GOSFORD CITY COUNCIL

WAGSTAFFE

DRAINAGE STUDY

November, 2000

IVAN TYE & ASSOCIATES PTY LTD

GOSFORD CITY COUNCIL

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1. INTRODUCTION

Gosford City Council has regularly received reports of flooding of properties in the Wagstaffe area, most notable at and around the intersection of Wagstaffe Avenue and Mulhall Street. The shop at the corner of Wagstaffe Avenue and Mulhall Street has reported floodwaters entering the building.

In May 2000 Gosford City Council commissioned Ivan Tye & Associates Pty Ltd to carry out a drainage investigation and to develop a drainage strategy for the Wagstaffe area. (Refer to Figure 1).

The scope of work for the drainage study was as follows:

- evaluate the existing drainage system,
- determine options to upgrade the existing drainage system to meet Council's current standards,
- provide a drainage management plan for the preferred trunk drainage system.

2. SURVEY

Gosford City Council carried out a survey of the existing drainage system for Wagstaffe, in February 1997. This survey was carried out as part of Council's asset condition audit and included such information as:

← gully pit type and size,
← pit depth,
← incoming and outgoing pipe sizes,
← material type, and
← condition.

Council provided a contour plan of the study area (Figure 1) and this was used to extract ground levels and stormwater pit cover levels.

3. BACKGROUND

3.1 Topography

The study area is generally steep with the high ground in the west located in Bouddi National Park and having a peak elevation of about R.L. 75 m AHD. The study area falls to the north-east towards Brisbane Water over a distance of approximately 350 metres. Wagstaffe is typical of most coastal areas in Gosford in that the steeper ground is located at the top of the catchment and the less steep to flat ground is located near the waterfront.

3.2 Existing Drainage Problems

The study area has an isolated low point located in Albert Street between Mulhall Street and Bulkara Street as shown on Figure 1. The ground level at the isolated low point is approximately 30 m AHD. The escape route or overland flow path for floodwaters from the isolated low point is across privately owned land between Albert Street and Wagstaffe Avenue. After floodwaters reach Wagstaff Avenue it travels to the intersection of Wagstaffe Avenue and Mulhall Street and then along Mulhall Street to Brisbane Water.

Mulhall Street is located in the low point of a mild gully and in times of above average rainfall performs as an overland flow path conveying floodwaters from the west to Brisbane Water. The intersection of Wagstaffe Avenue and Mulhall Street is a collection point for overland runoff and ponding of stormwater at this location is a regular event. The ponded stormwater then build up sufficient hydraulic head (depth) before flowing further north-eastwards along Mulhall Street and into Brisbane Water. Surface stormwater has also been reported to enter a garage located at the north-eastern most end of Mulhall Street and the tennis court located in Lot 16B, DP 402392 (No. 73 Wagstaffe Avenue). In addition the store/petrol station is known to have flooded several times. This flooding has been as a result of only minor rainfall and it is considered that many homes would flood in a 100 year storm event. The properties between No. 57 and No. 73 Wagstaffe Avenue have experienced flooding from overland flows.

4. DESIGN CRITERIA AND METHODS

4.1 General

The design criteria and methods to be adopted for this study were to be in line with Gosford City Council's publication *"Specification for the Drafting and Design of Stormwater Drainage Works and Roadworks*".

4.2 Design Flood Standard

The design flood standards selected are as follows:

(a) 10 years ARI drainage standard where secondary flow paths are available.
(b) 20 years ARI drainage standard where surface flow may cause property damage.
(c) 1 in 100 AEP drainage standard where no secondary flow paths are available.

4.3 Brisbane Water Levels

The starting level for Hydraulic Grade Line (HGL) backwater calculations was taken to be 1.5 mAHD for the 100 years ARI storm event and 0.35 mAHD for storm events less than or equal to the 10 years ARI. This is in accordance with Council's specification for Design of Stormwater Drainage Works.

4.4 Hydrology

The rainfall-runoff process was modelled using ILSAX. The ILSAX model layout is shown on Figure 2.

The rainfall data and soil infiltration parameters, used in the Killcare Drainage Strategy Study (Reference 1), were adopted.

The times of concentration for each sub-catchment was calculated using the *'kinematic wave'* formulae recommended in both Australian Rainfall and Runoff (Reference 2) and Council's Drainage Specification.

ILSAX was run for various storm durations (6 minutes to 120 minutes) so as to determine the critical duration for each length of pipe in the system. The critical duration storm for the catchment was determined to be 25 minutes. Peak flow rates were determined for each length of pipe and these are presented in Appendix A.

4.5 Hydraulics

Hydraulic Grade Line (HGL) calculations were performed using the Steady Flow Pressurised HGL model - as explained in Australian Rainfall & Runoff (Reference 2).

Friction losses in pipes were modelled using the Manning's equation with Manning's 'n' set to 0.012.

Pit losses were modelled using pit loss coefficients recommended in Council's Drainage Specification.

Pipe sizes were chosen by an iterative process. For each iteration a complete HGL backwater calculation was performed to see where the system failed.

5. DRAINAGE OPTIONS

5.1 Existing Pipes

The existing pipe system is shown on Figure 1. Hydraulic analysis of the existing system shows that the main systems in Mulhall Street and Albert Street low point have capacities of less than 5 years ARI. The hydraulic grade line analysis is presented in Appendix B.

5.2 Drainage System Upgrade Standard

In order to meet the "Design Flood Standards" quoted in Section 4.2 the standards listed in the following table are proposed.

Table 1: Design Flood Standard

ILSAX Model (Refer Figure 2)		Design Flood Standard - ARI
Branch	**Reach**	
A	A1 to A8	10 years
A	A9 to Outfall	20 years*
B	B1 to A5	100 years
C	C1 to Outfall	10 years
D	D1 to A11	20 years
E	E1 to A11	100 years
F	F1 to E3	10 years

* Should detailed design determine that the intersection cannot be regraded to eliminate the low point then the Design Flood standard should be revised upwards to 100 years.

5.3 Description of Drainage System Upgrade

The drainage system upgrade proposes no changes to the existing topography. The drainage system upgrade proposes the retention of:

← the existing land forms
← overland flow paths, and
← isolated low points.

It assumes that all overland flow will reach the intersection of Mulhall Street and Wagstaffe Avenue.

There are currently 33 gully pits and 4 inlet headwalls in the Wagstaffe drainage system. In order to meet the drainage design standard set out in Table 1 and the flows generated by the ILSAX model, an additional 35 to 40 standard inlet pits would be required to transfer surface runoff into the design pipes.

5.3.1 Low side of Wagstaffe Avenue, north of Mulhall Street

Existing Situation

The low side of Wagstaffe Avenue, north of Mulhall Street currently experience flooding from overland flows originating from the Albert Street low point and the north of the study area. The section of Wagstaffe Avenue between numbers 57 (on the corner of Mulhall Street and Wagstaffe Avenue) and 73 (property with tennis court) is on a very flat grade and the footpath is lower than the road. There is no kerb and gutter to guide the overland flow to the letterbox pit at the corner of the street. Approximately 10 properties and houses in this section are currently affected by overland flows.

Proposed Upgrade

To improve flood protection to properties on the low side of Wagstaffe Avenue between numbers 57 and 73 it is proposed that a kerb be constructed from asphalt, concrete or earth and be aligned in such a manner as to direct surface runoff from Wagstaffe Avenue into Mulhall Street. To not exacerbate flooding in Mulhall Street east, it is proposed that the kerb or berm be extended to include the eastern side of Mulhall Street and that the vertical alignment of Mulhall Street between Wagstaffe Avenue and Brisbane Water also be investigated to improve the conveyance of surface stormwater into Brisbane Water. Additional stormwater collection pits are recommended in this general area, refer to section 5.3.3 for more details.

To reduce the quantity of surface runoff originating from the north of the catchment the option of realigning the intersection of Wagstaffe Avenue and Bulkara Street such that overland flows instead of flowing southwards towards Mulhall Street, flows north-eastwards towards Brisbane Water and discharging into Brisbane Water adjacent to an existing Sewage Pumping Station was investigated.

At the intersection of Wagstaffe Avenue and Bulkara Street the difference in peak flows between the:

- 10 years and 20 years ARI storm event is 0.05 cubic metres per second, and
- 10 years and 100 years ARI storm event is 0.12 cubic metres per second.

The difference between the 10 years and 100 years ARI peak flow is approximately equal to the inlet capacity of a single standard inlet pit. Therefore rather than reconstruct the road intersection, it would be less costly to construct a single pit and divert its outlet into Wagstaffe Avenue.

5.3.2 Low side of Wagstaffe Avenue, south of Mulhall Street

Existing Situation

Stormwater drainage works recently undertaken in this section of Wagstaffe Avenue and in property number 47A Wagstaffe Avenue include the provision of additional surface water collection and the upsizing of the drainage pipe in number 47A from a 600 mm diameter pipe to a 675 mm diameter pipe. These works have raised the capacity of the drainage system to the 20 year ARI standard. Flows in excess of the drainage system capacity flows overland to the intersection of Wagstaffe Avenue and Mulhall Street.

Proposed Upgrade

No upgrades are proposed for this section of drainage works.

5.3.3 High side of Wagstaffe Avenue, north of Mulhall Street

Existing Situation

A 750 mm diameter pipe is located between numbers 48 and 54 Wagstaffe Avenue. This pipe is connected to the 525 mm pipe that services the Albert Street low point and the 450 mm pipe that is connected to an inlet headwall, located in Wagstaffe Avenue and which intercepts the surface runoff from the north of the study area. The system capacity is below Council's designated design standard of 100 year ARI for isolated low points.

Proposed Upgrade

In Wagstaffe Avenue provide an additional 1200 mm pipe between the Mulhall Street and number 56 Wagstaff Avenue. From number 56 Wagstaff Avenue to number 68 Wagstaff Avenue provide a 450 mm pipe to connect to the existing 450 mm pipe at the corner of Bulkara Street and Wagstaff Avenue. Provide up to 16 additional collection pits on new drainage line.

5.3.4 Albert Street Low Point

Existing Situation

The Albert Street low point is serviced by two letterbox type pits. One is located on each side of the road. Being an isolated low point, Council's drainage standard is the 100 year ARI event. The hydrologic analysis estimated a 100 year peak flow on the high side of the street of 1.16 m3/s. This is in excess of a letterbox pit inlet capacity and surface runoff would flow across the street and onto Wagstaffe Avenue via a number of private properties. A single 525mm pipe is located in the Drainage Easement between the Albert Street low point and Wagstaffe Avenue.

Proposed Upgrade

The hydraulic analysis estimates that an additional 600mm pipe is required to supplement the existing 525mm diameter pipe to raise the pipe system conveyance capacity to 100 year ARI standard. Additionally up to 10 pits are required to transfer the runoff from the surface into the pipe system.

The overland flow path from the Albert Street low point to Wagstaffe Avenue is located over land within and adjacent to the Drainage Easement. Lot 11, DP 857987 (No. 10A Albert Street) is located on the low side of the low point. The lot is currently vacant and overland flows pass through the site. Future development of this lot and other lots through which the easement traverses should retain the overland flow path and not construct structures or solid fences at property boundaries which can obstruct surface flow. Any such obstruction would direct surface flow along another path and could result in flooding of previously not flood areas.

5.3.5 Mulhall Street west of Wagstaffe Avenue

Existing Situation

Mulhall Street has existing pipe drainage from Albert Street down to Wagstaffe Avenue and is serviced with approximately 10 gully pits. The pipe system and the overland flow drains from west to east towards the intersection of Mulhall Street and Wagstaffe Avenue.

Proposed Upgrade

To meet Council's drainage standard it is proposed that the top half of the drainage system is upgraded to provide 10 year ARI capacity and the lower half be upgraded to a 20 year ARI capacity. The existing system would need to be at a minimum duplicated (refer to hydraulic calculation in Appendix B) and up to 10 additional pits provided to meet Council's latest drainage standard.

5.3.6 Mulhall Street east of Wagstaffe Avenue

Existing Situation

The pipe drainage systems from Mulhall Street west, Albert Street low point and Wagstaffe Avenue all join at the intersection of Wagstaffe Avenue and Mulhall Street. From there the flow is conveyed to Brisbane Water via a box culvert and single 1050mm diameter pipe. The 1050mm diameter pipe is approximately 3 metres long and only at the outfall.

The intersection of Wagstaffe Avenue and Mulhall Street is a large flat area and floodwaters have been known to pond to a considerable depth resulting in flooding of the store/petrol station at the corner.

Proposed Upgrade

Roadworks - to improve the flow of surface water from the intersection of Mulhall Street and Wagstaffe Avenue to Brisbane Water it is recommended that the re-contouring of the intersection and the re-alignment of this section of Mulhall Street be investigated. The crown level of Wagstaffe Avenue requires lowering to prevent floodwaters from being trapped on the western side of Wagstaffe Avenue should piping not be feasible. The lowering of the road surface will require accurate establishment of levels of existing underground services. Concrete encasement of these services may be required to ensure adequate protection from vehicle loads and accidental excavation. Kerb and guttering or an earth berm is also proposed along the northern side of Mulhall Street to channel surface water away from the garage at number 2 Mulhall Street. These works have been mentioned earlier in 5.3.1 above.

Drainage Works - the existing drain is a box culvert / 1050 mm diameter pipe. To raise the pipe drainage system to the 20 year ARI standard it will be necessary to provide an additional 1050 mm diameter pipe. If the intersection cannot be reconstructed to eliminate ponding, then the pipe system capacity should be upgraded to cater for the 100 year ARI peak flows.

5.3.7 Intersection of Albert Street and Bulkara Street

Existing Situation

The intersection is serviced with 5 letterbox gully pits and a 450mm diameter pipe system which discharges into a table drain on the high side of Wagstaffe Avenue. The drainage system meets Council's design standard of a 10 year ARI event.

Proposed Upgrade

No upgrades are proposed for this system.

5.3.8 Albert Street - South of Mulhall Street

Existing Situation

There is a low point outside No. 28 Albert Street and No. 16 Mulhall Street. Although there has been no reports of major flooding, in times of heavy rainfall the existing letterbox pit and small diameter pipe would be insufficient to contain moderate flows and this could result in damage to properties. There is an existing drainage easement over Nos. 14 and 16 Mulhall Street, which contains the existing drainage line from Albert Street to Mulhall Street.

Proposed Upgrade

To meet Council's drainage standard it is recommended to upgrade the existing pipeline to contain the 100 year ARI peak flows whilst improving pit inlet efficiency. In addition properties located downstream of the low point should be encoded on their 149 certificates with a suitable message advising relevant properties that are affected by a secondary flow path.

5.4 Costing of Drainage Upgrade Works

The cost for the upgrade drainage works including major roadworks recommended in 5.3 is estimated to be of the order of **$0.86M.**

A list of unit rates adopted for pipework is shown in Table 2.

Table 2 : Pipework Unit Rates ($ September 1999)

Pipe Size (mm)	Supply RCP ($/m)	Lay & Joint ($/m)	Pits & Fittings ($/m)	TOTAL ($/m)
375	42.70	56.80	10.50	110.00
450	60.90	66.60	11.50	139.00
525	77.60	73.00	12.50	163.10
600	95.40	74.70	14.60	184.70
675	124.80	81.10	16.70	222.60
750	147.20	88.00	18.80	254.00
825	182.30	94.40	20.80	297.50
900	222.40	109.60	23.00	355.00
1050	289.50	116.00	25.00	430.50
1200	363.80	124.60	27.10	515.50
1350	444.00	132.90	29.20	606.10
1500	540.50	135.60	31.30	707.40
1650	638.50	148.10	33.40	820.00
1800	747.10	150.60	35.40	933.10
1950	907.40	159.20	37.50	1104.10
2100	1021.20	161.30	39.60	1222.10
2400	1417.10	166.70	41.70	1625.50

Summary of Costs

A summary of the costs for various components of the proposed drainage upgrade works is presented in Table 3 below:

TABLE 3: Cost of Drainage Upgrades

Item	Location of works	Brief Description	COST $
A	**Low side of Wagstaffe Avenue, north of Mulhall Street**	Kerb and gutter, provide extra pits and duplicate 750 mm diameter pipe.	$80,000.00
B	**High side of Wagstaffe Avenue, north of Mulhall Street**	Provide upgrade pipes and additional pits.	$220,000.00
C	**Albert Street Low Point north of Mulhall Street**	Provide additional pits.	$30,000.00
D	**Mulhall Street west of Wagstaffe Avenue**	Provide additional pipes and pits.	$130,000.00
E	**Mulhall Street east of Wagstaffe Avenue**	Provide upgrade pipe.	$80,000.00
F	**Throughout catchment**	Provide minor drainage and collection.	$170,000.00
G	**Wagstaff Ave. / Mulhall St. intersection**	Roadworks	$70,000.00
H	**Albert Street Low Point south of Mulhall Street**	Provide additional pits and upgrade existing pipes.	$80,000.00
		TOTAL	**$860,000.00**

6. DRAINAGE MANAGEMENT PLAN

A description of the proposed drainage improvement works together with a priority for implementation is set out in the following table as well as being presented in a Drainage Management Plan (Figure 4).

TABLE 4: Proposed Drainage Improvement Works

ITEM	LOCATION	DESCRIPTION OF WORKS	COMMENTS	PRIORITY
A	**Low side of Wagstaffe Avenue, north of Mulhall Street**	Provide 100 year ARI drainage system and kerb and gutter or earth berm between no.'s 57 and 73 Wagstaffe Ave. **COST:** $80,000	This will reduce frequency of flooding of properties on the low side of Wagstaffe Ave.	HIGH
B	**High side of Wagstaffe Avenue, north of Mulhall Street**	Provide 100 year ARI drainage system from the low point in Albert St. to Wagstaffe Ave. to Mulhall St. **COST:** $220,000	This will reduce flooding of properties on the low side of Wagstaffe Ave.	HIGH
C	**Albert Street Low Point**	Provide extra pits to collect up to 100 year surface runoff. Encode properties to keep clear the overland flow path. **COST:** $30,000	This will reduce runoff through private properties between Albert St. & Wagstaffe Ave.	HIGH
D	**Mulhall Street west of Wagstaffe Avenue**	Provide 10 year ARI drainage system. **COST**: $130,000	Reduces quantity of surface flow that reaches Wagstaffe Ave.	LOW TO MEDIUM
E	**Mulhall Street east of Wagstaffe Avenue**	Provide 20 year ARI drainage system. Improve overland flow to Brisbane Water by regrading the intersection and road to Brisbane Water. **COST:** $150,000	This will reduce flooding at the intersection of Wagstaffe Avenue and Mulhall St. and flooding in Mulhall St.	HIGH

F	**Throughout catchment**	Provide minor drainage and collection. **COST:** $170,000	This will facilitate transfer of surface runoff into the pipe system	MEDIUM TO HIGH
H	**Albert Street Low Point south of Mulhall Street**	Provide extra pits to collect up to 100 year surface runoff, upgrade pipeline from Albert Street to Mulhall Street. Encode properties to keep clear the overland flow path. **COST:** $80,000	This will facilitate transfer of surface runoff into the pipe system and reduce overland flow through residential properties.	HIGH

7. REFERENCES

1. Webb, McKeown & Associates Pty Ltd
Killcare Drainage Strategy Study
Gosford City Council, October 1999.

2. Institution of Engineers, Australia
Australian Rainfall and Runoff
1987.

FIGURES

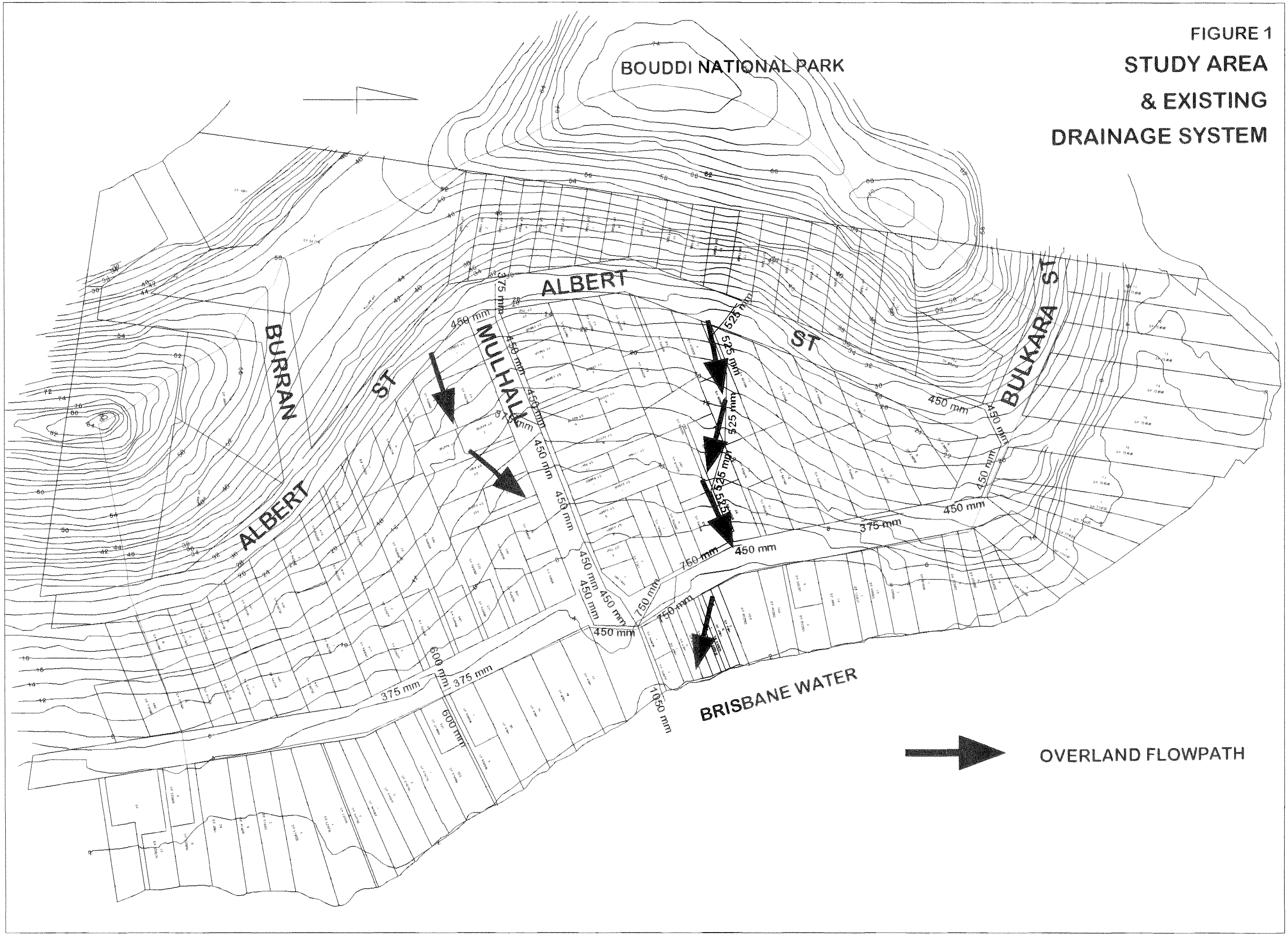


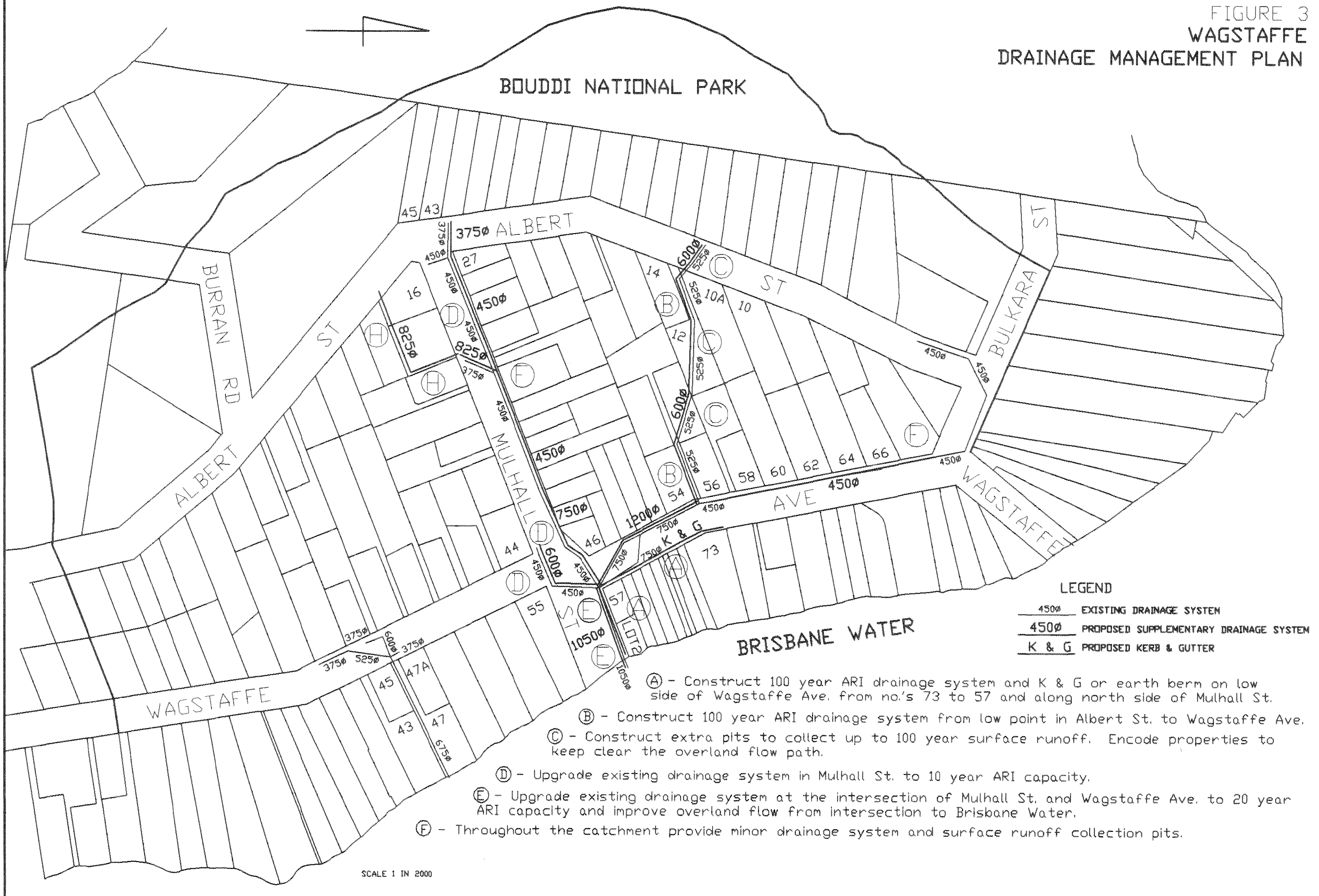
FIGURE 1
STUDY AREA
& EXISTING
DRAINAGE SYSTEM

FIGURE 2

ILSAX MODEL LAYOUT

FIGURE 3

WAGSTAFFE DRAINAGE MANAGEMENT PLAN



LEGEND

450ø	EXISTING DRAINAGE SYSTEM
450ø	PROPOSED SUPPLEMENTARY DRAINAGE SYSTEM
K & G	PROPOSED KERB & GUTTER

Ⓐ - Construct 100 year ARI drainage system and K & G or earth berm on low side of Wagstaffe Ave. from no.'s 73 to 57 and along north side of Mulhall St.

Ⓑ - Construct 100 year ARI drainage system from low point in Albert St. to Wagstaffe Ave.

Ⓒ - Construct extra pits to collect up to 100 year surface runoff. Encode properties to keep clear the overland flow path.

Ⓓ - Upgrade existing drainage system in Mulhall St. to 10 year ARI capacity.

Ⓔ - Upgrade existing drainage system at the intersection of Mulhall St. and Wagstaffe Ave. to 20 year ARI capacity and improve overland flow from intersection to Brisbane Water.

Ⓕ - Throughout the catchment provide minor drainage system and surface runoff collection pits.

APPENDIX A
ILSAX MODEL RESULTS

* * * I L S A X * * *

Version V2.14a March 1997
Produced at University of Technology, Sydney
for IBM-PC and compatible microcomputers

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* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                             *
*  WAGSTAFFE                                                                  *
*                                                                             *
*   5 yr freq, 25 min dur rainfall pattern for Terrigal                       *
*                                                                             *
*  RUN NUMBER :   1             NO. OF RAINFALL PATTERNS IS  1                *
*  HYDROGRAPHS ARE FORMED USING TIME-AREA METHOD APPLIED TO RAINFALLS         *
*  GRASSED AREA LOSSES ARE SUBTRACTED FROM FLOW DEPTH DISTRIBUTION            *
*  DEFAULT MODE IS DESIGN                                                     *
*  TIME SHIFT ROUTING                                                         *
*  LIMITED OUTPUT                                                             *
*  DIAMETER AND UNIT COST SET USED IS :                                       *
*   EXACT DIAMETERS 375 TO 1800 mm, COSTS AT DECEMBER 1990                    *
*  MINIMUM DIAMETER IS  375 mm                                                *
*  COLEBROOK-WHITE EQUATION IS USED FOR PIPES                                 *
*  OLD AND NEW DEFAULT PIPE ROUGHNESSES ARE 0.300 AND 0.300 mm                *
*                                                                             *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

RUN & RAINFALL FILE :   5Y25M.RRF
SYSTEM PIPE FILE :   DESIGN.SPF
OUTPUT DATA FILE :   DES525.OUT
INTERMEDIATE DATA FILE : not used

USER .... DATE ....

REFERENCE ....

....

CATCHMENT PARAMETERS
****

DEPRESSION STORAGE (mm) PAVED AREA	GRASSED	SOIL TYPE 1234=ABCD 5=NEW	AMC	INFILTRATION PARAMETERS
				FI = 75.0 mm
				F0 = 200.0 mm/h
				FC = 13.0 mm/h
1.0	5.0	2.00	3.00	K = 2.0 /h
				FID = 66.8 mm
				INITIAL RATE = 66.3 mm/h

RAINFALL PARAMETERS AND DATA
****

DURATION (minutes)	TIME INCREMENT (minutes)	NUMBER OF RAINFALL INCREMENTS	TOTAL RAINFALL (mm)
25.0	1.0	5	36.7

STANDARD AUSTRALIAN RAINFALL PATTERN FOR ZONE 1
WITH AVERAGE INTENSITY 88.00 mm/h (MULTIPLIER = 1.000)

74.8	74.8	74.8	74.8	74.8	123.2	123.2	123.2	123.2	123.2
171.6	171.6	171.6	171.6	171.6	39.6	39.6	39.6	39.6	39.6
30.8	30.8	30.8	30.8	30.8					

COMPUTATIONAL TIME STEP = 1.0 minutes

PIPE SYSTEM DETAILS
****

```
BCH RCH       AREAS (ha)        PAVED       GRASSED      C     VOL SURFACE PIT  PIPE
        PAV  SUP GRAS TOTAL TIME  Q    TIME     Q                    Q      Q     Q

LEN SLOPE          ORIGINAL             DESIGNED       CAP  VEL     VOLUMES  OFLOW
        H     B    SS  NO DIA nORk NO DIA nORk PAT  Q           BYP UPW OFL  Q

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 A_  1 0.29 0.06 0.81  1.15  6 0.131  0 -9 0.213 0.513  217 0.344 0.344 0.340
 20 2.00 0.00 0.00 0.00        0 0.00    450 0.30    0.496 3.1   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 AA_  1 0.03 0.00 0.28  0.31  6 0.014  0 -9 0.062 0.386   44 0.076 0.076 0.075
 15 2.00 0.00 0.00 0.00        0 0.00    375 0.30    0.307 2.8   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 A_  2 0.06 0.01 0.03  0.10  6 0.027  0 -6 0.014 0.773   28 0.041 0.455 0.449
 5720.00 0.00 0.00 0.00        0 0.00    450 0.30    1.577 9.9   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 A_  3 0.12 0.02 0.10  0.24  6 0.055  0 -6 0.042 0.708   63 0.097 0.545 0.544
 1420.00 0.00 0.00 0.00        0 0.00    450 0.30    1.577 9.9   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 B_  1 0.19 0.00 1.72  1.91  6 0.087  0 -9 0.384 0.386  271 0.471 0.471 0.468
 1910.00 0.00 0.00 0.00        0 0.00    375 0.30    0.691 6.3   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 A_  5 0.11 0.03 0.11  0.25  6 0.051  0 -8 0.043 0.675   62 0.094 1.106 1.096
 4215.00 0.00 0.00 0.00        0 0.00    450 0.30    1.365 8.6   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 A_  6 0.16 0.03 0.12  0.31  6 0.071  0 -7 0.051 0.708   81 0.122 1.218 1.209
 3110.00 0.00 0.00 0.00        0 0.00    525 0.30    1.667 7.7   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 A_  7 0.11 0.02 0.09  0.23  6 0.052  0 -8 0.036 0.707   59 0.088 1.297 1.280
 36 1.00 0.00 0.00 0.00        0 0.00    750 0.30    1.331 3.0   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 A_  8 0.07 0.01 0.04  0.12  6 0.032  0-10 0.014 0.773   34 0.046 1.323 1.323
 10 0.50 0.00 0.00 0.00        0 0.00    900 0.30    1.510 2.4   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 A_  9 0.04 0.01 0.01  0.05  6 0.018  0 -6 0.005 0.868   17 0.023 1.343 1.342
 21 0.50 0.00 0.00 0.00        0 0.00    900 0.30    1.510 2.4   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 C_  1 0.97 0.14 1.67  2.78  6 0.442  0-12 0.353 0.576  587 0.795 0.795 0.790
 12 1.00 0.00 0.00 0.00        0 0.00    675 0.30    1.010 2.8   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 C_  2 0.12 0.02 0.03  0.17  6 0.055  0 -6 0.019 0.840   53 0.073 0.863 0.846
 77 0.50 0.00 0.00 0.00        0 0.00    750 0.30    0.937 2.1   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 D_  1 0.77 0.17 0.77  1.71  6 0.350  0-13 0.197 0.672  422 0.545 0.545 0.540
 19 1.00 0.00 0.00 0.00        0 0.00    600 0.30    0.742 2.6   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 D_  2 0.07 0.01 0.02  0.10  6 0.031  0 -6 0.010 0.840   30 0.041 0.581 0.572
 26 0.50 0.00 0.00 0.00        0 0.00    675 0.30    0.711 2.0   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 E_  1 0.61 0.20 1.22  2.03  6 0.276  0 -7 0.455 0.576  428 0.731 0.731 0.729
 12 2.00 0.00 0.00 0.00        0 0.00    525 0.30    0.742 3.4   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 E_  2 0.11 0.02 0.03  0.16  6 0.050  0-10 0.015 0.839   48 0.064 0.793 0.778
14514.00 0.00 0.00 0.00        0 0.00    525 0.30    1.974 9.1   0   0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                       DESIGNING
 F_  1 0.09 0.03 0.50  0.62  6 0.043  0 -7 0.168 0.449  103 0.211 0.211 0.208
 5917.00 0.00 0.00 0.00        0 0.00    375 0.30    0.902 8.2   0   0    0 0.000
```

```
CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                      DESIGNING
  F_  2 0.07 0.01 0.04  0.12  6 0.032  0 -6 0.017 0.774   33 0.049 0.256 0.251
 58 5.00 0.00 0.00 0.00        0 0.00    375 0.30    0.488 4.4   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                      DESIGNING
  F_  3 0.25 0.05 0.25  0.55  6 0.111  0 -7 0.098 0.675  135 0.209 0.460 0.449
100 7.00 0.00 0.00 0.00        0 0.00    375 0.30    0.577 5.2   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                      DESIGNING
  E_  3 0.67 0.15 0.67  1.49  6 0.304  0-10 0.211 0.674  367 0.514 1.741 1.698
 50 0.50 0.00 0.00 0.00        0 0.00   1050 0.30    2.259 2.6   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                      DESIGNING
  G_  1 0.14 0.02 0.04  0.19  6 0.062  0 -6 0.021 0.840   60 0.083 0.083 0.081
 28 0.50 0.00 0.00 0.00        0 0.00    375 0.30    0.152 1.4   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                      DESIGNING
  E_  4 0.18 0.04 0.18  0.39  6 0.080  0 -9 0.064 0.674   97 0.144 1.842 1.830
 30 0.50 0.00 0.00 0.00        0 0.00   1050 0.30    2.259 2.6   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                      DESIGNING
  A_ 11 0.07 0.01 0.02  0.11  6 0.034  0 -6 0.012 0.840   32 0.045 3.852 3.844
 49 0.50 0.00 0.00 0.00        0 0.00   1350 0.30    4.354 3.0   0    0    0 0.000


                            OUTFALL HYDROGRAPH (m3/s)
                            *************************
                     (  35 VALUES AT  1.0 minute INTERVALS )

 0.000   0.013   0.088   0.214   0.356   0.501   0.690   0.921   1.148   1.386
 1.655   2.037   2.472   2.904   3.327   3.726   3.844   3.653   3.283   2.826
 2.311   1.741   1.265   0.926   0.692   0.543   0.422   0.315   0.232   0.166
 0.105   0.045   0.012   0.002   0.000

TOTAL AREA =              12.13 ha (  4.20 ha PAVED,  0.90 ha SUPPLEMENTARY
                                      7.02 ha GRASSED AND  0.00 ha UNDRAINED )
ACCUMULATED RUNOFF =       2629 m3
 INCLUDING BASEFLOW =         0 m3
 & USER HYDROGRAPHS =         0 m3
VOLUME DIVERTED OUT =         0 m3
OVERFLOWS IN TRANSIT =        0 m3 (NET)
RUNOFF COEFFICIENTS =     0.591 (VOLUMETRIC) BASED ONLY ON RAINFALL INPUTS
                          1.297 (PEAK/AVERAGE) AND 0.665 (PEAK/PEAK)
                            INCL. USER-PROVIDED HYDROGRAPHS, BUT NOT BASEFLOWS
NO. OF PIPES =               21
PEAK FLOWRATE =           3.844 m3/s   17.0 minutes AFTER START OF STORM
TOTAL BASEFLOW =          0.000 m3/s
GRASSED RUNOFF =           43.0 %

WARNING - FLOWS FROM BRANCH   C HAVE NOT BEEN DIRECTED TO ANY OUTLET
        - CHECK CONNECTIONS


COST SUMMARY
************              ( MULTIPLIER =  1.000 )

DIAMETER   UNIT COST   TOTAL LENGTH  TOTAL COST
   mm         $/m           m            $

   375.     143.00        279.0       39897.00
   450.     167.00        133.0       22211.00
   525.     196.00        188.0       36848.00
   600.     227.00         19.0        4313.00
   675.     257.00         38.0        9766.00
   750.     289.00        113.0       32657.00
   900.     367.00         31.0       11377.00
  1050.     443.00         80.0       35440.00
  1350.     612.00         49.0       29988.00
                                     ----------
                                     222497.00
                                     ----------

PIPE DATA FROM THE LAST DESIGNED OR UPGRADED PIPE SYSTEM HAS BEEN
STORED ON FILE  IOFILE7.DAT  -  RENAME THIS IF IT IS TO BE USED LATER
```

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                     * * *  I L S A X  * * *

                    Version V2.14a  March 1997
           Produced at University of Technology, Sydney
             for IBM-PC and compatible microcomputers

 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 *                                                                            *
 *  WAGSTAFFE                                                                 *
 *                                                                            *
 *   10 yr freq, 25 min dur rainfall pattern for Terrigal                     *
 *                                                                            *
 *  RUN NUMBER :   1           NO. OF RAINFALL PATTERNS IS  1                 *
 *  HYDROGRAPHS ARE FORMED USING TIME-AREA METHOD APPLIED TO RAINFALLS        *
 *  GRASSED AREA LOSSES ARE SUBTRACTED FROM FLOW DEPTH DISTRIBUTION           *
 *  DEFAULT MODE IS DESIGN                                                    *
 *  TIME SHIFT ROUTING                                                        *
 *  LIMITED OUTPUT                                                            *
 *  DIAMETER AND UNIT COST SET USED IS :                                      *
 *   EXACT DIAMETERS 375 TO 1800 mm, COSTS AT DECEMBER 1990                   *
 *  MINIMUM DIAMETER IS  375 mm                                               *
 *  COLEBROOK-WHITE EQUATION IS USED FOR PIPES                                *
 *  OLD AND NEW DEFAULT PIPE ROUGHNESSES ARE 0.300 AND 0.300 mm               *
 *                                                                            *
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RUN & RAINFALL FILE :    10Y25M.RRF
SYSTEM PIPE FILE :       DESIGN.SPF
OUTPUT DATA FILE :       DES1025.OUT
INTERMEDIATE DATA FILE : not used


USER ..............................................    DATE ...............

REFERENCE ..................................................................

............................................................................


CATCHMENT PARAMETERS
********************
                                                                INFILTRATION
          DEPRESSION STORAGE (mm)    SOIL TYPE      AMC          PARAMETERS
            PAVED AREA   GRASSED     1234=ABCD                 FI =    75.0 mm
                                       5=NEW                   F0 =   200.0 mm/h
                                                               FC =    13.0 mm/h
               1.0          5.0        2.00         3.00        K =     2.0 /h
                                                              FID =    66.8 mm
                                                     INITIAL RATE =    66.3 mm/h
RAINFALL PARAMETERS AND DATA
****************************

    DURATION        TIME INCREMENT        NUMBER OF       TOTAL RAINFALL
    (minutes)         (minutes)      RAINFALL INCREMENTS       (mm)

       25.0              1.0                 5                 40.8

STANDARD AUSTRALIAN RAINFALL PATTERN FOR ZONE  1
WITH AVERAGE INTENSITY   98.00 mm/h                       ( MULTIPLIER =  1.000 )

  83.3    83.3    83.3    83.3    83.3   137.2   137.2   137.2   137.2   137.2
 191.1   191.1   191.1   191.1   191.1    44.1    44.1    44.1    44.1    44.1
  34.3    34.3    34.3    34.3    34.3

COMPUTATIONAL TIME STEP =  1.0 minutes


                        PIPE SYSTEM DETAILS
                        *******************
```

```
BCH RCH        AREAS (ha)       PAVED     GRASSED      C     VOL SURFACE PIT  PIPE
          PAV  SUP GRAS TOTAL TIME  Q    TIME    Q                  Q      Q     Q

LEN SLOPE           ORIGINAL             DESIGNED       CAP  VEL     VOLUMES  OFLOW
          H     B     SS  NO DIA nORk NO DIA nORk PAT  Q           BYP UPW OFL  Q

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  A_  1 0.29 0.06 0.81  1.15  6 0.146  0 -9 0.269 0.557  262 0.414 0.414 0.410
 20 2.00 0.00 0.00 0.00         0 0.00   450 0.30     0.496 3.1   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
 AA_  1 0.03 0.00 0.28  0.31  6 0.016  0 -9 0.080 0.441   55 0.095 0.095 0.094
 15 2.00 0.00 0.00 0.00         0 0.00   375 0.30     0.307 2.8   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  A_  2 0.06 0.01 0.03  0.10  6 0.030  0 -6 0.016 0.796   32 0.046 0.550 0.543
 5720.00 0.00 0.00 0.00         0 0.00   450 0.30     1.577 9.9   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  A_  3 0.12 0.02 0.10  0.24  6 0.061  0 -6 0.048 0.736   73 0.109 0.652 0.650
 1420.00 0.00 0.00 0.00         0 0.00   450 0.30     1.577 9.9   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  B_  1 0.19 0.00 1.72  1.91  6 0.097  0 -9 0.496 0.441  344 0.593 0.593 0.589
 1910.00 0.00 0.00 0.00         0 0.00   375 0.30     0.691 6.3   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  A_  5 0.11 0.03 0.11  0.25  6 0.057  0 -8 0.050 0.705   72 0.107 1.346 1.335
 4215.00 0.00 0.00 0.00         0 0.00   450 0.30     1.365 8.6   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  A_  6 0.16 0.03 0.12  0.31  6 0.079  0 -7 0.059 0.735   94 0.138 1.473 1.463
 3110.00 0.00 0.00 0.00         0 0.00   525 0.30     1.667 7.7   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  A_  7 0.11 0.02 0.09  0.23  6 0.058  0 -8 0.042 0.735   69 0.099 1.563 1.543
 36 1.00 0.00 0.00 0.00         0 0.00   825 0.30     1.707 3.2   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  A_  8 0.07 0.01 0.04  0.12  6 0.036  0-10 0.016 0.794   38 0.053 1.592 1.591
 10 0.50 0.00 0.00 0.00         0 0.00  1050 0.30     2.259 2.6   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  A_  9 0.04 0.01 0.01  0.05  6 0.020  0 -6 0.006 0.885   19 0.026 1.615 1.613
 21 0.50 0.00 0.00 0.00         0 0.00  1050 0.30     2.259 2.6   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  C_  1 0.97 0.14 1.67  2.78  6 0.492  0-12 0.448 0.615  698 0.937 0.937 0.931
 12 1.00 0.00 0.00 0.00         0 0.00   675 0.30     1.010 2.8   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  C_  2 0.12 0.02 0.03  0.17  6 0.061  0 -6 0.021 0.856   60 0.082 1.014 0.994
 77 0.50 0.00 0.00 0.00         0 0.00   825 0.30     1.203 2.3   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  D_  1 0.77 0.17 0.77  1.71  6 0.390  0-13 0.243 0.702  491 0.629 0.629 0.623
 19 1.00 0.00 0.00 0.00         0 0.00   600 0.30     0.742 2.6   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  D_  2 0.07 0.01 0.02  0.10  6 0.034  0 -6 0.012 0.856   34 0.046 0.669 0.659
 26 0.50 0.00 0.00 0.00         0 0.00   675 0.30     0.711 2.0   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  E_  1 0.61 0.20 1.22  2.03  6 0.308  0 -7 0.525 0.616  510 0.833 0.833 0.830
 12 2.00 0.00 0.00 0.00         0 0.00   600 0.30     1.053 3.7   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  E_  2 0.11 0.02 0.03  0.16  6 0.055  0-10 0.017 0.854   54 0.072 0.903 0.888
14514.00 0.00 0.00 0.00         0 0.00   600 0.30     2.799 9.9   0    0    0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                     DESIGNING
  F_  1 0.09 0.03 0.50  0.62  6 0.047  0 -7 0.195 0.498  127 0.242 0.242 0.240
 5917.00 0.00 0.00 0.00         0 0.00   375 0.30     0.902 8.2   0    0    0 0.000
```

```
CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                    DESIGNING
  F_  2 0.07 0.01 0.04  0.12  6 0.036  0 -6 0.019 0.796   38 0.055 0.295 0.291
 58 5.00 0.00 0.00 0.00         0 0.00   375 0.30    0.488 4.4   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                    DESIGNING
  F_  3 0.25 0.05 0.25  0.55  6 0.124  0 -7 0.113 0.706  157 0.237 0.527 0.517
100 7.00 0.00 0.00 0.00         0 0.00   375 0.30    0.577 5.2   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                    DESIGNING
  E_  3 0.67 0.15 0.67  1.49  6 0.338  0-10 0.258 0.704  427 0.597 2.002 1.960
 50 0.50 0.00 0.00 0.00         0 0.00  1050 0.30    2.259 2.6   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                    DESIGNING
  G_  1 0.14 0.02 0.04  0.19  6 0.069  0 -6 0.024 0.856   68 0.093 0.093 0.091
 28 0.50 0.00 0.00 0.00         0 0.00   375 0.30    0.152 1.4   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                    DESIGNING
  E_  4 0.18 0.04 0.18  0.39  6 0.089  0 -9 0.076 0.705  113 0.165 2.125 2.100
 30 0.50 0.00 0.00 0.00         0 0.00  1050 0.30    2.259 2.6   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                    DESIGNING
  A_ 11 0.07 0.01 0.02  0.11  6 0.037  0 -6 0.013 0.856   37 0.051 4.493 4.490
 49 0.50 0.00 0.00 0.00         0 0.00  1500 0.30    5.730 3.2   0    0    0 0.000
```

OUTFALL HYDROGRAPH (m3/s)
****

(35 VALUES AT 1.0 minute INTERVALS)

0.000	0.021	0.112	0.255	0.414	0.576	0.795	1.090	1.404	1.729
2.066	2.516	3.013	3.502	3.963	4.384	4.490	4.238	3.786	3.250
2.661	2.019	1.490	1.113	0.838	0.659	0.507	0.369	0.263	0.184
0.116	0.049	0.012	0.002	0.000					

```
TOTAL AREA =              12.13 ha (  4.20 ha PAVED,  0.90 ha SUPPLEMENTARY
                                      7.02 ha GRASSED AND  0.00 ha UNDRAINED )
ACCUMULATED RUNOFF =       3113 m3
 INCLUDING BASEFLOW =         0 m3
 & USER HYDROGRAPHS =         0 m3
VOLUME DIVERTED OUT =         0 m3
OVERFLOWS IN TRANSIT =        0 m3 (NET)
RUNOFF COEFFICIENTS =     0.629 (VOLUMETRIC) BASED ONLY ON RAINFALL INPUTS
                          1.360 (PEAK/AVERAGE) AND 0.697 (PEAK/PEAK)
                            INCL. USER-PROVIDED HYDROGRAPHS, BUT NOT BASEFLOWS
NO. OF PIPES =              21
PEAK FLOWRATE =           4.490 m3/s   17.0 minutes AFTER START OF STORM
TOTAL BASEFLOW =          0.000 m3/s
GRASSED RUNOFF =           46.2 %

WARNING - FLOWS FROM BRANCH   C HAVE NOT BEEN DIRECTED TO ANY OUTLET
        - CHECK CONNECTIONS
```

COST SUMMARY
****

(MULTIPLIER = 1.000)

DIAMETER mm	UNIT COST $/m	TOTAL LENGTH m	TOTAL COST $
375.	143.00	279.0	39897.00
450.	167.00	133.0	22211.00
525.	196.00	31.0	6076.00
600.	227.00	176.0	39952.00
675.	257.00	38.0	9766.00
825.	326.00	113.0	36838.00
1050.	443.00	111.0	49173.00
1500.	708.00	49.0	34692.00
			238605.00

PIPE DATA FROM THE LAST DESIGNED OR UPGRADED PIPE SYSTEM HAS BEEN
STORED ON FILE IOFILE7.DAT - RENAME THIS IF IT IS TO BE USED LATER

```
                     * * *  I L S A X  * * *

                  Version V2.14a  March 1997
           Produced at University of Technology, Sydney
             for IBM-PC and compatible microcomputers

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                             *
*  WAGSTAFFE                                                                  *
*                                                                             *
*   20 yr freq, 25 min dur rainfall pattern for Terrigal                      *
*                                                                             *
*  RUN NUMBER :   1            NO. OF RAINFALL PATTERNS IS  1                 *
*  HYDROGRAPHS ARE FORMED USING TIME-AREA METHOD APPLIED TO RAINFALLS         *
*  GRASSED AREA LOSSES ARE SUBTRACTED FROM FLOW DEPTH DISTRIBUTION            *
*  DEFAULT MODE IS DESIGN                                                     *
*  TIME SHIFT ROUTING                                                         *
*  LIMITED OUTPUT                                                             *
*  DIAMETER AND UNIT COST SET USED IS :                                       *
*   EXACT DIAMETERS 375 TO 1800 mm, COSTS AT DECEMBER 1990                    *
*  MINIMUM DIAMETER IS  375 mm                                                *
*  COLEBROOK-WHITE EQUATION IS USED FOR PIPES                                 *
*  OLD AND NEW DEFAULT PIPE ROUGHNESSES ARE 0.300 AND 0.300 mm                *
*                                                                             *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RUN & RAINFALL FILE :    20Y25M.RRF
SYSTEM PIPE FILE :       DESIGN.SPF
OUTPUT DATA FILE :       DES2025.OUT
INTERMEDIATE DATA FILE : not used


USER ..............................................    DATE ................

REFERENCE ..................................................................

............................................................................


CATCHMENT PARAMETERS
********************
                                                                  INFILTRATION
          DEPRESSION STORAGE (mm)    SOIL TYPE       AMC           PARAMETERS
            PAVED AREA   GRASSED     1234=ABCD                 FI =    75.0 mm
                                       5=NEW                   F0 =   200.0 mm/h
                                                               FC =    13.0 mm/h
               1.0          5.0         2.00         3.00       K =     2.0 /h
                                                              FID =    66.8 mm
                                                     INITIAL RATE =    66.3 mm/h
RAINFALL PARAMETERS AND DATA
****************************

    DURATION        TIME INCREMENT        NUMBER OF       TOTAL RAINFALL
    (minutes)         (minutes)      RAINFALL INCREMENTS       (mm)

       25.0              1.0                 5                 46.7

STANDARD AUSTRALIAN RAINFALL PATTERN FOR ZONE  1
WITH AVERAGE INTENSITY  112.00 mm/h                     ( MULTIPLIER =  1.000 )

  95.2     95.2     95.2     95.2     95.2    156.8    156.8    156.8    156.8    156.8
 218.4    218.4    218.4    218.4    218.4     50.4     50.4     50.4     50.4     50.4
  39.2     39.2     39.2     39.2     39.2

COMPUTATIONAL TIME STEP =  1.0 minutes


                             PIPE SYSTEM DETAILS
                             *******************
```

```
BCH RCH       AREAS (ha)       PAVED     GRASSED      C     VOL SURFACE PIT  PIPE
        PAV  SUP GRAS TOTAL TIME  Q   TIME    Q                     Q     Q     Q

LEN SLOPE          ORIGINAL            DESIGNED       CAP  VEL    VOLUMES  OFLOW
        H     B    SS  NO DIA nORk NO DIA nORk PAT  Q          BYP UPW OFL  Q

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  A_  1 0.29 0.06 0.81  1.15  6 0.166  0 -9 0.345 0.607  326 0.511 0.511 0.506
 20 2.00 0.00 0.00 0.00        0 0.00    525 0.30    0.742 3.4   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
 AA_  1 0.03 0.00 0.28  0.31  6 0.018  0 -9 0.105 0.503   72 0.123 0.123 0.121
 15 2.00 0.00 0.00 0.00        0 0.00    375 0.30    0.307 2.8   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  A_  2 0.06 0.01 0.03  0.10  6 0.034  0 -6 0.019 0.820   38 0.053 0.680 0.673
 5720.00 0.00 0.00 0.00        0 0.00    525 0.30    2.36110.9   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  A_  3 0.12 0.02 0.10  0.24  6 0.070  0 -6 0.057 0.767   87 0.127 0.800 0.798
 1420.00 0.00 0.00 0.00        0 0.00    525 0.30    2.36110.9   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  B_  1 0.19 0.00 1.72  1.91  6 0.111  0 -9 0.652 0.503  449 0.763 0.763 0.758
 1910.00 0.00 0.00 0.00        0 0.00    450 0.30    1.114 7.0   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  A_  5 0.11 0.03 0.11  0.25  6 0.065  0 -8 0.059 0.739   86 0.124 1.681 1.668
 4215.00 0.00 0.00 0.00        0 0.00    525 0.30    2.043 9.4   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  A_  6 0.16 0.03 0.12  0.31  6 0.090  0 -7 0.070 0.767  112 0.160 1.829 1.818
 3110.00 0.00 0.00 0.00        0 0.00    600 0.30    2.364 8.4   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  A_  7 0.11 0.02 0.09  0.23  6 0.066  0 -8 0.049 0.766   82 0.115 1.933 1.902
 36 1.00 0.00 0.00 0.00        0 0.00    900 0.30    2.143 3.4   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  A_  8 0.07 0.01 0.04  0.12  6 0.041  0-10 0.020 0.818   45 0.061 1.963 1.952
 10 0.50 0.00 0.00 0.00        0 0.00   1050 0.30    2.259 2.6   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  A_  9 0.04 0.01 0.01  0.05  6 0.023  0 -6 0.007 0.899   22 0.029 1.981 1.959
 21 0.50 0.00 0.00 0.00        0 0.00   1050 0.30    2.259 2.6   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  C_  1 0.97 0.14 1.67  2.78  6 0.562  0-12 0.578 0.658  853 1.135 1.135 1.129
 12 1.00 0.00 0.00 0.00        0 0.00    750 0.30    1.331 3.0   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  C_  2 0.12 0.02 0.03  0.17  6 0.070  0 -6 0.025 0.873   70 0.095 1.224 1.201
 77 0.50 0.00 0.00 0.00        0 0.00    900 0.30    1.510 2.4   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  D_  1 0.77 0.17 0.77  1.71  6 0.446  0-13 0.306 0.736  588 0.746 0.746 0.740
 19 1.00 0.00 0.00 0.00        0 0.00    675 0.30    1.010 2.8   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  D_  2 0.07 0.01 0.02  0.10  6 0.039  0 -6 0.014 0.873   39 0.053 0.793 0.781
 26 0.50 0.00 0.00 0.00        0 0.00    750 0.30    0.937 2.1   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  E_  1 0.61 0.20 1.22  2.03  6 0.351  0 -7 0.624 0.661  625 0.976 0.976 0.973
 12 2.00 0.00 0.00 0.00        0 0.00    600 0.30    1.053 3.7   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  E_  2 0.11 0.02 0.03  0.16  6 0.063  0-10 0.020 0.871   63 0.083 1.056 1.040
14514.00 0.00 0.00 0.00        0 0.00    600 0.30    2.799 9.9   0   0   0 0.000

CIRCULAR PIPE,          UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  F_  1 0.09 0.03 0.50  0.62  6 0.054  0 -7 0.233 0.557  162 0.287 0.287 0.284
 5917.00 0.00 0.00 0.00        0 0.00    375 0.30    0.902 8.2   0   0   0 0.000
```

```
CIRCULAR PIPE,       UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  F_  2 0.07 0.01 0.04  0.12  6 0.041  0 -6 0.022 0.820   45 0.063 0.348 0.343
 58 5.00 0.00 0.00 0.00        0 0.00    375 0.30    0.488 4.4   0   0   0 0.000

CIRCULAR PIPE,       UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  F_  3 0.25 0.05 0.25  0.55  6 0.142  0 -7 0.134 0.740  188 0.275 0.619 0.609
100 7.00 0.00 0.00 0.00        0 0.00    450 0.30    0.931 5.9   0   0   0 0.000

CIRCULAR PIPE,       UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  E_  3 0.67 0.15 0.67  1.49  6 0.387  0-10 0.325 0.738  512 0.712 2.361 2.318
 50 0.50 0.00 0.00 0.00        0 0.00   1200 0.30    3.202 2.8   0   0   0 0.000

CIRCULAR PIPE,       UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  G_  1 0.14 0.02 0.04  0.19  6 0.079  0 -6 0.028 0.873   79 0.107 0.107 0.105
 28 0.50 0.00 0.00 0.00        0 0.00    375 0.30    0.152 1.4   0   0   0 0.000

CIRCULAR PIPE,       UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  E_  4 0.18 0.04 0.18  0.39  6 0.102  0 -9 0.091 0.739  135 0.192 2.510 2.482
 30 0.50 0.00 0.00 0.00        0 0.00   1200 0.30    3.202 2.8   0   0   0 0.000

CIRCULAR PIPE,       UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  A_ 11 0.07 0.01 0.02  0.11  6 0.043  0 -6 0.015 0.873   43 0.058 5.384 5.351
 49 0.50 0.00 0.00 0.00        0 0.00   1500 0.30    5.730 3.2   0   0   0 0.000
```

OUTFALL HYDROGRAPH (m3/s)
****
(35 VALUES AT 1.0 minute INTERVALS)

0.000	0.032	0.146	0.312	0.495	0.684	0.985	1.399	1.827	2.242
2.652	3.187	3.769	4.322	4.822	5.284	5.351	5.008	4.458	3.828
3.147	2.407	1.804	1.377	1.061	0.854	0.659	0.468	0.318	0.213
0.130	0.053	0.013	0.002	0.000					

```
TOTAL AREA =              12.13 ha (  4.20 ha PAVED,  0.90 ha SUPPLEMENTARY
                                      7.02 ha GRASSED AND  0.00 ha UNDRAINED )
ACCUMULATED RUNOFF =       3799 m3
 INCLUDING BASEFLOW =         0 m3
 & USER HYDROGRAPHS =         0 m3
VOLUME DIVERTED OUT =         0 m3
OVERFLOWS IN TRANSIT =        0 m3 (NET)
RUNOFF COEFFICIENTS =     0.671 (VOLUMETRIC) BASED ONLY ON RAINFALL INPUTS
                          1.418 (PEAK/AVERAGE) AND 0.727 (PEAK/PEAK)
                            INCL. USER-PROVIDED HYDROGRAPHS, BUT NOT BASEFLOWS
NO. OF PIPES =               21
PEAK FLOWRATE =           5.351 m3/s   17.0 minutes AFTER START OF STORM
TOTAL BASEFLOW =          0.000 m3/s
GRASSED RUNOFF =           49.5 %

WARNING - FLOWS FROM BRANCH   C HAVE NOT BEEN DIRECTED TO ANY OUTLET
        - CHECK CONNECTIONS
```

COST SUMMARY
************ (MULTIPLIER = 1.000)

DIAMETER mm	UNIT COST $/m	TOTAL LENGTH m	TOTAL COST $
375.	143.00	160.0	22880.00
450.	167.00	119.0	19873.00
525.	196.00	133.0	26068.00
600.	227.00	188.0	42676.00
675.	257.00	19.0	4883.00
750.	289.00	38.0	10982.00
900.	367.00	113.0	41471.00
1050.	443.00	31.0	13733.00
1200.	527.00	80.0	42160.00
1500.	708.00	49.0	34692.00
			259418.00

PIPE DATA FROM THE LAST DESIGNED OR UPGRADED PIPE SYSTEM HAS BEEN

```
                    * * *  I L S A X  * * *

                  Version V2.14a  March 1997
           Produced at University of Technology, Sydney
            for IBM-PC and compatible microcomputers

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                             *
*  WAGSTAFFE                                                                  *
*                                                                             *
*  100 yr freq, 25 min dur rainfall pattern for Terrigal                      *
*                                                                             *
*  RUN NUMBER :   1            NO. OF RAINFALL PATTERNS IS  1                 *
*  HYDROGRAPHS ARE FORMED USING TIME-AREA METHOD APPLIED TO RAINFALLS         *
*  GRASSED AREA LOSSES ARE SUBTRACTED FROM FLOW DEPTH DISTRIBUTION            *
*  DEFAULT MODE IS DESIGN                                                     *
*  TIME SHIFT ROUTING                                                         *
*  LIMITED OUTPUT                                                             *
*  DIAMETER AND UNIT COST SET USED IS :                                       *
*   EXACT DIAMETERS 375 TO 1800 mm, COSTS AT DECEMBER 1990                    *
*  MINIMUM DIAMETER IS  375 mm                                                *
*  COLEBROOK-WHITE EQUATION IS USED FOR PIPES                                 *
*  OLD AND NEW DEFAULT PIPE ROUGHNESSES ARE 0.300 AND 0.300 mm                *
*                                                                             *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RUN & RAINFALL FILE :     100Y25M.RRF
SYSTEM PIPE FILE :        DESIGN.SPF
OUTPUT DATA FILE :        DES10025.OUT
INTERMEDIATE DATA FILE : not used


USER ..............................................     DATE ...............

REFERENCE ..................................................................

............................................................................


CATCHMENT PARAMETERS
********************
                                                                INFILTRATION
           DEPRESSION STORAGE (mm)    SOIL TYPE      AMC          PARAMETERS
             PAVED AREA   GRASSED     1234=ABCD                FI =   75.0 mm
                                         5=NEW                 FO =  200.0 mm/h
                                                               FC =   13.0 mm/h
                1.0         5.0         2.00         3.00       K =    2.0 /h
                                                              FID =   66.8 mm
                                                     INITIAL RATE =   66.3 mm/h
RAINFALL PARAMETERS AND DATA
****************************

    DURATION        TIME INCREMENT       NUMBER OF       TOTAL RAINFALL
    (minutes)         (minutes)      RAINFALL INCREMENTS      (mm)

       25.0              1.0                 5                60.0

STANDARD AUSTRALIAN RAINFALL PATTERN FOR ZONE  1
WITH AVERAGE INTENSITY  144.00 mm/h                    ( MULTIPLIER =  1.000 )

 129.6   129.6   129.6   129.6   129.6   187.2   187.2   187.2   187.2   187.2
 252.0   252.0   252.0   252.0   252.0    79.2    79.2    79.2    79.2    79.2
  72.0    72.0    72.0    72.0    72.0

COMPUTATIONAL TIME STEP =  1.0 minutes


                             PIPE SYSTEM DETAILS
                             *******************
```

```
BCH RCH        AREAS (ha)        PAVED      GRASSED       C      VOL SURFACE PIT  PIPE
        PAV  SUP GRAS TOTAL TIME  Q    TIME     Q                       Q      Q     Q

LEN SLOPE           ORIGINAL             DESIGNED       CAP  VEL     VOLUMES  OFLOW
          H     B     SS  NO DIA nORk NO DIA nORk PAT  Q           BYP UPW OFL  Q

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 A_  1 0.29 0.06 0.81  1.15  6 0.193  0 -9 0.422 0.682  471 0.615 0.615 0.612
 20 2.00 0.00 0.00 0.00        0 0.00    525 0.30     0.742 3.4   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 AA_  1 0.03 0.00 0.28  0.31  6 0.021  0 -9 0.133 0.597  110 0.153 0.153 0.153
 15 2.00 0.00 0.00 0.00        0 0.00    375 0.30     0.307 2.8   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 A_  2 0.06 0.01 0.03  0.10  6 0.039  0 -6 0.022 0.857   50 0.062 0.826 0.823
5720.00 0.00 0.00 0.00        0 0.00    525 0.30     2.36110.9   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 A_  3 0.12 0.02 0.10  0.24  6 0.081  0 -6 0.068 0.815  118 0.149 0.971 0.970
1420.00 0.00 0.00 0.00        0 0.00    525 0.30     2.36110.9   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 B_  1 0.19 0.00 1.72  1.91  6 0.128  0 -9 0.824 0.597  684 0.953 0.953 0.951
1910.00 0.00 0.00 0.00        0 0.00    450 0.30     1.114 7.0   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 A_  5 0.11 0.03 0.11  0.25  6 0.076  0 -8 0.071 0.791  119 0.147 2.068 2.061
4215.00 0.00 0.00 0.00        0 0.00    600 0.30     2.89710.2   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 A_  6 0.16 0.03 0.12  0.31  6 0.105  0 -7 0.084 0.814  152 0.189 2.250 2.243
3110.00 0.00 0.00 0.00        0 0.00    600 0.30     2.364 8.4   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 A_  7 0.11 0.02 0.09  0.23  6 0.077  0 -8 0.060 0.812  111 0.136 2.379 2.360
 36 1.00 0.00 0.00 0.00        0 0.00   1050 0.30     3.205 3.7   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 A_  8 0.07 0.01 0.04  0.12  6 0.048  0-10 0.024 0.854   61 0.072 2.432 2.424
 10 0.50 0.00 0.00 0.00        0 0.00   1200 0.30     3.202 2.8   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 A_  9 0.04 0.01 0.01  0.05  6 0.026  0 -6 0.008 0.921   29 0.034 2.459 2.442
 21 0.50 0.00 0.00 0.00        0 0.00   1200 0.30     3.202 2.8   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 C_  1 0.97 0.14 1.67  2.78  6 0.651  0-12 0.786 0.721 1202 1.437 1.437 1.430
 12 1.00 0.00 0.00 0.00        0 0.00    825 0.30     1.707 3.2   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 C_  2 0.12 0.02 0.03  0.17  6 0.081  0 -6 0.030 0.899   93 0.111 1.541 1.514
 77 0.50 0.00 0.00 0.00        0 0.00   1050 0.30     2.259 2.6   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 D_  1 0.77 0.17 0.77  1.71  6 0.517  0-13 0.405 0.785  808 0.920 0.920 0.913
 19 1.00 0.00 0.00 0.00        0 0.00    675 0.30     1.010 2.8   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 D_  2 0.07 0.01 0.02  0.10  6 0.045  0 -6 0.017 0.899   52 0.062 0.975 0.963
 26 0.50 0.00 0.00 0.00        0 0.00    825 0.30     1.203 2.3   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 E_  1 0.61 0.20 1.22  2.03  6 0.407  0 -7 0.753 0.728  886 1.160 1.160 1.158
 12 2.00 0.00 0.00 0.00        0 0.00    675 0.30     1.433 4.0   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 E_  2 0.11 0.02 0.03  0.16  6 0.073  0-10 0.024 0.897   84 0.098 1.255 1.239
14514.00 0.00 0.00 0.00        0 0.00    675 0.30     3.80810.6   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                        DESIGNING
 F_  1 0.09 0.03 0.50  0.62  6 0.063  0 -7 0.281 0.644  241 0.344 0.344 0.341
5917.00 0.00 0.00 0.00        0 0.00    375 0.30     0.902 8.2   0    0    0 0.000
```

```
CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  F_  2 0.07 0.01 0.04  0.12  6 0.047  0 -6 0.027 0.857   61 0.074 0.416 0.411
 58 5.00 0.00 0.00 0.00        0 0.00    375 0.30    0.488 4.4   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  F_  3 0.25 0.05 0.25  0.55  6 0.164  0 -7 0.161 0.792  259 0.325 0.736 0.726
100 7.00 0.00 0.00 0.00        0 0.00    450 0.30    0.931 5.9   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  E_  3 0.67 0.15 0.67  1.49  6 0.448  0-10 0.403 0.788  703 0.851 2.816 2.776
 50 0.50 0.00 0.00 0.00        0 0.00   1200 0.30    3.202 2.8   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  G_  1 0.14 0.02 0.04  0.19  6 0.091  0 -6 0.034 0.899  105 0.125 0.125 0.123
 28 0.50 0.00 0.00 0.00        0 0.00    375 0.30    0.152 1.4   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  E_  4 0.18 0.04 0.18  0.39  6 0.118  0 -9 0.110 0.790  185 0.228 3.004 2.979
 30 0.50 0.00 0.00 0.00        0 0.00   1200 0.30    3.202 2.8   0    0    0 0.000

CIRCULAR PIPE,        UNRESTRICTED, NO-OVERFLOW INLET                  DESIGNING
  A_ 11 0.07 0.01 0.02  0.11  6 0.049  0 -6 0.018 0.899   57 0.068 6.574 6.492
 49 0.50 0.00 0.00 0.00        0 0.00   1650 0.30    7.346 3.4   0    0    0 0.000
```

OUTFALL HYDROGRAPH (m3/s)
****
(36 VALUES AT 1.0 minute INTERVALS)

0.000	0.066	0.240	0.477	0.774	1.143	1.690	2.299	2.845	3.338
3.814	4.407	5.019	5.580	6.072	6.490	6.492	6.099	5.517	4.863
4.159	3.405	2.807	2.393	2.090	1.901	1.651	1.319	0.972	0.641
0.362	0.146	0.040	0.007	0.001	0.000				

```
TOTAL AREA =             12.13 ha (  4.20 ha PAVED,  0.90 ha SUPPLEMENTARY
                                     7.02 ha GRASSED AND  0.00 ha UNDRAINED )
ACCUMULATED RUNOFF =      5347 m3
 INCLUDING BASEFLOW =        0 m3
 & USER HYDROGRAPHS =        0 m3
VOLUME DIVERTED OUT =        0 m3
OVERFLOWS IN TRANSIT =       0 m3 (NET)
RUNOFF COEFFICIENTS =    0.735 (VOLUMETRIC) BASED ONLY ON RAINFALL INPUTS
                         1.338 (PEAK/AVERAGE) AND 0.765 (PEAK/PEAK)
                           INCL. USER-PROVIDED HYDROGRAPHS, BUT NOT BASEFLOWS
NO. OF PIPES =             21
PEAK FLOWRATE =          6.492 m3/s   17.0 minutes AFTER START OF STORM
TOTAL BASEFLOW =         0.000 m3/s
GRASSED RUNOFF =          53.6 %

WARNING - FLOWS FROM BRANCH   C HAVE NOT BEEN DIRECTED TO ANY OUTLET
        - CHECK CONNECTIONS
```

COST SUMMARY
****
(MULTIPLIER = 1.000)

DIAMETER mm	UNIT COST $/m	TOTAL LENGTH m	TOTAL COST $
375.	143.00	160.0	22880.00
450.	167.00	119.0	19873.00
525.	196.00	91.0	17836.00
600.	227.00	73.0	16571.00
675.	257.00	176.0	45232.00
825.	326.00	38.0	12388.00
1050.	443.00	113.0	50059.00
1200.	527.00	111.0	58497.00
1650.	809.00	49.0	39641.00
			282977.00

PIPE DATA FROM THE LAST DESIGNED OR UPGRADED PIPE SYSTEM HAS BEEN
STORED ON FILE IOFILE7.DAT - RENAME THIS IF IT IS TO BE USED LATER

APPENDIX B
HGL MODEL RESULTS

WAGSTAFFE CATCHMENT
EXISTING PIPE SYSTEM

HGL ANALYSIS PIPE SYSTEM

I.TYE date

Pits	Pipes					HGL Loss Calculations									HGL					Freeboard	
Reach	Length (m)	Exist. Pipe Size (mm)	d/s IL (m)	u/s IL (m)	u/s Deflection Angle	Pipe Slope (%)	Q 5.00 (m3/s)	Pipe Full V (m/s)	HGL Slope (%)	Qu/Qo	Du/Do	Pit Loss Coeff (k)	Pit Losses kv2/2g (m)	Total Loss (m)	d/s of Pipe (m)	u/s of Pipe (m)	u/s of Pit U+R (m)	u/s Pipe Obvert Level	u/s of Pit W+R (m)	u/s Surface Level (m)	Freeboard (HGL to Surface) (m)
															36.231						
A2-A1	20.00	1.00 x 375.00	23.70	29.60		29.500	0.34	3.08	3.20	0.00	0.0	2.50	1.208	1.848	34.382	35.023	36.231	29.98	31.183	30.00	-6.231
A3-A2	57.00	1.00 x 450.00	13.00	23.70	22.00	18.772	0.45	2.83	2.12	0.76	0.8	0.70	0.286	1.496	32.887	34.097	34.382	24.15	24.436	25.00	-9.382
A5-A3	14.00	1.00 x 450.00	11.80	13.00	0.00	8.571	0.54	3.40	3.06	0.83	1.0	0.30	0.176	0.604	32.283	32.710	32.887	13.45	13.626	14.00	-18.887
A6-A5	42.00	1.00 x 450.00	7.80	11.80	0.00	9.524	1.10	6.92	12.68	0.49	1.0	0.30	0.731	6.059	26.224	31.551	32.283	12.25	12.981	13.00	-19.283
A7-A6	31.00	1.00 x 450.00	5.00	7.80	0.00	9.032	1.21	7.61	15.35	0.91	1.0	0.30	0.885	5.643	20.581	25.339	26.224	8.25	9.135	9.00	-17.224
A8-A7	36.00	1.00 x 450.00	4.20	5.00	0.00	2.222	1.28	8.05	17.17	0.95	1.0	0.30	0.990	7.173	13.408	19.591	20.581	5.45	6.440	6.20	-14.381
A9-A8	10.00	1.00 x 450.00	3.50	4.20	45.00	7.000	1.32	8.30	18.26	0.97	1.0	0.60	2.107	3.933	9.475	11.301	13.408	4.65	6.757	5.00	-8.408
A11-A9	21.00	1.00 450.00	1.70	3.50	40.00	8.571	1.34	8.43	18.82	0.99	1.0	0.60	2.171	6.124	3.351	7.304	9.475	3.95	6.121	4.50	-4.975
HW-A11	49.00	1.00 x 1050.00	0.60	1.70	5.00	2.245	3.84	4.43	1.68	0.35	0.4	0.60	0.601	1.427	0.350	1.176	1.777	2.75	3.351	4.00	0.649
															34.419						
A2-AA1	15.00	1.00 x 450.00	23.70	24.00		2.000	0.08	0.47	0.06	0.00	0.0	2.50	0.028	0.037	34.382	34.391	34.419	24.45	24.478	25.00	-9.419
															35.754						
A5-B1	19.00	1.00 x 375.00	11.80	13.00		6.316	0.47	4.26	6.12	0.00	0.0	2.50	2.307	3.471	32.283	33.446	35.754	13.38	15.682	14.00	-21.754
															5.603						
C2-C1	12.00	1.00 x 750.00	2.80	4.20		11.667	1.00	2.26	0.69	0.00	0.0	2.50	0.653	0.735	3.693	3.775	4.428	4.95	5.603	5.00	-0.603
HW-C2	77.00	1.00 x 750.00	0.60	2.80	0.00	2.857	1.35	3.06	1.25	0.74	1.0	0.30	0.143	1.108	2.000		0.143	3.55	3.693	3.80	0.107
															5.314						
D1-HW	20.00	1.00 x 450.00	1.97	2.07	0.00	0.500	0.15	0.94	0.24	0.00	0.0	0.30	0.014	0.061	5.253	5.300	5.314	2.52	2.534	5.00	-0.314
D2-D1	55.00	1.00 x 450.00	1.71	1.97	80.00	0.473	0.23	1.45	0.55	0.65	1.0	2.50	0.266	0.571	4.682	4.987	5.253	2.42	2.686	4.60	-0.653
A11-D2	70.00	1.00 x 450.00	1.32	1.39	45.00	0.100	0.50	3.14	2.62	0.46	1.0	-1.00	-0.504	1.331	3.351	5.185	4.682	1.84	1.336	4.40	-0.282
															29.874						
E2-E1	12.00	1.00 x 525.00	23.30	27.90		38.333	0.73	3.37	2.46	0.00	0.0	2.50	1.449	1.744	25.479	25.774	27.223	28.43	29.874	29.00	-0.874
E3-E2	145.00	1.00 x 525.00	3.50	23.30	90.00	13.655	0.78	3.60	2.80	0.94	1.0	2.50	1.654	5.718	6.650	10.714	12.369	23.83	25.479	25.00	-0.479
E4-E3	40.00	1.00 x 750.00	3.00	3.50	90.00	1.250	1.70	3.85	1.99	0.46	0.7	2.50	1.887	2.681	3.969	4.763	6.650	4.25	6.137	5.00	-1.650
A11-E4	40.00	2.00 x 750.00	1.70	3.00	45.00	3.250	1.83	2.07	0.58	0.93	1.0	1.00	0.219	0.449	3.351	3.581	3.800	3.75	3.969	4.50	0.531
															27.172						
F2-F1	59.00	1.00 x 450.00	15.00	26.50		19.492	0.21	1.32	0.46	0.00	0.0	2.50	0.222	0.495	15.576	15.849	16.071	26.95	27.172	27.50	0.328
F3-F2	58.00	1.00 x 450.00	12.00	15.00	45.00	5.172	0.25	1.57	0.66	0.84	1.0	1.00	0.126	0.506	12.858	13.238	13.364	15.45	15.576	16.00	0.424
E3-F3	100.00	1.00 x 450.00	3.50	12.00	0.00	8.500	0.45	2.83	2.12	0.56	1.0	1.00	0.408	2.531	6.650	8.773	9.181	12.45	12.858	13.00	0.142

WAGSTAFFE CATCHMENT HGL ANALYSIS PIPE SYSTEM

EXISTING PIPE SYSTEM

I.TYE date

Pits	Pipes					HGL Loss Calculations									HGL					Freeboard	
Reach	Length (m)	Exist. Pipe Size (mm)	d/s IL (m)	u/s IL (m)	u/s Deflection Angle	Pipe Slope (%)	Q 5.00 (m3/s)	Pipe Full V (m/s)	HGL Slope (%)	Qu/Qo	Du/Do	Pit Loss Coeff (k)	Pit Losses kv2/2g (m)	Total Loss (m)	d/s of Pipe (m)	u/s of Pipe (m)	u/s of Pit U+R (m)	u/s Pipe Obvert Level	u/s of Pit W+R (m)	u/s Surface Level (m)	Freeboard (HGL to Surface) (m)
															36.231						
A2-A1	20.00	1.00 x 375.00	23.70	29.60		29.500	0.34	3.08	3.20	0.00	0.0	2.50	1.208	1.848	34.382	35.023	36.231	29.98	31.183	30.00	-6.231
A3-A2	57.00	1.00 x 450.00	13.00	23.70	22.00	18.772	0.45	2.83	2.12	0.76	0.8	0.70	0.286	1.496	32.887	34.097	34.382	24.15	24.436	25.00	-9.382
A5-A3	14.00	1.00 x 450.00	11.80	13.00	0.00	8.571	0.54	3.40	3.06	0.83	1.0	0.30	0.176	0.604	32.283	32.710	32.887	13.45	13.626	14.00	-18.887
A6-A5	42.00	1.00 x 450.00	7.80	11.80	0.00	9.524	1.10	6.92	12.68	0.49	1.0	0.30	0.731	6.059	26.224	31.551	32.283	12.25	12.981	13.00	-19.283
A7-A6	31.00	1.00 x 450.00	5.00	7.80	0.00	9.032	1.21	7.61	15.35	0.91	1.0	0.30	0.885	5.643	20.581	25.339	26.224	8.25	9.135	9.00	-17.224
A8-A7	36.00	1.00 x 450.00	4.20	5.00	0.00	2.222	1.28	8.05	17.17	0.95	1.0	0.30	0.990	7.173	13.408	19.591	20.581	5.45	6.440	6.20	-14.381
A9-A8	10.00	1.00 x 450.00	3.50	4.20	45.00	7.000	1.32	8.30	18.26	0.97	1.0	0.60	2.107	3.933	9.475	11.301	13.408	4.65	6.757	5.00	-8.408
A11-A9	21.00	1.00 450.00	1.70	3.50	40.00	8.571	1.34	8.43	18.82	0.99	1.0	0.60	2.171	6.124	3.351	7.304	9.475	3.95	6.121	4.50	-4.975
HW-A11	49.00	1.00 x 1050.00	0.60	1.70	5.00	2.245	3.84	4.43	1.68	0.35	0.4	0.60	0.601	1.427	0.350	1.176	1.777	2.75	3.351	4.00	0.649
															34.419						
A2-AA1	15.00	1.00 x 450.00	23.70	24.00		2.000	0.08	0.47	0.06	0.00	0.0	2.50	0.028	0.037	34.382	34.391	34.419	24.45	24.478	25.00	-9.419
															35.754						
A5-B1	19.00	1.00 x 375.00	11.80	13.00		6.316	0.47	4.26	6.12	0.00	0.0	2.50	2.307	3.471	32.283	33.446	35.754	13.38	15.682	14.00	-21.754
															5.603						
C2-C1	12.00	1.00 x 750.00	2.80	4.20		11.667	1.00	2.26	0.69	0.00	0.0	2.50	0.653	0.735	3.693	3.775	4.428	4.95	5.603	5.00	-0.603
HW-C2	77.00	1.00 x 750.00	0.60	2.80	0.00	2.857	1.35	3.06	1.25	0.74	1.0	0.30	0.143	1.108	2.000		0.143	3.55	3.693	3.80	0.107
															5.314						
D1-HW	20.00	1.00 x 450.00	1.97	2.07	0.00	0.500	0.15	0.94	0.24	0.00	0.0	0.30	0.014	0.061	5.253	5.300	5.314	2.52	2.534	5.00	-0.314
D2-D1	55.00	1.00 x 450.00	1.71	1.97	80.00	0.473	0.23	1.45	0.55	0.65	1.0	2.50	0.266	0.571	4.682	4.987	5.253	2.42	2.686	4.60	-0.653
A11-D2	70.00	1.00 x 450.00	1.32	1.39	45.00	0.100	0.50	3.14	2.62	0.46	1.0	-1.00	-0.504	1.331	3.351	5.185	4.682	1.84	1.336	4.40	-0.282
															29.874						
E2-E1	12.00	1.00 x 525.00	23.30	27.90		38.333	0.73	3.37	2.46	0.00	0.0	2.50	1.449	1.744	25.479	25.774	27.223	28.43	29.874	29.00	-0.874
E3-E2	145.00	1.00 x 525.00	3.50	23.30	90.00	13.655	0.78	3.60	2.80	0.94	1.0	2.50	1.654	5.718	6.650	10.714	12.369	23.83	25.479	25.00	-0.479
E4-E3	40.00	1.00 x 750.00	3.00	3.50	90.00	1.250	1.70	3.85	1.99	0.46	0.7	2.50	1.887	2.681	3.969	4.763	6.650	4.25	6.137	5.00	-1.650
A11-E4	40.00	2.00 x 750.00	1.70	3.00	45.00	3.250	1.83	2.07	0.58	0.93	1.0	1.00	0.219	0.449	3.351	3.581	3.800	3.75	3.969	4.50	0.531
															27.172						
F2-F1	59.00	1.00 x 450.00	15.00	26.50		19.492	0.21	1.32	0.46	0.00	0.0	2.50	0.222	0.495	15.576	15.849	16.071	26.95	27.172	27.50	0.328
F3-F2	58.00	1.00 x 450.00	12.00	15.00	45.00	5.172	0.25	1.57	0.66	0.84	1.0	1.00	0.126	0.506	12.858	13.238	13.364	15.45	15.576	16.00	0.424
E3-F3	100.00	1.00 x 450.00	3.50	12.00	0.00	8.500	0.45	2.83	2.12	0.56	1.0	1.00	0.408	2.531	6.650	8.773	9.181	12.45	12.858	13.00	0.142

WAGSTAFFE CATCHMENT — HGL ANALYSIS PIPE SYSTEM

DESIGN PIPE SYSTEM

I.TYE date

Suggested Design Standard	Design Flow	Pits: Reach	Pipes: Length (m)	Design Pipe Size (mm)	d/s IL (m)	u/s IL (m)	HGL Loss Calculations: u/s Deflection Angle	Q Design (m3/s)	Pipe Full V (m/s)	HGL Slope (%)	Pit Loss Coeff (k)	Pit Losses kv2/2g (m)	Total Loss (m)	HGL: d/s of Pipe (m)	u/s of Pipe (m)	Part Full Flag	Freeboard: u/s Surface Level (m)	Freeboard (HGL to Surface) (m)
														29.814				
10.00	0.41	A2-A1	20.00	2.00 x 375	23.70	29.00		0.41	1.86	1.16	2.50	0.439	0.672	24.253	24.486	**	30.00	0.186
10.00	0.54	A3-A2	57.00	2.00 x 450	13.00	23.70	22.00	0.54	1.70	0.76	0.70	0.103	0.538	13.514	13.949	**	25.00	0.747
10.00	0.65	A5-A3	14.00	2.00 x 450	11.80	13.00	0.00	0.65	2.04	1.11	0.30	0.064	0.219	12.519	12.674	**	14.00	0.486
10.00	1.34	A6-A5	42.00	2.00 x 450	7.80	11.80	0.00	1.34	4.20	4.67	0.30	0.269	2.231	8.573	10.535	**	13.00	0.481
10.00	1.46	A7-A6	31.00	2.00 x 450	5.00	7.80	0.00	1.46	4.60	5.61	0.30	0.323	2.062	6.273	8.012	**	9.00	0.427
10.00	1.54	A8-A7	36.00	1.00 x 675	3.80	4.20	0.00	1.54	4.31	2.87	0.30	0.284	1.318	4.955	5.989		6.20	-0.073
20.00	1.95	A9-A8	10.00	1.00 x 1050	3.00	3.75	45.00	1.95	2.25	0.44	0.60	0.155	0.199	4.207	4.250	**	5.00	0.045
20.00	1.96	A11-A9	21.00	1.00 1050	1.70	3.00	40.00	1.96	2.26	0.44	0.60	0.157	0.249	3.042	3.134		4.50	0.293
20.00	5.35	HW-A11	49.00	2.00 x 1050	0.60	1.70	5.00	5.35	3.09	0.82	0.60	0.292	0.693	0.700	1.101	**	4.00	0.958
														24.495				
10.00	0.09	A2-AA1	15.00	1.00 x 450	23.70	24.00		0.09	0.59	0.09	2.50	0.045	0.058	24.253	24.267	**	25.00	0.505
														14.039				
100.00	0.95	A5-B1	19.00	1.00 x 750	11.80	12.70		0.95	2.15	0.62	2.50	0.589	0.707	13.000	13.118	**	14.00	-0.039
														5.016				
10.00	0.93	C2-C1	12.00	1.00 x 750	2.80	3.70		0.93	2.11	0.60	2.50	0.566	0.637	3.627	3.699	**	5.00	-0.016
10.00	0.99	HW-C2	77.00	1.00 x 750	0.60	2.80	0.00	0.99	2.25	0.68	0.30	0.077	0.600	0.350	0.873		3.80	0.173
														4.831				
20.00	0.74	D1-HW	20.00	1.50 x 600	1.97	2.07	0.00	0.74	1.74	0.55	2.50	0.388	0.498	4.333	4.443		5.00	0.169
20.00	0.74	D2-D1	55.00	1.50 x 600	1.71	1.97	80.00	0.74	1.74	0.55	2.50	0.388	0.690	3.642	3.945		4.60	0.267
20.00	0.78	A11-D2	70.00	1.50 x 600	1.32	1.39	45.00	0.78	1.84	0.61	1.00	0.172	0.600	3.042	3.470		4.40	0.758
														28.919				
100.00	1.16	E2-E1	12.00	2.43 x 525	23.30	27.90		1.16	2.20	1.05	2.00	0.494	0.620	24.532	24.657	**	29.00	0.081
100.00	1.24	E3-E2	145.00	2.43 x 525	3.50	23.30	90.00	1.24	2.36	1.20	2.50	0.707	2.444	4.919	6.656	**	25.00	0.468
100.00	2.78	E4-E3	40.00	3.60 x 750	3.00	3.50	90.00	2.78	1.75	0.41	2.50	0.388	0.552	4.367	4.531		5.00	0.081
100.00	2.98	A11-E4	40.00	3.60 x 750	1.70	3.00	45.00	2.98	1.87	0.47	1.00	0.179	0.367	4.000	4.188		4.50	0.133
														27.240				
10.00	0.24	F2-F1	59.00	1.00 x 450	15.00	26.50		0.24	1.51	0.60	2.50	0.290	0.646	15.621	15.977		27.50	0.260
10.00	0.29	F3-F2	58.00	1.00 x 450	12.00	15.00	45.00	0.29	1.83	0.89	1.00	0.171	0.685	12.989	13.503	**	16.00	0.379
10.00	0.52	E3-F3	100.00	1.00 x 450	3.50	12.00	0.00	0.52	3.25	2.80	1.00	0.539	3.340	5.000	7.802	**	13.00	0.011