SEEC

Water Cycle Management Study

for proposed 10-Lot subdivision of Lot 101 DP 1087389, Millingandi Road, Millingandi.

Prepared by:

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SEEC Reference 09000242-WCMS-02

9 June, 2010

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Document Certification

This report has been developed based on agreed requirements as understood by SEEC at the time of investigation. It applies only to a specific task on the nominated lands. Other interpretations should not be made, including changes in scale or application to other projects.

Any recommendations contained in this report are based on an honest appraisal of the opportunities and constraints that existed at the site at the time of investigation, subject to the limited scope and resources available. Within the confines of the above statements and to the best of my knowledge, this report does not contain any incomplete or misleading information.

Mark Passfield
SEEC

9 June 2010

Executive Summary

It is proposed to develop 13 Millingandi Road into ten new rural residential lots. This Water Cycle Management Plan shows how wastewater and stormwater will be managed to ensure there is no appreciable (or measurable) effect on the water quality leaving the site and, therefore, the requirements of SEPP62 Clause 15D (NSW Oyster Industry Sustainable Aquaculture Strategy) are met.

The study addresses various issues of submissions submitted by the NSW Department of Planning (DOP) in two letters referenced 06_0032 File number 9041722 and dated 7th September and 15th September 2009.

In particular this report addresses:

(i) Items 2 (a) (b) and (d) in DOP letter dated 15th September 2009 and the referenced appendices.

(ii) Items 3 and 4 in DOP letter dated 15th September 2009 and the referenced appendices.

In summary:

- Onsite wastewater will be managed by providing a suitably sized effluent management area (EMA) on each lot in which pathogens, viruses, nitrogen and phosphorous will be contained. Those EMAs are designed according to Bega Valley Shire Council's (BVSC) DCP 5 and will be located at least 40 m from the banks of a watercourse that dissects the site.
- Water Sensitive Design will be incorporated to:
  - (a) infiltrate and treat stormwater runoff from road surfaces; and
  - (b) re-use rainwater from rainwater tanks
- A wide riparian zone will be fenced and planted with native species endemic to the area.

MUSIC modelling shows that there will be a reduction in suspended solids and phosphorous and a neutral effect on nitrogen. The modelling incorporates modelling guidelines prepared by the Sydney Catchment Authority, as they represent the latest NSW-specific recommendations and provide a conservative approach. It is appreciated that the site is not an area administered by the SCA but we (and SCA) believe there is no reason why much of their work cannot be adopted elsewhere in NSW.

This study shows:

- how the development can proceed while having a neutral or beneficial effect (NorBE) on the water quality leaving the site, both surface water and groundwater.
- how each new home will have a sustainable water supply.
- how each new home will sustainably manage its own wastewater.

- how soil and water will be managed during construction of the new roads; and
- what riparian re-vegetation will be reinstated in the core riparian zone.

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1 Introduction

SEEC have been commissioned by Mr Neil Clements to provide this *Water Cycle Management Study* (WCMS). It is required to accompany an application to subdivide Lot 101 DP1087389 Millingandi Road, Millingandi (“the site” Figure 1) into ten new rural residential lots as shown on the layout plan in Figure 2, prepared by RW Surveying (reference 0835 A.3). It includes:

(i) a discussion on appropriate onsite wastewater management for the new lots;

(ii) an investigation into the existing stormwater cycle;

(iii) an assessment of how the proposed development will affect the stormwater cycle;

(iv) a plan for managing the stormwater cycle to achieve a neutral or beneficial effect on the quality of stormwater leaving the site.

The site is in the Merimbula Lake Catchment. SEEC staff inspected the site on 30th November and 1st December 2009. At that time the weather was cool and dry.

Figure 1 – Site Location. Princes Hwy to right.

2 The Proposed Development

The proposed development involves subdividing the site into ten rural residential lots of between 1.593 ha and 0.585 ha (Figure 2). To provide access to those lots there will be:

(i) a new public road approximately 250 m long and comprising a 6 m wide sealed carriageway in a 20 m easement;

(ii) Three new rights of way (ROW), totalling approximately 300 m and comprising a 3 m wide sealed carriageway with gravel shoulders in 15 m wide easements. One of these crosses an intermittent watercourse; and

(iii) short driveways to each home.

Although not included as part of this DA we have assumed a new house will be constructed on all new vacant lots. The existing house and an existing large steel shed will remain on proposed Lot 1. Another existing steel shed will remain on Lot 7.

PLAN OF PROPOSED SUBDIVISION

LOT 101 DP 1087389
MILLINGANDI ROAD, MILLINGANDI

—— E —— E ——	ELECTRICITY LINES
— — T — — T — —	TELSTRA CABLES
(grey box)	PROPOSED BUILDING ENVELOPE MAINTAINING 20 METRE SETBACK FROM LOT BOUNDARIES & 15 METRE SETBACK FROM VEGETATED BUFFER
*	PROPOSED EASEMENT FOR RIGHT OF ACCESS 7.50 METRES WIDE
—o—o—o—o—	EFFLUENT BUFFER (AS PER SEEC PLAN)
—··—··—··—	VEGETATED BUFFER (AS PER SEEC PLAN)
═══	CORE RIPARIAN ZONE (AS PER SEEC PLAN)

NOTES

NO SURVEY HAS BEEN MADE OF THE BOUNDARIES.

THE BOUNDARIES HAVE NOT BEEN MARKED.

AREAS AND DIMENSIONS ARE SUBJECT TO SURVEY.

NO INVESTIGATION OF UNDERGROUND SERVICES HAS BEEN MADE. ALL RELEVANT AUTHORITIES SHOULD BE NOTIFIED PRIOR TO ANY EXCAVATION ON OR NEAR THE SITE.

STRUCTURES AND FEATURES SHOWN ON THIS PLAN ARE REPRESENTED AS INDICATIVE ONLY AND HAVE NOT BEEN LOCATED OR SHOWN FOR DESIGN OR CONSTRUCTION PURPOSES.

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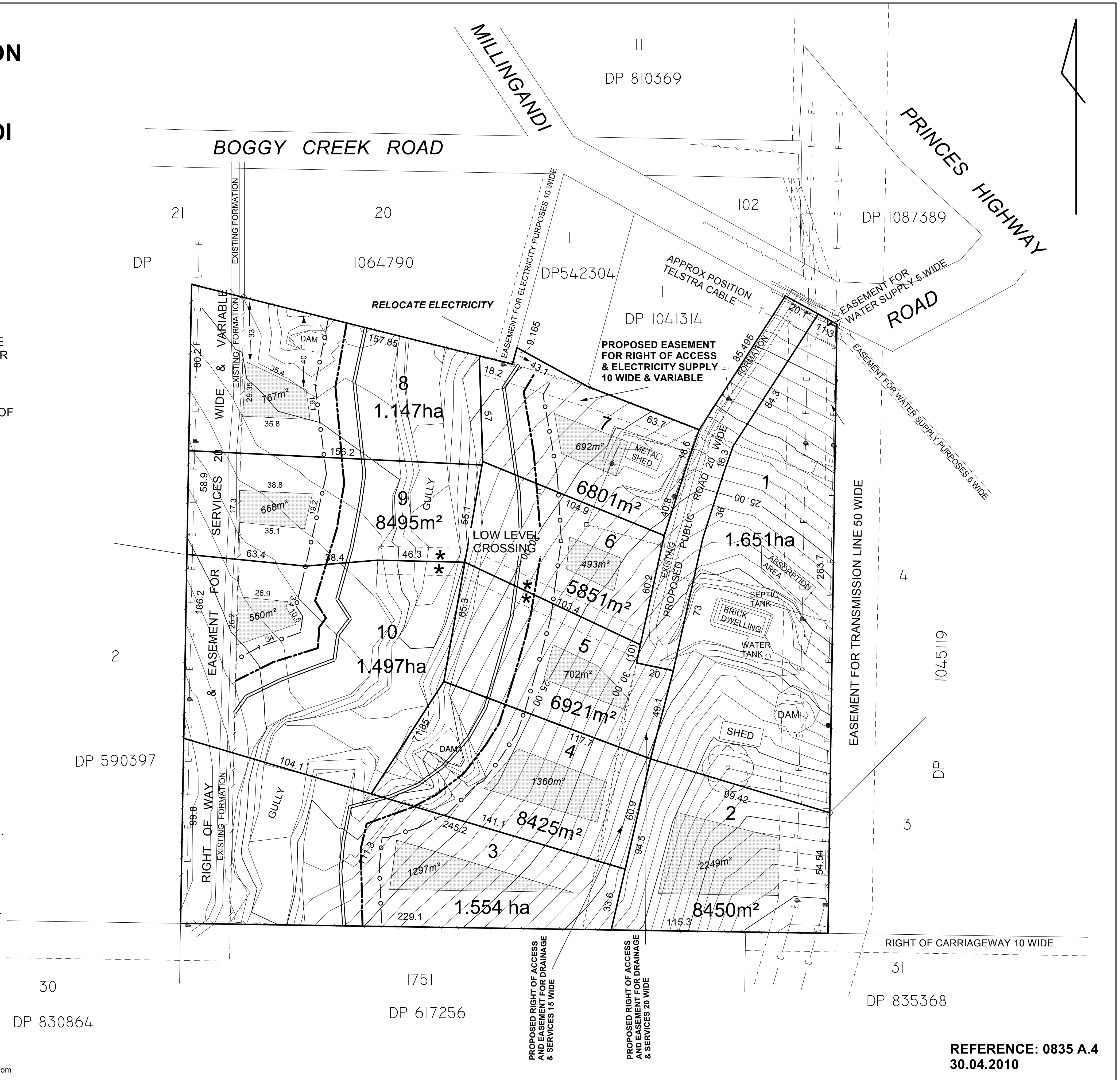

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3 General Site Description

Lot 101 occupies an area of 10.77 ha. It is a battle-axe block with a single access to Millingandi Road. At the time of inspection it was occupied by:

- a brick home with a roof area of about 300 m^2
- two steel sheds, each with a roof area of about 280 m^2
- two unformed driveways both about 3 m wide and totalling about 600 m long;
- about 1,000 m^2 of sealed hardstand near the house.

The remainder of the site is cleared (save a few remnant eucalypts) and used for cattle and goat grazing (Figure 3).

Figure 3 – Typical Conditions across the site looking SE.

4 General Topographic Conditions

The site is dissected by an intermittent watercourse which was not flowing when inspected. The watercourse divides the site into two areas:

(i) The east, which is formed on a side slope of mostly 10 percent gradient but locally up to 20 percent (on proposed Lot 2); and

(ii) The west, which is formed on a much gentler slope of about 5 percent.

The site elevation varies from about 50 m AHD in the far southeast to about 15 m AHD in the far north. Being cleared, all the proposed lots have good exposure to sun and wind.

5 Surface and Subsurface Hydrology

The predominant drainage feature is the intermittent watercourse that dissects the site. It flows north through adjoining land to a 350 mm piped culvert under Boggy Creek Road. That pipe is likely to partially clog in moderate rainfall events and the flow would over-top Boggy Creek Road, pond on the other side, and then turn east and flow over Millingandi Road.

The watercourse upstream of Boggy Creek Road has a catchment of about 60 ha, mostly undeveloped. Storm flows and flood levels in the watercourse are shown in SEEC Drawing 09000242-FS01. All floods including the probable maximum flood are predicted to be constrained in the channel and so there is no flood-affected land outside of the channel confines.

The channel itself is unusually wide for such a small catchment. Most likely this is because flash-floods meander through its base, rather than being confined in a distinct bed. This means that the recommended 40 m buffer from any effluent management area (EMA) must be taken from the top of the banks, not the centre of the channel.

Other drainage features are:

- Three small (<0.2 ML) farm dams; and
- A piped outlet approximately on the boundary of proposed Lots 8 and 9 that drains flow from upslope of the unformed road along the western boundary. This flow enters the existing small farm dam on Proposed Lot 8.

As part of SEEC's site investigation five tests pits were dug to about 2,000 mm. None of the test pits had free groundwater or wet soils. Groundwater was not noted in a previous soil survey done by C D Watts and Associates, 2005, who achieved similar investigation depths. The watercourse channel is about 3 m deep and there were no signs of seepage when it was inspected. This suggests that the watertable is deeper than 3 m at this site and so a detailed groundwater study is unwarranted.

According to NRATLAS the closest bore is located in a property to the west (about 750 m) (GR -36.888333S 149.859444E). It is licensed as GW064566. There are no bores closer than this from which to draw meaningful information.

6 Soils and Geology

6.1 Mapping

Soil Landscape mapping for this area was conducted by M. Tulau (1997), Department of Natural Resources (DNR, now part of the Department of Environment, Climate Change and Water DECCW). It shows that Lot 101 lies on two soil landscapes (Figure 4):

(i) The Yellow Pinch Soil Landscape – mapped over most of the site extending from the south; and

(ii) The Yellow Pinch Variant A soil landscape – mapped over the northern part of the site.

The Yellow Pinch soil landscape mainly consists of sandy loam topsoil over sandy clay loam or sandy clay subsoil. It is derived on sediments ranging from siltstone to conglomerate and so the soil profiles can be variable.

Much of the Yellow Pinch soil landscape occurs on steep slopes (up to 35 percent) but here slopes are mostly less than 10 percent (although on Lot 2 they are 20 percent). Therefore, we consider that the most of this site is actually on the Yellow Pinch Variant A soil landscape which has similar soils to the Yellow Pinch soil landscape but is characterised by gentler slopes.

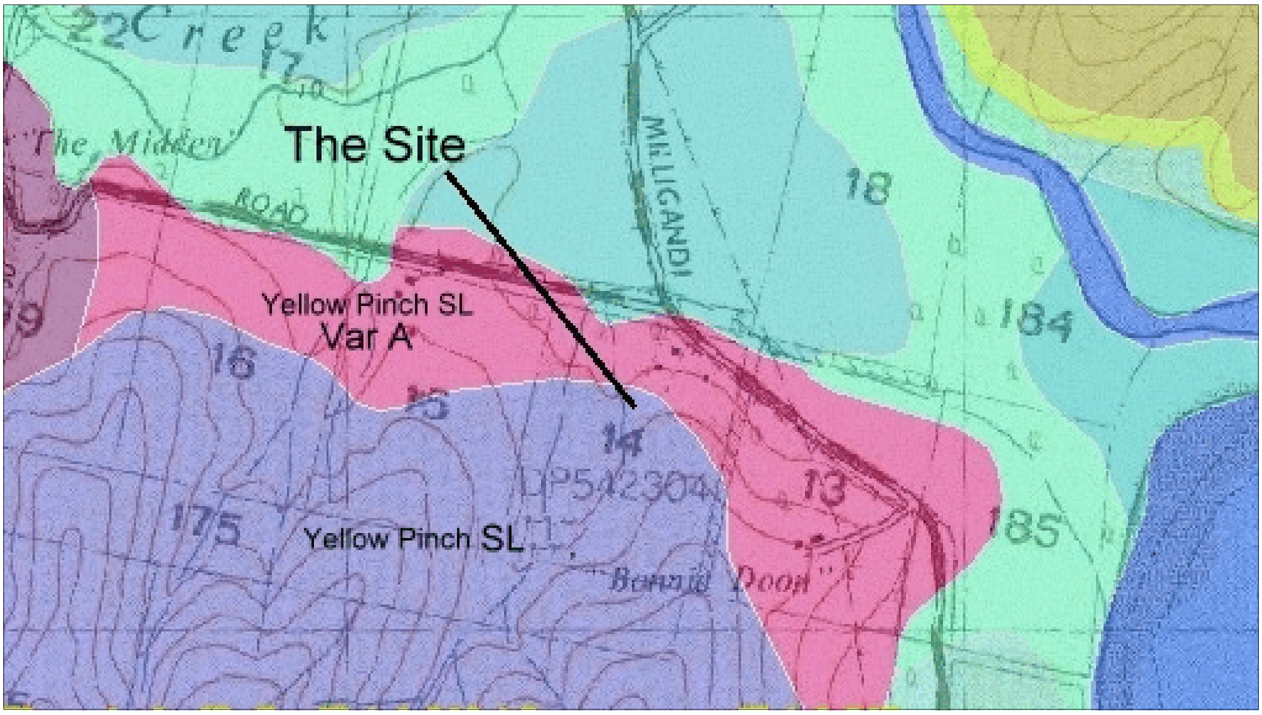

Figure 4 – Soil landscape mapping

Tulau (1997) identifies the following widespread soil landscape limitations:

- Generally extremely or very strongly acidic soils
- Generally hard setting soils
- Generally low water holding capacity
- Generally low fertility
- Generally high aluminum toxicity potential
- Generally water repellant.

6.2 Site Specific Soil Investigation

Soils were initially investigated by C D Watts and Associates (2005). However, as part of our investigation, we have described soil profiles in five new test pits dug by backhoe approximately where shown in drawing 09000242-WCMP01. Two of these test pits were dug east of the watercourse (one on a 20 percent slope and one on a 10 percent slope) and three test pits were dug west of the watercourse.

The soil profiles are described below. In particular they are described in a manner according to DLG (1998) and AS/NZS1547:2000. Soil samples were taken for laboratory analysis of a suite of effluent management-related chemical parameters as required by DLG 1998) (Section 12.4)

6.2.1 Profile Descriptions

The soil profiles differ significantly east and west of the watercourse.

East of the watercourse the soil profile is typically residual, with occasionally some colluvial influence:

TP1 and TP2

0 - 300 mm	Light grey sandy loam. Massive. 10 percent coarse fragments where slope less than 15 percent. Up to 20 percent coarse fragments (colluvial influence) where slope 15 - 20 percent (Lot 2). *(yp1)* [1]
300 - (1000 -1200) mm	Mottled orange and brown medium clay, strongly pedal, <5% coarse fragments. *(yp6)*
(1000-1200) - 1900 mm	Light grey, mottled orange brown, light to medium silty clay, moderately to strongly pedal. Remnant shale structure. *(Yp6)*
1900 mm+	Extremely weathered shale.

1 Soil material - Tulau 1997.

West of the watercourse the surface soils are alluvial gravels and sands that overlie residual soil at depth. The alluvial nature is attributed to the watercourse, with flash-floods having brought material down from steep, erodible lands south of this site.

TP3 (Lots 8/9)

0 - 500 mm	Light grey sandy loam . Massive. 40-50% coarse fragments including cobbles. Alluvial.
500 - 1000 mm	Light brown mottled orange strongly pedal sandy light clay, <10% coarse fragments. Residual. *(Yp6)*
1000 - 1700 mm	Grey mottled orange brown strongly pedal sandy light clay. Remnant shale structure. Residual. *(Yp6)*

TP4 (Lot 10)

0 - 300 mm	Light grey sandy loam. Massive. 10% coarse fragments including cobbles. Alluvial.
300 - 1800 mm+	Brown, slightly cemented, clayey sand to sandy clay loam. Moderately pedal. Common rounded quartz pebbles. Alluvial.

TP5 (Lots 9/10)

0 -400 mm	Light grey sandy loam. Massive. 40-50% coarse fragments including cobbles. Alluvial.
400 - 1900 mm	Brown sandy loam. Massive. 40-50% coarse fragments including cobbles. Alluvial.
1900 mm+	Grey mottled orange brown strongly pedal sandy light clay. Remnant shale structure. Residual. *(Yp6)*

Gravel-rich soils were also exposed in a bank of the watercourse on Lot 10 (Figure 5).

Figure 5 – Soil exposure on Lot 10. Light grey sandy loam over gravelly sandy clay loam subsoil (inferred alluvial). This exposure is about 2 m deep.

6.2.2 *Soil Depth*

The soil depth is greater than one metre in all test pits, *minor limitation* [2].

6.2.3 *Soil Moisture*

Light grey mottling from about 1,000 mm east of the watercourse suggests that soils are often wet beyond that depth there. Drainage appears deeper on the coarse alluvial soils west of the watercourse. A seasonally high watertable at 1,000 mm+ is a *Minor limitation*.

6.2.4 *Coarse Fragments*

Coarse fragments vary across the site and vertically in the soil profiles. East of the watercourse there are some colluvial cobbles in the near surface soils on steeper land (20 percent) on Lot 2. However, there are generally less than 10 percent coarse fragments throughout the soil profile this side of the watercourse (*Minor limitation, moderate limitation on Lot 2*).

West of the watercourse there can be over 40 percent coarse fragments in the near-surface soil, and some of them are cobble-sized. This poses a *moderate limitation* to effluent management as:

- the soils' permeability is relatively high (Section 6.2.5);

2 The "limitation" refers to the classifications given in DLG (1998).

- the soil's ability to sorb phosphorous is low (Section 6.2.6); and
- the soil's fertility is low (although grass growth was reasonable when inspected).

The implications of these limitations are discussed in Section 12.4.

6.2.5 Permeability

Soil permeability was not directly measured by SEEC but it can be inferred from the soil texture. AS/NZS1547 (2000) suggests that:

- the near surface soils across the whole site (sandy loam) will have a K_{sat} of approx 1.4 - 3 m/day m/day.
- the subsoils (medium clay) will have an indicative permeability of 0.06 - 0.5 m/day.

The permeability of the near-surface soils was measured by C D Watts (2005) who used the falling head method. CD Watts (2005) showed that the near-surface soils east of the watercourse have a typical permeability of 72 mm/hour (1.7 m/day). This compares favourably to the estimate given by textural inference above. West of the watercourse C D Watts showed the permeability is less, at 30 mm/hour (0.72 m/day). This is similar to the permeability of a massive loam, despite the high gravel content. It is probably a function of the dense nature of the soils and their slight cementation.

Based on these results the soil permeability is Class 2b (DLG, 1998) and so the measured and inferred permeability of the near-surface soils poses a *moderate limitation* to effluent management.

6.2.6 Laboratory Testing

Soils from TP 1, TP 3 and TP 4 were sent to NSW Department of Lands' Scone Research Laboratories for chemical testing. The soils were tested for a full suite of effluent-related parameters. The results are given in Table 1 and are discussed below.

Table 1 - Soil test results (Dept. Lands)

Lab No	Method	C1A/4	C2A/3	C5A/3 CEC & exchangeable cations (me/100g)						C8B/1		P9B/2	
	Sample Id	EC (dS/m)	pH	CEC	Na	K	Ca	Mg	Al	P sorp (mg/kg)	P sorp index	EAT	Texture
1	09000242 TP4 700	nt	nt	nt	nt	nt	nt	nt	nt	278	2.4	nt	nt
2	09000242 TP1 200	0.03	5.2	4.6	0.1	0.3	1.4	0.8	<0.1	295	2.5	3(1)	sandy loam
3	09000242 TP1 500	0.02	5.0	10.0	0.3	0.2	0.5	1.9	4.3	750	5.4	6	light clay
4	09000242 TP4 200	0.03	5.0	9.5	0.2	0.4	2.5	1.5	<0.1	245	2.2	8/3(1)	light sandy clay loam
5	09000242 TP3 700	0.03	5.7	11.4	0.9	0.2	0.4	4.4	0.3	391	2.9	2(1)	clay loam

nt = not tested

(i) pH

pH is a measure of the alkalinity or acidity of a soil and influences nutrient availability. The measured pH was 5.0 to 5.2. Soils are, therefore, considered strongly acidic (*Moderate limitation)*.

(ii) Electrical Conductivity

All tested soils had an electrical conductivity less than 0.05 dS/m. Soils at this site are non saline (*Minor limitation*).

(iii) Dispersibility

An Emerson Aggregate Test (EAT) is a subjective test used to assess the potential for soils to disperse. Topsoils were found to have class 3(1) (*Minor limitation).* Subsoils were 2(1) and 6 *(Moderate limitation)*.

(iv) Cation Exchange Capacity (C.E.C)

The C.E.C is the capacity of the soil to hold and exchange cations. It is a major controlling agent for soil structural stability and the ability of a soil to sorb nutrients and pollutants. The topsoil CEC was measured at 4.6 and 9.5 (very low and low). The subsoils' CEC was 10 and 11.4 (low, bordering moderate) *(Moderate Limitation).*

(v) Phosphorus sorption (P-Sorption)

A soil's capacity for sorbing (fixing) phosphorus is related to its texture and clay mineralogy. Generally, as clay content increases so does the P-sorption ability. Conversely, as the volume of coarse fragments increases the P-sorption decreases (as the fragments would not readily sorb phosphorous).

The soil profiles are distinctly different east and west of the watercourse and so two insitu P-Sorb calculations have been done:

EAST - here the soil profile is generally:

- 250 mm of sandy loam topsoil with 10 percent coarse fragments, an assumed bulk density of 1,500 kg/m^3 and a measured P-sorb of 295 mg/kg; over
- residual clay with no coarse fragments, an assumed bulk density of 1,500 kg/m^3 and a measured, mean, P-Sorb of 570 mg/kg.

Assuming that only the top 1,000 mm of soil contributes to P-sorption (DLG, 1998) this equates to a potential P-sorption of 8,700 kg/ha *(minor limitation)*. However, the *insitu* P-sorption capacity of the soil is taken as 35% of the potential value (on the assumption that not all soil particles will be in contact with the percolated effluent). Therefore, the *insitu* P-sorption east of the watercourse is taken as 3,000 kg/ha.

WEST - here the soil profile is taken as (worst case, TP4):

– 1,900 mm of gravelly sandy loam to clay loam with 40 percent coarse fragments, an assumed bulk density of 1,500 kg/m^3 and a measured P-sorb of 245 mg/kg.

Assuming that only the top 1,000 mm of soil contributes to P-sorption this equates to a potential P-sorption of 2,200 kg/ha *(moderate bordering major limitation)*. However, the *insitu* P-sorption capacity of the soil is taken as 35% of the potential value (on the assumption that not all soil particles will be in contact with the percolated effluent). Therefore, the *insitu* P-sorption east of the watercourse is taken as 770 kg/ha.

(vi) Exchangeable Sodium Percentage

ESP refers to the level of exchangeable sodium cations in the soil. It relates to likely dispersion on wetting and to shrink/swell properties. For most samples the ESP was measured below 6 and so the soils are non-sodic. However, the ESP for the subsoil in TP3 was 8, which is sodic. (*Generally minor limitation, potentially moderate).*

(vii) Erodibility - K-Factor

Soils were not tested for K-Factor but Tulau, 1997 gives values ranging from 0.025 (topsoil) to 0.045 (subsoil), which is high.

6.2.7 Salinity

Observations by SEEC staff did not identify any surface indications of salinity at this site. Tulau (1997) does not identify the soils to be prone to salinity.

6.2.8 Acid Sulfate Soils

The site is elevated at more than 15 m AHD and so acid sulfate soils will not be present.

6.3 Soils Summary

The top 1 m of the soil profile differs east and west of the watercourse. West of the watercourse the near-surface soils pose *Moderate* limitations to effluent management. Here they are permeable (Class 2b, DLG (1998)), infertile, acidic, often coarse grained, have low CEC and a low ability to sorb phosphorous. East of the watercourse, although the topsoils have similar constraints, the subsoils are better suited to effluent management.

Because of these limitations disposal of primary treated effluent is not recommended on any lot and a minimum secondary level of treatment is required. Wastewater management is addressed in more detail in Section 12.4.

The rooting depth was noted at about 0.5 m, typical of pasture grass. This is required in Section 13.2 for calibrating the pervious area fractions in MUSIC.

7 Climate and Erosion Potential

Merimbula/Pambula has a temperate coastal climate, with warm summers and temperatures below 15°C in winter. Mean annual rainfall at nearby Pambula is 854 mm (Australian Bureau of Meteorology). Rainfall is highest through summer. The 70th percentile rainfall figures are higher than the mean pan evaporation values for five months of the year.

Bega Council's DCP5 requires that onsite wastewater systems are hydraulically designed using 70th percentile rainfall data. This data for Pambula was provided by BOM and is given here in Table 2, together with the mean monthly evaporation also provided by BOM (by calculation - there is no evaporation station nearby).

Table 2 - 70th Percentile rainfall and mean pan evaporation data for Pambula PO [3].

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annu
70th Percentile Rainfall (mm)	105.2	97.8	108.3	83	66.3	77.5	58.8	61.1	70.8	73.8	92.6	85.3	957
Pan Evaporation (mm)	187	153	127	78	50	36	41	58	79	114	143	176	1241

The estimated rainfall erosivity (R-Factor) for Pambula is 3,000 (Landcom, 2004), which is moderate and so the site has a high erosion risk wherever land is more than about 8 percent (Figure 4.6, Landcom, 2004).

8 Proximity to Sensitive Environments.

Council's DCP 5 and associated Guideline 4.1.3(d) (October 2009) interprets Sensitive Environments to be:

8.1.1 Within 100 m of Identified Lands (Environmental Planning and Assessment Regulation 2000)

- There are no environment protection zones within 100 m of this site.
- There are no national parks, historic sites, dedicated nature reserves or wilderness areas within 100 m of this site.

8.1.2 Within 100 m of a natural water body, wetland or coastal dune field

- There are no such permanent creeks, wetlands or dune fields within 100 m of any proposed effluent management area (EMA). The far north of Lot 1 is within 100 m of a watercourse the other side of Millingandi Road.

3 Highlighted cells show rainfall above evaporation.

- There is an intermittent watercourse through the site that requires a 40 m buffer to any EMA.

8.1.3 High Water Table, Groundwater wells

- The water table is more than 3 m deep.
- The nearest registered bore is about 750 m from the site.

8.1.4 Highly Permeable Soils (more than 2.5 m/day)

(i) Soils are duplex in nature east of the watercourse. They consist of sandy loam topsoils over clay subsoils. The maximum measured permeability (CD Watts (2005)) is 2.6 m/day but the mean value is 1.6 m/day.

(ii) The near-surface soils west of the watercourse are deeper and alluvial but CD Watts (2005) measured their permeability a consistent 0.72 m/day.

8.1.5 Acid Sulfate or Saline soils

- The site is elevated well above levels associated with acid sulfate soils.
- The soil testing did not show elevated levels of salt.

8.1.6 Within A Drinking Catchment

- The site is not located within 100 m of any permanent fresh water used for drinking.
- The site is not located within 2 km upstream of a town water intake point.

8.1.7 Within 150 M of A Nominated Waterway

- The site is not located within 150 m of a nominated waterway, as defined in Schedule 6 of BVSC LEP, 2002 (includes tidal part of an oyster growing catchment).

9 Current Land Use

At the time of inspection the site was used for rural residential purposes and for grazing cattle and goats.

10 Existing Issues

At the time of inspection the site was in good condition. There only key issue to water quality was the open access to the creek by stock. Visibly, the existing septic to trenches system seems to be performing well, as there is no effluent noticeable at the surface. The trenches met required buffer distances to sensitive environments.

11 Identifying Future Water Quality Issues

11.1 Production, Management and Disposal of Wastes

11.1.1 Domestic Waste

We anticipate that new residences will have access to Council's waste transfer stations (as part of annual rates). As such, we expect that no domestic waste will be deposited onsite.

11.1.2 Effluent Disposal

The site is not serviced by reticulated sewer, so new houses will require onsite treatment and disposal systems for domestic effluent. This is discussed in Section 12.4.

11.1.3 Other Pollutants

It is unlikely that the proposed development will generate significant quantities of other pollutants that might become entrained in stormwater runoff.

11.2 Land Surface Changes

Land surface changes will be:

(i) a new sealed public road. This will:
- be 250 m long;
- be built in a 20 m road corridor;
- have a 6 m wide sealed pavement (30 percent actual impervious);
- be crowned to drain to grass-lined swale drains on both sides (Section 12.2)

(ii) three new sealed rights of way (ROWs):
- total about 300 m long;
- be built in a 15 m corridor;
- have a 3 m wide sealed pavement with shoulders (27 percent actual impervious);
- be crowned to drain to grass-lined swale drains on both sides (Section 12.2)

(iii) although not technically part of this DA, it is assumed there will be a new home built on the site. For the purpose of modelling each is assumed to have a roof area of 300 m^2 and other impervious areas (paving/driveway) of 500 m^2. It is assumed that each new roof will drain to a rainwater tank and that the other impervious areas will drain onto vegetated land.

There are no new dams proposed.

12 Water Cycle Management Plan

12.1 Construction Phase Erosion and Sediment Control

Parts of the site have been identified at high risk of erosion and more than 2,500 m^2 will be disturbed when the new roads are built. Therefore, a Soil and Water Management Plan to the requirements of Landcom (2004) is required. A conceptual SWMP has been prepared by SEEC separate to this report (SEEC Drawing 09000242-SWMP01).

12.2 Road Pavement Design

12.2.1 Generic Design

(i) Wherever possible (and this is the case for most of the roads, including the existing road in the west) vegetated table drains will be built on both sides of the road and the pavement cambered to drain to them. Tail-out drains will be provided at about 50 m intervals to regularly sheet water from the table drains onto well vegetated land. Tail-outs are to be at-grade and will have a sill at their end to encourage minor ponding of water (and subsequently to promote infiltration).

(ii) Cut and fill batters will be stabilised immediately following construction using hydroseed or hydromulch spraying (or equivalent) to lower C-factors [4] and aid the establishment of grass.

(iii) Table drains will be stabilised immediately following construction using bitumen-sprayed jute matting (or equivalent) over seed.

(iv) Sediment fencing will be erected 1 m from the toe of any fill batters until vegetation has stabilised them sufficiently.

(v) The public road will be sealed for its entire length.

(vi) The ROWs will be sealed.

12.2.2 Watercourse Crossings

(i) The ROW crossings will use a shallow causeway, sized according to the expected flow in the 100-year storm event. Trickle flow will be taken by concrete pipes under the causeways. Rip-Rap with geotextile underlay will be placed downslope of the causeways to dissipate flow.

4 C-Factor is a measure of ground cover. It varies from 1.0 for bare soil to 0.005 for well vegetated land

12.3 Individual Houses

Any new houses will include:

(i) A rainwater tank (or series of tanks) to capture roof runoff. These tanks:

- will have a minimum volume of 100 kL (Section 13.1);
- are to be plumbed to provide all internal and external water;
- are to be plumbed to capture as much of the roof runoff as is feasibly possible;
- are to have their overflow directed onto stabilised land;
- are to have a first-flush device;
- are to be screened and sealed to prevent the entry of leaves, twigs and mosquitos;
- are to be installed and maintained according to the manufacturer's instructions.

(ii) Water saving fixtures for any fittings. Toilets are to have AAA-rated (minimum), dual flush cisterns.

12.4 Onsite Wastewater Management

The site is not on reticulated sewer and so each lot must sustainably manage treated wastewater on site. There are a number of constraints to onsite wastewater management at this site, particularly the climate, the soils and the required 40 m buffer distance from the intermittent watercourse (DLG, 1998).

The 70th percentile rainfall is higher than the pan evaporation for five months of the year and so we do not recommend surface spray-irrigation on any lot. The soil profiles are very different east and west of the watercourse and so we make different recommendations for each.

12.4.1 East of the Watercourse

At a minimum secondary treatment with disinfection (chlorine or UV) is recommended on these lots. Therefore, any treatment system must be able to produce effluent of the following quality (NSW Health):

- BOD less than 30 mg/L
- Suspended Solids less than 45 mg/L
- Thermotolerant coliforms less than 100 cfu/100 ml

A hydraulic balance (DLG 1998) for these lots is given in Appendix 2 and assumes:

- 70th percentile monthly rainfall data from Pambula
- calculated evaporation data for Pambula (provided by BOM)
- a wastewater load of 1,000 L/day (Bega Valley Shire Council, DCP5)
- a design irrigation rate (DIR) of 35 mm/week (AS/NZS1547:2000).

The soils here consist of sandy loam topsoil over medium clay subsoil. Together they have an estimated *insitu* phosphorous sorption value of about 3,000 kg/ha (Appendix 2). A nutrient balance (DLG 1998) for these lots is given in Appendix 2 and assumes:

- a wastewater load of 1,000 L/day.
- a nitrogen concentration in the secondary treated effluent of 35 mg/L
- a phosphorus concentration in the secondary treated effluent of 12 mg/L.
- a nitrogen uptake of 80 $mg/m^2/day$ (well managed, formal lawn area in keeping with the recommendation for subsurface irrigation).
- a phosphorous uptake of 7.5 $mg/m^2/day$ (well managed, formal lawn area in keeping with the recommendation for subsurface irrigation).
- phosphorous sorption limited to the top 1 m of soil (DLG,1998).
- design life (phosphorous break-point) = 50 years.

The limiting balance is the phosphorous balance, as it requires an area of 494 m^2.

12.4.2 West of the Watercourse

At a minimum secondary treatment with disinfection (chlorine or UV) is also recommended on these lots. However, the soils here consist of very gravelly sandy loams and clay loams. They have an estimated *insitu* phosphorous sorption value of only 770 kg/ha (Appendix 2), which is much lower than that for Lots 2 to 7. It means that wastewater treatment systems capable of reducing phosphorous are required. Therefore, the required performance of any system on Lots 8 to 10 is:

- BOD less than 30 mg/L
- Suspended Solids less than 45 mg/L
- Thermotolerant coliforms less than 100 cfu/100 ml
- Nitrogen less than 35 mg/L
- Phosphorous less than 6 mg/L [5]

5 There are a number of systems capable of doing this.

The hydraulic balance is the same as that given above. A nutrient balance (DLG 1998) for these lots is given in Appendix 2 and assumes:

- a wastewater load of 1,000 L/day
- a nitrogen concentration in the secondary treated effluent of 35 mg/L
- a phosphorus concentration in the secondary treated effluent of 6 mg/L
- a nitrogen uptake of 80 mg/m^2/day (well managed, formal lawn area in keeping with the recommendation for subsurface irrigation).
- a phosphorous uptake of 7.5 mg/m^2/day (well managed, formal lawn area in keeping with the recommendation for subsurface irrigation).
- phosphorous sorption limited to the top 1 m of soil profile (DLG, 1998)
- design life (phosphorous break-point) = 50 years.

The limiting balance is the phosphorous balance, as it requires an area of 504 m^2.

12.4.3 General Mitigation

(i) All proposed EMAs will benefit from an application of lime at 250 gsm to reduce acidity and encourage good grass growth.

(ii) Lot 8 is subject to run-on from a piped drain under the unpaved driveway along the site's western boundary. This pipe will be removed and a new drain (and associated road drainage) installed to re-direct the flow into the existing dam. A 40 m buffer will be applied to that point.

12.4.4 Wastewater Summary

(i) At a minimum secondary treatment with disinfection (chlorine or UV) is recommended on all lots.

(ii) Lots 8 to 10 will require a system that is also capable of reducing phosphorous to less than 6 mg/L (i.e. an advanced secondary treatment system with nutrient reduction).

(iii) For ease of conditioning, the minimum irrigation size on all lots will be set as 500 m^2.

(iv) Each EMA will be serviced by 500 m^2 of subsurface irrigation, with the total area divided into two equal fields sequentially selected by an automatic index valve.

(v) Separate wet-weather storage is not recommended as, in our experience, it is rarely used properly in a domestic situation. The use of subsurface irrigation is considered an adequate wet-weather management tool, as treated effluent would be pushed down into the soil profile rather than coming to the surface.

(vi) The subsurface irrigation will be in areas of formal lawn that are regularly mown and the clippings composted on site.

The requirements for onsite wastewater management are summarised on SEEC plan 09000242-WCMP01. This plan shows that the required effluent management areas will fit on each lot and are considerate of the required 40 m buffer from the watercourse.

12.4.5 Cumulative Nutrient Impact Assessment; SEPP 62 (Wastewater)

By surface waters

The risk of treated effluent becoming entrained in surface water will be minimal because:

- the EMAs have been designed using 70^{th} percentile rainfall data per the requirements of Bega Valley Shire Council; and
- subsurface irrigation is proposed.

By groundwater

The nutrient balances are done to ensure there is no impact of treated effluent disposal outside of the confines of each EMA and, therefore, no impact outside the confines of the site. The soils and vegetation on each lot are shown to be sufficient to entrain nutrients within the designated EMAs for a period of at least 50 years, which is the generally adopted design life for onsite wastewater management systems (DLG 1998). Only the top 1 m of soil profile is assumed in the calculations and so the nutrient balances ensure there will be minimal risk of groundwater contamination (there were no signs of periodically saturated soils above this level).

12.4.6 Cumulative Pathogen Impact Assessment; SEPP 62 (Wastewater).

By surface waters

The risk of treated effluent becoming entrained in surface water will be minimal because:

- the EMAs have been designed using 70th percentile Rainfall data, per the requirements of Bega Valley Shire Council; and
- subsurface irrigation is proposed.

By groundwater

Because of the highly sensitive nature of the receiving waters it is critical that pathogens do not reach them. Once in the soil pathogens and viruses will be outside of their preferred environment and they will progressively die over a period of time. The potential distance travelled during that time is dependant on the quality of the effluent, the temperature in the ground, the soil's permeability and the hydraulic gradient.

Cromer *et al*, 2001 describes a method of calculating the time and distance that pathogens and viruses can be expected to travel in soils. Secondary treatment with disinfection is proposed on all lots and such treatment will result in a faecal colifirm count of no more than 10^2 cfu/100 ml. Therefore, to reach *no* residual coliforms an additional two log cycle reductions are required before the treated water reaches receiving waters. In this case the inputs are:

- Required additional log cycle reduction = 2 log cycles.
- Permeability is 100 mm/hour = 2.6 m/day [6].
- Soil thicknesses = 0.3 m (Lots 2 to 7) [7] and 1 m (lots 8 to 10)
- Porosity of the soil is 25 percent (0.25).
- Hydraulic gradients are taken as the slope gradients:
  - 5 percent on Lots 8 to 10,
  - 10 percent on Lots 3 to 7 and
  - 20 percent on Lot 2.
- Ground temperature is taken as the mean annual temperature (16ºC).

6 This is the highest value measured by CD Watts and Associates (2005) and represents a high value expected of massive sandy loam (AS/NZS1547:2000)

7 Soils here are duplex and it is conservatively assumed that percolated water will flow along the surface of the clay layer. In reality the clay subsoils are reasonably well drained.

At a temperature of 16ºC, the estimated time to achieve a two-log cycle reduction is 12 days (Cromer *et al*, 2001). Over that time, the calculated travel distances are approximately:

- 25 m on Lot 2
- 12 m on Lots 3 to 7
- 6 m on Lots 8 to 10.

Therefore, the recommended 40 m buffer from the watercourse is more than sufficient and we conclude the risk of pathogen export from this site will be minimal (as long as the wastewater management systems are installed and managed according to this report). There is minimal risk of pathogens leaving the confines of the site and so there is minimal risk of a cumulative impact on surrounding lands.

12.5 Riparian Re-vegetation.

The watercourse has been classified by DECCW as a Category 2 watercourse and requires:

- A core riparian zone (CRZ) of minimum width 20 m from the top of bank (TOB) (on both sides); plus
- An additional 10 m wide vegetated buffer, either side of the CRZ.

The base of the watercourse shows no obvious signs of a defined bed and banks. In the absence of a clear fluvial feature that could be mapped as the TOB it is common practice to set that level as the edge of land that would be inundated in a 20 percent flood event (1:5 year). SEEC report 09000242-FR01 shows that all flood events are contained in the deep, wide, channel base. The 1:5 year flood level would be approximately 0.3-0.5 m deep but the wide channel is actually about 3 - 4 m deep.

Given its relatively small catchment the channel is a peculiar size and shape,. It seems that flash-flows meander across the base, selecting a flow path that varies with time. Because of this, we have conservatively adopted the TOB to be top of the whole channel's banks (SEEC Drawing 09000242-WCMP01).

Therefore, it is proposed to vegetate the base of the watercourse and to extend this up the banks and for a distance of 20 m from the top of them. This will be the CRZ. From there there will be an additional 10 m vegetated buffer.

SEEC Drawing 09000242-WCMP01 shows the proposed vegetation corridor and lists the proposed native species. These have been selected from Keith, D. A. & Sanders, J. M. (1990). Plants will be planted at a grid spacing of approximately 3 m and the CRZ will be permanently fenced (with gates) to prevent stock access. A positive covenant will be placed on each lot to ensure the CRZ remains well vegetated and achieves a (almost) natural forest ecology.

12.6 Monitoring and Maintenance

An ongoing regime for maintenance of the various water quality control measures will be required to ensure their continued performance and stability. Monitoring and maintenance will need to consider the following:

12.6.1 Pavements and Watercourse Crossings

(i) These need to be checked regularly, paying particular attention to:

- table drains, to ensure they are stable and well armoured against erosion;
- pavement surfaces, to ensure they are not subject to deterioration;
- pipe outlets, to ensure they are free from blockages and are appropriately armoured against erosion;
- batters, to ensure they are well vegetated and do not show signs of sheet or rill erosion;
- tail-out drains, to ensure:
  - they are not filled with sediment;
  - they are stable; and
  - they remain connected to the main table drains
- causeways, to ensure they are free from blockages and are providing suitable passage for water.

12.6.2 Onsite Wastewater Systems

Applications to install wastewater management systems are assessed by Council under the requirements of the Local Government Act 1993 and the Environmental Planning and Assessment Act 1979.

Bega Valley Shire Council revised DCP 5 in 2008. One of the relevant procedures for DCP 5 is procedure 4.1.3(b) – *The Approvals to Operate and Reinspection Program.* The systems will be classified as *Low Risk* as no EMA is within prescribed buffer distances from a sensitive environment. Therefore, they will be subject to a five-year operational approval and will be self-certified, after initial Council Inspection. Targeted re-inspections might occur by Council Officers.

We expect Council to require quarterly inspections of the systems by an approved wastewater contractor. At those times compliance with the system's NSW Dept. Health's approval document will be proved. Service reports will be submitted to Council as requested.

The home owners are required to understand their obligations to onsite wastewater management and they must periodically check their system and its EMA to ensure:

- Any alarm is responded to within 24 hours
- Any filters are cleaned
- Distribution lines are buried and protected
- No effluent is disposed at the surface
- The vegetation in the EMA is regularly maintained (trimmed, mown, slashed, weeded etc.)
- Any unusual odours are reported to the manufactures as soon as possible and remedial action taken if required.

12.6.3 Rainwater Tanks

These will be maintained by the home owners per the manufacture's recommendations.

12.6.4 Riparian Vegetation

The developer will ensure that the riparian vegetation is growing effectively by inspecting it every six months for a period of three years or until each lot is sold, whichever occurs first. A short report will be submitted to Council at the completion of each inspection. If in any area less than 50 percent of the plants have taken that area will be inspected by a qualified horticulturalist to determine why and appropriate remedial action taken.

13 Water Quality Modelling

13.1 Water Demand for New Homes

A 100 kL tank (or a series of tanks to that volume) is recommended for each new home. 10 kL will be reserved for fire fighting. To model the performance of such a tank we have modelled it in an in-house spreadsheet model known as RATES. RATES uses daily rainfall data (here for a period of 94 years from Pambula (95% reliability)) to model the collection and re-use of rainwater. Inputs are:

- an assumed roof area of 300 m^2
- an assumed daily use of 690 L/day [8]
- a collection coefficient of 90 percent (0.9).

The results are given in Table 3 and show that a 100 kL tank could be expected to supply 81 percent of its demand. However, experience suggests that, as a tank gets low, the owners would most likely moderate their water use and achieve better than 81 percent. At 460 L/day [9] the tank could be expected to supply 99 percent of its demand.

8 Six people at 115L/day (AS/NZS1547:2000).

9 Four people at 115 L/day (AS/NZS 1547:2000).

Table 3 – Rainwater Tank Simulation Results

SEEC RATES IV Results
Site: Wonboyn
Rain station: Pamula Post Office 69024

Total years:	94.32	Avg annual rainfall (mm):	855.92
Total days:	34451	Max daily rainfall (mm):	422
Total no of days when rain fell:	7014	Longest dry spell (days):	119
Avg days per year when rain fell:	74.36386768	Days when rain > S1 initial loss:	6914
Avg wet day rainfall (mm):	11.51	Avg days/yr rain > S1 initial loss:	73.30365

Input statistics:	**Storage 1**		**Storage 2**	
Capacity (L):	90000		0	
Startup % full:	0		0	
Catchment area (sqm):	300		0	
Initial loss per day (mm):	0.3		1	
Runoff percentage:	90		90	
Apply use A on wet days (Y/N):	Y		N	
Apply use B on wet days (Y/N):	N		N	
Revert to mains at threshold (Y/N):	N		N	
Mains reversion threshold (% full):	0		0	
Overflows into Storage 2 (Y/N):	N		N/A	
USAGE stats (L/day):	**Storage 1**		**Storage 2**	
Usage type:	**A**	**B**	**A**	**B**
January	690	0	1	0
February	690	0	1	0
March	690	0	1	0
April	690	0	1	0
May	690	0	1	0
June	690	0	1	0
July	690	0	1	0
August	690	0	1	0
September	690	0	1	0
October	690	0	1	0
November	690	0	1	0
December	690	0	1	0
Results:	**Storage 1**		**Storage 2**	
% of time demand met:	81.42		0	
% of demand supplied from mains:	0		0	
Longest time storage ran dry (days):	112		34451	
Avg annual mains demand (L):	0		0	
Avg wet day overflow (L):	265.84		0	
Avg no of overflow events annually:	2.66115352		0	
Avg annual supply from rain in (L):	167074		0	
Max daily overflow (L):	60462		0	
Annual demand (L):	252027.0356		365.2565734	

13.2 MUSIC Modelling - Inputs

13.2.1 Modelling Introduction

To model the development's potential impact on stormwater quality we have modelled it, and the existing land use, in software known as MUSIC. The aim is to show that the stormwater quality post development will be no worse than it is now, i.e. there will be a neutral or beneficial effect (NorBE). As there are no particular issues to stormwater quality now, we believe showing that NorBE can be achieved is an acceptable outcome to stormwater quality.

MUSIC contains algorithms based on the known performance characteristics of common stormwater quality improvement structures used in Australia. These data are derived from research undertaken by various institutions. The models are appropriately calibrated and all amendments to MUSIC defaults are noted in Appendix 2. The modelling quantifies:

(i) the mean annual levels of the principal pollutants before and after development; and
(ii) the predicted nutrient concentrations, before and after development.

Statistics can be exported detailing pollutant concentrations in stormwater and mean annual amounts for:

(i) Flow (ML/yr)
(ii) TSS - Total Suspended Solids (kg/yr)
(iii) TP - Total Phosphorus (kg/yr)
(iv) TN - Total Nitrogen (kg/yr)
(v) Gross Pollutants (kg/yr).

13.2.2 Climate Data

Creation of a MUSIC catchment file requires an associated meteorological data file. The rainfall data required is known as pluviograph rainfall data. It is not the same as monthly data used for the hydraulic balance (Section 12.4) or the daily rainfall data used in RATES (Section 13.1). Pluviograph rainfall data is specialised data that measures rainfall in small time steps and is only available from a selected number of rainfall stations.

The closest suitable rainfall stations to this site are Green Cape and Genoa. Therefore, data used here is that for Green Cape 1974 to 1975 and for Genoa 1987 to 1990, both in 6 minute time steps. Data for these periods were chosen because:

- The Green Cape data has an average close to the mean rainfall of Pambula (779 mm compared to 854 mm); and
- The Genoa data has an average close to the 90^{th} Percentile rainfall of Pambula (1,081 mm compared to 1,163 mm).

Potential evapotranspiration (PET) data are derived from Genoa. Basic rainfall and PET statistics for Green Cape and Genoa are given in Tables 4 and 5 and the time-series graphs are in Figures 6 and 7.

Table 4 – Rainfall and PET statistics for Green Cape, 1974 to 1975

Measure	Statistics						
	mean	median	maximum	minimum	10%ile	90%ile	mean annual (mm)
Rainfall (mm/6 minute steps)	0.009	0	4.9	0	0	0	779
Potential ET (mm/day)	3.061	2.67	5	1.29	1.33	4.68	1117

Table 5 – Rainfall and PET statistics for Genoa, 1987 to 1990

Measure	Statistics						
	mean	median	maximum	minimum	10%ile	90%ile	mean annual (mm)
Rainfall (mm/6 minute steps)	0.012	0	9.55	0	0	0.04	1081
Potential ET (mm/day)	2.96	2.67	5	1.29	1.33	4.68	1081

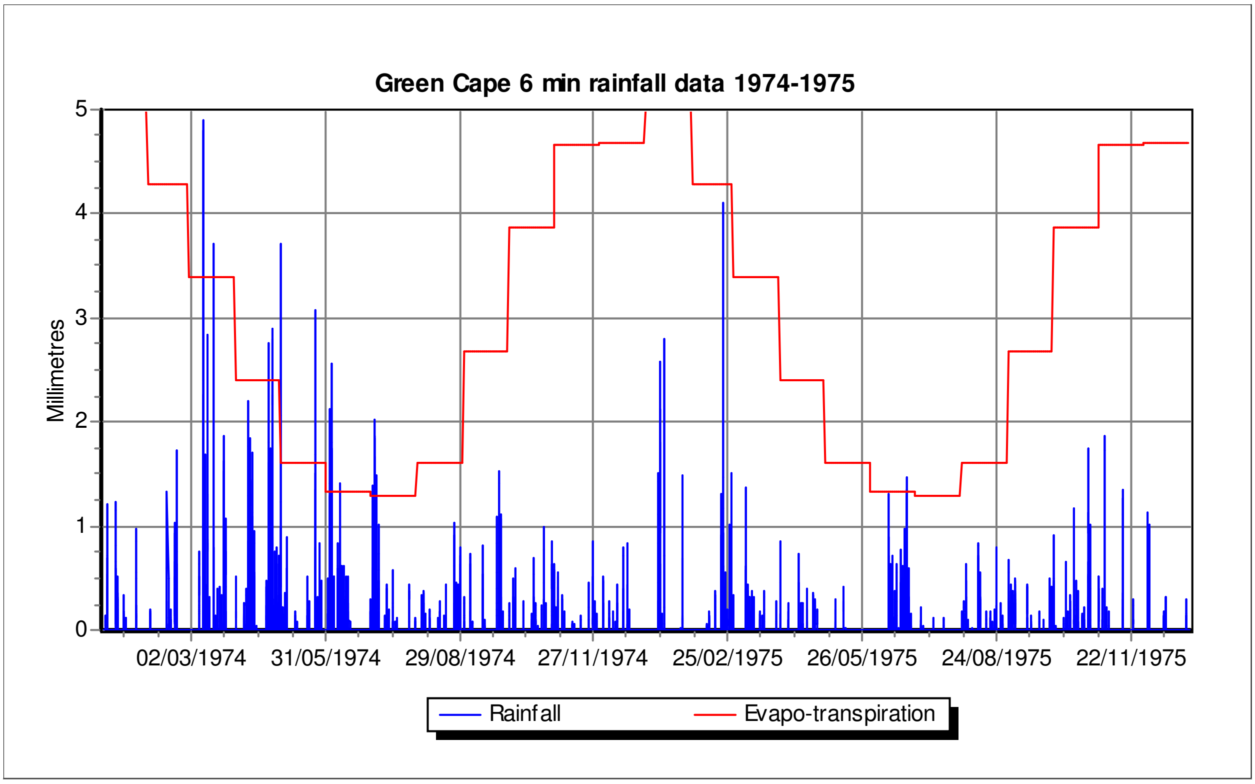

Figure 6 – Green Cape 6 min rainfall data 1974 - 1975

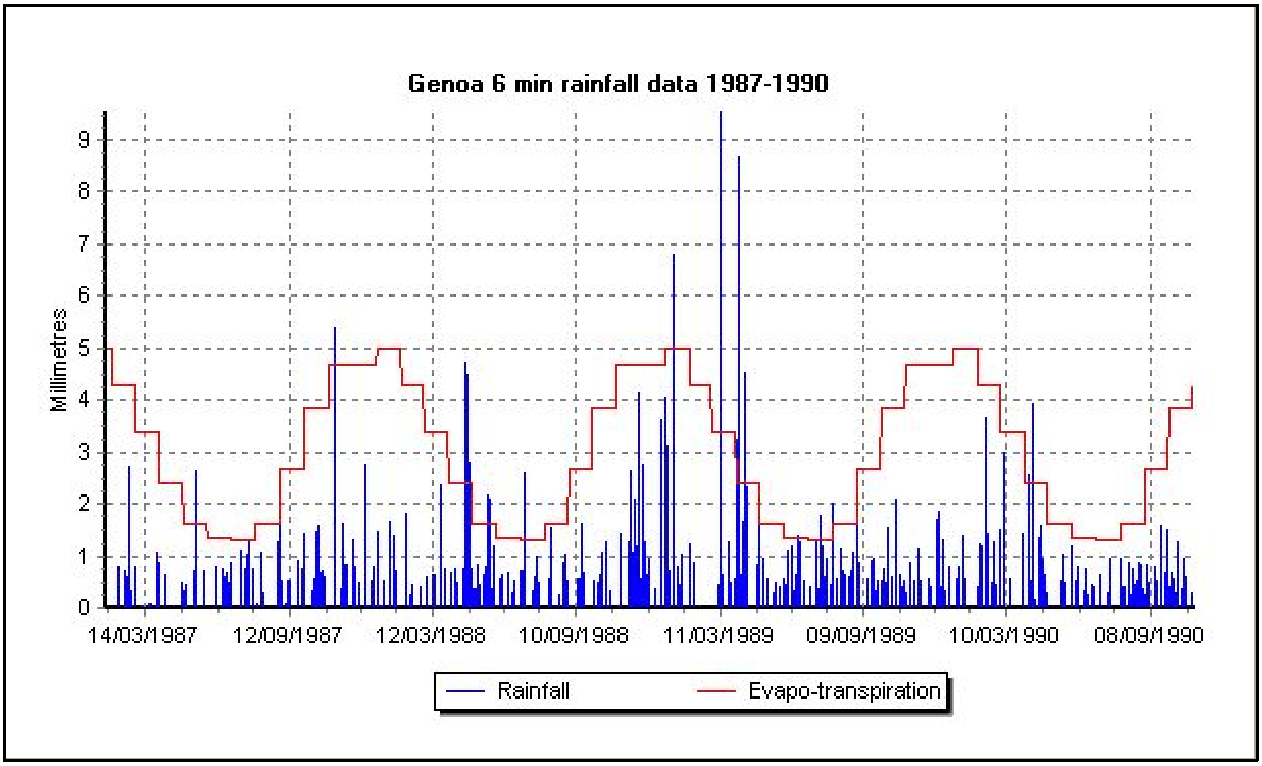

Figure 7 - Genoa 6 min rainfall data 1987 to 1990

13.2.3 Modelling Assumptions

MUSIC is primarily designed for urbanised catchments but it can be adapted for use with rural residential developments such as here. Source nodes are set up in the model to represent different land uses. Each of these nodes is given a percentage of imperviousness, to represent paved surfaces/roofs etc. It is important to know that the nominated percentage of imperviousness is not simply the *actual* area of impervious surfaces but is an estimation of *effective* imperviousness. For instance, if stormwater from a road pavement, or a paved surface around a house, flows onto a broad area of well-vegetated land it is not directly connected to receiving waters. In this case it is permissible to reduce the *actual* impervious area by a factor of half to give the *effective* impervious fraction (SCA, 2009). We have adopted this recommendation here.

The MUSIC modelling is based on the following calculations and assumptions:

(i) The pre-existing total site area is 10.77 ha and consists of:

- 6.44 ha of rural residential land including the watercourse and land east of it. It is one percent effective impervious because it has two sheds and some paved driveway in it. It is modelled with a “rural residential” node calibrated as in Appendix 1, Tables 7 and 8.
- 3.1 ha of rural residential land west of the watercourse on alluvial soils. It is 100 percent pervious and is modelled with a “rural residential” node calibrated as in Appendix 1, Tables 7 and 8.
- 0.7 ha being an existing 20 m wide access easement along the western boundary. It is 8 percent effective impervious because it has a 3 m wide unpaved road in it. It is modelled with an “unsealed road” node calibrated as in Appendix 1, Tables 7 and 8.
- 0.5 ha being an existing 20 m wide access easement to the existing house. It is 8 percent effective impervious because it has a 3 m wide unpaved road in it. It is modelled with an “unsealed road” node calibrated as in Appendix 1, Tables 7 and 8.
- 0.03 ha of existing roof (house) that drains to a 20 kL rainwater tank from which 250 L is drawn per day. The roof node is calibrated as in Appendix 1, Table 7.

(ii) The post development model remains at 10.77 ha and consists of:

- A combined 0.3 ha node representing 10 roofs at 300 m^2 each draining to a combined rainwater tank of 830 kL (9 x 90 kL new tanks plus the existing 20 kL tank). The roof node is calibrated as in Appendix 1, Table 7.

- 0.45 ha of ROW easements containing 3 m wide sealed pavements with shoulders. Modelled with an sealed road node as in Appendix 1, Tables 7 and 8.
- 0.7 ha being an existing 20 m wide access easement along the western boundary. It is 8 percent effective impervious because it has a 3 m wide unpaved road in it. It is modelled with an "unsealed road" node calibrated as in Appendix 1, Tables 7 and 8.
- 0.5 ha being 20 m wide new access easement east of the watercourse. This is 30 percent effective impervious because it will have a 6 m wide sealed pavement The node is modelled with a "sealed road" node calibrated as in Appendix 1, Tables 7 and 8.
- 1.1 ha of rural residential land west of the creek. It is 7 percent effective impervious on the assumption that each new home (3) on it will have 500 m^2 of 'other' impervious surfaces that drain onto surrounding vegetated land. It is modelled with a "rural residential" source node calibrated as in Appendix 1, Tables 7 and 8.
- 4.29 ha of rural residential land east of the creek. It is 4 percent effective impervious on the assumption that each home (6) on it will have 500 m^2 of 'other' impervious surfaces that drain onto surrounding vegetated land. It is modelled with a "rural residential" source node calibrated as in Appendix 1, Tables 7 and 8.
- 0.72 ha of land on Lot 2 that will drain to a swale along an easement. It is 3 percent effective impervious on the assumption that the new home on it will have 500 m^2 of 'other' impervious surfaces that drains onto surrounding vegetated land. It is modelled with a "rural residential" source node calibrated as in Appendix 1, Tables 7 and 8.
- Two areas of proposed revegetated riparian lands east and west of the creek:
  - 0.9 ha west of the creek; and
  - 1.76 ha east of the creek.

  They are both 100 percent pervious and modelled with a forest node calibrated as in Appendix 1, Tables 7 and 8.

(iii) All new road pavements will drain to vegetated swales. Where these grade at less than five percent (i.e. along the boundary of Lots 2/4 and around the ends of cul-de-sacs) these can be modelled as treatment swales. There will be about 280 m of such low gradient swales.

(iv) A base-flow generating node is used to return infiltrated water back into the model. The one used here is a "forest" node – on the assumption that infiltrated water will seep back into the channel within the riparian zone.

13.3 Results of Modelling

13.3.1 Mean Annual Loads

Eight scenarios were modelled:

(i) Pre development (i.e. existing) conditions;
- Subject site and total catchment;
- Mean rainfall (Green Cape data) and wet (Genoa data).

(ii) Post development (i.e. proposed) conditions including the water quality management measures from Section 12;
- Subject site and total catchment;
- Mean rainfall (Green Cape data) and wet (Genoa data).

Table 6 contains the results of the modelling.

Table 6 Results of MUSIC modelling

run 4	Pre	Pre	Post	Post	Change
green cape	Flow (ML/yr)	18.10	Flow (ML/yr)	21.3	18
	Total Suspended Solids (kg/yr)	2090.00	Total Suspended Solids (kg/yr)	897.0	-57
	Total Phosphorus (kg/yr)	2.96	Total Phosphorus (kg/yr)	2.3	-22
	Total Nitrogen (kg/yr)	25.60	Total Nitrogen (kg/yr)	27.4	7
	Gross Pollutants (kg/yr)	28.90	Gross Pollutants (kg/yr)	223.0	672
run 4	**Pre**	**Pre**	**Post**	**Post**	**Change**
Genoa	Flow (ML/yr)	37.70	Flow (ML/yr)	40.3	7
	Total Suspended Solids (kg/yr)	4360.00	Total Suspended Solids (kg/yr)	1940.0	-56
	Total Phosphorus (kg/yr)	6.37	Total Phosphorus (kg/yr)	5.0	-22
	Total Nitrogen (kg/yr)	56.20	Total Nitrogen (kg/yr)	53.1	-6
	Gross Pollutants (kg/yr)	43.70	Gross Pollutants (kg/yr)	298.0	582
run 4	**Pre**	**Pre**	**Post**	**Post**	**Change**
green cape	Flow (ML/yr)	75.70	Flow (ML/yr)	77.1	2
total catch	Total Suspended Solids (kg/yr)	3140.00	Total Suspended Solids (kg/yr)	2450.0	-22
	Total Phosphorus (kg/yr)	5.57	Total Phosphorus (kg/yr)	4.9	-13
	Total Nitrogen (kg/yr)	71.00	Total Nitrogen (kg/yr)	68.2	-4
	Gross Pollutants (kg/yr)	28.90	Gross Pollutants (kg/yr)	185.0	540
run4	**Pre**	**Pre**	**Post**	**Post**	**Change**
Genoa	Flow (ML/yr)	180.00	Flow (ML/yr)	182.0	1
Total catch	Total Suspended Solids (kg/yr)	9000.00	Total Suspended Solids (kg/yr)	6840.0	-24
	Total Phosphorus (kg/yr)	13.20	Total Phosphorus (kg/yr)	12.3	-7
	Total Nitrogen (kg/yr)	170.00	Total Nitrogen (kg/yr)	176.0	4
	Gross Pollutants (kg/yr)	43.70	Gross Pollutants (kg/yr)	298.0	582

The results show:

- There will be little change to overall flow (see also Section 13.3.3);
- There will be a reduction in suspended solids and phosphorous
- There will be no change to nitrogen export (some models show a slight reduction but others show an equal increase - net change should be zero.)
- A predicted increase in gross pollutants, although this is probably a function of the inability to change the concentrations generated by urban source nodes in MUSIC. Realistically we doubt if this would be the case because the proposal is to maintain a rural-residential development.

13.3.2 Nutrient Concentrations

For NorBE to be met, the post-development pollutant concentrations must also be less than or equal to the existing levels. MUSIC produces this data as a series of cumulative frequency curves, one each for suspended solids, phosphorous and nitrogen.

The graphs for both Genoa and Green Cape rainfall data are given in Figures 8 to 19 and they show pollutant concentrations (i.e. water quality) will be improved in all cases. The graphs are taken from the models for the total catchment to gain an understanding of the cumulative impact.

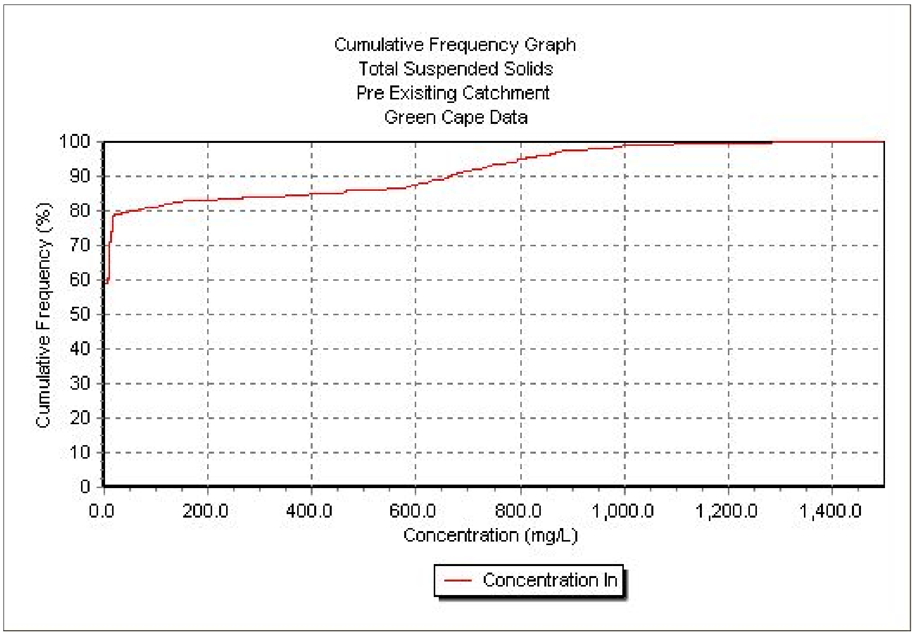

Figure 8

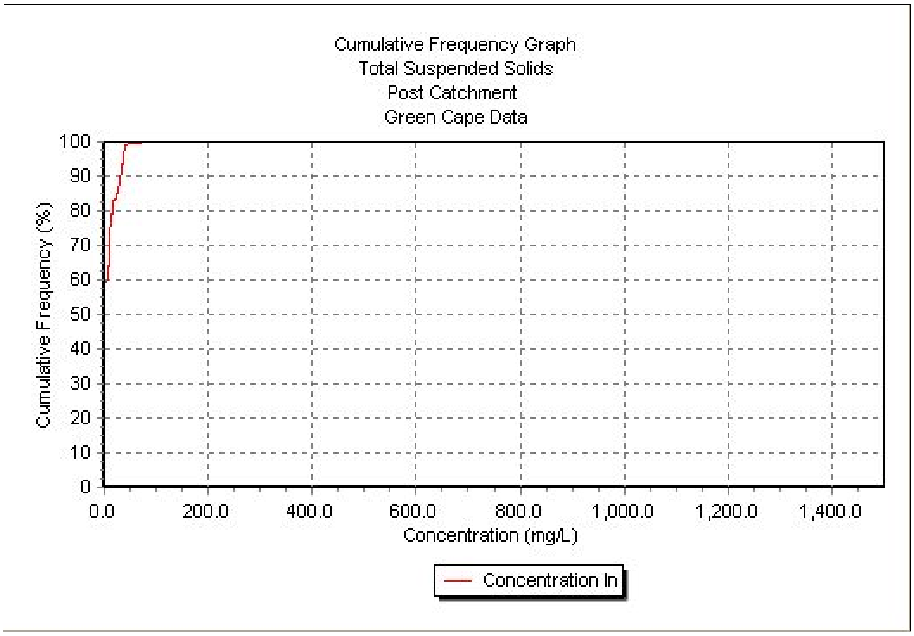
Cumulative Frequency Graph
Total Suspended Solids
Post Catchment
Green Cape Data
Cumulative Frequency (%)
100
90
80
70
60
50
40
30
20
10
0
0.0
200.0
400.0
600.0
800.0
1,000.0
1,200.0
1,400.0
Concentration (mg/L)
Concentration In

Figure 9

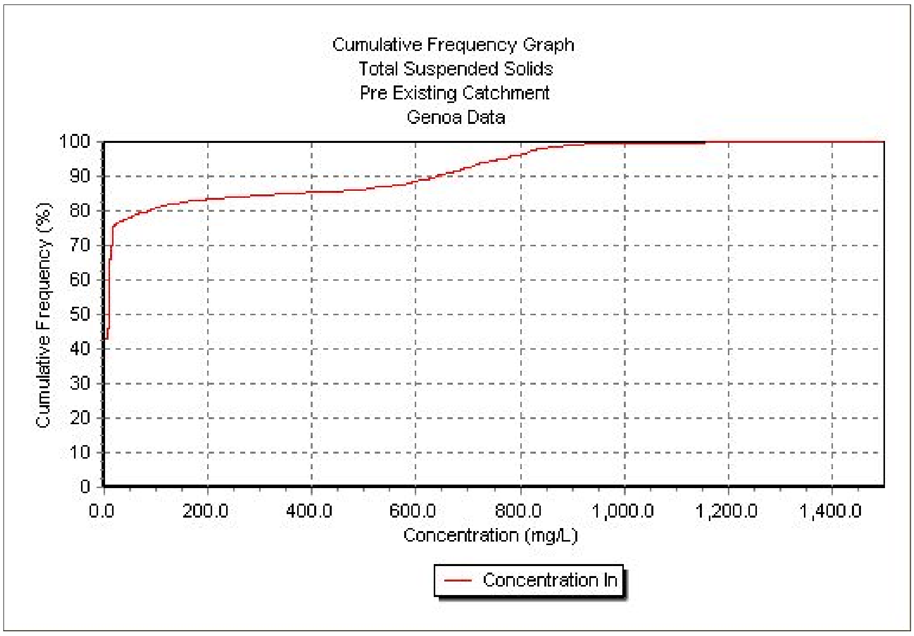

Figure 10

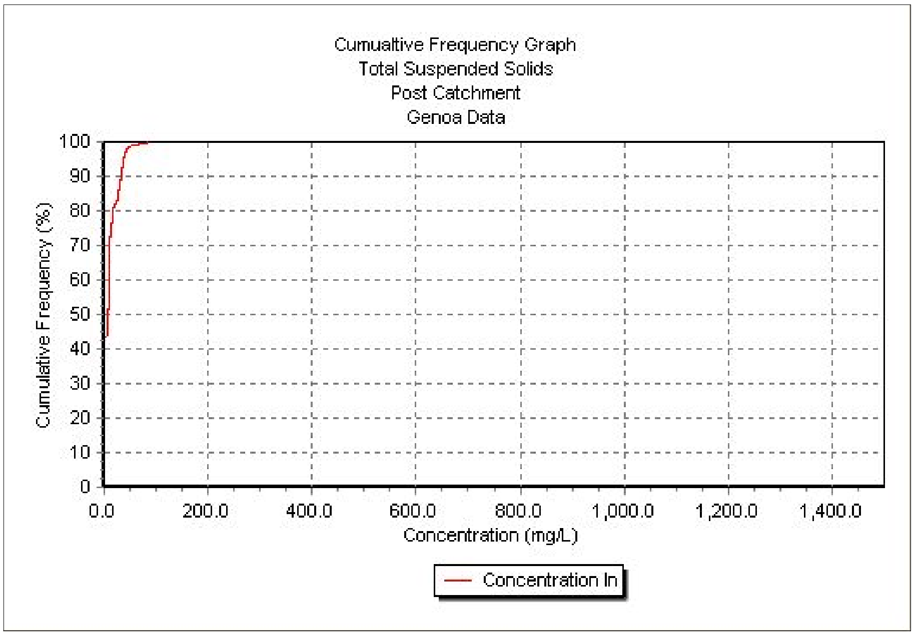

Figure 11

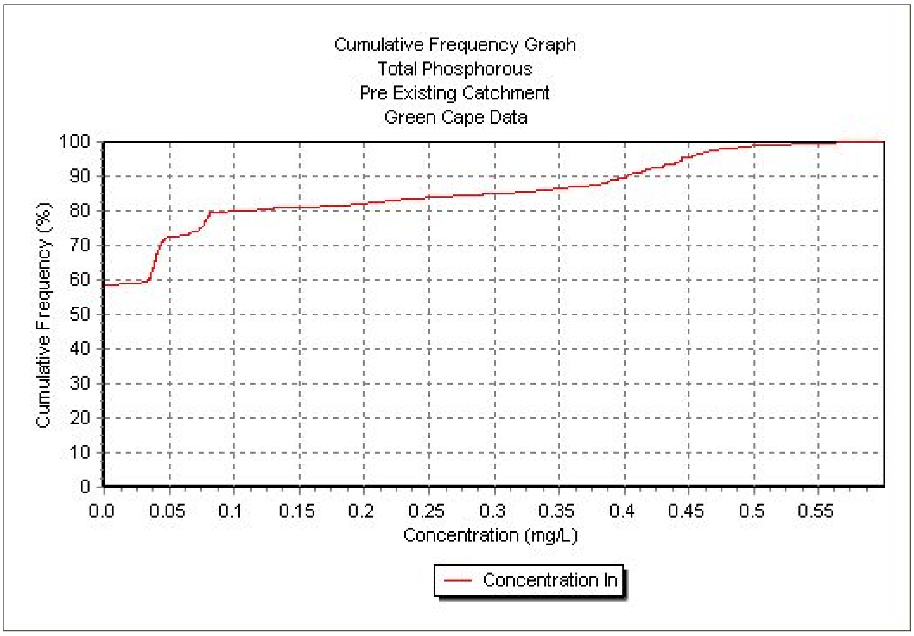
Cumulative Frequency Graph
Total Phosphorous
Pre Existing Catchment
Green Cape Data
Cumulative Frequency (%)
0
10
20
30
40
50
60
70
80
90
100
0.0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
Concentration (mg/L)
Concentration In

Figure 12

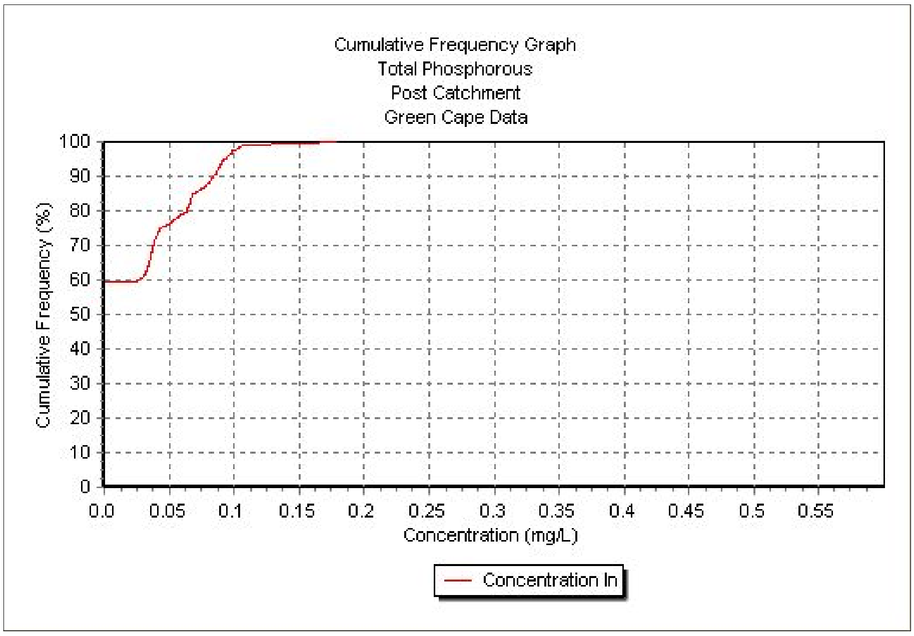

Figure 13

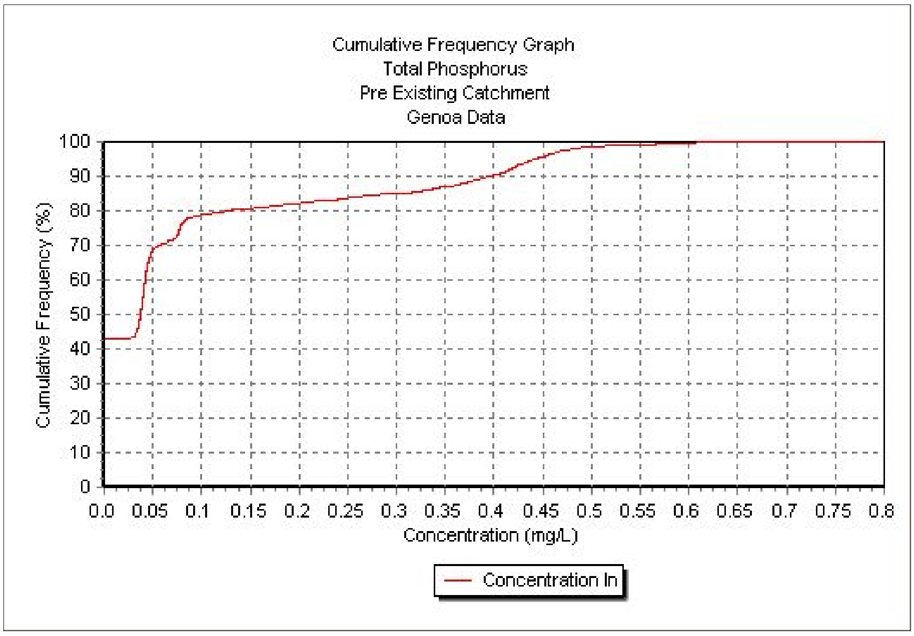

Figure 14

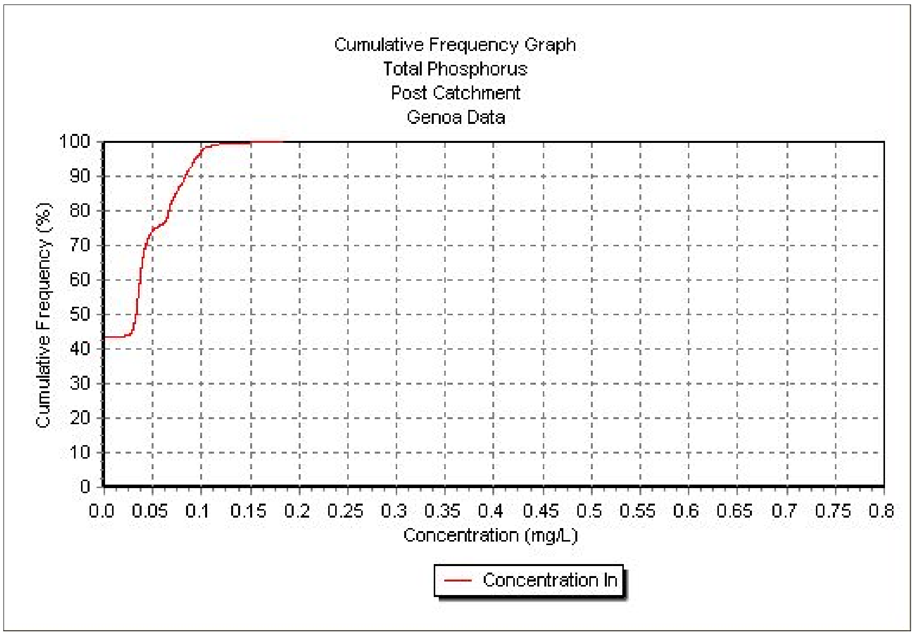

Figure 15

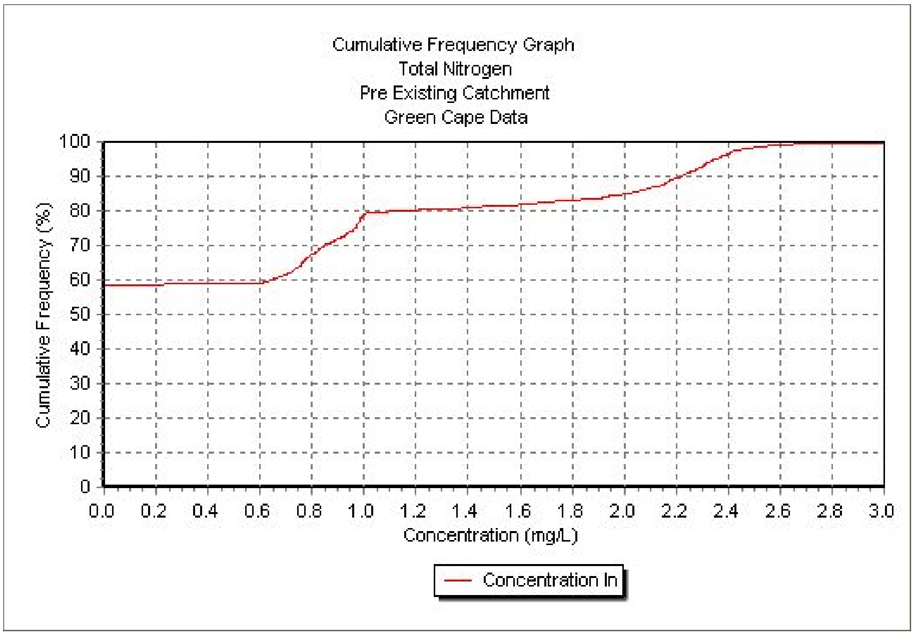

Figure 16

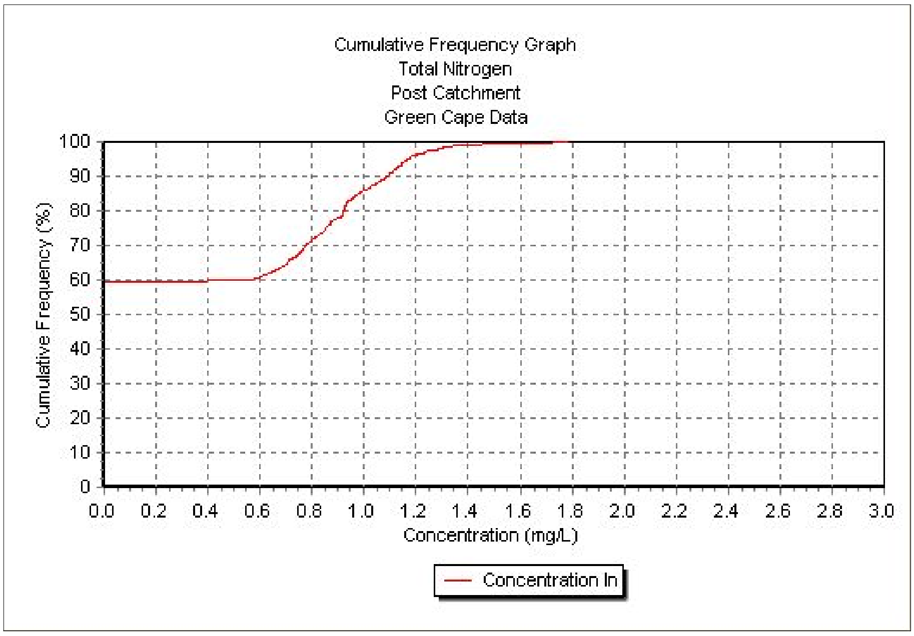

Figure 17

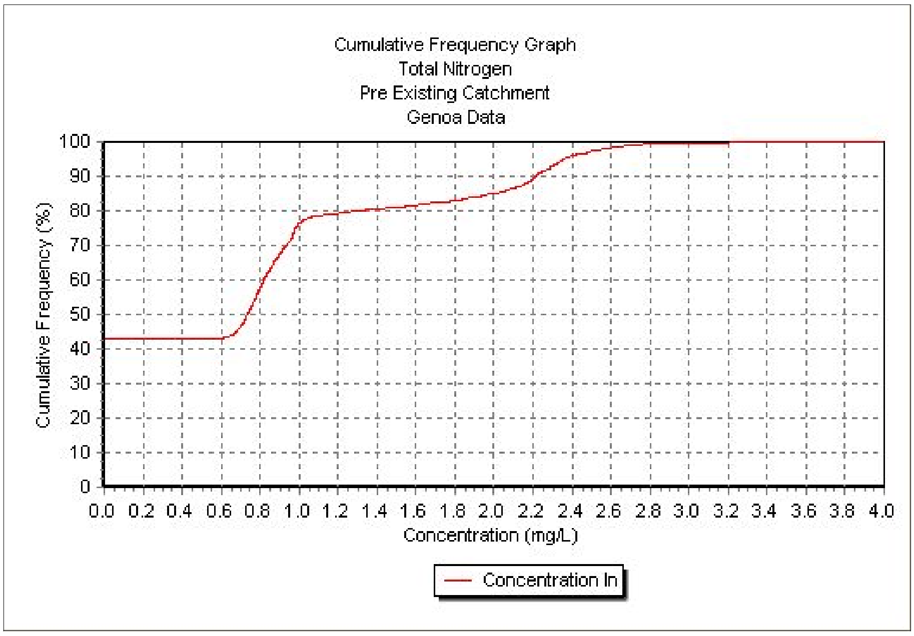

Figure 18

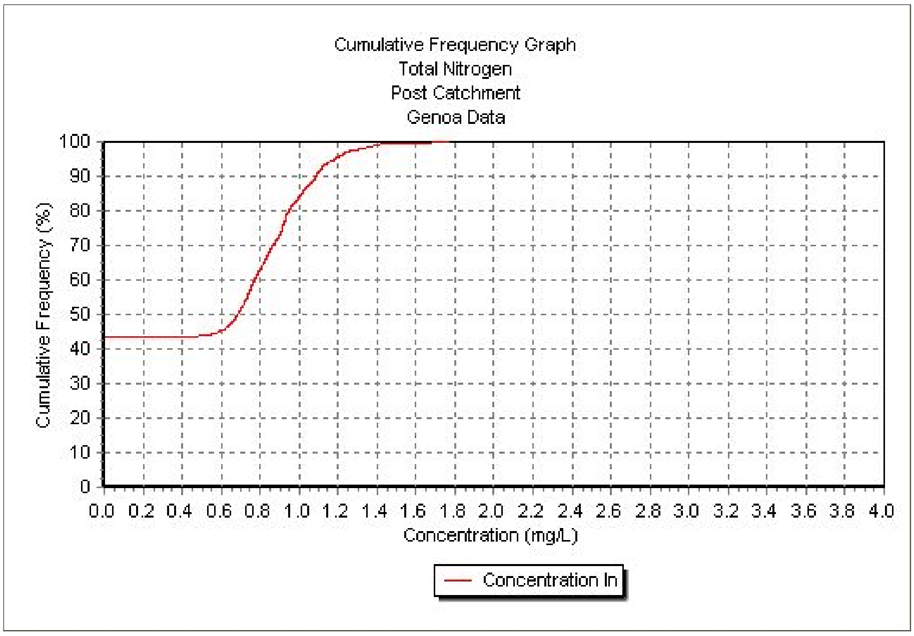

Figure 19

13.3.3 Surface Hydrology

MUSIC is able to predict flow rates at the receiving node (i.e. the watercourse as it enters adjoining land in the north). It does this by producing flow time-series graphs for the periods modelled. The catchment upstream of the site (54 ha) is included in this modelling. The time series graphs are given in Figures 20 to 23 (for both Green Cape and Genoa data).

MUSIC predicts there will be very little effect on the hydrology of the watercourse. This is because:

- there will only be a minor change to subject site's hydrology (less than 5 percent difference in flow rates); and
- what change there will be masked by the hydrology of the total catchment.

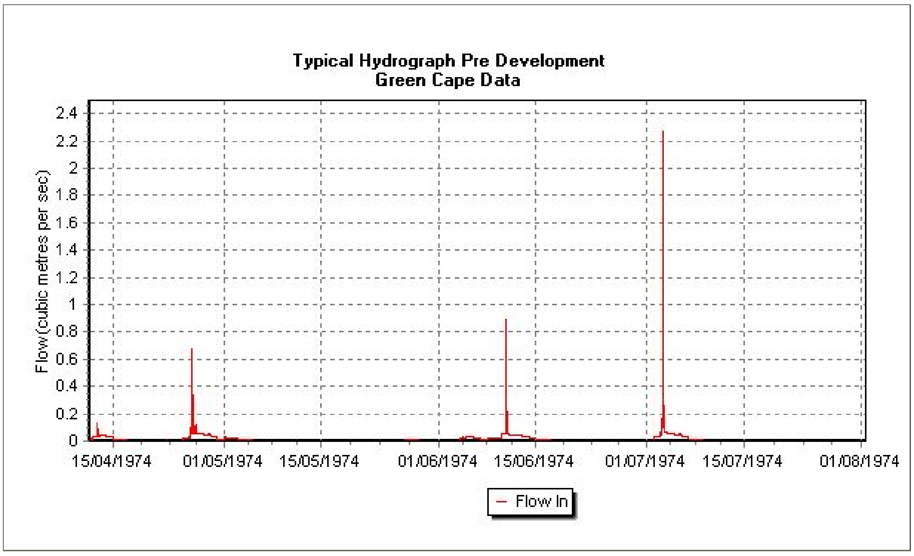

Figure 20 – Typical Hydrograph pre-development (Green Cape Data)

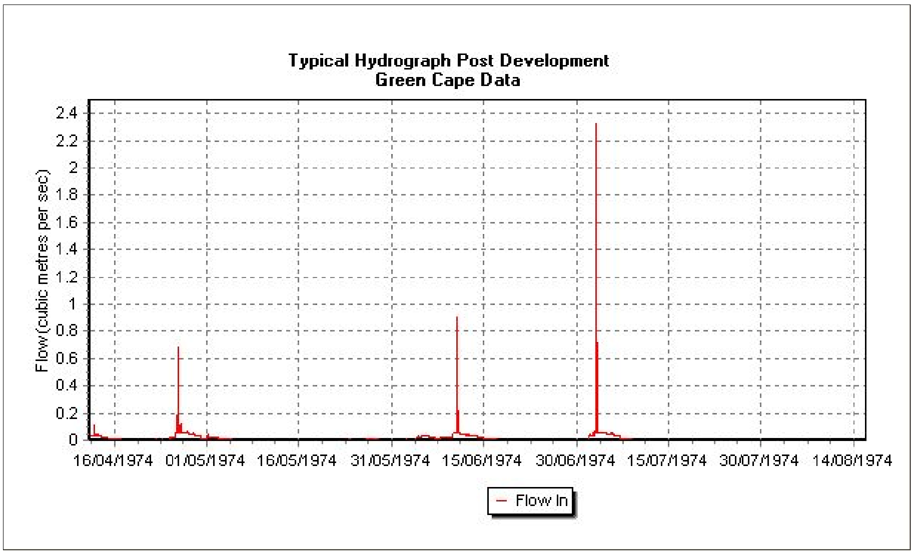

Figure 21 – Typical Hydrograph post development (Green Cape data)

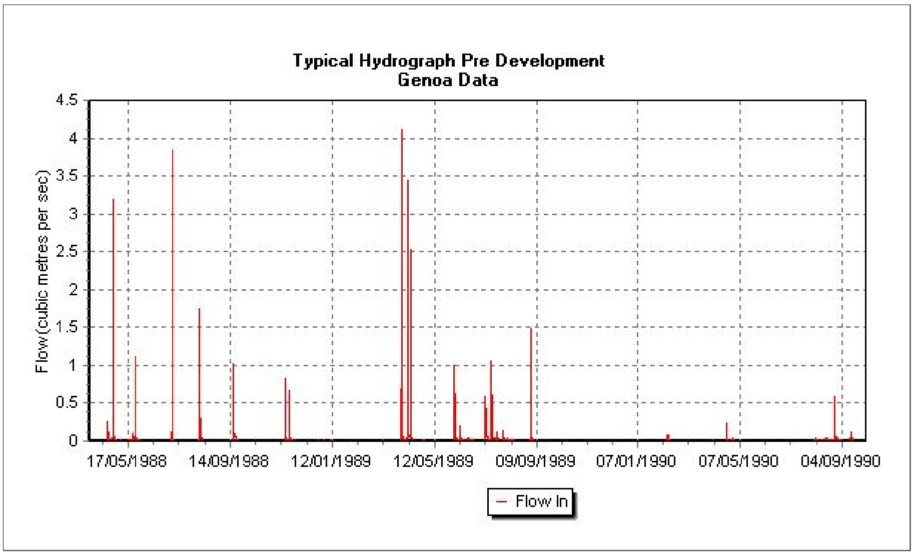

Figure 22 – Typical hydrograph pre development (Genoa data)

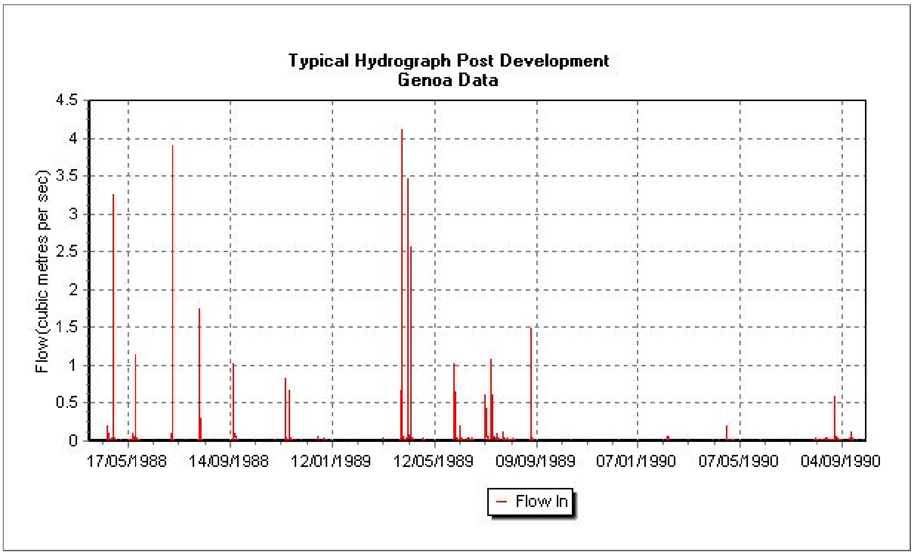

Figure 23 – Typical hydrograph post development (Genoa data)

14 Conclusions

It is proposed to subdivide Lot 1 DP 1087389 Millingandi Road, Millingandi into 10 new rural residential lots. This Water Cycle Management plan shows how wastewater and stormwater will be managed to ensure that a neutral or beneficial effect is achieved and there is no appreciable effect on downstream water quality.

Wastewater will be managed by providing suitably sized effluent management areas in which pathogens, nitrogen and phosphorous will be contained. Some lots will require advanced secondary treatment systems with nutrient reduction to achieve this.

Water Sensitive Design will be incorporated to infiltrate and treat stormwater runoff from road surfaces. Roads will be well-formed and well drained. Roof water will be used by the new residents.

15 References

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Charman, P.E.V., and Murphy, B.W. (eds.) (2007). *Soils: Their Properties and Management.* Oxford University Press.

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16 Appendices

16.1 Appendix 1: Universal MUSIC Calibration

Table 7 presents the universal calibrations used for calibrating the event mean concentrations (EMCs) of various surfaces and land uses. These are derived from SCA, 2009 who in turn have been advised by the developers of MUSIC.

Table 7 Stormflow concentration calibrations used in MUSIC at this site

	TSS mean (log mean)	TSS std dev (log std dev)	TP mean (log mean)	TP std dev (log std dev)	TN mean (log mean)	TN std dev (log std dev)
Roofs	20 (1.3)	2.1 (0.320)	7.8 (-0.89)	1.8 (0.25)	2.0 (0.3)	1.55 (0.19)
Rural Residential	89 (1.95)	2.1 (0.32)	0.22 (-0.66)	1.8 (0.25)	2 (0.3)	1.55 (0.19)
Rural Road (sealed)	269 (2.43)	2.1 (0.32)	0.5 (-0.30)	1.8 (0.25)	2.19 (0.34)	1.55 (0.19)
Rural Road (un-sealed)	1000 (3)	2.1 (0.32)	0.5 (-0.30)	1.8 (0.25)	2.19 (0.34)	1.55 (0.19)
Rehabilitated agricultural lands	89 (1.95)	2.1 (0.32)	0.22 (-0.66)	1.8 (0.25)	2.19 (0.34)	1.55 (0.19)
Agricultural land	141 (2.15)	2 (0.31)	0.6 (-0.22)	2 (0.3)	6.31 (0.48)	1.82 (0.26)

The pervious area characteristics for each node are calibrated based on soil, infiltration and groundwater conditions. In this case we have identified two main soil profiles east and west of the watercourse. Using the methodology of Macleod, 2008 we have estimated the soil storage capacity and the field capacity of the two soil profiles. Calibration for each is as shown in Table 8. The rooting depth was identified to be 0.5 m in the subject area but is assumed to be 1.0 m in forested areas.

Table 8 Pervious area calibrations used in MUSIC

Parameter	East	West	Re-Veg East	Re-veg West	Offsite Forest
Soil storage capacity	96 mm	139 mm	190 mm	195 mm	190 mm
Initial storage	30 mm	30 mm	30 mm	30 mm	30 mm
Field capacity	81 mm	72 mm	166 mm	151 mm	166 mm
Infiltration capacity coefficient	250 mm/hr	250 mm/hr	250 mm/hr	250 mm/hr	250 mm/hr
Infiltration capacity exponent	1.3	1.3	1.3	1.3	1.3
Groundwater initial depth	30 mm	30 mm	30 mm	30 mm	30 mm
Daily recharge rate	60%	60%	60%	60%	60%
Daily baseflow rate	45%	45%	45%	45%	45%
Daily deep seepage rate	5%	5%	5%	5%	5%

Note that all treatment nodes use default MUSIC parameters, as changing these criteria is not recommended in the absence of alternative measurements.

16.2 Appendix 2 - Hydraulic and Nutrient Balances

Hydraulic Balance

Hydraulic Balance

Rainfall Station	Pambula	
Evaporation Station	Pambula	
Wastewater Load	1000	L/day
Design Irrigation Rate	35	mm/week
Land Area	320	sqm
Storage required:	0.00	cubic m

Month	Days in month	70th percentile rainfall mm	Evaporation (mm)	Crop Factor
Jan	31	105.2	187	0.8
Feb	28	97.8	153	0.8
Mar	31	108.3	127	0.8
Apr	30	83	78	0.8
May	31	66.3	50	0.7
Jun	30	77.5	36	0.6
Jul	31	58.8	41	0.6
Aug	31	61.1	58	0.6
Sep	30	70.8	79	0.7
Oct	31	73.8	114	0.8
Nov	30	92.6	143	0.8
Dec	31	85.3	176	0.8
			1242	

INPUTS

	70th percentile rainfall mm	Effluent Irrigation (mm)	Inputs (mm)
Jan	105.2	96.88	202.08
Feb	97.8	87.50	185.30
Mar	108.3	96.88	205.18
Apr	83	93.75	176.75
May	66.3	96.88	163.18
Jun	77.5	93.75	171.25
Jul	58.8	96.88	155.68
Aug	61.1	96.88	157.98
Sep	70.8	93.75	164.55
Oct	73.8	96.88	170.68
Nov	92.6	93.75	186.35
Dec	85.3	96.88	182.18

OUTPUTS

	Evapotranspiration (mm)	Percolation (mm)	Outputs (mm)	Storage (mm)
Jan	149.6	155.00	304.60	-102.53
Feb	122.4	140.00	262.40	-77.10
Mar	101.6	155.00	256.60	-51.43
Apr	62.4	150.00	212.40	-35.65
May	35	155.00	190.00	-26.83
Jun	21.6	150.00	171.60	-0.35
Jul	24.6	155.00	179.60	-23.93
Aug	34.8	155.00	189.80	-31.83
Sep	55.3	150.00	205.30	-40.75
Oct	91.2	155.00	246.20	-75.53
Nov	114.4	150.00	264.40	-78.05
Dec	140.8	155.00	295.80	-113.63

Nutrient Balance - Lots 2 to 7

Application area:	Managed (mown)	
Wastewater Volume	1000	(L/day)

Nitrogen Balance

A = (C x Q) / Lx
Where:
A = Land Area (m2)

C = Concentration of Nutrient =	35	mg/L
Q = Wastewater Flow =	1000	L/day
Lx = Critical Loading Rate =	80	(mg/m2/day)

A = 437.5 m2

Phosphorus Loading

Step 1: P Sorption Calculation — Is Lab Data Available ? Yes

Psorb (topsoil)	295	mg/kg	(SCA Data)
Psorb (subsoil)	750	mg/kg	
Bulk Density (topsoil)	1500	kg/m3	
Thickness (topsoil)	300	mm	
Coarse Frags (topsoil)	10	%	
Bulk Density (subsoil)	1500	kg/m3	
Thickness (subsoil)	700	mm	
Coarse Frags (subsoil)	5	%	
Calculated Psorb (topsoil)	1195	kg/ha	
Calculated Psorb (subsoil)	7481	kg/ha	
Assumed P-sorb	3037	kg/ha	(insitu P-sorb assumed 35% of calculated P-sorb)

Step 2: Determine the required area to sorb phorphorus (50 year design life) :

P absorbed	=	8676	x 0.35	(default 6000 if no lab data available)
	=	3037	kg/ha	
	=	0.30	kg/m2	

P uptake = 7.5x 50x365
= 136,875 mg/m2
= 0.14 kg/m2

Determine the amount of phosphorus generated over that time:

Concentration of phosphorus =	12	mg/L
Phosphorus generated = Concentration x volume of wastewater =	219	kg
Irrigation Area = P generated / (P sorbed + P uptake) =	494	m2

Nutrient Balance - Lots 8 to 10.

Application area: Managed (mown)
Wastewater Volume 1000 (L/day)

Nitrogen Balance

A = (C x Q) / Lx
Where:
A = Land Area (m2)
C = Concentration of Nutrient = 35 mg/L
Q = Wastewater Flow = 1000 L/day
Lx = Critical Loading Rate = 80 (mg/m2/day)

A = 437.5 m2

Phosphorus Loading

Step 1: P Sorption Calculation Is Lab Data Available ? Yes

Psorb (topsoil)	245	mg/kg
Psorb (subsoil)	245	mg/kg
Bulk Density (topsoil)	1500	kg/m3
Thickness (topsoil)	500	mm
Coarse Frags (topsoil)	40	%
Bulk Density (subsoil)	1500	kg/m3
Thickness (subsoil)	500	mm
Coarse Frags (subsoil)	40	%
Calculated Psorb (topsoil)	1103	kg/ha
Calculated Psorb (subsoil)	1103	kg/ha
Assumed P-sorb	772	kg/ha (insitu P-sorb assumed 35% of calculated P-sorb)

Step 2: Determine the required area to sorb phorphorus (50 year design life) :

P absorbed = 2205 x 0.35 (default 6000 if no lab data available)
= 772 kg/ha
= 0.08 kg/m2

P uptake = 7.5x 50x365
= 136,875 mg/m2
= 0.14 kg/m2

Determine the amount of phosphorus generated over that time:

Concentration of phosphorus = 6 mg/L
Phosphorus generated = Concentration x volume of wastewater = 109.5 kg

Irrigation Area = P generated / (P sorbed + P uptake) = 504 m2