PROJECT

STORMWATER ASSESSMENT & MANAGEMENT PLAN ALTITUDE ASPIRE TERRANORA ROAD TERRANORA NEW SOUTH WALES

PREPARED FOR

NEWLAND DEVELOPERS PTY LTD

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PROJECT MANAGER N. Gifford
AUTHOR(S) A. Fullagar / N. Gifford
CLIENT Newland Developers Pty Ltd
CLIENT CONTACT Shaun Nicholson
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SYNOPSIS This report describes assessments of the proposed stormwater management measures required to ensure that the stormwater runoff from the Altitude Aspire development meets the NSW Department of Planning & Infrastructure and the Tweed Shire Council's expectations and objectives for stormwater quality treatment.

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SUMMARY

Newland Developers Pty Ltd commissioned Gilbert & Sutherland Pty Ltd (G&S) to complete a Stormwater Assessment (SWA) of the revised development layout for the proposed Altitude Aspire residential development at Terranora, New South Wales (NSW).

This SWA has been prepared to address issues raised by Tweed Shire Council (TSC) and the NSW Department of Planning and Infrastructure (DOPI) in response the Draft Preferred Project Report (Draft PPR) submitted in April 2012.

This SWA describes a revision of the water quality modelling to reflect recent changes to the earthworks, development layout and proposed stormwater drainage network. It details the assessed treatment train required to achieve TSC stormwater runoff quality objectives, with reference to the Water by Design 'Music Modelling Guidelines', Version 1.0 2010 (WBD, 2010) and the Healthy Waterways Water Sensitive Urban Design, Technical Design Guidelines for South East Queensland, 2006 – both of which TSC has deemed to be appropriate guidelines.

G&S used the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software tool to assess the quality of the stormwater runoff resulting from the proposed development over the site. An analysis of the estimated water quality after completion of the development was carried out. This analysis indicates that, provided the recommended water quality management measures are properly installed and maintained, the water quality of runoff from the proposed development and propose bioretention basins will achieve the adopted water quality objectives.

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GLOSSARY

TERM	MEANING
Australian Height Datum (AHD)	National reference for relative height measurement in Australia.
Average Recurrence Interval (ARI)	The average or expected length of time between exceedances of a given variable, such as rainfall.
Bund	An embankment constructed around an area to prevent the inflow or outflow of liquids. Also called Bunding.
Catchment	The area above a given point which contributes to the runoff.
Clay	Very fine-grained sediment or soil (often defined as having a particle size less than 0.002 mm, or 2 microns, in diameter).
Ephemeral	A stream that flows briefly only in direct response to precipitation in the immediate locality and the channel of which is at all times above the watertable.
Erosion	The process by which material (such as rock or soil) is worn away or removed (as by wind or water).
Groundwater	The water contained in interconnected pores located below the watertable in an unconfined aquifer or located in a confined aquifer.
Intermittent	A stream in which the flow is seasonal, usually in response to rainfall in the immediate area (see ephemeral).
Loam	Medium-textured soil composed of approximately 10% to 25% clay, 25% to 50% silt and less than 50% sand.
pH	The degree of acidity or alkalinity measured on a scale of 1 to 14 with 7 as neutral. From 0 to 7 is acidic; from 7 to 14 is alkaline.
Sand	Sediment composed of particles within the size range 63 microns to 2 millimetres.
Scouring	The action of removing sediment from stream banks, particle by particle. This is a more destructive process than collapse when viewed over time due to incremental effects.

TERM	MEANING
Sediment	Unconsolidated, fine-grained material (typically derived from the weathering of rocks), that is transported by water and settles on the floor of seas, rivers streams and other bodies of water.
Silt	Sediment having particles finer than sand and coarser than clay (i.e. 2 to 63 microns).
Sub-catchment	A smaller area within a catchment drained by one or more tributaries of the main water body.
Suspended Solids (SS)	The concentration of filterable particles in water (retained on a 1.2μm filter) and reported by volume (mg/L).
Total Nitrogen (TN)	Total nitrogen is the sum of the nitrogen present in all nitrogen-containing components in the water column. The nutrients, nitrogen and phosphorus are essential for plant growth. High concentrations indicate potential for excessive weed and algal growth.
Total Phosphorus (TP)	Total phosphorus is the sum of the phosphorus present in all phosphorus-containing components in the water column. The nutrients, nitrogen and phosphorus are essential for plant growth. High concentrations indicate potential for excessive weed and algal growth.
Turbidity	A measure of the cloudiness of water which is determined by the amount of light scattered by suspended particles.

1 Introduction

Newland Developers Pty Ltd commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare a revised Stormwater Assessment (SWA) in support of the Preferred Project Report (PPR) for the proposed residential subdivision, Altitude Aspire, located in Terranora, New South Wales (NSW).

1.1 Background

In November 2010, in response to the project's Director General's Environmental Assessment Requirements (DGRs), G&S prepared a report titled *'Conceptual Stormwater Assessment and Management Plan, Proposed Residential Development, Altitude Aspire Terranora, NSW'* (the CSWAMP). That report addressed conceptual stormwater quality impacts of the development and addressed the DGRs relevant to stormwater quantity (peak flow management) on a conceptual basis.

Following public exhibit of the project Environmental Assessment, the development layout was amended to consider State authority, Council and public submissions and to achieve consistency with Tweed Development Control Plan 2008, Section B24 – Area E Urban Release Development Code.

In April 2012, in response to statutory authority feedback, the CSWAMP was effectively split into two reports – one titled *'Hydrologic and Hydraulic Assessment, Altitude Aspire, Terranora Road, Terranora',* (the HHA) dealing with peak flow management and flooding, and a Stormwater Assessment report (SWA) dealing with stormwater quality assessment and management.

At the same time, also in response to feedback, the stormwater quality assessment approach moved from a 'deemed to comply' stormwater assessment to a more detailed modelled approach that addressed the efficacy of the proposed treatment train with reference to:

- Water by Design 'Music Modelling Guidelines', Version 1.0 2010 (WBD 2010).
- Healthy Waterways, Water Sensitive Urban Design, Technical Design Guidelines for South East Queensland, 2006 (HW 2006).

1.2 Revised Preferred Project Report

This report constitutes a revision of the SWA in response to comments received from Tweed Shire Council (TSC) and NSW Department of Planning & Infrastructure (DOPI) regarding the Draft PPR, and is written in support of the Revised PPR application.

The items from the TSC and DOPI reviews of the Draft PPR relating to the SWA are reproduced below (in *italic* text), followed (in plain text) by references to additional information provided by this report in respect of each. This report demonstrates that the revised design satisfies each of the relevant conditions.

1.2.1 Tweed Shire Council issues

At the request of DOPI, TSC provided the proponent with a letter dated 20 July 2012 (ref: DA09/0701 LN35979) detailing 24 pages of feedback, including the following comments relevant to this report.

> *5. Lawful Point of Stormwater Discharge and Stormwater Management*
>
> *The PPR concedes that the site does not currently have a lawful point of stormwater discharge, given that downstream land is within private ownership (Lot 227). Council is currently in negotiations with the applicant to prepare a VPA on various infrastructure matters, including stormwater drainage. The proposed approach is that prior to obtaining a subdivision certificate for the first stage of Altitude Aspire, Council will use its best endeavours to obtain a drainage easement over Lot 227 to provide a lawful point of discharge for the subject land and the rest of Area E. This will be at the applicant's expense. This process is subject to the successful finalisation and public exhibition of the VPA, including agreement on costs of the proposed works, as well as the success of the*

acquisition process for the easement. Refer to further discussion on the VPA below.

This is addressed in the April 2013 HHA report.

With regard to stormwater management, the removal of significant filling and development the central drainage area is an improvement in the PPR. The stormwater treatment facilities have also been removed from the wetland buffer, and are to be incorporated into this central area. This arrangement will need to be assessed in detail once the PPR is finalised, but is supported in principle, provided treatment areas can be bypassed in major flow events.

The design of the stormwater quality treatment devices provides for end-of-line treatment at the respective outlets of four separated piped stormwater drainage networks within the site. It is anticipated that each the piped system will be fitted with a high flow bypass to enable splitting of flows so that low flows enter the treatment basins and high flows are directed to the drainage channel for conveyance to the detention area and subsequently to the LPD. These treatment devices are offline with respect to the external catchments.

Council's Development Engineer has reviewed the two revised stormwater management documents by Gilbert & Sutherland, being Stormwater Assessment & Management Plan (SWAMP), and Hydrologic & Hydraulic Assessment (HHA) both dated April 2012 and stated that the following design concepts and baseline parameters are raised for attention.

c. The SWAMP states that a stormwater "treatment train" concept is being utilised, however this gives a false impression of the nominated scheme. There are 3 x biofiltration basins and 1 x artificial wetland that are NOT linked but all individually feed out to the new major channel that will traverse the site. (The concept is more accurately described as a 'herringbone' than a 'train'.)

The term ‘treatment train’ is an industry standard phrase referring to all (in essence one or more) components of stormwater quality treatment for a site, whether operating in sequence or in parallel. For the proposed development, this refers to the combination of at-source rainwater tanks for each allotment and end-of-line bioretention basins at outlets from the four (previously 3) separate piped stormwater drainage networks within the site. The combination of these measures provide treatment for all proposed developed areas within the site.

d. The overall concept of 'Integrated Water Cycle Management' as nominated on pages 24 & 25 of the SWAMP seems disjointed and inconsistent. The three bioretention basins are the main treatment process, but these are to be by-passed in Q3-month events. Such by-passes are claimed to be directed to wetlands (plural), but there is only one wetland - and this is not accessible to the eastern half of the site.

It seems that treatment of stormwater runoff for events > Q 3-month is intended via retention in the proposed bunded detention area within the SEPP 14 EEC. This is unacceptable.

These comments indicate a level of confusion. To clarify, the site for the proposed development is highly constrained with respect to options for IWCM (primarily due to its steep topography, shallow alluvial groundwater table and soil properties). Although many options were considered, the recommendations for this site include capture and re-use of roof runoff in lot-based rainwater tanks and the 4 (previously 3) bioretention basins for stormwater quality treatment. These basins are intended to collect and treat the first flush of stormwater runoff, which is generally defined as the Q3month storm. As such all stormwater requiring quality treatment will be captured and treated in the bioretention basins prior to discharge to the Coastal Wetland EEC north of Broadwater Parkway.

e. Sizing of bioretention basins

The design of the bioretention areas is based on QUDM and Healthy Waterways Technical

Design Guidelines, but the actual surface area of the basins is "in general accordance with TSC requirements". This does not appear to be a consistent design methodology, but a disjointed concoction of design parameters - raising suspicions that a much larger surface area could be required if the QUDM / HWTDG design requirements were fully utilised. A comparison would be helpful.

These comments are not helpful. The design of the bioretention basins has adopted a methodology consistent with the latest industry standard guidelines and Tweed Shire Council's recommendations. Nonetheless, reference to QUDM has now been removed from this SWA as it applies to the stormwater quantity assessment aspects of the design that are addressed in the HHA.

f. 'Communal' rainwater tanks are nominated as being further investigated as part of an overall water cycle management system (page 24). This concept has merit but considerable further information would be necessary prior to Council acceptance and this concept should not be incorporated as part of any 'Integrated Water Cycle Management' regime for the site.

Noted. The IWCM section of the previous report provided conceptual considerations for measures (in addition to the minimum requirements for stormwater quality treatment) that may be investigated further at the detailed design stage of the project. The IWCM section has been removed from the reporting for the revised PPR as further consideration of site constraints has limited the available options to those contained within the SWA.

g. It is noted that all the stormwater plans show the south-eastern catchment (Stages 4, 5 &11) to have a stormwater outlet discharging openly beside the main central channel, and not to a wetland or basin (see the north-western corner of the intersection of Roads 2 and 8). This is to be rectified.

Noted. All modelling has considered that low flows from these catchments will be conveyed to the basins for treatment. The revised drawings contained in this report reflect the proposed arrangement.

h. The two small biofiltration basins nearest Broadwater Parkway are required to have all inlets (to each wetland) in one location, and each basin is to have maximum separation between inlet and outlet zones.

Noted. The configuration of stormwater treatment devices throughout the site has been updated as part of the revised PPR. The maximum possible inlet/outlet separation will be provided in the basins subject to detailed civil design.

In summary while it is highly preferable to have the entire trunk drainage system constructed as part of Stage 1 works, it is not essential, and is also likely to be financially unreasonable. However it is not acceptable to defer the construction of the first bioretention basin to Stage 6. The stormwater reports should address the staging of the central drainage infrastructure to ensure continuity and constructability of all trunk drainage, including conveyance, treatment, volume and energy mitigation facilities. Each stage must be able to be serviced as a "stand alone" development that is individually independent of other stages, OR previously incorporated in prior stages. It is not acceptable to defer such infrastructure provision to later stages. This trunk drainage staging concept should be supported by a detailed earthworks staging plan that addresses works at the interface boundary between Stages.

Noted. It is agreed that this will be addressed in the detailed design phase of the development, following approval of the PPR.

1.2.2 New South Wales Department of Planning & Infrastructure issues

DOPI provided the proponent with a letter dated 4 December 2012 (ref: MP09_0166) detailing 17 pages of issues, including the following matters relevant to this report.

5. Ecological Considerations and the Conservation Area

a) Buffer to SEPP14 wetland – a 100 metre buffer is required (or provide justification if a smaller buffer is proposed), which does not include any infrastructure (including WSUD measures). This buffer should be clearly illustrated on the revised PPR plan with no infrastructure. Furthermore, the revised PPR must demonstrate/confirm that stormwater discharge onto Lot 227 (external to the site), which contains the SEPP 14 wetlands, is suitable in terms of water quality and quantity (owner's consent must be provided and implemented in the VPA documentation in the PPR).

The assessment described in this report demonstrates that the proposed development meets all requirements with respect to water quality treatment of site runoff. All the proposed WSUD measures described within this report are located within the site and to the south of Broadwater Parkway, and thus outside the required buffer. All treatment devices flow to an appropriate LPD. This is addressed further in the HHA report.

d) The Stormwater Assessment and Management Plan - there are several aspects of the Stormwater Assessment and Management Plan, prepared by Gilbert and Sutherland for the draft PPR dated April 2012 ("the SWAMP"), which need to be further considered, including:-

- *The use of the term "treatment train" is misleading and should not be used, since the three (3) bio filtration basins and the artificial wetland are not linked but all individually feed out to the new major channel that will traverse the site;*

Noted. Please refer to our response to TSC item 5c above.

- *The overall concept of 'Integrated Water Cycle Management' (pg 24 &25) ('IWCM') is disjointed and inconsistent. The three bioretention basins are the main treatment process, but these are to be by-passed in Q 3-month events. Such by-passes are claimed to be directed to wetlands (plural), but there is only one wetland, which is not accessible to the eastern half of the site. The treatment of stormwater runoff for events > Q 3-month is intended via retention in the proposed bunded detention area within the proposed conservation area to the north of the proposed Broadwater Parkway, which is unacceptable. This issue needs to be further considered and addressed in the Revised PPR.*

Noted. Please refer to our response to TSC item 5d above.

- *The sizing of the proposed bioretention basins should be justified using a consistent design methodology. A comparison of the controls under the Council and the Queensland Urban Drainage Manual (QUDM) may be useful.*

Noted. Please refer to our response to TSC item 5e above.

- *'Communal' rainwater tanks are nominated as being further investigated as part of an overall water cycle management system (page 24). This concept has merit but considerable further information would be necessary prior to Council acceptance and this concept should not be incorporated as part of any IWCM regime for the site. If rainwater tanks are proposed to be incorporated into the subdivision, using the Community Management Statement for the purpose, instead of relying solely on the BASIX requirements, is encouraged. It is considered that the provisions of the management statement could be used to either mandate or strongly encourage compliance with the requirement of the Tweed Shire Council Demand Management Strategy rather than relying upon the provisions of BASIX to provide adequate demand management.*

Noted. Please refer to our response to TSC item 5f above.

- *The SWAMP shows the south-eastern catchment on the site discharging directly to the central channel and not a wetland or basin, which is not supported. This needs to be addressed;*

Noted. Please refer to our response to TSC item 5g above.

- *The two small bio-filtration basins nearest Broadwater Parkway are required to have all inlets (to each wetland) in one location, and each basin is to have maximum separation between inlet and outlet zones.*

Noted. Please refer to our response to TSC item 5h above.

Construction staging of Stormwater Management - It is not acceptable to defer the construction of the first bioretention basin to Stage 6. The SWAMP should address the staging of the central drainage infrastructure to ensure continuity and constructability of all trunk drainage, including conveyance, treatment, volume and energy mitigation facilities. Each stage must be able to be serviced as a "stand alone" development that is individually independent of other stages, OR previously incorporated in prior stages. It is not acceptable to defer such infrastructure provision to later stages. This trunk drainage staging concept should be supported by a detailed earthworks staging plan that addresses works at the interface boundary between Stages.

Noted. Please refer to our response to the final comment within TSC item 5 above.

1.3 Scope of this report

This document constitutes a stormwater assessment, with respect to runoff quality, and stormwater management plan addressing maintenance and monitoring of the proposed treatment devices.

This report is divided into sections dealing with the proposal, a description of the physical characteristics of the site, an assessment of the likely stormwater runoff quality and management of the potential stormwater impacts during the construction and operational phases. These management measures are detailed in the Stormwater Management Plan (SWMP) that is included as Attachment 1.

This report, prepared by qualified G&S staff, is based on MUSIC Version 5.01 computer modelling of likely changes to annual stormwater sediment and nutrient loads due to the proposed development.

2 Site description and proposal

2.1 Site location

The site location is shown on Drawing No 10849-101 (included in Appendix 1). The site has an approximate area of 36ha and is located off Fraser Drive and Terranora Road at Terranora, New South Wales.

2.2 Receiving environment

The approximate elevation of the land ranges from RL 0m Australian Height Datum (AHD) to RL85mAHD. Runoff from this development flows in a north-easterly or north-westerly direction towards a central ephemeral gully that traverses the site from south to north. Runoff from this gully discharges onto the SEPP 14 wetland area, which is essentially flat, semi-tidal and drained by a number of agricultural, drains that discharge into the Terranora Broadwater. Terranora Broadwater adjoins the Tweed River, which discharges into the Pacific Ocean at Tweed Heads.

Overall, care should be taken to ensure that there is no worsening of the water quality in the receiving waters resulting from this development, during the construction or operational phases. In particular water quality should be of acceptable quality prior to being discharged from site to ensure the SEPP 14 wetland (receiving environment) is maintained at its pre-developed state and that the discharged water from site reflects that prior to the development of the site.

2.2.1 Strahler stream order

Strahler's (1952) stream order system is a simple method of classifying stream segments based on the number of tributaries upstream. A stream with no tributaries (headwater stream) is considered a first order stream. A segment downstream of the confluence of two first order streams is a second order stream. Thus, a n^{th} order stream is always located downstream of the confluence of two $(n-1)^{th}$ order streams.

As noted above, one watercourse traverses the site. It does not permanently flow and the site is near its source. There are no other watercourses that flow into or join the watercourse within or upstream of the site. The watercourse is therefore a 1^{st} order watercourse (as defined by the Strahler stream ordering method) for the full length of its course through the site.

It is also noted that there are three existing farm dams on the site as shown on Drawing No. 10849-102.

2.3 Geology / landform element

The geology of the investigation site is described by the Geological Survey of Queensland Moreton Geology 1:500,000 geology map,[1] as overlying Tertiary Basalt and sections of the Neranleigh-Fernvale beds. These groups consist of basalt, mudstone, shale, greywacke, chert, jasper, conglomerate, basic metavolcanics and pillow lava. The soil landscape belongs to the Carool colluvial landscape group (Morand 1996).[2]

Soil investigations conducted on the site by G&S, as recent as January 2012, found site soils to be characterised by grey, brown and black clay loams and grey and black light clays. These were overlying grey, brown and black medium clays, white, grey and yellow heavy clays, and grey and black sandy clays.

2.4 Existing development

The majority of the site has been extensively cleared, drained and used for agricultural and or grazing purposes. There are several dwellings and farm sheds located on the site.

2.5 Proposed development

The proposed Altitude Aspire development involves the construction of a system of roads to provide access to the residential allotments. The balance of the site would be dedicated to open space, a constructed system of bioretention

[1] Queensland Government (1980) *Geological Survey of Queensland, Moreton Geology, 1:500,000 geology map.*
[2] Morand D.T. *Soil landscapes of the Murwillumbah – Tweed Heads 1:100000 (Fingal, Pottsville, Green Pigeon, Tyalgum)* NSW Soil Conservation Service pp 30-33.

basins, a central drainage corridor for overland stormwater flow and land zoned environmental protection.

The proposed development, as shown on Drawing No. 10849-103, has a total area of approximately 36ha. The Altitude Aspire Subdivision Layout Plan (prepared by B&P Surveys and included in Appendix 3) proposes the creation of a residential community that will form part of and be integrated into the Terranora Area E Urban Land Release. The development would be completed in stages and would include substantial areas of open space, providing a buffer to the SEPP14 wetland area.

The proposed development would comprise the construction and/or installation of the following components:

- site earthworks
- roads
- stormwater drains
- sewer reticulation mains
- water reticulation mains
- underground electricity distribution cables
- telecommunication cables
- other ancillary services
- dwellings
- landscaping.

Once the development has been completed, all disturbed portions of the site will be rehabilitated or covered by some form of improvement protecting the soils from erosion, hence minimising the transport of suspended solids from the site. These improvements will include structures, paved areas, lawns and landscaping.

2.6 Catchment description

A review of aerial photographs of the site, confirmed by site inspection, indicates the site has been widely disturbed by previous clearing and farming activities.

An ephemeral gully traverses the site from south to north, with site runoff flowing overland into this gully prior to discharge into the SEPP14 Coastal Wetland across the northern site boundary.

The gully caters for discharge from a substantial (approximately 33ha) catchment upstream and to the south of the site, which is occupied by low-density residential development.

A catchment plan is provided in Drawing No. 10849-104.

3 Stormwater quality assessment method

To assess the likely impacts of the proposed development on water quality, we have moved from the previous 'deemed to comply' assessment against the relevant Tweed Shire Council development guidelines to a more detailed modelling approach using the CRC for Catchment Hydrology Model for Urban Stormwater Improvement Conceptualisation (MUSIC) Version 5.01 computer model.

MUSIC is a water resources package with components for generating surface and subsurface runoff, non-point source pollutant export and pollutant transporting and routing. It is specifically designed for the analysis of the effects of planned land use changes and for the evaluation of best management practice stormwater quality improvement devices. The input data requirements are described below.

3.1 Model input data

Rainfall data (in the form of 6 minute time-step pluviometer records) and evapotranspiration data are required for the model. Suitable records were available from 1972 to 2010 for the weather station of Murwillumbah.

From this data a continuous 6-minute time-step dataset was extracted from the dates 01/01/1990 to 31/12/2000. An analysis of the 6-minute time-step MUSIC dataset yielded an average annual rainfall of 1367mm and the annual totals shown in Table 3.1.1.

Table 3.1.1 Annual rainfall totals MUSIC dataset

Year	Total Rainfall (mm)
1990	2,121
1991	1,354
1992	1,339
1993	1,430
1994	1,678
1995	1,435
1996	1,694
1997	1,393
1998	1,327
1999	2,695
2000	1,436
Average	1,682

Suitable daily time-step records were obtained from the Bureau of Meteorology for its site, Number 058056 at Tweed Heads Golf Club, which is considered appropriate for this study in terms of proximity and relief.

An analysis of this daily time-step rainfall data set for the Tweed Heads Golf Course spanning the period from 1886 to 2011 provided the following annual rainfall data:

- Driest Year 688mm
- 10th percentile year 1,210mm
- Average year 1,686mm
- Median year 1,678mm
- 90th percentile year 2,200mm
- Wettest year 2,810mm

It should be noted that in the above analysis the results are statistical annual totals and may not necessarily refer to an actual historical year. A continuous model run using the MUSIC dataset from 1990 to 2000 would therefore be expected to yield representative results. This is because the average rainfall (1,682mm) of the dataset is close to the long term average (1,686mm).

Average monthly potential areal evapotranspiration values were obtained from the Tweed Shire Council's web site. These values are presented in Table 3.1.2.

Table 3.1.2 Evapotranspiration data

Month	Evapotranspiration (mm)
Jan	165
Feb	135
Mar	135
Apr	100
May	70
Jun	60
Jul	60
Aug	75
Sep	105
Oct	135
Nov	150
Dec	165

3.1.1 Runoff parameters

Relevant runoff parameters for the land uses were sourced from Table 3.7 of WBD 2010 and are presented in Table 3.1.1.1.

Table 3.1.1.1 Runoff Parameters

Parameter	Rural Land use	Urban Land use
Impervious Area Properties		
Rainfall threshold (mm)	1	1
Pervious Area Properties		
Soil storage capacity (mm)	98	500
Initial storage (%)	10	10
Field capacity (mm)	80	200
Infiltration coefficient	84	211
Infiltration exponent	3.3	5.0
Groundwater Properties		
Initial depth (mm)	50	50
Daily recharge rate (%)	100	28
Daily baseflow rate (%)	22	27
Daily deep seepage rate (%)	0	0

3.1.2 Water quality parameters

The water quality parameters modelled were:

- Suspended Sediment
- Total Nitrogen
- Total Phosphorus

The sediment and nutrient export characteristics (presented in Table 3.1.2.1) were adopted from Table 3.8 of WBD 2010. It should be noted that the rainfall to runoff model and the pollutant export expressions have not been calibrated for local catchments. This means the modelling results cannot be expected to produce accurate assessments of the amount of pollutants likely to be exported from the proposed development.

However, the results do provide useful assessments, which enable comparisons of the effectiveness of various stormwater management strategies.

An assessment of the pervious and impervious proportions for the urban areas in each catchment was carried out to provide input for the model using the recommendations in Section 3.3.3 of WBD 2010.

3.2 Modeling undertaken

The MUSIC model was used to assess the performance of the stormwater treatment system by comparing the Untreated Developed Case with the Treated Developed Case during the operational phase (after completion of the construction phase). This process enabled verification that the water quality objectives (pollutant load reduction targets) would be satisfied by the proposed treatment devices.

The modelled scenarios were as follows:

- Developed Case WITHOUT treatment measures.
- Developed Case WITH treatment measures.

Details of the stormwater treatment methods recommended and the results of the MUSIC modelling are provided in Section 4.

Table 3.1.2.1 Pollutant Export Parameters (Log_{10}mg/L)

Land use	Parameter	Suspended Solids		Total Nitrogen		Total Phosphorus	
		Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow
Rural	Mean	0.53	2.26	-0.52	0.32	-1.54	-0.56
	Std Deviation	0.24	0.51	0.39	0.30	0.38	0.28
Urban Road	Mean	1.00	2.43	0.20	0.26	-0.97	-0.30
	Std Deviation	0.34	0.39	0.20	0.23	0.31	0.31
Urban Roof	Mean	1.00	1.30	0.20	0.26	-0.97	-0.89
	Std Deviation	0.34	0.39	0.20	0.23	0.31	0.31
Urban Balance	Mean	1.00	2.18	0.20	0.26	-0.97	-0.47
	Std Deviation	0.34	0.39	0.20	0.23	0.31	0.31

3.3 Catchment description

The physical catchment characteristics were described in Section 2 of this report. The developed catchment boundaries are shown on Drawing No. 10849-104.

All catchments contributing runoff to the proposed bioretention treatment devices have been included in the MUSIC modelling. This includes a small external area of 0.47ha (Catchment 3) adjacent to the southwestern corner of the site.

The catchments which bypass the treatment devices (catchments 1, 2, 7, 15 and 16) have been excluded from the model, these areas are all either external or open space areas which do not require treatment.

Open space areas have been represented in the model using a 'rural' land use node with zero fraction impervious. The built-up areas within the development, represented in the model using an 'urban' land use split catchment approach, with each catchment dissected into roads, roofs (draining to or bypassing rainwater tanks), balance areas of the allotments and other urban areas (which are not proposed to be occupied by residential allotments). Impervious fractions for the urban areas have been estimated in accordance with WBD 2010.

The areas of each landuse type and respective impervious fractions for input into the MUSIC model are described in Table 3.3.1.

3.4 Water Quality Objectives

The Water Quality Objectives (WQO's) for site runoff during the operational phase have been based on recommendations from TSC in the form of pollutant load reduction targets and are detailed in Table 3.4.1.

Table 3.4.1 Developed Treated Case pollutant load reduction targets

	Suspended Solids	Total Nitrogen	Total Phosphorus
Target	80%	45%	60%

3.5 Water quality management

Stormwater management measures should be installed as described in Section 3.1. Provided

Table 3.3.1 Split catchment landuse inputs for MUSIC model

Catchment	Landuse areas							
	Open Space (ha)	Urban Road Reserve (ha)	Other Urban (ha)	Urban Roof (ha)		Urban lot balance		
				to Raintank	Balance	Area (ha)	Impervious Area (ha)	Fraction impervious
Impervious (%)	0%	60%	50%	100%	100%	Tabulated below		
3	0.47							
4	0.61			0.048	0.027	0.295	0.030	10%
5		2.04		1.200	0.675	4.025	0.750	19%
6		0.53	0.29	0.336	0.189	1.225	0.210	17%
8	0.56							
9		1.81		1.600	0.900	3.760	1.000	27%
10	0.66							
11		2.59	2.62	0.848	0.477	1.945	0.530	27%
12	0.15	0.29						
13	0.35							
14	0.56							
TOTAL	3.28	7.26	2.91	4.032	2.268	11.25	2.52	22%

these are properly designed, installed and maintained, the estimates detailed in Section 3.1 indicate that the quality of the stormwater runoff from the site will be acceptable.

Careful management will be required to ensure that the projected quality levels are achieved and maintained particularly during the construction phase. These details are considered in the stormwater management plan, which is included in this report as Attachment 1.

4 Stormwater quality assessment results

MUSIC model and catchment details have been provided in sections 3.4 and 3.5 respectively.

4.1 Developed Untreated Case

The results of the developed untreated case modelling, describing the runoff and pollutant loads that are likely to occur if the development was completed without any stormwater treatment measures, are shown in Table 4.1.1.

Table 4.1.1 Developed Untreated Case average annual loads

	Pollutant loads (kg/year)		
Runoff (ML/yr)	Suspended Solids	Total Nitrogen	Total Phosphorus
345	63,100	712	121

It should be noted that the above pollutant loads are estimates based on guideline values for appropriate model inputs described in Section 3 of this report. These values have not been calibrated for the site and thus actual results may vary from the estimated values. The results do however provide a useful assessment of the efficacy of the proposed treatment measures and thus are acceptable for the purposes of this assessment.

4.2 Developed Treated Case

The model was the modified to include the proposed stormwater treatment devices. In terms of stormwater treatment options, the topography and site soils are the limiting factors. After careful consideration of the design and operating requirements of each management measure, and the constraints imposed by site conditions such as soil type and permeability and slopes, the following devices have been included in the treatment train:

- Bioretention basins
- Rainwater tanks.

The locations of the permanent treatment measures are shown on Drawing No. 10849-105 and the characteristics of each proposed device are described in further detail herein.

4.2.1 Bioretention basins

The bioretention basins would be designed in accordance with the HW 2006.

It is envisaged that the basins used to manage water quality alone would generally be dry. However during (and for a short period after) wet weather, the basins may contain water to a ponding depth of up to 200mm. Where possible, a high flow bypass for flows in excess of the Q_{3month} (defined as 40% of the Q1) design storm would be installed. Where this is not possible, a combination of weir and pipe outlets would be provided.

The filter surface should be level, while the floor of the basin should have a minimum grade of 0.5% towards a low point that would be additionally drained by a system of subsurface perforated drains at 1.5m maximum spacings.

The subsurface drainage pipes are to be 100mm diameter class 400 perforated corrugated PVC pipe Type 1 with 6 rows of perforations 1.25mm wide by 7.4mm long. An un-perforated riser with a sealed removable screw cap is to be provided at the end of each perforated pipe for maintenance flushing. From previous experience local councils of South East Queensland recommend these pipes are NOT wrapped in geofabric. The bioretention basin filter media will consist of the following layers, which should not be separated by geofabric.

Filter media

The upper layer of the bioretention filter provides the majority of the pollutant removal function. This layer is intended to support the healthy growth of vegetation that enhances the treatment process. It is to consist of at least 400mm depth of sandy loam having a saturated hydraulic conductivity of 145 to 220 mm/hour and a nominal particle size of 0.45 to 0.5mm. The organic content (measured in accordance with AS 1289.4.1.1-1997) should be 5% to 10%. The filter media must meet the requirements of FAWB 2008.[3]

[3] Facility for Advancing Water Biofiltration, 2008, *Guidelines for Soil Filter Media in Bioretention Systems* (v 2.01) March 2008.

Transition layer
The transition layer underlies the filter medium and is intended to prevent the filter medium flowing into the drainage layer and the pipe drains. This layer is be 150mm thick and is to consist of coarse sand having a particle size distribution as shown below.

Sieve size	%passing
1.4mm	100%
1.0mm	80%
0.7mm	44%
0.5mm	8.4%

Drainage layer
The lowest layer in the system is to consist of 150mm depth of granular backfill (5mm to 10mm gravel) bedding medium surrounding the perforated pipes. It provides for the free flow of filtered water to the pipe drainage system.

Preliminary design details and overall areal extents of the bioretention basins are shown on the attached Drawing No. 10849-106. The basin characteristics adopted in the modelling are described in Table 4.2.1.1.

Initial sizing of the basins (as per previous reporting) was carried out based on the wetland area requirements in TSC guidelines. These estimates have now been refined/reduced based on the outcomes of the MUSIC modelling.

It should be noted that the modelling undertaken adopts a conservative estimate of basin 'surface' area being equal to the filter area. However, the basins themselves may have a floor area greater than the filter area (subject to detailed design requirements) and will generally have internal batter slopes of no less than 1 in 2, leading to a greater physical surface area and thus extended detention volume than included in the modelling.

It is intended that the bioretention basins would be landscaped and planted out as a 'rain garden', rather than simply top-soiled and turfed. Species used would be selected from the list of approved species included in Appendix A of the Healthy Waterways Technical Design Guidelines. Details of the plant species selection, size and spacing would be provided by the landscape architects at a later phase of the development application process.

Table 4.2.1.1 Bioretention basin properties

Parameter	Basin / Location (catchment)			
	Basin A C8	Basin B C10	Basin C C14	Basin D C12
Inlet Properties				
Low flow bypass (m^3/s)	0	0	0	0
High flow bypass (m^3/s)	100	100	100	100
Storage Properties				
Extended Detention depth (m)	0.2	0.2	0.2	0.2
Surface Area (m^2)	1,880	1,500	150	1,350
Filter and Media properties				
Filter Area (m^2)	1,880	1,500	150	1,350
Unlined filter media perimeter (m)	187	204	76	160
Saturated hydraulic conductivity	180	180	180	180
Filter depth (m)	0.4	0.4	0.4	0.4
TN Content of Filter Media (mg/kg)	800	800	800	800
Orthophosphate content of Filter Media (mg/kg)	50.0	50.0	50.0	50.0
Outlet properties				
Overflow weir width (m)	5.0	5.0	5.0	5.0

Table 4.2.2.1 Lumped rainwater tank inputs for MUSIC model

Parameter	Catchment C4	C5	C6	C9	C11
Inlet Properties					
Low flow bypass (m^3/s)	0	0	0	0	0
High flow bypass (m^3/s)	100	100	100	100	100
Storage Properties					
Volume below overflow pipe (kL)	15	375	105	500	265
Depth above overflow (m)	0.2	0.2	0.2	0.2	0.2
Surface Area (m2)	7.5	187.5	52.5	250	132.5
Outlet properties					
Overflow pipe diameter (mm)	156	779	412	900	655
Re-use properties					
Annual Demand (kL/yr) scaled by daily PET-Rain	1,017	12,563	3,894	10,587	5,428
Daily Demand (kL/day)	0.35	8.81	2.47	11.75	6.23

Bioretention basins are generally constructed in stages to prevent damage to the filter media. The construction sequence will be finalised at a later date and will be in accordance with Section 3.8.1 Option 1: Surface Protection described in Water by Design 2009.[4]

4.2.2 Rainwater Tanks

It has been assumed that one or more rainwater storage tanks, with a minimum total storage capacity of 5kL, would be installed by the land owners or builders on each lot to capture runoff from the roof areas.

In accordance with the recommendations contained within TSC Policy document *'Rainwater Tanks in Urban Areas -Version 2.1'* (adopted 20 September 2011) (TSC 2011), it is expected that the tanks would be connected to toilet cistern(s), the cold water supply to the washing machine and the majority of external garden taps.

As a reticulated water supply will be available to the development, the tank(s) are not recommended to be used for drinking, cooking or personal washing. A first flush diversion device or filtration unit should be installed on all rainwater tanks to satisfy TSC 2011 policy requirements.

For the purposes of the modelling, based on the TSC 2011, it has been assumed that:

- the tank storage volume would be at least 5,000L per single dwelling
- the roof area contributing to the tank would be $160m^2$/lot (although the total roof area may be larger than this).

Demand for the rainwater has been estimated using the recommendations in WBD 2010 and is based on the following assumptions:

- Average single/detached dwelling size is 3 bedrooms;
- Average occupancy = 2.5 people per dwelling (Table 4.3);
- Full water saving devices are installed
- Per capita internal water demand for laundry and toilet = 47L/day (Table 4.4);
- Total indoor demand of 117.5kL/day/lot; and
- Annual irrigation application of 548mm applied to 70% of the pervious areas within each allotment, based on daily potential evapotranspiration rainfall deficit.

The properties of the rainwater tanks (lumped together as one node per catchment) used in the modelling are shown in Table 4.2.2.1.

The overall rainwater tank performance within each catchment has been assessed using the water balance component of the MUSIC model.

[4] Water by Design 2009 *Construction and Establishment Guidelines, Swales Bioretention Systems and Wetlands* Version 1 February 2009.

The results of the tank balance component of the MUSIC modellling are included in Table 4.2.2.2.

Table 4.2.2.2 Raintank water balance

	Tank				
	C4	C5	C6	C9	C11
Flow in (ML/yr)	0.7	18.7	5.2	24.9	13.2
Reuse demand (ML/yr)	1.1	15.8	4.8	14.9	7.7
Reuse supplied (ML/yr)	0.4	7.9	2.3	9.8	5.2
% Reuse demand met	30.8	50.4	47.2	66.1	67.2
% Flow reduction	46.2	42.0	42.8	39.1	38.9

4.2.3 Additional Parameters

It should be noted that the final choice of management measures used, their location and size will be subject to detailed survey and design.

The retention of suspended sediment and nutrients is generally calculated by MUSIC using the default parameters of the exponential decay functions for each pollutant.

4.3 Modelling results

Modelling results for the Developed Treated Case are shown in Table 4.3.1. Detailed results for each sub-catchment are shown in Appendix 2.

Table 4.3.1 Developed Treated Case average annual loads

Pollutant loads (kg/year)			
Runoff (ML/yr)	Suspended Solids	Total Nitrogen	Total Phosphorus
308	9,830	327	46.3

The estimated load reductions for development are shown in Table 4.3.2 along with the performance criteria to meet the adopted load reduction targets specified in the Section 1.5 of HW2006 and in reference to WBD 2010.

Table 4.3.2 Developed Treated Case pollutant load reduction statistics

	Load reduction (%)		
	Suspended Solids	Total Nitrogen	Total Phosphorus
Site	84.4%	54.0%	61.6%
Target	80%	45%	60%

Based on the assessment and modelling described above, the adopted performance criteria referenced from TSC, Water by Design 'Music Modelling Guidelines', Version 1.0 2010 (WBD, 2010) and the Healthy Waterways Technical Guidelines can be met. The results are within the limits of accuracy of the model and the assumptions made in creating it and are therefore considered to be acceptable.

4.4 Water quality management

Stormwater management measures should be installed as described in Section 4.2. Provided these are properly designed, installed and maintained, the estimates detailed in Section 4.3 indicate that the quality of the stormwater runoff from the site during the operational phase of the development will be acceptable.

Careful management will be required to ensure that the projected quality levels are achieved and maintained particularly during the construction phase. These details are considered in the stormwater management plan, which is included in this report as Attachment 1.

5 Erosion and sediment control

5.1 Objectives

A detailed Erosion and Sediment Control Plan (ESCP) would be prepared during the detailed design phase to accompany an application for a Construction Certificate. The main objective of this ESCP would be to implement the requirements of Tweed Shire Council's *'Code of Practice for Soil and Water Management on Construction Works'* as required in Council's *'Development Design Specification, D7, Stormwater Quality'*. Additionally, the ESCP would provide information on site-specific management issues to minimise potential environmental impacts from the development during the construction phase.

The control measures suggested in this ESCP are designed to minimise impacts on the receiving environment. In addition, the ESCP is designed to achieve the following objectives:

- Minimise soil erosion and exposure.
- Minimise transportation of eroded soil by air and water.
- Limit suspended solids concentration in stormwater runoff to not more than 50mg/L.
- Limit/minimise the amount of site disturbance.
- Isolate the site by diverting clean upstream 'run on' water around the development.
- Control runoff and sediment at its source rather than at one final point.
- Stage ground disturbance/earthworks and progressively revegetate the site where possible to reduce the area contributing sediment.
- Retain topsoil for revegetation works.
- Locate sediment control structures where they are most effective and efficient.

5.2 Implementation

The ESCP would require the Proponent to mitigate the potential environmental impacts associated with the construction of the subdivision works. It is noted that the owner of the land being developed is responsible for the erosion and sediment control throughout the construction phase.

Altitude Aspire is proposed to be developed in stages. The staging of earthworks aids in minimising soil erosion and ultimately reducing the risk of receiving water(s) being impacted by the entrainment of sediment in run-off. The staging of works enables targeted ESCP's to be developed, implemented and rehabilitated on smaller areas.

As soon as is practicable, after the completion of the earthworks in each stage, the lots would be topsoiled and reseeded to establish a fast growing cover crop which would minimise erosion and movement of sediment across and off the site. On steeper slopes, hydro-mulching may be required.

Where ever possible the site shall remain grassed and otherwise undisturbed until construction commences.

5.3 Self-auditing system

According to TSC guidelines, where more than 2,500m^2 of land is disturbed, a self-auditing program is to be developed for the site. A site inspection, self-audit and monitoring program shall be undertaken.

The self-audit shall be undertaken systematically onsite including the recording of the following information:

- installation/removal of any erosion and sediment control device
- the condition of each device employed (particularly outlet devices)
- circumstances contributing to damage to any devices, accidental or otherwise
- storage capacity available in pollution control structures, including:
  - waste receptacles and portable toilets
  - trash racks
  - sediment barriers and traps
  - gross pollutant traps
  - wetlands/temporary sedimentation basin

- time, date, volume and type of any additional flocculants
- the volumes of sediment removed from sediment retention systems, and where this sediment has been disposed (if required)
- maintenance or repair requirements (if any) for each device
- circumstances contributing to the damage to device
- repairs affected on erosion and pollution control devices.

5.4 Construction phase control measures

Prior to commencement of bulk earthworks, temporary erosion and sediment controls shall be installed. In particular, the existing large dam in the central portion of the site (future bioretention basin A) should be modified for use as a temporary sediment basin during the initial earthworks stages (designated Stages 1 to 3). Proposed bioretention basin B should also be installed as a temporary sediment basin, as soon as practicable, to detain flows from the upper slopes during earthworks stages 2 and 3. However, it should be noted that, site constraints might exist during the first five (5) earthworks stages that prevent the initial direction of stormwater flows to these bioretention basins. As such, smaller temporary sediment basins have been sized in accordance with the proposed earthworks stages.

During the detailed design phase of the development and when the final earthworks staging plans are approved, individual staged ESC Plans should be designed to minimise the erosion risks of each earthworks stage, especially on the steeper slopes of the site (designated Stages 1-5).

Existing vegetation in the central watercourse should be retained as long as practicable to act as a filter zone. Silt fences should be installed and maintained along the perimeters of each proposed earthwork stages. Where runoff from disturbed areas cannot be directed to the existing dam and/ or bioretention basins, additional sedimentation basins for each earthworks stage should be constructed. Where practicable, runoff from undisturbed areas should be diverted around disturbed areas and away from the temporary sedimentation basin. Runoff from the filled areas should be diverted by means of surface slopes and V-drains to the temporary sedimentation basin.

Temporary sedimentation basins shall be designed in accordance with requirements detailed within 'Managing Urban Stormwater, Soils and Construction' Landcom, fourth edition, March 2004. The majority of the soils on the site have been classified as Ferrosols (or Krasnozems) Morand 1996.[5] These soils generally have a moderate erodibility but for estimating sediment basin sizes these have been classified as Type F soils. The size of the basin required for each stage is as shown in Table 5.4.1.

Table 5.4.1 Stage areas and associated sediment basin sizes

Stage No.	Area (ha)	Surface Area (m^2)	Minimum Volume (m^3)
1	3.30	1,524	1,297
2	3.50	1,552	1,376
3	0.85	438	334
4	4.80	2,079	1,887
5	2.98	1,339	1,172
6	4.50	1,956	1,769
7	3.70	1,634	1,455
8	3.92	1,630	1,541
9	3.30	1,524	1,297
10	4.80	2,079	1,887

Type F sedimentation basins are designed for fine grained materials, which require a much longer 'residence' time to settle in a sedimentation/ retention basin. These types of sedimentation basins often require the addition of a flocculant to assist in the settling process.

Gypsum is the most commonly used flocculant. Gypsum application rates are site specific and the

[5] Morand DT, 1996, Soil Landscapes of the Murwillumbah-Tweed Heads.

appropriate rate for this site will need to be determined once construction commences. As a guide, Landcom provides a maximum rate of 70kg of gypsum per 100m^3 of water. Previous experience with soils similar to those found on this site indicates that an application rate of 30kg per 100m^3 should be adequate.

Other control measures such as (but not limited to) silt fences, contour drains, and straw bales should be installed and maintained in accordance with the recommendations contained in 'Managing Urban Stormwater, Soils and Construction' Landcom, fourth edition, March 2004.

6 Limitations of reporting

This report has been prepared by G&S specifically for Newland Developers Pty Ltd, to provide advice on stormwater quality management in relation to the proposed Altitude Aspire development, located on Fraser Drive and Terranora Road, Terranora in New South Wales. As such its use is limited to this purpose and may not be applicable beyond this scope. Third parties should therefore seek advice from G&S on applicability for any other use.

In preparing this report, we have relied on information supplied by others including:

- Site survey and digital terrain models supplied by B&P Surveys Pty Ltd.
- Altitude Aspire Subdivision Layout Plan prepared by B&P Surveys.
- Civil design prepared by BradLees Ptv Ltd.
- Proposed earthworks staging and cut and fill planning completed by BradLees Pty Ltd.

The accuracy of this report is limited to the accuracy of the information supplied.

While G&S's report assesses average annual pollutant loads, the accuracy of these assessments is limited by the input parameters recommended in the Water by Design 'Music Modelling Guidelines', Version 1.0 2010 (WBD, 2010) that have been accepted by Tweed Shire Council as appropriate guidelines for the purposes of this assessment. The models have not been calibrated. The predicted average annual loads may therefore differ from those measured on site.

Our analysis and overall approach have been specifically to cater for the particular requirements of Newlands and may not be applicable beyond this scope. For this reason any third parties are not authorised to utilise the report without further input and advice from G&S.

7 Appendix 1 – G&S Drawings

ORIENTATION
NORTH

SCALE
100 200 300 400 500
metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs **www.access.gs**

LEGEND

Site boundary

SOURCES

Image source: Tweed Shire Council 'Area E' Aerial Photography
Image date: May 2007
(supplied by B&P Surveys 17/04/2013)

Background DCDB: supplied by B&P surveys
Received:17/04/2013

PROJECT	CLIENT	DRAWING
ALTITUDE ASPIRE TERRANORA NEW SOUTH WALES	NEWLAND DEVELOPERS PTY LTD	SITE LOCATION

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:10 000@A3	17/04/2013	AJF	CMA	10849	101

Brisbane Sydney Melbourne and regions

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ORIENTATION
NORTH

SCALE
40 80 120 160 200
metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs www.access.gs

LEGEND
- Site boundary
- 0.5m contours
- 2.5m contours

SOURCES
Image source: Google Earth Pro
Image date:24/06/2011

PROJECT
ALTITUDE ASPIRE
FRASER DRIVE
TERRANORA
NEW SOUTH WALES

CLIENT
NEWLAND
DEVELOPERS
PTY LTD

DRAWING
EXISTING
DEVELOPMENT

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:4 000@A3	17/04/2013	AJF	CMA	10849	102

Brisbane Sydney Melbourne and regions
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ORIENTATION
NORTH

SCALE
40 80 120 160 200
metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs **www.access.gs**

LEGEND
- Site boundary
- 0.5m contours
- 2.5m contours

SOURCES

Base plan: BradLees Consulting
Received: 20/02/2013

Earthworks contours: BradLees Consulting
Received: 22/22/2013

Background DCDB: supplied by B&P surveys
Received:17/04/2013

PROJECT
ALTITUDE ASPIRE
FRASER DRIVE
TERRANORA
NEW SOUTH WALES

CLIENT
NEWLAND
DEVELOPERS
PTY LTD

DRAWING
PROPOSED
DEVELOPMENT

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:4 000@A3	17/04/2013	AJF	CMA	10849	103

Brisbane Sydney Melbourne and regions
GILBERT SUTHERLAND
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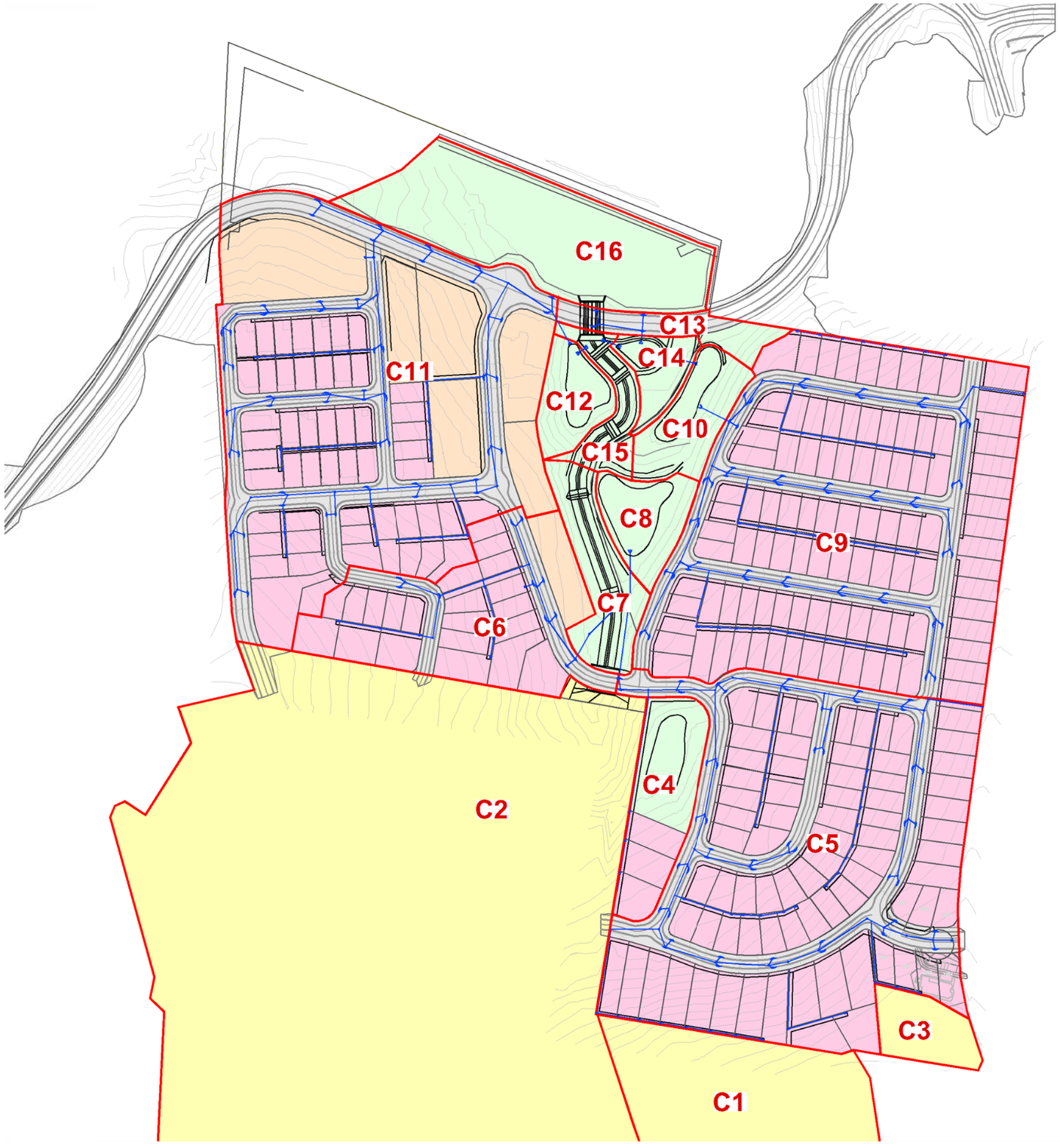

Catchment	Area (ha)	Landuse(s)	Drainage detail	Treatment device(s)
C1	4.46	External	Discharge through central drainage channel bypassing all treatment basins	n/a
C2	30.59	External	Discharge through central drainage channel bypassing all treatment basins	n/a
C3	0.47	External	Discharge through C5 (cannot bypass treatment)	n/a (but treated in bioretention basin 1)
C4	0.98	Urban & Open space	Piped to basin A in C8	Rainwater tanks & Bioretention basin A (C8)
C5	7.94	Urban	Piped to basin A in C8	Rainwater tanks & Bioretention basin A (C8)
C6	2.57	Urban	Piped to basin A in C8	Rainwater tanks & Bioretention basin A (C8)
C7	0.79	Open space	Central drainage channel	n/a
C8	0.56	Open space	Surface runoff to internal bioretention basin A	Bioretention basin A
C9	8.07	Urban	Piped to basin B in C10	Rainwater tanks & Bioretention basin B (C10)
C10	0.66	Open space	Surface runoff to internal bioretention basin B	Bioretention basin B
C11	8.48	Urban	Piped to basin D in C12	Rainwater tanks & Bioretention basin D (C12)
C12	0.48	Open space	Surface runoff to internal bioretention basin D	Bioretention basin D
C13	0.44	Urban (road) & Open space	Piped to basin C in C14	Bioretention basin C
C14	0.35	Open space	Surface runoff to internal bioretention basin C	Bioretention basin C
C15	0.43	Open space	Central drainage channel	n/a
C16	2.44	Open space	Detention area (refer to HHA report) downstream of Broadwater Parkway	n/a

ORIENTATION
NORTH

SCALE
40 80 120 160 200
metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs www.access.gs

LEGEND
- Catchment boundary
- 2.5m contours
- Landuse - urban lots
- Landuse - urban roads
- Landuse - other urban
- Landuse - open space, parks & drainage easement
- Landuse - existing external residential development

SOURCES
Base plan: BradLees Consulting
Received: 20/02/2013

Earthworks contours: BradLees Consulting
Received: 22/22/2013

PROJECT
ALTITUDE ASPIRE
FRASER DRIVE
TERRANORA
NEW SOUTH WALES

CLIENT
NEWLAND
DEVELOPERS
PTY LTD

DRAWING
DEVELOPED CASE
CATCHMENT PLAN
AND DRAINAGE
DETAIL

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:4 000@A3	17/04/2013	AJF	CMA	10849	104

Note (additional treatment requirements):
All single residential dwellings to be fitted with one or more rainwater tanks with total minimum volume of 5kL. Tanks to be connected to toilet cistern(s), washing machine cold water and outdoor taps.

ORIENTATION
NORTH

SCALE
10 20 30 40 50 60
metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs www.access.gs

LEGEND
2.5m contours
Bioretention filter area

SOURCES
Base plan: BradLees Consulting
Received: 20/02/2013

Earthworks contours: BradLees Consulting
Received: 22/22/2013

PROJECT	CLIENT	DRAWING
ALTITUDE ASPIRE FRASER DRIVE TERRANORA NEW SOUTH WALES	NEWLAND DEVELOPERS PTY LTD	STORMWATER QUALITY TREATMENT MEASURES

SCALE	DATE	DRAWN	CHECKED	PROJECT NO	DRAWING NO
1:1 250@A3	17/04/2013	AJF	CMA	10849	105

Brisbane Sydney Melbourne and regions
GILBERT SUTHERLAND
Agriculture. Water. Environment.