CRI

UTS KU-RING-GAI CAMPUS REDEVELOPMENT

URBAN INFRASTRUCTURE MANAGEMENT STRATEGY

Issue No. 5
JULY 2006

Patterson Britton
& Partners Pty Ltd

consulting engineers

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EXECUTIVE SUMMARY

This urban infrastructure management strategy has been prepared to support a re-zoning application for the UTS site at Ku-ring-gai. It addresses the following issues:

- Stormwater quality;
- Stormwater quantity;
- Provision of potable water;
- Provision of sewer reticulation;
- Provision of electricity reticulation;
- Telecommunications services; and
- Geological conditions.

A water sensitive urban design approach has been adopted for the proposed rezoning with proposed controls to contribute to the long term improvement in receiving water quality and flow impacts on adjacent bushland. The indicative development scheme and this strategy incorporate a combination of at source controls such as rainwater tanks and bioretention swales along roadways. Further runoff treatment measures include bioretention basins, gross pollutant traps and detention tanks. These measures will:-

- reduce the number of stormwater outlets;
- improve stormwater quality by reducing runoff pollutant loads significantly below existing rates;
- improve stormwater discharge and reduce peak flow rates in the proposed 50 year ARI to natural 20 year ARI rates; and
- allow for the reduction of potable water use by 46%.

The beneficial effect of some control measures have not been taken into account in the results presented as part of this assessment. Therefore the level of improvement achieved has been understated. The extent of control measures can be refined at subsequent approval stages in the knowledge that it is feasible to achieve the above objectives.

The proposed conceptual water management strategy for the re-zoning application conforms to best management practice and Councils relevant guidelines. The stormwater quality and quantity control measures proposed in this report will have the combined beneficial effect of improving the existing conditions of the surrounding bushland and the water quality in receiving water bodies.

The servicing of the site has been investigated and confirmation sought from Sydney Water, Energy Australia, AGL, and Telstra that it is possible to service the site. The responses from the service providers support the proposed rezoning application. Water supply is adequate for fire fighting with the provision of a reticulated hydrant supply.

As established in the Parramatta Rail Link EIS, due to the underlying sandstone any settlement beneath the site as a result tunnelling during the construction of the Parramatta Rail Link will have negligible impact on surface buildings or underground service utilities proposed as part of the re-zoning application and potential development of the site, and is also not an impediment to re-zoning. It is considered that generally, with good engineering design, the site's geological conditions are likely to be suitable for urban development subject to detailed geotechnical investigations.

1 INTRODUCTION

Patterson Britton and Partners has been engaged by CRI on behalf of The University of Technology Sydney (UTS) to prepare a report in support of a re-zoning application for their site at Ku-ring-gai with respect to urban infrastructure. The re-zoning application is accompanied by an indicative development scheme (*refer* **Figure 1**) which indicates possible future land use.

This report assesses the impact of the development in the indicative development scheme on stormwater management issues, the servicing of the site and any geological impact of the Parramatta Rail Link. These issues include the assessment and management of stormwater quality and quantity and the provision of potable water, sewer, electricity, fire fighting and telecommunications services. The report has been prepared in accordance with Ku-ring-gai Council's (*Council's*) *–Water Management Development Control Plan – DCP 47(March 2004)* and *Managing Urban Stormwater : Treatment Techniques* (*EPA, 1996*).

This report was originally undertaken in June 2004 and re-issued with minor amendments in July 2006.

2 SITE DETAILS

2.1 STORMWATER DRAINAGE

The subject site is situated along a ridge line in West Lindfield and there are numerous small subcatchments draining to the surrounding area. To the south, east and west the site adjoins bushland contained within the Lane Cove National Park and to the north is the Film Australia site and residential areas. Stormwater exiting the site is discharged via 22 existing outlets into the adjacent bushland that in turn drains into a number of tributary creeks and ultimately the Lane Cove River.

A *Draft Stormwater Management Report for –UTS Ku-ring-gai Campus (Robyn Tuft & Associates, May 1999)* identifies the 22 subcatchments and details the existing stormwater treatments on site *(refer* **Figure 2***)*. A review of this document has been undertaken and the catchments have been assessed for the following parameters:

- Catchment area;
- Slope;
- Percentage impervious;
- Land use type; and
- Discharge receiving water body.

It was found that the catchment areas as reported by Robyn Tuft and Associates only varied slightly from areas calculated digitally and the digitally calculated areas have been adopted for this report. In addition there are some minor discrepancies with regards to the percentage impervious of some catchments. A site inspection was carried out on the 13th of October 2003 which confirmed the findings below.

The adopted catchment parameters are detailed in **Table 1** below.

Table 1– Existing Catchment Parameters

Sub Catchment	Area (m^2)	Slope (%)	Impervious (%)	Landuse	Discharge water body
1	781	2.1	95	Car parking, landscaping	Little Blue Gum Creek
2	7552	3.3	95	Car parking, landscaping	Little Blue Gum Creek
3	937	2.1	95	Car parking, landscaping	Little Blue Gum Creek
4	4648	2.6	95	Car parking, landscaping	Little Blue Gum Creek
5	1065	3.6	20	Tennis courts landscaping	College Creek
7	16907	0.1(perv) 8.7(imp)	10	Tennis courts landscaping	College Creek

Sub Catchment	Area (m^2)	Slope (%)	Impervious (%)	Landuse	Discharge water body
8	6886	11.3	50	Roads, landscaping (weeds at outlet)	College Creek
9	10631	2.9(perv) 5.7(imp)	10	Oval (dense weeds at outlet)	College Creek
10	4940	0.1(perv) 80(imp)	5	Oval, steep bank(dense weeds at outlet)	College Creek
11	7098	10	80	Buildings landscaping	College Creek
12	2199	15.4	75	Buildings landscaping (dense weeds)	Blue Gum Creek
13	3575	10.7	70	Buildings landscaping (dense weeds)	Blue Gum Creek
14	2807	12.7	50	Roads, landscaping (dense weeds)	Blue Gum Creek
15	913	30(perv) 8(imp)	40	Car parking, landscaping	Blue Gum Creek
16	3524	17.8	40	Car parking, landscaping (some weeds)	Blue Gum Creek
17	7395	14.3	40	Car parking, landscaping	Blue Gum Creek
18	7354	21	45	Car parking, landscaping	Blue Gum Creek
19	6213	4.5	45	Roads, landscaping	Blue Gum Creek
20	5240	4	60	Child care centre, Film Australia, road	College Creek
21	13910	9	30	Buildings, roads landscaping (dense weeds)	Blue Gum Creek
22	6086	15.75	55	Roads, landscaping	Blue Gum Creek
Total	120,661	-	-	-	Lane Cove river

2.2 POTABLE WATER

The UTS Ku-ring-gai campus is located in the Chatswood/Killara/Pymble water supply system. The supply is drawn from major mains along the Pacific Highway. There is a dedicated 200 mm diameter supply main from the highway along Bayswater, Ortona and Eton Roads. At Austral Avenue, the main decreases to a 150 mm diameter and then to a 100 mm diameter main which delivers water to the campus from Abingdon Road *(along Eton Road)*.

Adjacent to the security officer's residence there is a fire booster point to enable supply of increased quantities of water in the 100 mm diameter water main in the case of a fire.

A feasibility letter has been prepared by Sydney Water, Case Number 38634 that outlines Sydney Water's requirements for potable water. The proposed rezoning and potential development would require a water main augmentation of the 100mm CICL water main in Eton Road to a 150mm main.

A bushfire hazard assessment has been carried out for the subject site (*Holmes, 2004*), this assessment requires that a reticulated hydrant supply serve the site. This must be addressed in subsequent designs.

Upon completion of the above requirements the proposed re-zoning and potential development can be supplied with potable water and provide adequate supply for fire fighting purposes.

2.3 SEWERAGE

The campus is within the East Lane Cove sewerage system. The East Lane Cove submain *(1350mm dia pipe)* passes diagonally under the site *(north west to south east)* at depth. There are two access chambers from this main within the campus. The site drains via a 225 mm diameter main along the western side of the site to a connection point south of the sites southern boundary.

A feasibility letter has been prepared by Sydney Water, Case Number 38634 that outlines Sydney Water's requirements for sewer. The proposed re-zoning and potential development would require a sewer main extension from the sewer submain within the National Park below the development site. The extension would be via an existing Sydney Water Corporation easement.

Upon completion of the above requirements the proposed re-zoning and potential development can be appropriately served by the Sydney Water sewerage system.

2.4 POWER

The campus power supply is from Eton Road with twin 1600 amp supply mains located generally along the main access road *(underground)* servicing substations in Film Australia and on the western end of Building 2. The underground supply line continues through the site to the southern boundary where it joins an overhead link line to the surrounding reticulation.

Notification of satisfactory arrangements for the provision of electricity supply to the proposed subdivision has been made with Energy Australia. This confirms that the proposed re-zoning and potential development can be supplied with power by Energy Australia.

2.5 GAS

There is a special secondary main gas supply to the campus from Eton Road. The gas supply is aligned on the eastern side of the main access road and increases in size from 150 to 225 mm diameter.

It is AGL's policy to extend natural gas infrastructure into all new residential developments wherever economically viable.

2.6 TELECOMMUNICATIONS

The campus and Film Australia sites are served from a facility at the entrance on Eton Road. There is optical fibre supply to both sites.

The developer would be required to provide the cost for trench excavation during installation. Telstra advised that their preference is to share conduits with other services, primarily internal electricity reticulation. Should the existing capacity be less than that required for the development, Telstra would provide the required upgrades at their own cost.

The proposed re-zoning application and potential development would be supplied with sufficient telecommunications, including all design and planning prior to construction by Telstra.

2.7 EASEMENTS

At the northern end of the site, there is an easement for drainage of the Film Australia site near to the rear of properties along Abingdon Road and Kimo Street. Also, there is a 2 m wide easement for power across Eaton Road serving Film Australia.

There is a right of carriageway diagonally across the site from north east to south west which is 20.115 m wide.

2.8 EXISTING GEOLOGICAL CONDITIONS

Assessment of the 1:100, 000 series geological maps indicates that the UTS Ku-ring-gai campus is underlain with Hawkesbury Sandstone which is a geological formation which underlays most areas of northern Sydney. Areas underlain with Hawkesbury Sandstone are typically topographically irregular and have a relatively thin mantle. This description is consistent with the conditions encountered on-site.

It was proposed by the NSW State Government to construct a rail link between Parramatta and Chatswood. The original proposal for the rail link has been modified, however there is still some tunnelling directly beneath the subject site.

An Environmental Impact Statement has been prepared for the Parramatta Rail Link by ERM Mitchell McCotter Pty Ltd and Kinhill Pty Ltd and completed in December 1999. This document discusses the existing geological conditions likely to be encountered during construction and the potential surface settlement that may arise in certain geological conditions. A review of the findings contained in the EIS reveals the following:-

- The tunnelling below the UTS Ku-ring-gai site is shown to be located under approximately 25m of cover to the ground at its shallowest point.

- Where tunnels are excavated in shale or sandstone and the cover of ground above the tunnel crown is at least 15m or more, surface settlement is not expected to exceed 1mm or 2mm above the tunnel centreline.

Given that the depth of tunnelling is greater then 15m below the subject site and the excavation is likely to be located in Hawkesbury Sandstone, the settlement trough formed above the tunnel in these cases will have negligible impact on surface buildings or underground service utilities proposed as part of the re-zoning application and potential development of the site.

Given the underlaying geological formation (Hawkesbury Sandstone) and the negligible impact created by the rail tunnel, it is considered that with good engineering design the site would be generally suitable for urban development. Notwithstanding this, prior to any future development occurring on the site, it is recommended that detailed geotechnical investigations be completed.

3 WATER MANAGEMENT STRATEGY

3.1 OBJECTIVES

The stormwater management strategy is based on Ku-ring-gai Council's (*Council's*) – *Water Management Development Control Plan – DCP 47(March 2004)* and the recognition of the following major objectives.

- **Minimise Impacts on Water Quality -**

  Ensure there is no impact on water quality (*nutrients, sediment and gross pollutants*) during and following construction activities, and where possible improve existing conditions.

- **Minimise Impacts on Water Quantity -**

  Minimise the impact of flooding (*water quantity*) on downstream areas, to ensure the safety of people, property and the stability of channels, and where possible improve existing conditions.

  .

3.2 WATER SENSITIVE URBAN DESIGN

Often water sensitive urban design is narrowly defined in relation to only stormwater management, however in terms of achieving an environmentally sustainable development *(ESD)* it should also encompass potable water usage. For the UTS Ku-ring-gai site, the principles of water sensitive urban design *(WSUD)* have been applied to form the basis for a development which will demonstrate industry best practice commitment to ESD.

3.3 WATER CYCLE MANAGEMENT STRATEGY

3.3.1 Overview

A design approach has been adopted in the concept plan with emphasis on source control. The objectives of the strategy are to: -

- reduce peak flow rates in the 50 year ARI storm in post development conditions to the 20 year ARI flows for natural predevelopment conditions *(this will reduce flows to below rates for the natural site conditions)*;

- maximise runoff quantity and quality controls at the source; and

- reduce annual pollutant load exported from the site compared with existing conditions.

In order to achieve these objectives, source controls such as stormwater tanks, bioretention swales and bioretention basins would be coupled with more common control measures such as gross pollutant traps and detention basins.

Bioretention swales would be incorporated into road reserves where they can aesthetically enhance the visual impact of the development. The location of stormwater tanks and bioretention systems creates a mix of at-source and downstream controls. The combination of at-source and downstream controls would achieve the maximum reduction in the runoff pollutant load prior to discharge to the receiving water bodies. The elements of the water management strategy include:-

- **source controls**
  - minimise areas of impervious surfaces to minimise runoff volume;
  - incorporate rainwater tanks with reuse of stormwater to reduce the volume of runoff and potable water use;
  - use water saving devices to reduce the domestic household demand for potable water; and
  - incorporate bioretention swales to remove fine sediment, nutrients, oils and greases.

- **downstream controls**
  - bioretention basins to remove additional fine sediment, nutrients, oils and grease;
  - gross pollutant traps at the outlets to capture litter, debris, coarse sediment, oils and greases; and
  - detention tanks to reduce the peak flow exiting the site.

3.3.2 Stormwater Treatment Train

Generally, the stormwater treatment flow path for runoff would be: -

- runoff from roofed areas would be collected and detained in rainwater tanks with an overflow by-pass to street drainage system;
- large impervious areas such as roads would be directed to bioretention swales where they would be filtered and treated biologically;
- flows would enter grassed bioretention basins located at the downstream areas of each major building where they would be filtered and treated biologically;
- excess flows from the bioretention swales and basins would flow to the pipe drainage system designed to cater for the 10year ARI event;
- stormwater exiting the pipe drainage system would pass through a gross pollutant trap to remove remaining coarse sediment, litter, debris, oils and greases; and
- stormwater would enter a detention tank and would be released at a controlled flow rate.

3.4 CONCLUSIONS

The industry best practice stormwater quality and quantity control measures proposed in this strategy will have the combined beneficial effects of improving the existing conditions of the surrounding bushland and the water quality in receiving water bodies.

Peak runoff flow rates would be reduced to significantly less than existing and even below those for natural conditions to ensure that erosion of flow paths and streams is not perpetuated.

The export of suspended solids, total nitrogen and total phosphorus would be reduced significantly in comparison to the existing state, thereby placing less pressure on native vegetation due to the nutrient load and weed infestation.

The demand for potable water will be reduced by 46% compared to than that of a traditional household with the introduction of water saving devices and rainwater tanks.

This more than achieves the State government's stated objective for new development to achieve a 40% reduction in potable water use. Finally the introduction of welded sewer pipes will further reduce the possibility of exfiltration of nutrients into the water cycle.

With the above strategies in place, stormwater can be effectively and appropriately managed and conditions in the surrounding bushland improved compared with the existing state as part of the proposed re-zoning application and potential development.

4 STORMWATER QUANTITY IMPACT ASSESSMENT

4.1 MINIMUM REQUIREMENTS

Ku-ring-gai Council's – *Water Management Development Control Plan – DCP 47 (March 2004)* contains the design objectives for stormwater quantity management. These standards outline (*Sections 5 and 6)* the following water quantity controls for discharge directly to bushland and waterways;

a) On-site detention is not permitted;
b) Mandatory rainwater tanks are required;
c) The number of run-off days from the post development site during the 1 in 50 year storm shall not exceed the state of nature case during the 1 in 20 year storm. This shall be achieved using an appropriate retention device; and
d) In addition to any mandatory rainwater tank, the developer shall propose an on-site retention (OSR) system that retains either the;
   - the first 20mm of rainfall from all roof areas, or
   - 5,000 L storage volume.

In addition, the existing and proposed state 2 year ARI storm events have been modelled to ensure that there is no increase in peak flow from the existing state as a result of the proposed development in the 2 year ARI event.

4.2 RAINWATER TANKS

It is proposed to provide each single dwelling with a 5,000L rainwater tank and each apartment with a 3,000L rainwater tank as required by Council. This satisfies the mandatory requirements outlined in Section 6.4 of DCP 47. **Table 2** shows the volume of storage provided by the proposed rainwater ranks.

Table 2 – Rainwater tanks

Landuse	DCP Requirement (*L/Lot)*	Number of proposed lots	Total Volume provided (m^3)
Single dwellings	5,000	36	180
Multi unit developments	3,000	530	1,590

Rainwater tanks assist in reducing runoff in frequent events and contribute to runoff characteristics which are more akin to natural conditions.

Research for the Upper Parramatta River Catchment Trust has identified that up to 30% of the rainwater tank capacity can be accounted for as onsite retention (OSR). It is estimated, therefore, that 531m^3 of OSR volume will be provided within the proposed rainwater tanks.

Runoff is also to be directed through the stormwater network of bioretention basins and swales, piped drainage and extended on-site detention tanks providing more attenuation of flows.

4.3 RAFTS HYDROLOGIC MODEL

Hydrologic modelling established specifically for the site was undertaken using RAFTS. The model was used to estimate design flows under the state of nature, existing state, developed catchment and developed treated (50 year event) conditions.

RAFTS is a non-linear rainfall/runoff program developed by WP Software. RAFTS can be used to estimate peak flows for catchments, using actual storm events, or design rainfall data derived from *Australian Rainfall and Runoff (AR&R)* (*IEAust, 1987*).

RAFTS was chosen for this investigation because it has the following attributes:

- it accounts for spatial and temporal variation in storm rainfall across a catchment;
- it estimates discharge hydrographs at any location within the catchment;
- it accommodates variations in catchment characteristics;
- it is able to route hydrographs though detention basins; and
- it has successfully been widely used across NSW and is accepted by Councils and DIPNR.

Calculations undertaken as part of the RAFTS modelling are summarised in **Appendix A**.

4.4 MODEL SET-UP

The RAFTS parameters adopted for the model are shown in **Table 3**.

Table 3 – RAFTS Hydrologic Parameters

Parameter	Value
Rainfall Losses	
Pervious initial loss	20 mm
Pervious continuing loss	5 mm/hr
Impervious initial loss	2.5 mm
Impervious continuing loss	0 mm/hr
Roughness	
Pervious	0.025
Impervious	0.015
BX factor	1

The existing 22 subcatchments as shown in **Figure 2** have been analysed to determine catchment-specific parameters including area, percentage impervious and weighted average catchment slope. A summary of the adopted existing state subcatchment parameters is shown in **Table 1**. For the state of nature conditions a 15% impervious area has been adopted for all catchments.

4.5 STATE OF NATURE 20 YEAR ARI FLOW RATES

Results of the state of nature condition for the 20 year ARI storm modelling are summarised in **Table 4** for all subcatchments altered as part of the proposed indicative development scheme. Full results for all locations for the critical storm event are contained in **Appendix A**.

Table 4 – RAFTS Results: State of Nature

Sub catchment (Outlet Node)	20 YR. ARI	
	Q(m^3/s)	$T_{critical}$ (min)
1 (Out 1)	0.04	90
2 (Out 2)	0.31	90
3 (Out 3)	0.04	90
4 (Out 4)	0.20	90
5 (Out 5)	0.05	90
7 (Out 7)	0.36	90
9 (Out 9)	0.40	90
10 (Out 10)	0.14	90
15 (Out 15)	0.05	90
16 (Out 16)	0.20	90
17 (Out 17)	0.40	90
18 (Out 18)	0.41	90
19 (Out 19)	0.28	90
20 (Out 20)	0.24	90
21 (Out 21)	0.69	90
22 (Out 22)	0.33	90
Blue Gum Creek	**2.4**	**90**
Little Blue Gum Creek	**0.58**	**90**
College Creek	**1.79**	**90**
Lane Cove River	**4.14**	**90**

4.6 PROPOSED DEVELOPED CONDITIONS (NO TREATMENT) MODEL SET-UP

The state of nature RAFTS model was modified to reflect the increase in impervious area and changes in topography for the redevelopment of the UTS site. The adopted hydrologic parameters are shown in **Table 3**. The proposed catchment plan is shown on **Figure 1** and the catchment parameters are detailed in **Table 5**.

Table 5 – Catchment Parameters: Proposed Development

Subcatchment	**Area** (*ha*)	**Slope** (*%*)	**Impervious** (*%*)
P1	1.16	3.2	75
P2	1.91	1.7	75
P3	1.89	14	70
P4	4.38	12	75
P5*	0.69	11	50
P6*	0.84	8.5	50
P7*	0.21	15	75
P8 *	0.36	11	70
P9 *	0.28	13	50
P10*	0.44	17	40
P11*	0.72	14	40
P12	1.56	21	70
P13	1.1	13	75

*Note that land use in these catchments remains unchanged from the existing to the proposed state.

4.7 PROPOSED DEVELOPED CONDITIONS (*NO TREATMENT*) FLOW RATES

Results of the proposed developed state (*no treatment*) modelling are summarised in **Table 6** for all the altered subcatchments within the UTS Ku-ring-gai site. Full results for all locations during the critical storm event are contained in **Appendix A**.

The change in land use would result in a number of existing stormwater outlets becoming obsolete. Each of the proposed 13 outlets have been located as close as possible to an existing outlet. Where two or more existing catchments have been amalgamated the combined state of nature peak flows have been compared with the proposed peak flow. The difference between the proposed development *(50 year ARI)*, relative to the state of nature *(20 year ARI)* conditions, is to increase peak discharges and decrease the time of concentration.

Table 6 – RAFTS Results: Proposed Developed State (*No Treatment*)

Outlet Node	PEAK FLOWS (m^3/s)	
	$Q_{20\ NATURE}$	$Q_{50\ PROPOSED}$
P1 (combined out 1,2,3 and 4)	0.59	0.71
P2 (combined out 20 and 9)	0.64	1.1
P3 (combined out 5 and 10)	0.19	1.17
P4 (out 7)	0.36	2.7
P10 (out 15 and 16)	0.25	0.27
P11 (out 17)	0.4	0.44
P12 (22 and 18)	0.74	0.95
P13 (combined out 19 and 21)	0.97	0.71
Blue Gum Creek	2.4	2.9
Little Blue Gum Creek	0.58	0.7
College Creek	1.79	6.5
Lane Cove River	4.14	9.4

4.8 PROPOSED DEVELOPED CONDITIONS (*WITH TREATMENT*) FLOW RATES

The proposed development conditions have been modelled with detention storage to determine the volume of water that is required to be stored to control runoff peak flows from the site. There is no development proposed for subcatchments P5 to P9. The external components of subcatchments P1, 12 and 13 have been redirected to subcatchment P4.

A summary of the proposed developed conditions with treatment is shown in **Table 7** while full results for all locations in the critical storm event are contained in **Appendix A**.

Table 7 – RAFTS Results: Proposed Developed State (*With Treatment*)

Outlet Node	PEAK FLOWS (m^3/s)			
	$Q_{20\ NATURE}$	$Q_{50\ PROPOSED}$	$Q_{50\ PROPOSED\ TREATED}$	STORAGE VOLUME (m^3)
P1 (combined out 1,2,3 and 4)	0.59	0.71	0.59	30
P2 (combined out 20 and 9)	0.64	1.1	0.64	145
P3 (combined out 5 and 10)	0.19	1.17	0.19	800
P4 (out 7)	0.36	2.7	0.36	2150
P10 (out 15 and 16)	0.25	0.27	0.27	
P11 (out 17)	0.4	0.4	0.4	
P12 (combined out 22 and 18)	0.74	0.95	0.74	50
P13 (out 19 and 21)	0.97	0.71	0.71	
Blue Gum Creek	2.4	2.9	2.2	
Little Blue Gum Creek	0.58	0.7	0.6	
College Creek	1.79	6.5	1.8	
Lane Cove River	4.14	9.4	3.9	

The provision of storage volume as follows; 30 m^3 at P1, 145 m^3 at P2, 800m^3 at P3, 2,150 m^3 at P4 and 50m^3 at P12, reduces the proposed 50 year ARI peak flow rates to below the rates of the state of nature for the 20 year ARI storm event *(refer* **Table 7***)*.

4.9 EXISTING CONDITIONS FLOW RATES

The existing conditions have been modelled to assess the degree to which flows would be reduced in the proposed development below the existing conditions Modelling has been carried out to determine existing and proposed peak flow rates in the 2 year ARI storm event. A summary of the developed flows is shown in **Table 8** while full results for all locations in the critical storm event are contained in **Appendix A**.

Table 8 – Peak Flows Compared with Existing Conditions (2 yr ARI)

Outlet Node	PEAK FLOWS (m^3/s)		
	Q_{2EXIST}	$Q_{2PROPOSED\ No\ Treatment}$	$Q_{2PROPOSED\ TREATED}$
P1 (combined out 1,2,3 and 4)	0.64	0.71	0.455
P2 (combined out 20 and 9)	0.8	1.1	0.24
P3 (combined out 5 and 10)	0.21	1.17	0.06
P4 (out 7)	0.39	2.7	0.1
P10 (out 15 and 16)	0.28	0.27	0.13
P11 (out 17)	0.45	0.44	0.21
P12 (combined out 22 and 18)	0.85	0.95	0.41
P13 (out 19 and 21)	1.09	0.71	0.41
Blue Gum Creek	2.67	2.9	1.1
Little Blue Gum Creek	0.64	0.7	0.31
College Creek	2.06	6.5	0.71
Lane Cove River	4.7	9.4	1.82

The provision of storage as proposed (*refer* **Section 4.8**) reduces the proposed 2 year ARI peak flow rates significantly below the peak rates for the existing site (*refer* **Table 8**).

4.10 PROPOSED RETENTION STORAGE

The volume of storage required to be treated as on-site retention to satisfy DCP 47 is 440m^3 to satisfy the requirement to store 20mm of runoff from roofs and 3,175m^3 to reduce the 50 year ARI post development flows to the 20 year ARI natural condition flows. Also shown **Table 9** is the volume of OSR proposed as part of the storm water management strategy. Storage would be provided in a combination of rainwater tanks, bioretention swales/basins and tanks located unde the roadway.

Bioretention swales and basins have been provided as outlined in **Section 5** for water quality treatment purposes. The role of the bioretention swale is not to promote infiltration into the sub soils but into a specially constructed infiltration media. The swales and basins also allow for the following extended storage on the surface:

- Bioretention swales at an average 0.2m depth - 1,260m^3; and
- Bioretention basins at an average 0.3m depth - 1,340m^3.

This amounts to a total of 2,600m^3 of on-site retention.

Table 9 - Storage Summary

	Required OSR DCP 47 (m^3) 1*	Required OSR DCP 47 (m^3) 2*	Storage Provided: OSR Rainwater Tank (m^3)	Storage Provided: OSR Bioretention (m^3)	Storage Provided: Tank Storage (m^3)	Total Storage Provided (m^3)
P1	43	30	21 (70x0.3)	123	-	144
P2	72	145	109 (363 x0.3)	408	-	517
P3	72	800	92 (306x0.3)	360	420	872
P4	123	2,150	221 (738x0.3)	1,265	787	2,273
P5*	-	-	-	24	-	24
P6*	-	-	-	64	-	64
P7*	-	-	-	48	-	48
P8 *	-	-	-	24	-	24
P9 *	-	-	-	14	-	14
P10*	-	-	-	-	-	-
P11*	-	-	-	-	-	-
P12	44	50	67 (222x0.3)	170	-	237
P13	26	-	20 (65 x0.3)	100	-	120
Total	**380**	**3,175**	**531 (1,770x0.3)**	**2,600**	**1,207**	**4,337**

Note: * These catchments do not contain any proposed development;
1* DCP 27 requirement to store 20mm of run off from all roofs; and
2* DCP 27 requirement to control post development 50 year flows to 20 year natural condition flows.

This analysis demonstrates that it is feasible to meet the requirements of Council's DCP 47 with the provision of the above storage. In addition, the proposed storage strategy significantly reduces the existing 2 year ARI peak flows below existing conditions. Further analysis can be undertaken at subsequent approval stages to refine the storage requirements and means of accounting for the beneficial impact of pipe and infiltration media storage on control of runoff rates.

4.11 DISCHARGE OUTLETS

Each of the proposed outlets has been located as close as possible to a recognised existing outlet. The proposed stormwater outlets shall generally consist of a headwall followed by a shallow tail-out channel that is protected from scour with either rock rip-rap and/or suitable vegetation (*eg macrophytes in the invert that protect from scour velocities during high flows*).

5 STORMWATER QUALITY IMPACT ASSESSMENT

5.1 COUNCIL REQUIREMENTS

Ku-ring-gai Council's (*Council's*) – *Water Management Development Control Plan – DCP 47(March 2004)* contains the design objectives for stormwater quality management. These standards require (*Section 8.3.1)* the following reductions in the post development pollutant load that would be discharged from the site if no stormwater reuse or treatment measures were applied:

- Litter 70% reduction;
- Suspended solids 80% reduction;
- Total Phosphorus 45% reduction; and
- Total Nitrogen 45% reduction.

These criteria have been adopted for the key pollutant attenuation objectives. In addition, the existing state has been modelled to ensure that there is no increase in pollutant load export from the existing state as a result of the proposed development.

5.2 MUSIC WATER QUALITY MODEL

MUSIC is a continual-run conceptual water quality assessment model developed by the Cooperative Research Centre for Catchment Hydrology (*CRCCH*). MUSIC can be used to estimate the long-term annual average stormwater volume generated by a catchment as well as the expected pollutant loads. MUSIC is able to conceptually simulate the performance of a group of stormwater treatment measures (*treatment train*) to assess whether a proposed water quality strategy is able to meet specified water quality objectives.

To undertake the water quality assessment component of the stormwater management strategy, a long-term MUSIC model was established for the UTS Ku-ring-gai Campus site. The model was used to estimate the annual pollutant load generated under natural state and developed conditions for a mean rainfall year.

MUSIC was chosen for this investigation because it has the following attributes:

- it can account for the temporal variation in storm rainfall throughout the year;
- modelling steps can be as low as 6 minutes to allow accurate modelling of treatment devices;
- it can model a range of treatment devices;
- it can be used to estimate pollutant loads at any location within the catchment; and
- is based on logical and accepted algorithms.

5.3 EXISTING STATE SIMULATION

The adopted objective of the water quality management strategy is to achieve the required reductions outlined in **Section 4.1** and no net increase in pollutant export to receiving waters relative to existing state conditions. Therefore, the existing pollutant export from the site was estimated to establish the base case against which to measure the performance of proposed development.

The catchments defined in **Table 1** and **Figure 2** were adopted to create a MUSIC model for the UTS Ku-ring-gai site.

5.3.1 Rainfall

In order to develop a model that could comprehensively assess the performance of water quality treatment devices such as swales and bioretention, the use of 6 minute pluviograph data was necessary. Long term annual rainfall measurements for the region, as measured by the Bureau of Meteorology (West Lindfield) give the following rainfall statistics;

Mean - 1324.2mm/year
Max - 1905mm/year (1978)
Min – 721.3mm/year (1957)

This estimate was based on 42 complete years of record at this site, between 1950 and 1992 (*Bureau of Meteorology, 2004*). No pluviograph data to provide six minute rainfall records is available for this station.

Pluviograph data recorded at Sydney Observatory Hill was adopted for the analysis. The following records have been adopted and are considered to be representative of the average, maximum and minimum annual rainfall experienced at the UTS Ku-ring-gai site.

Mean – 1343mm/year (1983)
Wet – 1765mm/year (1984)
Dry – 840mm/year (1982)
Resultant mean – 1316mm/hr

5.3.2 Evaporation

Monthly areal potential evapotranspiration values were obtained for the site from ‘Climate Atlas of Australia, Evapotranspiration’ (*Bureau of Meteorology, 2001*) and are shown in **Table 10.**

Table 10 - Monthly Areal Potential Evapotranspiration

Month	Areal Potential Evapotranspiration (mm)
January	175
February	135
March	125
April	80
May	58
June	45
July	45
August	60
September	89
October	125
November	151
December	165

5.4 SOIL DATA AND MODEL CALIBRATION

A rainfall-runoff analysis was undertaken prior to modelling being undertaken. The model produced a natural state volumetric runoff coefficient 0.28 with the default soil parameters. This is considered to be a low runoff coefficient for the subject site. However, it has been adopted because it provides a low estimation of the existing annual runoff pollutant load and makes the requirements for runoff water quality control for the development more stringent.

The following default soil parameters were adopted for the site: -

- field capacity 80mm
- soil capacity 120mm
- Initial storage 30mm
- coefficient '*a*' 200
- coefficient '*b*' 1.0

5.5 POLLUTANT CONCENTRATIONS

The event mean pollutant concentrations used for the various land-uses in the existing and developed catchments were derived from '*Urban Stormwater Quality: A Statistical Overview*' (*Duncan, February 1999*). The adopted pollutant concentrations are shown in **Table 11. Table 1** contains the existing land use types for each of the existing catchments.

Table 11 – Adopted Runoff Pollutant Concentrations

	Pollutant Concentration (mg/L)		
	Suspended Solids	**Total Phosphorous**	**Total Nitrogen**
Source Values			
Commercial (Duncan 1999)	129	0.33	2.09
Urban (Music default)	158	0.355	2.63
Rural (Music default)	200	0.537	3.89
Roof (Duncan 1999)	35	0.13	0.84
Local Existing Land Use			
Car parking	158	0.355	2.63
Tennis courts	129	0.330	2.09
Roads	158	0.355	2.63
Oval	200	0.537	3.89
Buildings	158	0.355	2.63
Child care centre, Film Australia, road	129	0.330	2.09
Proposed			
P3, P4 and P12 Roof	35	0.13	0.84
P1, P2, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14, P15,	158	0.355	2.63
P3 P4	129	0.330	2.09

5.6 EXISTING STATE POLLUTANT EXPORT

The MUSIC model, once setup for runoff, was used to simulate the pollutant export generated during a mean rainfall and evaporation year using the typical pollutant concentrations contained in **Table 11**.

The estimated annual export of pollutants at the outlets of the existing state subcatchments for a mean rainfall year are shown in **Table 12**.

Table 12 – Annual Pollutant Export Loads – Existing State

Node / Location	Pollutant Load (kg/yr)		
	Suspended Solids	Total Phosphorous	Total Nitrogen
Out 1	191	0.4	2.7
Out 2	1800	3.7	25.2
Out 3	221	0.4	3
Out 4	1110	2.3	15.2
Out 5	78	0.2	1.3
Out 7	875	2.4	17.4
Out 8	991	2.1	15.4
Out 9	867	2.3	16.5
Out 10	335	0.9	6.9
Out 11	1440	1.4	21
Out 12	433	0.9	6.2
Out 13	690	1.4	9.6
Out 14	412	0.9	6.2
Out 15	112	0.2	1.8
Out 16	438	0.9	7
Out 17	891	1.9	13.9
Out 18	1010	2.1	15.4
Out 19	834	1.77	12.8
Out 20	1480	3.2	24
Out 21	706	1.7	10.3
Out 22	992	2	14
Blue Gum Creek	**7280**	**15.4**	**111**
Little Blue Gum Creek	**3330**	**6.8**	**46**
College Creek	**5290**	**12.5**	**88.6**
Lane Cove River	**15900**	**34.6**	**246**

5.7 DEVELOPED (*NO TREATMENT*) POLLUTANT EXPORT

To assess the requirements of the water quality management strategy, the existing state model was modified to reflect the degree of proposed development. No treatment techniques were implemented in the developed (*no treatment*) model. The model was modified to reflect the impervious proportions of the subcatchments as defined in **Table 5**.

The estimated annual export of pollutants from the developed (*no treatment*) site for a mean rainfall year compared with the existing conditions are shown in **Table 13**.

Table 13 – Annual Pollutant Export Loads – Developed State (*No Treatment*)

Node / Location	Pollutant Load (kg/yr)					
	Suspended Solids		Total Phosphorous		Total Nitrogen	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
P1 (combined out 1,2,3 and 4)	3322	2260	6.8	4.66	46.1	33
P2 (out 9 and 20)	2347	3510	5.5	7.18	40.5	50.5
P3 (combined out 5 and 10)	413	2940	1.1	6.8	8.2	40.4
P4 (out 7)	875	2900	2.4	7.2	17.4	46
P5 (out 8)	991	862	2.1	1.8	15.4	13.1
P6 (out 11)	1440	1200	1.4	2.5	21	18.4
P7 (out 12)	433	541	0.9	1.1	6.2	7.8
P8 (out 13)	690	689	1.4	1.4	9.6	10.3
P9 (out 14)	412	464	0.9	1	6.2	7.1
P10 (out 15 and 16)	550	620	1.1	1.3	8.8	10
P11 (out 17)	891	930	1.9	1.95	13.9	14.4
P12 (out 18 and 22)	2002	2990	4.1	6.3	29.4	46
P13 (out 19 and 21)	1540	1830	3.47	3.9	23.1	27
Blue Gum Creek	**7280**	**8190**	**15.4**	**17.1**	**111**	**122**
Little Blue Gum Creek	**3330**	**2260**	**6.8**	**4.6**	**46**	**33**
College Creek	**5290**	**11500**	**12.5**	**25.6**	**88.6**	**168**
Lane Cove River	**15900**	**21800**	**34.6**	**47.3**	**246**	**322**

Table 13 shows that a reduction in all pollutants is required to achieve the existing state pollutant loads in Blue Gum Creek, College Creek and Lane Cove Creek. However the proposed state model produces less pollutant load in Little Blue Gum Creek due to the change in land use from car parking to residential.

5.8 PROPOSED TREATMENT STRATEGY

The proposed water management for each subcatchment is as follows:

P 1

- Each detached lot to utilise a 5,000 L and each unit to utilise a 3,000 L rain water tank for re-use;
- 616m^2 bioretention swale (77m^2 of filter area, 0.3m ponding depth);
- 1 Gross Pollutant Trap.

P 2

- Each detached lot to utilise a 5,000 L and each unit to utilise a 3,000 L rain water tank for re-use;
- 1440m^2 of bioretention swale (186m^2 of filter area, 0.3m ponding depth);
- 400m^2 bioretention basin (200m^2 of filter area, 0.3m ponding depth);
- 1 Gross Pollutant Trap.

P 3

- Each detached lot to utilise a 5,000 L and each unit to utilise a 3,000 L rain water tank for re-use;
- 180m^2 of bioretention swale (23m^2 of filter area, 0.3m ponding depth);
- 1080m^2 bioretention basin (500m^2 of filter area, 0.3m ponding depth);
- 1 Gross Pollutant Trap.

P4

- Each detached lot to utilise a 5,000 L and each unit to utilise a 3,000 L rain water tank for re-use;
- 1843m^2 of bioretention swale (230m^2 of filter area, 0.3m ponding depth);
- 2142m^2 of bioretention basin (1071m^2 of filter area, 0.3m ponding depth);
- 847m^2 of bioretention basin (420m^2 of filter area, 0.3m ponding depth);
- 1 Gross Pollutant Trap.

P 5

- 120m^2 of bioretention swale (15m^2 of filter area 0.3m ponding depth).

P 6

- 320m^2 of bioretention swale (40m^2 of filter area 0.3m ponding depth).

P 7

- 240m^2 of bioretention swale (38m^2 of filter area 0.3m ponding depth).

P 8

- 120m^2 of bioretention swale (15m^2 of filter area 0.3m ponding depth).

P 9

- 68m^2 of bioretention swale (8.5m^2 of filter area 0.3m ponding depth).

P10

- 1 Gross Pollutant Trap.

P 12

- Each detached lot to utilise a 5,000 L and each unit to utilise a 3,000 L rain water tank for re-use;
- 844m^2 of bioretention swale (106m^2 of filter area 0.3m ponding depth);
- 1 Gross Pollutant Trap.

P 13

- Each detached lot to utilise a 5,000 L and each unit to utilise a 3,000 L rain water tank for re-use;
- 500m^2 of bioretention swale (63m^2 of filter area 0.3m ponding depth).

A brief description of water tanks, bioretention areas and gross pollutant traps is provided in the following sections.

5.8.1 Rainwater Tanks

Each detached lot to utilise a 5,000 L and each unit to utilise a 3,000 L rainwater tank that will capture the stormwater collected on the roof. This water will be available for re-use for toilet flushing, clothes washing, car washing and external irrigation. It should be noted that the provision of rainwater tanks and reuse of runoff has not been modelled in MUSIC and as such, there would be the added benefit from these tanks of further reducing the runoff volume and hence the pollutant load discharged to surrounding bushland. The extent of control measures can be refined at subsequent approval stages in the knowledge that it is feasible to achieve the stated. objectives.

5.8.2 Bioretention Swales and Basins

Bioretention swales and basins consist of low relief areas consisting of native grasses, shrubs and trees with an infiltration area. The swales would be gravel filled approximately 700mm deep with 200mm of sandy loam topsoil and 500mm wide wrapped in geotextile with a perforated pipe at the base. The trenches would be connected to the pipe drainage system. Typical sections of the proposed bioretention swales and basins are shown in **Figure 3**. The bioretention basins would be wider areas of open space heavily vegetated with a series of infiltration trenches through out the basin area.

The purpose of bioretention is to provide a filtering effect when the runoff flows on the surface through the vegetation to remove pollutants in the runoff. Further treatment would be achieved by filtering through the gravel trench and biological action due to growth on the gravel. Low flows are maintained as much as possible on the surface exposed to sunlight and with turbulence introducing oxygen to the flows.

The role of the bioretention swales and basins is not to promote infiltration into the subsoils.

The proposed location of the bioretention system is shown in **Figure 1**.

5.8.3 Gross Pollutant Trap

The GPT's would capture litter, debris, coarse sediment, oils and greases. While the pollutant capture efficiency of various traps may vary, the paper "*Removal of Suspended Solids and Associated Pollutants by a Gross Pollutant Trap*" (*Cooperative Research Centre for Catchment Hydrology, 1999*) suggests the following efficiencies; -

- gross pollutants majority
- sediments up to 70%
- total phosphorous up to 30%
- total nitrogen up to 13%

Due to the level of treatment the stormwater will have already undergone prior to GPT's the capture rates for GPT's downstream of treatment devices have been reduced to more conservative values. The following treated capture rates have been adopted:-

- gross pollutants majority
- sediments up to 48%
- total phosphorous up to 18%
- total nitrogen up to 8%

5.9 DEVELOPED (*TREATED*) POLLUTANT EXPORT

The water quality controls outlined in **Section 5.8** were incorporated into the developed MUSIC model as described above. The estimated annual export of pollutants from the developed (*with treatment*) site for a mean rainfall year are shown in **Table 14**.

Table 14 – Performance of Proposed Water Quality Management Strategy

Node / Location	Pollutant Load (kg/yr)					
	Suspended Solids		Total Phosphorous		Total Nitrogen	
	Existing	Proposed Treated	Existing	Proposed Treated	Existing	Proposed Treated
P1 (combined out 1,2,3 and 4)	3322	236	6.8	1.2	46.1	13.6
P2 (out 9 and 20)	2347	167	5.5	1.1	40.5	11.9
P3 (combined out 5 and 10)	413	136	1.1	0.9	8.2	7.8
P4 (out 7)	875	160	2.4	1.2	17.4	11.5
P5 (out 8)	991	302	2.1	0.9	15.4	7.5
P6 (out 11)	1440	272	1.4	0.9	21.0	8.1
P7 (out 12)	433	74	0.9	0.3	6.2	2.9
P8 (out 13)	690	199	1.4	0.6	9.6	5.2
P9 (out 14)	412	156	0.9	0.4	6.2	4.0
P10 (out 15 and 16)	550	157	1.1	0.8	8.8	7.6
P11 (out 17)	891	915	1.9	1.9	13.9	14.1
P12 (out 18 and 22)	2002	298	4.1	1.5	29.4	15.9
P13 (out 19 and 21)	1540	415	3.5	2.0	23.1	18.7
Blue Gum Creek	**7280**	**2210**	**15.4**	**7.6**	**111**	**68.4**
Little Blue Gum Creek	**3330**	**236**	**6.8**	**1.2**	**46**	**16.6**
College Creek	**5290**	**1040**	**12.5**	**4.9**	**88.6**	**47.2**
Lane Cove River	**15900**	**3480**	**34.6**	**13.7**	**246**	**129**

Table 14 shows that the water quality objective of maintaining developed pollutant export rates to existing levels can be readily achieved at all outlets. The pollutant export into the receiving water bodies of the Lane Cove River, Blue Gum Creek, College Creek and Little Blue Gum Creek are significantly less then in the existing state as a result of incorporating the stormwater quality controls as shown in **Figure 1**. The development would therefore contribute to the long term improvement in water quality in these creeks.

Ku-ring-gai Council's (*Council's*) – *Draft Water Management Development Control Plan – DCP 47(November 2003)* require the following reductions from the post untreated to post treated;

- Suspended solids 80% reduction
- Total Phosphorus 45% reduction
- Total Nitrogen 45% reduction

Table 15 shows that Little Blue Gum Creek, College Creek and the Lane Cove River satisfy the above requirements. The ultimate receiving water body the Lane Cove River satisfies both Councils reduction requirements and less pollutant export is produced in the proposed treated model then the existing state.

Table 15 - Percentage pollutant load reductions from post untreated to post treated.

Node / Location	**Suspended Solids**	**Total Phosphorous**	**Total Nitrogen**
	Reduction (%)	**Reduction** (%)	**Reduction** (%)
P12 and P13	91	80	72
Little Blue Gum Creek	90	74	50
College Creek	91	81	72
Lane Cove River	84	71	60

This assessment does not incorporate the beneficial effects of rainwater tanks on runoff water quality. Even with this exclusion, this assessment demonstrates that it is feasible to control and improve runoff pollutant loads discharged from the site. The water quality control mechanisms can be refined at subsequent approval stages with inclusion of the beneficial effect of rainwater tanks.

5.10 CONSTRUCTION PHASE

The development application for each stage will provide a sediment and erosion control plan designed in accordance with the NSW Department of Housing "*Managing Urban Stormwater – Soils and Construction*" (*Blue Book*) and to the satisfaction of Council's requirements. Staging of the development would minimise impacts during construction. These controls would ensure that there are no significant adverse impacts on receiving water quality during the construction stage.

6 WATER CYCLE MANAGEMENT

6.1 POTABLE WATER USE REDUCTION

Ku-ring-gai Council's–*Water Management Development Control Plan – DCP 47(March 2004)* sets out Water Conservation Requirements. Section 10.3 of DCP 47 requires introduction of water saving devices including shower heads, taps (other then taps in baths) and toilets with a certified rating of at least AAA. Section 6.4 of DCP 47 requires that all single dwelling be equipped with a 5000L water tank and multi unit developments be equipped with a 3000L rainwater tank. In addition it is required that all lots containing rainwater tanks shall have the tanks connected to toilets and washing machines at a minimum.

The NSW Government announced recently that new developments approved after July 2004 would have to achieve a 40% reduction in potable water use compared to a traditional household.

It is proposed to provide all single dwellings with a 5000L water tank and all apartments with a 3000L water tank for use in toilets, washing machines, car washing and irrigation purposes in combination with water saving devices.

The main uses of potable water in a traditional household are garden irrigation (28%), toilet (17%) and washing machine (16% - *refer **Table 15***). Reduced potable water usage or its substitution with runoff in these areas has the potential to achieve significant savings for each household. The typical potable water usage in a traditional household is presented in **Table 15.**

Table 16 Typical Household Water Usage

Area/Use	***Traditional Household***		***With Water Saving Devices***	
	Usage l/person/day	**Percentage of Total Use (%)**	**Usage l/person/day**	**Percentage Reduction (%)**
1. Internal				
• Kitchen	11.8	4.6	11.8	-
• Bathroom basin	6.9	2.7	6.9	-
• Laundry basin	7.9	3.1	7.9	-
• Bath	8.8	3.4	8.8	-
• Shower	55.9	21.8	39.2	30%
• Toilet	44.2	17.2	26.9	39%
• Washing machine	40.2	15.6	31.4	22%
• Dishwasher	1.9	0.7	1.3	29%
Sub Total	177.5	69	134.1	24%
2. External				
• Irrigation	72.5	28.2	72.5	-
• car washing	2.3	0.9	2.3	-
Sub Total	74.8	31	74.8	-
TOTALS	**257.1**	**100**	**208.9**	**18%**

The reductions in potable water use due to water saving devices have been derived from discussions with Sydney Water and the report, *Investigation of Options to Minimise Potable Water Demand and Reduce Wastewater Flows* (URS 2003). These reductions are listed in **Table 16**. The typical water saving devices consists of:

- shower – AAA shower head;
- toilet – 6/3 L dual flush;
- washing machine – AAA rated front loading; and
- dishwater – AAA rated.

It is proposed to include these water saving devices in the UTS development. This would reduce potable water usage by approximately 18%.

6.2 RAINWATER REUSE

Runoff from roofs can be reused for various purposes including irrigation, car washing, toilet flushing and washing machines. This has the potential to make considerable reductions in potable water usage in concert with water savings devices. With full substitution of these uses, the reduction in potable water usage would be 56% *(with the 18% reduction due to water saving devices – see* **Section 6.1**). However, full substitution would not be achieved at any location due to the variability of rainfall.

A water balance analysis was undertaken for the subject site using recorded daily rainfall data for Castle Cove (66080) from January 1984 to May 2004 (*average annual rainfall of 1340mm/yr*) and daily evaporation data over the same period recorded at Sydney Airport. The water balance was used to determine the efficiency of the 5000L rainwater tanks in each detached dwelling and 3000L rainwater tanks in each apartment. *(refer* **Appendix B***)*.

Three scenarios have been modelled with the first being a traditional household with no controls. The second scenario (*Option A*) includes the implementation of water saving devices as described in **Section 6.1**. The final scenario (*Option B*) includes rainwater for irrigation, car washing, toilet flushing and washing machines used in concert with water saving devices.

Table 17 Water Balance Summary – Water Usage (m^3/yr)

All volumes in (m^3/yr), for annual average	Traditional Household	Option - A	Option - B
Total potable water use	70,664	57,521	37,953
Potable Water Use Reduction (%)		**19%**	**46%**

The total potable water use decreases from 70,664m^3/yr in the traditional household model to 57,521m^3/yr with the introduction of water saving devices. This represents a reduction in potable water usage of 19%. The introduction of rainwater tanks further reduces the potable water usage to 37,953m^3/yr achieving a predicted saving of 46%.

The State government's requirement for a 40% reduction in potable water use can be achieved with a 5000L rainwater tank for each detached dwelling and 1000L for each unit. It is proposed to explore with Council the use of a range of rainwater tank sizes to suit the site and development constraints while still complying with the State government potable water use reduction target. For instance, slimline tanks can be more readily incorporated into a house design to provide an overall better design outcome in terms of visual and private open space amenity. These tanks have a maximum size of 4000L. These tanks could be used on detached housing with adequate tank sizes adopted for the units to ensure achievement of the 40% potable water use reduction target. Further analysis can be undertaken at subsequent approval stages to refine the tank sizes to achieve the required ESD targets and the best outcome for the overall design amenity for the site.

7 REFERENCES

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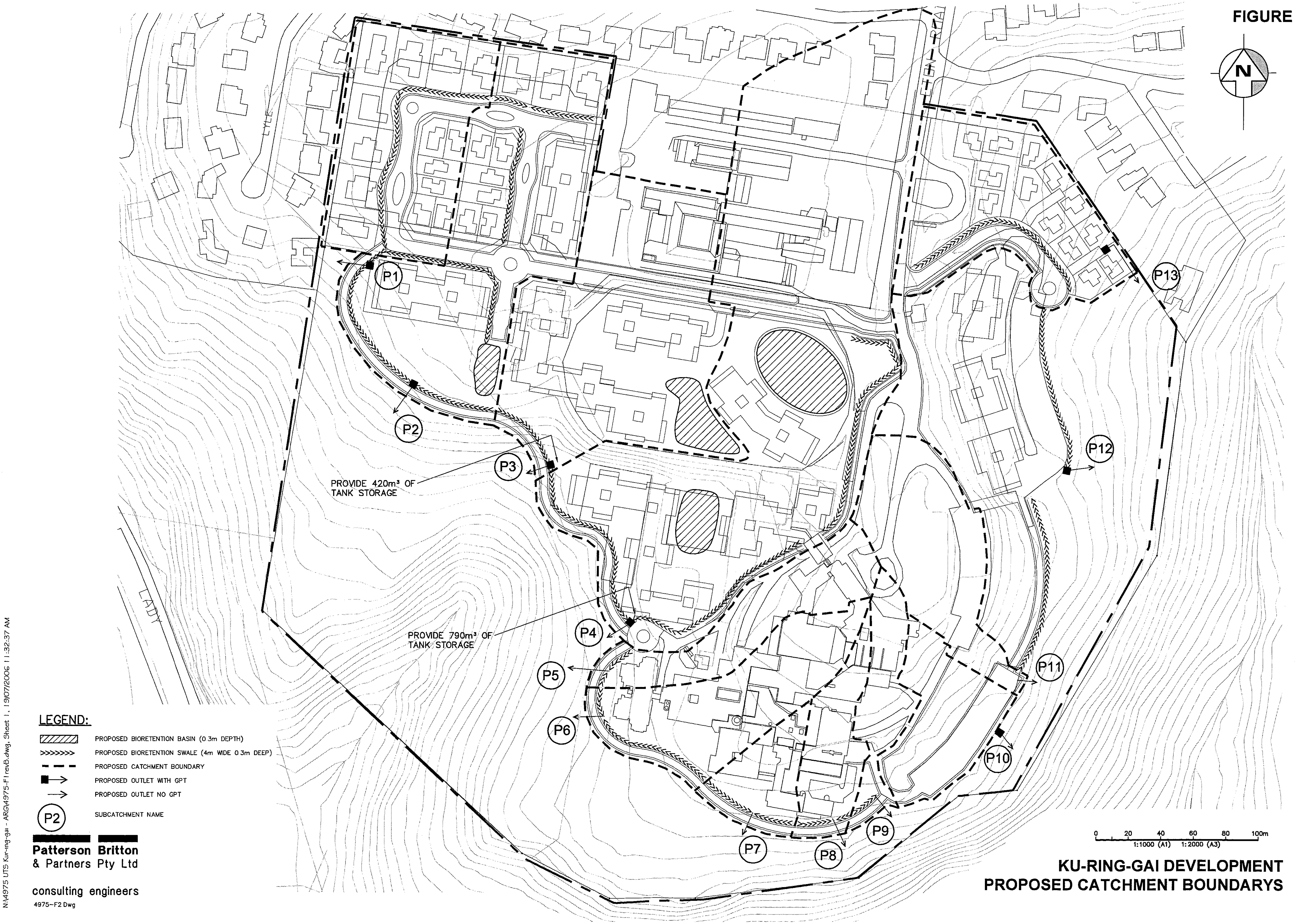
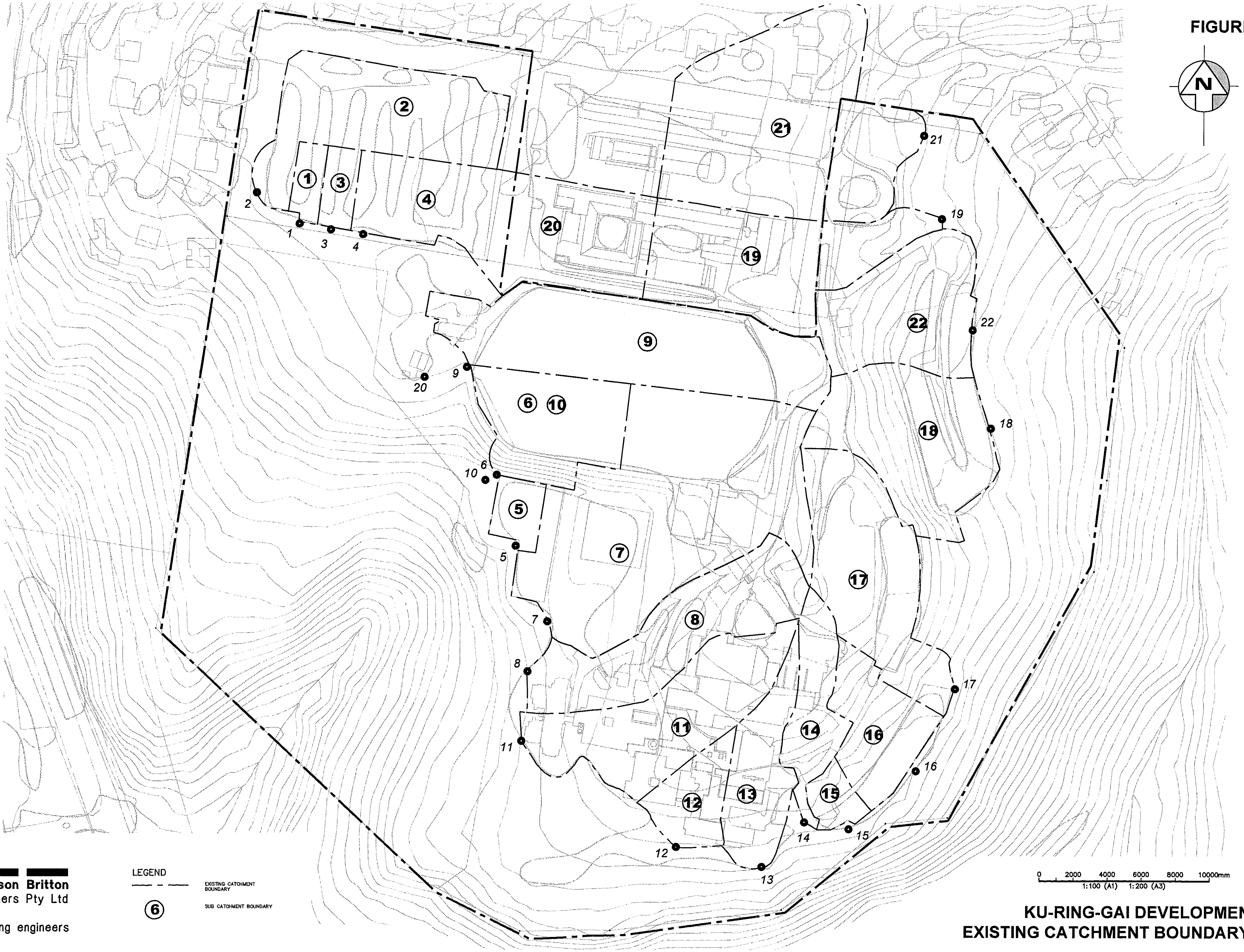
DRAWINGS

FIGURE 1



KU-RING-GAI DEVELOPMENT
PROPOSED CATCHMENT BOUNDARYS

FIGURE 2



LEGEND

EXISTING CATCHMENT BOUNDARY

⑥ SUB CATCHMENT BOUNDARY

0 2000 4000 6000 8000 10000mm
1:100 (A1) 1:200 (A3)

Patterson Britton
& Partners Pty Ltd

consulting engineers

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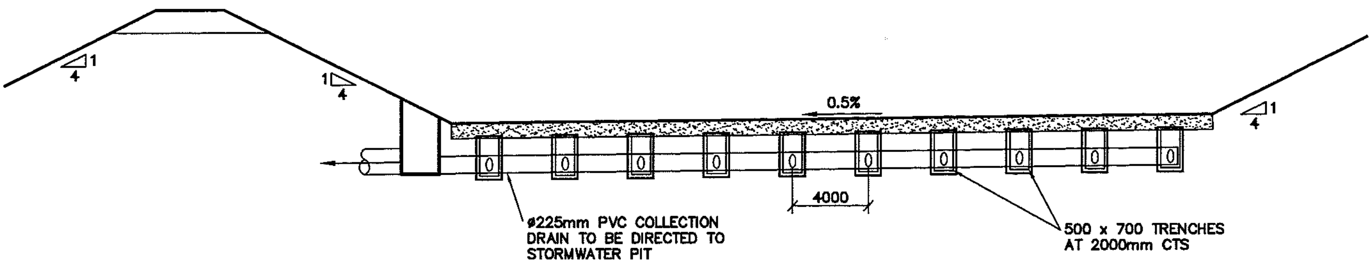
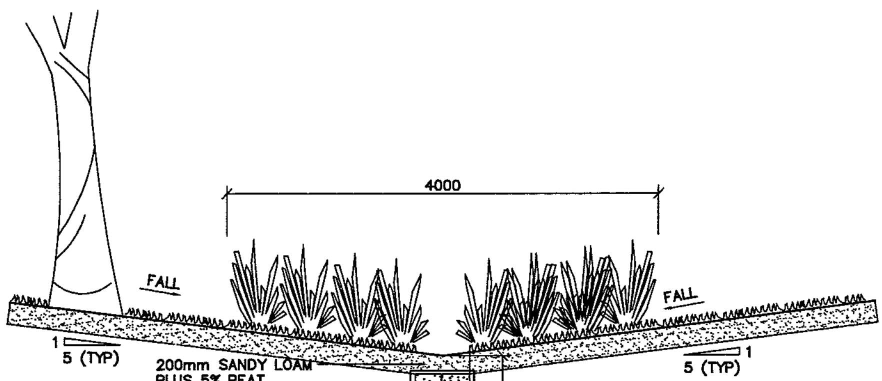
KU-RING-GAI DEVELOPMENT
EXISTING CATCHMENT BOUNDARYS

FIGURE 3



SECTION 1
1H: 2V

TYPICAL SECTION THROUGH BIORETENTION BASIN



TYPICAL CROSS SECTION THROUGH BIORETENTION SWALE
NTS

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TYPICAL SECTION THROUGH BIO-RETENTION BASIN AND SWALE