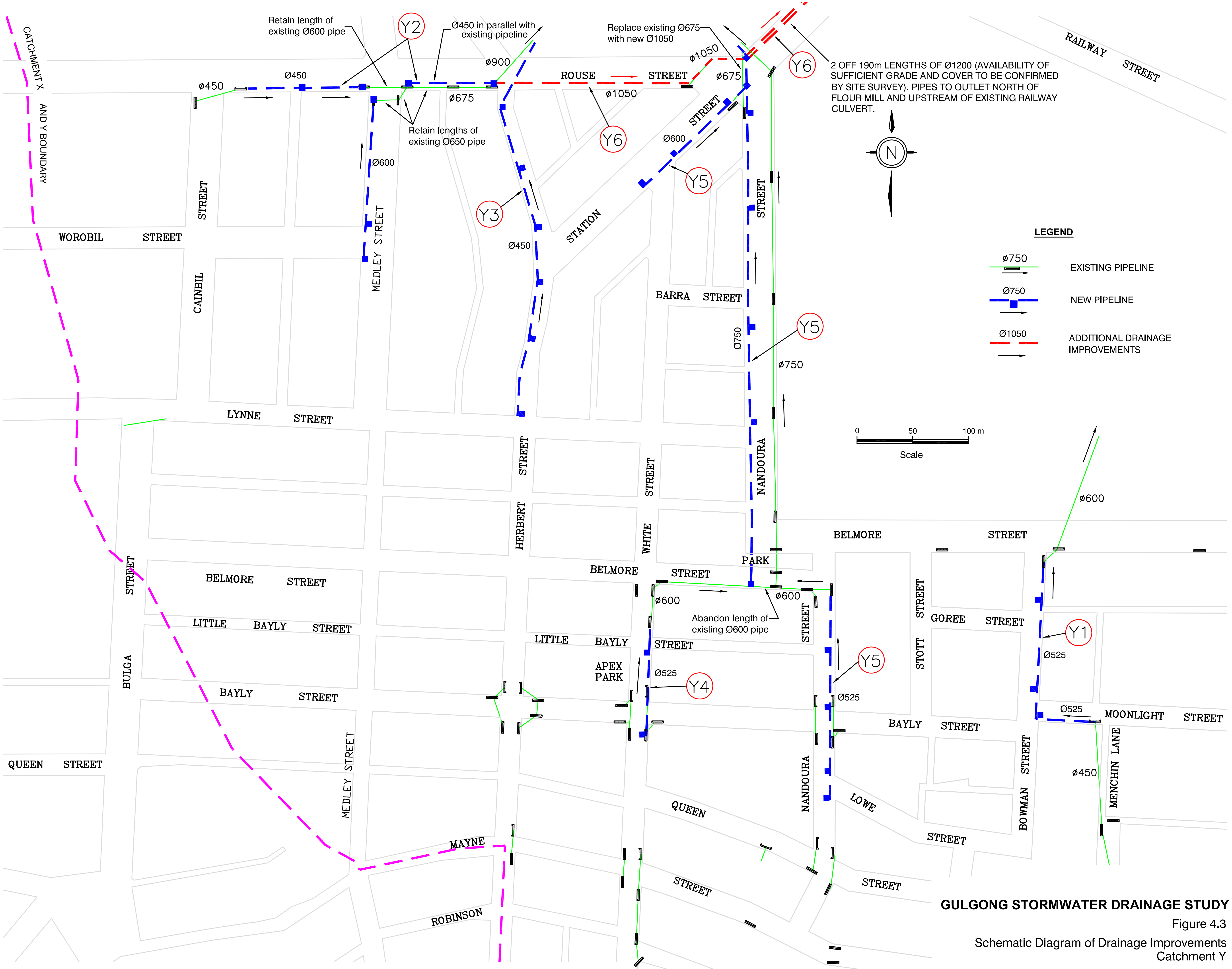
LOCATION PLAN
WYNELLA ROAD - YOUNG STREET AREAS



GULGONG STORMWATER DRAINAGE STUDY

Figure 4.2

SCHEMATIC DIAGRAM OF DRAINAGE IMPROVEMENTS
CATCHMENT X



GULGONG STORMWATER DRAINAGE STUDY

Figure 4.3

Schematic Diagram of Drainage Improvements
Catchment Y

5. REFERENCES

Institution of Engineers Australia, 1998 “***Australian Rainfall and Runoff”***

NSW Government, 2005, *“**Floodplain Development Manual”***

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