APPENDIX G

WATER MANAGEMENT REPORT - REZONING AND DEVELOPMENT APPLICATION STAGE

By Patterson Britton and Partners Pty Ltd

SEAFORTH MAC PTY LTD

WARRIEWOOD VALLEY
11,13 & 15 ORCHARD STREET
(*PART OF SECTOR 10*)

Water Management Report
Rezoning & Development Application Stage

Issue No. 1
NOVEMBER 2003

Patterson Britton
& Partners Pty Ltd
consulting engineers

SEAFORTH MAC PTY LTD

Warriewood Valley
11, 13 & 15 Orchard Street
(*Part of Sector 10*)

Water Management Report
Rezoning & Development Application Stage

Issue No. 1
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level 2
104 Mount Street
North Sydney 2060

PO Box 515
North Sydney 2059
Australia

telephone: (02) 9957 1619
facsimile: (02) 9957 1291
reception@patbrit.com.au
ABN 89 003 220 228

Newcastle Office
8 Telford Street
Newcastle East 2300

PO Box 668
Newcastle 2300
Australia

telephone: (02) 4928 7777
facsimile: (02) 4926 2111
mail@newcastle.patbrit.com.au

Patterson Britton & Partners Pty Ltd
consulting engineers

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1 INTRODUCTION

The proposed development site (*11, 13 & 15 Orchard Street, Warriewood Valley*) is part of Sector 10 and is included within the Warriewood Valley Urban Release Area, which has been released for urban purposes by the then Minister for Planning.

The site has a total area of approximately 1.66ha and has access from Orchard Street at Warriewood. The site is at the foothills of the Warriewood Escarpment and is bounded by a private accessway to the east, private property to the north, bushland to the west and Irrawong Reserve to the south (*refer to **Figure 1** for details*). No creeks or major overland flow paths currently traverse the site, although Mullet Creek exists in proximity to the southern border of the site.

Patterson Britton & Partners *(PBP)* have been engaged by Ingham Planning on behalf of Seaforth Mac Pty Ltd to prepare a Water Management Report (*WMR*) relating to the impacts of the proposed development on water management issues. These issues include long-term hydrologic assessment *(water balance)*, water quality assessment, flood attenuation, floodplain management and stormwater quantity management.

This report has been prepared for the Rezoning and Development Application stages of the overall development process.

The Water Management Report has been prepared in accordance with Pittwater Council's publication "*Warriewood Valley Urban Land Release – Water Management Specification*" *(February, 2001) (WMS)*.

A completed copy of the "*Documentation Checklist – Development Application*", confirming that all tasks required by Council's WMS have been undertaken, is found at **Appendix A**.

1.1 CERTIFICATION

The contents of this report are certified by Mark Tooker, who is a registered NPER engineer with the Institution of Engineers, to comply with the requirements of Pittwater Council's Water Management Specification (*February 2002*).

2 EXECUTIVE SUMMARY

2.1 WATER MANAGEMENT APPROACH

Pittwater Council's Warriewood Valley Water Management Specification *(2001)* (*WMS*) requires that for the overall development:

- peak runoff flow rates do not exceed existing values;
- average annual runoff volume after development be reduced to approach the existing values; and
- average annual pollutant load in runoff after development does not exceed existing values.

In adherence to the above, PBP have incorporated the principles of Water Sensitive Urban Design (*WSUD*) and Ecologically Sustainable Development (*ESD*).

The development, therefore, has been designed with a water management strategy which incorporates stormwater detention *(to reduce localised peak runoff flow rates),* on-site retention, reuse and infiltration *(to reduce runoff volumes)* and pollutant removal devices *(to reduce pollutant load).*

2.2 PROPOSED DEVELOPMENT

The development proposal is shown in **Figure 1**. The proposal includes the provision of 16 residential lots with associated water management infrastructure.

2.3 WATER CYCLE ASSESSMENT

A detailed water cycle assessment has been undertaken for the proposed subdivision to analyse the interaction between runoff volumes, stormwater re-use and subsoil infiltration for a range of development scenarios over a 4 year historical rainfall period (*1995 to 1998*).

The inhouse water balance programme utilised in this assessment uses a dynamic analysis to represent the sites stormwater losses and gains. The programme is a daily rainfall model, which accounts for all inputs and outputs within a closed system.

Inputs to the system include:

- rainfall; and
- potable water supply.

Outputs to the system include:

- interception;

- depression storage;
- soil moisture storage;
- infiltration;
- internal reuse; and
- evapotranspiration.

The water balance model offers the analysis of a combination of the following variable factors:

- impervious and pervious areas;
- forested areas;
- infiltration basins;
- rainwater collection tanks;
- internal reuse of collected rainwater; and
- irrigation of pervious areas with collected rainwater.

The water balance used for the site is an updated version of the water balance programme used for the Stockland development within Sector 10 (*considering 11,13 & 15 Orchard Street in isolation*), improved to account for tank volume limits, tank overflow, specific infiltration systems and to trigger irrigation only when it is required. Field parameters (*ie DRI test results*) collected specifically for this site were used in the analysis.

The water balance assessment revealed that without introduction of specific stormwater retention facilities, the volumetric runoff co-efficient for the proposed sub-division would increase from 0.24 to 0.56. With the introduction of the proposed rainwater tanks (*6.3KL per lot*), internal reuse (*toilet flushing*) and external reuse (*irrigation*) of the collected rainwater for each lot, the proposed bio-retention basin and allotment scale Atlantis cell infiltration systems (*average 606m^3 in total*), the volumetric runoff co-efficient for the sub-division is reduced back to 0.23.

This means that the proposed facilities enable achievement of a post development volumetric runoff co-efficient that is comparable to existing conditions.

2.4 WATER QUALITY ASSESSMENT

A water quality monitoring plan has been formulated in accordance with Council's Water Management Specification, to develop an understanding of the runoff water quality from the site following development. Baseline data to compare the proposed conditions runoff quality with that of the pre-development state has already been gathered as part of the Stockland development.

No waterbodies currently exist within the subject site to enable pre-development water quality sampling, however following development, monitoring will be undertaken within the constructed piped drainage system. The selected internal monitoring location is at the most downstream point of the site prior to discharge into Mullet Creek.

The closest waterbody to the site is Mullet Creek, which as part of the Stockland development has already been monitored and continues to be monitored for water quality (*dry and wet*), bed sediment quality and biological quality.

2.5 WATER QUALITY MANAGEMENT

2.5.1 Construction Phase

During the construction phase, sediment and erosion control facilities will be designed and installed in accordance with the Council's specifications and the requirements of the publication *"Managing Urban Stormwater – Soils and Construction" (Dept. of Housing, 1998).*

2.5.2 Post Development Phase

The proposed piped drainage system from the subject site will ultimately discharge to Mullet Creek. The primary control of stormwater runoff quality before it is discharged into this waterway is the below ground GPT and bio-retention basin proposed to be sited in Lot 16.

Further reduction in pollutant loads will also result from the proposed implementation of other water quality measures. These measures include:

- Atlantis infiltration systems (*average volume of 606m^3 in total*);
- Large Atlantis purification units to be used at all inlets to the proposed infiltration systems;
- Rainwater tanks (*6.3kL per lot*) which reduce runoff volumes and hence pollutant loads; and
- Maximisation of the infiltration potential as a result of the site coverage requirements for pervious surfaces.

2.6 STORMWATER QUANTITY MANAGEMENT

2.6.1 Flow/Volume Management

The integrated strategy proposed for management of stormwater runoff quantity on the site is comprised of:

- source control which includes:
  - use of rainwater tanks (*6.3 m^3/lot (**88.2m^3**), of which 25% is counted as effective OSD storage – **22.1m^3***) to reduce runoff volume, maximise non-potable supply/re-use and minimise peak flows discharging from individual allotments;
  - minimising impervious surfaces (*limited to 50% site wide*) to maximise infiltration potential and reduce runoff volumes;
  - the use of landscaping which encourages the maximisation of infiltration.

- the conveyance system which includes:
  - the proposed 20yr ARI piped drainage system (*effective detention storage volume = 30m³*) to reduce peak flow rates in events between the 20yr and 100yr ARI events;

- the bio-retention basin which includes approximately **350m³** of storage for capture of first flush events only;

- formal stormwater detention facilities to be incorporated at the downstream area of each lot which includes:
  - the proposed "Atlantis Tank" on site detention system (*also utilised for infiltration purposes*) to provide a total detention volume of 366m³/ha or **606.2m³** at a PSD of 225L/s/ha or 232.2L/s for the entire subdivision.

Event based hydrologic modelling undertaken for the site indicates that peak runoff rates at the downstream point of the site do not increase above existing values for all storm events and durations when utilising the above detention volume (*606.2m³*) and permitted site discharge (PSD).

In total, **1008.3m³** (*or 607.4m³/ha*) of effective stormwater detention storage is proposed. This exceeds Council's requirement of 366m³/ha.

2.6.2 Flood Management

Existing 100yr ARI and PMF flood extents are illustrated on **Figure 5**. The proposed development is sited well clear of the floodwaters for both of these events. Hence, all habitable floor levels will be sited clear of both the 100yr ARI and PMF events.

Major overland flows are proposed to be conveyed via the roadway to the east of the site directly to Mullet Creek (*ie not through Sector 10*).

Flood evacuation to PMF free ground is available to all lots of the proposed development.

No interim flood protection measures are required for this site due to its position in the upper catchment areas of Warriewood Valley (*ie no development allowed upstream of the site*).

2.7 STORMWATER DRAINAGE CONCEPT PLAN

The elements of the proposed Stormwater Drainage Concept Plan are presented in **Figures 1-5**.

All flows generated as runoff are proposed to be directed to rainwater tanks, detention and infiltration infrastructure sited at the downstream end of each lot. An interallotment drainage line (*20yr ARI capacity*) is proposed along the eastern boundary of the site to service all lots. This line eventually delivers all piped flows to the proposed bio-retention basin located in Lot 16.

Runoff water quality from the site is primarily managed through the proposed bio-retention basin and GPT to be sited in Lot 16, although additional stormwater quality treatment will be provided by the following measures:

- Atlantis infiltration;
- Large Atlantis purification units to be used at all inlets to the proposed infiltration systems;
- Rainwater tanks (*6.3kL per lot*) which reduce runoff volumes and hence pollutant loads; and
- Maximisation of the infiltration potential as a result of the site coverage requirements for pervious surface.

It has been estimated that the pollutant loads discharging from the site as a whole will be lower than for the existing site conditions, making a substantial contribution to long-term improvements in receiving water quality (*ie in Mullet Creek*).

Both runoff peaks and runoff volumes will not be greater than existing values based on implementation of the proposed water management systems for 11, 13 & 15 Orchard Street.

3 WATER CYCLE ASSESSMENT

3.1 WATER CYCLE ASSESSMENT OVERVIEW

This water cycle assessment addresses the issue of runoff volume. This section indicates how the quantitative assessment has been undertaken to demonstrate a reduction in the post development runoff volume for 11, 13 & 15 Orchard Street back to existing conditions.

An assessment of the water cycle of 11, 13 & 15 Orchard Street was carried out to ascertain the impact of proposed development on runoff volume and baseflow. The existing water cycle was used as a basis of comparison for two development scenarios. The first scenario explored the impact of development where minimal management practices were introduced. The second scenario compares existing conditions with the proposed development layout where a suite of water management practices are proposed.

There are three types of flow that have been investigated for each case:

- baseflow and interflow;
- pervious surface area runoff; and
- impervious surface runoff.

Within the development area, there are differing levels of contribution from each of these sources. To predict the relative contributions, an inhouse long-term water balance program (*developed by Patterson Britton based on Boughtons model*) was developed to calculate the various flow volumes. Development was represented by an increase in the impervious fraction. Losses considered included infiltration, evaporation, transpiration, interception and manmade storage. The timeframe for the model input is 4 years (*1995 to 1998 inclusive*).

The site sub catchment proposed in the development area generally mimic the sub catchment under existing conditions. As such, the relative flow distribution to downstream areas is maintained in the development.

Details of the water cycle assessment are included in **Appendix B**. The following sections describe the steps in the analysis.

3.2 REVIEW OF WATER CYCLE AND PBP WATER BALANCE MODEL

During the initial stages of precipitation, a small proportion of rain falling upon impervious areas evaporates. Water stored in depressions following rainfall also evaporates. These two forms of rainfall loss have been combined as paved area depression storage.

During the course of precipitation, the canopy of trees and other vegetation intercepts some of the initial rainfall before it reaches the ground. This phenomenon is known as interception. When the interception capacity is exceeded, water will drip to the ground (*through fall*) and run down the tree trunks (*stem flow*). The water captured by the interception storage of the vegetation is evaporated. The amount of precipitation lost to interception can be significant. Fetter (*1994*) suggests dense forests can intercept 8% to 35% of annual precipitate while Kuczera (1996) suggests interception loss accounts for about 10% - 20% of above canopy rainfall of a eucalypt forest.

Rainfall that reaches the pervious areas from direct precipitate, through flow and stem flow can infiltrate into the soil. The amount infiltration is dependent upon the type of soil, the degree of saturation (*antecedent moisture condition*) and the intensity of rainfall. When precipitation exceeds the infiltration capacity of the soil, puddles may form and runoff can occur. The amount of water trapped as puddles is termed depression storage.

Many models have been developed to determine the rate of infiltration of various soils. Generally however, these models provide infiltration capacities that vary hourly (*or more frequent*) as the moisture level of the soil increases. While these models provide an accurate representation of infiltration they are not applicable to daily rainfall records. Given daily precipitation records, it is not know whether any particular rainfall depth occurred during a single event lasting less than an hour or by several small events evenly spaced over a 24 hour period. Traditional models, while defining the amount of infiltration entering a soil column, do not differentiate between deep infiltration to groundwater and infiltration to the capillary or root zone. While not significant in terms of runoff volumes, this has a large influence on determining the amount of irrigation required to sustain vegetation, and the amount of water available to recharge aquifers. For these reasons, a soil storage model was developed to replace the traditional infiltration model.

The conceptual infiltration model, *(refer to* **Diagram 1***)*, refers more to the moisture content of the soil rather than any physical water elevation. At any time the "moisture level" of the soil is dependent upon four variables, precipitation, irrigation, evapotranspiration and deep infiltration.

Both precipitation and irrigation will have the effect of increasing the moisture level, while deep infiltration and evapotranspiration will decrease the moisture level. As the moisture level decreases, a level will be reached where plants will begin to wilt. At this level, irrigation is necessary and will be applied until a satisfactory moisture level is restored. If however, precipitation and/or irrigation increase the moisture level to beyond that of the capillary zone, deep infiltration will occur and water will be lost to the aquifer. If precipitation and/or irrigation continues, the soil will become saturated and runoff will result.

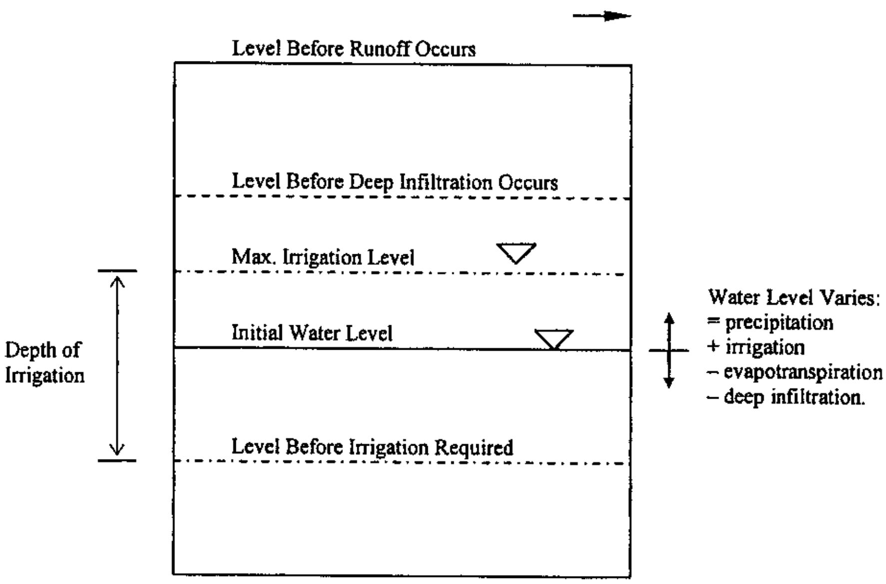

Diagram 1 – Soil Water Balance.

3.3 PHYSICAL CATCHMENT CHARACTERITICS

The site (*11, 13 & 15 Orchard Street*) has a total area of 16,566m^2 and is situated in the upper slopes of Sector 10. The site subcatchment is characterised by moderate to steep slopes of approximately 19%.

The existing landuse of the site is classified semi rural/forest. For the purposes of this study it was conservatively assumed that the site contained 5% impervious surfaces under existing conditions. The adopted percentage impervious fraction for the post development scenario was 50% (*in accordance with Councils Water Management Specification*).

The water cycle assessment has been based on the total site area of 16,566m^2. Based on the relatively homogeneous properties of the site, a single node was used for the water balance calculations.

3.3.1 Subsurface Conditions

Details of the Sector 10A subsurface conditions are described in the September 2003 report by Jeffery & Katauskas Pty Ltd, which is included in **Appendix E**. In total, nine boreholes were excavated and three Double Ring Infiltrometer (*DRI*) tests were carried out.

Jeffery & Katauskas (*J&K*) describe Sector 10A as being "*at the boundary between an area of deep alluvial deposits and shallow sandstone bedrock* ". A summary of the J&K site subsurface profiles is as follows (*refer to Figure 1 of the J & K report for borehole locations*):

- topsoil/fill was generally encountered between 0.1m to 0.2m depth;
- fill was encountered in BH's 3, 4, 5 and 6 and consisted of silty sand and gravely sand. The fill extended to depths of between 0.5m in BH3 to 1.5m in BH6;
- natural soils consisting of interbedded clayey and sandy soils were encountered across the site and extended to depths of between 0.5m and greater than 4.5m (*BH5 and 6 terminated in soils without encountering bedrock*). In general the clayey soils were very stiff to hard strength, while the sandy soils were loose to medium dense relative density. However, in BH5 between 1.4m and 2.6m depth the clayey sand/sand clays were of soft strength and very loose relative density;
- with the exception of BH5 and 6, sandstone bedrock was encountered in all other boreholes at inferred depths ranging from between 0.5m to 3.7m. In general, the sandstone bedrock was extremely weathered and of low strength when first encountered but quickly gained strength with depth. In BH's 5 and 6 the boreholes were terminated within the alluvial soils at 4.5m depth without encountering bedrock;
- With the exception of BH5 all boreholes were dry on completion of drilling. In BH5 seepage was encountered at a depth of 3.5m while on completion it had collapsed to 1.8m suggesting that this may be the depth of the groundwater table at this location.

3.3.2 Infiltration

Infiltration rates were also reported by J&K.

Three Double Ring Infiltrometer (*DRI*) tests were completed adjacent to BH 2, 5 & 9 (*distributed evenly across site*). Tests were carried out at the surface level to provide an estimate of existing near surface infiltration characteristics.

Infiltration rates near the surface were reported to be "*relatively low*"(J&K) corresponding with the observed nature of soil throughout the site (*ie high percentage of fines*). Below are the details of the measured permeability of soils at the three tested locations:

Test Pit	Depth Tested (m)	Co-Efficient of Permeability (K) (cm/s)	Co-Efficient of Permeability (K) (mm/h)
2	At surface	3×10^{-4}	10.8
5	At surface	3×10^{-4}	10.8
9	At surface	4×10^{-3}	144

Continuing storm loss rates derived from NSW gauged catchments (*ARR1987-Table 6.1*) and infiltration loss parameters utilised by G. O'Loughlin (ILSAX) were referenced for comparison to the DRI test results. From NSW catchments of similar size to Sector 10, mean loss rates ranged from 2.9mm/h to 17.0mm/h (*accounts for all continuing losses not just infiltration*). Final infiltration rate losses for class A(1) soils (*soils consisting of sand and gravel*) are reported by G. O'Loughlin to be approximately 25mm/h.

Borehole falling head test results (*an indicator of infiltration capacity with depth*) for the adjacent (*downstream*) Sector 12 yielded values ranging from 9mm/day to 43mm/day.

It is evident that the DRI test results far exceed typical published values (*even for sites exhibiting good infiltration*) and are not representative of site wide infiltration rates as they do not account for reduction in infiltration capacity with depth. It would therefore be unrealistic to adopt them to simulate infiltration over the entire site during a storm event. Hence, for consistency with the previous Stockland Sector 10 assessment and based on average antecedent moisture conditions (*not dry as per the DRI testing conditions*), consideration of a reduction in capacity with depth and scaling effects, a value of 100mm/day was adopted. Considering the high measured DRI values, this rate is considered more than achievable in the post development scenario for the proposed infiltration measures.

No data was recorded for deep infiltration rates at both the Bubalo and wider Sector 10 site. Hence, a value typical of similar sites was adopted (*8mm/day*). This value yielded a volumetric runoff co-efficient that would be expected for a site under non developed conditions.

3.4 RAINFALL DATA

Daily rainfall data was compiled for the year's 1995 to 1998. The data was obtained from the Bureau of Meteorology for the rainfall gauge closest to the site (Ingleside *66183).* The period from 1995 to 1998 was selected as it contains the full range of average, wet and dry years.

The average annual rainfall depth for the area between 1995 to 1998 was 1463mm. The long term average for the region is approximately 1230 mm/yr. Hence, the period analysed was wetter than average.

3.5 EVAPOTRANSPIRATION DATA

Monthly average point potential evapotranspiration values were obtained from the BOM publication titles "*Climatic Atlas of Australia – Evapotranspiration*" 2001 and converted to daily evaporation rates to be used in the evapotranspiration component of the water cycle analysis.

3.6 WATER CYCLE FLOW GAUGING

No flow gauging has been undertaken for calibration of the water balance assessment as there is no waterbody or major overland flow path on the site.

The proportion of total runoff predicted in the PBP water cycle model is consistent with published data on gauged catchments and the hydrologic NAM model constructed for Council by Lawson and Treloar in the "*Integrated Water Management Strategy (IWMS) – Warriewood Valley*" *(November 1997).*

3.7 WATER CYCLE ASSESSMENT RESULTS

3.7.1 Existing Conditions

The results indicated that 23% of total rainfall was converted to runoff for existing conditions (*refer to **Appendix B1** for a detailed summary*).

The average annual volume of runoff from impervious surfaces was 1,211 m^3.

The average annual volume of pervious surface runoff (*including the forested areas*) was 4,461m^3.

The total volume of infiltration was 3,380 m^3.

The total runoff as a percentage of total rainfall (23%) is slightly lower than the percentage calculated in the IWMS (36%), however considering that the IWMS model (*NAM*) simulated a 10 year period of rainfall for a much larger area with likely lower average infiltration rates than Sector 10, the result is considered acceptable.

3.7.2 Post Development – No Water Management Practices

The results indicated that 60% of total rainfall was converted to runoff for the post development conditions without introduction of specific water volume reduction measures (*refer to **Appendix B2** for a detailed summary*).

The average annual volume of runoff from impervious surfaces was 12,116 m^3.

The average annual volume of pervious surface runoff was 2,360 m^3.

The total volume of infiltration was 1,790 m^3.

3.7.3 Post Development – Introduction of Water Management Practices

Water management practices proposed to reduce the surface runoff volume include:

- construction of Atlantis infiltration tanks/lot;
- construction of major bio-retention basin;
- Installation of 6.3kL rainwater tanks/lot;
- maximisation of the infiltration potential for all pervious areas on site.

Refer to **Figure 3** for an illustration of the proposed rainwater tank and Atlantis cell infiltration systems. **Appendix D** contains details of the proposed Atlantis cell tanks and proposed purification units.

It was assumed that all pervious areas of the proposed lots would be subject to irrigation when required, only roof area runoff was directed to each rainwater tank and rainwater captured in each tank was used internally for toilet flushing at a rate of 135.25L/house/day and externally for irrigation (*average rate required was 315.6L/house/day*). Both these reuse rates compare well with NSW Planning's measured rates of domestic water use for detached dwellings (*average occupancy rate = 3.06 people per dwelling*). Refer to **Table 1** for details.

The results of the water balance indicated that 23% of total rainfall was converted to runoff for the post development conditions with the introduction of the above mentioned measures (*refer to **Appendix B3** for a detailed summary and full printout of the water balance calculations*).

The average annual flow volume to the rainwater tanks was 7,268m^3, total reuse demand was 2,112m^3, 739m^3 of domestic water was required and 5,906m^3 spilled to the infiltration systems.

The average annual flow to the infiltration systems was 12,009m^3 (*rainwater tank overflow, irrigated area overflow, and impervious area not directed to the tanks*).

The total volume of infiltration was 10,278 m^3.

Introduction of the proposed water management practices reduces the fraction of runoff from 60% to 23% of the total rainfall, which is equivalent to the runoff rate for existing conditions.

Table 1- NSW Planning Measured Water Use Rates

Occupancy Rate = 3.06													
Internal	**End Use**	**Calculated Usage L/person/d**	**Proportion of total water use**	**Best Practise Feature**	**Reduction – if possible**	**Reduction L/person/d**	**Reduction as a % of total use**	**Score**	**Second Reduction Feature**	**Reduction if possible**	**Reduction L/person/d**	**Reduction as a percentage of total use**	**Score**
a	Kitchen Sink	11.8	4.6%	Flow Regulator	50%	5.9	2%	2					
b	Bathroom Basin	6.9	2.7%	Flow Regulator	50%	3.4	1%	1					
c	Laundry Trough	7.9	3.1%	N/A	0%	0.0	0%	0					
d	Bath	8.8	3.4%	N/A	0%	0.0	0%	0					
e	Shower	55.9	21.8%	AAA-rated Shower head	55%	30.8	12%	12					
f	Toilet	44.2	17.2%	6/3 L Dual Flush	67%	29.6	12%	12	Flush Arrestor	17%	7.5	3%	3
g	Washing Clothes	40.2	15.6%	AAA rating best practice front loading washing machine	63%	25.4	10%	10	AAA rating top loading washing machine	25%	10.1	4%	4
h	Washing Dishes	1.9	0.7%	Current AAA-rated dishwasher	64%	1.2	0%	0	1993-96 Model Dishwasher	42%	0.8	0%	0
TOTAL INDOOR		**177.5**	**69.0%**										
External													
j	Garden Irrigation	72.5	28.2%	Controlled Irrigation System with Moisture Sensor	50%	36.2	14%	14	Tap Timer	20%	14.5	6%	6
k	Car Washing	2.3	0.9%	Bucket Washing	44%	1.0	0%	0					
l	Swimming Pool	4.8	1.9%	Pool Cover	50%	2.4	1%	1					
TOTAL OUTDOOR		**79.6**	**31.0%**										
Service													
m	Cooling Towers	257.1	0%										
	TOTAL	**257.1**	**100.0%**										

4 WATER QUALITY ASSESSMENT

4.1 SECTOR 10 MONITORING PLAN OBJECTIVES

Prior to urbanisation of Sector 10, a monitoring plan was developed for Stocklands in accordance with Council's Water Management Specification (*February 2001*) and AS/NZ 5667.6: 1998 "*Water Quality Sampling – Guidance on Sampling of Rivers and Streams*". The Stocklands monitoring plan was developed based on a sector wide approach and hence incorporates 11, 13 & 15 Orchard Street.

The objectives of the monitoring plan are to:-

- develop an understanding of the existing conditions present in the waterways within and adjacent to Sector10;
- continually assess the quality of these waterways during the construction phase of Sector 10; and
- assess the impact of constructed water quality measures following construction to ensure the development is ecologically sustainable.

Monitoring undertaken prior to the development of Sector 10 has been used to establish the pre-development quality of the waterways within and adjacent to Sector 10 (*termed "baseline data"*). This data will be compared with future results to determine whether pollution controls are operating adequately and if the water quality is improving.

During the development stage of 11, 13 & 15 Orchard Street, implementation of the monitoring plan will also allow early detection of any adverse impacts likely to risk the health of the public or the quality of downstream waterways such as Mullet Creek and Warriewood Wetlands.

4.2 SCOPE OF MONITORING PLAN

All of 11, 13 & 15 Orchard Street is proposed to drain directly to Mullet Creek.

4.2.1 Monitoring Locations

The primary waterway that has been selected for monitoring as part of the Stockland monitoring programme is Mullet Creek. This creek receives runoff in part from Sector 10 and then discharges into Warriewood Wetlands. Sampling locations for existing conditions have been selected at the downstream and upstream ends of this creek with relation to Sector 10 (*refer to **Figure 1***).

A third internal sampling site has also been monitored at the discharge point from Sector 10 into Sector 12 (*refer to **Figure 1***).

As part of the post subdivision certificate water quality monitoring programme for the Stocklands owned land, both the inlets and outlets from WQCP1 and WQCP 2 are being monitored.

Currently no water body exists within or immediately adjacent to 11, 13 & 15 Orchard Street.

Following development of 11, 13 & 15 Orchard Street, a new sampling site (IS3) will be added to the Sector 10 monitoring stations at the piped discharge point from 11, 13 & 15 Orchard Street (*refer to **Figure 1***) into Mullet Creek.

4.2.2 Types of Monitoring

The monitoring plan for Sector 10 consists of three main categories:-

- physico-chemical water quality monitoring;
- ecosystem/rapid biological assessment monitoring; and
- riparian sediment toxicant monitoring.

4.2.3 Water Quality Monitoring (*Discrete Sampling*)

The water quality monitoring component of the plan consists of:-

- dry weather sampling undertaken quarterly; and
- wet weather sampling undertaken for at least 3 events (*recording a rainfall depth greater than 20mm over the catchment in a 24 hour period*) spread evenly over the year and sampling throughout the rainfall event (*rising and falling limbs of storm hydrograph*).

Samples are tested for the constituents listed in Council's WMS and reported to conform with Council's specification.

As mentioned above, discrete sampling will also be undertaken at the discharge point of 11, 13 & 15 Orchard Street following construction.

4.2.4 Rapid Biological Assessment Monitoring

Habitat monitoring has been undertaken as part of the Stocklands development in Mullet Creek (*ie. at the location of the water sampling stations*).

As no natural aquatic systems exist on the site (*11, 13 & 15 Orchard Street*), no additional rapid biological assessment will be required.

4.2.5 Sediment Toxicant Monitoring

Sampling and testing of bed sediment has already been undertaken in Mullet Creek as part of the Stocklands development and will be undertaken within the proposed WQCP's following construction.

All sediment samples will be tested for metals, pesticides and oils/greases. Reporting will conform to the Council's specifications.

As no natural waterways currently exist on the site (*11, 13 & 15 Orchard Street*) no additional bed sediment sampling will be required.

4.2.6 SQUID Monitoring

All Stockland constructed stormwater quality improvement devices (*SQUID's*) for Sector 10 are currently being monitored until handover. This includes:

- Measurement of volume/mass of material removed from GPT's and an assessment of its relative composition;
- Discrete sampling at the major inlets/outlets of the proposed WQCP; and
- Qualitative assessment of effectiveness of other proposed water quality control measures (*ie bio-retention swales*)

Following construction within 11, 13 & 15 Orchard Street, the qualitative assessment for Stockland constructed devices will be extended to quarterly inspection of the proposed infiltration tanks within 11, 13 & 15 Orchard Street (*for a 2 year period*) and the proposed bio-retention basin.

4.2.7 Flow Gauging for Monitoring

To assess the magnitude of wet weather events and determine the position of a particular sample within a storm event, both the rainfall depth and flood depth will be recorded. Rainfall depth data will be obtained from the BoM, whilst flood depths will be recorded at the closest available flood gauge to the site (*Garden Street crossing of Mullet Creek*).

The total depth of rainfall experienced during the event will allow PBP to determine if the event sampled will comply with Council's minimum 20mm depth over 24 hours criteria. A sustained length of record of the water levels at Garden Street will allow PBP to determine if the sample has been taken on either the rising or falling limb of the regional storm hydrograph.

4.2.8 Quality Assurance/Measurement Accuracy

All samples collected for the monitoring plan will be tested by a NATA certified laboratory. Copies of all original data testing certificates will be provided along with information detailing the collection and preservation status upon delivery at the laboratory. The laboratory testing detection limits will also be included on all test certificates.

4.3 MONITORING RESULTS

4.3.1 Water Quality Monitoring Results

To date, water samples have been collected for Sector 10 both prior to and during construction. These results are summarised in **Tables 2 and 3** respectively.

4.3.2 Rapid Biological Assessment Monitoring Results

For details of the rapid biological assessment monitoring results for Sector 10 refer to the Stockland water management reports (*DA to sub-division certificate issues*).

4.3.3 Bed Sediment Toxicant Monitoring Results

For details of the bed sediment toxicant monitoring results for Sector 10 refer to the Stockland water management reports (*DA to sub-division certificate issues*).

Table 2– Sector 10 Pre Construction Water Quality Monitoring Results

Parameter	Units	Short-Term Goal	Medium-Term Goal	Long-Term Goal*	15-Sep-99 3:00 PM		21-Sep-99		11-Oct-99 3:30 PM		18-Oct-99 1:30 PM		20-Oct-99 2:30 PM		14-Jun-01 11:30 AM	11 October-01	
					W1US	W1DS	W2US	W2DS	WS3US	WS3DS	WS4US	WS4DS	WS5US	WS5DS	WSI	WS10US	WS10DS
Total rain over 5 days preced. sampling	mm				2.6	2.6	14.8	14.8	2.0	2.0	0.0	0.0	38.0	38.0	7.2	3.2	3.2
Ammonia - N	mg/L	<2.3	<0.3	<0.3	0.039	0.087	0.022	0.060	0.047	0.16	0.031	0.082	0.025	0.042	0.014	-	-
Total Nitrogen	mg/L	SQ	<1.6	1.0	0.953	0.610	0.464	1.08	0.66	1.01	0.50	0.79	0.76	0.49	*1.9*	-	-
NOx	mg/L	NS	NS	NS	0.493	0.020	0.024	0.46	0.22	0.01	0.09	0.01	0.30	0.02	0.79	-	-
Filterable Phosphorous	mg/L	NS	NS	NS	0.014	0.037	0.02	0.07	<0.02	0.08	<0.05	0.079	0.065	0.052	0.069	-	-
Non-Filterable Phosphorous	mg/L	NS	NS	NS	0.006	0.013	0.04	0.06	<0.02	0.11	<0.05	0.12	0.075	0.043	0.071	-	-
Total Phosphorous	mg/L	SQ	<0.1	0.04	0.020	0.050	0.06	*0.13*	<0.02	*0.19*	≤0.05	*0.20*	*0.14*	0.095	*0.14*	-	-
Total Dissolved Solids	mg/L	<1000	<1000	<1000	193	221	184	199	196	210	200	220	180	180	240	-	-
Suspended Solids		SQ	<20	<6	<2	<2	<2	<2	<2	6	2	11	4	4	17	-	-
Turbidity	NTU	SQ	<50	<20	1.4	3.6	2.0	5.0	2.0	6.6	5.6	12	4.7	4.0	8.1	-	-
Faecal Coliforms	cfu/100 ml	<1000	<150	<150	4	*220*	*300*	77	40	29	*530*	14	*690*	*360*	90	-	-
Total Kjeldahl Nitrogen	mg/L	NS	NS	NS	0.46	0.59	0.44	0.62	0.44	1.0	0.41	0.78	0.46	0.47	1.1	-	-
pH	pH unit	6.6-8	6.6-8	6.6-8	7.4	6.8	7.6	7.3	7.0	6.4	7.2	6.7	7.4	6.7	7.4	-	-
Dissolved Oxygen (field)	mg/L	SQ	<90% sat.	<90% s	-	-	-	2.51	5.14	0.26	4.78	0.13	-	1.70	2.0	-	-
Temperature (field)	°C	SQ	SQ	SQ	-	-	-	9.1	21.1	19.1	22.4	20.3	-	17.2	18.1	-	-
Arsenic	ug/L	SQ	50%SQ	50	-	-	-	-	-	-	-	-	-	-	-	<1	<1
Chromium	ug/L	SQ	50%SQ	10	-	-	-	-	-	-	-	-	-	-	-	<1	<1
Copper	ug/L	SQ	50%SQ	2	-	-	-	-	-	-	-	-	-	-	-	1	<1
Lead	ug/L	SQ	50%SQ	1	-	-	-	-	-	-	-	-	-	-	-	<1	<1
Mercury	ug/L	SQ	50%SQ	0.1	-	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1
Zinc	ug/L	SQ	50%SQ	50	-	-	-	-	-	-	-	-	-	-	-	3.8	7.3
Organo chlorine Pesticides (OC)	ug/L	SQ	50%SQ	NS	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Phenols	ug/L	SQ	50%SQ	NS	-	-	-	-	-	-	-	-	-	-	-	<2	<2
Organo phosphate Pesticides (OP)	ug/L	SQ	50%SQ	NS	-	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1
Hardness	mg/L	NS	NS	NS	-	-	-	-	-	-	-	-	-	-	-	80	110
Chlorophyll A	mg/L	15	15	10	-	-	-	-	-	-	-	-	-	-	-	0.001	0.002

Parameter	7 Nov-01 1:17 to 6:21 PM (rising limb)			8 Nov-01 8:26 to 9:07AM (falling limb)			20 Nov-01 3:00PM (rising limb)			21 Nov-01 9:30AM (falling limb)			7 Jan-02 5:00AM (rising limb)			7 Jan-02 5:00PM (falling limb)		
	WSUS (MC2)	WSDS (MC1)	WSIS (MC3)	WSUS (MC2)	WSDS (MC1)	WSIS (MC3)	WSUS 20	WSDS 20	WSIS 20	WSUS 21	WSDS 21	WSIS 21	WSUS 30	WSDS 30	WSIS 30	WSUS 31	WSDS 31	WSIS 31
Total rain over 5 days preced. sampling	17.2	17.2	17.2	21.6	21.6	21.6	41.8	41.8	41.8	67.4	67.4	67.4	21.2	21.2	21.2	21.2	21.2	21.2
Ammonia - N	0.04	0.02	0.01	0.12	0.05	0.03	0.015	0.027	0.026	0.018	0.012	0.047	0.017	0.034	0.24	0.043	0.058	0.28
Total Nitrogen	0.54	0.66	1.34	0.53	0.79	*1.92*	0.42	0.37	0.49	0.58	0.37	0.8	0.84	0.87	*2.5*	0.63	0.62	*2.7*
NOx	0.02	0.03	0.07	<0.01	0.01	0.01	-	-	-	-	-	-	-	-	-	-	-	-
Filterable Phosphorous	0.044	0.05	0.235	0.035	0.031	0.125	<0.02	0.021	0.13	<0.02	0.025	0.11	<0.05	0.062	0.73	<0.05	<0.05	1
Non-Filterable Phosphorous	0.024	0.024	0.184	0.014	0.009	0.1	0.013	0.033	0.112	0.033	0.026	0.08	0.026	0.058	0.06	-	0.06	-
Total Phosphorous	0.074	*0.110*	*0.479*	0.066	0.069	*0.441*	0.033	0.054	0.018	0.035	0.051	*0.19*	0.076	*0.12*	*0.79*	0.066	*0.11*	*1.1*
Total Dissolved Solids	235	248	273	258	270	281	180	200	100	200	200	170	140	140	190	140	180	210
Suspended Solids	3	6	10	4	4	13	<2	<2	12	2	<2	*41*	4	6	*83*	2	2	*120*
Turbidity	5.3	*68.4*	*171.5*	2.1	4.8	12.5	6	4	15	10	4	23	4	5	28	5	5	22
Faecal Coliforms	**3200**	**6400**	**9000**	*550*	**1000**	*990*	*230*	*930*	**4700**	*450*	*530*	**6100**	**5500**	**15000**	**4500**	**2200**	**7500**	*870*
Total Kjeldahl Nitrogen	0.52	0.63	1.27	0.53	0.78	1.91	-	-	-	-	-	-	-	-	-	-	-	-
pH	6.37	6.42	6.84	6.42	6.49	6.89	7.4	6.8	7.4	7.4	6.9	7.3	6.7	6.4	6.6	6.8	6.7	6.7
Dissolved Oxygen (field)	1.4	2.6	1.6	1.0	0.8	1.5												
Temperature (field)	17.47	17.59	16.86	16.39	16.48	15.6	17	17.1	16.5	18	18	17.4	18	19	20.3	17	17.1	17.1
Arsenic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chromium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercury	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Organo chlorine Pesticides (OC)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenols	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Organo phosphate Pesticides (OP)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hardness	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorophyll A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1. Long-Term water quality goals are derived from ANZECC, 1992 guidelines and Councils WMS Table C2 – Feb 2001.
2. Figures in normal case satisfy any long-term water quality goals.
3. Figures underlined achieve the medium-term water quality goal.
4. Figures in *italics* achieve the short-term water quality goal.
5. Figures in Bold do not achieve the short term goal or where SQ is the short term goal
6. Rainfall data obtained from Bureau of Meteorology. Sampling Station – Observatory Hill.
7. NS – Not Specified by Council, SQ – Status Quo

Table 3– Sector 10 Construction Stage Water Quality Monitoring Results

Parameter	Units	During Const.	Short-Term Goal	Medium-Term Goal	Long-Term Goal*	8 Apr-02 (Dry)			17 Apr –02 4:00PM (rising limb)	18 Apr –02 10:00AM (falling limb)	28 May-02 1:30PM (rising limb)		29 May-02 9:00AM (falling limb)		3/7/02 Physical Properties (DRY)		28/10/02 (Dry)		
						Mullet Creek		DS of Internal Creek	DS of Internal Creek	DS of Internal Creek	Mullet Creek		Mullet Creek		Mullet Creek		Mullet Creek		DS of Internal
						WSUS100	WSDS100	S12D1US (ds of IS)	200S12US (ds of IS)	202USS12 (ds of IS)	WS500US	WS500 DS	WS600US	WS600 DS	US	DS	WS700US	WS700DS	WS700IS (ds of IS)
Total rain over 5 days preceding sampling	mm					2.2	2.2	2.2	6.6	13.8	33.6	33.6	47.0	47	0	0			
Ammonia - N	mg/L	NS	<2.3	<0.3	<0.3	0.015	0.12	0.26	0.14	0.21	0.024	0.006	0.045	0.021	-	-	0.19	0.10	0.18
Total Nitrogen	mg/L	<1.6	SQ	<1.6	1.0	0.5	0.7	**12**	**4.0**	7.5	0.67	0.40	1.1	0.48	-	-	0.59	0.54	*5.0*
Nitrate	mg/L	NS	NS	NS	NS	0.094	<0.005	6.3	1.8	5.8	0.025	0.018	0.41	0.064	-	-	0.01	<0.005	3.5
Nitrite	mg/L	NS	NS	NS	NS	<0.005	0.008	2.7	0.22	1.2	<0.005	<0.005	0.015	<0.005	-	-	<0.005	<0.005	0.071
Filterable Phosphorous	mg/L	NS	NS	NS	NS	<0.05	0.09	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	0.027	0.043	<0.02
Non-Filterable Phosphorous	mg/L	NS	NS	NS	NS	<0.05	0.08	0.26	0.49	0.071	<0.05	<0.05	<0.05	<0.05	-	-			
Total Phosphorous	mg/L	<0.1	SQ	<0.1	0.04	<0.05	**0.17**	**0.31**	**0.54**	0.076	<0.05	0.053	0.083	0.063	-	-	0.097	0.17	0.043
Phospahte – Ortho as P	mg/L	NS	NS	NS	NS	0.007	0.021	0.03	0.016	0.009	0.009	0.007	0.014	0.01	-	-	0.014	0.012	<0.005
Total Dissolved Solids	mg/L	NS	<1000	<1000	<1000	-	-	-	-	-	-	-	-	-	-	-			
Suspended Solids		<100	SQ	<20	<6	<2	8	**550**	**570**	17	6	4	14	4	-	-	7	10	40
Turbidity	NTU	NS	SQ	<50	<20	-	-	-	-	-	-	-	-	-	-	-			
Faecal Coliforms	cfu/100ml	<150	<1000	<150	<150	50	40	*420*	**24000**	*850*	<10	<10	**2900**	120	-	-	20	470	<10
Total Kjeldahl Nitrogen	mg/L	NS	NS	NS	NS	0.4	0.7	3.0	2.0	0.5	0.65	0.38	0.68	0.42	-	-	0.58	0.54	1.4
pH	pH unit	NS	6.6-8	6.6-8	6.6-8	-	-	-	-	-	-	-	-	-	7.96	7.2	6.5	6.5	4.9
Dissolved Oxygen (field)	mg/L	NS	SQ	<90% sat.	<90% s	-	-	-	-	-	-	-	-	-	11.7	2.2			
Temperature (field)	°C	NS	SQ	SQ	SQ	-	-	-	-	-	-	-	-	-	8.4	9.0			
Conductivity @25deg C		NS				-	-	0.67	0.43	0.56	0.33	0.30	0.31	0.28	0.4	0.4	0.33	0.37	0.58
Salinity (ppt)		NS													0.18	0.18			
ORP (mV)		NS													110	92			
Arsenic	ug/L	NS	SQ	50%SQ	50	-	-	0.008	-	-	-	-	-	-			<1	<1	-
Chromium	ug/L	NS	SQ	50%SQ	10	-	-	0.016	-	-	-	-	-	-			<1	<1	-
Copper	ug/L	NS	SQ	50%SQ	2	-	-	0.018	-	-	-	-	-	-			<1	<1	-
Lead	ug/L	NS	SQ	50%SQ	1	-	-	0.048	-	-	-	-	-	-			<1	<1	-
Mercury	ug/L	NS	SQ	50%SQ	0.1	-	-	<0.0001	-	-	-	-	-	-			<0.1	<0.1	-
Zinc	ug/L	NS	SQ	50%SQ	50	-	-	0.064	-	-	-	-	-	-			<1	1	-
Organo chlorine Pesticides (OC)	ug/L	NS	SQ	50%SQ	NS	-	-	<0.01 (apart from Dieldrin at 0.051)	-	-	-	-	-	-			<0.01	<0.01	-
Phenols	ug/L	NS	SQ	50%SQ	NS	-	-	<2.0	-	-	-	-	-	-			<2	<2	-
Organo phosphate Pesticides (OP)	ug/L	NS	SQ	50%SQ	NS	-	-	<0.1	-	-	-	-	-	-			<0.1	<0.1	-
Hardness	mg/L	NS	NS	NS	NS	-	-	200	-	-	-	-	-	-			89	100	-
Chlorophyll A	mg/L	NS	15	15	10	-	-	<0.001	-	-	-	-	-	-					
Oil and Grease	mg/L	NS	NS	NS	NS	-	-	<5	-	-	-	-					<5	<5	-

1. Long-Term water quality goals are derived from ANZECC, 1992 guidelines and Councils WMS Table C2 – Feb 2001.
2. Figures in normal case satisfy any long-term water quality goals.
3. Figures underlined achieve the medium-term water quality goal.
4. Figures in *italics* achieve the short-term water quality goal.
5. Figures in Bold do not achieve the short term goal or where SQ is the short term goal
6. Rainfall data obtained from Bureau of Meteorology.
7. NS – Not Specified by Council, SQ – Status Quo

5 WATER QUALITY MANAGEMENT

5.1 CONSTRUCTION PHASE

During bulk earthworks and construction for the proposed development, sediment and erosion control facilities will be designed and constructed/installed in accordance with Council's specifications and with the requirements of the publication "*Managing Urban Stormwater – Soils and Construction*" *(Dept of Housing, 1998).*

A sediment and erosion control plan will be developed for construction which outlines the strategies proposed to prevent excessive pollutant loads being exported from the site in runoff during and immediately following construction.

5.2 POST DEVELOPMENT PHASE

As required in Council's WMS, the objective of the water quality management strategy for the proposed development of the site is to ensure a "*no net increase*" in pollutant loads discharged from the developed site compared to the existing conditions.

The proposed water quality management system for 11, 13 & 15 Orchard Street consists of the following elements:

- the maximisation of pervious areas *(on each development lot)* so as to maximise the infiltration potential;
- use of rainwater storage tanks for reuse in non-potable supply purposes and irrigation;
- use of Atlantis infiltration tanks *(described earlier in this report)*;
- installation of Atlantis Purification Units (*refer to **Appendix D** for details*);
- construction of a below ground GPT; and
- construction of a bio-retention basin

It has been estimated using MUSIC that the pollutant loads discharging from 11, 13 & 15 Orchard Street will be lower than for the existing site conditions, making a substantial contribution to long-term improvements in receiving water quality.

5.2.1 MUSIC

"*MUSIC simulates the performance of a group of stormwater management measures, configured in series or in parallel to form a treatment train.*" In this case, MUSIC has been run on a continuous basis (*6 minute intervals from January 1995 to December1998*), allowing rigorous analysis of the merit of proposed strategies over the long-term.

"*The adoption of a continuous simulation approach is recommended in water quality modelling. This stems from the fact that impacts of poor stormwater quality on aquatic* *ecosystem health are associated with cumulative pollutant loads and frequency of aquatic ecosystem "exposure" to poor water quality. Pollutant loads delivered to receiving waters from many of the small storm events (e.g. of magnitude less than the 3 month ARI peak discharge) can make up in excess of 90% of the annual loads discharged from the catchment.*

The evaluation of the adequacy's of the stormwater management systems is based on a risk-based approach associated with examination of the long-term mean annual pollutant load delivered to the receiving waters.

MUSIC is designed to simulate stormwater systems in urban catchments and have the capability to operate at a range of temporal and spatial scales, suitable for catchment areas from 0.01 km² to 100 km². Modelling time step can range from 6 minutes to 24 hours to match the range of spatial scale.

The model's algorithms are based on the known performance characteristics of common stormwater quality improvement measures. These data, derived from research undertaken by CRCCH and other organisations, represent the most reliable information currently available in our industry" MUSIC Manual, CRC for Catchment Hydrology (*Version 1*) May 2002.

5.2.1.1 Site Sub-Catchment Areas

The MUSIC model has been constructed for the entire 1.66ha area of 11, 13 & 15 Orchard Street.

The impervious fractions adopted were as follows:

- Existing (*total*) 5%
- Post Development Urban (*total*) 50%

5.2.1.2 Rainfall and Evaporation

Rainfall and evaporation data was sourced from the Bureau of Meteorology (*BoM*) for the station at Observatory Hill (*OH*).

Six minute rainfall data was utilised in the MUSIC models for a range of rainfall years representing a mix of average, wet and dry years for the region (*1995 to 1998*). Details of the rainfall records are included in **Appendix F**.

The average annual rainfall depth at OH between 1995 to 1998 was 974mm. The long term average for the region is approximately 1,230 mm/yr. Hence, the historical period assessed was marginally drier than the average.

Evaporation data was extrapolated for the site using the BoM publication titled "*Climatic Atlas of Australia - Evapotranspiration*" (*BoM 2001*).

5.2.1.3 Soil Properties

Table 4 includes a summary of the adopted soil properties used for input into the runoff module of MUSIC. The parameter values adopted were based on those adopted for similar sites and the resultant volumetric runoff coefficients were comparable with published values and that derived in the water balance assessment (*refer to **Section** 3*). It should be noted that the model is "*significantly more sensitive to the accurate definition of the fraction impervious and the selection of simulation time step*" MUSIC Manual (*CRCCH, 2002*).

Table 4 - Adopted MUSIC Soil Properties

Parameter	Existing	Urban
Field Capacity (mm)	200	200
Infiltration Capacity Co-efficient "a" (mm/d)	200	200
Infiltration Capacity Co-efficient "b"	0.65	0.65
Rainfall Threshold for Impervious area (mm/d)	1.0	1.0
Shallow soil area capacity (mm)	NA	NA
Shallow soil area initial storage (%)	NA	NA
Deep soil capacity (mm)	400	400
Deep soil area initial storage (%)	25	25
Groundwater daily recharge rate	0.55	0.55
Groundwater daily drainage rate	0.65	0.65
Groundwater initial depth (mm)	30	30

NA = Not applicable as only the deep soil capacity was used

5.2.1.4 Pollutant Loads

Table 5 includes a summary of the adopted pollutant Event Mean Concentrations (*EMCs*) for the various landuse scenarios. The EMC values are based on values derived from Council's WMS assuming an existing landuse of 50% rural/residential and 50% forest.

Councils EMC values were utilised as the mean value in lieu of the default MUSIC "*mean storm flow pollutant concentrations*" to enure consistency in application of Councils water management specification (*Feb 2001*).

Table 5 - Adopted EMC's

Landuse Scenario	SS (mg/L)	TP (mg/L)	TN (mg/L)
Existing	22.5	0.065	0.66
Urban	100	0.3	1.5

5.2.1.5 Pollutant Reduction Assumptions

The following treatment assumptions were made for the proposed water quality measures:

- Available rainwater tank volume = $6.3m^3$/dwelling. Volume reused for toilet flushing and irrigation (*127L/day/ET*). This will assist in reduction of runoff volume and hence a reduction in pollutant load as the load = runoff volume x EMC;
- GPT's will be used as pre-treatment before swales and achieve the following removal rates:
  - TSS 80%;
  - TN 13%
  - TP 30%
- The available bio-retention systems are as follows:

Node	*Retention Area (m^2)*	*Retention Volume (m^3)*	*Filter Area (m^2)*
Basin	700	350	700

In order to achieve the water quality objectives for all pollutants it is proposed to install a gross pollutant trap and a bio-retention basin. The Bio-retention systems promote the filtration of stormwater through a prescribed filter medium. The filtered flow is collected by an underdrain and is returned to the watercourse. The location of these proposed treatment strategies is shown in **Figure 4**.

5.2.1.6 MUSIC Modelling Results

Table 6 includes a summary of the annual pollutant loads for all three scenarios. Refer to **Appendix F** for MUSIC details.

Table 6 - Estimated Average Annual Runoff Pollutant Loads

Scenario & Catchment	Runoff (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
Existing				
Out	**3.89**	**70**	**0.2**	**2.1**
Cv	**0.24**			

Scenario & Catchment	Runoff (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
Post Development (No Treatment)				
Out	**9.06**	**865**	**2.6**	**13.0**
Increase (%)*	***133%***	***1140%***	***1144%***	***531%***
Cv	**0.56**			
Post Development (With Treatment)				
Out	**3.67**	**22**	**0.2**	**1.5**
Reduction Below Existing (%)	**0.23**	**69%**	**0%**	**29%**

Notes
* Compared with existing

Table 6 shows that the results for the proposed development meet the required objectives for TP and exceeds Council's objective for reduction of SS and TN.

The resultant volumetric runoff co-efficients under both existing and developed conditions (*without measures*) compare well with those derived in the water balance assessment (*refer to **Section** 3*).

5.2.2 Maintenance

The maintenance program for all water quality control measures implemented with 11, 13 & 15 Orchard Street is as follows:

- Periodic *(3 monthly)* inspection and removal of accumulated sediments and trash from the Atlantis purification units; and
- Yearly inspection and removal of accumulated sediments from rainwater tanks and the Atlantis infiltration units;
- Yearly inspection and flushing of the bio-retention basin.

5.2.3 Preliminary Mosquito Risk Assessment

A preliminary assessment of the mosquito risk for all water quality control measures implemented within 11, 13 & 15 Orchard Street has been undertaken. This risk assessment will be refined through the detailed design phase.

The outcomes of the preliminary assessment have resulted in incorporation of the following design measures to minimise mosquito nuisance:

- Pre-screening all flows to both the rainwater and infiltration tanks;
- Regular maintenance of infiltration tanks to prevent blockage; and

- Providing a seal to all maintenance access points to both the rainwater and infiltration tanks.

6 STORMWATER QUANTITY MANAGEMENT

The integrated strategy proposed for management of stormwater runoff quantity on the site is comprised of:

- source control which includes:
  - use of rainwater tanks (*6.3 m³/lot (**88.2m³**), of which 25% is counted as effective OSD storage – **22.1m³***) to reduce runoff volume, maximise non-potable supply/re-use and minimise peak flows discharging from individual allotments;
  - minimising impervious surfaces (*limited to 50% site wide*) to maximise infiltration potential and reduce runoff volumes;
  - the use of landscaping which encourages the maximisation of infiltration.

- the conveyance system which includes:
  - the proposed 20yr ARI piped drainage system (*effective detention storage volume = **30m³***) to reduce peak flow rates in events between the 20yr and 100yr ARI events;

- the bio-retention basin which includes approximately **350m³** of storage for capture of first flush events only;

- formal stormwater detention facilities to be incorporated at the downstream area of each lot which includes:
  - the proposed Atlantis Tank On site Detention system (*also utilised for infiltration purposes*) to provide a total detention volume of 366m³/ha or **606.2m³** at a PSD of 225L/s/ha or 232.2L/s for the entire subdivision.

6.1 STORMWATER DETENTION

Council's WMS requires a nominal detention storage volume of **366 m³/ha** for Sector 10. In total **1008.3m³** (*or 607.4m³/ha*) of effective stormwater detention storage is proposed in 11, 13 & 15 Orchard Street. This exceeds Council's requirement.

The proposed rainwater tanks will assist in reduction of peak flow rates for the more frequent events. Studies show that up to 25% of a tanks volume can be counted as effective OSD storage. The bio-retention basins will also provide effective detention in the smaller more frequent storm events. However, due to the bypass system proposed, larger events will not benefit by this detention storage.

Whilst the volume within the proposed piped drainage systems is not considered effective detention volume for events up to the 20yr ARI event, this volume does become effective when the piped drainage system capacity is exceeded (*ie larger events such as the 100yr ARI*).

The major contributor to detention storage is the proposed Atlantis Tank On site Detention system (*also utilised for infiltration purposes*) to provide a total detention volume of 366m^3/ha or **606.2m^3** at a PSD of 225L/s/ha or 232.2L/s for the subdivision (*refer to **Figure** 4 for an illustration of the system proposed).*

RAFTS modelling has been undertaken to assess the impact on outflows from 11, 13 & 15 Orchard Street due to implementation of the OSD systems only, details of which are included in **Appendix** C and summarised in **Table 4.**

Table 7– RAFTS Modelling Results

Storm Duration	Peak Flow at Outlet to 11, 13 & 15 Orchard Street (m^3/s)					
	100yr ARI (1% AEP)		20yr ARI (5% AEP)		5yr ARI (20% AEP)	
	Base	Post with Detention	Base	Post with Detention	Base	Post with Detention
60 minutes	0.765	-	-	-	-	-
120 minutes	0.867	0.232	0.669	0.232	0.416	0.232
180 minutes	0.605	-	-	-	-	-
360 minutes	0.386	-	-	-	-	-

In the all cases, implementation of the proposed detention storage results in post development outflows from 11, 13 & 15 Orchard Street that are lower than for the base conditions model.

6.1.1 Flood Flow Gauging

No waterways exist on the site (*11, 13 & 15 Orchard Street*), hence no flood flow gauging was undertaken.

6.2 FLOOD MANAGEMENT

The extents of the Mullet Creek 100yr ARI and PMF event are illustrated in **Figure 5**. This figure shows that the proposed development is sited well clear of the floodwaters for both of these events. Hence, all habitable floor levels will be sited clear of both the 100yr ARI and PMF events.

No interim flood protection measures are required for this site due to its position in the upper catchment areas of Warriewood Valley (*ie no development allowed upstream of the site*).

6.3 FLOOD EVACUATION

A safe flood evacuation path is available for all proposed lots to PMF free ground and in most cases the PMF does not impact on the proposed lots (*the exception being Lot 16, however no development proposed on this lot*).

7 STORMWATER DRAINAGE CONCEPT PLAN

The elements of the proposed Stormwater Drainage Concept Plan are presented in **Figures 1-5**.

All flows generated as runoff are proposed to be directed to rainwater tanks, detention and infiltration infrastructure sited at the downstream end of each lot. An interallotment drainage line (*20yr ARI capacity*) is proposed along the eastern boundary of the site to service all lots.

Runoff water quality from the site is primarily managed through the downstream bio-retention basin and GPT. In addition, stormwater quality treatment will be provided by the following measures:

- Atlantis infiltration systems on each lot;
- Large Atlantis purification units to be used at all inlets to the proposed infiltration systems;
- Rainwater tanks (*6.3kL per lot*) which reduce runoff volumes and hence pollutant loads; and
- Maximisation of the infiltration potential as a result of the site coverage requirements for pervious surface.

It has been estimated that the pollutant loads discharging from the site as a whole will be lower than for the existing site conditions, making a substantial contribution to long-term improvements in receiving water quality.

Both runoff peaks and runoff volumes will not be greater than existing values based on implementation of the proposed water management systems for 11, 13 & 15 Orchard Street.

8 REFERENCES

Institution of Engineers, Australia
"*Australian Rainfall and Runoff, a Guide to Flood Estimation*" Canberra, 1987

Lawson & Treloar Pty Ltd
"*Integrated Water Management Strategy – Warriewood Valley* " November 1997
Report prepared for Pittwater Council

NSW Department of Public Works
"*Narrabeen Lagoon Flood Study*" January 1990
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Patterson Britton & Partners
"*Water Management Report Sector 10*
Warriewood Valley" Issue 1, June 2001
Prepared for Stockland Trust Group

Patterson Britton & Partners
"*Water Management Report Sector 10*
Warriewood Valley-Construction Certificate Issue" Issue 7, February 2002
Prepared for Stockland Constructors

Patterson Britton & Partners
"*Post Subdivision Certificate Water Quality Monitoring Report Sector 10*
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Prepared for Stockland Constructors

Patterson Britton & Partners
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Prepared for CPG Developments

Pittwater Council
"*Flood Risk Management Policy for Pittwater Council*" 19 June 2001

Pittwater Council
"*Building/Development Works Adjacent to Easements and Watercourses*" November 2000

Pittwater Council
"*Warriewood Valley Urban Land Release Water Management Specification*" February, 2001

FIGURES

FIGURE 1

NOTE:

1. LEVELS SHOWN ARE BASED ON AUSTRALIAN HEIGHT DATUM
2. ORIGIN OF LEVELS – P.M.25544 R.L. 8.69 A.H.D. LOCATED NEAR THE INTERSECTION OF ORCHARD & GARDEN STREETS
3. CONTOURS ARE AT 1 METRE INTERVALS AND ARE APPROXIMATE ONLY – LEVELS CRITICAL TO DESIGN SHOULD BE DETERMINED BY SURVEY AND NOT BY INTERPOLATION
4. BASIC LEVEL & DETAIL SURVEY ONLY – THE POSITION OF IMPROVEMENTS ARE APPROXIMATE
5. FEATURES CRITICAL TO DESIGN SHOULD BE LOCATED BY A MORE ACCURATE SURVEY
6. NO FINITE LOCATION OF ROCK OUTCROPS, TREES OR OTHER SPECIFIC NATURAL FEATURES HAVE BEEN LOCATED FOR LOTS 1 & 2 D.P.715324 AND LOTS 5 & 6 D.P.749791 AS OUTLINED IN OUR FEE PROPOSAL DATED 27/2/98
7. SERVICES SHOWN HAVE BEEN LOCATED PARTLY BY SURVEY AND SCALED FROM INFORMATION PROVIDED BY THE RELEVANT SERVICE AUTHORITIES – THE SERVICE AUTHORITIES SHOULD BE CONTACTED TO DETERMINE THEIR EXACT LOCATION
8. THE ORIENTATION OF THE NORTH POINT HAS BEEN TAKEN FROM THE I.S.G. CO-ORDINATED OF P.M. 25544 AND S.S.M. 43671
9. UNLESS SHOWN OTHERWISE ALL TREES ARE EUCALYPTS
10. PIT & PIPE INVERTS ARE APPROXIMATE AS DIRECT MEASUREMENTS ARE DIFFICULT TO DETERMINE

LEGEND

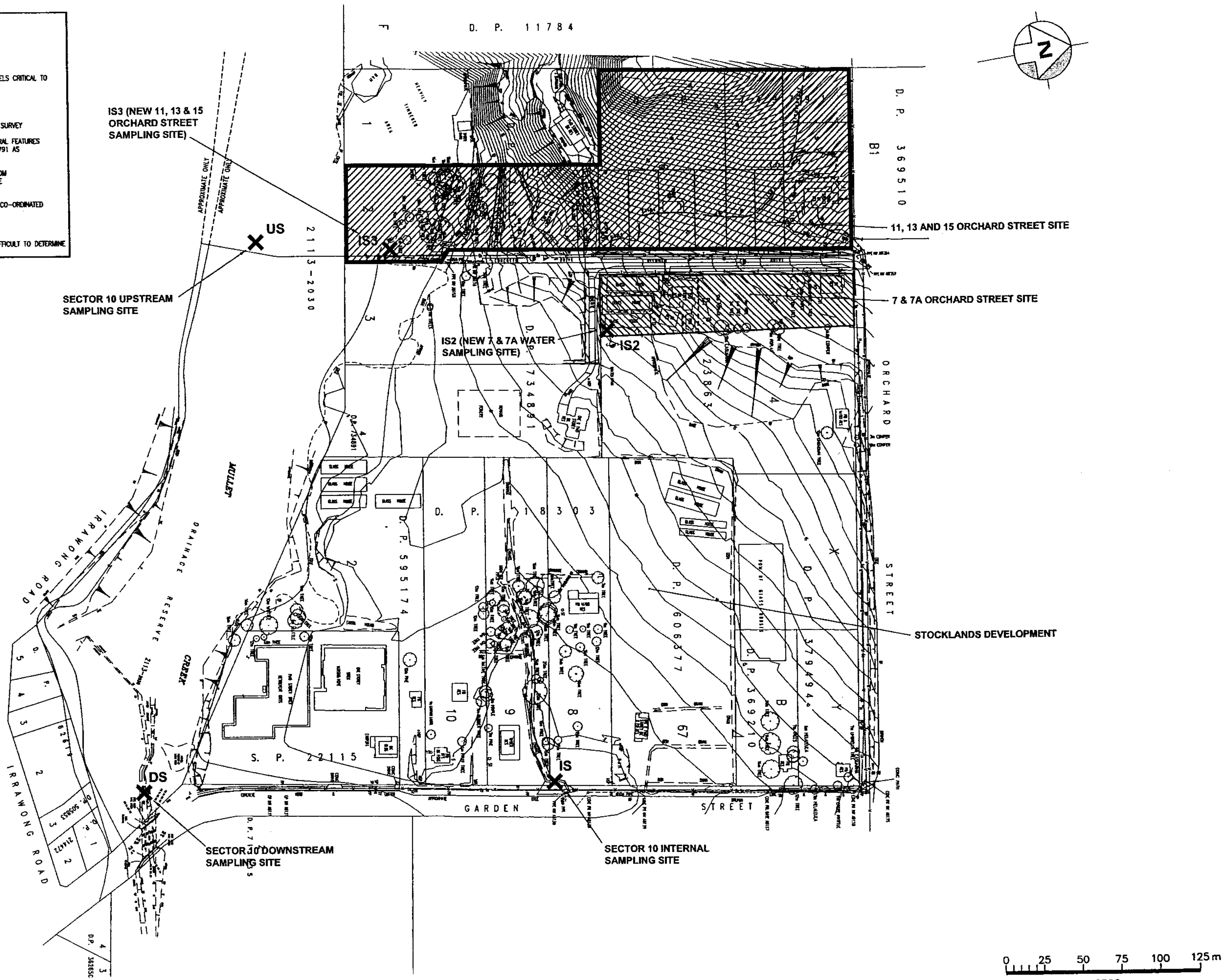
- ●H – HYDRANT
- ○ST – SEPTIC TANK
- ●TP – TELSTRA PIT
- ●PP – POWER POLE
- ●HSP – HOUSE SERVICE POWER POLE
- ●SV – STOP VALVE
- ●SIP – SEWER INPECTION POINT
- □GP – GULLY PIT
- —T—T— TELSTRA CABLE
- —Ee—Ee— OVERHEAD ELECTRICITY
- —Te—Te— OVERHEAD TELSTRA CABLE
- —W—W— WATER MAIN

FOR DETAILS OF EASEMENTS REFER TO TITLE INFORMATION

EASEMENT FOR ELECTRICITY PURPOSES 7.62 WIDE – VIDE TSFR J954099

EASEMENT FOR SERVICES 1.525 WIDE – REFER TITLE INFORMATION

SOURCE: PLAN No. A1-8465D & A1-8465D2 BYRNE & ASSOCIATES PTY LTD



level 2
104 Mount Street
North Sydney 2060
telephone (02) 9957 1619
facsimile (02) 9957 1291

Patterson Britton & Partners Pty Ltd
consulting engineers

4812-F1

0 25 50 75 100 125 m
1: 2500

LOCALITY PLAN

FIGURE 2

NOTE:

1. LEVELS SHOWN ARE BASED ON AUSTRALIAN HEIGHT DATUM
2. ORIGIN OF LEVELS – P.M.25544 R.L. 8.69 A.H.D. LOCATED NEAR THE INTERSECTION OF ORCHARD & GARDEN STREETS
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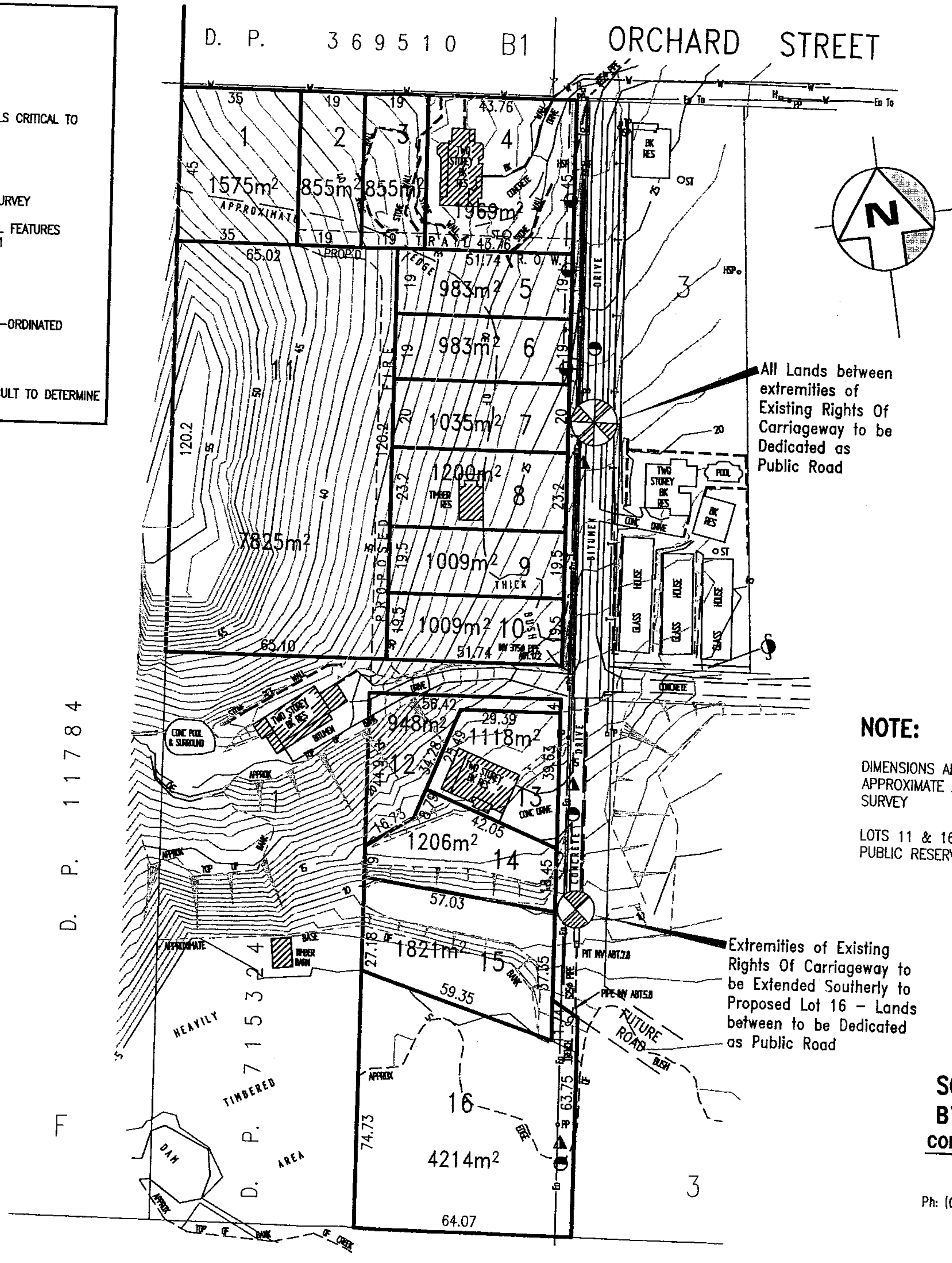
- SV – STOP VALVE
- SP – SEWER INPECTION POINT
- GP – GULLY PIT
- —T—T— TELSTRA CABLE
- —Eo—Eo— OVERHEAD ELECTRICITY
- —To—To— OVERHEAD TELSTRA CABLE
- —W—W— WATER MAIN

RIGHT OF CARRIAGEWAY AND EASEMENT FOR SERVICES 2 WIDE

FOR DETAILS OF EASEMENTS REFER TO TITLE INFORMATION

EASEMENT FOR ELECTRICITY PURPOSES 7.62 WIDE – VIDE TSFR J954099

EASEMENT FOR SERVICES 1.525 WIDE – REFER TITLE INFORMATION



NOTE:

DIMENSIONS AND AREAS HEREON ARE APPROXIMATE AND ARE SUBJECT TO SURVEY

LOTS 11 & 16 ARE TO BE CREATED AS PUBLIC RESERVES

SOURCE:
BYRNE & ASSOCIATES PTY LIMITED
CONSULTING SURVEYORS & ENGINEERS
63 WATERLOO STREET
NARRABEEN 2101
Ph: (02) 9913 7110 Fax: (02) 9913 1583
Email: bysurvey@ozemail.com.au

Plan No. A2 - 9441 P

2113 – 2030

PROPOSED SUBDIVISION LAYOUT

level 2
104 Mount Street
North Sydney 2060
telephone (02) 9957 1619
facsimile (02) 9957 1291
Patterson Britton & Partners Pty Ltd
consulting engineers

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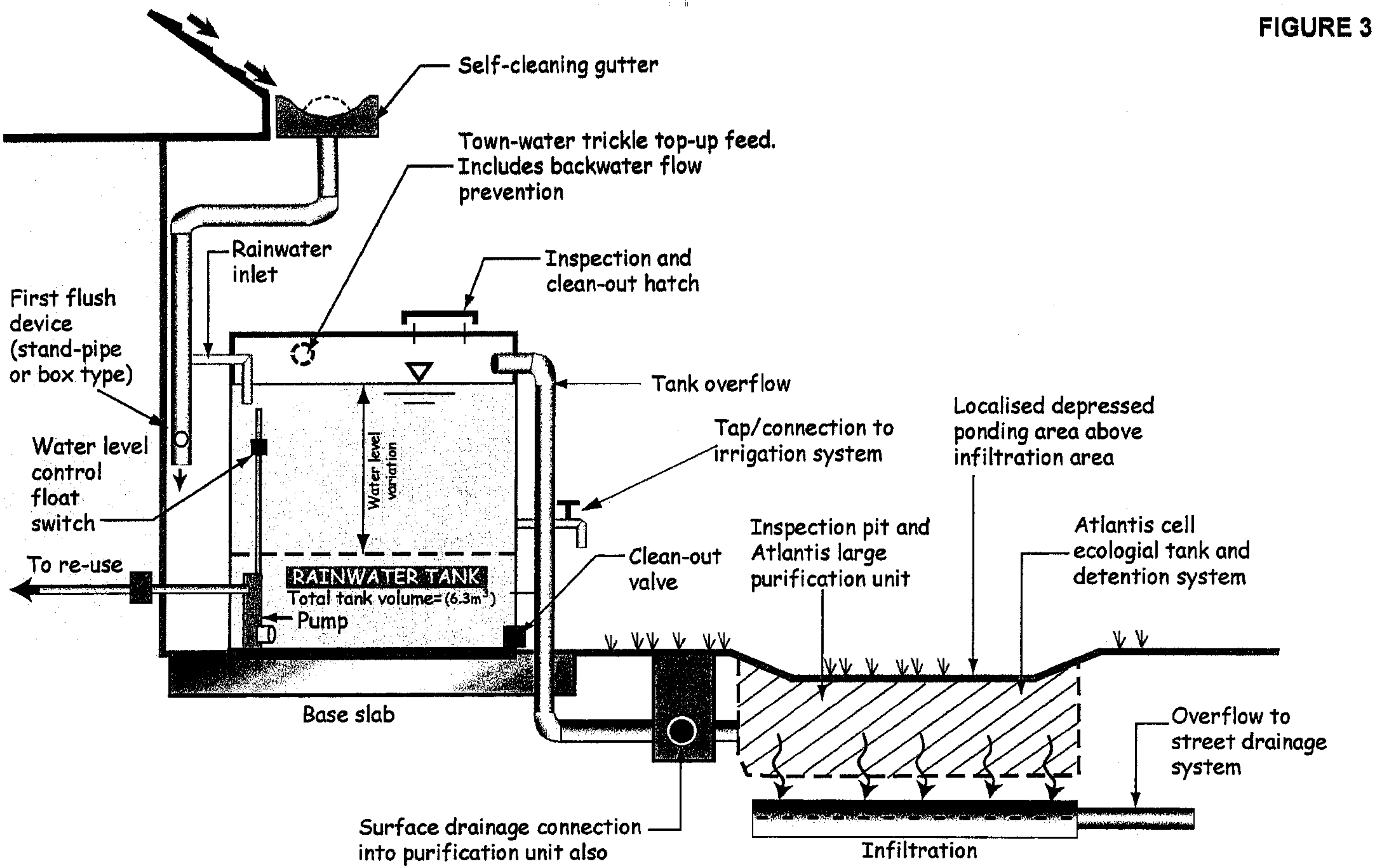
FIGURE 3



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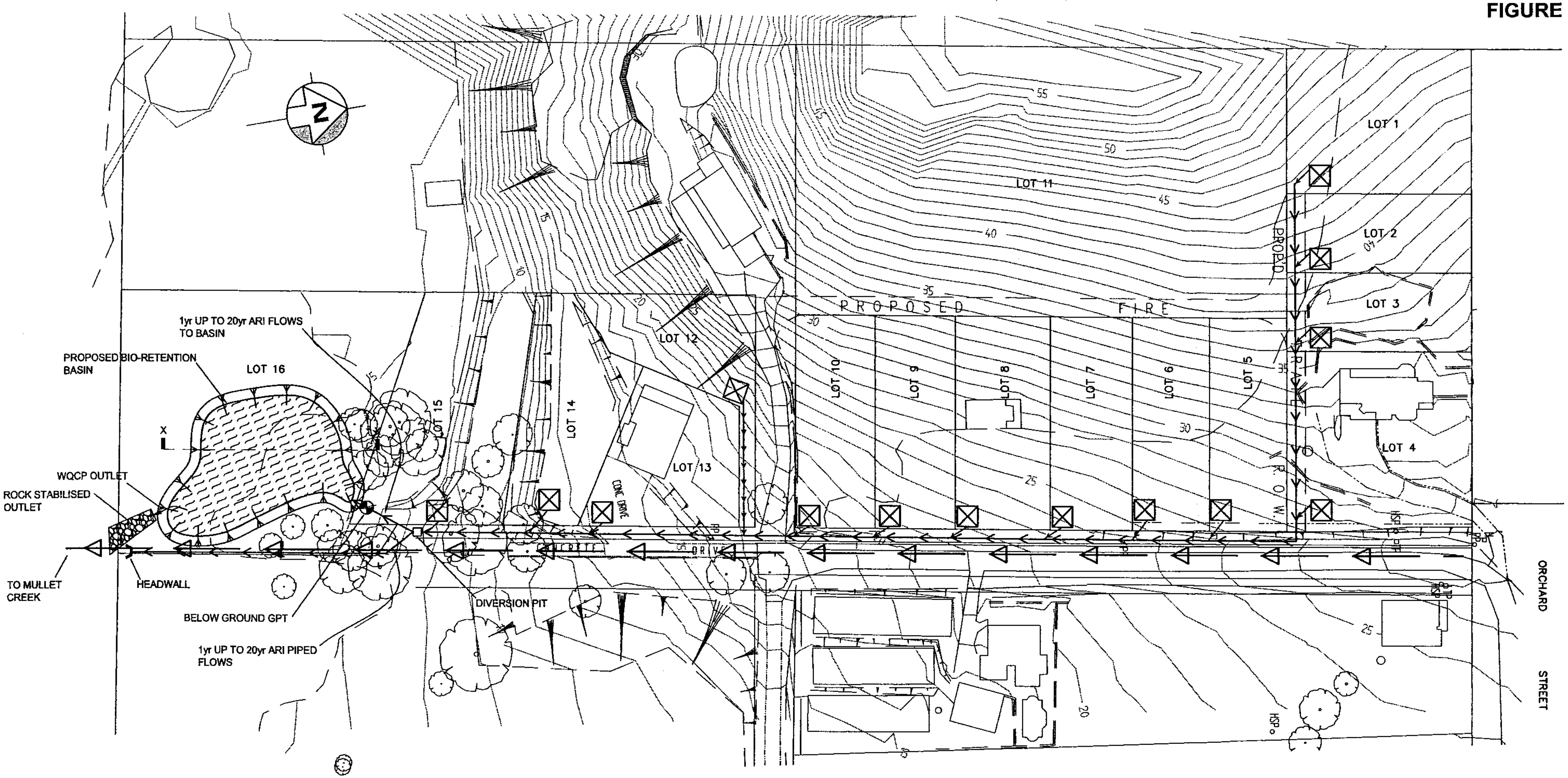
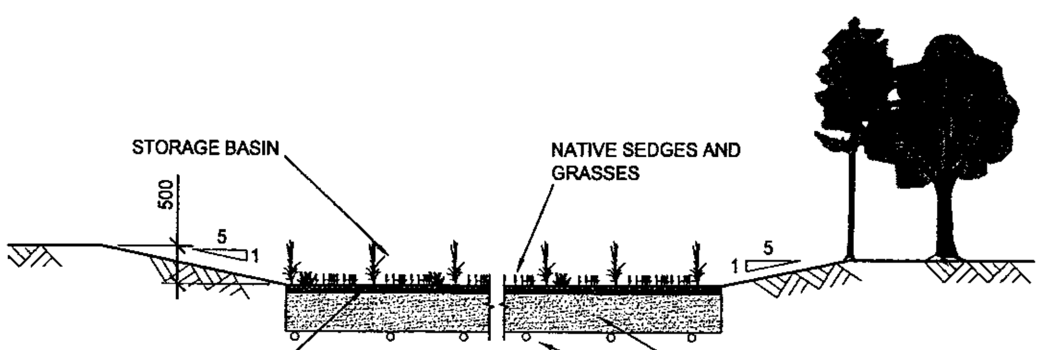
& Partners Pty Ltd
J4812/ FIG3_rainwater_tanksketch.ai

PROPOSED RAINWATER TANK AND INFILTRATION SYSTEM APPLICATION

FIGURE 4





SECTION X - X
NTS

NOTES

1. ATLANTIS CELL OR EQUIVALENT DETENTION/INFILTRATION TANK TO BE USED ON EACH SITE (SEE TABLE ON THIS DRAWING FOR DETAILS

2. ATLANTIS OR EQUIVALENT LARGE PURIFICATION UNIT TO BE INSTALLED PRIOR TO EACH DETENTION TANK

3. PROPOSED GPT TO BE DESIGNED TO TREAT THE PEAK OF THE 1 IN 3 MONTH ARI STORM.

4. A 6.3m3 RAINWATER TANK TO BE INSTALLED ON EACH LOT. WATER COLLECTED IS TO BE RE-USED FOR TOILET FLUSHING AND GARDEN IRRIGATION PURPOSES.

5. BASE PLAN SOURCE IS AS FOLLOWS:

BYRNE & ASSOCIATES PTY LIMITED
CONSULTING SURVEYORS & ENGINEERS
63 WATERLOO STREET
NARRABEEN 2101
Ph: (02) 9913 7110 Fax: (02) 9913 1583
Email: bysurvey@ozemail.com.au
Plan No. A2 - 9441 P DATED 25/10/03

STORMWATER DETENTIONTANK DETAILS

LOT No.	AREA (m²)	SSR (m³)	PSD (L/s)
1	1575	57.6	22.1
2	855	31.3	12.0
3	855	31.3	12.0
4	1969	72.1	27.8
5	983	36.0	13.8
6	983	36.0	13.8
7	1035	37.9	14.5
8	1200	43.9	16.8
9	1009	36.9	14.1
10	1009	36.9	14.1
11	NA	NA	NA
12	948	34.7	13.3
13	1118	40.9	15.7
14	1206	44.1	16.9
15	1821	66.6	25.5
TOTAL	16566	606.2	232.2

LEGEND

- 40 — EXISTING SURFACE CONTOUR (1m INTERVAL)
- MAJOR OVERLAND FLOWPATH
- PROPOSED 20yr ARI PIPED DRAINAGE LINE
- PROPOSED DETENTION TANK (REFER TO TABLE FOR VOLUMES)
- PROPOSED BELOW GROUND GPT
- BIO-RETENTION BASIN

0 10 20 30 40 50m
1:500 (A1) 1:1000 (A3)

level 2
104 Mount Street
North Sydney 2060
telephone (02) 9957 1619
facsimile (02) 9957 1291

Patterson Britton & Partners Pty Ltd
consulting engineers

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STORMWATER DRAINAGE CONCEPT PLAN

FIGURE 5

NOTE:

1. LEVELS SHOWN ARE BASED ON AUSTRALIAN HEIGHT DATUM
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10. PIT & PIPE INVERTS ARE APPROXIMATE AS DIRECT MEASUREMENTS ARE DIFFICULT TO DETERMINE
11. 100 YEAR ARI FLOOD EXTENT ILLUSTRATED ON THIS PLAN IS APPROXIMATE ONLY. REFER TO LEVELS SHOWN IN HYDRAULIC ANALYSIS REPORT FOR MORE DETAIL
12. THE CROSS SECTIONS SURVEYED BY BYRNE & ASSOCIATES HAVE BEEN EXTENDED HORIZONTALLY FOR THE HYDRAULIC ANALYSIS
13. PMF FLOOD EXTENTS ARE INDICATIVE ONLY (INSUFFICIENT SURVEY DATA EXISTS TO MAP ACCURATELY). PMF FLOOD LEVELS REPORTED IN THE TABLE SHOWN ON THIS PLAN SHOULD BE USED IN CONJUNCTION WITH DETAILED SURVEY TO DEFINE EXTENTS MORE ACCURATELY
14. FLOOD EXTENTS SHOWN ARE FOR MULLET CREEK ONLY (PREDEVELOPMENT CONDITIONS) YR 2000

LEGEND

- H – HYDRANT
- ST – SEPTIC TANK
- TP – TELSTRA PIT
- PP – POWER POLE
- HSP – HOUSE SERVICE POWER POLE
- SV – STOP VALVE
- SP – SEWER INPECTION POINT
- GP – GULLY PIT
- TELSTRA CABLE
- OVERHEAD ELECTRICITY
- OVERHEAD TELSTRA CABLE
- WATER MAIN
- MULLET CREEK PREDEVELOPMENT 100 YEAR ARI FLOOD EXTENT
- MULLET CREEK PREDEVELOPMENT PMF FLOOD EXTENT
- MULLET CREEK CROSS SECTION
- SECTION 1 – SURVEYED CROSS SECTION NAME BY BYRNE & ASSOCIATES
- (99) – HECRAS CROSS SECTION NAME BY PATTERSON BRITTON & PARTNERS

- FOR DETAILS OF EASEMENTS REFER TO TITLE INFORMATION
- EASEMENT FOR ELECTRICITY PURPOSES 7.62 WIDE – VIDE TSFR J954099
- EASEMENT FOR SERVICES 1.525 WIDE – REFER TITLE INFORMATION

SOURCE: PLAN No. A1-8465D & A1-846502 BYRNE & ASSOCIATES PTY LTD

PREDEVELOPED FLOOD LEVELS (YR 2000)

SECTION	FLOOD LEVEL (mAHD)	
	100 YR ARI	PMF
0 (100)	4.7	6.0
1 (99)	4.5	5.7
2 (98)	4.4	5.6
3 (97)	4.3	5.5
4 (96)	4.3	5.3
5 (95)	4.3	5.3
6 (94)	4.3	5.1
7 (93)	4.2	4.9
8 (92)	4.2	4.9

level 2
104 Mount Street
North Sydney 2060
telephone (02) 9957 1619
facsimile (02) 9957 1291

Patterson Britton & Partners Pty Ltd
consulting engineers

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OVERVIEW OF PREDEVELOPED 100 YEAR ARI AND PMF FLOOD EXTENTS FOR MULLET

APPENDIX A
COUNCIL CHECKLIST

APPENDIX B
WATER CYCLE RESULTS

APPENDIX B1
EXISTING CONDITIONS

4812-existing.xls

Data - existing

		Area (m2)	To Inf (%)
1.0	**General Catchment Data**		
1.1	- Impervious Area to Rainwater Tanks	0	0%
1.2	- Impervious Area not to Rainwater Tanks	828	0%
1.3	- Pervious Area to be Irrigated	0	0%
1.4	- Pervious Area not to be Irrigated	7455	0%
1.5	- Forested Area	8283	0%
1.6	- Infiltration system (inf)	0	-
1.7	- Total Area	16566	0%
2.0	**Interception**		
2.1	- Proportion of Irrigated Pervious Area as Canopy	0%	
2.2	- Proportion of No Irrigated Pervious Area as Canopy	0%	
2.3	- Proportion of Forested Area as Canopy	50%	
2.4	- Maximum Canopy Storage	1.5	mm
3.0	**Depression Storage**		
3.1	- Impervious Depression Storage	0	mm
3.2	- Pervious Depression Storage	0.5	mm
3.3	- Forested Depression Storage	1	mm
4.0	**Forest Soil Moisture Storage**		
4.1	- Maximum Storage	80	mm
4.2	- Initial Moisture Storage	70	mm
4.3	- Storage Before Infiltration Occurs	60	mm
4.4	- Deep Infiltration Rate	8	mm/day
5.0	**Pervious Soil Moisture Storage**		
5.1	- Maximum Storage	80	mm
5.2	- Initial Moisture Storage	70	mm
5.3	- Storage Before Infiltration Occurs	60	mm
5.4	- Deep Infiltration Rate	8	mm/day
5.5	- Storage Before Watering	5	mm
5.6	- Water Until Storage Reaches...	8	mm
6.0	**Infiltration System**		
6.1	- Volume to Macrophyte Bed Depth	0	m^3
6.2	- Volume of Deep Zone	0	m^3
6.3	- Maximum Storage	0	m^3
6.4	- Initial Storage	0	m^3
6.5	- Total Surface Area	0	m^2
6.6	- Surface Area of Deep Zone	0	m^2
7.0	**Rainwater Tank and Internal Reuse**		
7.1	- Maximum Rainwater Tank Volume	0	m^3
7.2	- Initial Rainwater Tank Volume	0	m^3
7.3	- Number of Equivalent Tenements with Reuse	0	ET
7.4	- Estimated Daily Demand per ET	0	L

		Pervious	Forest
8.0	**Crop Factors**		
8.1	January	5.65	5.65
8.2	February	4.82	4.82
8.3	March	4.03	4.03
8.4	April	2.83	2.83
8.5	May	1.94	1.94
8.6	June	1.45	1.45
8.7	July	1.45	1.45
8.8	August	2	2
8.9	September	2.9	2.9
8.10	October	4.19	4.19
8.11	November	5	5
8.12	December	5.32	5.32

Summary - Existing

Study Duration (years)	4			
Rainfall				
- Rainfall Depth	1462.75	mm	**Infiltration Area (Inf Area)**	
Rainfall Volumes			- Flow from Rainwater Tanks	0
- Impervious Area to Rainwater Tanks	0	m³	- Flow from Impervious Area (*no tank*)	0
- Impervious Area not to Rainwater Tanks	1211	m³	- Flow From Pervious Irrigated Area	0
- Pervious Area to be Irrigated	0	m³	- Flow From Pervious (*non-Irrigated*) Area	0
- Pervious Area not to be Irrigated	10905	m³	- Flow from Forested Area	0
- Forested Area	12116	m³	- Direct Rainfall	0
- Infiltration Area	0	m³		
- Total Area	24232	m³	Water Balance	
			- Total Flow to Inf Area	0
Rainwater Tanks Hydrology			- Overflow to Outlet	0
- Flow to Tanks	0	m³	- Evaporation	0
- Domestic Water Required	0	m³	- Change in Storage (averaged)	0
- Reuse Demand (*including irrigation*)	0	m³	Balance	0
- Spillage to Infiltration Area	0	m³		
- Spillage to Outlet	0	m³	**Total Outflow**	
- Change in Storage	0	m³	- Direct	5672
Balance	0	m³	- From Infiltration Area	0
No of times Domestic Water Required	0		- Total	5672
Runoff Coefficient into Tank	#DIV/0!		Balance	0
Runoff Coefficient from Tank	#DIV/0!			
			Total Site Runoff Coefficient	0.23
Irrigated Area Hydrology				
- Net Flow to Irrigation Area	0	m³		
- Irrigation	0	m³		
- Infiltration	0	m³		
- Spillage to Infiltration Area	0	m³		
- Spillage to Outlet	0	m³		
- Change in Storage	0	m³		
Balance	0			
No of times Irrigation Required	0			
Runoff Coefficient	#DIV/0!			
Impervious Area not to Tank Hydrology				
- Net Flow from Impervious Area	1211	m³		
- Spillage to Infiltration Area	0	m³		
- Spillage to Outlet	1211	m³		
Balance	0			
Runoff Coefficient	1.00			
Forested Area Hydrology				
- Net Flow to Forested Area	2869	m³		
- Infiltration	1143	m³		
- Spillage to Infiltration Area	0	m³		
- Spillage to Outlet	1871	m³		
- Change in Storage	-145	m³		
Balance	0			
Runoff Coefficient	0.15			
Pervious (*non-Irrigated*) Area Hydrology				
- Net Flow to Pervious Area	4696	m³		
- Infiltration	2237	m³		
- Spillage to Infiltration Area	0	m³		
- Spillage to Outlet	2590	m³		
- Change in Storage	-130	m³		
Balance	0			
Runoff Coefficient	0.24			

APPENDIX B2
PROPOSED CONDITIONS – NO MEASURES

4812-post(no measures).xls

Data - Post Development (no measures)		Area (m2)	To Inf (%)
1.0	**General Catchment Data**		
1.1	- Impervious Area to Rainwater Tanks	0	0%
1.2	- Impervious Area not to Rainwater Tanks	8283	0%
1.3	- Pervious Area to be Irrigated	0	0%
1.4	- Pervious Area not to be Irrigated	4141.5	0%
1.5	- Forested Area	4141.5	0%
1.6	- Infiltration system (inf)	0	-
1.7	- Total Area	16566	0%
2.0	**Interception**		
2.1	- Proportion of Irrigated Pervious Area as Canopy	0%	
2.2	- Proportion of No Irrigated Pervious Area as Canopy	10%	
2.3	- Proportion of Forested Area as Canopy	50%	
2.4	- Maximum Canopy Storage	1.5	mm
3.0	**Depression Storage**		
3.1	- Impervious Depression Storage	0	mm
3.2	- Pervious Depression Storage	0.5	mm
3.3	- Forested Depression Storage	1	mm
4.0	**Forest Soil Moisture Storage**		
4.1	- Maximum Storage	80	mm
4.2	- Initial Moisture Storage	70	mm
4.3	- Storage Before Infiltration Occurs	60	mm
4.4	- Deep Infiltration Rate	8	mm/day
5.0	**Pervious Soil Moisture Storage**		
5.1	- Maximum Storage	80	mm
5.2	- Initial Moisture Storage	70	mm
5.3	- Storage Before Infiltration Occurs	60	mm
5.4	- Deep Infiltration Rate	8	mm/day
5.5	- Storage Before Watering	5	mm
5.6	- Water Until Storage Reaches...	8	mm
6.0	**Infiltration System**		
6.1	- Volume to Macrophyte Bed Depth	0	m^3
6.2	- Volume of Deep Zone	0	m^3
6.3	- Maximum Storage	0	m^3
6.4	- Initial Storage	0	m^3
6.5	- Total Surface Area	0	m^2
6.6	- Surface Area of Deep Zone	0	m^2
7.0	**Rainwater Tank and Internal Reuse**		
7.1	- Maximum Rainwater Tank Volume	0	m^3
7.2	- Initial Rainwater Tank Volume	0	m^3
7.3	- Number of Equivalent Tenements with Toilet Use	14	ET
7.4	- Estimated Daily Demand per ET	135.25	L
		Pervious	**Forest**
8.0	**Crop Factors**		
8.1	January	5.65	5.65
8.2	February	4.82	4.82
8.3	March	4.03	4.03
8.4	April	2.83	2.83
8.5	May	1.94	1.94
8.6	June	1.45	1.45
8.7	July	1.45	1.45
8.8	August	2	2
8.9	September	2.9	2.9
8.10	October	4.19	4.19
8.11	November	5	5
8.12	December	5.32	5.32

4812-post(no measures).xls

Summary

Summary - Post Development with No Measures		
Study Duration (years)	4	
Rainfall		
- Rainfall Depth	1462.75	mm
Rainfall Volumes		
- Impervious Area to Rainwater Tanks	0	m³
- Impervious Area not to Rainwater Tanks	12116	m³
- Pervious Area to be Irrigated	0	m³
- Pervious Area not to be Irrigated	6058	m³
- Forested Area	6058	m³
- Infiltration Area	0	m³
- Total Area	24232	m³
Rainwater Tanks Hydrology		
- Flow to Tanks	0	m³
- Domestic Water Required	692	m³
- Reuse Demand (*including irrigation*)	692	m³
- Spillage to Infiltration Area	0	m³
- Spillage to Outlet	0	m³
- Change in Storage	0	m³
Balance	0	m³
No of times Domestic Water Required	365	
Runoff Coefficient into Tank	#DIV/0!	
Runoff Coefficient from Tank	#DIV/0!	
Irrigated Area Hydrology		
- Net Flow to Irrigation Area	0	m³
- Irrigation	0	m³
- Infiltration	0	m³
- Spillage to Infiltration Area	0	m³
- Spillage to Outlet	0	m³
- Change in Storage	0	m³
Balance	0	
No of times Irrigation Required	0	
Runoff Coefficient	#DIV/0!	
Impervious Area not to Tank Hydrology		
- Net Flow from Impervious Area	12116	m³
- Spillage to Infiltration Area	0	m³
- Spillage to Outlet	12116	m³
Balance	0	
Runoff Coefficient	1.00	
Forested Area Hydrology		
- Net Flow to Forested Area	1435	m³
- Infiltration	572	m³
- Spillage to Infiltration Area	0	m³
- Spillage to Outlet	936	m³
- Change in Storage	-72	m³
Balance	0	
Runoff Coefficient	0.15	
Pervious (*non-irrigated*) Area Hydrology		
- Net Flow to Pervious Area	2569	m³
- Infiltration	1218	m³
- Spillage to Infiltration Area	0	m³
- Spillage to Outlet	1424	m³
- Change in Storage	-72	m³
Balance	0	
Runoff Coefficient	0.24	

Infiltration Area (Inf Area)	
- Flow from Rainwater Tanks	0
- Flow from Impervious Area (*no tank*)	0
- Flow From Pervious Irrigated Area	0
- Flow From Pervious (*non-Irrigated*) Area	0
- Flow from Forested Area	0
- Direct Rainfall	0
Water Balance	
- Total Flow to Inf. Area	0
- Overflow to Outlet	0
- Evaporation	0
- Change in Storage (averaged)	0
Balance	0
Total Outflow	
- Direct	14475
- Infiltration Area	0
- Total	14475
Balance	0
Total Site Runoff Coefficient	0.60

APPENDIX B3
PROPOSED CONDITIONS – INCLUDING MEASURES

4812-post(with measures).xls

Data - Post Development (with measures)			
		Area (m2)	To Inf (%)
1.0	**General Catchment Data**		
1.1	- Impervious Area to Rainwater Tanks	4969	100%
1.2	- Impervious Area not to Rainwater Tanks	3314	100%
1.3	- Pervious Area to be Irrigated	3535.5	100%
1.4	- Pervious Area not to be Irrigated	0	100%
1.5	- Forested Area	4141.5	0%
1.6	- Infiltration system (inf)	606	-
1.7	- Total Area	16566	75%
2.0	**Interception**		
2.1	- Proportion of Irrigated Pervious Area as Canopy	10%	
2.2	- Proportion of No Irrigated Pervious Area as Canopy	10%	
2.3	- Proportion of Forested Area as Canopy	50%	
2.4	- Maximum Canopy Storage	1.5	mm
3.0	**Depression Storage**		
3.1	- Impervious Depression Storage	0	mm
3.2	- Pervious Depression Storage	0.5	mm
3.3	- Forested Depression Storage	1	mm
4.0	**Forest Soil Moisture Storage**		
4.1	- Maximum Storage	80	mm
4.2	- Initial Moisture Storage	70	mm
4.3	- Storage Before Infiltration Occurs	60	mm
4.4	- Deep Infiltration Rate	8	mm/day
5.0	**Pervious Soil Moisture Storage**		
5.1	- Maximum Storage	80	mm
5.2	- Initial Moisture Storage	70	mm
5.3	- Storage Before Infiltration Occurs	60	mm
5.4	- Deep Infiltration Rate	8	mm/day
5.5	- Storage Before Watering	5	mm
5.6	- Water Until Storage Reaches...	8	mm
6.0	**Infiltration System**		
6.1	- Volume of Infiltration Storage	606	m^3
6.2	- Initial Storage	303	m^3
6.3	- Infiltration Rate	100	mm/day
7.0	**Rainwater Tank and Internal Reuse**		
7.1	- Maximum Rainwater Tank Volume	88.2	m^3
7.2	- Initial Rainwater Tank Volume	44	m^3
7.3	- Number of Equivalent Tenements with Toilet Use	14	ET
7.4	- Estimated Daily Demand per ET	135.25	L
		Pervious	Forest
8.0	**Crop Factors**		
8.1	January	5.65	5.65
8.2	February	4.82	4.82
8.3	March	4.03	4.03
8.4	April	2.83	2.83
8.5	May	1.94	1.94
8.6	June	1.45	1.45
8.7	July	1.45	1.45
8.8	August	2	2
8.9	September	2.9	2.9
8.10	October	4.19	4.19
8.11	November	5	5
8.12	December	5.32	5.32

Summary - Post Development (with Measures)				
Study Duration (years)	4			
Rainfall				
- Rainfall Depth	1462.75	mm	**Infiltration System (Inf Sys)**	
Rainfall Volumes			- Flow from Rainwater Tanks	5906
- Impervious Area to Rainwater Tanks	7268	m^3	- Flow from Impervious Area (*no tank*)	1255
- Impervious Area not to Rainwater Tanks	4848	m^3	- Flow From Pervious Irrigated Area	4848
- Pervious Area to be Irrigated	5172	m^3	- Flow From Pervious (*non-Irrigated*) Area	0
- Pervious Area not to be Irrigated	0	m^3	- Flow from Forested Area	0
- Forested Area	6058	m^3	- Direct Rainfall	886
- Infiltration Area	886	m^3		
- Total Area	24232	m^3	Water Balance	
			- Total Flow to Inf Area	12895
Rainwater Tanks Hydrology			- Overflow to Outlet	4164
- Flow to Tanks	7268	m^3	- Evaporation	694
- Domestic Water Required	739	m^3	- Infiltration	8113
- Reuse Demand (*including irrigation*)	2112	m^3	- Change in Storage (averaged)	-76
- Spillage to Infiltration Area	5906	m^3	Balance	0
- Spillage to Outlet	0	m^3		
- Change in Storage	-11	m^3	**Total Outflow**	
Balance	0	m^3	- Direct	1306
No of times Domestic Water Required	55		- From Infiltration Area	4164
Runoff Coefficient into Tank	1.00		- Total	5470
Runoff Coefficient from Tank	0.81		Balance	0
Irrigated Area Hydrology			Total Site Runoff Coefficient	0.23
- Net Flow to Irrigation Area	827	m^3		
- Irrigation	1420	m^3		
- Infiltration	1047	m^3		
- Spillage to Infiltration Area	1255	m^3		
- Spillage to Outlet	0	m^3		
- Change in Storage	-55	m^3		
Balance	0			
No of times Irrigation Required	83			
Runoff Coefficient	0.24			
Impervious Area not to Tank Hydrology				
- Net Flow from Impervious Area	4848	m^3		
- Spillage to Infiltration Area	4848	m^3		
- Spillage to Outlet	0	m^3		
Balance	0			
Runoff Coefficient	1.00			
Forested Area Hydrology				
- Net Flow to Forested Area	2352	m^3		
- Infiltration	1118	m^3		
- Spillage to Infiltration Area	0	m^3		
- Spillage to Outlet	1306	m^3		
- Change in Storage	-72	m^3		
Balance	0			
Runoff Coefficient	0.22			
Pervious (*non-irrigated*) Area Hydrology				
- Net Flow to Pervious Area	0	m^3		
- Infiltration	0	m^3		
- Spillage to Infiltration Area	0	m^3		
- Spillage to Outlet	0	m^3		
- Change in Storage	0	m^3		
Balance	0			
Runoff Coefficient	#DIV/0!			

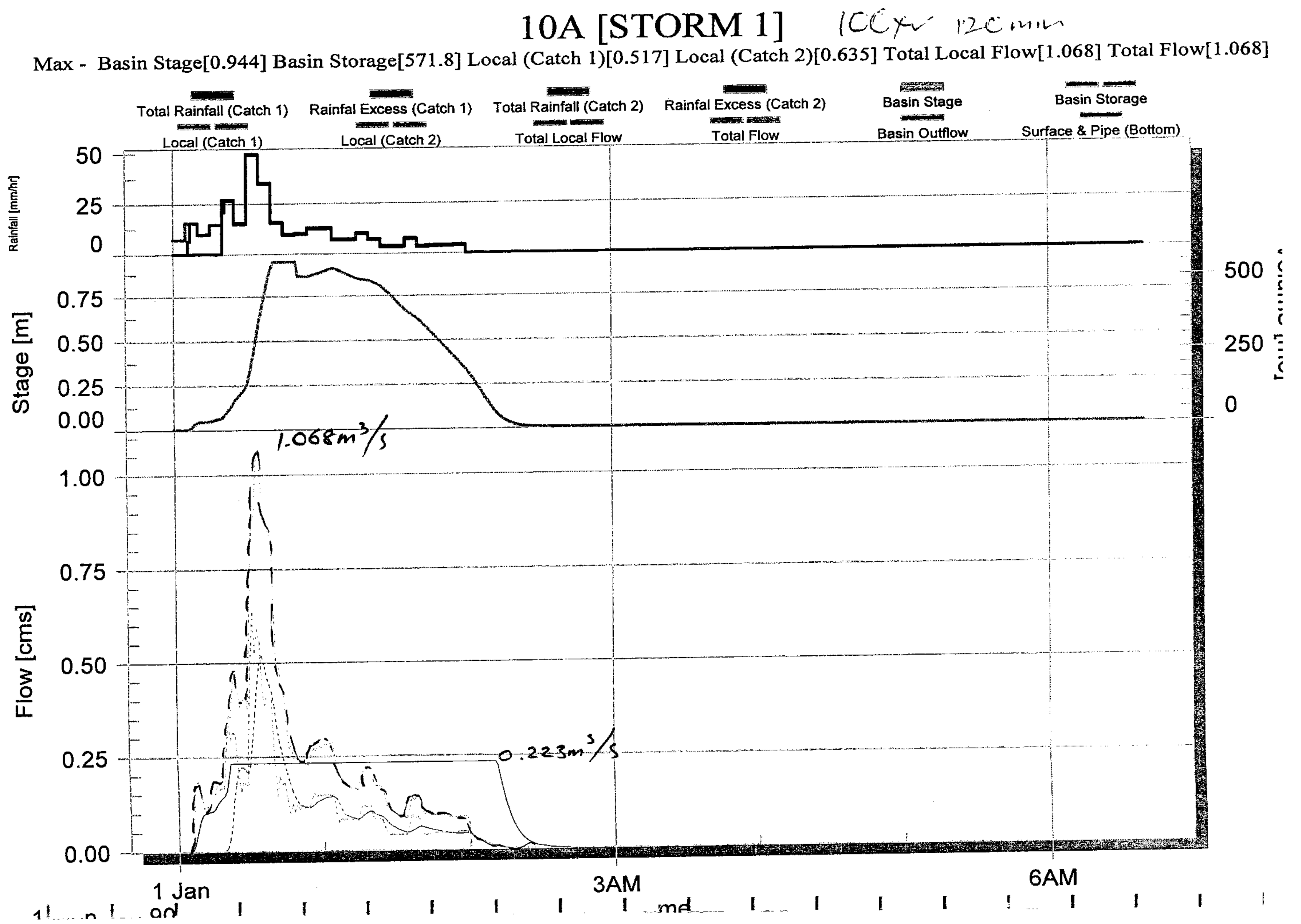
Date	Rain on Impervious Tank Area (m3)	Rain on Impervious No Tank Area (m3)	Rain on Pervious Irrigation Area (m3)	Rain on Pervious No Irrigation Area (m3)	Rain on Forested Area (m3)	Rain on Inf Sys Area (m3)	Potential ET on Pervious Irrigation Area (m3)	Potential ET on Pervious No Irrigation Area (m3)	Potential ET on Forested Area (m3)	Potential Evaporation from Inf Area (m3)	Potential Interception - Pervious Irrigated Area (m3)	Potential Interception - Pervious Not Irrigated Area (m3)	Potential Interception - Forested Area (m3)	Potential Depression Store on Impervious Tank Area (m3)	Potential Depression Store on Impervious No Tank Area (m3)	Potential Depression Store on Pervious Irrigation Area (m3)	Potential Depression Store on Pervious No Irrigation Area (m3)	Potential Depression Store on Forested Area (m3)	Initial Pervious Irrigation Soil Storage (m3)	Net flow to Pervious - Irrigation Soil (m3)	Perv. - Irr. Soil Storage before Irrigation (m3)	Required Irrigation (m³)	Is Irrigation Required?	Perv. - Irr. Soil Storage before Infiltration (m3)	Pervious - Irrigation Deep Infiltration (m3)	Runoff from Pervious - Irrigation Area (m3)	Pervious - Irrigation Area Runoff to Inf Sys (m3)	Pervious - Irrigation Area Runoff to Outlet (m3)	Initial Storage in Rainwater Tanks (m3)		Flow to Rainwater Tanks (m3)	Storage in Tanks After Rainfall (m3)	Spillage From Tanks (m3)	
January 1, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	247.5	-20.0	227.5	0.0	0.0	227.5	28.3	0.0	0.0	0.0	44	0	0	44	0	0
January 2, 1995	34.783	23.198	24.7485	0	28.9905	4.242	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	199.2	2.5	201.7	0.0	0.0	201.7	0.0	0.0	0.0	0.0	42.1065	0	34.783	76.8895	0	0
January 3, 1995	173.915	115.99	123.7425	0	144.9525	21.21	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	201.7	101.5	282.8	0.0	0.0	282.8	28.3	20.3	20.3	0.0	74.996	1	173.915	88.2	160.711	1
January 4, 1995	59.628	39.768	42.426	0	49.698	7.272	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	254.6	20.2	274.7	0.0	0.0	274.7	28.3	0.0	0.0	0.0	86.3065	1	59.628	88.2	57.7345	1
January 5, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	246.4	-20.0	226.4	0.0	0.0	226.4	28.3	0.0	0.0	0.0	86.3065	1	0	86.3065	0	0
January 6, 1995	6.9566	4.6396	4.9497	0	5.7981	0.8484	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	198.2	-17.3	180.8	0.0	0.0	180.8	0.0	0.0	0.0	0.0	84.413	1	6.9566	88.2	3.1696	1
January 7, 1995	90.4358	60.3148	64.3461	0	75.3753	11.0292	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	180.8	42.1	222.9	0.0	0.0	222.9	28.3	0.0	0.0	0.0	86.3065	1	90.4358	88.2	88.5423	1
January 8, 1995	7.9504	5.3024	5.6568	0	6.6264	0.9696	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	194.6	-18.6	178.0	0.0	0.0	178.0	0.0	0.0	0.0	0.0	86.3065	1	7.9504	88.2	6.0569	1
January 9, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	178.0	-20.0	158.0	0.0	0.0	158.0	0.0	0.0	0.0	0.0	86.3065	1	0	86.3065	0	0
January 10, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	158.0	-20.0	138.1	0.0	0.0	138.1	0.0	0.0	0.0	0.0	84.413	1	0	84.413	0	0
January 11, 1995	9.938	6.628	7.071	0	8.283	1.212	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	138.1	-15.2	122.9	0.0	0.0	122.9	0.0	0.0	0.0	0.0	82.5195	1	9.938	88.2	4.2575	1
January 12, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	122.9	-20.0	102.9	0.0	0.0	102.9	0.0	0.0	0.0	0.0	86.3065	1	0	86.3065	0	0
January 13, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	102.9	-20.0	82.9	0.0	0.0	82.9	0.0	0.0	0.0	0.0	84.413	1	0	84.413	0	0
January 14, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	82.9	-20.0	62.9	0.0	0.0	62.9	0.0	0.0	0.0	0.0	82.5195	1	0	82.5195	0	0
January 15, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	62.9	-20.0	43.0	0.0	0.0	43.0	0.0	0.0	0.0	0.0	80.626	1	0	80.626	0	0
January 16, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	43.0	-20.0	23.0	0.0	0.0	23.0	0.0	0.0	0.0	0.0	78.7325	1	0	78.7325	0	0
January 17, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	23.0	-20.0	3.0	25.3	1.0	28.3	0.0	0.0	0.0	0.0	76.839	1	0	76.839	0	0
January 18, 1995	6.9566	4.6396	4.9497	0	5.7981	0.8484	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-17.3	11.0	17.3	1.0	28.3	0.0	0.0	0.0	0.0	49.666675	0	6.9566	56.623275	0	0
January 19, 1995	29.814	19.884	21.213	0	24.849	3.636	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-1.1	27.2	0.0	0.0	27.2	0.0	0.0	0.0	0.0	37.405825	0	29.814	67.219825	0	0
January 20, 1995	131.1816	87.4896	93.3372	0	109.3356	15.9984	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	27.2	71.1	98.3	0.0	0.0	98.3	0.0	0.0	0.0	0.0	65.326325	1	131.1816	88.2	108.307825	1
January 21, 1995	120.2498	80.1988	85.5591	0	100.2243	14.6652	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	98.3	63.3	161.8	0.0	0.0	161.8	0.0	0.0	0.0	0.0	86.3065	1	120.2498	88.2	118.3563	1
January 22, 1995	7.9504	5.3024	5.6568	0	6.6264	0.9696	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	161.8	-16.8	145.0	0.0	0.0	145.0	0.0	0.0	0.0	0.0	86.3065	1	7.9504	88.2	6.0569	1
January 23, 1995	9.938	6.628	7.071	0	8.283	1.212	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	145.0	-15.2	129.8	0.0	0.0	129.8	0.0	0.0	0.0	0.0	86.3065	1	9.938	88.2	8.0445	1
January 24, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	129.8	-20.0	109.8	0.0	0.0	109.8	0.0	0.0	0.0	0.0	86.3065	1	0	86.3065	0	0
January 25, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	109.8	-20.0	89.8	0.0	0.0	89.8	0.0	0.0	0.0	0.0	84.413	1	0	84.413	0	0
January 26, 1995	2.9814	1.9884	2.1213	0	2.4849	0.3636	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	89.8	-20.0	69.8	0.0	0.0	69.8	0.0	0.0	0.0	0.0	82.5195	1	2.9814	85.5009	0	0
January 27, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	69.8	-20.0	49.9	0.0	0.0	49.9	0.0	0.0	0.0	0.0	83.6074	1	0	83.6074	0	0
January 28, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	49.9	-20.0	29.9	0.0	0.0	29.9	0.0	0.0	0.0	0.0	81.7139	1	0	81.7139	0	0
January 29, 1995	16.8946	11.2676	12.0207	0	14.0811	2.0604	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	29.9	-10.3	19.6	0.0	0.0	19.6	0.0	0.0	0.0	0.0	79.8204	1	16.8946	88.2	8.515	1
January 30, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	19.6	-20.0	-0.4	28.6	1.0	28.3	0.0	0.0	0.0	0.0	86.3065	1	0	86.3065	0	0
January 31, 1995	0	0	0	0	0	0	19.975575	0	23.399	3.424	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-20.0	8.3	20.0	1.0	28.3	0.0	0.0	0.0	0.0	55.77545	0	0	55.77545	0	0
February 1, 1995	0.9938	0.6628	0.7071	0	0.8283	0.1212	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-17.0	11.2	17.0	1.0	28.3	0.0	0.0	0.0	0.0	33.906375	0	0.9938	34.900175	0	0
February 2, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-17.0	11.2	17.0	1.0	28.3	0.0	0.0	0.0	0.0	15.965565	0	0	15.965565	0	0
February 3, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-17.0	11.2	17.0	1.0	28.3	0.0	0.0	0.0	0.0	0	0	0	0	0	0
February 4, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-17.0	11.2	17.0	1.0	28.3	0.0	0.0	0.0	0.0	0	0	0	0	0	0
February 5, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-17.0	11.2	17.0	1.0	28.3	0.0	0.0	0.0	0.0	0	0	0	0	0	0
February 6, 1995	77.5164	51.6984	55.1538	0	64.6074	9.4536	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	35.8	64.1	0.0	0.0	64.1	0.0	0.0	0.0	0.0	0	0	77.5164	77.5164	0	0
February 7, 1995	0.9938	0.6628	0.7071	0	0.8283	0.1212	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	64.1	-17.0	47.1	0.0	0.0	47.1	0.0	0.0	0.0	0.0	75.6229	1	0.9938	76.6167	0	0
February 8, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	47.1	-17.0	30.0	0.0	0.0	30.0	0.0	0.0	0.0	0.0	74.7232	1	0	74.7232	0	0
February 9, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	30.0	-17.0	13.0	15.3	1.0	28.3	0.0	0.0	0.0	0.0	72.8297	0	0	72.8297	0	0
February 10, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-17.0	11.2	17.0	1.0	28.3	0.0	0.0	0.0	0.0	55.827485	0	0	55.827485	0	0
February 11, 1995	16.8946	11.2676	12.0207	0	14.0811	2.0604	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-7.3	21.0	0.0	0.0	21.0	0.0	0.0	0.0	0.0	36.692875	0	16.8946	53.587475	0	0
February 12, 1995	27.8264	18.5584	19.7988	0	23.1924	3.3936	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	21.0	0.5	21.4	0.0	0.0	21.4	0.0	0.0	0.0	0.0	51.693975	0	27.8264	79.520375	0	0
February 13, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	21.4	-17.0	4.4	23.9	1.0	28.3	0.0	0.0	0.0	0.0	77.626875	0	0	77.626875	0	0
February 14, 1995	14.907	9.942	10.6065	0	12.4245	1.818	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-8.7	19.6	0.0	0.0	19.6	0.0	0.0	0.0	0.0	51.833395	0	14.907	66.740395	0	0
February 15, 1995	15.9008	10.6048	11.3136	0	13.2528	1.9392	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	19.6	-8.0	11.5	16.8	1.0	28.3	0.0	0.0	0.0	0.0	64.846895	0	15.9008	80.747695	0	0
February 16, 1995	73.5412	49.0472	52.3254	0	61.2942	8.9688	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	33.0	61.3	0.0	0.0	61.3	0.0	0.0	0.0	0.0	82.095925	0	73.5412	88.2	47.437125	1
February 17, 1995	91.4296	60.9776	65.0532	0	76.2036	11.1504	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	61.3	45.7	107.0	0.0	0.0	107.0	0.0	0.0	0.0	0.0	86.3065	1	91.4296	88.2	89.5361	1
February 18, 1995	25.8388	17.2328	18.3846	0	21.5358	3.1512	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	107.0	-1.0	106.0	0.0	0.0	106.0	0.0	0.0	0.0	0.0	86.3065	1	25.8388	88.2	23.9453	1
February 19, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	106.0	-17.0	89.0	0.0	0.0	89.0	0.0	0.0	0.0	0.0	86.3065	1	0	86.3065	0	0
February 20, 1995	1.9876	1.3256	1.4142	0	1.6566	0.2424	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	89.0	-17.0	71.9	0.0	0.0	71.9	0.0	0.0	0.0	0.0	84.413	1	1.9876	86.4006	0	0
February 21, 1995	31.8016	21.2096	22.6272	0	26.5056	3.8784	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	71.9	3.3	75.2	0.0	0.0	75.2	0.0	0.0	0.0	0.0	84.5071	1	31.8016	88.2	28.1087	1
February 22, 1995	6.9566	4.6396	4.9497	0	5.7981	0.8484	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	75.2	-14.4	60.8	0.0	0.0	60.8	0.0	0.0	0.0	0.0	86.3065	1	6.9566	88.2	5.0631	1
February 23, 1995	11.9256	7.9536	8.4852	0	9.9396	1.4544	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	60.8	-10.9	50.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	86.3065	1	11.9256	88.2	10.0321	1
February 24, 1995	0.9938	0.6628	0.7071	0	0.8283	0.1212	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	50.0	-17.0	33.0	0.0	0.0	33.0	0.0	0.0	0.0	0.0	86.3065	1	0.9938	87.3003	0	0
February 25, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	33.0	-17.0	15.9	12.4	1.0	28.3	0.0	0.0	0.0	0.0	85.4068	1	0	85.4068	0	0
February 26, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-17.0	11.2	17.0	1.0	28.3	0.0	0.0	0.0	0.0	71.13905	0	0	71.13905	0	0
February 27, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-17.0	11.2	17.0	1.0	28.3	0.0	0.0	0.0	0.0	52.20444	0	0	52.20444	0	0
February 28, 1995	0	0	0	0	0	0	17.04111	0	19.862	2.921	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-17.0	11.2	17.0	1.0	28.3	0.0	0.0	0.0	0.0	33.26983	0	0	33.26983	0	0
March 1, 1995	79.504	53.024	56.568	0	66.264	9.696	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	40.0	68.3	0.0	0.0	68.3	0.0	0.0	0.0	0.0	14.33522	0	79.504	88.2	5.63922	1
March 2, 1995	93.4172	62.3032	66.4674	0	77.8602	11.3928	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	68.3	49.9	118.2	0.0	0.0	118.2	0.0	0.0	0.0	0.0	86.3065	1	93.4172	88.2	91.5237	1
March 3, 1995	269.3198	179.6168	191.6241	0	224.4693	32.8452	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	118.2	175.1	282.8	0.0	0.0	282.8	28.3	10.5	10.5	0.0	86.3065	1	269.3198	88.2	267.4263	1
March 4, 1995	49.69	33.14	35.355	0	41.415	6.06	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	254.6	18.8	273.4	0.0	0.0	273.4	28.3	0.0	0.0	0.0	86.3065	1	49.69	88.2	47.7965	1
March 5, 1995	263.357	175.642	187.3815	0	219.4995	32.118	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	245.1	170.8	282.8	0.0	0.0	282.8	28.3	133.1	133.1	0.0	86.3065	1	263.357	88.2	261.4635	1
March 6, 1995	59.628	39.768	42.426	0	49.698	7.272	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	254.8	25.9	280.4	0.0	0.0	280.4	28.3	0.0	0.0	0.0	86.3065	1	59.628	88.2	57.7345	1
March 7, 1995	48.6962	32.4772	34.6479	0	40.5867	5.9388	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	252.2	18.1	270.3	0.0	0.0	270.3	28.3	0.0	0.0	0.0	86.3065	1	48.6962	88.2	46.8027	1
March 8, 1995	105.3428	70.2568	74.9526	0	87.7998	12.8472	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	242.0	58.4	282.8	0.0	0.0	282.8	28.3	17.5	17.5	0.0	86.3065	1	105.3428	88.2	103.4493	1
March 9, 1995	1.9876	1.3256	1.4142	0	1.6566	0.2424	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	254.8	-14.2	240.3	0.0	0.0	240.3	28.3	0.0	0.0	0.0	86.3065	1	1.9876	88.2	0.0941	1
March 10, 1995	31.8016	21.2096	22.6272	0	26.5056	3.8784	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	212.0	6.1	218.1	0.0	0.0	218.1	28.3	0.0	0.0	0.0	86.3065	1	31.8016	88.2	29.9081	1
March 11, 1995	53.8652	35.7912	38.1834	0	44.7282	6.5448	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	189.8	21.8	211.5	0.0	0.0	211.5	0.0	0.0	0.0	0.0	86.3065	1	53.8652	88.2	51.7717	1
March 12, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	211.5	-14.2	197.2	0.0	0.0	197.2	0.0	0.0	0.0	0.0	86.3065	1	0	86.3065	0	0
March 13, 1995	1.9876	1.3256	1.4142	0	1.6566	0.2424	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	197.2	-14.2	183.0	0.0	0.0	183.0	0.0	0.0	0.0	0.0	84.413	1	1.9876	86.4006	0	0
March 14, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	183.0	-14.2	168.7	0.0	0.0	168.7	0.0	0.0	0.0	0.0	84.5071	1	0	84.5071	0	0
March 15, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	168.7	-14.2	154.5	0.0	0.0	154.5	0.0	0.0	0.0	0.0	82.6136	1	0	82.6136	0	0
March 16, 1995	59.628	39.768	42.426	0	49.698	7.272	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	154.5	25.9	180.3	0.0	0.0	180.3	0.0	0.0	0.0	0.0	80.7201	1	59.628	88.2	52.1481	1
March 17, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	180.3	-14.2	166.1	0.0	0.0	166.1	0.0	0.0	0.0	0.0	86.3065	1	0	86.3065	0	0
March 18, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	166.1	-14.2	151.8	0.0	0.0	151.8	0.0	0.0	0.0	0.0	84.413	1	0	84.413	0	0
March 19, 1995	0.9938	0.6628	0.7071	0	0.8283	0.1212	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	151.8	-14.2	137.6	0.0	0.0	137.6	0.0	0.0	0.0	0.0	82.5195	1	0.9938	83.5133	0	0
March 20, 1995	37.7644	25.1864	26.8698	0	31.4754	4.6056	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	137.6	10.3	147.9	0.0	0.0	147.9	0.0	0.0	0.0	0.0	81.6198	1	37.7644	88.2	31.1842	1
March 21, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	147.9	-14.2	133.7	0.0	0.0	133.7	0.0	0.0	0.0	0.0	86.3065	1	0	86.3065	0	0
March 22, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	133.7	-14.2	119.4	0.0	0.0	119.4	0.0	0.0	0.0	0.0	84.413	1	0	84.413	0	0
March 23, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	119.4	-14.2	105.2	0.0	0.0	105.2	0.0	0.0	0.0	0.0	82.5195	1	0	82.5195	0	0
March 24, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	105.2	-14.2	90.9	0.0	0.0	90.9	0.0	0.0	0.0	0.0	80.626	1	0	80.626	0	0
March 25, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	90.9	-14.2	76.7	0.0	0.0	76.7	0.0	0.0	0.0	0.0	78.7325	1	0	78.7325	0	0
March 26, 1995	6.9566	4.6396	4.9497	0	5.7981	0.8484	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	76.7	-11.8	65.1	0.0	0.0	65.1	0.0	0.0	0.0	0.0	76.839	1	6.9566	83.7956	0	0
March 27, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	65.1	-14.2	50.8	0.0	0.0	50.8	0.0	0.0	0.0	0.0	81.9021	1	0	81.9021	0	0
March 28, 1995	2.9814	1.9884	2.1213	0	2.4849	0.3636	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	50.8	-14.2	36.6	0.0	0.0	36.6	0.0	0.0	0.0	0.0	80.0086	1	2.9814	82.99	0	0
March 29, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	36.6	-14.2	22.3	0.0	0.0	22.3	0.0	0.0	0.0	0.0	81.0965	1	0	81.0965	0	0
March 30, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	22.3	-14.2	8.1	20.2	1.0	28.3	0.0	0.0	0.0	0.0	79.203	1	0	79.203	0	0
March 31, 1995	0	0	0	0	0	0	14.248065	0	16.690	2.442	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-14.2	14.0	14.2	1.0	28.3	0.0	0.0	0.0	0.0	57.121795	0	0	57.121795	0	0
April 1, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-10.0	18.3	0.0	0.0	18.3	0.0	0.0	0.0	0.0	40.96023	0	0	40.96023	0	0
April 2, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	18.3	-10.0	8.3	20.0	1.0	28.3	0.0	0.0	0.0	0.0	39.06673	0	0	39.06673	0	0
April 3, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-10.0	18.3	0.0	0.0	18.3	0.0	0.0	0.0	0.0	17.1823	0	0	17.1823	0	0
April 4, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	18.3	-10.0	8.3	20.0	1.0	28.3	0.0	0.0	0.0	0.0	15.2888	0	0	15.2888	0	0
April 5, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-10.0	18.3	0.0	0.0	18.3	0.0	0.0	0.0	0.0	0	0	0	0	0	0
April 6, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	18.3	-10.0	8.3	20.0	1.0	28.3	0.0	0.0	0.0	0.0	0	0	0	0	0	0
April 7, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-10.0	18.3	0.0	0.0	18.3	0.0	0.0	0.0	0.0	0	0	0	0	0	0
April 8, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	18.3	-10.0	8.3	20.0	1.0	28.3	0.0	0.0	0.0	0.0	0	0	0	0	0	0
April 9, 1995	2.9814	1.9884	2.1213	0	2.4849	0.3636	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-10.0	18.3	0.0	0.0	18.3	0.0	0.0	0.0	0.0	0	0	2.9814	2.9814	0	0
April 10, 1995	1.9876	1.3256	1.4142	0	1.6566	0.2424	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	18.3	-10.0	8.3	20.0	1.0	28.3	0.0	0.0	0.0	0.0	1.0879	0	1.9876	3.0755	0	0
April 11, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-10.0	18.3	0.0	0.0	18.3	0.0	0.0	0.0	0.0	0	0	0	0	0	0
April 12, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	18.3	-10.0	8.3	20.0	1.0	28.3	0.0	0.0	0.0	0.0	0	0	0	0	0	0
April 13, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	28.3	-10.0	18.3	0.0	0.0	18.3	0.0	0.0	0.0	0.0	0	0	0	0	0	0
April 14, 1995	92.4234	61.6404	65.7603	0	77.0319	11.2716	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	18.3	53.5	71.7	0.0	0.0	71.7	0.0	0.0	0.0	0.0	0	0	92.4234	88.2	4.2234	1
April 15, 1995	27.8264	18.5584	19.7988	0	23.1924	3.3936	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	71.7	7.5	79.2	0.0	0.0	79.2	0.0	0.0	0.0	0.0	86.3065	1	27.8264	88.2	25.9329	1
April 16, 1995	278.264	185.584	197.988	0	231.924	33.936	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	79.2	185.7	264.9	0.0	0.0	264.9	28.3	0.0	0.0	0.0	86.3065	1	278.264	88.2	276.3705	1
April 17, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	236.6	-10.0	226.6	0.0	0.0	226.6	28.3	0.0	0.0	0.0	86.3065	1	0	86.3065	0	0
April 18, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	198.3	-10.0	188.3	0.0	0.0	188.3	0.0	0.0	0.0	0.0	84.413	1	0	84.413	0	0
April 19, 1995	0	0	0	0	0	0	10.005465	0	11.720	1.715	0.530325	0	3.106125	0	0	1.76775	0	4.1415	188.3	-10.0	178.3	0.0	0.0	178.3	0.0	0.0	0.0	0.0	82.5195	1	0	82.5195	0	0

Date	Spillage to Inf Sys (m3)	Spillage Directly to Outlet (m3)	Internal Reuse Demand From Tanks (m3)	Final Rainwater Tank Storage (m3)	Potable Water Required (m3)	Is Potable Water Required?	Flow from Impervious no Tank Area (m3)	Impervious No Tank to Inf Sys (m3)	Impervious No Tank to Outlet (m3)
November 18, 1998	0	0	1.9	63.7	0.0	0.0	9.9	9.9	0.0
November 19, 1998	19.271425	0	1.9	86.3	0.0	0.0	29.2	29.2	0.0
November 20, 1998	14.0073	0	1.9	86.3	0.0	0.0	10.6	10.6	0.0
November 21, 1998	0	0	15.0	71.3	0.0	0.0	0.0	0.0	0.0
November 22, 1998	0	0	16.7	54.6	0.0	0.0	0.0	0.0	0.0
November 23, 1998	0	0	16.7	37.9	0.0	0.0	0.0	0.0	0.0
November 24, 1998	54.030605	0	1.9	86.3	0.0	0.0	69.6	69.6	0.0
November 25, 1998	0.0941	0	1.9	86.3	0.0	0.0	1.3	1.3	0.0
November 26, 1998	218.7425	0	1.9	86.3	0.0	0.0	145.8	145.8	0.0
November 27, 1998	3.0755	0	1.9	86.3	0.0	0.0	3.3	3.3	0.0
November 28, 1998	0.0941	0	1.9	86.3	0.0	0.0	1.3	1.3	0.0
November 29, 1998	4.0693	0	1.9	86.3	0.0	0.0	4.0	4.0	0.0
November 30, 1998	0	0	1.9	84.4	0.0	0.0	0.0	0.0	0.0
December 1, 1998	43.9154	0	1.9	86.3	0.0	0.0	31.8	31.8	0.0
December 2, 1998	7.0507	0	1.9	86.3	0.0	0.0	6.0	6.0	0.0
December 3, 1998	0	0	1.9	84.4	0.0	0.0	0.0	0.0	0.0
December 4, 1998	0	0	1.9	82.5	0.0	0.0	0.0	0.0	0.0
December 5, 1998	4.2575	0	1.9	86.3	0.0	0.0	6.6	6.6	0.0
December 6, 1998	8.0445	0	1.9	86.3	0.0	0.0	6.8	6.8	0.0
December 7, 1998	0	0	1.9	84.4	0.0	0.0	0.0	0.0	0.0
December 8, 1998	155.221	0	1.9	86.3	0.0	0.0	106.0	106.0	0.0
December 9, 1998	0	0	1.9	85.4	0.0	0.0	0.7	0.7	0.0
December 10, 1998	0	0	1.9	83.5	0.0	0.0	0.0	0.0	0.0
December 11, 1998	0	0	1.9	81.6	0.0	0.0	0.0	0.0	0.0
December 12, 1998	0	0	1.9	79.7	0.0	0.0	0.0	0.0	0.0
December 13, 1998	0	0	1.9	77.8	0.0	0.0	0.0	0.0	0.0
December 14, 1998	0	0	1.9	75.9	0.0	0.0	0.0	0.0	0.0
December 15, 1998	12.5843	0	1.9	86.3	0.0	0.0	16.6	16.6	0.0
December 16, 1998	59.7221	0	1.9	86.3	0.0	0.0	41.1	41.1	0.0
December 17, 1998	8.0383	0	1.9	86.3	0.0	0.0	7.3	7.3	0.0
December 18, 1998	0	0	1.9	84.4	0.0	0.0	0.0	0.0	0.0
December 19, 1998	0	0	1.9	83.5	0.0	0.0	0.7	0.7	0.0
December 20, 1998	0	0	1.9	81.6	0.0	0.0	0.0	0.0	0.0
December 21, 1998	0.3764	0	27.3	60.9	0.0	0.0	4.6	4.6	0.0
December 22, 1998	0	0	16.9	51.0	0.0	0.0	4.6	4.6	0.0
December 23, 1998	0	0	19.6	31.4	0.0	0.0	0.0	0.0	0.0
December 24, 1998	0	0	19.6	12.8	0.0	0.0	0.7	0.7	0.0
December 25, 1998	0	0	19.6	0.0	6.8	1.0	0.0	0.0	0.0
December 26, 1998	0	0	19.6	0.0	19.6	1.0	0.0	0.0	0.0
December 27, 1998	0	0	19.6	0.0	19.6	1.0	0.0	0.0	0.0
December 28, 1998	0	0	19.6	0.0	19.6	1.0	0.0	0.0	0.0
December 29, 1998	0	0	19.6	0.0	19.6	1.0	0.0	0.0	0.0
December 30, 1998	0	0	19.6	0.0	19.6	1.0	0.0	0.0	0.0
December 31, 1998	0	0	19.6	0.0	18.6	1.0	0.7	0.7	0.0
	23625.282	0	8446.926705	90364.89498	2954.5897	218	19390.214	19390.214	0

Date	Initial Forest Soil Storage (m3)	Potential flow to Forest Soil (m3)	Net Flow to Forest Soil (m3)	Forest Soil Storage before Infiltration (m3)	Forest Deep Infiltration (m3)	Runoff from Forest Area (m3)	Forest Area Runoff to Inf Sys (m3)	Forest Area Runoff to Outlet (m3)	Initial Pervious - No Irrigation Soil Storage (m3)	Potential Flow to Pervious - No Irrigation Soil (m3)	Net Flow to Pervious - No Irrigation Soil (m3)	Perv. - No Irr. Soil Storage before Infiltration (m3)	Pervious - No Irrigation Deep Infiltration (m3)	Runoff from Pervious - No Irrigation Area (m3)	Pervious - No Irrigation Area Runoff to Inf Sys (m3)	Pervious - No Irrigation Area Runoff to Outlet (m3)
November 18, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
November 19, 1998	0.0	11.8	11.8	11.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
November 20, 1998	11.8	-11.3	-11.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
November 21, 1998	0.5	-17.4	-0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
November 22, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
November 23, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
November 24, 1998	0.0	62.4	62.4	62.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
November 25, 1998	62.4	-17.4	-17.4	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
November 26, 1998	45.0	157.6	157.6	202.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
November 27, 1998	202.6	-17.4	-17.4	185.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
November 28, 1998	185.3	-17.4	-17.4	167.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
November 29, 1998	167.9	-17.4	-17.4	150.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
November 30, 1998	150.6	-17.4	-17.4	133.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 1, 1998	133.2	11.8	11.8	145.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 2, 1998	145.0	-20.5	-20.5	124.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 3, 1998	124.5	-20.7	-20.7	103.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 4, 1998	103.8	-20.7	-20.7	83.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 5, 1998	83.1	-19.7	-19.7	63.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 6, 1998	63.4	-19.7	-19.7	43.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 7, 1998	43.8	-20.7	-20.7	23.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 8, 1998	23.1	104.6	104.6	127.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 9, 1998	127.6	-20.7	-20.7	106.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 10, 1998	106.9	-20.7	-20.7	86.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 11, 1998	86.2	-20.7	-20.7	65.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 12, 1998	65.5	-20.7	-20.7	44.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 13, 1998	44.8	-20.7	-20.7	24.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 14, 1998	24.1	-20.7	-20.7	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 15, 1998	3.4	-7.2	-3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 16, 1998	0.0	23.4	23.4	23.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 17, 1998	23.4	-18.8	-18.8	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 18, 1998	4.6	-20.7	-4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 19, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 20, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 21, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 22, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 23, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 24, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 25, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 26, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 27, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 28, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 29, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 30, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
December 31, 1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	137751.7154	8941.45709	9408.630365	141934.63	4472.82	5223.715365	0	5223.715365	0	0	0	0	0	0	0	0

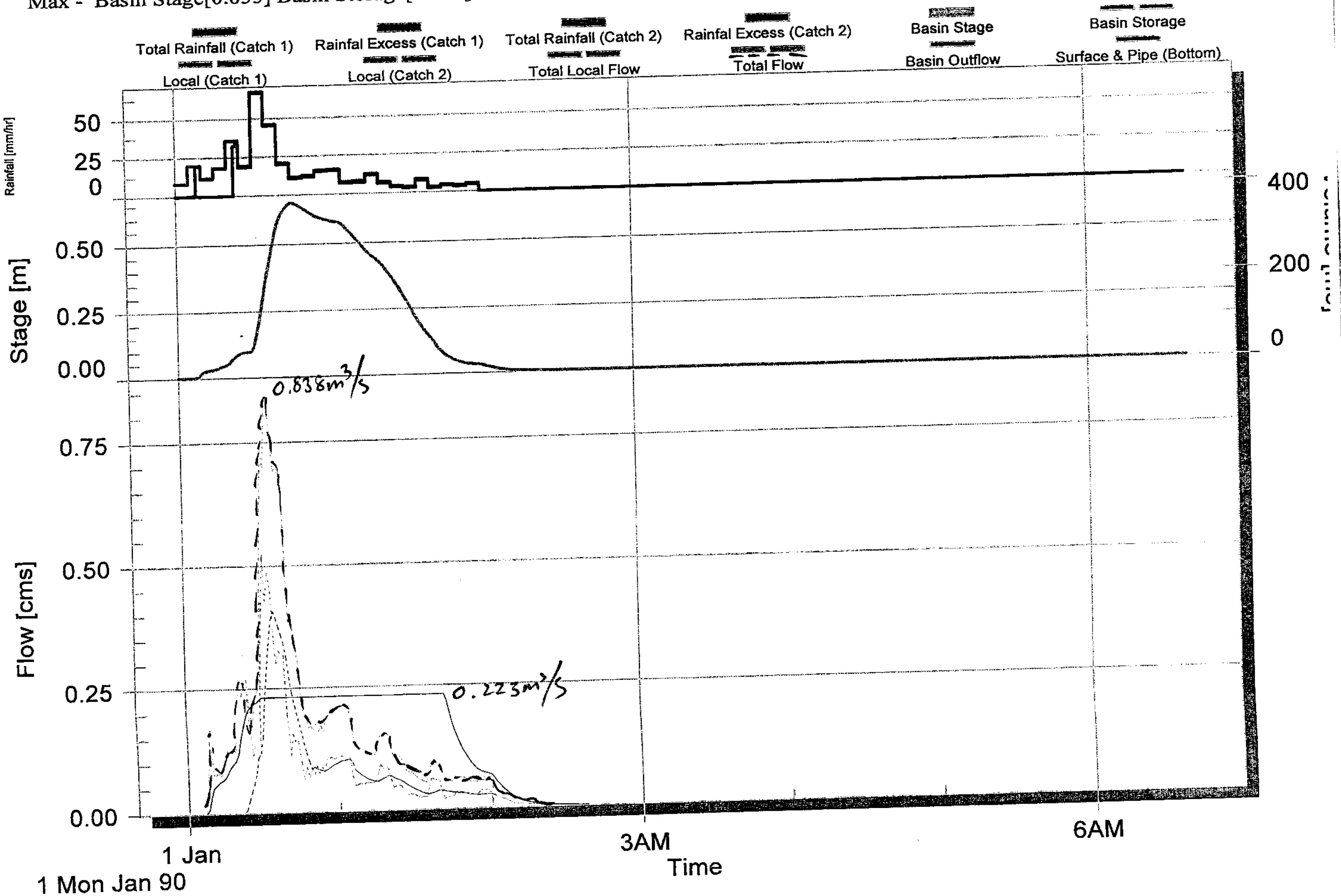
Date	Initial Inf Sys Storage (m3)	Total Flow to Inf Sys (m^3)	Inf Sys Storage After Rainfall (m3)	Potential Inf Sys Infiltration (m3)	Final Inf Sys Storage (m3)	Spillage From Inf Sys to Outlet (m3)	Total Flow to Outlet (m^3)
November 18, 1998	0.000	9.221	9.221	60.600	0.000	0.0	0.0
November 19, 1998	0.000	51.228	51.228	60.600	0.000	0.0	0.0
November 20, 1998	0.000	24.012	24.012	60.600	0.000	0.0	0.0
November 21, 1998	0.000	-2.539	0.000	60.600	0.000	0.0	0.0
November 22, 1998	0.000	-2.539	0.000	60.600	0.000	0.0	0.0
November 23, 1998	0.000	-2.539	0.000	60.600	0.000	0.0	0.0
November 24, 1998	0.000	133.812	133.812	60.600	73.212	0.0	0.0
November 25, 1998	73.212	-0.877	72.335	60.600	11.735	0.0	0.0
November 26, 1998	11.735	386.683	398.418	60.600	337.818	0.0	0.0
November 27, 1998	337.818	4.456	342.274	60.600	281.674	0.0	0.0
November 28, 1998	281.674	-0.877	280.797	60.600	220.197	0.0	0.0
November 29, 1998	220.197	6.234	226.431	60.600	165.831	0.0	0.0
November 30, 1998	165.831	-2.539	163.292	60.600	102.692	0.0	0.0
December 1, 1998	102.692	78.517	181.210	60.600	120.610	0.0	0.0
December 2, 1998	120.610	11.077	131.686	60.600	71.086	0.0	0.0
December 3, 1998	71.086	-3.030	68.056	60.600	7.456	0.0	0.0
December 4, 1998	7.456	-3.030	4.426	60.600	0.000	0.0	0.0
December 5, 1998	0.000	9.067	9.067	60.600	0.000	0.0	0.0
December 6, 1998	0.000	12.855	12.855	60.600	0.000	0.0	0.0
December 7, 1998	0.000	-3.030	0.000	60.600	0.000	0.0	0.0
December 8, 1998	0.000	277.631	277.631	60.600	217.031	0.0	0.0
December 9, 1998	217.031	-2.246	214.785	60.600	154.185	0.0	0.0
December 10, 1998	154.185	-3.030	151.155	60.600	90.555	0.0	0.0
December 11, 1998	90.555	-3.030	87.525	60.600	26.925	0.0	0.0
December 12, 1998	26.925	-3.030	23.895	60.600	0.000	0.0	0.0
December 13, 1998	0.000	-3.030	0.000	60.600	0.000	0.0	0.0
December 14, 1998	0.000	-3.030	0.000	60.600	0.000	0.0	0.0
December 15, 1998	0.000	29.154	29.154	60.600	0.000	0.0	0.0
December 16, 1998	0.000	105.300	105.300	60.600	44.700	0.0	0.0
December 17, 1998	44.700	14.632	59.332	60.600	0.000	0.0	0.0
December 18, 1998	0.000	-3.030	0.000	60.600	0.000	0.0	0.0
December 19, 1998	0.000	-2.246	0.000	60.600	0.000	0.0	0.0
December 20, 1998	0.000	-3.030	0.000	60.600	0.000	0.0	0.0
December 21, 1998	0.000	2.834	2.834	60.600	0.000	0.0	0.0
December 22, 1998	0.000	2.458	2.458	60.600	0.000	0.0	0.0
December 23, 1998	0.000	-3.030	0.000	60.600	0.000	0.0	0.0
December 24, 1998	0.000	-2.246	0.000	60.600	0.000	0.0	0.0
December 25, 1998	0.000	-3.030	0.000	60.600	0.000	0.0	0.0
December 26, 1998	0.000	-3.030	0.000	60.600	0.000	0.0	0.0
December 27, 1998	0.000	-3.030	0.000	60.600	0.000	0.0	0.0
December 28, 1998	0.000	-3.030	0.000	60.600	0.000	0.0	0.0
December 29, 1998	0.000	-3.030	0.000	60.600	0.000	0.0	0.0
December 30, 1998	0.000	-3.030	0.000	60.600	0.000	0.0	0.0
December 31, 1998	0.000	-2.246	0.000	60.600	0.000	0.0	0.0
	119048.808	48804.37249	152508.0751	88536.6	118745.808	18655.90937	21879.6

APPENDIX C
RAFTS DETENTION MODELLING RESULTS


10A [STORM 1]
100yr 120min
Max - Basin Stage[0.944] Basin Storage[571.8] Local (Catch 1)[0.517] Local (Catch 2)[0.635] Total Local Flow[1.068] Total Flow[1.068]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Total Rainfall (Catch 2)
Rainfal Excess (Catch 2)
Basin Stage
Basin Storage
Local (Catch 1)
Local (Catch 2)
Total Local Flow
Total Flow
Basin Outflow
Surface & Pipe (Bottom)
Rainfall [mm/hr]
Stage [m]
Flow [cms]
1.068m3/s
0.223m3/s
1 Jan
3AM
6AM

10A [STORM 2]

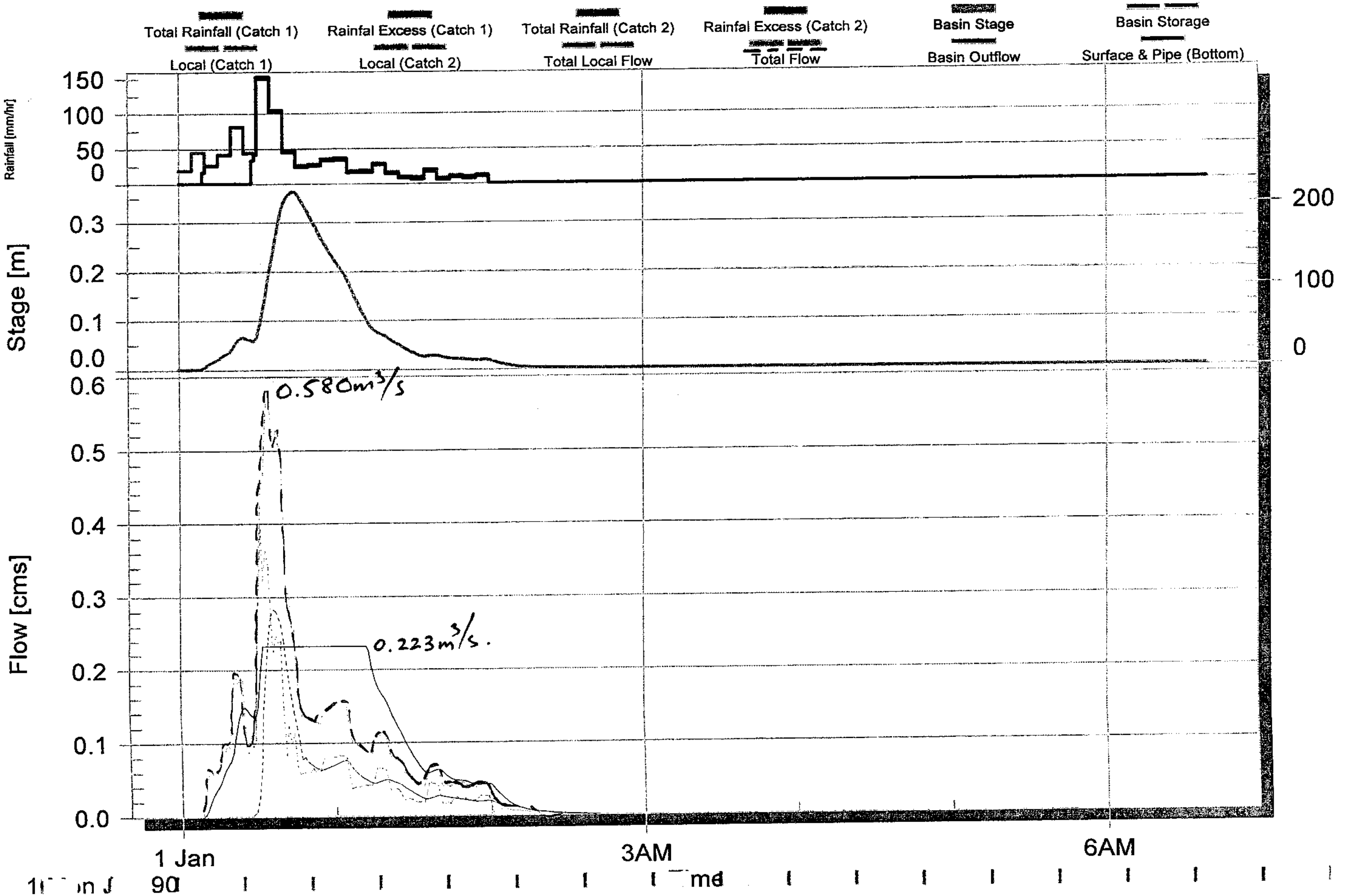
Max - Basin Stage[0.655] Basin Storage[396.8] Local (Catch 1)[0.407] Local (Catch 2)[0.523] Total Local Flow[0.838] Total Flow[0.838]



10A [STORM 3]

5yr 120min

Max - Basin Stage[0.361] Basin Storage[218.9] Local (Catch 1)[0.282] Local (Catch 2)[0.394] Total Local Flow[0.580] Total Flow[0.580]



Run started at: 15th July 2003 13:43:59

Existing 15/7/03

##

RUNTIME RESULTS

##

Max. no. of links allowed = 2000

Max. no. of routng increments allowed = 30000

Max. no. of rating curve points = 30000

Max. no. of storm temporal points = 30000

Max. no. of channel subreaches = 25

Max link stack level = 25

Input Version number = 600

LINK 10A 1.000

ESTIMATED VOLUME (CU METRES*10**3) = 1.661
ESTIMATED PEAK FLOW (CUMECS) = 0.87
ESTIMATED TIME TO PEAK (MINS) = 40.00

LINK out 1.001

ESTIMATED VOLUME (CU METRES*10**3) = 1.661
ESTIMATED PEAK FLOW (CUMECS) = 0.87
ESTIMATED TIME TO PEAK (MINS) = 40.00

##
Existing -sector 10a -100yr, 20yr and 5yr

Results for period from 0: 0.0 1/ 1/1990
to 6:40.0 1/ 1/1990
##

ROUTING INCREMENT (MINS) = 1.00
STORM DURATION (MINS) = 120.
RETURN PERIOD (YRS) = 100.
BX = 1.0000
TOTAL OF FIRST SUB-AREAS (km2) = 1.57
TOTAL OF SECOND SUB-AREAS (km2) = 0.08
TOTAL OF ALL SUB-AREAS (km2) = 1.66

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	#2	Slope #1 (%)	#2	% Impervious #1 (%)	#2	Pern #1	#2	B #1	#2	Link No.
10A	1.574	0.0828	19.00	19.00	1.000	99.00	.070	.015	.0159	0.000	1.000
out	.00001	0.000	1.000	0.000	1.000	0.000	.015	0.00	0.000	0.000	1.001

Link Label	Average Intensity	Init. Loss #1	#2	Cont. Loss #1	#2	Excess Rain #1	#2	Peak Inflow	Time to	Link Lag

10A	61.800	20.00	5.000	2.500	.5000	99.433	117.65	0.8665	40.00	0.000
out	61.800	0.000	0.000	2.500	0.000	118.60	0.000	0.8665	40.00	0.000

LINK 10A 1.000

ESTIMATED VOLUME (CU METRES*10**3) = 1.166
ESTIMATED PEAK FLOW (CUMECS) = 0.67
ESTIMATED TIME TO PEAK (MINS) = 40.00

LINK out 1.001

ESTIMATED VOLUME (CU METRES*10**3) = 1.166
ESTIMATED PEAK FLOW (CUMECS) = 0.67
ESTIMATED TIME TO PEAK (MINS) = 40.00

##
#####
Existing -sector 10a -100yr, 20yr and 5yr

Results for period from 0: 0.0 1/ 1/1990
to 6:40.0 1/ 1/1990
##
#####

ROUTING INCREMENT (MINS) = 1.00
STORM DURATION (MINS) = 120.
RETURN PERIOD (YRS) = 20.
BX = 1.0000
TOTAL OF FIRST SUB-AREAS (km2) = 1.57
TOTAL OF SECOND SUB-AREAS (km2) = 0.08
TOTAL OF ALL SUB-AREAS (km2) = 1.66

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	#2	Slope #1 (%)	#2	% Impervious #1 (%)	#2	Pern #1	#2	B #1	#2	Link No.
10A	1.574	0.0828	19.00	19.00	1.000	99.00	.070	.015	.0159	0.000	1.000
out	.00001	0.000	1.000	0.000	1.000	0.000	.015	0.00	0.000	0.000	1.001

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	#2	Cont. Loss #1 (mm/h)	#2	Excess Rain #1 (mm)	#2	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
10A	46.700	20.00	5.000	2.500	.5000	69.358	87.458	0.6686	40.00	0.000
out	46.700	0.000	0.000	2.500	0.000	88.400	0.000	0.6686	40.00	0.000

LINK 10A 1.000

ESTIMATED VOLUME (CU METRES*10**3) = 0.7841
ESTIMATED PEAK FLOW (CUMECS) = 0.42
ESTIMATED TIME TO PEAK (MINS) = 41.00

LINK out 1.001

ESTIMATED VOLUME (CU METRES*10**3) = 0.7841
ESTIMATED PEAK FLOW (CUMECS) = 0.42
ESTIMATED TIME TO PEAK (MINS) = 41.00

##
#####
Existing -sector 10a -100yr, 20yr and 5yr

Results for period from 0: 0.0 1/ 1/1990
to 6:40.0 1/ 1/1990
##
#####

```
ROUTING INCREMENT (MINS) =          1.00
STORM DURATION (MINS)    =          120.
RETURN PERIOD (YRS)      =            5.
BX                       =        1.0000
TOTAL OF FIRST SUB-AREAS  (km2) =          1.57
TOTAL OF SECOND SUB-AREAS (km2) =          0.08
TOTAL OF ALL SUB-AREAS (km2)    =          1.66
```

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2	Slope #1 (%)	Slope #2	% Impervious #1 (%)	% Impervious #2	Pern #1	Pern #2	B #1	B #2	Link No.
10A	1.574	0.0828	19.00	19.00	1.000	99.00	.070	.015	.0159	0.000	1.000
out	.00001	0.000	1.000	0.000	1.000	0.000	.015	0.00	0.000	0.000	1.001

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	Init. Loss #2	Cont. Loss #1 (mm/h)	Cont. Loss #2	Excess Rain #1 (mm)	Excess Rain #2	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
10A	35.200	20.00	5.000	2.500	.5000	46.567	64.475	0.4164	41.00	0.000
out	35.200	0.000	0.000	2.500	0.000	65.400	0.000	0.4164	41.00	0.000

Run completed at: 15th July 2003 13:44:00

Run started at: 15th July 2003 13:47:04

Post (No det) 15/7/03

##
#####

RUNTIME RESULTS

##
#####

Max. no. of links allowed = 2000

Max. no. of routng increments allowed = 30000

Max. no. of rating curve points = 30000

Max. no. of storm temporal points = 30000

Max. no. of channel subreaches = 25

Max link stack level = 25

Input Version number = 600

LINK 10A 1.000

ESTIMATED VOLUME (CU METRES*10**3) = 1.799
ESTIMATED PEAK FLOW (CUMECS) = 1.07
ESTIMATED TIME TO PEAK (MINS) = 35.00

LINK out 1.001

ESTIMATED VOLUME (CU METRES*10**3) = 1.799
ESTIMATED PEAK FLOW (CUMECS) = 1.07
ESTIMATED TIME TO PEAK (MINS) = 35.00

##
#####
Proposed -sector 10a -100yr, 20yr and 5yr

Results for period from 0: 0.0 1/ 1/1990
to 6:40.0 1/ 1/1990
##
#####

ROUTING INCREMENT (MINS) = 1.00
STORM DURATION (MINS) = 120.
RETURN PERIOD (YRS) = 100.
BX = 1.0000
TOTAL OF FIRST SUB-AREAS (km2) = 0.83
TOTAL OF SECOND SUB-AREAS (km2) = 0.83
TOTAL OF ALL SUB-AREAS (km2) = 1.66

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2	Slope #1 (%)	Slope #2	% Impervious #1 (%)	% Impervious #2	Pern #1	Pern #2	B #1	B #2	Link No.
10A	0.8283	0.8283	10.00	10.00	1.000	99.00	.025	.015	.0071	.0004	1.000
out	.00001	0.000	1.000	0.000	1.000	0.000	.015	0.00	0.000	0.000	1.001

Link Label	Average Intensity	Init. Loss #1	Init. Loss #2	Cont. Loss #1	Cont. Loss #2	Excess Rain #1	Excess Rain #2	Peak Inflow	Time to	Link Lag

10A	61.800	20.00	5.000	2.500	.5000	99.433	117.65	1.068	35.00	0.000
out	61.800	0.000	0.000	2.500	0.000	118.60	0.000	1.068	35.00	0.000

LINK 10A 1.000

ESTIMATED VOLUME (CU METRES*10**3) = 1.299
ESTIMATED PEAK FLOW (CUMECS) = 0.84
ESTIMATED TIME TO PEAK (MINS) = 35.00

LINK out 1.001

ESTIMATED VOLUME (CU METRES*10**3) = 1.299
ESTIMATED PEAK FLOW (CUMECS) = 0.84
ESTIMATED TIME TO PEAK (MINS) = 35.00

##
#####
Proposed -sector 10a -100yr, 20yr and 5yr

Results for period from 0: 0.0 1/ 1/1990
to 6:40.0 1/ 1/1990
##
#####

ROUTING INCREMENT (MINS) = 1.00
STORM DURATION (MINS) = 120.
RETURN PERIOD (YRS) = 20.
BX = 1.0000
TOTAL OF FIRST SUB-AREAS (km2) = 0.83
TOTAL OF SECOND SUB-AREAS (km2) = 0.83
TOTAL OF ALL SUB-AREAS (km2) = 1.66

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	#2	Slope #1 (%)	#2	% Impervious #1 (%)	#2	Pern #1	#2	B #1	#2	Link No.
10A	0.8283	0.8283	10.00	10.00	1.000	99.00	.025	.015	.0071	.0004	1.000
out	.00001	0.000	1.000	0.000	1.000	0.000	.015	0.00	0.000	0.000	1.001

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	#2	Cont. Loss #1 (mm/h)	#2	Excess Rain #1 (mm)	#2	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
10A	46.700	20.00	5.000	2.500	.5000	69.358	87.458	0.8383	35.00	0.000
out	46.700	0.000	0.000	2.500	0.000	88.400	0.000	0.8384	35.00	0.000

LINK 10A 1.000

ESTIMATED VOLUME (CU METRES*10**3) = 0.9207
ESTIMATED PEAK FLOW (CUMECS) = 0.58
ESTIMATED TIME TO PEAK (MINS) = 35.00

LINK out 1.001

ESTIMATED VOLUME (CU METRES*10**3) = 0.9207
ESTIMATED PEAK FLOW (CUMECS) = 0.58
ESTIMATED TIME TO PEAK (MINS) = 35.00

##
#####
Proposed -sector 10a -100yr, 20yr and 5yr

Results for period from 0: 0.0 1/ 1/1990
to 6:40.0 1/ 1/1990
##
#####

ROUTING INCREMENT (MINS) = 1.00
STORM DURATION (MINS) = 120.
RETURN PERIOD (YRS) = 5.
BX = 1.0000
TOTAL OF FIRST SUB-AREAS (km2) = 0.83
TOTAL OF SECOND SUB-AREAS (km2) = 0.83
TOTAL OF ALL SUB-AREAS (km2) = 1.66

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2 (ha)	Slope #1 (%)	Slope #2 (%)	% Impervious #1 (%)	% Impervious #2 (%)	Pern #1	Pern #2	B #1	B #2	Link No.
10A	0.8283	0.8283	10.00	10.00	1.000	99.00	.025	.015	.0071	.0004	1.000
out	.00001	0.000	1.000	0.000	1.000	0.000	.015	0.00	0.000	0.000	1.001

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	Init. Loss #2 (mm)	Cont. Loss #1 (mm/h)	Cont. Loss #2 (mm/h)	Excess Rain #1 (mm)	Excess Rain #2 (mm)	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
10A	35.200	20.00	5.000	2.500	.5000	46.567	64.475	0.5804	35.00	0.000
out	35.200	0.000	0.000	2.500	0.000	65.400	0.000	0.5804	35.00	0.000

Run completed at: 15th July 2003 13:47:05

Run started at: 15th July 2003 13:50:46

Post with OS D 15/7/03

##
#####
RUNTIME RESULTS
##
#####

Max. no. of links allowed = 2000

Max. no. of routng increments allowed = 30000

Max. no. of rating curve points = 30000

Max. no. of storm temporal points = 30000

Max. no. of channel subreaches = 25

Max link stack level = 25

Input Version number = 600

LINK 10A 1.000

ESTIMATED VOLUME (CU METRES*10**3) = 1.799
ESTIMATED PEAK FLOW (CUMECS) = 1.07
ESTIMATED TIME TO PEAK (MINS) = 35.00

LINK out 1.001

ESTIMATED VOLUME (CU METRES*10**3) = 1.708
ESTIMATED PEAK FLOW (CUMECS) = 0.23
ESTIMATED TIME TO PEAK (MINS) = 31.00

##
#####
Proposed -sector 10a -100yr, 20yr and 5yr

Results for period from 0: 0.0 1/ 1/1990
to 6:40.0 1/ 1/1990
##
#####

ROUTING INCREMENT (MINS) = 1.00
STORM DURATION (MINS) = 120.
RETURN PERIOD (YRS) = 100.
BX = 1.0000
TOTAL OF FIRST SUB-AREAS (km2) = 0.83
TOTAL OF SECOND SUB-AREAS (km2) = 0.83
TOTAL OF ALL SUB-AREAS (km2) = 1.66

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	#2	Slope #1 (%)	#2	% Impervious #1 (%)	#2	Pern #1	#2	B #1	#2	Link No.
10A	0.8283	0.8283	10.00	10.00	1.000	99.00	.025	.015	.0071	.0004	1.000
out	.00001	0.000	1.000	0.000	1.000	0.000	.015	0.00	0.000	0.000	1.001

Link Label	Average Intensity	Init. Loss #1	#2	Cont. Loss #1	#2	Excess Rain #1	#2	Peak Inflow	Time to	Link Lag

10A	61.800	20.00	5.000	2.500	.5000	99.433	117.65	1.068	35.00	0.000
out	61.800	0.000	0.000	2.500	0.000	118.60	0.000	0.2322	31.00	0.000

SUMMARY OF BASIN RESULTS

Link Label	Time to Peak	Peak Inflow (m^3/s)	Time to Peak	Peak Outflow (m^3/s)	Total Inflow (m^3)	Basin Vol. Avail	Basin Vol. Used	Basin Stage Used
10A	35.00	1.067	23.00	.2322	1798.7	0.0000	571.82	0.9436

SUMMARY OF BASIN OUTLET RESULTS

Link Label	No. of	S/D Factor (m)	Dia (m)	Width (m)	Pipe Length (m)	Pipe Slope (%)
10A	1.0	1.000		0.000	0.5000	0.2000

LINK 10A 1.000

ESTIMATED VOLUME (CU METRES*10**3) = 1.299
ESTIMATED PEAK FLOW (CUMECS) = 0.84
ESTIMATED TIME TO PEAK (MINS) = 35.00

LINK out 1.001

ESTIMATED VOLUME (CU METRES*10**3) = 1.331
ESTIMATED PEAK FLOW (CUMECS) = 0.23
ESTIMATED TIME TO PEAK (MINS) = 31.00

###
#####
Proposed -sector 10a -100yr, 20yr and 5yr

Results for period from 0: 0.0 1/ 1/1990
to 6:40.0 1/ 1/1990
###
#####

ROUTING INCREMENT (MINS) = 1.00
STORM DURATION (MINS) = 120.
RETURN PERIOD (YRS) = 20.
BX = 1.0000
TOTAL OF FIRST SUB-AREAS (km2) = 0.83
TOTAL OF SECOND SUB-AREAS (km2) = 0.83
TOTAL OF ALL SUB-AREAS (km2) = 1.66

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2	Slope #1 (%)	Slope #2	% Impervious #1 (%)	% Impervious #2	Pern #1	Pern #2	B #1	B #2	Link No.
10A	0.8283	0.8283	10.00	10.00	1.000	99.00	.025	.015	.0071	.0004	1.000
out	.00001	0.000	1.000	0.000	1.000	0.000	.015	0.00	0.000	0.000	1.001

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	Init. Loss #2	Cont. Loss #1 (mm/h)	Cont. Loss #2	Excess Rain #1 (mm)	Excess Rain #2	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
10A	46.700	20.00	5.000	2.500	.5000	69.358	87.458	0.8383	35.00	0.000
out	46.700	0.000	0.000	2.500	0.000	88.400	0.000	0.2322	31.00	0.000

SUMMARY OF BASIN RESULTS

Link Label	Time to Peak	Peak Inflow (m^3/s)	Time to Peak	Peak Outflow (m^3/s)	Total Inflow (m^3)	Basin Vol. Avail	Basin Vol. Used	Basin Stage Used
10A	35.00	.8383	31.00	.2322	1299.0	0.0000	396.79	0.6548

SUMMARY OF BASIN OUTLET RESULTS

Link Label	No. of	S/D Factor (m)	Dia (m)	Width (m)	Pipe Length (m)	Pipe Slope (%)
10A	1.0	1.000		0.000	0.5000	0.2000

LINK 10A 1.000

ESTIMATED VOLUME (CU METRES*10**3) = 0.9207
ESTIMATED PEAK FLOW (CUMECS) = 0.58
ESTIMATED TIME TO PEAK (MINS) = 35.00

LINK out 1.001

ESTIMATED VOLUME (CU METRES*10**3) = 0.9649
ESTIMATED PEAK FLOW (CUMECS) = 0.23
ESTIMATED TIME TO PEAK (MINS) = 33.00

##
#####
Proposed -sector 10a -100yr, 20yr and 5yr

Results for period from 0: 0.0 1/ 1/1990
to 6:40.0 1/ 1/1990
##
#####

ROUTING INCREMENT (MINS) = 1.00
STORM DURATION (MINS) = 120.
RETURN PERIOD (YRS) = 5.
BX = 1.0000
TOTAL OF FIRST SUB-AREAS (km2) = 0.83
TOTAL OF SECOND SUB-AREAS (km2) = 0.83
TOTAL OF ALL SUB-AREAS (km2) = 1.66

SUMMARY OF CATCHMENT AND RAINFALL DATA

Link Label	Catch. Area #1 (ha)	Catch. Area #2 (ha)	Slope #1 (%)	Slope #2 (%)	% Impervious #1 (%)	% Impervious #2 (%)	Pern #1	Pern #2	B #1	B #2	Link No.
10A	0.8283	0.8283	10.00	10.00	1.000	99.00	.025	.015	.0071	.0004	1.000
out	.00001	0.000	1.000	0.000	1.000	0.000	.015	0.00	0.000	0.000	1.001

Link Label	Average Intensity (mm/h)	Init. Loss #1 (mm)	Init. Loss #2 (mm)	Cont. Loss #1 (mm/h)	Cont. Loss #2 (mm/h)	Excess Rain #1 (mm)	Excess Rain #2 (mm)	Peak Inflow (m^3/s)	Time to Peak	Link Lag mins
10A	35.200	20.00	5.000	2.500	.5000	46.567	64.475	0.5804	35.00	0.000
out	35.200	0.000	0.000	2.500	0.000	65.400	0.000	0.2322	33.00	0.000

SUMMARY OF BASIN RESULTS

Link Label	Time to Peak	Peak Inflow (m^3/s)	Time to Peak	Peak Outflow (m^3/s)	Total Inflow (m^3)	Basin Vol. Avail	Basin Vol. Used	Basin Stage Used
10A	35.00	.5804	33.00	.2322	920.65	0.0000	218.89	0.3612

SUMMARY OF BASIN OUTLET RESULTS

Link Label	No. of	S/D Factor (m)	Dia (m)	Width (m)	Pipe Length (m)	Pipe Slope (%)
10A	1.0	1.000		0.000	0.5000	0.2000

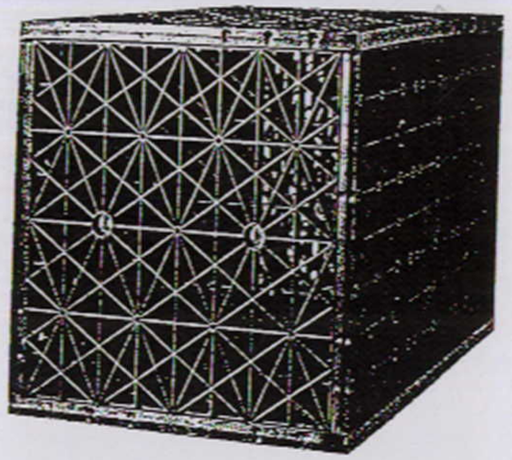
Run completed at: 15th July 2003 13:50:48

APPENDIX D
ATLANTIS INFILTRATION TANK DETAILS

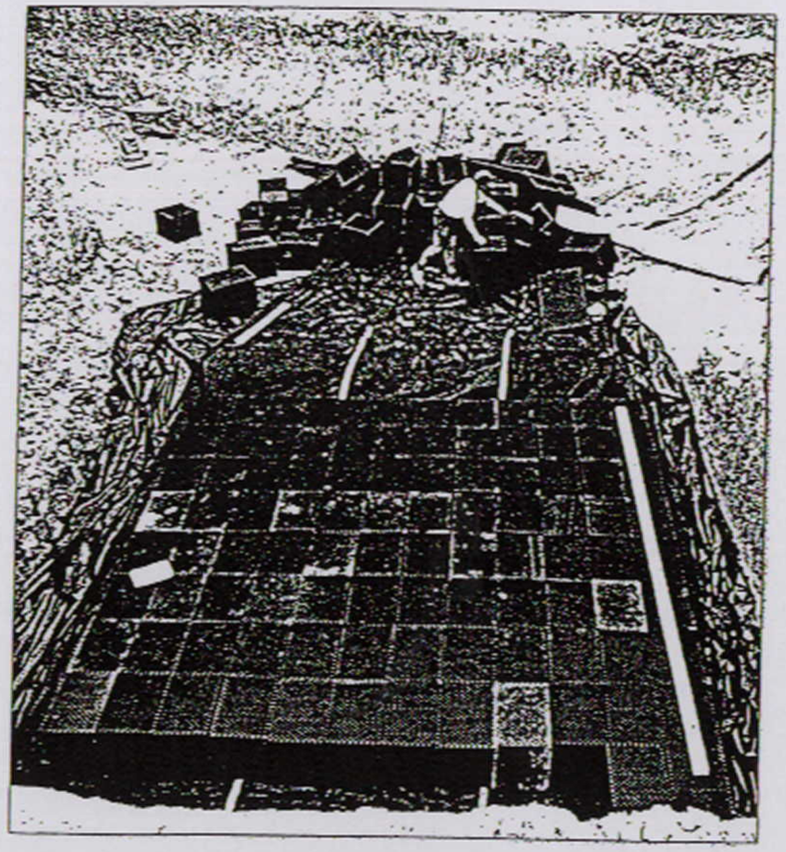
Atlantis Ecological Tank System

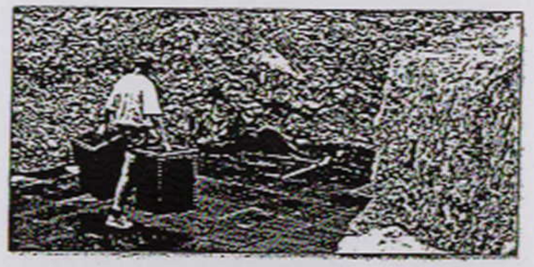
Retention, Infiltration & Detention

The Atlantis Ecological Systems use surface and sub surface infiltration techniques that result in purified water that can be reused or allowed to re-enter the natural water system. The modular Atlantis Ecological Tanks offer a highly efficient option for stormwater management in any kind of soils.



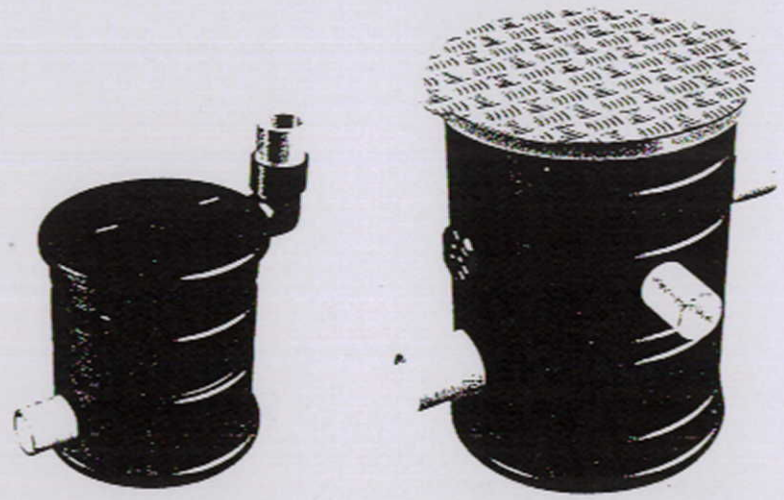
The Atlantis Ecological Tank Systems excel when there is a requirement to achieve high water quality, particularly in the effective removal of nutrients and gross pollutants. The system offers a unique solution where no utility based drainage system is available. In addition to the obvious environmental benefits the sub surface location of the tank system provides more useable space and an enhanced aesthetic setting compared to above ground concrete or plastic tank. The design of the system successfully augments any landscape feature by providing an enduring moisture supply.





The Atlantis Ecological Tank Systems can be categorised into percolation and reuse applications. The main system components are the Stormwater Filtration Unit, Atlantis Geotextile, Atlantis Ecosoils and Atlantis Ecological Tanks. The following descriptions summarise the percolation and reuse systems.

Atlantis Filtration Units



Small Purification Unit (Single Down Pipe)

Large Purification Unit (Multiple Down Pipes)

Incorporating a unique two-stage filter system that improves stormwater quality.

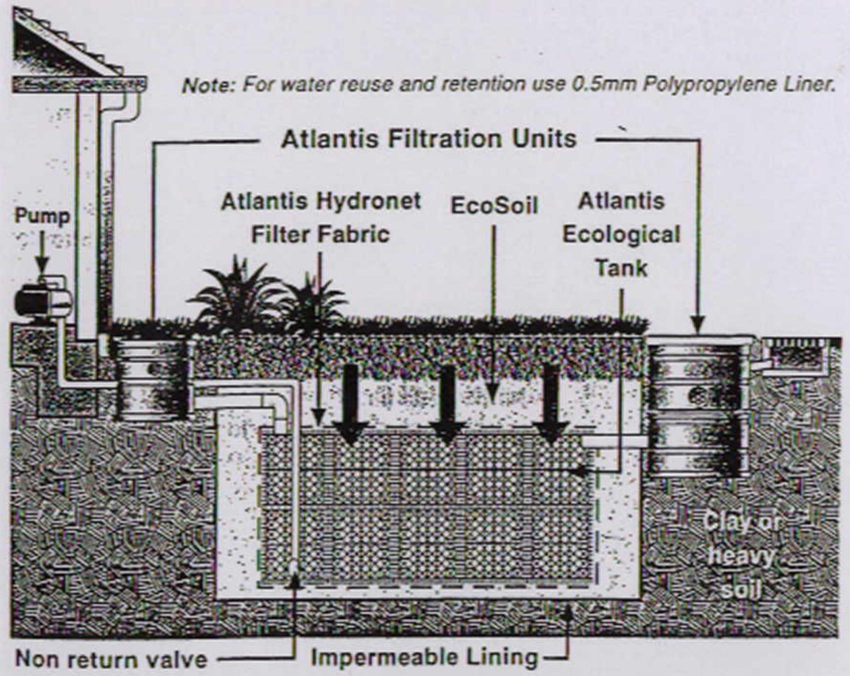
Purifying storm water at source is considered the most effective method of reducing waterway contamination. The Atlantis Filtration Unit is a revolutionary device that is specifically designed to remove pollutants from stormwater runoff from roofs (can also filter gray water for reuse). The unit features a removable trash screen for easy cleaning, which ensures that litter free water enters the tank system. The unit also contains a filter system that can bio-remediate soluble stormwater contaminants. This filtration chamber provides primary macro and secondary biological water filtration. The unit delivers decontaminated water to the Atlantis Ecological Tanks where continuous filtration occurs. The unit is designed for easy installation and user friendly maintenance.

Part Number	Application	Flow Rate	Size
60002	Small Filtration Unit	12 l/sec	450 x 480 x 575mm
60003	Large Filtration Unit	20 l/sec	680 x 880mm

Benefits:

- Filters Stormwater at Source
- Easy Installation
- User Friendly Maintenance

Atlantis Ecological Tanks

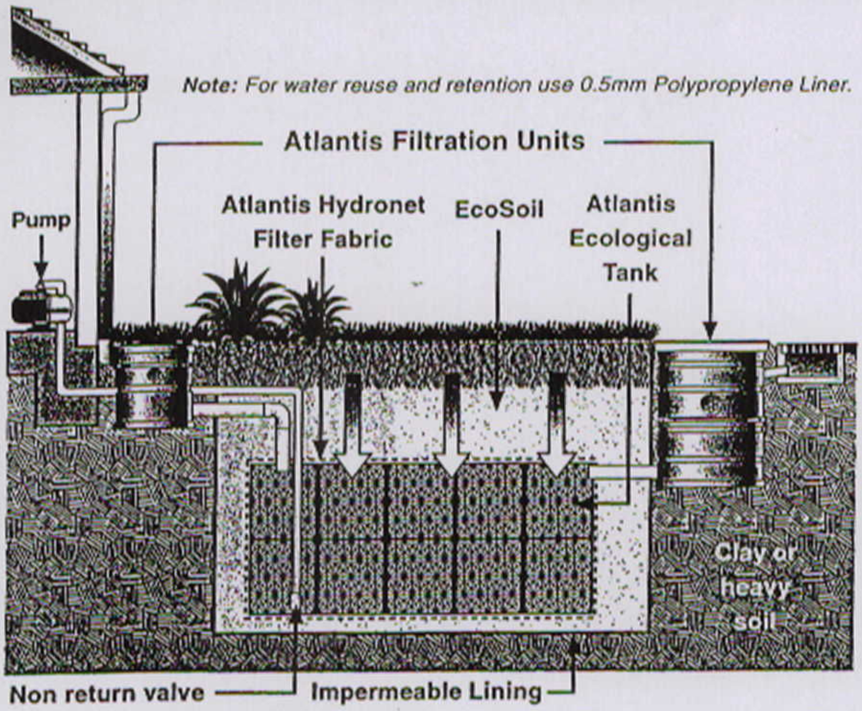


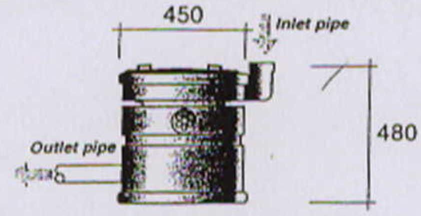
Part Number	Size (approx)	Units per /m³	Flow Rate
50002	410 x 610 x 467 mm	8.5 boxes m³	2280 l/min
50003	410 x 610 x 903 mm	4.43 boxes m³	4560 l/min
50004	410 x 610 x 1340 mm	3 boxes m³	6840 l/min

The Atlantis Ecological Systems use surface and sub surface infiltration techniques that result in purified water that can be reused or allowed to re-enter the natural water system. The modular Atlantis Ecological Tanks offer a highly efficient option for stormwater management in any kind of soils.

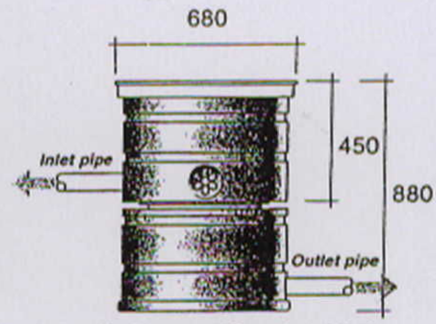
The Atlantis Ecological Tank Systems excel when there is a requirement to achieve high water quality, particularly in the effective removal of nutrients and gross pollutants. The system offers a unique solution where no utility based drainage system is available. In addition to the obvious environmental benefits the sub surface location of the tank system provides more useable space and an enhanced aesthetic setting compared to above ground concrete or plastic tank. The design of the system successfully augments any landscape feature by providing an enduring moisture supply.
The Atlantis Ecological Tank Systems can be categorised into percolation and reuse applications. The main system components are the Filtration Unit, Atlantis Geotextile, Atlantis Ecosoils and Atlantis Ecological Tanks.

Atlantis Filtration Unit





Atlantis Small Filtration Unit



Atlantis Large Filtration Unit

Atlantis Filtration Units

Item No.	Description	
60002	**Small Filtration Unit** (Single Down Pipe) Suitable for single pipe applications of 12 l/sec. Size (W)450mm x (H)480mm	
60003	**Large Filtration Unit** (Multiple Down Pipes) Suitable for flow situations of 20 l/sec. (150mm outlet pipe). Size (W)680mm x (H)880mm	

Accessories

Item No.	Description	
60004	**Large Aluminium lid** Pedestrian Duty Lid	
60006	**Large Replacement Basket** Made from geotextile.	
60007	**Small Replacement Basket** Made from geotextile.	

Atlantis Water Management Rebirth Pty Ltd trading as Atlantis Water Management

Suite 402/781 Pacific Highway Chatswood NSW, 2067 Australia
Phone • + 61 2 9419 6000 **Fax** • + 61 2 9419 6710
Email • info@atlantiscorp.com.au **Web Site** • www.atlantiscorp.com.au

Atlantis Water Management

APPENDIX E
GEOTECHNICAL REPORT

REPORT

TO

SEAFORTH MAC PTY LTD

ON

GEOTECHNICAL INVESTIGATION

FOR

PROPOSED SUB DIVISION

AT

SECTOR 10A, LOTS 11, 13 AND 15, ORCHARD STREET WARRIEWOOD

24 September 2003

Ref: 17871SLrpt

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

A.B.N. 17 003 550 801 A.C.N. 003 550 801

Principals
B F WALKER BE DIC MSc
P STUBBS BSc MICE FGS
D TREWEEK Dip Tech
E H FLETCHER BSc (Eng)

Senior Associates
F A VEGA BSc(Eng) GDE
A ZENON BSc(Eng) GDE
Consultant
R P JEFFERY BE DIC MSc

Associates
A B WALKER BE(Hons) MEngSc
P C WRIGHT BE(Hons) MEngSc
L J SPEECHLEY BE(Hons) MEngSc

39 BUFFALO ROAD
GLADESVILLE
NSW 2111
Tel: 02-9809 7322
02-9807 0200
Fax: 02-9809 7626

REPORT

TO

SEAFORTH MAC PTY LTD

ON

GEOTECHNICAL INVESTIGATION

FOR

PROPOSED SUB DIVISION

AT

SECTOR 10A, LOTS 11, 13 AND 15, ORCHARD STREET WARRIEWOOD

24 September 2003 Ref:17871SLrpt

TABLE OF CONTENTS

1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed subdivision at Sector 10A, Lots 11, 13 and 15 Orchard Street, Warriewood. The investigation was commissioned by Mr Ray Balcomb of Seaforth Mac Pty Ltd and was carried out in accordance with our proposal (Ref: P9472SL Dated: 3 July 2003).

It is proposed that the existing three lots, Lots 11, 13 and 15 be subdivided into 16 lots ranging in size from 855m^2 to 7825m^2. Only some of the proposed lots will be developed, with proposed Lots 11 and 16 to be zoned 7(b): Conservation and Scenic Protection while proposed Lot 11a is not part of the proposed subdivision.

The purpose of the investigation was to obtain geotechnical information on the subsurface conditions at the borehole locations and surface permeability rates at the double ring infiltrometer (DRI) test locations. Based on this we have presented the coefficients of permeability to allow a water balance of the site to be completed. In addition we also classified the site in accordance with AS2870-1996.

2 INVESTIGATION PROCEDURE

Nine boreholes were drilled to depths between 0.5m and 4.5m. Where access was available the boreholes were drilled using a truck mounted drill rig with spiral augers and a tungsten carbide (TC) bit. Where access was not available boreholes were drilled using hand auger techniques. As the hand augered boreholes neither penetrate nor prove the continuity of the bedrock the depth of refusal is only the inferred depth to bedrock. Adjacent to three of the boreholes DRI tests were completed to determine the surface infiltration rates at those test locations.

The three DRI tests were carried out in different areas of the site to gauge the permeability characteristics of the varying types of soils encountered. The apparatus consisted of two steel rings, one 970 mm in diameter and one 470 mm in diameter.

Both rings were placed at level test sites, sealed with bentonite and then filled with water. Both the inner and outer rings were filled at the same rate so that there was no hydraulic gradient between the two. Once a nominal head of water had been achieved, the rate at which the head dropped was measured for a sufficient period to establish the rate of fall. After testing, the depth of soil wetted by the test was determined by augering a shallow borehole inside the inner ring using a hand auger. A coefficient of permeability, k, was then calculated using established seepage formula.

The borehole and test locations, as shown in Figure 1, were set out by taped measurement from existing site features, buildings and apparent site boundaries. The approximate reduced levels were estimated by interpolation between contours shown on the supplied survey plan.

The strength/degree of compaction of the soils/fill was assessed from Standard Penetration Test (SPT) 'N' values. Where cohesive soils were encountered these values were augmented by hand penetrometer readings completed on samples recovered from the SPT split tube sampler. The strength of the sandstone bedrock was assessed by observation of the drilling resistance together with examination of the recovered rock chips.

Groundwater observations were made both during drilling and soon after completion of the boreholes. No longer term monitoring of groundwater levels was carried out.

Our geotechnical engineer, set out the borehole locations, nominated the sampling and testing locations, and prepared logs of the strata encountered and recorded the DCP test results. The borehole logs, which include field test results and groundwater observations, are attached to this report together with a set of explanatory notes, which describe the investigation techniques and their limitations, and define the logging terms and symbols used.

Selected samples were tested in our NATA registered laboratory for testing. This included Liquid Limits and Linear Shrinkage and percentage fines testing. The results of the laboratory testing are summarised in Tables A and B.

Contamination testing of the site soils was outside the scope of this investigation.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site is located at the intersection of the escarpment and coastal plains. The site is located on the lower northern, eastern and southern slopes of a hill and in general slopes down to the north, east and south at about 8° to 12°. The site is predominantly tree covered with the exception of grassed areas located in the immediate vicinity of the three existing houses. The site in general can be described by dividing the site into three distinct areas, the northern area (proposed lots 1 to 4), the eastern area (proposed lots 5 to 10 and 12) and the southern area (proposed lots 11, 14, 15 and 16).

The northern and eastern areas are very similar, both being located on the side of the hill and both sloping down at between 8° to 16°. The northern area is predominantly grass covered with ground slopes generally unaltered except for some terracing, ranging in height up to about 1m, that surrounds the existing house on site. The house is located over the lower reaches of the site towards Orchard Street is two-storey, of brick construction and appears in a good condition when viewed externally. The eastern area however is predominantly wooded except for a grassed area to the north and east of the single storey timber clad house that likewise appeared in good condition when viewed externally. In the southern portion of the eastern area of the site, in the vicinity of proposed Lot 12, a small sandstone outcrop forms a cliff line.

The southern area of the site is predominantly grass covered with a scattering of trees. It is benched and steps down the south-east. A two-storey brick house that appeared in good condition when viewed externally is located towards the upper portion of the southern area. The benches appear to be formed predominantly from filling rather than a mix of cut and fill and were approximately 3m to 4m high. Batter slopes have been formed at an angle of about 25^0.

Adjoining the site the north was a large grassed paddock containing a two story timber house and a large metal portal frame shed. To the east the site is bounded by an asphaltic concrete road that appeared in good condition while a heavily wooded creek forms the southern boundary of the site. To the west thick bush adjoins the site.

Surface Features Affecting Groundwater Levels

Trees are the main natural means of reducing groundwater levels. Most of the site is heavily wooded which results in moisture being removed from the ground. In addition the site is located on the side of a small hill with limited upslope catchment area in which infiltration will occur. The fairly steep site slopes would result in a fairly high run-off coefficient.

3.2 Subsurface Conditions

From examination of the 1:100,000 geological map of the Sydney region, the site is located at the boundary between an area of deep alluvial deposits and shallow sandstone bedrock. The borehole logs revealed that much of the site is underlain by a relatively thin sandy and clayey soil profile that in turn overlies sandstone bedrock. In the lower reaches of the site deeper fill and alluvial deposits were encountered. Reference should be made to the attached borehole logs for detailed information on the subsurface profile at each location. The main features are summarised below. A graphical summary of the borehole logs is presented as Figure 2.

Topsoil/Fill

Topsoil/fill was encountered in all boreholes and was found to extend to depths of between 0.1m and 0.2m. The topsoil/fill comprised silty sands, sandy silty clays, and sandy silts.

Fill

Fill was encountered in BH3, BH4, BH5 and BH6. The fill consisted of silty sand and gravelly sand. The fill extended to depths of between 0.5m in BH3 to 1.5m in BH6. The fill was generally assessed as being poorly to moderately compacted.

Natural Soils

Interbedded clayey and sandy soils were encountered across the site and extended to depths varying between 0.5m and greater than 4.5m (BH5 and BH6 terminated in soils without encountering bedrock). In general the clayey soils were very stiff to hard strength while the sandy soils were of loose to medium dense relative density. However in BH5 between 1.4m and 2.6m the clayey sand/sandy clays were of soft strength and very loose relative density.

Sandstone Bedrock

With the exception of BH5 and BH6, sandstone bedrock was encountered in all other boreholes at inferred depths ranging from between 0.5m and 3.7m. In general the sandstone bedrock was extremely weathered and of extremely low strength when first encountered but quickly increased in strength with depth. In BH5 and BH6 the boreholes were terminated within the alluvial soils at 4.5m without encountering bedrock.

Groundwater

With the exception of BH5 all boreholes were dry on completion of drilling. In BH5 seepage was encountered at a depth of 3.5m while on completion it had collapsed to

1.8m suggesting that this may be the depth of the groundwater table at this location. No long term groundwater monitoring was undertaken.

3.3 Laboratory Results

The results of the laboratory tests indicate that the silty clay tested was of high plasticity with a high shrink/swell potential. The two percentage fine tests completed indicated that the two samples tested (BH5 and BH9) contained 23% and 15% fines respectively.

4 COMMENTS AND RECOMMENDATIONS

4.1 Site Infiltration Rates

Three Double Ring Infiltrometer (DRI) Tests were carried out at existing ground surface levels adjacent to Boreholes 2, 6 and 9. The purpose of these tests was to calculate the coefficient of permeability of the surface soils across the site in its unaltered state so that a water balance could be carried out for the proposed subdivision.

The table below details the permeability of the soils at the three tested locations.

Double Ring Infiltrometer Test Results			
Borehole Location	2	5	9
Coefficient of Permeability(cm/s)	3×10^{-4}	3×10^{-4}	4×10^{-3}

All test locations indicated relatively low permeability rates with the highest measured permeability being 4×10^{-3}. These results are consistent with the high percentage of fine particles present in the soils as was confirmed by the percentage fine tests that returned values of 23% and 13% for Boreholes 5 and 9 respectively.

4.2 Site Classification

Due to the steep site slopes Pittwater Council has the site designated as a Landslip area as set out within their Geotechnical Risk Management Map 2003. Consequently, prior to any development of the land the council will require stability assessments of each lot to be completed. Construction of all buildings will then need to be in accordance with engineering principles and good hillside practice. Technically, classifications in accordance with AS2870-1996 would be Class 'P', which means footings should be designed according to engineering principles.

5 GENERAL COMMENTS

Occasionally, the subsurface soil conditions between the completed boreholes may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

The offsite disposal of soil may require classification in accordance with the EPA guidelines as inert, solid, industrial or hazardous waste. We can complete the necessary classification and testing if you wish to commission us. As testing requires about seven days to complete, allowance should be made for such testing in the construction programme unless testing is completed prior to construction. If contamination is found to be present then substantial further testing and delays should be expected.

If there is any change in the proposed development described in this report then all recommendations should be reviewed.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. Copyright in this report is the property of Jeffery and Katauskas Pty Ltd. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

Should you have any queries regarding this report, please do not hesitate to contact the undersigned.

W Theunissen
Geotechnical Engineer

Reviewed by:

P Stubbs
Principal
For and on behalf of
JEFFERY AND KATAUSKAS PTY LTD

Soil Test Services Pty Ltd
ABN 43 002 145 173
Unit 3, 39 Buffalo Road
Gladesville, NSW 2111
Telephone 02 9809 7322
Facsimile 02 9809 7626
Email dtreweek@bigpond.com

SOIL TEST SERVICES

Ref No:17871SL

TABLE A
SUMMARY OF LABORATORY TEST RESULTS

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1	3.6.1
BOREHOLE NUMBER	DEPTH m	MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	LINEAR SHRINKAGE %	PERCENTAGE FINER THAN 0.075mm %
2	0.50-0.95	41	82	22	60	17	
5	0.20-0.50						23
9	0.10-0.20						13

NATA Accredited Laboratory Number: 1327

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its scope of accreditation. This document shall not be reproduced except in full.

Authorised Signature (ASHWIN TATIKONDA)
Date 4/9/03

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **1**
1/1

Client: SEAFORTH MAC PTY LTD
Project: PROPOSED SUBDIVISION
Location: SECTOR 10A, LOTS 11,13,15 ORCHARD STREET, WARRIEWOOD, NSW

Job No. 17871SL
Date: 13-8-03
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 34.0m
Datum: AHD
Logged/Checked by: N.E.S./WT

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 5 HRS			0			TOPSOIL/FILL: Silty sand, fine to medium grained, with bark chips.	M	(L)		GARDEN BED
						FILL: Concrete, 50mm.t				
		N > 20 4,20/ 150mm			CH	SANDY CLAY: medium to high plasticity, orange mottled grey, fine grained sand with occasional ironstone bands.	MC≅PL	H	- 580 500 500	RESIDUAL
			1		-	SANDSTONE: grey mottled orange and red brown.	XW	EL	-	LOW 'TC' BIT RESISTANCE
							DW	VL-L		LOW RESISTANCE WITH MODERATE BANDS
										LOW RESISTANCE
			2							HIGH TO MODERATE RESISTANCE
						END OF BOREHOLE AT 2.5m				
			3							
			4							
			5							
			6							
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **2**
1/1

Client: SEAFORTH MAC PTY LTD
Project: PROPOSED SUBDIVISION
Location: SECTOR 10A, LOTS 11,13,15 ORCHARD STREET, WARRIEWOOD, NSW

Job No. 17871SL
Date: 13-8-03
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 27.0m
Datum: AHD
Logged/Checked by: N.E.S./WT

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 4.5 HRS			0			TOPSOIL: Sandy silty clay, medium to high plasticity, dark grey, with fine to medium grained sand.	MC≅PL			GRASS COVER
					SM	SILTY SAND: fine to medium grained, dark grey.	M	(L)	-	
		N = 11 2,4,7			CL	SILTY CLAY: high plasticity, red brown.	MC>PL	VSt -H	320 370 380 480	
			1		-	SANDSTONE: light grey mottled red brown and orange.	XW	EL	-	LOW 'TC' BIT RESISTANCE
							DW	L-M		MODERATE RESISTANCE
			2							MODERATE TO HIGH RESISTANCE
			3			END OF BOREHOLE AT 3.0m				
			4							
			5							
			6							
			7							

PYRI

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **3**
1/1

Client: SEAFORTH MAC PTY LTD
Project: PROPOSED SUBDIVISION
Location: SECTOR 10A, LOTS 11,13,15 ORCHARD STREET, WARRIEWOOD, NSW

Job No. 17871SL
Date: 13-8-03
Method: SPIRAL AUGER JK350
Logged/Checked by: N.E.S./
R.L. Surface: ≅ 21.5m
Datum: AHD

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 4 HRS			0			TOPSOIL/FILL: Silty sand, fine to medium grained, dark grey.	M			
						FILL: Silty sand, fine to medium grained, grey brown.				
		N = 17 3,5,12			CL-CH	SANDY CLAY: medium to high plasticity, orange brown.	MC≅PL	H	520 580 >600	
			1			as above, but orange brown mottled red and light grey.				
		N = 26 1,9,17	2						570 580 >600	
						as above, but light grey mottled red brown and orange brown.				
		N = 33 11,14,19	3						>600 >600 >600	
			4		-	SANDSTONE: fine to medium grained, light grey mottled red brown and orange brown.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
						END OF BOREHOLE AT 4.5m				
			5							
			6							
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **4** 1/1

BOREHOLE LOG

Client: SEAFORTH MAC PTY LTD
Project: PROPOSED SUBDIVISION
Location: SECTOR 10A, LOTS 11,13,15 ORCHARD STREET, WARRIEWOOD, NSW

Job No. 17871SL
Date: 13-8-03
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 27.5m
Datum: AHD
Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 3 HRS			0			TOPSOIL/FILL: Sandy silt, low plasticity, grey brown, with a trace of rootlets.	MC<PL			GRASS COVER
						FILL: Silty sand, fine to medium grained, yellow brown.	M			
	DS	N = 9 4,3,6			CH	as above, but grey brown.	MC≅PL	VSt -H	370 380 430	RESIDUAL
			1			as above, but dark grey, with a trace of ironstone gravel.				
	DS	N = 31 4,11,20				SILTY CLAY: high plasticity, orange brown, fine to medium grained sand.		H	>600 >600 >600	
						as above, but grey to light grey mottled orange brown, with ironstained bands.				
			2		-	SANDSTONE: grey to light grey mottled orange brown.	XW	EL	-	VERY LOW 'TC' BIT RESISTANCE
							DW	VL-L		LOW RESISTANCE
	DS									MODERATE RESISTANCE
			3			END OF BOREHOLE AT 3.0m				
			4							
			5							
			6							
			7							

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BOREHOLE LOG

Borehole No. 5
1/1

Client: SEAFORTH MAC PTY LTD
Project: PROPOSED SUBDIVISION
Location: SECTOR 10A, LOTS 11,13,15 ORCHARD STREET, WARRIEWOOD, NSW

Job No. 17871SL
Date: 13-8-03
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 4.0m
Datum: AHD
Logged/Checked by: N.E.S./

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 2 HRS		0		TOPSOIL/FILL: Sandy silt, low plasticity, dark grey, with fine to medium grained sand and a trace of rootlets.	MC≅PL			GRASS COVER
	N = 4 5,3,1			FILL; Silty sand, fine to medium grained, grey, with a trace of fine grained igneous gravel.	M	-	-	APPEARS POORLY COMPACTED
		1		FILL: Silty sand, fine to medium grained, dark grey.				
ON COMPLETION	N = 2 1,1,1	2	SC	CLAYEY SAND/SANDY CLAY: fine to medium grained, high plasticity, grey to grey brown.	W/ MC>PL	VL/S	- 50 50 40	
▶	N = 6 2,2,4	3	CH	SANDY CLAY: high plasticity, grey.	MC>PL	St	140 160	ORGANIC ODOUR
				END OF BOREHOLE AT 4.5m				
		5						
		6						
		7						

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Borehole No.
6
1/1

BOREHOLE LOG

Client: SEAFORTH MAC PTY LTD
Project: PROPOSED SUBDIVISION
Location: SECTOR 10A, LOTS 11,13,15 ORCHARD STREET, WARRIEWOOD, NSW

Job No. 17871SL
Date: 13-8-03
Method: SPIRAL AUGER JK350
Logged/Checked by: N.E.S./B
R.L. Surface: ≅ 9.0m
Datum: AHD

Groundwater Record	SAMPLES (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 1 HOUR			0			TOPSOIL/FILL: Sandy silt, low plasticity, dark grey, with rootlets.	MC>PL			GRASS COVER
						FILL: Gravelly sand, fine to coarse grained, yellow brown, fine to medium grained sandstone gravel, with some clay.	M			RIPPED SANDSTONE APPEARS POORLY TO MODERATELY COMPACTED
	DS	N = 7 5,3,4								
			1			FILL: Silty sand, fine to medium grained, grey brown.				
	DS	N = 22 5,11,11			CH	SANDY CLAY: high plasticity, orange brown, fine to medium grained sand.	MC≅PL	H	>600 >600 >600	
			2							
						as above, but orange brown mottled grey.				
	DS	N = 15 6,8,7	3						>600 >600 >600	
	DS		4							
						END OF BOREHOLE AT 4.5m				
			5							
			6							
			7							

PYRI

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BOREHOLE LOG

Borehole No. **7**
1/1

Client: SEAFORTH MAC PTY LTD
Project: PROPOSED SUBDIVISION
Location: SECTOR 10A, LOTS 11,13,15 ORCHARD STREET, WARRIEWOOD, NSW

Job No. 17871SL **Method:** HAND AUGER **R.L. Surface:** ≅ 28.0m
Date: 13-8-03 **Datum:** AHD
Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0		SM	TOPSOIL: Sandy silt, low plasticity, fine grained, dark grey.	MC≅PL			GRASS COVER
									SILTY SAND: fine to medium grained, red brown, with a trace of ironstone gravel.	M	(L)		
								CL-CH	SANDY CLAY: medium to high plasticity, orange brown, fine to coarse grained sand.	MC≅PL	VSt	360 370	
								SC	CLAYEY SAND: fine to coarse grained, orange brown mottled red.	M	(L- MD)	-	HAND AUGER REFUSAL
									END OF BOREHOLE AT 0.7m				
						1							
						2							
						3							
						4							
						5							
						6							
						7							

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Borehole No. 8
1/1

BOREHOLE LOG

Client: SEAFORTH MAC PTY LTD
Project: PROPOSED SUBDIVISION
Location: SECTOR 10A, LOTS 11,13,15 ORCHARD STREET, WARRIEWOOD, NSW

Job No. 17871SL **Method:** HAND AUGER **R.L. Surface:** ≅ 42.0m
Date: 13-8-03 **Datum:** AHD
Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0			TOPSOIL: Silty sand, fine grained, grey.	M			PATCHY GRASS COVER
								SP	SAND: fine to medium grained, grey.	M	(L- MD)	-	
									as above, but orange brown.				
						1			as above, but orange mottled light grey, with some clay grading to light grey mottled orange.				HAND AUGER REFUSAL
									END OF BOREHOLE AT 0.8m				
						2							
						3							
						4							
						5							
						6							
						7							

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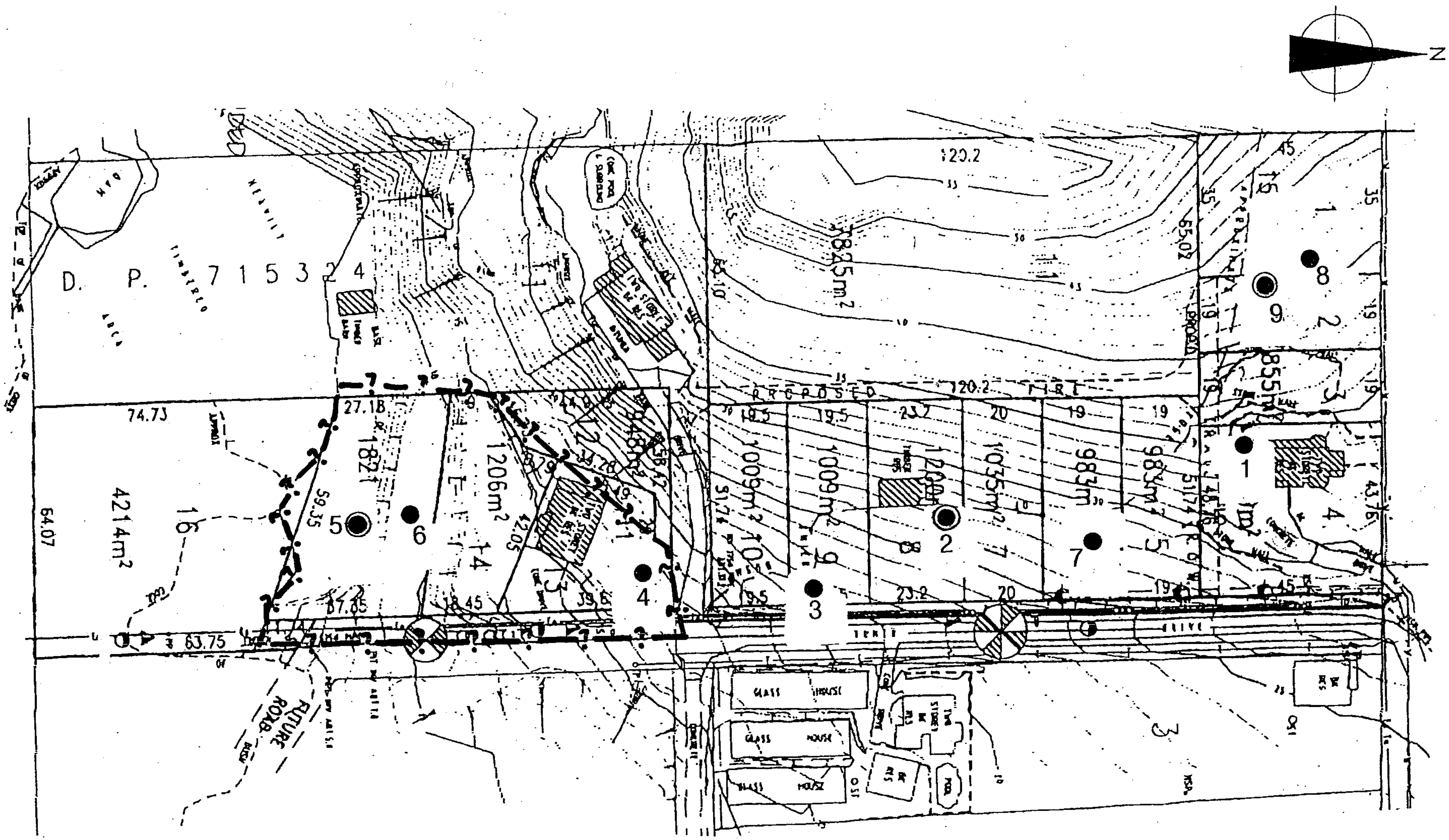
BOREHOLE LOG

Borehole No. **9**
1/1

Client: SEAFORTH MAC PTY LTD
Project: PROPOSED SUBDIVISION
Location: SECTOR 10A, LOTS 11,13,15 ORCHARD STREET, WARRIEWOOD, NSW

Job No. 17871SL
Date: 14-8-03
Method: HAND AUGER
Logged/Checked by: N.E.S./ [initials]
R.L. Surface: ≅ 42.0m
Datum: AHD

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
				■		0			TOPSOIL: Silty sand, fine to medium grained, grey brown.	M			
								SM	SILTY SAND: fine to medium grained, orange with a trace of clay.	M	(L)	-	
									END OF BOREHOLE AT 0.5m				HAND AUGER REFUSAL
						1							
						2							
						3							
						4							
						5							
						6							
						7							



LEGEND

● BOREHOLE

◉ BOREHOLE AND DOUBLE RING INFILTROMETER

—?— PROBABLE EXTENT OF FILL

INVESTIGATION LOCATION PLAN

0 — 50m

SCALE

PROJECT NORTH

Jeffery and Katauskas Pty Ltd

Report No. 17871SL

Figure No. 1

HEAVILY WOODED SLOPE – LOOKING SOUTH & EAST FROM ORCHARD STREET

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Report No. 17871SL Figure No. 3

HEAVILY WOODED SLOPE – LOOKING NORTH FROM LOT 9

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Report No. 17871SL
Figure No. 4

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REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of containing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the SAA Site Investigation Code. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the grading of other particles present (eg sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding risk classification is given in the text of the report. In the Sydney Basin, "Shale" is used to describe thinly bedded to laminated siltstone.

SAMPLING

Sampling is carried out during drilling or from other excavations to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All except test pits, hand auger drilling and portable dynamic cone penetrometers require the use of a mechanical drilling rig which is commonly mounted on a truck chassis.

shown as "N_c" on the borehole logs, together with the number of blows per 150mm penetration.

Static Cone Penetrometer Testing and Interpretation – Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been copies from the original records.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

There are two scales available for measurement of cone resistance. The lower (A) scale (0 to 5MPa) is used in softer soils where increased sensitivity is required. The main (B) scale has a range of 0 to 50MPa.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on friction ratios are only inferred and must not be considered as exact.

Correlations between EFCP and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of EFCP values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where show, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometers – Portable Dynamic Cone Penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scale Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the sub-surface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment, but is not always practicable or possible or justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

Where groundwater levels are measured in boreholes, there are several potential problems:

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.

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GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL

- FILL
- TOPSOIL
- CLAY (CL, CH)
- SILT (ML, MH)
- SAND (SP, SW)
- GRAVEL (GP, GW)
- SANDY CLAY (CL, CH)
- SILTY CLAY (CL, CH)
- CLAYEY SAND (SC)
- SILTY SAND (SM)
- GRAVELLY CLAY (CL, CH)
- CLAYEY GRAVEL (GC)
- SANDY SILT (ML)
- PEAT AND ORGANIC SOILS

ROCK

- CONGLOMERATE
- SANDSTONE
- SHALE
- SILTSTONE, MUDSTONE, CLAYSTONE
- LIMESTONE
- PHYLLITE, SCHIST
- TUFF
- GRANITE, GABBRO
- DOLERITE, DIORITE
- BASALT, ANDESITE
- QUARTZITE

DEFECTS AND INCLUSIONS

- CLAY SEAM
- SHEARED OR CRUSHED SEAM
- BRECCIATED OR SHATTERED SEAM/ZONE
- IRONSTONE GRAVEL
- ORGANIC MATERIAL

OTHER MATERIALS

- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM

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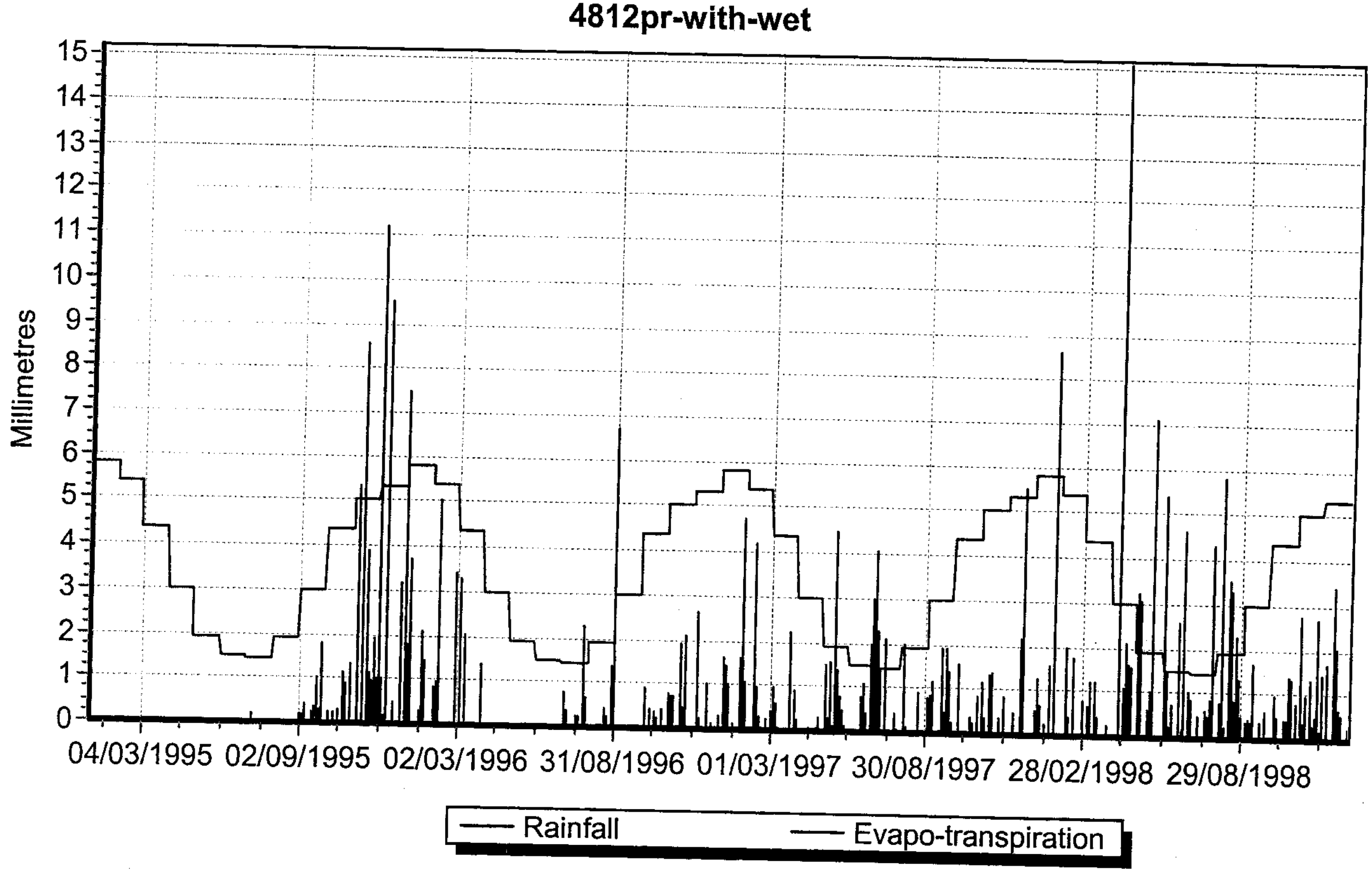
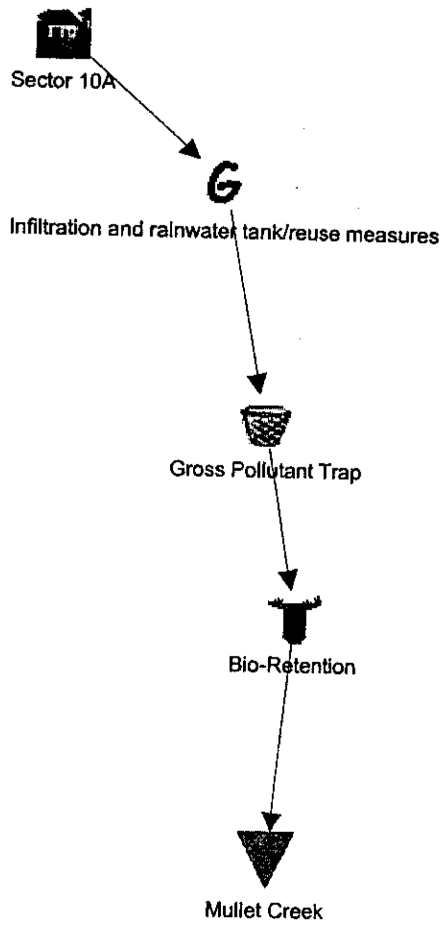
LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record	▼	Standing water level. Time delay following completion of drilling may be shown.
	—C—	Extent of borehole collapse shortly after drilling.
	▶—	Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY - runs freely through fingers.
	M	MOIST - does not run freely but no free water visible on soil surface.
	W	WET - free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT - Unconfined compressive strength less than 25kPa
	S	SOFT - Unconfined compressive strength 25-50kPa
	F	FIRM - Unconfined compressive strength 50-100kPa
	St	STIFF - Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF - Unconfined compressive strength 200-400kPa
	H	HARD - Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		Density Index (I_D) Range (%) — SPT 'N' Value Range (Blows/300mm)
	VL	Very Loose <15 — 0-4
	L	Loose 15-35 — 4-10
	MD	Medium Dense 35-65 — 10-30
	D	Dense 65-85 — 30-50
	VD	Very Dense >85 — >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T 60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

APPENDIX F
MUSIC RESULTS



4812pr-with-wet
Millimetres
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
04/03/1995
02/09/1995
02/03/1996
31/08/1996
01/03/1997
30/08/1997
28/02/1998
29/08/1998
Rainfall
Evapo-transpiration



Proposed with measures 16/10/03

Mullet Creek

16/10/2003 4:09:59 PM

Mean Annual Loads

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Inflow	3.67	21.7	0.228	1.53	58.9E-3
OutFlow	0.00	0.00	0.00	0.00	0.00

Proposed with measures @ outlet 16/10/03

Bio-Retention

16/10/2003 4:10:10 PM

Mean Annual Loads

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Inflow	3.67	70.8	0.732	4.60	66.5
OutFlow	3.67	21.7	0.228	1.53	58.9E-3

Proposed with
measures at
bio-retention basin 16/10/05

Gross Pollutant Trap

16/10/2003 4:10:19 PM

Mean Annual Loads

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Inflow	3.67	350	1.05	5.25	66.5
OutFlow	3.67	70.8	0.732	4.60	66.5

Proposed with
measures @
GPT 16/10/03

Infiltration and rainwater tank/reuse measures

16/10/2003 4:10:40 PM

	Mean Annual Loads				
	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Inflow	9.01	860	2.58	12.9	164
OutFlow	3.67	350	1.05	5.25	66.5

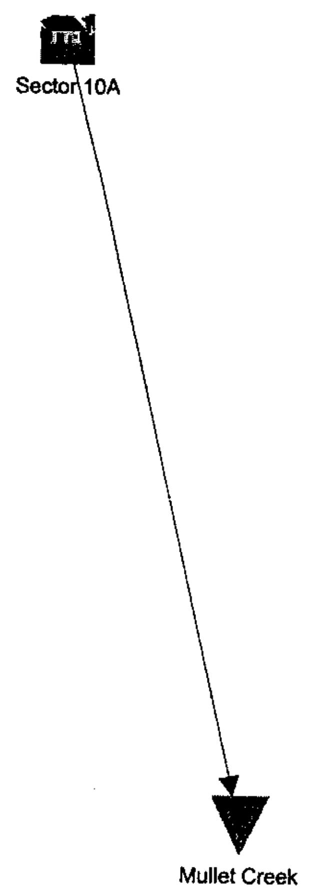
Proposed with measures at rainwater tanks/reuse & infiltration measures
16/10/03

Sector 10A

Mean Annual Loads

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Inflow	0.00	0.00	0.00	0.00	0.00
OutFlow	9.01	860	2.58	12.9	164

Proposed with measures at catchment
16/10/03



Proposed no measures
16/10/03

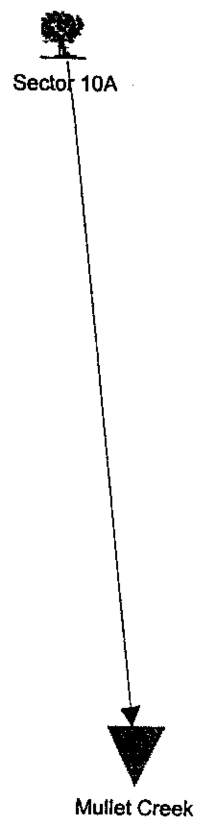
Mullet Creek

16/10/2003 4:11:05 PM

Mean Annual Loads

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Inflow	9.06	865	2.60	13.0	164
OutFlow	0.00	0.00	0.00	0.00	0.00

Proposed no measures
at Mullet Creek
16/10/03



Existing 16/10/03

Mullet Creek

Mean Annual Loads

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Inflow	3.89	69.7	0.209	2.06	0.00
OutFlow	0.00	0.00	0.00	0.00	0.00

Existing @ Mullet Creek 16/10/03