APPENDIX "A"

LAND CAPABILITY REPORT

FOR

NEBRASKA ESTATE

THE WOOL ROAD,

ST. GEORGES BASIN

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Executive Summary

This urban land capability study was conducted at the request of Shoalhaven City Council to assess the constraints faced by the proposed residential development, and to provide the basis for the preparation of a *Soil and Water Management Plan.* The proposed development is located at The Wool Road, St. Georges Basin.

Two soil landscapes were identified in the study area: the Wandrawandian (Morse McVey, 1991) and Tomerong Creek soil landscapes. The soils of these units provide significant constraints to residential development. However, we believe that these constraints can be addressed satisfactorily by the identification and implementation of appropriate soil and water management measures.

1 Introduction

This report was written at the request of Shoalhaven City Council to assess the site constraints and assist in the preparation of a *Soil and Water Management Plan* for a proposed residential development at The Wool Road, St. Georges Basin (figure 1). To this end, soils and other physical constraints have been analysed to prepare an urban land capability study.

This report presents the results of this work and is divided into three main sections:

(i) this introductory section;

(ii) a description of the physical attributes/constraints of the site; and

(iii) the urban land capability assessment.

This report should enable planning authorities to make wise decisions regarding the development of the site based on land capability.

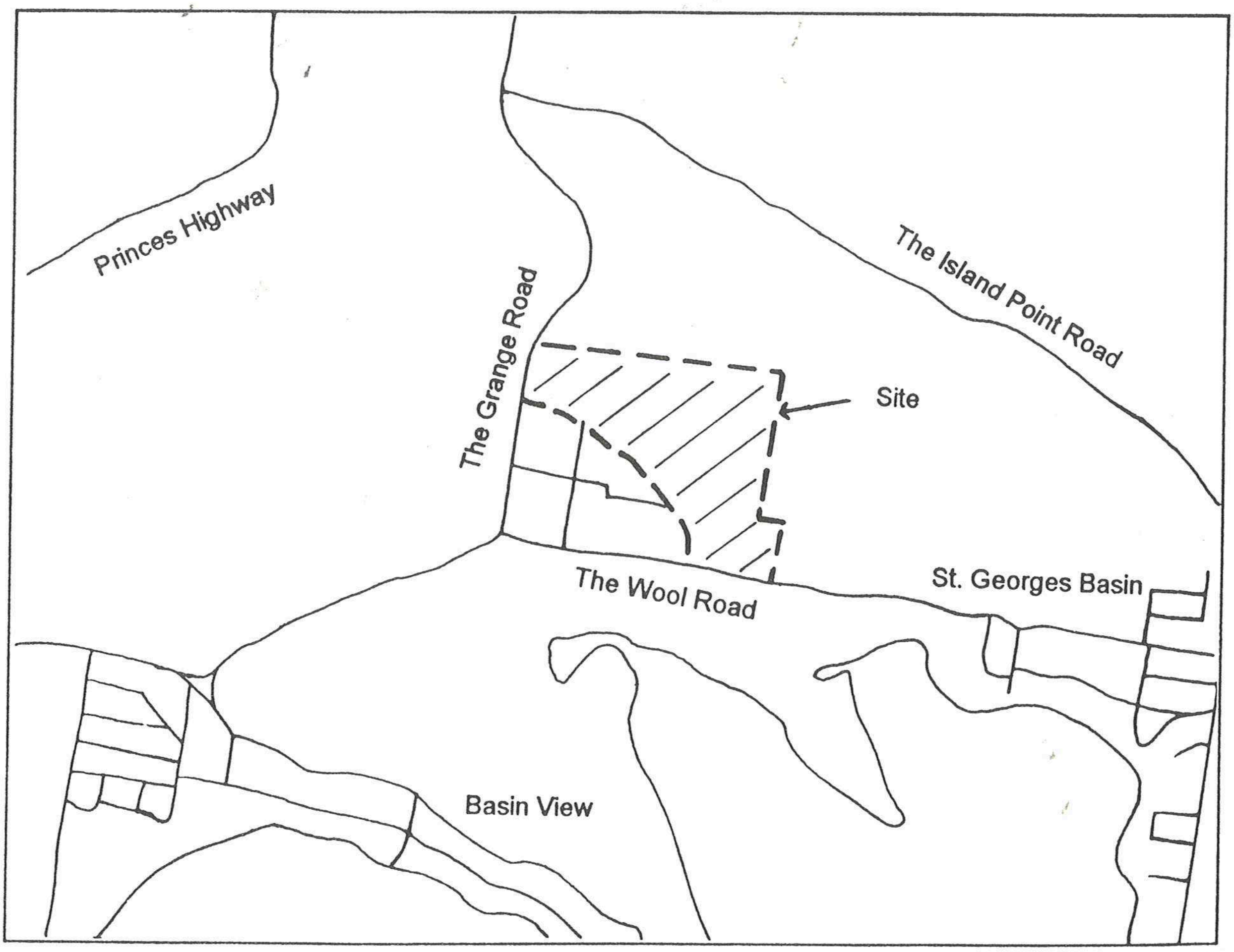


Figure 1 Site Location

A soil survey of the site was conducted on the 21st of September 1994. A total of 5 soil profiles were examined and described using the Soil Data Cards produced by the Department of Conservation and Land Management (CaLM). The completed cards were entered into CaLM's Soil Data System and the "plain English reports" produced are attached in Appendix 5. These provide:

(i) a summary of site characteristics, e.g. topography, landform attributes, lithology, erosion, etc; and

(ii) a description of soil and regolith characteristics, e.g. layer status, colour, mottles, layer boundary, soil water status, field texture, structure, fabric, coarse fragments, pans, segregations, etc.

The five soil profile locations were chosen to give an even spread or distribution over the study area (figure 2). Profiles were exposed to a minimum depth of 0.75 metres. Soil samples were collected at four of the five profiles for analysis at a NATA registered laboratory (see Appendix 3 for results).

Bedrock and sub-surface water was not encountered at any of the five profiles. As such, depth to a residual layer or permanent watertable does not represent a constraint at the site.

2 Physical Attributes

2.1 Location

St. Georges Basin is located approximately 190 kilometres south of Sydney. The study area is located on lands bounded by The Wool Road to the south, The Grange Road to the west and Nebraska Road (unsealed) to the north (figure 1). The site straddles an unnamed creek that drains southward to St. Georges Basin. It adjoins existing residential developments to the north and south. The site has a catchment area of approximately 238 hectares.

2.2 Climate

St. Georges Basin has a humid, temperate climate. Annual rainfall averages about 1 400 millimetres, with a slight late summer/autumn predominance. Average maximum temperatures for July and February are 16°C and 24°C respectively, and average minimum temperatures 9°C and 18°C.

2.3 Topography

The site is predominantly on the Wandrawandian soil landscape. The terrain consists of gently to moderately inclined (<10%) undulating rises. Local relief is very low (<25 metres). Narrow crests (<80 metres wide) grade into sideslopes with narrow drainage depressions thatrange in width from 20 to 50 metres. There is no rock outcrop in the study area.

2.4 Geology

Soil materials adjacent to St. Georges Basin are derived from formations of the Permian Shoalhaven Group and, to a lesser extent, Quaternary alluvial deposits along creek lines. The geology of the study area is the Wandrawandian Siltstone Unit of the Permian Shoalhaven Group. Where exposed as an outcrop (off-site, Gloster, 1988) it is a mid grey, lithic sandstone and silty sandstone containing some pebbles, fossilised marine organisms and burrows and occasional sandy layers.

2.5 Soil Landscapes

Two soil landscapes are identified at the site: Wandrawandian and Tomerong Creek (appendix 4). A brief description of their general characteristics follows.

Wandrawandian

The Wandrawandian Soil Landscape occurs throughout the study area. It is underlain by Wandrawandian Siltstone which, in the study area, weathers to soil materials ranging in texture from lithic sandstone to silty sandstone. It is typified by gently to moderately inclined undulating rises.

Narrow crests grade into sideslopes with narrow drainage depressions. Topsoil limitations include high erodibility, low fertility and strong acidity; while subsoil limitations include moderate to high erodibility, low fertility, strong acidity, high amounts of aluminium (toxic to some plants) and poor drainage.

Tomerong Creek

The Tomerong Soil Landscape occurs along the three tributaries of the unnamed creek that pass through the study area. It is characterised by low slopes (<5 percent) along narrow drainage depressions (20-50 metres wide). The subsoils are fine textured with a high clay and silt fraction, and can be moderately plastic and highly reactive (large shrink-swell). Other limitations include low fertility, strong acidity, and potential aluminium toxicity.

2.6 Soil Constraints

Erodibility

The erodibility of the site's soils is measured by the *K*-factor - a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. It is computed using the Universal Soil Loss Equation (USLE) (Appendix 1). In NSW, it normally ranges from 0.005 (low erodibility) to 0.070 (very high erodibility). At the subject site, soils have moderate to high erodibility ratings ranging from 0.026 to 0.046.

USCS Class

The Unified Soil Classification System (USCS) is an engineering classification based on particle size distribution and characteristics of fine grains. Profile 5 has a USCS class of CL-OL. This class is characterised by low shear strengths when saturated, medium susceptibility to cracking and low resistance to piping. The poor stability of these organic soils in the creek lines will need to be taken into account for any proposed road or drainage works. They may require the application of specialised engineering techniques.

Profiles 1, 3 and 4, which are located on the Wandrawandian Soil Landscape, have a USCS class of CL. This area of the site will not require the application of specialised engineering techniques as these soils are stable for earthworks.

Percent Dispersible of the whole subsoil

The proportion of the subsoil materials that are dispersible is another important soil characteristic. Dispersible soils are structurally unstable in water and readily disperse into their constituent particles (sand, silt, clay), with those particles finer than about 0.005 mm (clay and fine silt) staying in suspension for far longer periods than expected by physical settling alone. Chemicals such as gypsum need to be added to waters polluted by such materials to cause flocculation.

The percentage of the whole subsoil that is dispersible ranges from 0.5 to 1.4 percent. None of the four sites have a percentage that is significant (ie. exceeds 10 percent) (Department of Housing, 1993). However, flocculation of soil particles within sediment control structures is still suggested, in order to ensure the protection of downstream waters from sediment pollution. This is because the soils have a large clay and fine silt fraction (31 to 51 percent) and the use of a flocculant would enhance the rate of settling and reduce the export of pollutants.

2.7 Rainfall erosivity

Rainfall erosivity (*R*-factor) is a measure of the force and intensity of rain at the site in a normal year. It is computed from the equation:

$$R = 29.22(I)^{1.89}$$

where I is the 2 year ARI, 6 hour storm event (Rosewell and Turner, 1992). The 2 year ARI, 6 hour storm event for St. Georges Basin is provided in the IFD table in Appendix 2. In NSW, the *R*-factor varies from 500 in the far west to 9 500 on the north coast. St. Georges Basin has a high rainfall erosivity rating of 4 550.

2.8 Vegetation

The study area, which is generally uncleared, consists mainly of wet sclerophyll forest. Groundcover is good but the erosion hazard is moderate due to the high rainfall erosivity and moderate to high soil erodibility at the site. The key to the management of erosion during the construction phase is to minimise the time of exposure and area of disturbed land that is uncovered to erosive forces.

2.9 Site Constraints

Limiting constraints include:

- flooding
- USCS classes of the subsoils
- high erodibility (*K*-factor).

3 Urban Land Capability

3.1 The Urban Land Capability Classes

The land capability methodology used here is similar to a previous system developed by the Soil Conservation Service (Hannam and Hicks, 1980). In this system, land units are the method of synthesising the various resource data, with individual units classified according to capability. Further, the specific constraints that apply to each class are identified so that the end users have a firm basis for planning for sustainable development.

There are three classes of Urban land capability in this system (Table 1) with each higher capability class indicating progressively greater constraints to development.

Table 1
Urban land capability classes (Morse, Chapman and Hird 1992)

Class	Description
1	The particular land use is acceptable, with any land, soil or water constraints occurring only at a low degree. Standard design, construction and management techniques can be used.
2	The particular land use is acceptable. However, one or more land, soil or water constraints exist at a moderate (but not high) degree and which are likely to require specialised management and/or construction techniques.
3	The particular land use might not be acceptable. One or more land, soil or water constraints occur at a high degree which should be the subject of further detailed investigations into the appropriate geotechnical/engineering, and/or soil/water conservation matter.

The site can be divided into two major areas:

- the drainage depressions (creek lines)
- the surrounding low hills.

The majority of the lands are in the second area and are Class 1. However, the flood-prone areas surrounding the creek lines (Tomerong Creek Soil Landscape) are Class 3 due to the high constraint of flooding. This area also has the moderate constraints of high soil erodibility and constraining USCS classes (subsoils). It is understood that this flood-prone area will not be developed.

3.2 The Constraints

The appropriate hydrological, pedological or geomorphological constraints are identified as a subscript attached to the appropriate urban land capability class. *Moderate* constraints are indicated by uncapitalised subscripts, while *high* constraints are differentiated by a capitalised subscript. Lands with one (1) or more *moderate* constraints but no *high* constraints are classified as Class 2. Lands are classified as Class 3 when one or more *high* constraints are identified. Table 2 is a listing of various physical constraints to urban residential development which apply at the subject site.

Table 2
Limitations to Earthworks and Housing for Urban Residential Development

Constraint	Degree of Constraint			Mapping symbol	
	low	moderate	high	mod.	high
Flooding	>100 yr ARI	na	<100 yr ARI	na	F
USCS	all others	MH, ML, OL, OH	Pt	u	U
Soil Erodibility (*K*-factor)*	< 0.045	≥ 0.045	na	k	na

* See Appendix 1 for a description of the USLE.

At this site the high constraint of flooding exists for areas immediately surrounding the three tributaries of the unnamed creek that passes through the centre of the study area and also forms its south-western boundary. Further constraints include:

- USCS class CL-OL (Tomerong Creek Soil Landscape)
- K-factor of 0.046 (Tomerong Creek Soil Landscape).

The site can therefore be mapped according to differing constraints that are derived from the changes in soil landscapes (figure 2). The two urban land capability classes are:

- 1 (no constraints)
- 3Fku.

A single land capability map (figure 2) is presented, as the lack of constraints outside the Tomerong Creek Soil Landscape (flood zone) means the constraints do not vary for minimal or extensive development.

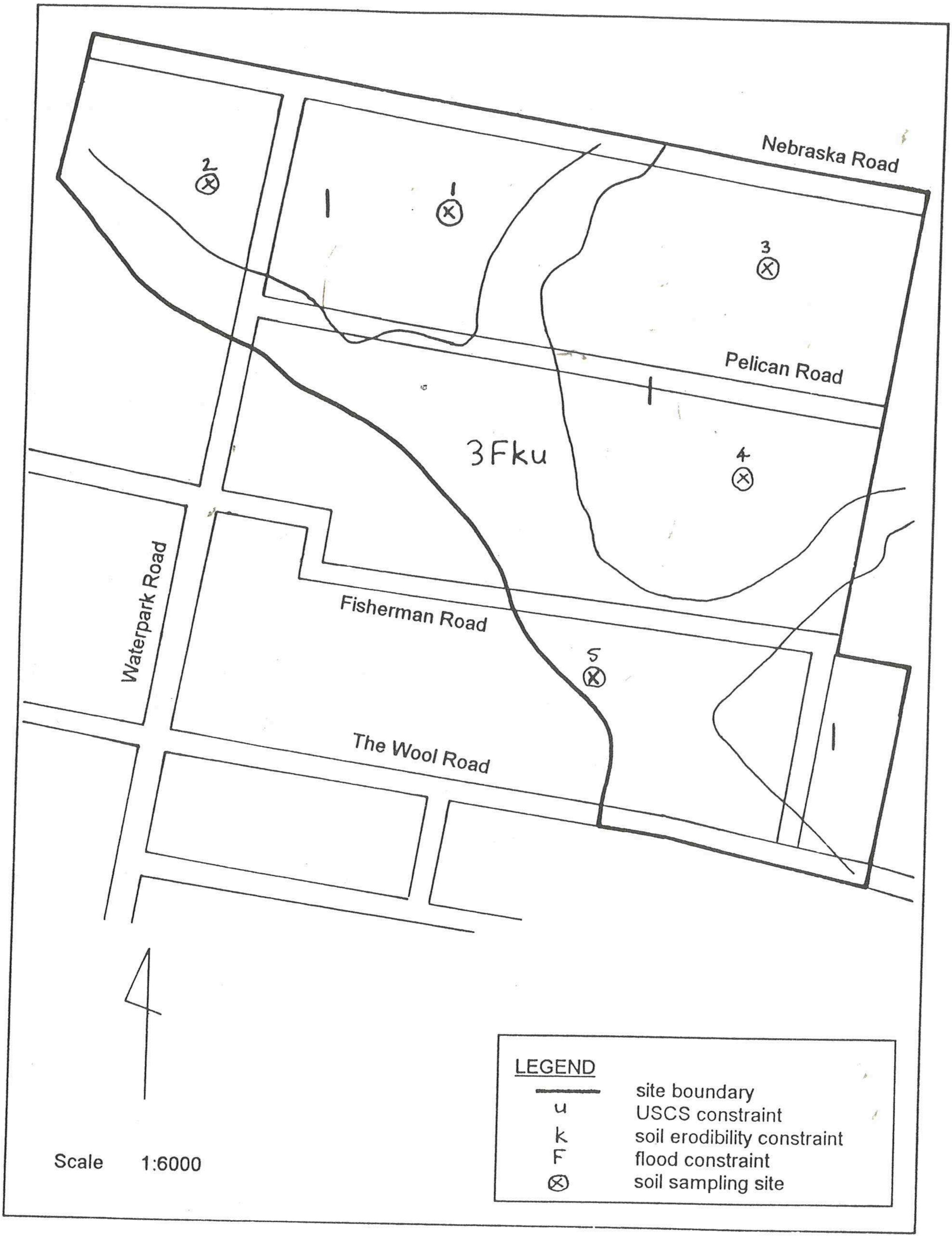


Figure 2 Land Capability Map

4 Water Quality

4.1 Sediment Retention Basins - Design Criteria

(a) The soils at the site are classified as *Type F* - where more than 33 per cent of the total soil mass is finer than 0.02mm. Based on this classification sediment retention structures will meet the following specifications:

(i) capacities that will contain the whole of the 1 in 5 year ARI, time of concentration storm event, plus an extra 20 percent to allow for likely sediment deposition.

(ii) storage depth over two-thirds of the surface area, including both settling and sediment zones, of at least 1.5 metres;

(iii) internal batter gradients consistent with personal safety and within the following upper limits:

- where water depth is less than 150 mm when surcharging, 3(H):1(V) on earth structures
- where water depth between 150 and 1 500 mm when unfenced and surcharging, a maximum slope of 5(H):1(V)
- where water depth between 150 and 1 500 mm when fenced and surcharging or greater than 1 500 mm –
  3(H):1(V) on earth structures
  1½(H):1(V) on rock gibber structures
  1(H):4(V) on gabion basket structures
  1(H):4(V) on stacked (rough squared) rock structures;

(iv) internal dimensions that provide an equivalent flow path, from inlet to outlet, as long as practical and at least three times longer than the width;

(v) a primary outlet:

- of sufficient width so that water does not exceed 100 mm depth during or after a 5 year ARI, one hour storm event
- in the case of riser structures, preferably fitted with an anti-vortex device
- with a level at least 300 mm below any emergency outlet
- constructed for stability in at least the 20 year ARI, critical duration flood event;

(vi) line rock and gabion basket structures on the inside with a suitable impermeable material to ensure removal of sediment particles from the system.

(b) Operation of the basins should ensure that, where possible, water has drained from them by the commencement of next storm event. This can be achieved dosing within 24 hours of conclusion of each storm event and then by pumping out 36 to 48 hours after each storm event. Lower the water level to a peg or similar marker previously placed in the structure to indicate the level above which capacity is available for containment in the design storm event. Use a floating inlet on the pump to minimise the opportunity for picking up any settled sediment – it is essential that these materials are not picked up in the pumping process.

(c) Maintain sediment control structures such that the design capacity is always preserved. Dispose of any waste material in sediment dumps where further pollution to downslope lands and waterways will not occur.

4.2 Constructed Wetlands - Design Criteria

Consructed wetlands are designed to retain nutrients, heavy metals, bacteria and other pollutants. They should aim to ensure that discharge water quality post-development is, at least equal to, or better than the quality pre-development in average annual runoff.

Where practical, water entering wetlands should be relatively free of sediment, particularly dispersed colloids. Sediment sumps should be incorporated at the inlet to wetlands to provide a permanent sediment retention basin.

The general design criteria for the construction of wetlands is given below:

(a) To maximise the natural treatment functions of wetlands

(i) Construct the inlet zone to ensure that in-flowing water is distributed horizontally across the pond and will not bypass as a plume – might be achieved using wide flat weirs, level spreaders, baffles, islands and the like. Velocity of flow should not exceed 0.3 metres per second in the one year ARI event;

(ii) consider the use of multiple inlets to disperse the total inlet load around the upstream end of a pond;

(iii) aquatic vegetation should occupy about 30 per cent of the pond surface area, planted on a littoral shelf; and

(iv) ideally, the pond should have a length width ratio of at least 3:1. This can be achieved through strategic location of the inlet and outlet structures, and/or construction of baffles or islands.

The Permanent Pool

(b) Various techniques are available for estimating the appropriate size of the permanent pool. One such technique involves the following 3 steps:

(i) estimate the mean annual runoff (m^3/yr) (unless other relevant data are available, assume it as the product of percentage impervious area in the catchment and mean annual rainfall);

(ii) determine the required hydraulic residence time (yrs) to achieve a nominated pollutant retention percentage (figure 3); and

(iii) calculate the required capacity (m^3) from the product of (i) and (ii), above. Where effective sediment removal is not achieved before inlet to the wetlands, add 20 per cent to allow for sedimentation.

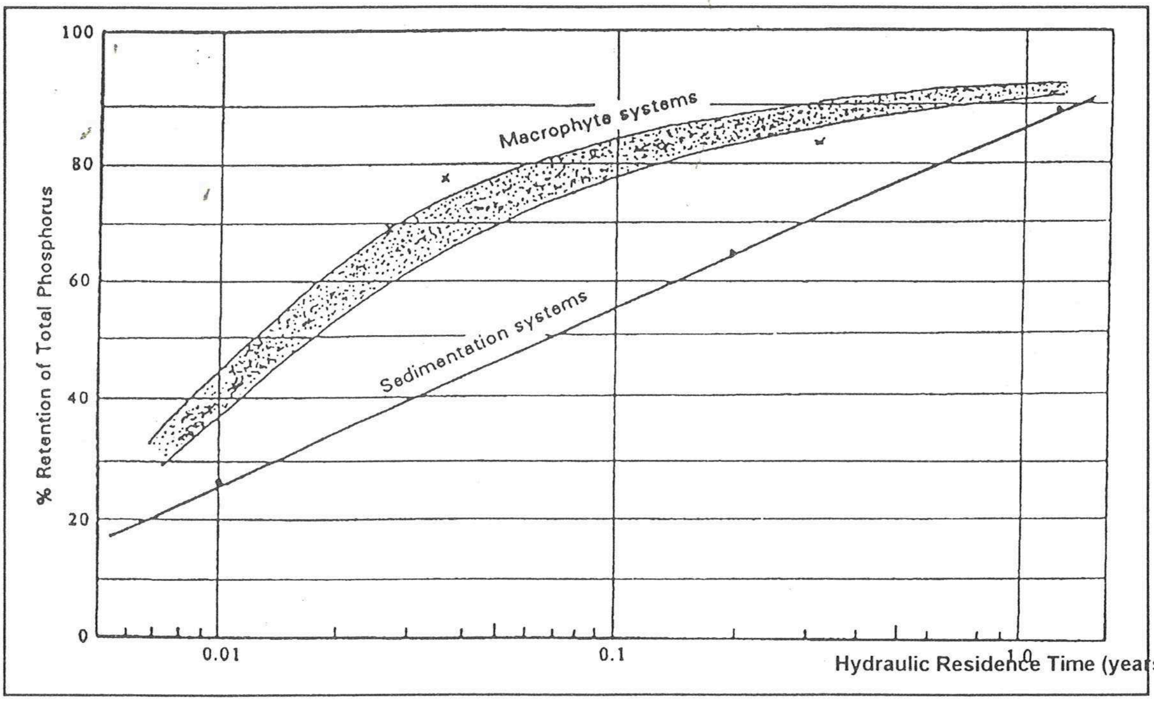


Figure 3 **Hydraulic residence time for phosphorus retention (Lawrence, 1986)**

(c) The depth of the permanent pool should be

(i) in the littoral zone (about 30% of pond surface area) 0.3 to 0.6 metres where emergent macrophytes are to grow; and down to 2.4 metres where submerged macrophytes are to grow; and

(ii) in the open water zone, 2.4 to 5-8 metres.

The likelihood of stratification and, where appropriate, methods to address it must be considered with ponds deeper than about 4 metres.

(d) Internal batter gradients should be no steeper than 2(H):1(V). However, to provide for a 30 per cent littoral zone, average gradients are likely to be less steep than 5(H):1(V) in the top 1.5 metres depth. If practicable, protect shorelines exposed to prevailing winds and wave erosion with

- emergent macrophytes and gradients of at least 10(H):1(V)
- other appropriate stabilisation techniques.

(e) Verify the performance of any constructed wetlands through application of appropriate models and modify design where necessary.

The Surcharge Pool

(f) In the surcharge pool, embankments should have a minimum grade of 10(H):1(V). Vertical walls might be installed providing they are no higher than 300 mm.

(g) Ensure the outlet from the surcharge pool draws surcharge water down over no less than 40 hours (preferably three days) and with no more than half the surcharge volume discharged within one third of that time. It should contain a secondary outlet to cater for flood flows. Very low flows should bypass the spillway area to prevent slime build-up.

Maintenance

(h) To allow for maintenance, there should be provision in the pond design for drainage of

(i) at least 60 per cent of the pond volume for removal of pollution deposits; and

(ii) 1.5 metres depth for manipulation of plant growth (e.g., harvesting). This can be critical, especially around the inlet zone. Invasive plants, e.g., *Typha, Phragmites* and *Juncus spp*, can completely clog parts of the wetland, resulting in water bypassing as a plume with a consequent reduction in the effective residence time.

Where possible, drainage by gravity is preferred, although pumping is acceptable.

(i) Maintain wetlands such that any sediment or other pollutants are removed when less than 90 per cent of the capacity necessary to meet pollution control requirements remains in the settling zone. An advantage of water that is relatively sediment free when it enters wetlands is that the maintenance requirements of the wetlands are reduced. Dispose of any pollutants removed from sediment basins or wetlands in areas where further pollution to downslope lands and waterways will not occur.

Other Considerations

(j) Generally, encourage emergent macrophytes right to the water's edge to assist in

- removal of nutrients and toxic products
- trapping any extraneous sediment or litter
- restriction of human access.

(k) Occasionally, however, it might be necessary to discourage emergent macrophytes at specific locations for landscaping or other reasons. At such locations edges constructed in stone, concrete, timber, etc., are acceptable.

(l) Choose plant species which do

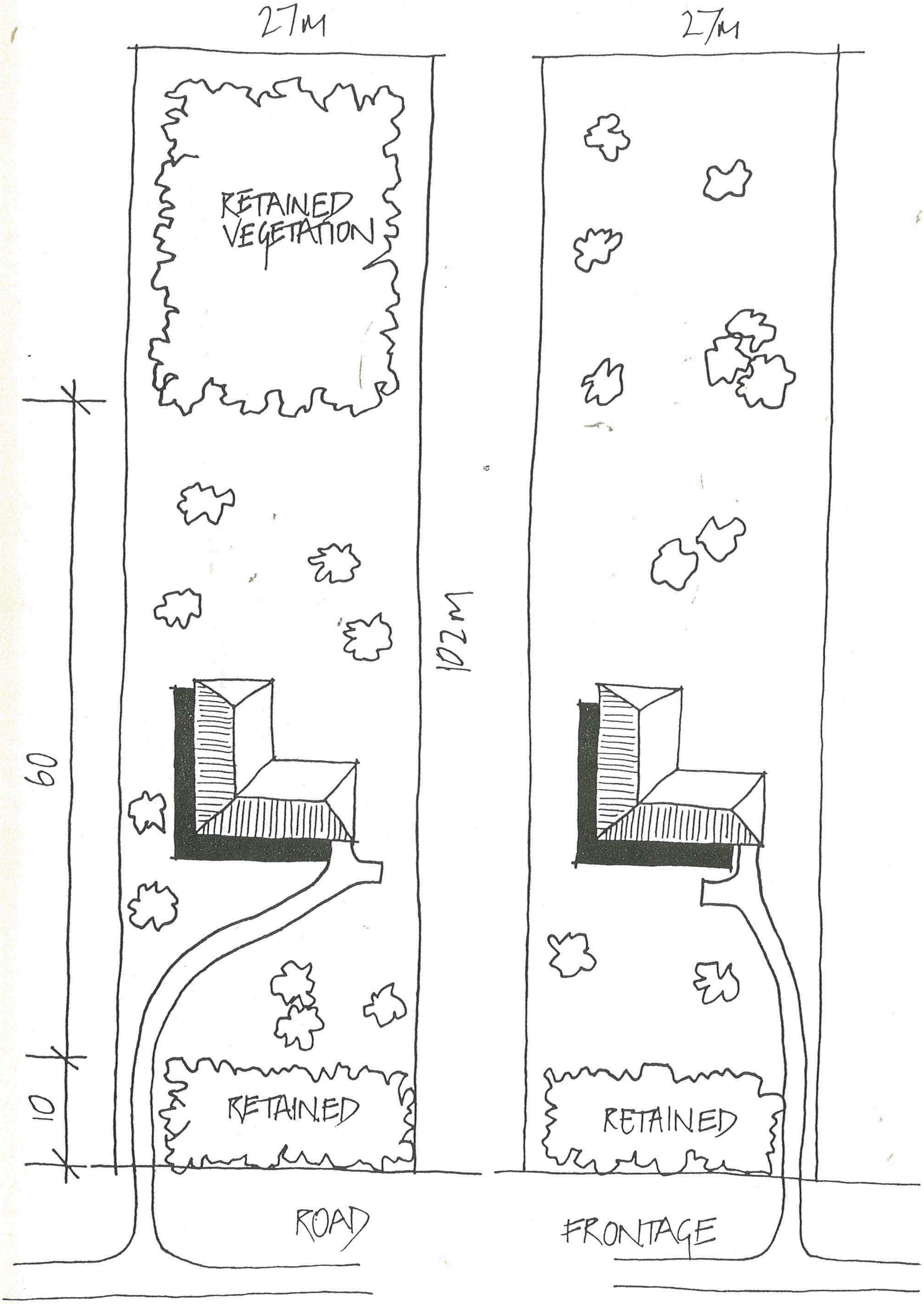
- not result in undesirable impacts on downstream ecosystems or elsewhere in the pond
- enhance the visual impact of the pond.

(m) Trees and other plants near the water's edge should include water-tolerant species, such as Melaleucas, Casuarinas, etc. Deciduous exotic species are not desirable because of the high oxygen demand that leaf fall might impose on the pond. Generally, planting of trees on embankments is not recommended.

(n) To minimise mosquito problems, limit expanses of water with more than 50 per cent shading and ensure no sections of water become isolated from the main body.

(o) Islands are highly beneficial as wildlife refuges, especially for birds. Their design should consider the effects on changes in water tables.

(p) Stock ponds with selected native fish to improve the water quality (not for sport), especially species which will control mosquito larvae and select zooplankton in preference to phytoplankton. Avoid use of fish which are bottom feeders.



LEVEL 1:
MINIMAL DEVELOPMENT

LEVEL 2:
EXTENSIVE DEVELOPMENT

SKETCH LAYOUT ONLY 1:500

4.3 Ausqual Modelling

The impact of the development on water quality has been assessed by using the *Australian Water Quality Management Tool* - ***Ausqual*** using Mode 1 - Gross Annual Model.

The catchment area was split into 2 catchments for modelling purposes - the east and west developments and the modelling carried out on a average annual basis.

Table 3 lists indicative values for continuous proportional runoff loss coefficients and percent impervious values of urban land uses.

Table 3
Rational method runoff coefficients for different land-use zonings

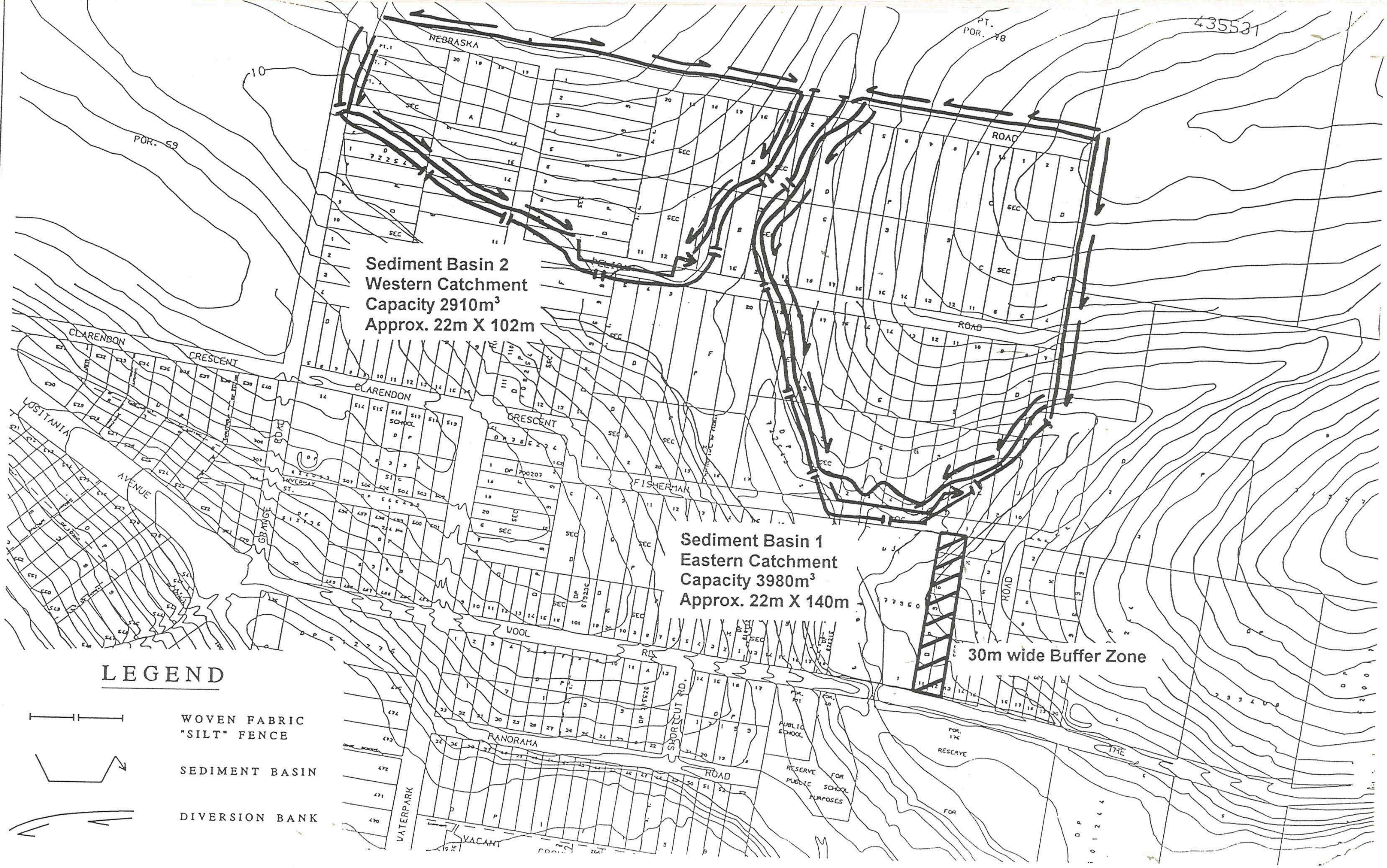
Land Use Zoning	Coefficient pervious	Coefficient impervious	Per cent impervious
Natural Forest	0.10	0.90	5
Open Space	0.20	0.80	5
Residential	0.25	0.85	45
Medium Density	0.30	0.80	70
Commercial	0.35	0.85	80
Industrial	0.40	0.85	80

The **coefficients pervious** and **impervious** have been adapted from Australian Rainfall & Runoff 1987 (ARR 1987). The **Per cent Impervious** has been adopted from ARR 1987.

The water quality component of AUSQUAL is based on assigning export coefficients for unit area loadings of nominated diffuse pollutant loadings. **Table 4** lists the export coefficients for various urban land uses.

Table 4
Export coefficients for various urban land uses

Land Use	Suspended Solids mg/L	Total Nitrogen mg/L	Total Phosphorus mg/L	Faecal Coliforms /100mL
Natural Forest	50	0.60	0.09	1 000
Residential	80	1.00	0.14	3 000
Medium Density	120	1.50	0.21	3 500
Commercial	200	2.00	0.28	1 500
Industrial	200	2.00	0.28	1 500



MORSE McVEY AND ASSOCIATES Pty Ltd

SOIL & WATER MANAGEMENT PLAN
NEBRASKA ESTATE DP 9699
ST GEORGES BASIN

SCALE: 1:~~4000~~
DATE: November 1994
DRAWN: A. Ball
DESIGNED: G. McVey
PLAN No: 14522-01

NORTH

Table 4b
Export coefficients for various rural land-uses

Land Use	Suspended Solids mg/L	Total Nitrogen mg/L	Total Phosphorus mg/L
Rural Residential	100	1.0	0.15
Natural Forest	5	0.5	0.04
Improved Pasture	10	0.6	0.10
Unimproved Pasture	8	0.5	0.08
Cultivated Land	20	5.0	1.20

The results of the AUSQUAL modelling are shown at APPENDIX VII and are summarised in Table 5.

Table 5
Summary of average annual pollutant loads

Catchment	Average Annual Runoff ML	Average Annual Export			
		Suspended Solids mg/L	Total Nitrogen mg/L	Total Phosphorus mg/L	Faecal Coliforms /100mL
Western Status Quo	23	119	11.9	1	11.9
Western Minimum Development	48	3470	45.4	6.6	131.5
Western Extensive De-velopment	51	3930	50	7.4	148
Eastern Status Quo	33	427	18.2	1.7	25.2
Eastern Minimal Development	62	4510	59.1	8.6	171
Eastern Extensive Development	67	5110	65.1	9.7	192.4

The modelling shows that the urbanisation of the proposed area will significantly increase the pollutants in the drainage network. The existing wet sclerophyll forest is an excellent

The modelling was carried out for two levels of development that allows:

- minimal development of each lot; or
- extensive development of each lot.

The two levels of development are shown at **Figure 4**.

The modelling shows that any residential development increases the pollution export loads significantly and that the difference between the proposed minimal development and extensive development is minor.

Natural buffer zones play an important role in the maintenance of water quality and the area of the proposed buffer zones at the rear of the block should be increased to provide an adequate contiguous buffer zone. This may be done by retaining all vegetation at the rear of blocks for a depth of about 30 metres to provide a contiguous buffer zone. The area should be fenced from normal rural residential activities and be retained in its current state with no clearing on the fence lines.

The existing drainage line and watercourse is an effective pollution reduction system. and should not be disturbed for development. The catchment areas of the study area are small in relation to the total catchment of the system and pollution control devices should be located offline in relation to the major drainage network. The development of the site should aim at maintaining the existing drainage system.

4.3.1 Sediment Retention Basins

During the construction phase the water quality control pond may be used for sediment detention. Effective sediment detention may be provided by the construction of site specific works that separate treatment of the site into two distinct pieces - east and west of the watercourse.

The basin capacities are based on storing the whole of the 5 year ARI, time of concentration storm event (NSW Department of Housing, *Soil and Water Management for Urban Development*).

The required capacities of sediment detention basins are:

- 2 910 cubic metres for the western catchment; and
- 3 980 cubic metres for the eastern catchment .

The sediment detention basins will capture the whole of the storm event and will require chemical treatment (flocculation) prior to discharge to the watercourse.

4.3.2 Constructed Wetlands

Permanent Pool

The capacity of the permanent pool is based on the following:

- 1 150mm average annual rainfall for St. Georges Basin;
- catchment area of 10 and 13 hectares for the western and eastern development areas respectively;
- volumetric runoff coefficients of 20% to 45%;
- sedimentation allowance of 20% of permanent pool;
- reduction of 80% in retention of Total Phosphorus.

This gives a permanent pool capacity of:

- 5 740 cubic metres for the western catchment; and
- 7 460 cubic metres for the eastern catchment .

Surcharge Pool

The capacity of the surcharge pool is based on storing the first 10mm of runoff from the catchment. The required capacity of the surcharge pool is:

- 1 000 cubic metres for the western catchment; and
- 1 300 cubic metres for the eastern catchment .

Total Pond Capacity

The total capacity of the water pollution control pond is:

Capacity = permanent pool + surcharge pool + 20 % for sediment detention.

Total Pond Capacity is:

- 6 740 cubic metres for the western catchment; and
- 8 760 cubic metres for the eastern catchment .

The pond capacities are adequate for the promotion of an efficient artificial wetland. An investigation was carried out into providing a number of smaller basins for water quality control. Due to site constraints due to drainage lines and ownership the two sites chosen are the most practical and efficient to provide the required pollution control.

Effect on Pollution

The proposed artificial wetlands have been designed to reduce phosphorus nutrient loads by 80% following urban development. The net effect of the development when lands are fully urbanised and wetlands are operation is no increase in nutrient pollution to St. Georges Basin.

The typical wetland shape and structure are shown at **Figure 6.**

To construct a basin of this volume with an average depth of 2.5 metres a surface area of 3 500 square metres is required.

Some lots 1, 3, 5, 7, 9 and 11-15 on the western side of Park Drive do not drain into the proposed wetlands. The lots must retain a buffer zone on the downslope side of the lots to provide a filter system for runoff from possible future development. A buffer zone 50 metres wide will provide a filter for nutrient pollution from urban runoff. The buffer zone should be fenced and excluded from normal residential activities. These lots have been included in the calculation for the western constructed wetland and should be rated in the cost for that work.

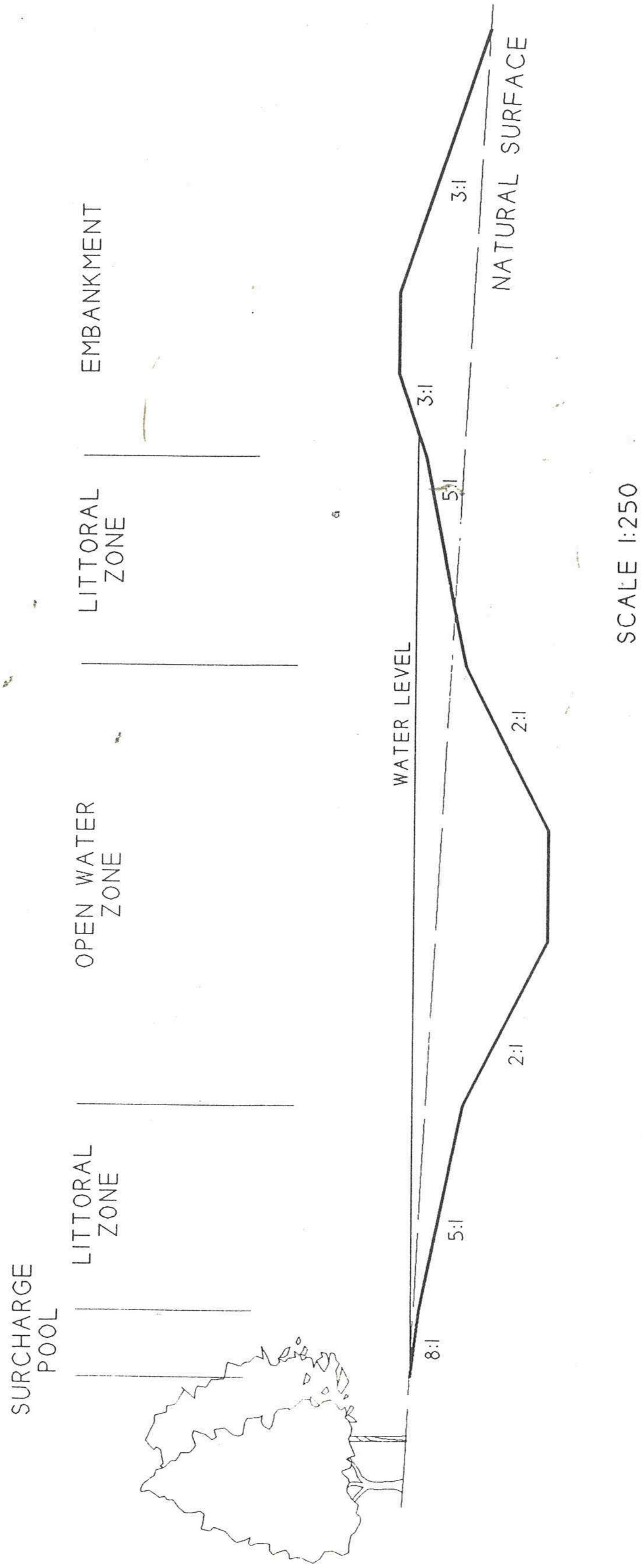


Figure 6 **Typical Wetland Structure**

5 Estimated Costs

5.1 Structural Work

The estimated costs of the work is shown in Table 7.

Table 7 Estimated Costs

ITEM	EASTERN CATCHMENT	WESTERN CATCHMENT
Sediment Basin	$10 800	$14 000
Artificial Wetland	$34 560	$27 960
Diversion Banks	$12 870	$15 210

The estimated costs do not include fencing the buffer zones or the constructed wetlands.

5.2 Maintenance Costs

The annual maintenance costs of the constructed wetlands is estimated to be:

- western catchment $1 165; and
- eastern catchment $1 440.

5.3 Section 94 Contribution

All lots in the study area should contribute to the cost of development of the pollution control works and to the annual maintenance costs.

Lots 1, 3, 5, 7, 9 and 11-15 DP 9699, on the western side of Park Drive do not drain into the proposed wetlands. These lots have been included in the calculation for the western constructed wetland and should be rated in the capital and recurrent cost for that work.

6 Recommendations

(a) *General*

(i) The soils are *Type F* (fine) in texture. Any sediment retarding basins used during the construction phase to contain sediment will be "wet" basins designed for total storm capture.

(ii) A flocculating agent be used to increase the settling rate of clays and fine silts (< 0.005 mm) within any sediment retarding basins constructed. This would ensure that the export of pollutants, a large proportion of which attach themselves to the colloidal fraction, is prevented.

The following recommendations are made:

- Type F (fine) sediment basins be constructed;
- sediment control basins be located off the watercourse;
- water pollution control ponds be located off the water course;
- trunk drainage should maintain the existing natural waterway;
- contiguous buffer zone be located at the rear of the blocks;
- catch drain be located at the downstream side of the development to direct storm water to the pollution control ponds.

(b) *Tomerong Creek Soil Landscape (Class 3 lands)*

(i) The moderate constraint of the presence of USCS class CL-OL (Tomerong Creek Soil Landscape) requires the use of specialised engineering techniques. The constraints imposed by its engineering characteristics include:

- unsuitability for water retaining embankments
- poor performance in other embankments
- poor performance as fill
- poor performance as road subgrade
- potential to shrink/swell in housing foundations
- poor slope stability and need for shoring in trenches
- unsuitability as unformed roads and tracks.

(ii) Tomerong Creek Soil Landscape also has the moderate constraint of high soil erodibility (a *K*-factor in excess of 0.045). Disturbance of existing ground cover should be minimised along the creek lines or flood prone areas (see figure 2), and unnecessary access during the construction phase should be prevented through the use of barrier fencing. Implementation of sediment control measures such as "silt" fencing should also occur in these areas, although 30 to 50 percent of soil particles will pass through "silt" fences at this site due to the large clay and silt fractions present (Appendix 3).

7 Bibliography

Brunker, R.L. and Rose, G. 1967. Sydney Basin, 1:500 000 Geological Sheet. Geological Survey of New South Wales.

Department of Housing (1993). *Soil & Water Management for Urban Development* (second edition). Department of Housing, Sydney.

Gloster, A. (1988). *The recent sediments of St. Georges Basin and the catchment area geology.* BSc(Hons) thesis. University of New South Wales. Unpublished.

Goldman, S.J., Jackson, K. and Bursztynsky, T.A. (1986). *Erosion and Sediment Control Handbook*, McGraw-Hill, New York.

Hannam, I.D. and Hicks, R.W. (1980). "Soil Conservation and Urban Land Use Planning", *Journal of the Soil Conservation Service of N.S.W.*, 36: 134-145.

Morse McVey and Associates (1991). *Land Capability Study and Soil and Water Management Plan for lands at St. Georges Basin*, unpublished, July 1991.

Rosewell, C.J. and Turner, L.B. (1992). "Rainfall Erosivity in New South Wales", *CaLM Technical Report No. 20*. Department of Conservation and Land Management, Sydney.

Rosewell, C.J. and Edwards, K. (1988). *SOILOSS - A program to assist in the selection of Management Practices to Reduce Erosion.* Soil Conservation Service Technical Handbook No. 11. Department of Conservation and Land Management, Sydney.

The Institution of Engineers, Australia. (1987) *Australian Rainfall and Runoff.* Volume 1 and Volume 2.

Wishchmeier, W.H. and Smith, D.D. (1978). *Predicting Rainfall Erosion Losses - A Guide to Conservation Planning*, United States Department of Agriculture, Agriculture Handbook No. 537. United States Government Printing Office, Washington DC, USA.