GOSFORD CITY COUNCIL

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POINT CLARE
TRUNK DRAINAGE STUDY
MANAGEMENT STUDY
AND
MANAGEMENT PLAN

MAY 1994

WEBB, McKEOWN & ASSOCIATES PTY. LTD.

CONSULTING ENGINEERS

GOSFORD CITY COUNCIL

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FOREWORD

The study was completed in October 1993 and exhibited for public comment in the same year.

The study and management plan was adopted by Gosford City Council, Minute _ _ _ _ _ _ _ _ on _ _ _ _ _ _ _ _ _.

This report is an exact copy of the original study and plan completed in October 1993 and adopted by Council on _ _ _ _ _ _ _ _ _.

POINT CLARE TRUNK DRAINAGE STUDY

MANAGEMENT STUDY

AND MANAGEMENT PLAN

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EXECUTIVE SUMMARY

Point Clare, a suburb of East Gosford, is located on a strip of land (approximately 2.8km long) between Brisbane Water and Brisbane Water National Park (refer Figure 2).

In 1990, the area was severely affected by flood producing storms on both 8 January and 9 February. At least twenty-seven reports of houses being flooded were notified to Council. Many more properties were affected by floodwaters passing through their yards and entering garages. Brisbane Water Drive became impassible at the height of the storm.

In response to the concerns of the local residents, Gosford City Council commissioned a Stormwater Trunk Drainage Study in February 1993. The aim of the study was to develop a feasible cost-effective combination of mitigation options which would provide 1 in 100 (1%) AEP flood freedom for the houses, and reduce the frequency of flooding of the properties themselves to a level acceptable to Council and the Community.

In order to define the drainage requirements necessary to achieve these objectives, a hydrologic/hydraulic computer model was established for the study area. The model was then used to assess the existing drainage system behaviour, determine the design 1 in 10, 1 in 20, 1 in 50 and 1 in 100 AEP floods, and quantify the relative effects of alternative flood mitigation measures.

The study determined that the existing pipe drainage system currently has capacities ranging from less than 1 in 10 up to 1 in 100 AEP in different parts of the system.

The mitigation measures considered in this study included:

- pipe, culvert and channel amplification,
- extension of drainage lines,
- additional stormwater pits,
- kerb and guttering,
- road regrading,
- purchase of flood liable properties,
- retarding basins,
- new drainage lines,
- minimum floor levels for new developments.

An important consideration in assessing the level of protection affordable to the area was Council's budget limitations for stormwater drainage works. The proposed overall drainage strategy for the area would need to be funded over a number of years. Individual items of work have been costed and given a priority to assist Council in preparing a Works Programme for the area. The construction cost of the recommended improvement works is approximately $3.0M.

1. INTRODUCTION

In February 1993, Gosford City Council commissioned Webb, McKeown & Associates to investigate the Trunk Drainage requirements for Point Clare (Figure 2). The need for an investigation was highlighted by the incidence of a major flood on 8 January 1992, and a slightly lesser flood on 9 February 1992.

Twenty-seven (27) residents reported floodwaters entering their houses and many more reported floodwaters entering garages and/or flowing through their yards. Brisbane Water Drive was impassable between Koolinda Avenue and Sunnyside Avenue during the peak of the storm.

The investigation was divided into three stages, these being:

Stage I - Trunk Drainage Study to:

- assess the capacity of the existing drainage system,
- determine sections of the system which fail for various frequency storms,
- determine overland flow paths and areas of ponding.

Stage II - Trunk Drainage Management Study to:

- identify drainage strategies or mitigation works to either solve or minimise the flooding problems within the catchments. (Although Gross Pollutant Traps (GPT's), Nutrient Filters (NF's) and erosion control do not form part of the trunk drainage works, consideration was given to the provision of GPT's, NF's and embankment protection measures in the Management Study.)

Stage III - Trunk Drainage Management Plan to:

- identify the works best suited to achieving the primary aim of Council, that is to relieve flooding so that all houses (where feasible) are flood free up to the 1 in 100 AEP standard.

2. STAGE 1 - TRUNK DRAINAGE STUDY

2.1 Catchment Description

The upper third (approximately) of the catchment lies within Brisbane Water National Park, and consists of heavy vegetation on steep terrain. The terrain is underlain with sandstone, and rock is exposed in some of the defined waterways.

The lower two-thirds (approximately) of the catchment is made up mainly of free-standing residential buildings with small pockets of medium density housing, schools, and commercial development. This developable portion of the catchment is almost fully developed.

2.2 Data Collection

To effectively carry out the study various information had to be assessed, including historical flood data, details on the existing drainage network, surface levels, etc. These were required to understand the physics of flooding behaviour in the catchments. Sources of information were Council records, resident interview information, flood marks, etc.

2.2.1 Council Records

Council provided the following:

- 1 in 4 000 scale plans showing most of the existing drainage layout, including pipe sizes and locations of pits,
- design plans showing some pipe invert levels,
- correspondence files, in particular arising from the 8 January, 1992 and 9 February, 1992 storms.

The lateral extent and likely causes of flooding from the January and February 1992 storms are described in the following sub-sections which are based on identifiable localities.

Coolarn Avenue

One commercial site was identified as being affected by flooding above floor level from resident interview information. Flooding was primarily due to runoff from the upper reaches of the catchment (mainly from Brisbane Water National Park and the cemetery) which ponded at the low point in Coolarn Avenue near its intersection with Brisbane Water Drive. A single 375mm diameter pipe drains this catchment, and this appears inadequate to prevent floodwaters ponding at the low point.

Wendy Drive to Brisbane Water

At the upper end of Wendy Drive, three defined watercourses in the National Park enter the residential area at the following locations:

- rear of Lot 14 (No. 67) Wendy Drive,
- between Lot 56 (No. 81) and Lot 57 (No. 83) Wendy Drive, and
- adjacent to Lot 63 (No. 95) Wendy Drive.

Three houses in Wendy Drive and one house in Golden Avenue were identified as being affected by flooding above floor level from resident information.

The National Park makes up more than 75% of the catchment draining to the open channel between Wendy Drive and Golden Avenue. The runoff from the National Park is thus a substantial proportion and results in the flooding of houses and properties located on the eastern side of Wendy Drive and backing onto the National Park. These properties are also on the low side of Wendy Drive.

At Brisbane Water Drive the culverts became blocked by debris (mostly garden clippings) and resulted in floodwaters overtopping the road and entering the Ambulance Station building.

Henman Close to Brisbane Water

Twelve (12) houses were identified as affected by flooding above habitable floor level from Council records and resident information. All the houses flooded were between Brisbane Water Drive and Brisbane Water.

Two open earth channels to the south of Henman Close and Robson Close divert the runoff from the National Park into an open channel between Robson Close and Coral Tree Place. The open channel then runs parallel to Girralong Avenue to culverts at Brisbane Water Drive. In the 1992 storms the floodwaters overtopped the culverts and flowed on to and across Brisbane Water Drive (the culverts became blocked by debris carried by the floodwaters). The land bounded by Brisbane Water Drive, Jirrah Avenue, Bryline Drive and Byarong Avenue became the flow path for the floodwaters draining to Brisbane Water. Lack of secondary flow paths resulted in ponding in Bayline Drive and Byarong Avenue.

The properties to the east of Henman Close and backing on to the National Park, suffered damages from excess runoff emanating from the National Park and passing through their properties. Land slippage caused by either prolonged saturation and/or erosion is an additional concern for the same properties.

Tania Drive and Koolinda Avenue

Properties on the high side of Tania Drive experienced excess runoff from the National Park passing through the properties to Tania Drive, and then on to the low point at the head of the cul-de-sac. A cutoff drain lying between the properties on the high side of Tania Drive and the National Park was inadequate to re-direct all the runoff from the National Park to a pipe drain in Koolinda Avenue. At the low point in Tania Drive floodwaters overtopped the kerb and flowed through four properties on their way to Koolinda Avenue. Some of this runoff flowed down Koolinda Avenue, whilst the remainder crossed Koolinda Avenue and flowed through the grounds of Orana Village. The runoff flowing down Koolinda Avenue was increased by runoff from Grace

Avenue. When the combined runoff reached Brisbane Water Drive, sufficient runoff overtopped the kerb to flow through the three properties at the corner of Brisbane Water Drive and Jirrah Avenue.

Fiona Street to Brisbane Water

Three (3) houses in Althea Place were identified as being affected by flooding above habitable floor level from Council records and resident information. Flooding was due to overland runoff in the upper parts of the catchment ponding at the lower (downstream) end of the catchment, and the lack of a suitable secondary flow path to Brisbane Water. Some properties in Clematis Place were similarly affected. Elsewhere there was minor flooding of yard areas at the end of low points, eg., at both ends of Fiona Street.

Karranga Avenue to Brisbane Water

No houses were identified in this area as affected by flooding above floor level. Two properties at the upper end of Scott Street reported runoff from Scott Street entering their properties. The problem appears to be caused by pipes used for driveway crossings in the table drain.

Hughes Street to Brisbane Water

No houses were reported to have been flooded in this area. Council reports indicate some minor overland flow problems from the National Park to Talinga Avenue and Nokia Avenue, and overflow from Nokia Avenue to properties on the low side.

Melaleuca Crescent to Victory Parade

Approximately seven houses were identified as being affected by flooding above habitable floor level from Council records and resident information. Flooding was primarily due to an under capacity pipe being laid in what was previously an open watercourse.

Runoff from the National Park is conveyed in two well defined watercourses which are then piped where they meet the upper limit of the residential development. The pipes are laid in what use to be the old watercourse at the rear of properties fronting Melaleuca Crescent. The pipe, when it reaches Melaleuca Park, reverts to an open earth channel until it reaches Glenrock Parade. From Glenrock Parade the flow passes through a series of culverts at Glenrock Parade, the Railway Line and Victory Parade which are linked by open channels.

During the storms in 1992, the covers on the stormwater pits were blown off by the water pressure in the pipe system. This usually happens where a steep pipe on the upstream side joins a pipe on a much flatter slope on the downstream side. Only by having a significantly larger pipe on the downstream side can this problem be prevented.

Where pit covers were blown off, stormwater then flooded out to flow overland through backyards. Residents reported that flows were sufficiently large to flatten fences and damage retaining walls.

At the eastern end of Victory Parade significant surface flows emanated from the properties fronting Noonan Point Avenue. These flows made their way to Brisbane Water via the properties located downstream of Victory Parade.

2.2.2 Resident Information

In order to verify and expand on Council's data base, standard interview sheets were distributed to residents in known flood liable areas. Out of a total of 100 interview sheets distributed, 57 replies were received. These are attached as Appendix C.

2.2.3 Survey

Surveys were carried out in each of the four open channels. The purpose of the surveys was to:

- obtain channel cross-sections,
- obtain culvert details,
- obtain road levels at culverts,
- utilise this information to set up a hydraulic model to determine flood profiles.

2.2.4 Catchment Topography

The catchment is generally very steep at the upstream end with slopes becoming mild midway and flat towards the outfall.

On the steep slopes sandstone was exposed in a number of locations indicating a shallow soil profile (and hence low infiltration rate) and, in combination with the steep slopes, likely to result in very short times of concentration.

At the downstream end of the catchment, where the ground flattens, sandy soils were visible on the surface. Travel times would be longer in these areas and infiltration rates would be higher due to the sandy soils.

2.2.5 Public Utility Services

To ensure the feasibility of drainage works proposed in this study, it was necessary to search the location of existing services in roadways, proposed drainage easements and proposed drainage reserves. The services investigated were - Sewer, Water, Gas, Electricity and Telecom lines.

2.3 Design Rainfalls

Design rainfall intensities for the catchments were estimated using the data and procedures documented in Chapter 2 of Australian Rainfall and Runoff, 1987 (AR&R) (Reference 1). Table 1 presents the intensities obtained for a range of storm durations and frequencies. The rainfall intensities fall between those quoted by Council in their Design Manual for Woy Woy and Narara (Reference 3).

The design storm temporal patterns were obtained from Volume 2 of AR&R.

TABLE 1

Design Rainfall Intensities at Pt Clare (mm/h)

Duration	Average Recurrence Interval (years)			
	10	20	50	100
5 min	167.4	190.6	220.6	243.3
6 min	157.3	179.3	207.6	229.0
10 min	129.7	148.0	171.6	189.5
15 min	109.1	124.6	144.7	160.0
20 min	95.5	109.2	127.0	140.5
25 min	85.7	98.1	114.2	126.4
30 min	78.2	89.6	104.4	115.6
45 min	63.3	72.6	84.7	93.9
1.0 hour	54.0	62.1	72.5	80.5
1.5 hour	43.0	49.5	57.9	64.4
2.0 hour	36.4	41.9	49.2	54.7

2.4 Hydrologic and Hydraulic Modelling

A suitable hydrologic/hydraulic model for analysing stormwater systems such as the existing and proposed systems at Pt Clare, is the mathematical computer program ILSAX (Reference 2) which is recommended in AR&R. ILSAX calculates runoff hydrographs for each sub-catchment and then models the hydraulic flow through the system as non-pressurised pipe flow and overflows. In addition to using ILSAX, the hydraulic behaviour of the proposed stormwater drainage systems for each of the main drainage lines were further analysed using the Hydraulic Grade Line (HGL) method.

Analysis of the hydrologic behaviour of a catchment using ILSAX follows through a sequence of logical steps. Runoff hydrographs for each sub-catchment are generated using the time-area method. Each sub-catchment is split into paved areas and grassed areas. A time of concentration for the paved area and grassed area for each of the sub-catchments is estimated based on sub-catchment size, slope and shape, and by considering the available flow paths and obstructions to flow. Rainfall hyetographs are calculated using design rainfall intensities and design temporal patterns from AR&R. These are changed into paved and grassed area hydrographs by considering the contributing runoff area (which is less than the whole sub-catchment area before the time of concentration is reached) and then subtracting losses. Infiltration losses in grassed areas are modelled by Horton's infiltration equation. The paved and grassed area hydrographs are then superimposed to give runoff hydrographs for each sub-catchment.

Each sub-catchment hydrograph corresponds to an inflow point (pit) in the pipe system. At each inflow point all of the hydrograph is modelled as entering the pipe system. This inflow hydrograph is combined with the hydrograph already in the pipe system at that point and then routed downstream.

Hydraulic behaviour is modelled by ILSAX using a simple steady-flow, open-channel model. This represents pipe flow as just full but not under pressure. Therefore the pipe sizes chosen by ILSAX are generally conservative because it does not consider the extra flow carried under pressure. However, ILSAX does not model shock losses at junctions. These losses are significant when velocities are high, typically when lines are on steep grades. Hydraulic analyses of the proposed systems for each catchment were subsequently carried out using the HGL method to account for pressurised flow and pit losses.

Each existing drainage system layout and total inlet capacity was modelled (refer Figures 4A, 4B & 4C). The model was run in design mode for the 1 in 10, 1 in 20, 1 in 50 and 1 in 100 AEP rainfalls for a range of storm durations. In design mode ILSAX automatically sizes the pipe required to convey the peak flow calculated for each pipe reach.

The capacity of the existing system was estimated by comparing the calculated pipe sizes with the existing sizes. The results are shown in Appendix A.

Each proposed drainage system layout, as shown on Figures 5A, 5B & 5C, was modelled using ILSAX in design mode for the 1 in 10, 1 in 20, 1 in 50 and 1 in 100 AEP rainfalls for a range of storm durations. The results are also shown in Appendix A. From these results design peak flows were selected for the Hydraulic Grade Line (HGL) analysis of the drainage system proposed in the Management Plan. HGL analysis of the proposed systems are presented in Appendix B.

The 1 in 10 and 1 in 100 AEP storms were selected for sizing the conduits for the following reasons:

i) the 1 in 100 AEP storm is Council's designated storm for isolated low points,

ii) the 1 in 10 AEP storm is Council's designated design standard for a street with an overflow or bypass along the street.

3. STAGE II - MANAGEMENT STUDY

3.1 Drainage Strategies

3.1.1 General

Stormwater trunk drainage strategies can be categorised as either structural or non-structural. The purpose of such strategies is to reduce damages caused by drainage surcharge.

Structural measures control surface flows by physical means. Structural measures to reduce flood damages include:

- amplification of the existing drainage system,
- diversion of flow into adjoining catchments,
- provision of secondary flow/overland flow paths,
- provision of flood storage/retarding basins,
- improvement of the hydraulic efficiency of the existing system.

Non-Structural measures are intended to lessen the extent of damages by ensuring that all development within the catchment is flood compatible. This is generally accomplished by:

- **Flood Proofing**:- changes made to buildings to minimise flood damages. These measures are usually carried out on a house by house basis.
- **Planning and Building Regulations (zoning)**: - in this study area, each of the catchments is almost fully developed. However, ensuring the regulations properly address the control of catchment re-development with respect to flooding, will provide benefits in the future.
- **Permanent Evacuation (Voluntary Purchase)** - the nature of the flood problems within the catchments would not appear to warrant such measures considering the high capital outlay that would be involved.

The drainage strategies considered in this report are based mainly on the structural measures referred to above.

3.1.2 Pipe System Amplification

The existing drainage systems for this area:

- were inadequate to control flooding as evidenced in the January and February, 1992 floods,
- do not satisfy Council's current drainage requirements as set out in Reference 3. This has resulted from changes such as:
    - higher design standards,
    - increases in design rainfall intensities,
    - higher community expectations,
    - increases in average house size,
    - increase in paved area.

The capacity of the existing pipe system could be increased by either:

- supplementing the existing pipes with additional pipe(s) in parallel to increase the total capacity to meet Council's standards, or
- where space is limited, removing the old pipes and replacing them with larger ones.

The second option does not utilise the capacity of the existing pipes and would in most cases be more expensive. However, in certain circumstances it may provide a more practical solution, for example, if easement widths or existing pipe and pit configurations are not favourable to the installation of a parallel pipe. In such cases the construction costs of installing a parallel pipe may be greater than replacement by a single larger pipe. The age and condition of the existing pipes and the water tightness of pipe joints may also warrant total replacement in some cases.

3.1.3 Kerb and Gutter

In steep catchments, stormwater runoff which is generated on the high side of a road often crosses the road to flow down driveways on the low side of the road. To reduce the incidences of this problem, the following measures could be employed:

- provide kerb and gutter or catch drains on the high side of the road and drain to gully pits,
- provide kerb and gutter on the low side of the road and ensure laybacks (driveway entrances) are at least sloped to approximately the same height as the top of kerb (refer Sketch 1 - Gosford City Council's standard access for properties on the low side of the road),
- provide raised kerb and gutter (up to 200mm may be considered) to increase the gutter flow capacity.

3.1.4 Stormwater Collection Pits

In the hydraulic analyses, stormwater collection pits located in road gutters were assumed to have an inlet capacity of:

$0.1 m^3/s$ when on grade,

$0.2 m^3/s$ when located at a low point.

(These inlet capacities are based on pits commonly used by the Roads and Traffic Authority and on research by the then Department of Main Roads - Reference 5.)

To improve the inlet capacity of standard stormwater pits the following measures might be considered:

- using welded steel grating (see Sketch 2) instead of cast iron grating. (Cast iron gratings were commonly used before the 1950's, however they are inefficient in transferring runoff from road gutters into stormwater pits due to their small openings. Welded mild steel grates with a much larger combined opening area are preferred.),

- ensuring throat depths of kerb inlets are at least 120mm for a 150mm raised kerb,
- using extended kerb lintels (1.8m minimum and 3.6m maximum opening length),
- using grooved gutters to direct the flow towards the throat,
- using deflector humps in the gutter (especially on steep slopes) to direct the flow to the throat.

3.1.5 Extension of Drainage Lines

By extending existing lines with additional stormwater pits the volume of overland flow or street flow can be reduced.

This measure would have to be preceded by amplification of the existing drainage lines downstream to convey the extra flow. If this was not done, then the existing system would surcharge and could adversely affect different properties from those already affected.

3.1.6 Retarding Basins

Where space is available retarding basins might be constructed to temporarily hold the floodwaters and release them at a rate no greater than the downstream system capacity. Retarding basins for small urban catchments are best located near the top of the catchments. A reasonably level open space area is best suited for such purposes.

3.1.7 On Site Detention

On site detention might be considered for future small unit, villa, townhouse or commercial developments in order to temporarily store floodwaters and ensure that the peak rate of release is no greater than that prior to the development of the site. This would not solve existing flooding problems, but it would control the extra runoff generated by the increase in roofed and paved areas.

3.1.8 Regrading of Roads

Roads are typical overland flow paths for stormwater flows. In general, residential pipe drainage systems are designed for the 1 in 10 or 1 in 20 AEP floods. The excess flow in a 1 in 100 AEP flood is conveyed by roads, drainage reserves, pathways, cycle tracks, public reserves, drainage easements, etc., before discharging into a downstream trunk drainage system capable of conveying the 1 in 100 AEP flood.

To reduce the concentration of flow at drainage problem spots, road profiles can be reshaped to direct overland flows along paths that have spare carrying capacity.

3.1.9 Dual Occupancy

The number of dual occupancies in the catchment is minimal, however this could potentially change due to recent policy directives by the State Government. The probable impact on the stormwater drainage regime would be to decrease the time the runoff takes to reach the outfall.

In physical terms, redevelopment of one dwelling per lot to two dwellings per lot means extra paving and roofing which decreases the area allowing direct infiltration into the ground and thereby increases the amount flowing overland as surface runoff. The likely impact of dual occupancy on design flows is accounted for in the ILSAX model by reducing the percentage of grassed area and increasing the percentage of paved area whether connected directly or indirectly to the drainage system.

3.1.10 Overland Flow Paths

An overland flow path or secondary flow path is a location where water flows when the capacity of the primary drain is exceeded. It can be natural or man-made. It is usually designed as an emergency flow path to prevent houses and other property from being flooded when underground drainage capacity is exceeded or where there is the potential for drains to block. In contemporary town planning practice, roads are often located to act as minor overland flow paths. Where overland flow exceeds the capacity of the roadway to safely convey the flow, then drainage reserves are established. This is common practice in new subdivisions.

In earlier town planning practice it was common to locate minor waterways at the rear of properties. Also the standard for pipe capacity was usually limited to the 1 in 5 AEP peak flow. Evidence of this practice is clearly demonstrated in the Melaleuca Crescent area. Flooding is common where developments have been allowed to proceed adjacent to waterways. The flooding is exacerbated by the construction of solid fences, garden sheds, carports, and houses in or to close to the waterways. Where drainage easements have been provided over these waterways, the planting of dense vegetation together with some of the abovementioned obstructions to the flow is enough to redirect floodwaters into houses.

Often the only solutions available to Council to rectify the inadequacy of overland flow paths is to:

- acquire the land retrospectively,
- provide pipe drains to the 1 in 100 AEP capacity,
- intercept some of the overland flow and redirect either in a pipe system or open channel to a safe discharge point.

3.1.11 Minimum Floor Levels

On lots which are known to be subject to flooding, Council has a policy of setting a Minimum Floor Level (MFL). The MFL is usually 0.5m above the 1 in 100 AEP frequency flood height as determined by Council from analysis or from historical floods. This is compatible with the following:

- Floodplain Development Manual of NSW which advises "a freeboard of 0.5m for floor levels above the designated flood level with provision for departure where damage potential is low",
- Local Government Floodplain Management Policy which states "where applications for new residential developments in flood liable areas are considered, Council should require the applicant to lodge a survey plan showing the relative ground levels, floor levels and location of existing buildings. These levels should be specified to A.H.D.

  Floor levels of all habitable rooms should be specified in terms of Design Floor Level (DFL) and should be not less than 0.5m above the flood standard. A certificate by a registered practicing surveyor certifying the level of the completed building should be required.

  Where in the opinion of Council, a proposed development could sustain structural damage by flooding, no work should be allowed to commence until the applicant obtains and submits a certificate of structural adequacy from a qualified structural/civil engineer".

The latter policy should also apply to redevelopment of sites which are subject to flooding.

3.1.12 Outfalls

The invert levels of outfalls from the catchment are critical to ensure that:

- the outfalls are high enough to avoid silting from the build up of mud in the bay,
- the outfalls are low enough to provide a reasonable grade for the pipes leading to the outfalls thus ensuring adequate velocities to keep the pipes clear, i.e., to prevent silt settling out.

3.2 Gross Pollutant Traps & Nutrient Filters

Gross pollutant traps (GPT's) and Nutrient Filters (NF's) have in recent years become an integral part of urban stormwater drainage systems. GPT's are used to reduce the quantity of litter and coarse sediment being discharged into creeks, rivers, lagoons, bays, etc. It is now common practice immediately downstream of GPT's to construct nutrient filters (which are also known as macrophyte ponds or water quality control ponds). These artificial wetlands are filled with both submerged and emergent macrophytes to assist in the removal of nutrients from stormwater inflows. In general it is recommended that up to 0.5% of a catchment be set aside for nutrient filters (Reference 6).

GPT's can create significant head losses in a drainage system and therefore the retro-fitting of such a structure to a drainage system must be carefully analysed to ensure it does not adversely affect the hydraulic efficiency.

This catchment is almost fully developed and areas for GPT's are restricted to existing drainage reserves, park areas, and the Council owned land downstream of the Railway Line and along the foreshore.

3.3 Drainage Management Options

For each of the sub-catchments, up to three alternative management options for each segment of the drainage system are presented in the following tables and on Figures 6A, 6B and 6C.

The costs associated with each item in the various options have been estimated by using unit rates supplied by Council's Engineering Department. The costs include all pipe and channel work required as well as culverts and services relocation (5% of the total cost).

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(a)	Coolarn Avenue	Has 2 isolated low points. Low point at southern end is drained and has a secondary flow path. Low point at northern end is drained by a 375ø RCP and has no secondary flow path. In medium to large storms floodwaters pond sufficiently deep to flood the commercial building site adjacent to the school by up to 250mm, and the ambulance carpark area.	Provide secondary flow path from northern low point to existing 2 x 825ø RCP culvert at Brisbane Water Drive.	1	Upgrade 375ø RCP to 1 in 100 AEP capacity.	60	Upgrade 375ø RCP to 1 in 10 AEP capacity and provide secondary flow path for excess flows to the 1 in 100 AEP peak flow.	40
(b)	Wendy Drive (southern end)	An existing 450ø RCP collects runoff from the National Park and conveys the flow via No. 67 and No. 54 Wendy Drive. Runoff in excess of the pipe and collection capacity passes overland through No. 65 and No's 52 and 54 Wendy Drive. No habitable floor area was inundated by the 1992 storms.	Do nothing. Existing RCP has 1 in 20 AEP capacity. Provide swing type fence at sags.	1	Upgrade existing RCP's and collection to 1 in 100 AEP capacity. Provide swing type fence at sags.	38	Upgrade collection in Wendy Drive to 1 in 20 AEP capacity and formalise overland flow path. Provide swing type fence at sags.	19

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(c)	Wendy Drive (eastern end)	A major watercourse draining the National Park drains to Wendy Drive between No's 81 and 83. The flow is then conveyed in a 1650ø RCP. Excess flow is conveyed in an open channel at the rear of the properties to a 1650ø RCP north of No. 95 Wendy Drive. In the January 1992 storm properties from No. 83 to No. 95 were affected by floodwaters, houses were flooded and the open channel at the rear of the properties badly scoured. A levee was completed in June 1993 to provide additional flood protection to these properties.	Provide retarding basins in the National Park to control the discharge from the National Park.	74	Upgrade the collection of the two 1650ø RCP's. The two 1650ø RCP's have adequate capacity to convey the 1 in 100 AEP peak flow.	105	Raise the level of the levee at No.95 Wendy Drive and upgrade the collection to ensure the 1650ø RCP flows full.	11
(d)	Camden Close	The pipes from (b) and (c) above meet at the low point in Camden Close and pass through a drainage easement, Public Reserve and culverts at Priestley Parade to discharge into a large open earth channel. No nuisance flooding was reported after the January 1992 storm. Existing pipes have adequate capacity to convey the 1 in 100 AEP peak flow.	Do nothing.	-	Provide swing type fence between D.E. in Lot 37, DP260225 and Public Reserve. Formalise secondary flowpath.	1		

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(e)	Open Channel between Wendy Drive and Golden Avenue and culverts at Brisbane Water Drive	During the January 1992 storm, the channel bank was overtopped at the Brisbane Water Drive end, resulting in flooding of the Ambulance Station. Elsewhere the floodwaters were contained within the channel. Erosion of the channel banks occurred along much of its length. The culverts at Brisbane Water Drive were substantially blocked by debris.	Upgrade the culverts at Brisbane Water Drive to 1 in 100 AEP capacity. Protect channel banks from erosion and trees from falling into channel by using sandstone boulders. Protect existing stand of swamp mahogany trees by the use of rock boulders. Provide rock bars in invert to control erosion. Establish a public education program to deter disposal of rubbish in the Drainage Reserve which causes blockage of culverts. Avoid excessive use of hard engineering works e.g. reinforced concrete and adopt Dept. of Planning latest guidelines for drainage systems.	334				

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(f)	Golden Avenue	Surface runoff flows to the low point in the road adjacent to No's 11 and 13. A 375ø RCP drains the low point. In the January 1992 storm the house at No. 11 was inundated.	Upgrade the low point collection and drainage system to the 1 in 100 AEP capacity.	19	Existing RCP has 1 in 10 AEP capacity. Improve collection by installation of additional gully pits or enlarging lintel of existing pits. Provide formalised secondary flow path for excess flows.	5		
(g)	Sunnyside Avenue	Runoff from the National Park is directed on to Sunnyside Avenue. In large storms the runoff flows down the driveway into the Downer Memorial Orange Homes Site which is located at the south-eastern end of Sunnyside Avenue. Most of the runoff to Sunnyside Avenue flows to the intersection with Brisbane Water Drive. A number of gully pits at the intersection collect some of the surface flow, with the rest flowing down Brisbane Water Drive to the open channel within Bega Avenue Reserve.	Provide reticulation and collection in Sunnyside Avenue for the 1 in 10 AEP peak flows. Extend reticulation via Brisbane Water Drive to discharge into open channel at Bega Avenue Reserve. Reconstruct the driveway at Downer Home Site as per Sketch 1.	359	Provide reticulation and collection in Sunnyside Avenue for the 1 in 10 AEP peak flows. Extend reticulation via Brisbane Water Drive to Byarong Avenue to discharge at existing ø450 outfall into Fagans Bay. Reconstruct driveway at Downer Home Site as per Sketch 1.	428		

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(h)	Coral Tree Place and Sage Place	A minor depression at the rear of properties along Sage Place drains surface runoff from the National Park in the south and Northwind Avenue, northwards to the low point in Coral Tree Place and then to the open channel east of Coral Tree Place. No flooding was reported from this area after the January 1992 storm.	Do nothing. Existing pipes between Coral Tree Place and open channel have 1 in 100 AEP capacity.	-				

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(i)	Robson Close and Henman Close	Runoff to the south of Robson Close and Henman Close, originating from the National Park, is intercepted by a large open drain and diverted to the open channel between Robson Close and Coral Tree Place and an 825mm pipe in No. 21 Henman Close. Runoff to the east of Henman Close, originating from the National Park, flows overland through the properties on to Henman Close. Three properties had substantial flow passing through them including one property which had floodwaters through its garage. From resident reports, the diversion drain was breached in the January 1992 storm resulting in floodwaters spilling into the properties to the south of Robson Close. A large boulder also rolled down the cliff face to the south of Henman Close damaging a fence and carport. Since the January 1992 storm, Council has upgraded the diversion drain and provided an additional diversion drain to both convey stormwater away from private property and protect residents from falling boulders.	To prevent runoff from the National Park entering properties to the east of Henman Close a diversion drain with 1 in 100 AEP capacity in the National Park is required to redirect the runoff into Koolinda Avenue in a pipe with 1 in 10 AEP capacity along Koolinda Avenue - Jirrah Avenue to Brisbane Water. A levee needs to be provided at the N-W corner Jirrah Avenue & Brisbane Water Drive.	264				

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(j)	Open Channel from Northwind Avenue to Brisbane Water Drive and adjacent to Girralong Avenue	No flooding was reported from this area after the January 1992 storm. A large open channel, which is located parallel to Girralong Road, collects runoff from the National Park and the Robson Close - Henman Close area. In the January 1992 storm the floodwaters in the channel overtopped Brisbane Water Drive flooding properties north of Brisbane Water Drive.	Formalise open channel and stabilise bank area to reduce soil erosion.	32				
(k)	Tania Drive and Koolinda Avenue	An open drain to the south of Tania Drive diverts runoff from the National Park into Koolinda Avenue. However in large storms the open drain is overtopped resulting in floodwaters from the National Park flowing through properties south of Tania Drive and on to the low point at the head of the cul-de-sac. From there the floodwaters flow through 4 properties, Lots 46 to 49, into Koolinda Avenue and also into the Orana Village run by the Baptist Homes Trust.	Upgrade open drain to 1 in 100 AEP capacity and extend east to catchment divide (ridge line). Upgrade drainage line in Koolinda Avenue to 1 in 10 AEP capacity (flow from open channel proposed in (i) above to be intercepted). Existing system in Tania Drive can then cater for reduced catchment up to 1 in 10 year AEP flows. Formalise secondary flowpath over pathway.	Cost included in (i) above.				

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(l)	Brisbane Water Drive to Brisbane Water between Jirrah Avenue and Bega Avenue	In the Jan 1992 storm, significant surface runoff from the area to the south flowed down Koolinda Ave, the open channel parallel to Girralong Ave, and Sunnyside Ave. The culverts at Brisbane Water Dr closest to Girralong Avenue became blocked with debris during the storm, resulting in significant flow on to Brisbane Water Dr, which became impassable during the peak of the storm. 16 houses were flooded above habitable floor level and many more reported flooding through their yard areas. Surface runoff flowed from Brisbane Water Dr into properties at Jirrah Ave, Waterside Cl, Shoreview Cl, Turtle Cl, Byarong Ave and Bayline Dr. Lack of secondary flowpaths from Bayline Dr to Brisbane Water resulted in considerable ponding in Bayline Dr. These properties are also affected by Narara Ck flooding and by high water levels in Brisbane Water. In early 1993, Council constructed 2 secondary flowpaths (cum cycleways) from Bayline Dr to Brisbane Water. These are located at the ends of Byarong Ave and Shoreview Cl. This should relieve ponding in Bayline Dr. Council have also constructed additional surcharge pits along the drainage line from Brisbane Water Dr to Brisbane Water	Upgrade drainage line from Brisbane Water Drive to Bayline Drive via Shoreview Close to 1 in 100 AEP capacity. This includes upgrading the culverts under Brisbane Water Drive near Girralong Avenue. Depress gutter fronting No's 192, 194 & 196 Brisbane Water Drive to direct overland flow into Jirrah Avenue without overtopping the kerb.		Raise kerb height, footpaths and driveway entrances on low side of Brisbane Water Drive to prevent overland flow entering properties on low side of Brisbane Water Drive. Provide additional drainage in Brisbane Water Drive to pipe runoff to the 1 in 10 AEP peak flow to Byarong Avenue. Depress gutter fronting No's 192, 194 & 196 Brisbane Water Drive to direct overland flow into Jirrah Avenue without overtopping the kerb.			

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(m)	Fiona Street	Fiona Street collects surface runoff from properties on the high side and a small catchment in the National Park. Fiona Street drains both to the west and the east. At the western end runoff is collected at the low point and conveyed in a 375mm pipe via a drainage easement to Brisbane Water Drive. Flow in excess of the collection system flows overland to Tania Drive creating nuisance flooding to properties on the eastern side of Tania Drive. At the eastern end of Fiona Street, runoff in excess of the street collection system flows into the Jacaranda Village causing nuisance flooding.	At both ends of Fiona Street the existing pipe drains have adequate capacity for the 1 in 100 AEP peak flows. Upgrade collection system in National Park and Fiona Street.	45				
(n)	Lorraine Avenue	Lorraine Avenue drains a small portion of Fiona Street to Brisbane Water Drive. Existing surface runoff is minimal and is contained within the road reserve. There were no reports of flooding in this area. There are existing collection pits at the northern end of the street to minimise flow into Brisbane Water Drive.	Existing system in Lorraine Avenue has 1 in 10 AEP capacity. Do nothing.	-				

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(o)	Fisher Road	There is no pipe drainage system in Fisher Rd. It has a very small catchment which consists of 6 properties fronting Brisbane Water Dr, properties fronting Fisher Rd and Fisher Rd itself. During the Jan 1992 storm there were reports of minor flooding at the north western end of the street outside Lots 27 & 28.	Provide kerb and gutter and pipe drainage to 1 in 10 AEP capacity.	50				
(p)	Matthews Parade	Surface flow in Matthews Parade drains to the low point adjacent to the Public Reserve. At the low point flow is collected in 2 kerb inlet pits, one on each side of the road. The flow is conveyed in a 375mm pipe to Brisbane Water. Flows in excess of the pipe capacity flow overland (via the Public Reserve) to Brisbane Water. Ponding occurs in the road.	Depress kerb at low point to allow overland flow into the Public Reserve.	2	Upgrade collection at the low point and the pipe system to cater for the 1 in 10 AEP peak flow.	20	Upgrade collection at the low point and the pipe system to cater for the 1 in 100 AEP peak flow.	25

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(q)	Collard Road, Jindalee Avenue, Welwyn Grove, Althea Place and Clematis Place	During the January 1992 storm, 3 houses were reported flooded and an additional 4 properties reported floodwaters through their yard areas. Collard Road is located at the low point in Brisbane Water Drive and collects runoff from Penang Street, Fiona Street and Lorraine Avenue. Runoff is conveyed in a 600mm pipe in Althea Place and then into a 900mm pipe in Clematis Place before discharging into Brisbane Water. Runoff in excess of the pipe system is conveyed overland into Althea Place and Clematis Place where it ponds and floods a number of properties due to a lack of overland flow paths to Brisbane Water.	Upgrade drainage system in Collard Road between: • Brisbane Water Drive and Welwyn Grove to 1 in 10 AEP capacity, • Welwyn Grove and northern end of Collard Road to 1 in 100 AEP capacity and extend to Brisbane Water via pathway. Upgrade drainage system in Althea Place to the 1 in 100 AEP capacity for the reduced runoff.	370	Reconstruct Althea Place - Collard Road intersection to prevent surface runoff from Collard Road flowing down Althea Place. Provide 1 in 10 AEP drainage system and secondary flow path in Collard Road and discharge to Brisbane Water via pathway. Upgrade drainage system in Althea Place to 1 in 100 AEP capacity for reduced catchment. Lower pathway at Clematis Place for overland flow path to Brisbane Water.	333	Provide 1:10 AEP drainage system in Welwyn Grove & Jindalee Ave and discharge to open channel in railway corridor. Provide 1:10 AEP drainage system in Brisbane Water Dr & Collard Rd and extend to northern end of road. Discharge to Brisbane Water via laneway. Disconnect existing system via Althea Pl. Provide 1:100 AEP drainage in Althea Pl and connect to existing system in Clematis Place. Kerb south side of Brisbane Water Drive from Penang Street to Collard Street. Create overland flowpath from Althea Place low point to Brisbane Water over drainage easement in Lots 25 & 26, DP242771.	280

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(r)	Penang Street	Penang Street is located at the top of a ridge and its catchment is small. Nuisance flooding has been recorded at the intersection with Brisbane Water Drive. Runoff from Penang Street is directed to Brisbane Water Drive, the railway corridor and Collard Road.	Provide 1 in 10 AEP drainage system in Penang Street and in laneway between Penang Street and Brisbane Water Drive.	26				
(s)	Scott Street	Properties at the south-western end of Scott Street have recorded flooding through their properties. A pipe in the table drain creates high hydraulic losses forcing the water in the table drain to rise and flow through the properties to the open channel at the rear of the properties.	Provide kerb and gutter on the southern side of Scott Street to control surface flow and 1 in 10 AEP capacity drainage system. Upgrade collection at intersection of Scott Street and Brisbane Water Drive.	92				
(t)	Open Channel between Scott Street and Takari Avenue	The open channel is located in a laneway and follows approximately the northern boundary of Point Clare Public School. It passes under Brisbane Water Drive in a 900mm pipe and discharges into an open drain with concrete invert and grass sides. At the railway embankment a 625mm pipe intercepts the flow. The 625mm pipe enlarges to a 900mm pipe in the embankment.	Formalise open channel to prevent scour and erosion. Replace 625mm pipe at entrance to railway culvert with 900mm pipe.	43				

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(u)	Takari Avenue, Hughes Street, Nioka Avenue and Talinga Avenue	This area takes in a small portion of the National Park. Nuisance flooding has been reported at the rear of properties fronting Talinga Avenue and west of Nioka Avenue. Surface flow along Nioka Avenue has been reported to flow down driveways of properties on the low side of the road.	Provide collection in the National Park and to the rear of properties fronting Talinga Avenue. Provide kerb and gutter on the low side of Nioka Avenue and provide stormwater collection for the 1 in 10 AEP peak flows.	208				
(v)	Kurrawa Avenue, Munong Avenue, Broadwater Street, Alukea Avenue, Gosford Street, and Coogee Road	No reports of flooding from stormwater runoff were reported from this area. The area around Coogee Road is high and relatively steep and free of drainage problems. Properties with frontage to Kurrawa Avenue and backing onto Brisbane Water are low and are affected by extreme high water levels in Brisbane Water.	Provide drainage to the 1 in 10 AEP capacity. Set minimum floor level of RL 2.5m AHD for properties fronting Kurrawa Avenue and backing on to Brisbane Water.	79			Refer to Narara Creek Floodplain Management Plan for this area.	

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(w)	Noonan Point Avenue	Noonan Point Avenue receives runoff from Gosford Street and the properties between Noonan Point Avenue and Coogee Road. Noonan Point Avenue drains overland into Brisbane Water. Properties No's 1 - 11 on the low side of Noonan Point Avenue drain into No. 132 Brisbane Water Drive. Floodwaters initially pond in No. 132 before discharging into Victoria Parade. Properties No. 13 to 19 on the low side of Noonan Point Avenue drain towards No.83 Victory Parade. Floodwaters flowed to a depth of 200mm along the eastern boundary of No. 83 during the January 1992 storm.	Provide collection and drainage to properties on the low side of Noonan Point Avenue. Create drainage easement over proposed drainage line.	49				

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(x)	Melaleuca Crescent	Melaleuca Crescent is located in a well defined valley. Two watercourses from the National Park are piped where they pass through the residential development and join at the rear of No's 38 and 44. Additionally, runoff from Kateena Avenue is collected at the low point (at the head of the cul-de-sac) and piped to join the trunk drain at the rear of No. 28. The watercourse reverts to an open channel when it reaches Melaleuca Park. Six houses were reported to be flooded above habitable floor level and 4 other properties reported significant flow through their yard areas during the January 1992 storm. Retaining walls and fences were damaged during the storm.	Provide 1 in 100 AEP capacity pipe drainage system from the National Park and Kateena Avenue to Melaleuca Park. Upgrade the open channel in Melaleuca Park and culverts under Glenrock Parade to cater for the 1 in 100 AEP peak flow. Provide special fences (as per sketch 3) over drainage easements and other overland flow paths. Upgrade culverts under railway embankment to 1 in 100 AEP capacity and extend to upstream side of Glenrock Parade to provide maximum headwater level 0.2m above Glenrock Parade road level.	515	Provide retarding basin at Melaleuca Park. Reconstruct Melaleuca Crescent to shift low point to be adjacent to Melaleuca Park. Provide 1 in 100 AEP capacity pipe drainage system from National Park and Kateena Avenue to Melaleuca Park. Relocate existing services and adjust existing driveways.	413	Provide retarding basin at Melaleuca Park. Divert up to 1 in 100 AEP runoff from eastern side of Melaleuca Crescent by pipes to Melaleuca Park. Upgrade culverts at Glenrock Parade.	407

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(y)	Victory Parade	In the January 1992 storm one resident reported floodwaters through his house and 2 others reported floodwaters through their property. Floodwaters emanate mainly from the Melaleuca Crescent catchment and flow through the Victory Parade area in an open channel and triple pipe culvert at Victory Parade. The open channel capacity is low due to flat grades and low lying nature of the land. The capacity is further reduced when the water levels in Brisbane Water are elevated by storm surge. At the eastern end of Victory Parade overland flooding is exacerbated by runoff from properties on the low side of Noonan Point Avenue (see Item W). Much of the land between Brisbane Water Drive and Brisbane Water lies below the 1 in 100 AEP water level (RL 2.0m AHD) of Brisbane Water. Minimum floor levels of RL 2.5m AHD have already been set for new development in this area.	Enlarge the open channel to the width of the drainage reserve and concrete line the invert and sides to maximise its capacity. Replace the 3 pipe culvert at Victory Parade with a bridge to reduce the hydraulic losses created by pipe culverts. Lower the ground level in the lane between Lots 11 & 12 (DP9417) to act as a secondary flow path or construct an open earth drain.	175	Floodproof the two houses inundated in the January 1992 storm. Lower the ground level in the lane between Lots 11 & 12 (DP9417) to act as a secondary flow path.	21	Purchase the properties adjacent to the open channel and widen channel to the 1 in 100 AEP capacity. Provide sediment trap and gross pollutant trap in this area. Provide a bridge or multi-cell box culvert across Victory Parade to convey 1 in 100 AEP peak flow.	599

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
(z)	Brisbane Water foreshore area	There were a number of reports from residents expressing concern on build up of sediments at stormwater outfalls and along the foreshore area.	Provide silt traps on trunk drainage lines. Possible locations are within: • Melaleuca Park, • No. 83 Brisbane Water Drive (north of Pt Clare Public School), • Fagan Park, • corner of Girralong Avenue and Brisbane Water Drive, • within the recreation area along the foreshore.	100				

TABLE 2

MANAGEMENT OPTIONS (Refer Figures 6A, 6B & 6C)

Item	Location	Existing Situation (Refer Fig. 3A)	Option 1	Constr. Cost $1000's	Option 2	Constr. Cost $1000's	Option 3	Constr. Cost $1000's
	OTHER		Encode 149 certificates to indicate flood liable properties. Provide a minimum floor level of at least 500mm above either the kerb or the overflow level from isolated low points or the flood level in the January 1992 storm for new development.	-				

4. STAGE III - MANAGEMENT PLAN

The Point Clare Trunk Drainage Management Plan constitutes the third stage of the drainage management process.

The Drainage Management Plan consists of the following:

- a review of all the drainage options listed in Stage II,
- recommended drainage works,
- priorities of the recommended drainage works,
- short term recommendations,
- cost of the recommended drainage works,

and provides the basis for the future management of trunk drainage works and flood liable land within the catchments.

A Management Plan for each of the sub-catchments is provided on Figures 7A, 7B and 7C. A full description of each of the Management Plans is given in the following tables.

The priority or ranking of the recommended drainage works is based on the need to:

- maximise the number of houses or properties that are made flood free up to the 1 in 100 AEP flood, and
- ensure that the proposed drainage works do not worsen the flooding situation elsewhere.

The following priority system was developed for the catchment to assist in the budgeting and staging of the proposed works. It is based on the least cost to provide flood relief.

Priority	Description
1	These works would provide immediate benefit to existing flood liable houses.
2	These works would provide immediate benefit to existing flood liable properties.
3	These works are necessary to raise the capacity of the drainage system to Council's existing standard.
4	These works, although not related to improving the drainage capacity, would improve the water quality being discharged into Fagans Bay or The Broadwater.

The priority system has been used in Table 3.

TABLE 3

MANAGEMENT PLAN (Refer Figures 7A, 7B & 7C)

Item	Location	Description	Services	Cost ($ x 1000)	Priority	Remarks
(a)	Coolarn Avenue	Upgrade 375ø RCP to 1 in 10 AEP capacity and provide secondary flow path for excess flows to the 1 in 100 AEP peak flow. BENEFIT - one commercial building made flood free to the 100 year flood.		2 38	1 for secondary flow path and Priority 3 for pipe upgrade.	The most cost effective option in providing immediate flooding relief to the commercial site and the Coolarn Avenue low point.
(b)	Wendy Drive (southern end)	Upgrade collection to 1 in 20 AEP capacity and formalise overland flow path. Provide swing type fence at sags. BENEFIT - the risk of property damage is reduced.	-	19	2	This proposal would upgrade the system to Council's latest drainage standard.
(c)	Wendy Drive (eastern end)	Raise the level of the levee at No. 95 Wendy Drive and upgrade the collection to ensure the 1650ø RCP flows full. BENEFIT - this would increase protection to No.95 and other properties on the eastern side of Wendy Drive.	-	11	1	This would permit better use of the existing pipes. Under existing conditions the pipes do not flow full.
(d)	Camden Close	Provide swing type fence between D.E. in Lot 37, DP260225 and Public Reserve. Formalise seconary flowpath.	-	1	2	This would provide unrestricted surface flow from Camden Place to Priestly Parade.

TABLE 3

MANAGEMENT PLAN (Refer Figures 7A, 7B & 7C)

Item	Location	Description	Services	Cost ($ x 1000)	Priority	Remarks
(e)	Open Channel between Wendy Drive and Golden Avenue and culverts at Brisbane Water Drive	Upgrade the culverts at Brisbane Water Drive to 1 in 100 AEP capacity. Protect channel banks from erosion and trees from falling into channel by using sandstone boulders. Protect existing stand of swamp mahogany trees. Provide rock bars in invert to control erosion. Establisha public education program to deter disposal of rubbish in the Drainage Reserve which causes blockage of culverts. Avoid excessive use of hard engineering works eg. reinforced concrete and deopt DOP latest guidelines for drainage systems.	-	142 192	1 for culvert upgrade and Priority 4 for rest of the proposed works.	Enlarging the culverts would reduce the incidence of blockage by debris as occurred in January 1992. The channel banks are currently subject to erosion.
(f)	Golden Avenue	Existing RCP has 1 in 10 AEP capacity. Improve collection by installation of additional gully pits or enlarging lintel of existing pits. Provide formalised secondary flow path for excess flows.	-	5	1	This would reduce the potential for flooding of No. 11 Golden Avenue.
(g)	Sunnyside Avenue	Provide reticulation and collection in Sunnyside Avenue for the 1 in 10 AEP peak flows. Extend reticulation via Brisbane Water Drive to discharge into open channel at Bega Avenue Reserve. Reconstruct driveway at Downer Memorial Orange Home Site as per Sketch 1. BENEFITS - reduce incidence of overland		359	1 for reconstruction of driveway and Priority 3 for the rest of the proposed works.	This would provide drainage to Council's standard and reduce surface flow to Brisbane Water Drive. Reconstruction of the driveway would prevent surface flow in Sunnyside Avenue flowing into the Downer Home Site.

TABLE 3

MANAGEMENT PLAN (Refer Figures 7A, 7B & 7C)

Item	Location	Description	Services	Cost ($ x 1000)	Priority	Remarks
(h)	Coral Tree Place and Sage Place	Do nothing. Existing pipes between Coral Tree Place and open channel have 1 in 100 AEP capacity.	-	-	-	
(i)	Robson Close and Henman Close	To prevent runoff from the National Park entering properties to the east of Henman Close a diversion drain with 1 in 100 AEP capacity in the National Park is required to redirect the runoff into Koolinda Avenue in a pipe with 1 in 10 AEP capacity along Koolinda Avenue - Jirrah Avenue to Brisbane Water. Provide levee at N-W corner of Jirrah Avenue and Brisbane Water Drive.		264	1	Construction of the diversion channel in Brisbane Water National Park would require concurrence of National Parks and Wildlife Service. The proposed drainage upgrade would need to be constructed at the downstream end first and proceed upstream so as not to worsen flooding at Brisbane Water Drive and Jirrah Avenue.
(j)	Northwind Avenue and Girralong Avenue	Formalise open channel and turf bank area to reduce soil erosion.		32	4	Open channel requires regular maintenance to reduce the potential of culvert blockage due to branches, twigs and other debris.

TABLE 3

MANAGEMENT PLAN (Refer Figures 7A, 7B & 7C)

Item	Location	Description	Services	Cost ($ x 1000)	Priority	Remarks
(k)	Tania Drive and Koolinda Avenue	Upgrade open drain to 1 in 100 AEP capacity and extend to catchment divide (ridge line). Upgrade drainage line in Koolinda Avenue to 1 in 10 AEP capacity (flow from open channel proposed in (i) above to be intercepted).		(included in (i) above)	1	A gross pollutant trap at the top end of Koolinda Avenue would assist in controlling sediment and debris from Brisbane Water National Park.
(l)	Brisbane Water Drive to Brisbane Water between Jirrah Avenue and Bega Avenue	Raise kerb height, footpaths and driveway entrances on low side of Brisbane Water Drive to prevent overland flow entering properties on low side of Brisbane Water Drive. Provide additional drainage in Brisbane Water Drive to pipe runoff to the 1 in 10 AEP peak flow to Bega Avenue. Depress gutter fronting No.'s 192, 194 & 196 Brisbane Water Drive to direct overland flow into Jirrah Avenue without overtopping the kerb.		355	1	The proposed works would also benefit properties in Bayline Drive, Turtle, Shoreview and Waterside Closes by reducing the quantity of surface flow through their yards.
(m)	Fiona Street	At both ends of Fiona Street the existing pipe drains have adequate capacity for the 1 in 100 AEP peak flows. Upgrade collection system in National Park and Fiona Street.		45	3	This would improve the drainage system to Council's standard.
(n)	Lorraine Avenue	Existing system in Lorraine Avenue has 1 in 10 AEP capacity. Do nothing.	-	-	-	-
(o)	Fisher Road	Provide kerb and gutter and pipe drainage to 1 in 10 AEP capacity.		50	3	This would provide drainage to Council's standard.

TABLE 3

MANAGEMENT PLAN (Refer Figures 7A, 7B & 7C)

Item	Location	Description	Services	Cost ($ x 1000)	Priority	Remarks
(p)	Matthews Parade	Depress kerb at low point to allow overland flow into the Public Reserve.		2	3	This would prevent ponding in Matthews Parade.
(q)	Collard Road, Jindalee Avenue, Welwyn Grove, Althea Place and Clematis Place	Provide 1:10AEP drainage systems in Welwyn Grove and Jindalee Avenue and discharge to open channel in railway corridor. Provide 1:10AEP drainage system in Brisbane Water Drive and Collard Road and extend to northern end of road. Discharge to Brisbane Water via laneway. Disconnect existing system via Althea Place. Provide 1:100AEP drainage in Althea Place and connect to existing system in Clematis Place. Kerb and gutter south side of Brisbane Water Drive from Penang Street to Collard Street. Create overland flow path from Althea Place low point to Brisbane Water over drainage easement in Lots 25 & 26, DP242771.		280	1	Retain existing drainage system at top end of Althea Place and Clematis Place. Disconnect Collard Street drainage from Althea Place/Clematis Place drainage system.
(r)	Penang Street	Provide 1 in 10 AEP drainage system in Penang Street.		26	2	This would provide drainage to Council's standard.
(s)	Scott Street	Provide kerb and gutter on southern side of Scott Street to control surface flow and 1 in 10 AEP capacity drainage system. Upgrade collection at intersection of Scott Street and Brisbane Water Drive.		92	2	This would provide drainage to Council's standard.

TABLE 3

MANAGEMENT PLAN (Refer Figures 7A, 7B & 7C)

Item	Location	Description	Services	Cost ($ x 1000)	Priority	Remarks
(t)	Open Channel between Scott Street and Takari Avenue	Formalise open channel to prevent scour and erosion. Replace 625mm pipe at entrance to railway culvert with 900mm pipe.		43	2 for upgrading of pipe and Priority 4 for rest of the proposed works.	This would improve capacity of railway culvert and reduce surface flow to Point Clare Station.
(u)	Takari Avenue, Hughes Street, Nioka Avenue and Talinga Avenue	Provide collection in the National Park and to the rear of properties fronting Talinga Avenue. Provide kerb and gutter on the low side of Nioka Avenue and provide stormwater collection for the 1 in 10 AEP peak flows.		208	3	This would provide drainage to Council's standard.
(v)	Kurrawa Avenue, Munong Avenue, Broadwater Street, Alukea Avenue, Gosford Street, and Coogee Road	Provide drainage to the 1 in 10 AEP capacity. Set minimum floor level of RL 2.5m AHD for properties fronting Kurrawa Avenue and backing onto Brisbane Water.		79	3	This would provide drainage to Council's standard.
(w)	Noonan Point Avenue	Provide collection and drainage to properties on the low side of Noonan Point Avenue.		49	2	This would reduce runoff to low point in No. 132 Brisbane Water Drive.
(x)	Melaleuca Crescent	Provide retarding basin at Melaleuca Park. Divert up to 1 in 100 AEP runoff from eastern side of Melaleuca Crescent by pipes to Melaleuca Park. Upgrade culverts at Glenrock Parade.		407	1	This would reduce the flow to the existing trunk drainage line by about one third, thus reducing the potential to surcharge and cause flooding.

TABLE 3

MANAGEMENT PLAN (Refer Figures 7A, 7B & 7C)

Item	Location	Description	Services	Cost ($ x 1000)	Priority	Remarks
(y)	Victory Parade	Enlarge the open channel to the width of the drainage reserve and concrete line the invert and sides to maximise its capacity. Replace the 3 pipe culvert at Victory Parade with a bridge to reduce the hydraulic losses created by pipe culverts. Lower the ground level in the lane between Lots 11 & 12 (DP9417) to act as a secondary flow path or construct an open earth drain.		175	1	Enlarging and concrete lining the channel would improve its hydraulic capacity. Mangroves in the channel would need to be removed.
(z)	Brisbane Water foreshore area	Provide silt traps on trunk drainage lines. Possible locations are within: • Melaleuca Park, • No. 83 Brisbane Water Drive (north of Pt Clare Public School), • Fagan Park, • corner of Girralong Avenue and Brisbane Water Drive, • within the recreation area along the foreshore.		100	4	Many of the reports received from residents during this study raised concerns about siltation in Brisbane Water. Silt traps would assist in reducing the annual sediment load to Brisbane Water. However the traps require regular cleaning out to be fully effective.
	OTHER	Encode 149 certificates to indicate flood liable properties. Provide a minimum floor level of at least 500mm above either the kerb or the overflow level from isolated low points or the flood level in the January 1992 storm for new development.		-	1	
			TOTAL	3029		

5. DISCUSSION

The Management Plan presented in this report has been selected on the basis of:

- being socially the least disruptive (minimum purchase of existing homes),
- providing flood freedom up to the 1 in 10 AEP (10%) flood except for the low areas in the vicinity of Brisbane Water,
- providing a safe passage for floodwaters in excess of the 1 in 10 AEP flood and up to the 1 in 100 AEP flood, and
- being cognisant of cost.

The drainage system recommended in the Management Plan does not solve all the flooding to Council's designated 1 in 100 AEP design storm. Minimum floor levels have been specified for those areas which cannot be effectively and efficiently serviced to this standard. Those areas adjacent to Brisbane Water which are subject to flooding have generally been noted on the Lower Narara Creek Floodplain Management Plan prepared by Council and adopted in May 1991.

To implement all of the drainage works in the Management Plan will take many years depending on when funds become available. In the short term it has been necessary to set minimum floor levels for locations that are in or close to known flood liable areas.

In the Management Plan, the recommended works have been ranked, i.e., given a priority order. It is important that the recommended sequence of works be followed in priority order to ensure that flooding is not exacerbated elsewhere as works are progressively implemented.

6. REFERENCES

1. Institution of Engineers, Australia
   Australian Rainfall and Runoff
   Volumes I & II, 1987.

2. G G O'Loughlin
   The ILSAX Program for Urban Stormwater Drainage Design and Analysis
   University of Technology, Sydney, August 1988.

3. Gosford City Council
   Specification for the Drafting and Design of Stormwater Drainage Works and Roadworks
   July 1993 Edition.

4. Hare, C M
   Magnitude of Hydraulic Losses at Junctions in Piped Drainage Systems
   Civil Engineering Transactions, I.E. Aust., Vol. CE25, 1983.

5. Department of Main Roads, New South Wales
   Model Analysis to Determine Hydraulic Capacities of Kerb Inlets and Gully Pit Gratings
   1979.

6. State Pollution Control Commission
   Pollution Control Manual for Urban Stormwater
   August 1989.

FIGURES

FIGURE 1

LOCALITY MAP

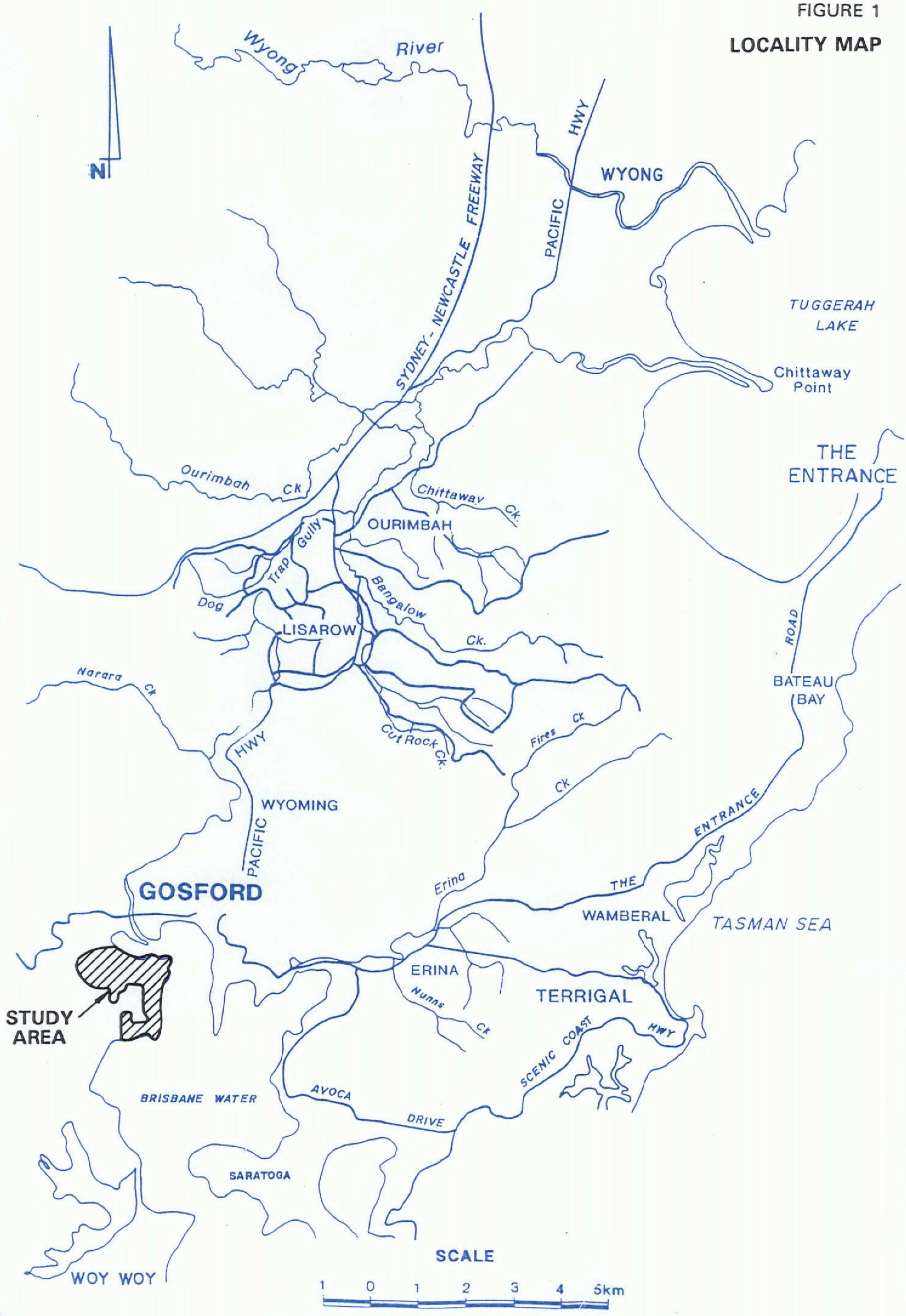


FIGURE 2

STUDY AREA

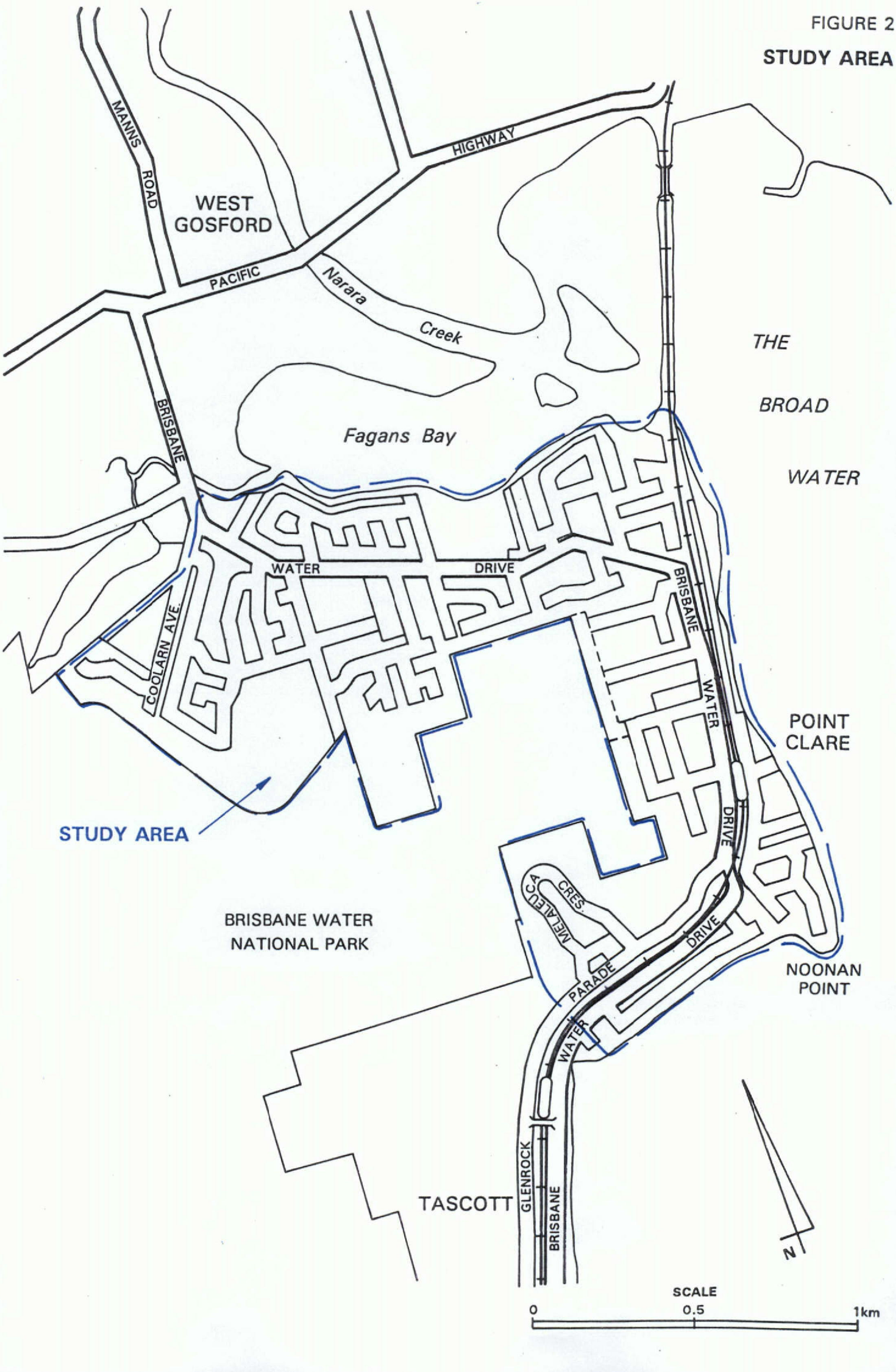


FIGURE 3A

EXTENT OF FEBRUARY 1992 FLOOD SUB-CATCHMENTS A - H

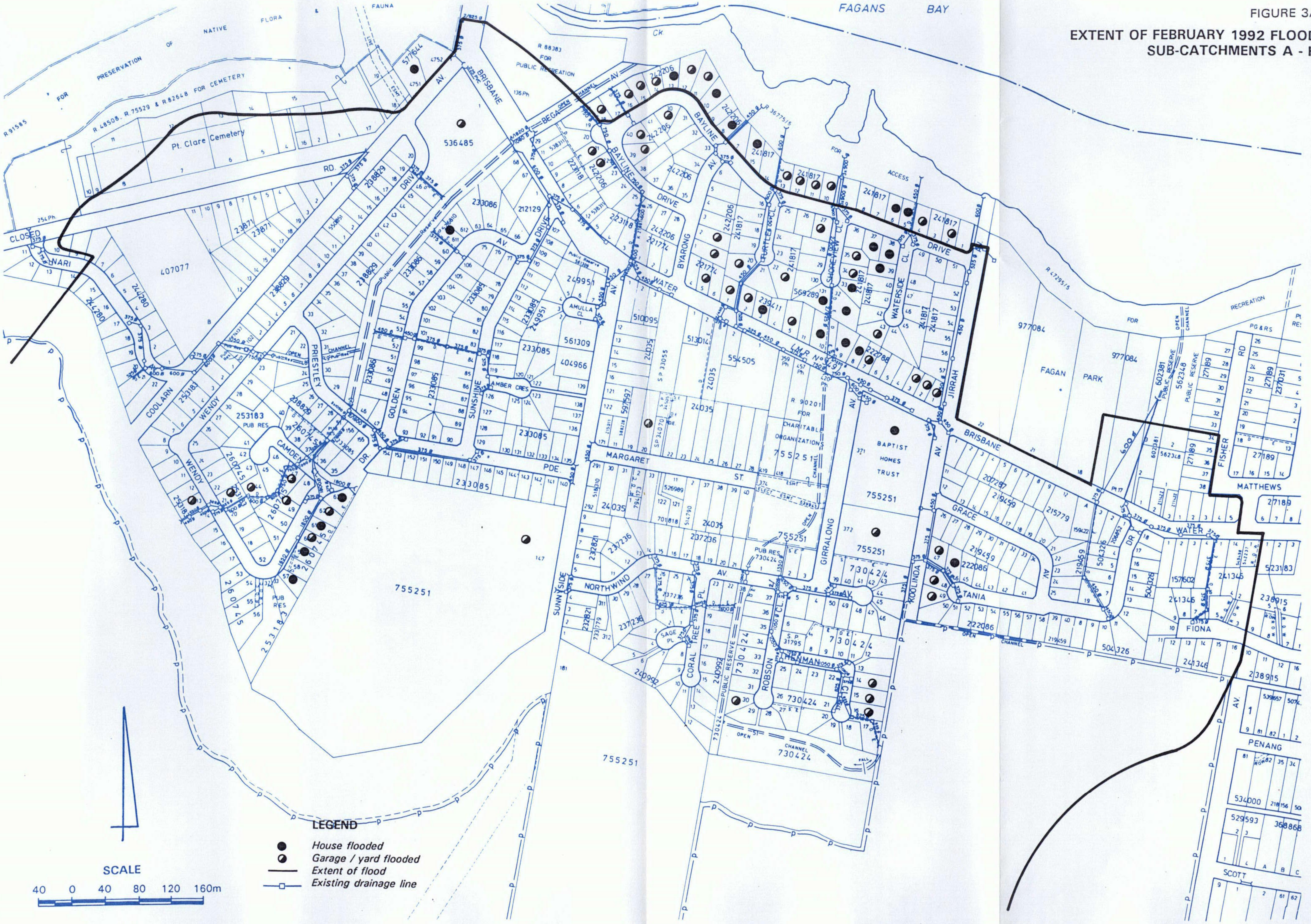


FIGURE 3B

EXTENT OF FEBRUARY 1992 FLOOD SUB-CATCHMENTS I - N

LEGEND

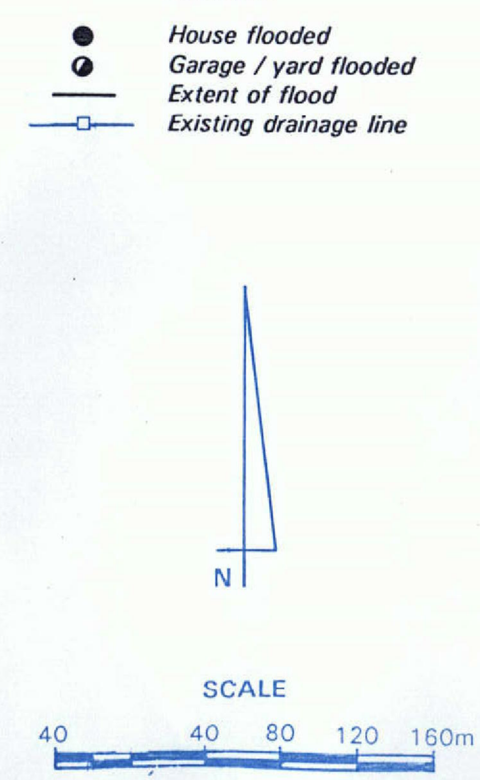


FIGURE 3C

EXTENT OF FEBRUARY 1992 FLOOD SUB-CATCHMENTS O - W

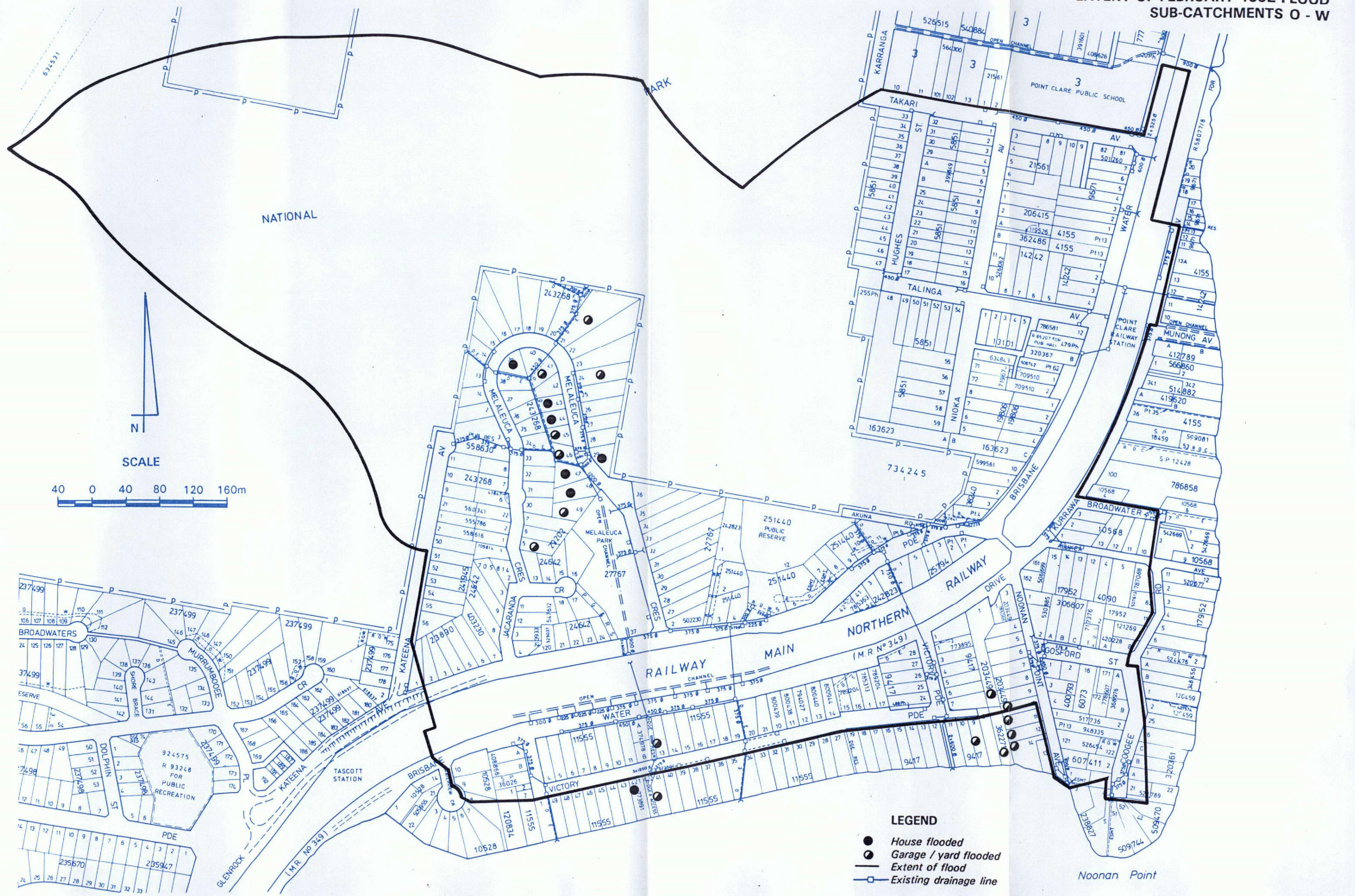


FIGURE 4A

ILSAX MODEL LAYOUT
SUB-CATCHMENTS A - H
(EXISTING)

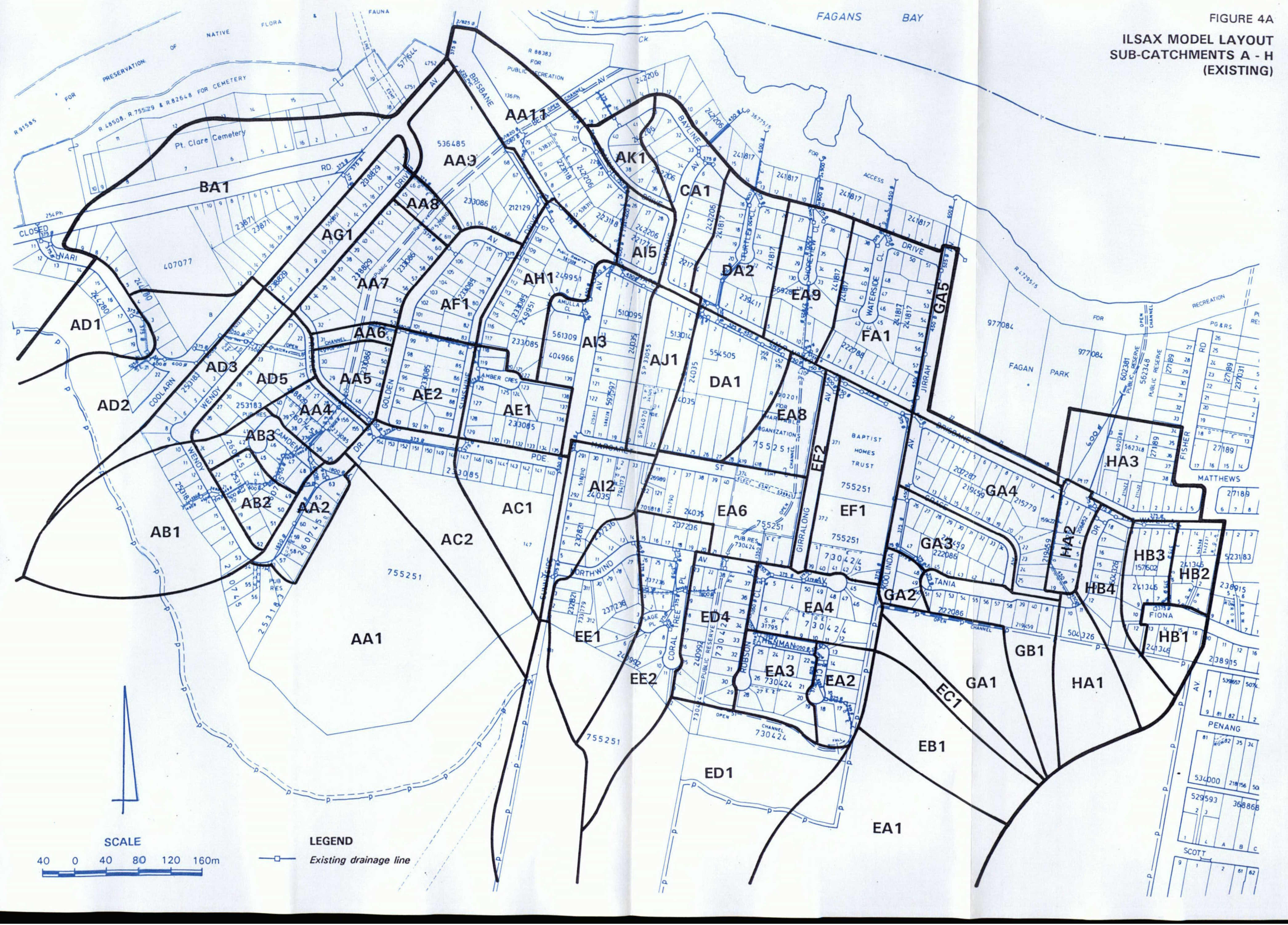


FIGURE 4B

ILSAX MODEL LAYOUT
SUB-CATCHMENTS I - N
(EXISTING)

LEGEND

Existing Drainage Line

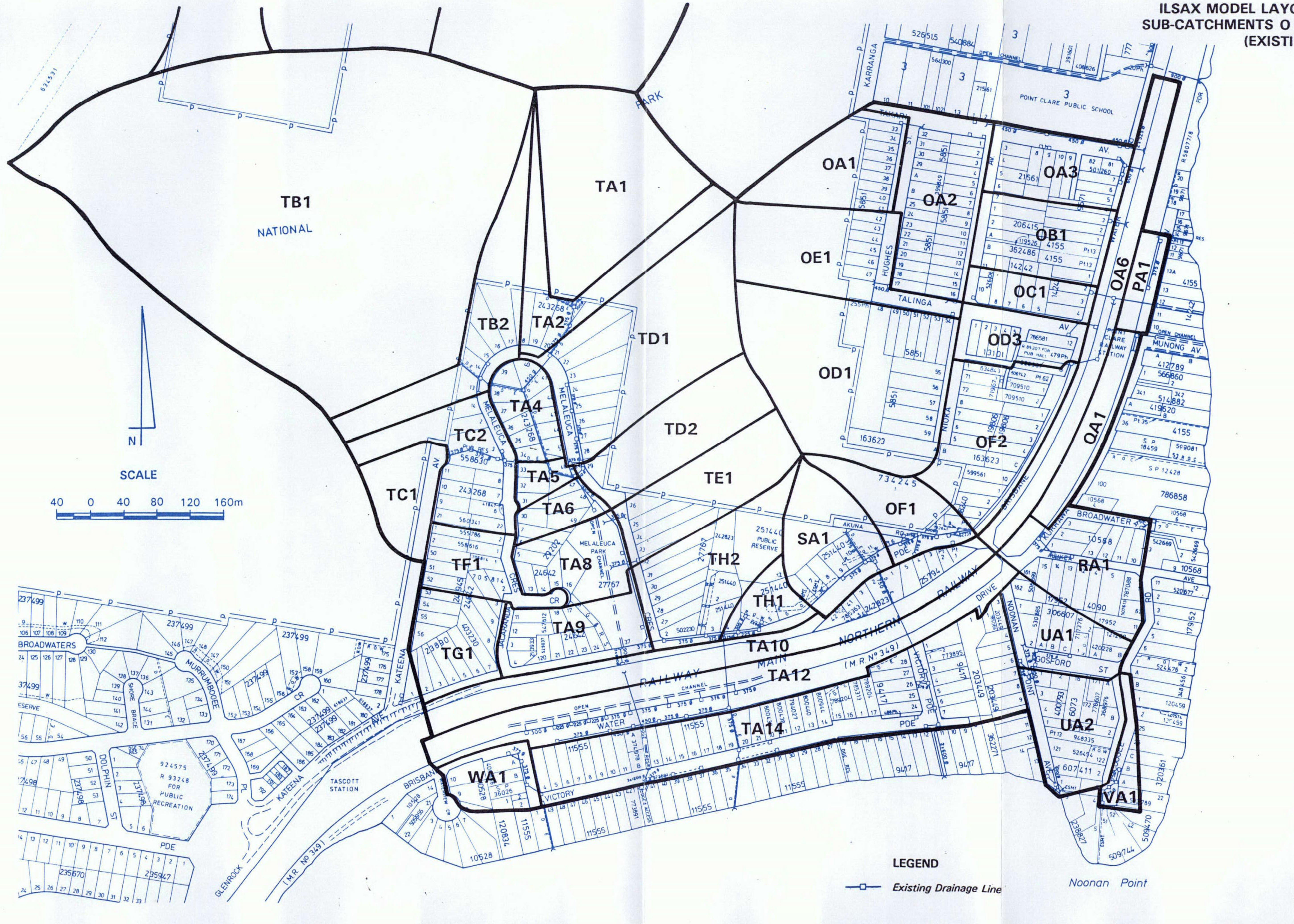
N

SCALE

40 | 40 | 80 | 120 | 160m

FIGURE 4C

ILSAX MODEL LAYOUT SUB-CATCHMENTS O - W (EXISTING)



LEGEND

Existing Drainage Line

FIGURE 5A
ILSAX MODEL LAYOUT SUB-CATCHMENTS A - H (PROPOSED)

FIGURE 5B

ILSAX MODEL LAYOUT SUB-CATCHMENTS I - N (PROPOSED)

LEGEND

Existing Drainage Line

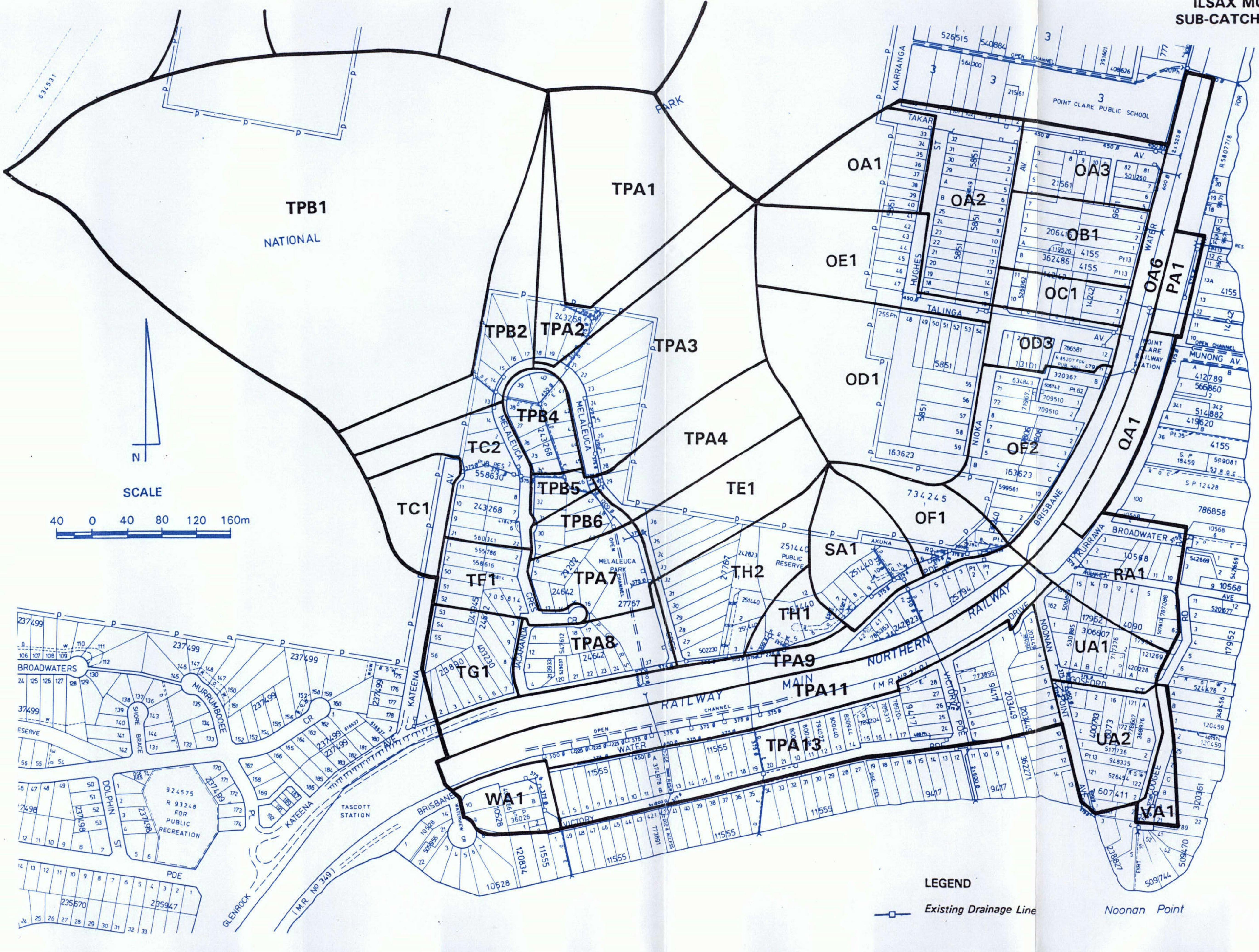
N

SCALE

40 0 40 80 120 160m

FIGURE 5C

ILSAX MODEL LAYOUT
SUB-CATCHMENTS O - W
(PROPOSED)



LEGEND

Existing Drainage Line

Noonan Point

FIGURE 6A

MANAGEMENT OPTIONS
SUB-CATCHMENTS A - H

FIGURE 6B

MANAGEMENT OPTIONS
SUB-CATCHMENTS I - N

LEGEND

Existing drainage line

N

SCALE

40 40 80 120 160m

FIGURE 6C

MANAGEMENT OPTIONS SUB-CATCHMENTS O' - W

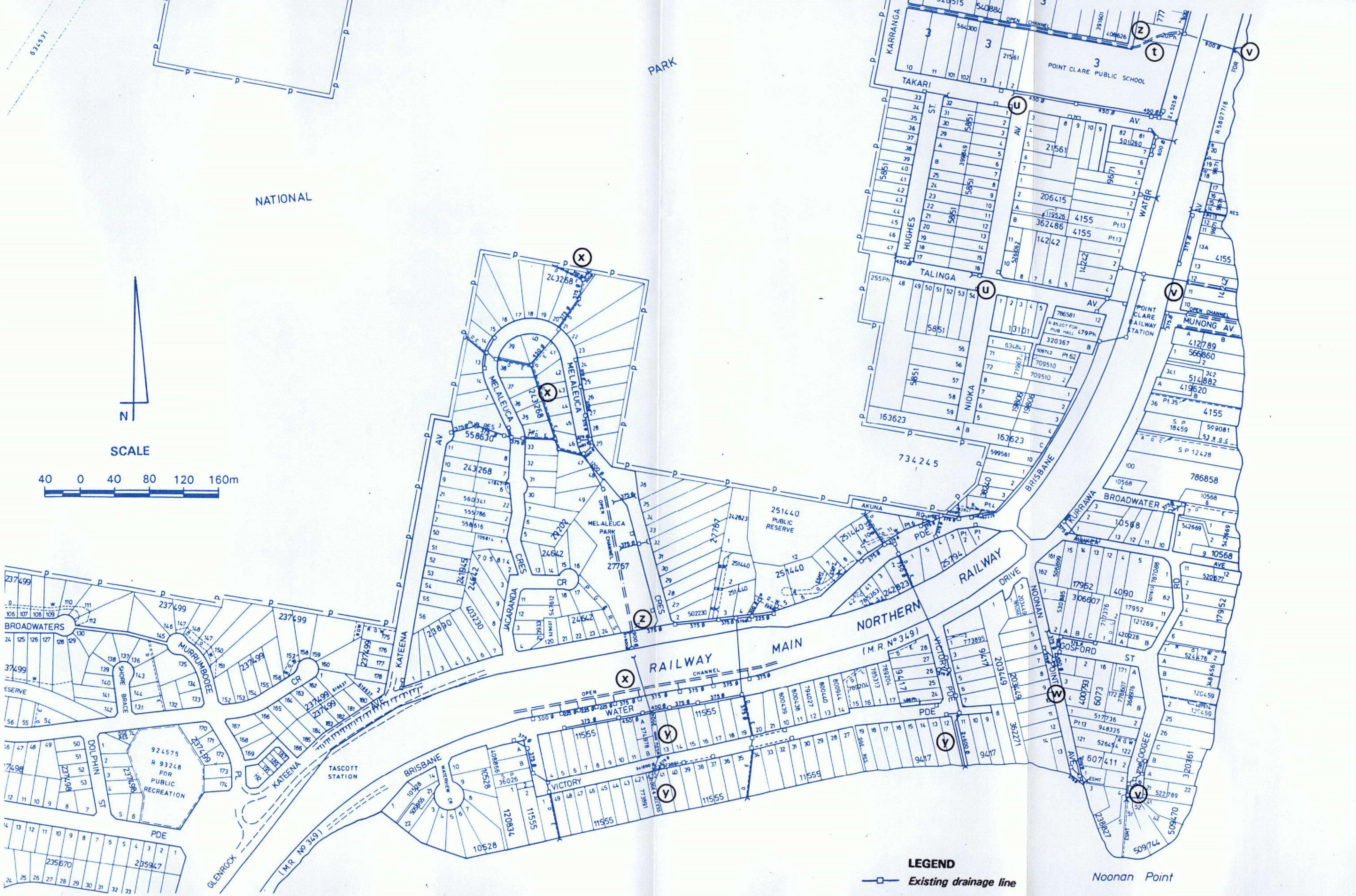


FIGURE 7A

MANAGEMENT PLAN
SUB-CATCHMENTS A - H

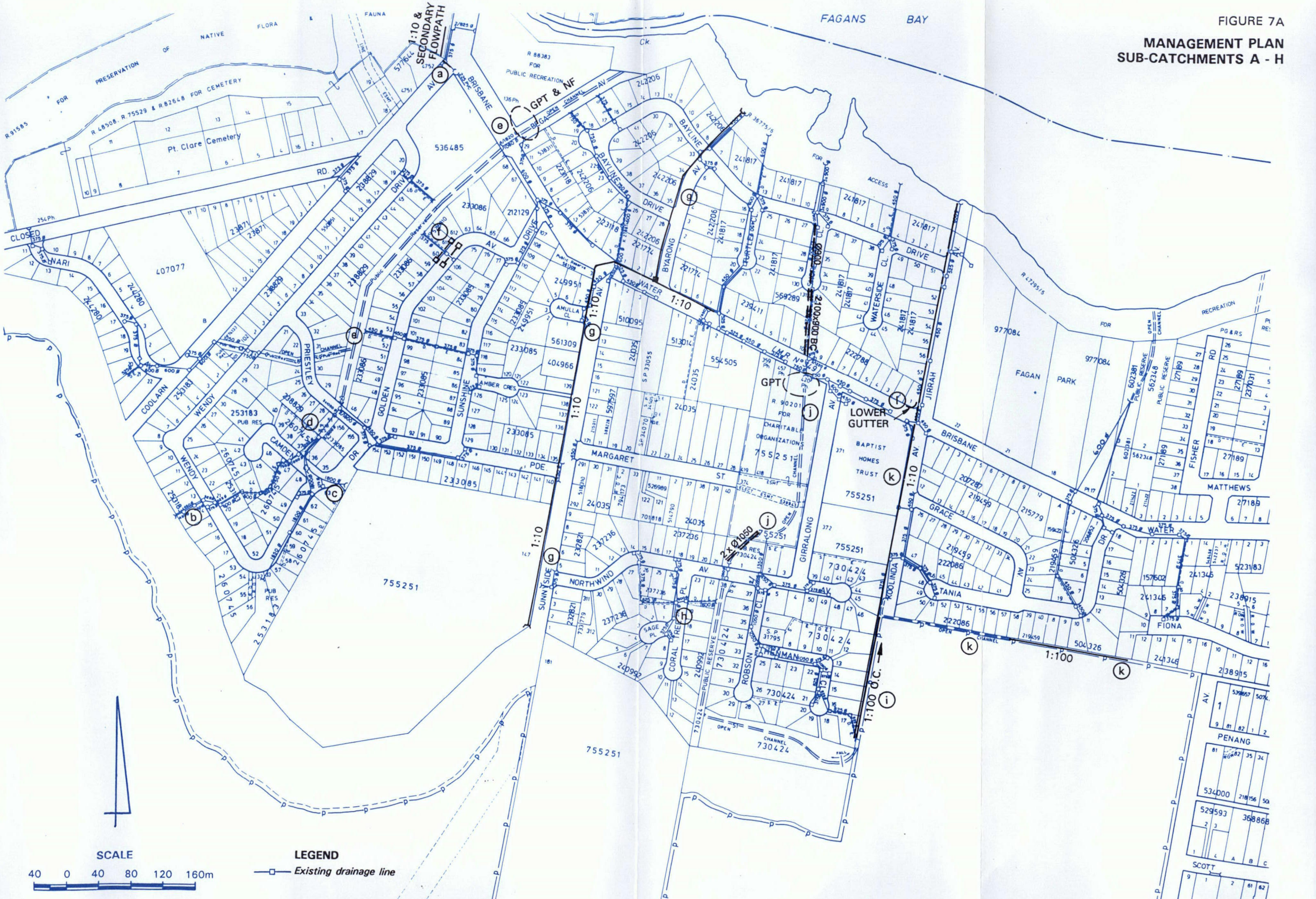
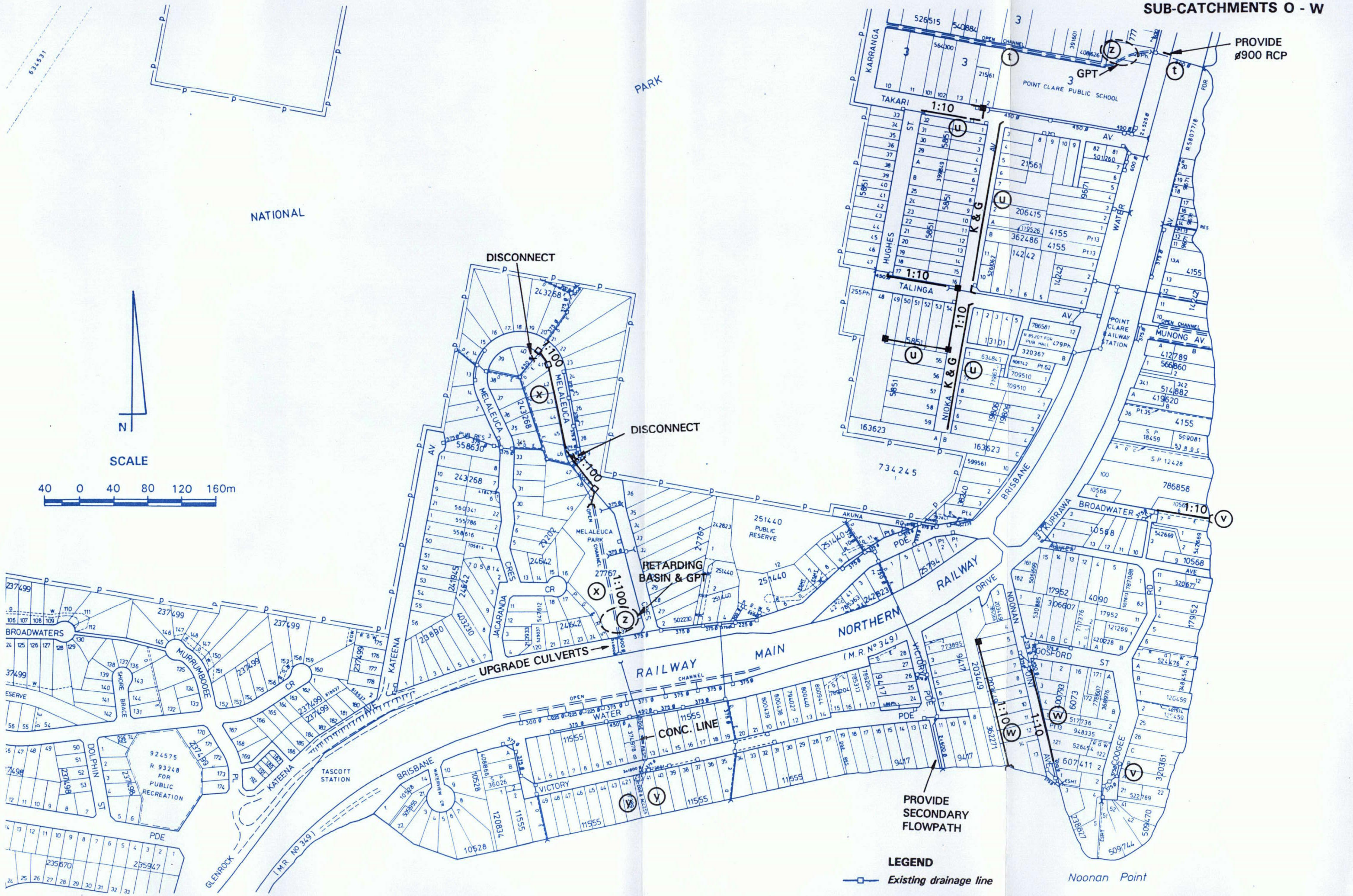


FIGURE 7B

MANAGEMENT PLAN
SUB-CATCHMENTS I - N

FIGURE 7C

MANAGEMENT PLAN
SUB-CATCHMENTS O - W

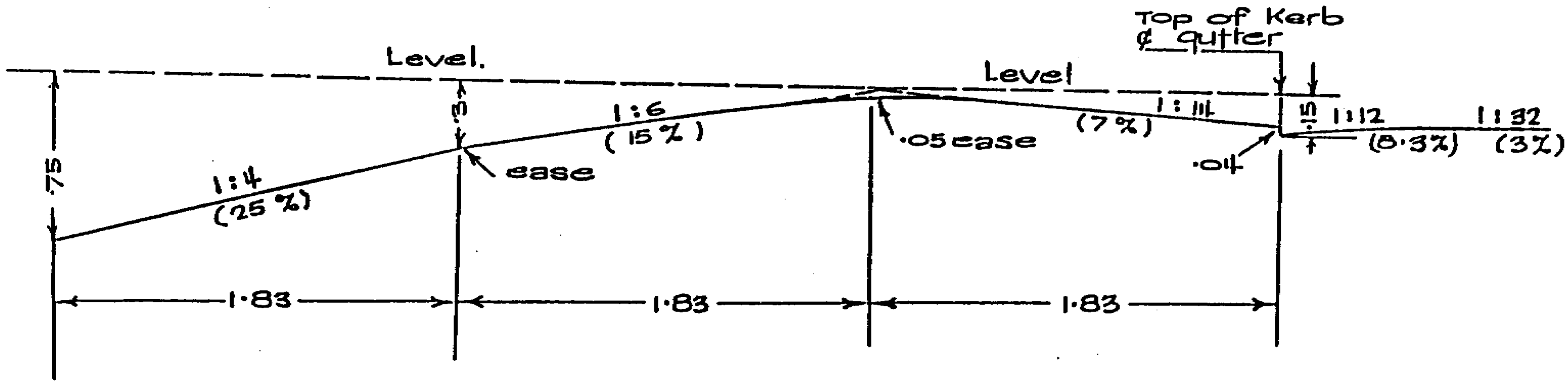


SKETCHES

SKETCH 1

DRIVEWAY CONSTRUCTION ON LOW SIDE OF ROAD

APPENDIX C (2)



METRIC MEASUREMENTS

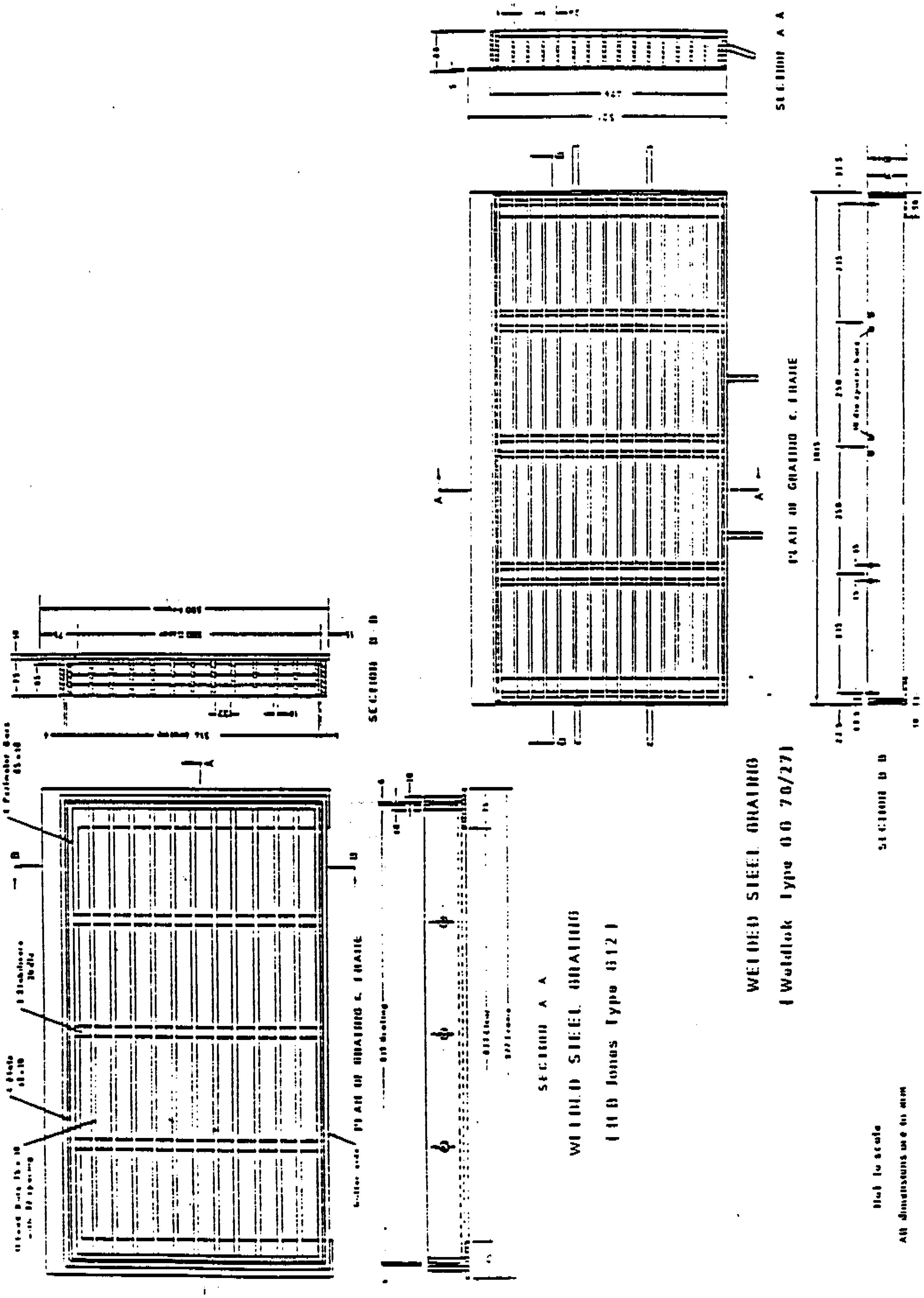
CITY OF GOSFORD

standard access for Properties below the road.

Scale: 1:25

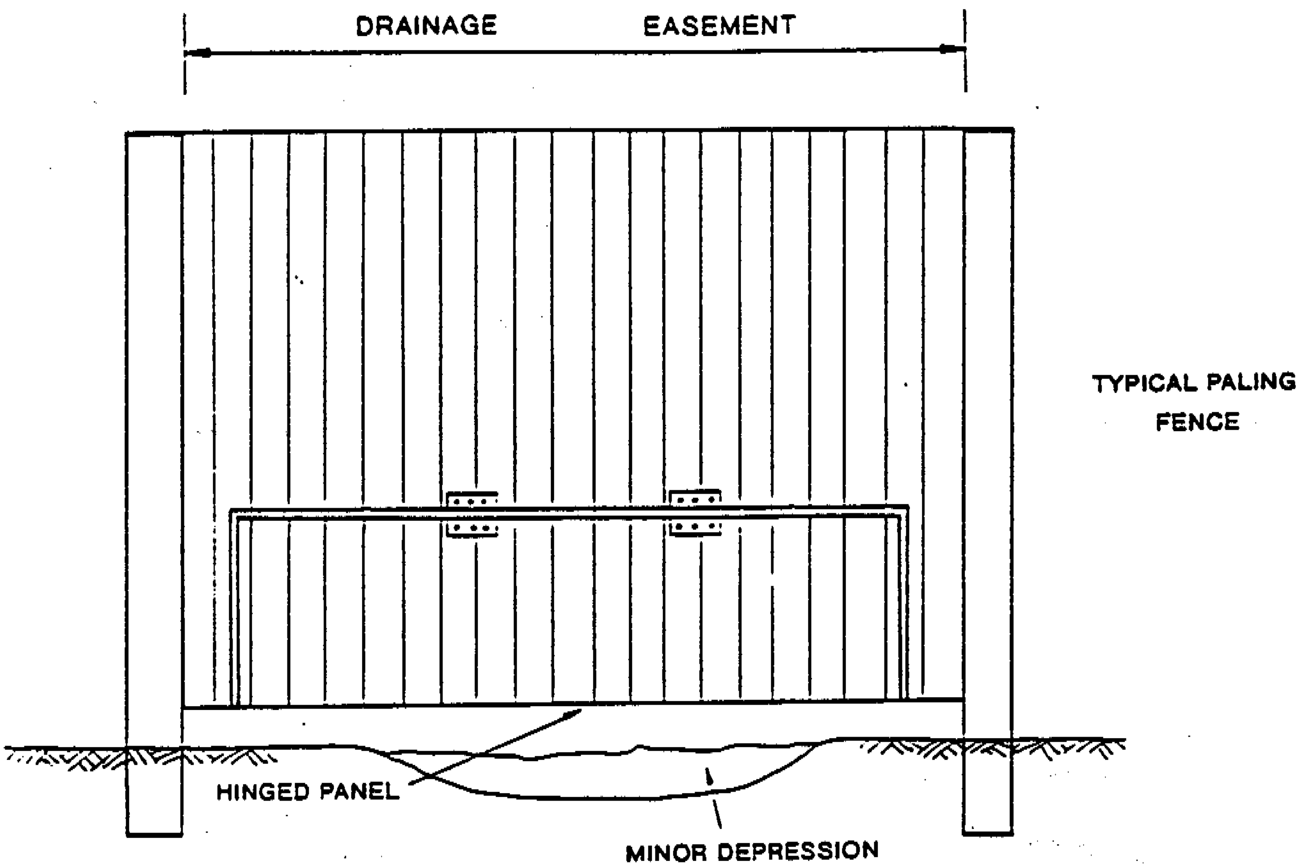
SKETCH 2

WELDED STEEL GRATING FOR INLET PITS



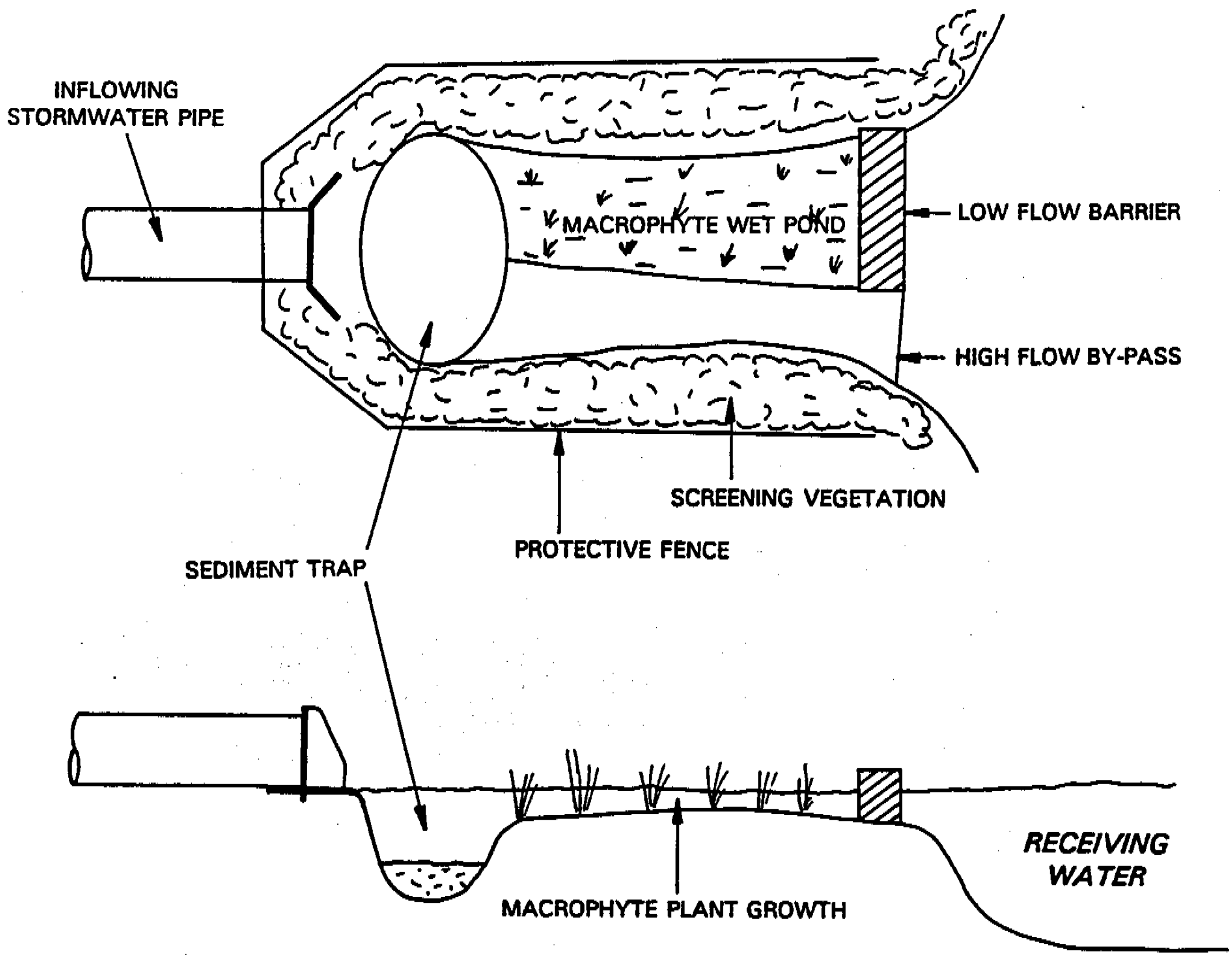
SKETCH 3

FREE SWINGING FLOODWAY FENCE



SKETCH 4

MINOR SEDIMENT TRAP AND NUTRIENT FILTER



APPENDIX A

ILSAX (Hydrologic & Hydraulic) RESULTS

EXISTING AND PROPOSED SUB-CATCHMENTS

Pipe System				Catchment Parameters				Existing		Existing Levels			10% AEP			5% AEP			2% AEP			1% AEP		
branch & reach	add hyd to	L (m)	S (%)	sub-area (ha)	Equiv Paved (%)	Paved t (min)	Grassed t (min)	conduit size (mm)	data source	invert level (mAHD)	ground level (mAHD)	depth to invert (m)	flow (m3/s)	Design Pipe N	Design Pipe dia	flow (m3/s)	Design Pipe N	Design Pipe dia	flow (m3/s)	Design Pipe N	Design Pipe dia	flow (m3/s)	Design Pipe N	Design Pipe dia
Point Clare - Existing Catchment Layout																								
A																								
AA 1		110	1.9	60.920	0	17	35	2/1650	C,O	6.5	10.0	3.5	2.7	1	900	4.1	1	1050	6.2	1	1200	7.8	1	1350
AA 2		85	1.4	0.900	50	5	11	1650+1800	C	4.4	6.7	2.3	2.9	1	1050	4.2	1	1200	6.3	1	1500	7.9	1	1500
AB 1		80	5.5	3.772	20	5	11	600	C	10.8	11.8	1.0	0.8	1	450	1.0	1	525	1.2	1	525	1.4	1	600
AB 2		55	3.5	0.708	50	5	8	750	C	6.4	7.6	1.2	1.0	1	600	1.3	1	675	1.5	1	675	1.7	1	675
AB 3	AA	50	2.6	0.844	50	5	9	1050	C	4.5	6.4	1.9	1.2	1	600	1.6	1	675	1.8	1	750	2.1	1	750
AA 3		50	0.8	0.000	0	5	5	2/1800	C	3.2	5.9	2.7	4.1	1	1200	5.7	1	1350	7.1	1	1500	8.6	1	1650
AC 1		100	3.0	1.900	20	5	11	375	C,O	11.0	11.8	0.8	0.4	1	450	0.5	1	450	0.6	1	450	0.7	1	525
AC 2	AA	65	8.0	2.508	20	5	9	2/1800	C,O	8.0	10.0	2.0	0.9	1	450	1.3	1	525	1.5	1	600	1.7	1	600
AA 4		80	2.8	0.720	50	5	8	OPEN	S A9	2.8	6.3	3.5	5.2	1	1200	7.2	1	1350	8.7	1	1500	10.5	1	1650
AD 1		110	1.9	1.240	20	5	11	600	C	8.4	12.5	4.1	0.2	1	375	0.3	1	375	0.4	1	450	0.5	1	450
AD 2		60	3.5	14.940	10	9	19	1050	C	6.3	9.0	2.7	1.9	1	750	2.6	1	825	3.1	1	900	3.8	1	1050
AD 3		50	1.6	1.372	50	6	12	OPEN	S AA4	4.2	5.9	1.7	2.3	1	825	3.0	1	1050	3.6	1	1050	4.3	1	1050
AD 4		15	5.3	0.000	0	5	5	2/900	S AA3	3.4	5.3	1.9	2.3	1	825	3.0	1	1050	3.6	1	1050	4.3	1	1050
AD 5	AA	50	4.0	0.904	50	5	8	OPEN	S AA2	2.6	5.1	2.5	2.6	1	825	3.4	1	1050	4.0	1	1050	4.7	1	1050
AA 5		25	0.8	0.640	50	5	12	OPEN	S A7	0.6	4.2	3.6	7.9	1	1500	10.7	1	1800	12.9	1	1800	15.4	3	1350
AE 1		100	1.7	1.268	50	5	11	375	C,O	7.2	7.7	0.5	0.4	1	450	0.5	1	450	0.5	1	450	0.6	1	525
AE 2	AA	45	11.3	1.256	50	5	6	450	C	5.5	7.0	1.5	0.8	1	450	1.0	1	450	1.1	1	525	1.2	1	525
AA 6		150	0.5	0.248	50	5	10	OPEN	S A6	0.4	3.6	3.2	8.6	1	1650	11.7	1	1800	13.9	3	1350	16.6	3	1500
AF 1	AA	45	5.1	1.208	50	5	8	375	C	2.6	3.8	1.2	0.4	1	375	0.5	1	450	0.5	1	450	0.6	1	450
AA 7		45	0.7	1.560	50	8	16	OPEN	S A5	0.3	2.9	2.6	9.3	1	1650	12.5	1	1800	14.8	3	1350	17.7	3	1500
AG 1	AA	40	4.0	1.204	50	5	9	375	O	1.6	3.0	1.4	0.4	1	375	0.5	1	450	0.5	1	450	0.6	1	450
AA 8		100	0.5	0.348	50	5	11	OPEN	S A4	0.0	2.2	2.2	9.7	1	1650	13.0	1	1800	15.3	3	1350	18.3	3	1500
AH 1	AA	115	2.3	1.720	50	5	12	600	C,O	2.7	4.0	1.3	0.5	1	525	0.6	1	525	0.7	1	525	0.8	1	600
AA 9		25	0.5	1.900	60	9	19	4/1820*1080	S A3	0.1	2.0	1.9	10.6	1	1800	14.0	3	1350	16.5	3	1500	19.6	3	1650
AA 10		75	0.5	0.000	0	5	5	OPEN	S A2	0.0	1.4	1.4	10.5	1	1800	13.9	3	1350	16.4	3	1500	19.5	3	1650
AI 1		170	7.7	3.524	0	5	10	375	O	29.6	31.0	1.4	0.5	1	375	0.8	1	450	1.0	1	525	1.2	1	525
AI 2		190	6.2	1.280	50	5	8	450	O	16.5	18.0	1.5	1.0	1	525	1.3	1	525	1.5	1	600	1.8	1	600
AI 3		80	1.9	1.704	50	6	12	450	O	4.7	6.0	1.3	1.4	1	675	1.8	1	750	2.1	1	825	2.5	1	900
AJ 1	AI	65	0.5	1.176	50	8	16	450	O,C	3.2	4.6	1.4	0.3	1	450	0.3	1	450	0.4	1	525	0.4	1	525
AI 4		85	2.5	0.412	50	5	7	600	C	2.9	3.7	0.8	1.8	1	750	2.3	1	825	2.7	1	900	3.1	1	1050
AI 5	AA	130	0.8	0.624	50	6	12	750	C	0.8	2.0	1.2	1.9	1	900	2.5	1	1050	2.9	1	1050	3.4	1	1200
AA 11		40	0.5	2.616	30	10	21	OPEN	S A1	-0.2	1.3	1.5	12.8	1	1800	16.9	3	1500	19.8	3	1650	23.5	3	1650
AK 1	AA	40	2.5	0.560	50	5	8	375	C	0.7	1.6	0.9	0.2	1	375	0.2	1	375	0.2	1	375	0.3	1	375
AA 12		80	0.5	0.000	0	5	5	OPEN	O	-0.3	1.2	1.5	12.8	1	1800	16.9	3	1500	19.9	3	1650	23.6	3	1650
BA 1		50	2.0	5.724	10	8	17	375	O	0.6	2.0	1.4	0.7	1	525	1.0	1	600	1.1	1	675	1.4	1	675
CA 1		55	0.5	1.564	50	8	18	450	C	0.5	1.3	0.8	0.4	1	525	0.4	1	525	0.5	1	525	0.5	1	525
DA 1		170	2.1	1.960	50	6	12	450	C	3.9	5.1	1.2	0.6	1	525	0.7	1	525	0.8	1	600	0.9	1	600
DA 2		75	1.0	1.568	50	7	14	600	O	0.3	1.9	1.6	0.9	1	675	1.2	1	750	1.3	1	750	1.5	1	825

Pipe System					Catchment Parameters				Existing	Existing Levels				10% AEP			5% AEP			2% AEP			1% AEP		
branch & reach		add hyd to	L (m)	S (%)	sub-area (ha)	Equiv Paved (%)	Paved t (min)	Grassed t (min)	conduit size (mm)	data source	invert level (mAHD)	ground level (mAHD)	depth to invert (m)	flow (m3/s)	Design Pipe N	dia	flow (m3/s)	Design Pipe N	dia	flow (m3/s)	Design Pipe N	dia	flow (m3/s)	Design Pipe N	dia
Point Clare - Existing Catchment Layout																									
E																									
EA	1		120	7.5	8.228	0	6	13	825	O	23.0	25.0	2.0	1.0	1	450	1.4	1	525	1.9	1	600	2.4	1	675
EB	1	EA	70	12.9	2.000	0	5	7	0	O	23.0	25.0	2.0	0.4	1	375	0.6	1	375	0.7	1	375	0.8	1	375
EA	2		70	1.4	0.828	50	5	11	1050	O	14.0	16.0	2.0	1.6	1	825	2.3	1	1050	2.8	1	1050	3.4	1	1200
EA	3		100	3.5	1.092	50	5	9	1050	O	13.0	15.0	2.0	2.0	1	825	2.7	1	1050	3.2	1	1050	3.8	1	1200
EC	1	EA	95	8.4	0.600	0	5	6	375	O	17.5	19.0	1.5	0.2	1	375	0.2	1	375	0.2	1	375	0.3	1	375
EA	4		50	3.8	1.432	50	5	9	1350	O	9.5	12.0	2.5	2.5	1	825	3.4	1	1050	4.0	1	1050	4.7	1	1200
ED	1		140	2.1	6.212	0	8	17	OPEN	S B10	15.5	17.8	2.3	0.6	1	525	0.9	1	600	1.2	1	675	1.4	1	675
EE	1		55	10.9	2.128	30	5	8	375	C,O	23.5	27.0	3.5	0.6	1	375	0.8	1	450	0.9	1	450	1.0	1	450
EE	2	ED	45	10.9	2.360	30	5	8	600	O	17.5	19.0	1.5	1.3	1	525	1.7	1	525	1.8	1	600	2.1	1	600
ED	2		25	8.4	0.000	0	5	5	OPEN	S B8	12.6	14.2	1.6	1.8	1	600	2.4	1	675	2.8	1	675	3.3	1	750
ED	3		15	2.7	0.000	0	5	5	2/1050	S B7	10.5	13.8	3.3	1.8	1	750	2.4	1	825	2.8	1	825	3.2	1	900
ED	4	EA	75	3.3	1.412	50	5	10	OPEN	S B6	10.1	12.8	2.7	2.2	1	750	2.9	1	825	3.3	1	900	3.9	1	1050
EA	5		80	0.5	0.000	0	5	5	OPEN	S B4	7.6	12.9	5.3	4.7	1	1350	6.3	1	1500	7.3	1	1500	8.6	1	1650
EA	6		135	1.3	1.948	40	7	14	OPEN	S B3	7.3	11.5	4.2	5.1	1	1350	6.7	1	1500	7.8	1	1500	9.2	1	1650
EF	1		30	1.7	2.120	50	6	13	450	C	6.2	7.2	1.0	0.6	1	525	0.7	1	525	0.8	1	600	0.9	1	600
EF	2	EA	25	0.8	0.548	60	5	11	750	C	5.7	6.9	1.2	0.8	1	675	0.9	1	675	1.0	1	750	1.2	1	750
EA	7		20	1.0	0.000	0	5	5	3/1200	S B1	5.5	6.9	1.4	5.7	1	1350	7.5	1	1500	8.7	1	1650	10.3	1	1650
EA	8		185	2.8	0.940	40	5	9	2/825	O	5.3	6.7	1.4	5.9	1	1350	7.8	1	1500	9.0	1	1650	10.6	1	1650
EA	9		65	2.5	1.568	50	5	11	3/900	O	0.1	2.0	1.9	6.3	1	1350	8.3	1	1500	9.6	1	1650	11.2	1	1650
FA	1		70	3.0	2.200	50	5	11	450	O	0.1	1.6	1.5	0.7	1	525	0.8	1	525	0.9	1	525	1.0	1	600
GA	1		65	6.9	1.480	0	5	8	375	O	19.5	21.0	1.5	0.3	1	375	0.4	1	375	0.5	1	375	0.6	1	375
GB	1	GA	50	10.6	1.600	30	5	7	375	C,O	20.3	21.5	1.2	0.5	1	375	0.6	1	375	0.7	1	375	0.8	1	450
GA	2		60	9.2	0.420	50	5	5	375	O	15.0	16.2	1.2	0.9	1	450	1.2	1	525	1.4	1	525	1.6	1	525
GA	3		20	14.0	1.144	50	5	6	450	O	9.5	12.0	2.5	1.4	1	525	1.7	1	525	1.9	1	525	2.2	1	600
GA	4		215	3.0	2.160	50	5	11	450	O,C	6.7	7.8	1.1	2.0	1	750	2.4	1	825	2.7	1	825	3.1	1	900
GA	5		60	2.5	0.620	50	5	8	600	O	0.2	1.8	1.6	2.1	1	750	2.7	1	825	3.0	1	825	3.4	1	900
HA	1		150	9.4	1.428	20	5	7	450	O	24.5	26.0	1.5	0.4	1	375	0.5	1	375	0.6	1	375	0.6	1	375
HB	1		120	13.9	0.748	40	5	5	375	O	38.6	40.0	1.4	0.3	1	375	0.3	1	375	0.3	1	375	0.4	1	375
HB	2		70	5.9	0.832	50	5	7	375	C	21.9	23.3	1.4	0.6	1	450	0.7	1	450	0.7	1	450	0.8	1	450
HB	3		30	14.3	0.828	50	5	5	375	C	17.8	18.6	0.8	0.9	1	450	1.1	1	450	1.1	1	450	1.3	1	450
HB	4	HA	25	12.4	1.212	40	5	6	375	O	13.5	15.0	1.5	1.3	1	525	1.6	1	525	1.7	1	525	1.9	1	600
HA	2		130	6.5	0.588	50	5	6	?600	O	10.4	12.0	1.6	1.9	1	675	2.3	1	675	2.4	1	675	2.8	1	750
HA	3		110	4.0	2.260	30	5	11	OPEN	O	2.0	6.0	4.0	2.4	1	750	2.9	1	825	3.2	1	825	3.6	1	900
IA	1		50	1.0	2.220	50	7	16	0	O	0.4	1.5	1.1	0.5	1	525	0.7	1	600	0.7	1	600	0.8	1	675
JA	1		50	1.0	1.496	50	7	14	375	O	3.4	5.0	1.6	0.4	1	525	0.5	1	525	0.5	1	525	0.6	1	600
KA	1		40	1.0	1.984	50	7	15	?	O	3.8	5.8	2.0	0.5	1	525	0.6	1	600	0.7	1	600	0.8	1	675

Pipe System					Catchment Parameters				Existing	Existing Levels				10% AEP			5% AEP			2% AEP			1% AEP		
branch &	reach	add hyd to	L (m)	S (%)	sub-area (ha)	Equiv Paved (%)	Paved t (min)	Grassed t (min)	conduit size (mm)	data source	invert level (mAHD)	ground level (mAHD)	depth to invert (m)	flow (m3/s)	Design Pipe N	dia	flow (m3/s)	Design Pipe N	dia	flow (m3/s)	Design Pipe N	dia	flow (m3/s)	Design Pipe N	dia
Point Clare - Existing Catchment Layout																									
L																									
LA	1		90	21.4	0.572	50	5	5	450	O	25.0	28.0	3.0	0.2	1	375	0.3	1	375	0.3	1	375	0.3	1	375
LB	1	LA	55	9.6	1.408	50	5	7	375	O,C	11.0	12.4	1.4	0.5	1	375	0.6	1	375	0.6	1	375	0.7	1	450
LC	1	LA	10	1.0	1.304	50	6	14	0	O	5.8	7.0	1.2	0.3	1	450	0.4	1	525	0.5	1	525	0.5	1	525
LA	2		165	1.6	0.564	50	5	9	?	O,C	5.7	6.8	1.1	1.2	1	675	1.5	1	750	1.6	1	750	1.8	1	750
LA	3		140	1.7	1.612	50	6	12	675	O	3.0	6.0	3.0	1.7	1	750	2.0	1	825	2.2	1	825	2.5	1	900
LA	4		70	1.0	0.644	50	5	11	900	C,O	0.6	2.5	1.9	1.8	1	900	2.2	1	1050	2.4	1	1050	2.8	1	1050
MA	1		20	25.0	0.756	60	5	5	525?	O	16.0	19.0	3.0	0.3	1	375	0.4	1	375	0.4	1	375	0.4	1	375
MB	1	MA	40	17.5	1.792	50	5	6	0	O	18.0	21.0	3.0	0.7	1	375	0.8	1	375	0.8	1	375	0.9	1	450
MA	2		60	3.3	0.424	50	5	7	525	O	11.0	12.0	1.0	1.1	1	600	1.3	1	675	1.4	1	675	1.6	1	675
MA	3		280	3.2	0.372	30	5	7	RAIL	O	9.0	13.0	4.0	1.2	1	600	1.4	1	675	1.5	1	675	1.7	1	675
MD	1		80	0.6	2.904	50	9	20	525	O	1.5	3.0	1.5	0.6	1	600	0.8	1	675	0.9	1	675	1.0	1	675
MD	2	MA	70	1.4	0.936	50	5	11	675	O	1.0	2.5	1.5	0.9	1	675	1.1	1	750	1.2	1	750	1.4	1	825
MA	4		10	1.0	0.808	0	6	12	RAIL	O	0.0	1.0	1.0	2.2	1	1050	2.7	1	1050	2.9	1	1050	3.3	1	1200
NA	1		90	6.0	6.808	0	6	13	0	S C5	12.6	15.6	3.0	0.8	1	450	1.2	1	525	1.6	1	600	1.9	1	675
NA	2		100	1.9	1.280	40	5	11	0	S C4	7.2	15.5	8.3	1.1	1	675	1.6	1	750	1.9	1	825	2.4	1	825
NA	3		140	1.9	1.480	40	5	12	0	S C3	5.3	11.3	6.0	1.5	1	750	2.0	1	825	2.4	1	825	2.9	1	900
NB	1		60	5.8	5.612	40	6	12	?	,C	10.5	12.1	1.6	1.4	1	600	1.7	1	600	2.0	1	675	2.3	1	675
NB	2	NA	55	7.8	1.112	50	5	7	600	C	7.0	9.0	2.0	1.8	1	600	2.2	1	675	2.4	1	675	2.8	1	675
NA	4		30	7.0	2.036	40	5	9	900	O	2.7	4.2	1.5	3.7	1	825	4.8	1	900	5.6	1	900	6.6	1	1050
NA	5		30	3.0	0.848	10	5	9	900	C	0.6	2.5	1.9	3.9	1	1050	5.1	1	1050	5.9	1	1200	6.9	1	1200
OA	1		100	11.4	2.144	30	5	8	?	O	24.0	26.0	2.0	0.6	1	375	0.8	1	450	0.9	1	450	1.0	1	450
OA	2		160	6.1	2.120	50	5	9	450	C	12.6	15.0	2.4	1.3	1	600	1.6	1	600	1.8	1	600	2.0	1	675
OA	3		20	0.5	1.672	50	8	18	525	C	2.8	5.2	2.4	1.7	1	825	2.1	1	900	2.3	1	1050	2.6	1	1050
OA	4		90	0.5	0.000	0	5	5	RAIL	O	2.7	4.0	1.3	1.6	1	825	2.0	1	900	2.2	1	1050	2.5	1	1050
OB	1	OA	70	1.3	1.260	50	6	12	525	O	3.5	5.0	1.5	0.4	1	525	0.4	1	525	0.5	1	525	0.6	1	600
OA	5		90	0.5	0.000	0	5	5	RAIL	O	2.6	4.0	1.4	2.0	1	900	2.4	1	1050	2.7	1	1050	3.1	1	1050
OC	1	OA	70	0.5	0.536	50	6	13	?	O	2.7	4.2	1.5	0.1	1	375	0.2	1	375	0.2	1	375	0.2	1	375
OD	1		20	2.5	4.532	30	7	15	?	O	14.5	16.0	1.5	0.9	1	525	1.1	1	600	1.3	1	600	1.5	1	675
OE	1	OD	70	8.6	2.036	20	5	8	450	O	20.0	24.0	4.0	0.5	1	375	0.7	1	450	0.8	1	450	0.9	1	450
OD	2		170	6.2	0.000	0	5	5	?	O	14.0	15.5	1.5	1.4	1	600	1.8	1	600	2.0	1	675	2.3	1	675
OD	3	OA	40	2.5	1.128	50	5	10	?	O	3.5	5.0	1.5	1.7	1	675	2.2	1	750	2.5	1	825	2.8	1	825
OF	1		240	7.3	1.072	20	5	7	?	O	22.5	24.0	1.5	0.3	1	375	0.4	1	375	0.4	1	375	0.5	1	375
OF	2	OA	100	2.5	2.112	50	6	12	?	O	5.0	6.5	1.5	0.9	1	525	1.1	1	600	1.2	1	600	1.4	1	675
OA	6		20	2.5	1.800	0	5	11	?	O	2.5	4.0	1.5	4.9	1	1050	6.3	1	1200	7.0	1	1200	8.1	1	1350
OA	7		80	0.5	0.000	0	5	5	OPEN	O	2.0	3.5	1.5	4.9	1	1350	6.2	1	1500	7.0	1	1500	8.1	1	1500
PA	1		40	0.5	0.420	20	6	12	OPEN	C	0.3	1.4	1.1	0.1	1	375	0.1	1	375	0.1	1	375	0.1	1	375
QA	1		70	0.5	0.800	10	7	14	OPEN	C	3.5	6.0	2.5	0.1	1	375	0.2	1	375	0.2	1	375	0.2	1	375
RA	1		60	0.5	1.700	50	8	18	?	O	6.0	8.0	2.0	0.4	1	525	0.5	1	525	0.5	1	525	0.6	1	600

Pipe System				Catchment Parameters				Existing	Existing Levels				10% AEP			5% AEP			2% AEP			1% AEP		
branch & reach	add hyd to	L (m)	S (%)	sub-area (ha)	Equiv Paved (%)	Paved t (min)	Grassed t (min)	conduit size (mm)	data source	invert level (mAHD)	ground level (mAHD)	depth to invert (m)	flow (m3/s)	Design Pipe N	Design Pipe dia	flow (m3/s)	Design Pipe N	Design Pipe dia	flow (m3/s)	Design Pipe N	Design Pipe dia	flow (m3/s)	Design Pipe N	Design Pipe dia
Point Clare - Existing Catchment Layout																								
S																								
SA 1		200	10.8	1.472	30	5	7	750	O	24.5	26.5	2.0	0.4	1	375	0.6	1	375	0.6	1	375	0.7	1	375
SA 2		50	0.5	0.000	0	5	5	2/600	O	3.0	5.0	2.0	0.4	1	525	0.6	1	600	0.6	1	600	0.7	1	600
TA 1		75	40.0	3.460	0	5	6	2/300	O	43.5	45.0	1.5	0.9	1	375	1.2	1	375	1.3	1	375	1.5	1	450
TA 2		50	9.0	1.404	30	5	7	450	,C	13.5	14.9	1.4	1.3	1	525	1.8	1	600	1.9	1	600	2.2	1	600
TB 1		40	7.5	17.216	0	8	16	?	O	13.5	15.0	1.5	1.7	1	600	2.5	1	675	3.4	1	750	4.2	1	825
TB 2	TA	40	3.8	2.000	30	5	10	?	O	10.5	12.0	1.5	2.1	1	750	3.1	1	825	3.8	1	900	4.6	1	1050
TA 3		90	3.9	0.000	50	5	5	?	O	9.0	11.0	2.0	3.4	1	900	4.7	1	1050	5.6	1	1050	6.7	1	1200
TC 1		90	27.8	1.036	0	5	5	375	O	38.5	40.0	1.5	0.3	1	375	0.4	1	375	0.4	1	375	0.5	1	375
TC 2	TA	35	22.9	1.608	20	5	6	?	O	13.5	15.0	1.5	0.8	1	375	1.0	1	375	1.1	1	450	1.2	1	450
TA 4		45	1.6	0.828	50	5	10	?	O	5.5	7.0	1.5	4.4	1	1050	5.9	1	1200	6.9	1	1350	8.1	1	1350
TD 1		10	2.0	3.336	20	7	15	450	O	5.3	6.8	1.5	0.5	1	450	0.7	1	525	0.8	1	600	1.0	1	600
TD 2	TA	10	3.0	1.812	10	5	11	450	O	5.1	6.8	1.7	0.9	1	525	1.1	1	600	1.4	1	675	1.6	1	675
TA 5		50	0.8	0.280	50	5	9	1200	O	4.8	6.7	1.9	5.3	1	1350	7.1	1	1500	8.3	1	1650	9.9	1	1650
TA 6		70	1.6	0.408	50	5	8	OPEN	S D9	4.4	5.8	1.4	5.4	1	1350	7.3	1	1500	8.5	1	1650	10.0	1	1650
TE 1	TA	30	2.3	1.708	20	5	11	?	O	4.0	6.0	2.0	0.3	1	375	0.5	1	450	0.5	1	525	0.6	1	525
TA 7		35	1.1	0.000	0	5	5	OPEN	S D8	3.3	5.4	2.1	5.7	1	1350	7.7	1	1500	9.0	1	1650	10.7	1	1800
TF 1	TA	60	6.8	1.000	50	5	7	0	O	7.0	9.0	2.0	0.4	1	375	0.4	1	375	0.5	1	375	0.5	1	375
TA 8		60	1.2	1.140	50	6	12	OPEN	S D7	2.9	4.8	1.9	6.3	1	1500	8.4	1	1650	9.7	1	1650	11.6	1	1800
TG 1	TA	140	6.3	1.132	50	5	7	0	O	11.0	13.0	2.0	0.4	1	375	0.5	1	375	0.5	1	375	0.6	1	450
TH 1		65	15.4	0.520	50	5	5	375	O	13.6	15.0	1.4	0.2	1	375	0.2	1	375	0.3	1	375	0.3	1	375
TH 2	TA	50	2.8	1.860	50	5	11	375	O	3.6	5.0	1.4	0.8	1	525	0.9	1	600	1.0	1	600	1.1	1	600
TA 9		20	5.0	1.328	50	5	8	900+3/600	S D6	2.2	4.1	1.9	7.8	1	1500	10.2	1	1650	11.7	1	1650	13.8	1	1800
TA 10		40	2.8	2.960	20	6	13	1850	S D4	1.2	3.6	2.4	8.2	1	1500	10.9	1	1650	12.5	1	1650	14.7	1	1800
TA 11		40	0.5	0.000	0	5	5	3/1350	O	0.1	2.0	1.9	8.2	1	1650	10.8	1	1800	12.5	1	1800	14.7	3	1350
TA 12		50	0.8	2.912	30	9	18	OPEN	S D3	0.0	1.6	1.6	8.6	1	1650	11.4	1	1800	13.1	3	1350	15.5	3	1350
TA 13		20	0.5	0.000	0	5	5	3/1050	S D2	-0.4	1.4	1.8	8.5	1	1650	11.3	1	1800	13.1,	3	1350	15.4	3	1350
TA 14		50	0.5	4.712	50	12	24	OPEN	S D1	-0.4	1.4	1.8	9.4	1	1650	12.3	1	1800	14.2	3	1350	16.7	3	1500
UA 1		85	4.7	1.100	50	5	8	?	C,O	4.6	6.5	1.9	0.4	1	375	0.5	1	375	0.5	1	375	0.5	1	375
UA 2		10	1.0	1.364	50	6	14	?	C,O	0.6	2.5	1.9	0.7	1	675	0.9	1	675	1.0	1	675	1.1	1	750
VA 1		70	0.5	0.364	50	5	11	?	O	0.5	2.5	2.0	0.1	1	375	0.1	1	375	0.1	1	375	0.2	1	375
WA 1		55	0.5	0.668	50	6	14	?	O	0.1	1.5	1.4	0.2	1	375	0.2	1	375	0.2	1	375	0.3	1	450

Pipe System				Catchment Parameters				Existing	Existing Levels				10% AEP			5% AEP			2% AEP			1% AEP		
branch & reach	add hyd to	L (m)	S (%)	sub-area (ha)	Equiv Paved (%)	Paved t (min)	Grassed t (min)	conduit size (mm)	data source	invert level (mAHD)	ground level (mAHD)	depth to invert (m)	flow (m3/s)	Design Pipe N	Design Pipe dia	flow (m3/s)	Design Pipe N	Design Pipe dia	flow (m3/s)	Design Pipe N	Design Pipe dia	flow (m3/s)	Design Pipe N	Design Pipe dia
Point Clare - Proposed Catchment Layout																								
E																								
EA 1		120	7.5	8.228	0	6	13	825	O	23.0	25.0	2.0	1.0	1	450	1.4	1	525	1.9	1	600	2.4	1	675
EA 2		70	1.4	0.828	50	5	11	1050	O	14.0	16.0	2.0	1.2	1	750	1.7	1	900	2.1	1	900	2.6	1	1050
EA 3		100	3.5	1.092	50	5	9	1050	O	13.0	15.0	2.0	1.5	1	750	2.1	1	900	2.5	1	900	3.1	1	1050
EA 4		50	3.8	1.432	50	5	9	1350	O	9.5	12.0	2.5	2.0	1	750	2.6	1	900	3.1	1	900	3.7	1	1050
ED 1		140	2.1	6.212	0	8	17	OPEN	S B10	15.5	17.8	2.3	0.6	1	525	0.9	1	600	1.2	1	675	1.4	1	675
EE 1		55	10.9	2.128	30	5	8	375	C,O	23.5	27.0	3.5	0.6	1	375	0.8	1	450	0.9	1	450	1.0	1	450
EE 2	ED	45	10.9	2.360	30	5	8	600	O	17.5	19.0	1.5	1.3	1	525	1.7	1	525	1.8	1	600	2.1	1	600
ED 2		25	8.4	0.000	0	5	5	OPEN	S B8	12.6	14.2	1.6	1.8	1	600	2.4	1	675	2.8	1	675	3.3	1	750
ED 3		15	2.7	0.000	0	5	5	2/1050	S B7	10.5	13.8	3.3	1.8	1	750	2.4	1	825	2.8	1	825	3.2	1	900
ED 4	EA	75	3.3	1.412	50	5	10	OPEN	S B6	10.1	12.8	2.7	2.2	1	750	2.9	1	825	3.3	1	900	3.9	1	1050
EA 5		80	0.5	0.000	0	5	5	OPEN	S B4	7.6	12.9	5.3	4.1	1	1200	5.5	1	1350	6.4	1	1500	7.5	1	1500
EA 6		135	1.3	1.948	40	7	14	OPEN	S B3	7.3	11.5	4.2	4.5	1	1350	5.9	1	1350	6.9	1	1500	8.1	1	1650
EF 1		30	1.7	2.120	50	6	13	450	C	6.2	7.2	1.0	0.6	1	525	0.7	1	525	0.8	1	600	0.9	1	600
EF 2	EA	25	0.8	0.548	60	5	11	750	C	5.7	6.9	1.2	0.8	1	675	0.9	1	675	1.0	1	750	1.2	1	750
EA 7		20	1.0	0.000	0	5	5	3/1200	S B1	5.5	6.9	1.4	5.2	1	1350	6.7	1	1500	7.8	1	1500	9.2	1	1650
EA 8		185	2.8	0.940	40	5	9	2/825	O	5.3	6.7	1.4	5.4	1	1350	7.0	1	1500	8.1	1	1500	9.6	1	1650
EA 9		65	2.5	1.568	50	5	11	3/900	O	0.1	2.0	1.9	5.8	1	1350	7.5	1	1500	8.7	1	1500	10.2	1	1650
FA 1		70	3.0	2.200	50	5	11	450	O	0.1	1.6	1.5	0.7	1	525	0.8	1	525	0.9	1	525	1.0	1	600
GPA 1		90	10.0	2.000	0	5	8	OPEN	O	23.0	25.0	2.0	0.4	1	375	0.6	1	375	0.7	1	450	0.8	1	450
GPA 2		90	8.9	0.600	0	5	6	OPEN	O	17.5	19.0	1.5	0.5	1	375	0.8	1	450	0.9	1	450	1.0	1	450
GPA 3		65	6.9	1.480	0	5	8	375	O	19.5	21.0	1.5	0.8	1	450	1.2	1	525	1.4	1	525	1.6	1	600
GPB 1	GPA	50	10.6	1.600	30	5	7	375	C,O	20.3	21.5	1.2	0.5	1	375	0.6	1	375	0.7	1	375	0.8	1	450
GPA 4		60	9.2	0.420	50	5	5	375	O	15.0	16.2	1.2	1.4	1	525	1.9	1	600	2.2	1	600	2.6	1	675
GPA 5		20	14.0	1.144	50	5	6	450	O	9.5	12.0	2.5	1.8	1	525	2.4	1	600	2.7	1	600	3.2	1	675
GPA 6		215	3.0	2.160	50	5	11	450	O,C	6.7	7.8	1.1	2.5	1	825	3.2	1	900	3.6	1	900	4.1	1	1050
GPA 7		60	2.5	0.620	50	5	8	600	O	0.2	1.8	1.6	2.6	1	825	3.4	1	900	3.8	1	1050	4.4	1	1050
HA 1		150	9.4	1.428	20	5	7	450	O	24.5	26.0	1.5	0.4	1	375	0.5	1	375	0.6	1	375	0.6	1	375
HB 1		120	13.9	0.748	40	5	5	375	O	38.6	40.0	1.4	0.3	1	375	0.3	1	375	0.3	1	375	0.4	1	375
HB 2		70	5.9	0.832	50	5	7	375	C	21.9	23.3	1.4	0.6	1	450	0.7	1	450	0.7	1	450	0.8	1	450
HB 3		30	14.3	0.828	50	5	5	375	C	17.8	18.6	0.8	0.9	1	450	1.1	1	450	1.1	1	450	1.3	1	450
HB 4	HA	25	12.4	1.212	40	5	6	375	O	13.5	15.0	1.5	1.3	1	525	1.6	1	525	1.7	1	525	1.9	1	600
HA 2		130	6.5	0.588	50	5	6	?600	O	10.4	12.0	1.6	1.9	1	675	2.3	1	675	2.4	1	675	2.8	1	750
HA 3		110	4.0	2.260	30	5	11	OPEN	O	2.0	6.0	4.0	2.4	1	750	2.9	1	825	3.2	1	825	3.6	1	900
IA 1		50	1.0	2.220	50	7	16	0	O	0.4	1.5	1.1	0.5	1	525	0.7	1	600	0.7	1	600	0.8	1	675
JA 1		50	1.0	1.496	50	7	14	375	O	3.4	5.0	1.6	0.4	1	525	0.5	1	525	0.5	1	525	0.6	1	600
KA 1		40	1.0	1.984	50	7	15	?	O	3.8	5.8	2.0	0.5	1	525	0.6	1	600	0.7	1	600	0.8	1	675

Pipe System					Catchment Parameters				Existing	Existing Levels				10% AEP			5% AEP			2% AEP			1% AEP		
branch &	reach	add hyd to	L (m)	S (%)	sub-area (ha)	Equiv Paved (%)	Paved t (min)	Grassed t (min)	conduit size (mm)	data source	invert level (mAHD)	ground level (mAHD)	depth to invert (m)	flow (m3/s)	Design Pipe N	dia	flow (m3/s)	Design Pipe N	dia	flow (m3/s)	Design Pipe N	dia	flow (m3/s)	Design Pipe N	dia
Point Clare - Proposed Catchment Layout																									
S																									
SA	1		200	10.8	1.472	30	5	7	750	O	24.5	26.5	2.0	0.4	1	375	0.6	1	375	0.6	1	375	0.7	1	375
SA	2		50	0.5	0.000	0	5	5	2/600	O	3.0	5.0	2.0	0.4	1	525	0.6	1	600	0.6	1	600	0.7	1	600
TPA	1		75	40.0	3.460	0	5	6	2/300	O	43.5	45.0	1.5	0.9	1	375	1.2	1	375	1.3	1	375	1.5	1	450
TPA	2		150	5.8	1.404	30	5	8	375	,C	13.5	14.9	1.4	1.3	1	600	1.7	1	600	1.8	1	675	2.1	1	675
TPA	3		70	0.5	3.336	20	10	22	0	O	5.3	6.8	1.5	1.7	1	825	2.2	1	1050	2.4	1	1050	2.8	1	1050
TPA	4		60	1.2	1.812	10	7	14	0	O	5.0	6.7	1.7	1.9	1	900	2.5	1	1050	2.8	1	1050	3.3	1	1200
TPB	1		40	7.5	17.216	0	8	16	?	O	13.5	15.0	1.5	1.7	1	600	2.5	1	675	3.4	1	750	4.2	1	825
TPB	2		40	3.8	2.000	30	5	10	?	O	10.5	12.0	1.5	2.1	1	750	3.1	1	825	3.8	1	900	4.6	1	1050
TPB	3		90	3.9	0.000	50	5	5	?	O	9.0	11.0	2.0	2.1	1	750	3.1	1	825	3.8	1	900	4.6	1	1050
TC	1		90	27.8	1.036	0	5	5	375	O	38.5	40.0	1.5	0.3	1	375	0.4	1	375	0.4	1	375	0.5	1	375
TC	2	TPB	35	22.9	1.608	20	5	6	?	O	13.5	15.0	1.5	0.8	1	375	1.0	1	375	1.1	1	450	1.2	1	450
TPB	4		45	1.6	0.828	50	5	10	?	O	5.5	7.0	1.5	3.1	1	1050	4.2	1	1050	5.1	1	1200	6.1	1	1200
TPB	5		50	0.8	0.280	50	5	9	1200	O	4.8	6.7	1.9	3.2	1	1050	4.3	1	1200	5.2	1	1350	6.2	1	1500
TPB	6	TPA	10	1.0	0.408	50	5	10	OPEN	S D9	4.4	5.8	1.4	3.3	1	1200	4.5	1	1200	5.3	1	1350	6.4	1	1500
TPA	5		60	1.7	0.000	50	5	5	OPEN	O	4.3	5.7	1.4	5.1	1	1200	7.0	1	1350	8.1	1	1350	9.7	1	1500
TE	1	TPA	30	2.3	1.708	20	5	11	?	O	4.0	6.0	2.0	0.3	1	375	0.5	1	450	0.5	1	525	0.6	1	525
TPA	6		35	1.1	0.000	0	5	5	OPEN	S D8	3.3	5.4	2.1	5.4	1	1350	7.4	1	1500	8.6	1	1650	10.3	1	1650
TF	1	TPA	60	6.8	1.000	50	5	7	0	O	7.0	9.0	2.0	0.4	1	375	0.4	1	375	0.5	1	375	0.5	1	375
TPA	7		60	1.2	1.140	50	6	12	OPEN	S D7	2.9	4.8	1.9	6.0	1	1350	8.1	1	1650	9.4	1	1650	11.2	1	1800
TG	1	TPA	140	6.3	1.132	50	5	7	0	O	11.0	13.0	2.0	0.4	1	375	0.5	1	375	0.5	1	375	0.6	1	450
TH	1		65	15.4	0.520	50	5	5	375	O	13.6	15.0	1.4	0.2	1	375	0.2	1	375	0.3	1	375	0.3	1	375
TH	2	TPA	50	2.8	1.860	50	5	11	375	O	3.6	5.0	1.4	0.8	1	525	0.9	1	600	1.0	1	600	1.1	1	600
TPA	8		20	5.0	1.328	50	5	8	900+3/600	S D6	2.2	4.1	1.9	7.5	1	1350	9.9	1	1650	11.4	1	1650	13.4	1	1800
TPA	9		40	2.8	2.960	20	6	13	1850	S D4	1.2	3.6	2.4	7.9	1	1350	10.5	1	1650	12.1	1	1650	14.3	1	1800
TPA	10		40	0.5	0.000	0	5	5	3/1350	O	0.1	2.0	1.9	7.9	1	1500	10.5	1	1800	12.1	1	1800	14.3	3	1350
TPA	11		50	0.8	2.912	30	9	18	OPEN	S D3	0.0	1.6	1.6	8.3	1	1650	11.0	1	1800	12.7,	1	1800	15.0	3	1350
TPA	12		20	0.5	0.000	0	5	5	3/1050	S D2	-0.4	1.4	1.8	8.3	1	1650	11.0	1	1800	12.7	1	1800	15.0	3	1350
TPA	13		50	0.5	4.712	50	12	24	OPEN	S D1	-0.4	1.4	1.8	9.2	1	1650	12.0	1	1800	13.9	3	1350	16.3	3	1500
UA	1		85	4.7	1.100	50	5	8	?	C,O	4.6	6.5	1.9	0.4	1	375	0.5	1	375	0.5	1	375	0.5	1	375
UA	2		10	1.0	1.364	50	6	14	?	C,O	0.6	2.5	1.9	0.7	1	675	0.9	1	675	1.0	1	675	1.1	1	750
VA	1		70	0.5	0.364	50	5	11	?	O	0.5	2.5	2.0	0.1	1	375	0.1	1	375	0.1	1	375	0.2	1	375
WA	1		55	0.5	0.668	50	6	14	?	O	0.1	1.5	1.4	0.2	1	375	0.2	1	375	0.2	1	375	0.3	1	450

APPENDIX B
HYDRAULIC GRADE LINE RESULTS

HEC RESULTS

A) WEND CATCHMENT	XS	DIST (m)	H (mAHD)	Q (m3/s)
	1	0	1.50	23.4
	2	75	1.58	19.5
Brisbane Water Drive Height			1.59	
	3	15	1.60	19.5
	4	100	1.90	18.2
	5	65	2.13	17.8
	6	70	2.46	17.0
	7	55	2.68	16.6
	8	35	2.77	10.7
	9	60	3.61	10.5
Priestley Pde Height			6.30	
	9.1	20	4.72	10.5
	-8	0	2.77	10.7
	10	1	2.79	4.7
	11	40	3.36	4.7
Wendy Drive Height			4.98	
	12	20	4.95	4.3
	13	50	4.96	4.3
Coolam Ave Height			5.84	
	13.1	20	4.98	4.3

B) GIRR CATCHMENT	XS	DIST (m)	H (mAHD)	Q (m3/s)
	0.9	0	6.19	10.3
Brisbane Water Drive Height			6.57	
	1	20	6.29	10.3
	2	80	7.46	9.7
	3	60	8.52	9.2
	4	40	9.27	8.9
	5	40	10.29	8.6
	6	35	10.95	3.9
Northwind Ave Height			13.78	
	7	30	11.80	3.2
	8	50	13.06	2.1
	9	70	14.43	1.7
	10	30	15.88	1.4

C) TAKA CATCHMENT	XS	DIST (m)	H (mAHD)	Q (m3/s)
	0.9	0	2.36	3.8
Brisbane Water Drive Height			4.32	
	1	23	5.59	3.8
	2	50	5.80	3.4
	3	60	5.95	2.9
	4	95	7.84	2.4
	5	80	12.92	1.9

D) MELA CATCHMENT (Existing)	XS	DIST (m)	H (mAHD)	Q (m3/s)
	1	0	1.50	16.7
Victory Pde Height			1.28	
	2	15	1.53	15.4
	3	55	1.65	15.4
Brisbane Water Drive Height			2.29	
	4	70	6.69	14.7
	5	10	6.69	14.3
Glenrock Pde Height			4.28	
	6	15	6.69	13.8
	7	60	6.69	11.6
	8	55	6.69	10.4
	9	50	6.69	10.0

D) MELA CATCHMENT (Future) (with Retarding Basin)	XS	DIST (m)	H (mAHD)	Q (m3/s)
	1	0	1.50	16.7
Victory Pde Height			1.28	
	2	15	1.86	15.4
	3	55	1.92	15.4
Brisbane Water Drive Height			2.29	
	4	70	3.47	14.7
	5	10	3.48	14.3
Glenrock Pde Height			4.28	
	6	15	3.60	13.8
	7	60	4.09	11.8
	8	55	4.82	10.4
	9	50	5.86	10.0

End of Report