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On-site Wastewater Management Report for proposed 3-lot subdivision at 3611 The Lakes Way, Charlotte Bay, NSW

Whitehead & Associates Environmental Consultants Pty Ltd ("W&A") were engaged by Brett Phillips of Lands Advisory Services Pty Ltd (the "Client)" on behalf of the property owner (the "Owner") to prepare an On-site Wastewater Management Report (WMR) for a proposed 3-lot subdivision at 3611 The Lakes Way, Charlotte Bay NSW (the "Site"). The Site, identified as Lot 22 DP236679, is zoned R5 (large lot residential) under the MidCoast LEP (2023) and has a total area of ~9.964ha.

W&A understand the Client is submitting a development application (DA) to MidCoast Council ("MCC" or "Council") regarding the 3-lot subdivision, consisting of a southern lot ("Southern Lot") of approximately 2.372ha, a northern lot ("Northern Lot") of approximately 2.2ha and a middle lot ("Middle Lot") of approximately 5.357ha which is situated between the Northern and Southern lots.

The property features large areas of remnant open-forest in the south, minor patches along the western boundary, and extensive forest throughout the remaining areas. An intermittent dry creek runs through the Middle Lot, extending from the western boundary to the north-eastern boundary. Existing developments include a shed in the Southern Lot, located in a cleared area near the southern road frontage. Plans indicate an access road, nominal building envelope and development footprint for a proposed residential building within each lot. All infrastructure and on-site sewerage management (OSSM) systems are to be retained within these designated development footprint areas. While mains (town) water supply is available to the property, no reticulated sewer service is currently available or anticipated.

The Site is bordered by The Lakes Way road to the south and various private properties with extensive forest surrounding them. The Site is identified as moderately bushfire-affected (vegetation category 3), located in a flood planning area (1% AEP), and has the potential for acid sulfate soils (ASS) at depths greater than 2 meters below ground level in the north-eastern portion of the Northern Lot and Middle Lot (category 4), according to the Great Lakes Local Environmental Plan (2014).

To assess the potential impacts of the sub-division proposal, MidCoast Council ("Council") requires a comprehensive Wastewater Management Report with the DA, in accordance with the

OSSM policy, in order to assess the ongoing capability for sustainable on-site wastewater management at the Site. This WMR presents the results of a detailed site and soil assessment that considers the inherent conditions and constraints of the Site with regard to OSSM to ensure compliance with the relevant standards and guidelines.

1 Author Statement

This WMR was prepared by Errol Delandro who is a graduate Environmental Consultant with W&A, holding a Bachelor of Environmental Science and Management from the University of Newcastle. He has completed the On-site Wastewater Management professional short-course with the Centre for Environmental Training (CET).

2 Introduction

This assessment has been undertaken in reference to the assessment and design principles of:

- *AS/NZS 1547:2012* On-site Domestic Wastewater Management (Standards Australia / Standards New Zealand, 2012);
- Environment & Health Protection Guidelines: On-site Sewage Management for Single Households (Department of Local Government, 1998);
- On-site Sewage Development Assessment Framework (DAF). Final Version, dated 13 October 2020 (MidCoast Council, 2020); and
- On-site Sewage Management Technical Manual. Final Version, dated 1 September 2020 (MidCoast Council, 2020).

The following table presents information on the property investigated.

Feature	Description
Site Address	3611 The Lakes Way, Charlotte Bay NSW
Lots	Lot 22 DP236679
LGA	MidCoast Council
Land Zoning	R5 (large lot residential)
Site Size (ha)	~9.964ha
Sewer Connection Available	No
Potable Water Supply	Mains (town) water supply

3 Site and Soil Assessment

The Site investigation was undertaken by Errol Delandro of W&A on the 16th of July 2024. The following tables present the results of our site and soil investigation for the property.

A description of the Site physical constraints and the degree of limitation they pose to OSSM is provided in the following table. Reference is made to the rating scale in Table 4 of the NSW DLG (1998).

SITE ASSESSMENT			
Parameter	**Data / Observation**	**Reference**	**Classification/ Outcome**
Climate	The Site experiences a temperate climate typical of south eastern Australia. Median annual rainfall for the Site is 1,086.6mm. Monthly rainfall ranges from 58.9mm in September to 126.2mm in May.	BOM Station 060028 (Seal Rocks Camping Reserve)	Minor limitation
	Mean annual pan evaporation for the Site is 1396.52mm. Potential evaporation exceeds rainfall for 8 months of a typical year at the Site.	SILO POINT DATA (-32.35, 152.5)	
Sizing		per NSW DLG (1998) and *AS/NZS 1547:2012* procedures (refer Appendix C)	
Hydraulic modelling attached:	Yes		
Nutrient modelling attached:	Yes		
Land application area (LAA) sizing attached:	Yes		
Wet weather storage requirement:	N/A	N/A	
Flooding		LEP mapping (2014) indicates the site is flood affected (1% AEP)	Minor limitation
LAAs above 1:20 ARI flood level:	Yes		
LAAs above 1:100 ARI flood level:	Yes		
Electrical components above 1:100 ARI flood level:	Yes		
Exposure and Aspect	The Site is heavily vegetated with open forest, with an area of cleared vegetation in the south-western area around the existing shed. Vegetation within the development footprint is to be cleared (shown in Figure 2 Appendix A). Aspect is predominantly to the south within the available effluent management areas (EMA) in the Northern and Middle Lots, and the EMA within the Southern lot has a north-eastern aspect.	Minor limitation	
Slope	Slopes within the available EMA **Southern Lot:** 6% - 13% **Northern Lot:** 8% - 15% **Middle Lot:** 2% - 8%	Minor to Moderate limitation	
Landform	**Southern Lot:** Most of EMA is on the top of a hill crest with the northern side being on a linear divergent slope **Northern Lot:** Linear divergent **Middle Lot:** Waxing planar	Minor limitation	

Run-on and Seepage	Potential for run-on within EMA of Northern and Middle Lot, none identified for Southern Lot		Minor to moderate limitation
Erosion Potential	No erosion evident within available EMA		Minor limitation
Site Drainage	Well-drained ground surface in proposed LAA locations		Minor limitation
Fill	None observed or apparent		Minor limitation
Groundwater	No shallow groundwater ("GW") encountered during the soil survey. NSW Office of Water GW bore registry indicates no registered 'domestic' bores are located within 250m of the Site.		Minor limitation
Applicable Buffers			
Permanent rivers and creeks (100m):		Yes	Achievable
Intermittent creeks, drainages and dams (40m):		Yes	Reduced buffer justification
Domestic groundwater bore (250m):		N/A	
Lot boundaries (3m if EMA downslope – 6m if EMA upslope):		Yes	Achievable
Buildings, driveways and swimming pools (3m if EMA downslope – 6m if EMA upslope):		Yes	Achievable
Limiting horizon (groundwater, bedrock etc.) (0.6m):		Yes	Achievable
Other sensitive receptors:		N/A	
Surface Rocks / Outcrops	No surface rocks or outcrops observed during the Site investigation.		Minor limitation
Available EMA	Available EMA is presented in Appendix A Figure 2 **Southern Lot:** Available EMA = 1.4ha, available EMA within development footprint = 0.23ha; **Northern Lot:** Available EMA = 1.31ha, available EMA within development footprint = 0.25ha; **Middle Lot:** Available EMA = 1.68ha, available EMA within development footprint = 0.23ha		Minor limitation – moderate limitation (EMA within development footprint)
Concluding Remarks Slope and available EMA within development footprint pose a moderate constraint to OSSM at the Site; however, these can be mitigated or avoided through conservative LAA location, design and installation.			

Potential for run-on and up-slope seepage pose a moderate constraint to OSSM at the Northern and Middle lots, however these can be mitigated by directing stormwater from upslope areas away from proposed LAAs (refer Section 8.3).

SOIL ASSESSMENT (physical)			
Parameter	**Data/ Observation**	**Reference**	**Classification/ Outcome**
Soil Depth	>1,200mm	Minor limitation	
Soil Profile	**<u>BH1:</u>** A: 0mm - 200mm, moderately structured, black, clay loam (Cat 4) B_1: 200mm - 900mm, weakly structured, grey, medium clay (Cat 6) B_2: 900mm – 1,200mm, weakly structured, light grey, medium clay (Cat 6) **<u>BH2:</u>** A: 0mm - 200mm, moderately structured, black, clay loam (Cat 4) B_1: 200mm - 900mm, weakly structured, grey, medium clay (Cat 6) B_2: 900mm – 1,200mm, weakly structured, light grey, medium clay (Cat 6) **<u>BH3:</u>** A: 0mm - 200mm, moderately structured, black, clay loam (Cat 4) B_1: 200mm - 600mm, weakly structured, grey, medium clay (Cat 6) B_2: 600mm – 1,200mm, weakly structured, light grey, medium clay (Cat 6) **<u>BH4:</u>** A: 0mm – 200mm, moderately structured, black, clay loam (Cat 4) B_1: 200mm – 550mm, weakly structured, grey, medium clay (Cat 6) B_2: 550mm – 1,200mm, weakly structured, light grey, medium clay (Cat 6) **<u>BH5:</u>** A: 0mm – 50mm, moderately structured, black, clay loam (Cat 4) B_1: 50mm – 600mm, weakly structured, grey, medium clay (Cat 6) B_2: 600mm – 1,200mm, weakly structured, light grey, medium clay Cat 6) **<u>BH6:</u>**	Major limitation	

SOIL ASSESSMENT (physical)			
Parameter	**Data/ Observation**	**Reference**	**Classification/ Outcome**
	A: 0mm – 100mm, moderately structured, black, clay loam (Cat 4) B_1: 100mm – 500mm, weakly structured, grey, medium clay (Cat 6) B_2: 500mm – 1,200mm, weakly structured, medium clay (Cat 6) *Locations of boreholes shown in Figure 2 of Appendix A.* *Soil borelogs and laboratory results presented as Appendix B.*		
Depth to Water Table	Shallow (episodic) water table not encountered.	Minor limitation	
Coarse Fragments (%)	<2%	Minor limitation	
Soil Permeability	<0.06m/day (inferred)	Based on limiting weakly structured medium clay (Cat 6)	Major limitation
Modified Emerson Aggregate Class (EAT)	Topsoil: 3(1) – 3(2) (slightly to moderately unstable) Subsoils: 3(2) – 1 (slightly to very highly unstable)	Moderate - Major limitation	
Soil Landscape	**Myall Forest:** Gently undulating rises to rolling low hills on Koolanock Sandstone in the central east of the Hunter Region. Slopes 0 - 30 %, local relief 20 - 50 m, elevation 10 - 80 m. Partly cleared open-forest. Deep (100 - <150 cm), well-drained Mottled Red Kurosols (Red Podzolic Soils); moderately deep (50 - <100 cm), imperfectly drained Mottled Dystrophic Brown Kurosols (Yellow Podzolic Soils); moderately deep (50 - <100 cm), imperfectly drained Bleached-Sodic Grey Kurosols (Soloths and Solods); and shallow (25 - <50 cm), well-drained Bleached-Leptic Tenosols (Lithosols). **Shringlers Creek:** Level plains to undulating plains and fans on eroded Quaternary sediments in the	Soil Landscapes of the Bulahdelah 1:100 000 Sheet	

SOIL ASSESSMENT (physical)			
Parameter	**Data/ Observation**	**Reference**	**Classification/ Outcome**
	Kempsey-Myall Coastal Low Hills in the north east of the Hunter Region. Slopes 0 - 5%, local relief 2 - 10 m, elevation 10 - 280 m. Partially cleared tall open-forest. Very deep (150 - 500 cm), slowly permeable and poorly drained Bleached-Sodic Natric Brown Kurosols (Soloths); deep (100 - <150 cm), slowly permeable and imperfectly drained Eutrophic Mottled-Subnatric Yellow Sodosols (Soloths and Solods); and moderately deep (50 - <100 cm) to very deep (150 - 500 cm), slowly permeable and poorly drained Acidic-Sodic Kurosolic Redoxic Hydrosols (Humic Gleys).		

Concluding Remarks

Site natural soils are categorised by 0mm – 200mm of moderately structured, clay loam top soils (Category 4) underlain by 200mm – 1,200mm weakly structured medium clay (Category 6).

Soil permeability and soil stability pose a major constraint within the EMA; however, Soil permeability limitations can be mitigated or avoided through conservative LAA selection and design. Soil stability limitations can be managed by soil improvement measures (refer Section 8.1).

Based on identified soil characteristics a (maximum) Design Loading Rate (DLR) of 2mm/day is recommended for secondary subsurface irrigation systems, with reference to Table M1 AS/NZS 1547:2012 for weakly structured medium clay (Cat 6) subsoils.

SOIL ASSESSMENT (chemical)				
Parameter	**Data/ Observation**		**Reference**	**Classification / Outcome**
Myall Forest (Southern Lot)				
pH	Topsoil: 2.92 – 5.25 Subsoil: 2.52 – 3.5	Strongly acidic to extremely acidic	Moderate - Major limitation	
EC (EC_e)	Topsoil: 0.13 – 0.24 Subsoil: 0.10 – 1.3	Non-saline	Minor limitation	
ESP (%)	14.8	Strongly sodic	SALIS Report: WEL/96/37/446(1) (refer Appendix B)	Major limitation
CEC (me/100g)	17.3	Medium fertility		Minor limitation

SOIL ASSESSMENT (chemical)				
Parameter	**Data/ Observation**		**Reference**	**Classification / Outcome**
Myall Forest (Southern Lot)				
P-sorption (mg/kg)	825	Very high P-sorption		Minor limitation
Shinglers Creek (Northern and Middle Lots)				
pH	Topsoil: 2.93 – 3.60 Subsoil: 2.64 – 3.66	Extremely acidic	Major limitation	
EC (EC_e)	Topsoil: 0.09 – 0.18 Subsoil: 0.08 – 0.32	Non-Saline	Minor limitation	
ESP (%)	20.7	Strongly sodic	SALIS Report: WEL/94/37/265(1)(refer Appendix B)	Major limitation
CEC (me/100g)	29	High fertility		Minor limitation
P-sorption (mg/kg)	376	Medium-high P-sorption		Minor limitation
Concluding Remarks The pH and sodicity (ESP) of Site soils pose a major constraint to OSSM; however it can be mitigated through soil improvement recommendations (refer Section 8.1). *Site soil test results and soil chemistry data is presented in Appendix B.* *General notes on soil chemistry parameters are presented in Appendix E.*				

4 Wastewater Generation

4.1 Wastewater Quantity

Each created lot is required to have a separate OSSM system. For assessment, W&A have assumed a five (5) bedroom dwelling on all three (3) lots. Potable water for each lot will be supplied by reticulated town (mains) water supply.

The assumed wastewater hydraulic load associated with future dwellings on each lot is presented in the following table.

	Value	Description
Number of Bedrooms (Each Lot)	5	Proposed five (5) bedroom dwelling
Occupancy Rate (Persons Per Bedroom)	2 equivalent population (EP) for the first 2 bedrooms, 1EP thereafter.	Section 6.2 (MCC DAF, 2020)

	Value	Description
Equivalent Population (EP) Proposed Dwelling (Each Lot)	7	(2 beds x 2EP) + (3 beds x 1EP)
Wastewater Generation (L/person/day)	150	Table 30 of MCC DAF (2020) for reticulated water supply
Design Hydraulic Load (L/day) Proposed Dwelling (Each Lot)	**1,050**	7EP x 150 L/person/day

4.2 Wastewater Quality

The contaminants in wastewater have the potential to create undesirable public health concerns and pollute waterways unless managed appropriately. As a result, wastewater must be treated to remove the majority of pollutants and enable attenuation of the remaining pollutants through soil processes and plant uptake.

Wastewater generated by the dwellings on the created lots is expected to be of ‘typical’ domestic nature, with combined wastewater; blackwater (toilet) and greywater (kitchen, laundry and shower) streams. As such, untreated wastewater is expected to have characteristics similar to that described in the table below; which incorporates information taken from the NSW DLG (1998).

Parameter	Loading	Greywater %	Blackwater %
Daily Flow		65	35
Biochemical Oxygen Demand	200-300mg/L	35	65
Suspended Solids	200-300mg/L	40	60
Total Nitrogen	20-100mg/L	20-40	60-80
Total Phosphorus	10-25mg/L	50-70	30-50
Faecal Coliforms	10^3 – 10^{10}cfu/100ml	Medium – High	High

4.3 Water Saving Measures

To minimise wastewater generation, it is recommended that all domestic water use fixtures in the proposed dwelling be installed in accordance with BASIX requirements, including installation of ‘standard’ water reduction fittings.

Standard water reduction fixtures for internal and external water use include:

- Taps – WELS 4-star (or better) rated;
- Toilets – 4.5/3.0 litre dual flush pan and cistern;
- Showers – WELS 3-star (or better) rated; and
- Dishwashers (if used) – AAA rated using as little as 18 litres per wash.

Implementation of these measures is expected to reduce water use, and thereby wastewater generation, by as much as 10 – 15%.

5 Proposed Wastewater Treatment

5.1 Sub Division Lots

The following sections describes the Site's capability for sewage treatment for a (maximum) 5-bedroom dwelling on each of the Northern Lot, Southern Lot and Middle Lot.

Given the identified site and soil limitations, primarily Category 6 subsoils and vegetation limiting the area available to only the development footprint; Primary treatment systems (i.e. septic tanks) are not recommended as they significantly limit effluent disposal and reuse options and pose a higher risk to human and environmental health compared to secondary or tertiary treatment systems.

5.2 Recommended Wastewater Treatment System

Secondary treatment is aimed at the removal of dissolved and suspended organic material by a combination of physical and biological methods, usually incorporating both aerobic and anaerobic phases. Secondary treatment presents a significantly lower risk to human health and the environment when compared to conventional primary (septic tank) systems.

The NSW Ministry of Health ("NSW Health") provides accreditation for domestic secondary treatment systems in NSW. The system selected for each lot must hold such an accreditation. Appropriate secondary treatment technologies include (but are not limited to) the following:

- Aerated wastewater treatment systems (AWTS);
- Media / textile filter systems (site-specific design required); and
- Aerobic sand filters (site-specific design required).

A detailed list of suitable NSW Health accredited systems can be found at:

http://www.health.nsw.gov.au/environment/domesticwastewater/Pages/default.aspx

Disinfection units are typically installed as a standard component of proprietary secondary treatment systems, or can be installed as an add-on by the system supplier. W&A recommend that a disinfection unit is installed with the chosen system. Domestic systems typically use one or a combination of the following disinfection methods:

- Ultra violet (UV) irradiation; and / or
- Chlorination.

Final system selection will be the responsibility of the Client; however, selection and installation of the system must follow Council requirements and consistently achieve the prescribed minimum secondary effluent quality standard (refer Section 5.3).

5.3 Treated Effluent Quality

Table 14 of DLG (1998) describes the minimum effluent quality standard for secondary treatment systems. For reference, these effluent quality parameters are reproduced in the table below.

Parameter	Loading
Biochemical Oxygen Demand	≤20mg/L (>90% of samples)
Suspended Solids	≤30mg/L (>90% of samples)
Faecal Coliforms	≤30cfu/100mL (>90% of samples)

Parameter	Loading
Total Nitrogen	≤35mg/L
Total Phosphorus	≤15mg/L

The listed phosphorus and nitrogen concentration values are targets and have been adopted for nutrient balance modelling.

5.4 System Siting

The exact positioning of the treatment systems will depend on the local gradient and level controls and can be determined in consultation with a licensed plumber and Council prior to obtaining consent for the installation of the system. All plumbing and drainage works must be completed in accordance with the National Construction Code, which incorporates the Plumbing Code of Australia.

5.5 System Operation and Management

Successful performance of wastewater treatment systems relies on periodic monitoring and maintenance, which will be the responsibility of the individual property Owner. The selected treatment system should be serviced by a suitably qualified technician at the prescribed intervals.

6 Proposed Effluent Management

This section describes the Site's capability for effluent management and provides design details, including sizing of the required LAA for the dwellings on both lots. As detailed in the previous section, secondary treatment (with disinfection) is considered the most appropriate wastewater treatment option for all lots.

6.1 On-site Effluent Management Options

W&A have considered the suitability of various land application systems with regard to the identified site and soil limitations. In determining the suitability of the various options, we have assessed the Site constraints and the relative environmental and public health risks associated with each.

The following table provides a summary analysis of the effluent land application options considered for each lot, and presents recommendation for the preferred approach to be used in conjunction with the proposed secondary treatment system selected.

Land Application Option	Suitable	Reasoning
Absorption Trenches / Beds	No	Considered unsuitable for Cat 6 subsoils due to slowly permeable soils (Table L1, AS/NZS 1547:2012)
ETA Beds	Yes	Considered unsuitable due to slope (>10%) and area constraints (*AS/NZS 1547:2012*).
Mounds	No	Considered suitable, but Site conditions do not indicate the necessity for mounds to overcome an identified site or soil constraint. Mounds are further discounted due to their substantial cost.
Surface Irrigation	No	Not recommended due to risk of exposure.

Land Application Option	Suitable	Reasoning
Subsurface Irrigation (SSI)	Yes	Considered suitable as effluent is able to be applied high in the soil profile, maximising evapotranspiration and vegetation uptake. Treated effluent must be disinfected.

6.2 Subsurface Irrigation

SSI is the preferred method of effluent disposal for each lot. SSI is suitable within lawn and landscaped areas and applies effluent within the root-zone of plants for optimum irrigation efficiency. It is an ideal option for ensuring even, widespread coverage of the proposed irrigation area. SSI installation does not require any bulk materials or heavy machinery; irrigation lines can be simply installed with a small trench digger or "ditch-witch".

Proprietary, pressure-compensating subsurface drip (PCSD) irrigation pipe designed for use with treated effluent should be used that will ensure distribution of effluent at uniform, controlled application rates. These products have been specifically designed for use with effluent and allow for the higher BOD_5, suspended solids, nutrient and biological loads usually present in effluent compared to potable water. They contain specially designed emitters that reduce the risk of blockage, typically incorporating chemicals that provide protection against root intrusion and biofilm development (e.g. Trifluralin or copper). The dripper lines are coloured lilac to clearly identify that they are irrigating treated effluent.

6.3 Buffers

Buffer distances from LAAs are recommended to minimise risk to public health, maintain public amenity and protect sensitive environments. Buffer or setback distances are recommended to provide a form of mitigation against unidentified hazards and reduce potential pathways of human and environmental exposure.

The following environmental buffers are required, based on Table 5 of DLG (1998):

- 250m from domestic groundwater bores;
- 100m from permanent watercourses;
- 40m from intermittent watercourses and dams;
- 6m if area up-gradient and 3m if area down-gradient of driveways, swimming pools, property boundaries and buildings;
- 0.6m vertical separation from hardpan or bedrock.

All of the required buffers can be achieved at the Site; however, the strict application of 40m setbacks from intermittent water courses (intermittent dry creek) significantly limits available EMA at the Site.

Therefore, a reduced buffer from intermittent watercourse features is proposed. Buffer risk assessment and viral die-off modelling was undertaken to support an appropriate reduction in the applied buffers to these features (refer Section 7).

6.4 LAA Sizing

Water and nutrient balance modelling was undertaken to determine the sustainable application rate for the Site soils and to estimate the necessary size of the LAA required to manage the proposed hydraulic and nutrient load from each dwelling. The procedures for this generally follow the NSW DLG (1998) guidelines.

The water balance used is a monthly model adapted from the “Nominated Area Method” described in the NSW DLG (1998). These calculations determine the minimum LAA size for the given effluent load for each month of the year. The water balance can be expressed by the following equation:

Precipitation + Effluent Applied = Evapotranspiration + Percolation + Storage

A conservative (annual) nutrient balance was also undertaken, which calculates the minimum application area required to ensure no nutrients will leach into the water table. The nutrients (nitrogen and phosphorus compounds) are removed from the effluent via assimilation within the soil strata and uptake by the overlying crop. The nutrient balance used here is based on the simplistic NSW DLG (1998) methodology, but improves this by more accurately accounting for natural nutrient cycles and processes.

The inputs and results of the analyses are presented in the following table. Full water and nutrient balance results are presented in Appendix C.

Parameter	Units	Value	Comments	
Design (daily) hydraulic load	L/day	1,050	All lots	Refer Section 4.1
Precipitation	mm/month	Median monthly	BOM Station 060028	
Pan evaporation	mm/month	Mean monthly	Silo Data (-32.35, 152.5)	
Retained rainfall	Unitless	0.7	Conservative assumption that 70% of rainfall remains on-site and infiltrates the soil	
Crop factor	Unitless	0.6 – 0.8	Conservative annual value for grass (adjusted for seasons)	
DIR	mm/day	2	Based on Table M1 *AS/NZS 1547:2012* for secondary effluent in Cat 6 soils (all subdivision lots)	
Effluent total nitrogen concentration	mg/L	≤35	Target effluent quality following secondary treatment, from Table 14 NSW DLG (1998)	
Nitrogen lost to soil processes	annual percentage	20	Geary & Gardner (1996)	
Effluent total phosphorus concentration	mg/L	12	Target effluent quality following secondary treatment, from Table 14 NSW DLG (1998)	
Soil phosphorus sorption capacity (Northern Lot and Middle Lot)	mg/kg	376	SALIS Report: WEL/94/37/265(1)	
Soil phosphorus sorption capacity (Southern Lot)	mg/kg	823	SALIS Report: WEL/96/37/446(1)	

Parameter	Units	Value	Comments
Nitrogen uptake rate by plants	kg/ha/yr	260	Conservative estimate based on published nutrient uptake rates in DECCW (2004) for grass (September – March)
Phosphorus uptake rate by plants	kg/ha/yr	30	
Design life of system (for nutrient management)	Years	50	NSW DLG (1998) guideline recommended design life.

Results			
	Southern Lot	**Middle Lot**	**Northern Lot**
Water Balance (m^2)	2,264	2,264	2,264
Nitrogen Balance (m^2)	354	354	354
Phosphorus Balance (m^2)	228	411	411

Based on the hydraulic and nutrient modelling outcomes, the hydraulic load is the limiting factor for sizing on all three (3) subdivision lots. Therefore, a minimum SSI LAA of 2,264m^2 is required to service each subdivision.

6.5 Installation and Detail

A critical element of the design process is hydraulic design including selection of appropriate dripline, dosing and flush manifold pipe, lateral and emitter spacing and pump performance. Dripline typically needs an operating pressure at the emitter of 10 – 40m (head) to maintain pressure compensation. As such, higher head, low flow pumps are required to service drip irrigation systems that differ from pumps traditionally used in OSSM.

Lateral pipes should be spaced to provide good and even coverage of the area they service. Generally, they should be no more than 1m apart, roughly parallel and along the contour as close as possible. SSI shall be installed at a depth of 100 – 150mm into the topsoil as per AS/NZS 1547:2012. The MCC DAF (2020) also requires a minimum depth of 600mm of soil to exist from the bottom of the irrigation laterals to the limiting layer (bedrock or weathered rock) or water table.

General specifications for the SSI LAAs are as follows:

- Effluent must be applied evenly across the LAA;
- LAAs should be fenced off from livestock access;
- Driplines to be buried at a minimum 100mm depth below the finished ground surface;
- PCSD line specifically designed for effluent irrigation (e.g. Toro Drip-in, Netafim Bioline or Safe-T-Flo) shall be installed. 1.6 – 2.1 litres per hour emitters should be used;
- An in-line 120µm disc filter may be installed to minimise the amount of solids entering the pipelines and emitters. This must be removed and cleaned regularly (at least at 3-monthly intervals). Alternately, a flush main may be installed to periodically clean-out the irrigation lines to provide effective long-term performance. Either manual or automatic flush valves may be installed, with flush water directed back to the treatment system;

- Air release valves will be installed at the high points in individual irrigation areas to prevent soil particles being sucked into the lines at the end of pump cycles as pipelines depressurise; and
- An ‘as-built’ layout of the OSSM system (treatment and LAA) shall be provided to Council and the system Owner upon completion.

Figure 3 in Appendix A provides a schematic representation of a generic SSI system. Specialist advice must be obtained for designing and installing the irrigation systems.

6.6 LAA Positioning

Available and suitable areas for effluent application are shown in Figure 2 of Appendix A as ‘Available EMA’. These areas exclude minimum setback distances as described in Section 6.3 and the reduced buffer described in Section 7.1.

6.7 Reserve LAA

Section 6.5.4 of the MCC DAF (2020) removes the need for the provision of a reserve area for LAAs dosed with secondary effluent.

7 Risk Analysis

Strict application of a recommended (40m) buffer to an identified intermittent watercourse (Middle Lot western boundary through to north-eastern boundary) significantly reduces the available EMA at the Site.

7.1 Buffer Risk Assessment

AS/NZS 1547:2012 recommends that if a high level of constraint is identified for any Site feature, the maximum setback values should be considered. However, in practice the overall setback distance should be “based on an evaluation of the [relevant] constraint items and corresponding sensitive features and how these interact to provide a pathway or barrier for wastewater movement” to the Site feature.

The following assumptions are used in assessing the proposed LAA design and to support a reduction in the recommended setback distance:

- Secondary treated effluent (with disinfection);
- Category 6 (limiting) well-drained soils;
- Slope ~12% across the proposed LAA;
- Subsurface application method (SSI) with surface water features and 20m downslope (intermittent water course); and
- Proposed LAA located outside of any flood impacted lands.

AS/NZS 1547:2012 recommends a setback distance range of 15m (low risk) – 100m (high risk) for surface water features. Based on the analysis, a reduction in the setback to surface water features to <u>20m</u> is supported. A copy of the buffer justification matrix is presented in Appendix D.

7.2 Viral Die-Off Modelling

To quantify the risk regarding the transport of pathogens away from the LAA towards intermittent waterways, W&A have considered the movement of viruses away from the LAA using an established 1-dimensional viral die-off model developed by Beavers and Gardner (1993) and refined by Cromer *et al*. (2001). Details of the methodology can be found in Cromer *et al*. (2001).

The model generally applies to effluent moving in saturated soils, i.e. in shallow GW beneath a LAA. These conditions are considered most conducive to pathogen transport. In unsaturated (vadose zone) soils, the travel distances will be substantially less. As such, the method is considered very conservative when applied to sites with drained topsoils and deep water tables. Some key assumptions used in the modelling are as follows:

- Bacteria have lesser die-off times than viruses and can therefore be assumed to be eliminated within a shorter distance than viruses (Cromer *et al*. 2001);
- Viral reduction has been set at three (3) orders of magnitude for secondary treatment within the existing AWTS (Cromer *et al*. 2001); and
- GW temperature based on the assumption of 13.5°C (SILO Point Data (-32.35, 152.5) mean minimum temperature. Cooler temperatures allow viruses to reside longer in the soil and hence provide potentially greater travel distances.

Modelling inputs and predicted maximum viral transport distances are provided in the following table. Appendix D provides additional information on the modelling methodology and full results.

Parameter	Value
GW Temperature (ºC)	13.5
Days Required for Viral Reduction Level	29
Porosity of Soil (decimal)	0.47
K_{sat} (m/day)	0.06
Groundwater Gradient (%)	12
Depth to GW (m)	1.2
Horizontal distance travelled in GW (m)	0.3

Viral die-off modelling demonstrates that with secondary treatment (with disinfection), 100% pathogen reduction within the soil is expected to occur within 0.3m from the installed LAA boundary; reducing contaminants to background levels well within the available downslope setback of 20m, and well before reaching any sensitive receptors.

8 Mitigation Measures

8.1 Soil Improvement

Given that Site soils are sodic and are identified as extremely acidic vegetative growth may be impacted within the LAA. These properties can combine to reduce the soils' capacity to sustainably manage wastewater.

Prolonged application of sodium rich wastewater can exacerbate the situation. Application of a calcium mineral is a recognised way of reducing the effects of poor soil fertility and instability. It does this by supplying calcium to the affected soil and thereby elevating calcium concentrations with respect to sodium. Added calcium will improve the soil CEC and Ca/Mg ratio, improving fertility, while reducing the potential for soil structural degradation. Gypsum is the preferred soil amendment for improving soil fertility via raising calcium levels.

Site soils are also defined as very strongly acidic; as such, lime application is recommended to off-set potential future impacts on vegetation and pipework while improving the calcium / magnesium ratio and general soil fertility and improve groundcover growth.

Gypsum and Lime are only slowly soluble in water, so simply broadcasting at the surface can be of limited benefit as it can take a long time for the calcium to penetrate the soil and reach the deeper soil layers. Therefore, it is recommended to incorporate a 50/50 Gypsum/Lime mixture into the subsoil during construction of the land application system. A suitable application rate of approximately 0.6kg/m^2 should be applied.

8.2 Vegetation Establishment

Vegetation that is suited to the application of effluent, preferably with high water and nutrient requirements (such as turf) should be established over the LAAs following construction. A complete vegetation cover is important to reduce the erosion hazard and optimise water and nutrient uptake.

It is recommended to establish and maintain a vegetated buffer around the LAAs. It should be planted with moisture-tolerant vegetation and remain well maintained to maximise moisture uptake. Plants must be selected that will not be so large as to shade the LAAs once fully grown. It is important that the LAAs receive maximum exposure to sun and wind to maximise evapotranspiration.

To maximise assimilation of effluent-borne nutrients within the LAAs, vegetation clippings should be removed from the LAAs and mulched elsewhere on-site for use in other landscaped areas that are not used for wastewater application. Mulching the clippings back onto the area from which they were cut is not recommended. An alternative is to dispose clippings in the general waste bin, or green waste bin collection service, if provided.

8.3 Stormwater Management

The performance of LAAs (and potentially treatment systems) can be adversely affected if stormwater is allowed to run onto these areas. Stormwater diversion devices should be designed and constructed to collect, divert and dissipate collected run-on away from the LAAs. The structure(s) should be designed and installed by a suitably qualified professional and be compliant with relevant guidelines and standards.

A diagram of a ‘typical’ stormwater diversion, which would be appropriate for this purpose, is provided in Appendix A as Figure 4. The outlet must be stabilised and must discharge water in a safe location where it will not create an erosion hazard or impact on structures or neighbouring properties.

9 Conclusions and Recommendations

This completes our assessment of the Site's capability for sustainable OSSM in relation to the proposed subdivision at 3611 The Lakes Way, Charlotte Bay NSW. Specifically, we recommend the following:

- Wastewater generated from the future dwellings on all three (3) subdivision lots is to be treated to a secondary standard within an appropriately sized and located NSW Health accredited secondary treatment system (with disinfection);
- Secondary treated effluent is to be reused on-site via a pressure-compensating SSI LAA, with a minimum area of 2,264m^2;
- The SSI LAA should be designed and installed by an experienced professional taking into account the expected flows and other recommendations contained within this report;
- The proposed LAAs must be located within the available EMA, Nominal LAA locations are shown in figure 2 Appendix A;
- A suitable 50/50 gypsum/lime application rate of approximately 0.6kg/m^2 should be applied at the base of the land application systems during installation;
- Vegetation must be established over the LAAs immediately after installation;
- Stormwater run-on must be directed away from the proposed LAAs; and
- Vehicles and grazing animals must be prevented from entering the designated LAAs.

Yours Sincerely,

Errol Delandro
Graduate Environmental Consultant
Whitehead & Associates Environmental Consultants Pty Ltd

Appendix A

Figures

Figure 1: Site Locality

Job Number 3703: WMR for proposed 3-lot subdivision at 3611 The Lakes Way, Charlotte Bay, NSW

Whitehead & Associates Environmental Consultants

Revision	001
Drawn	ED
Approved	MS

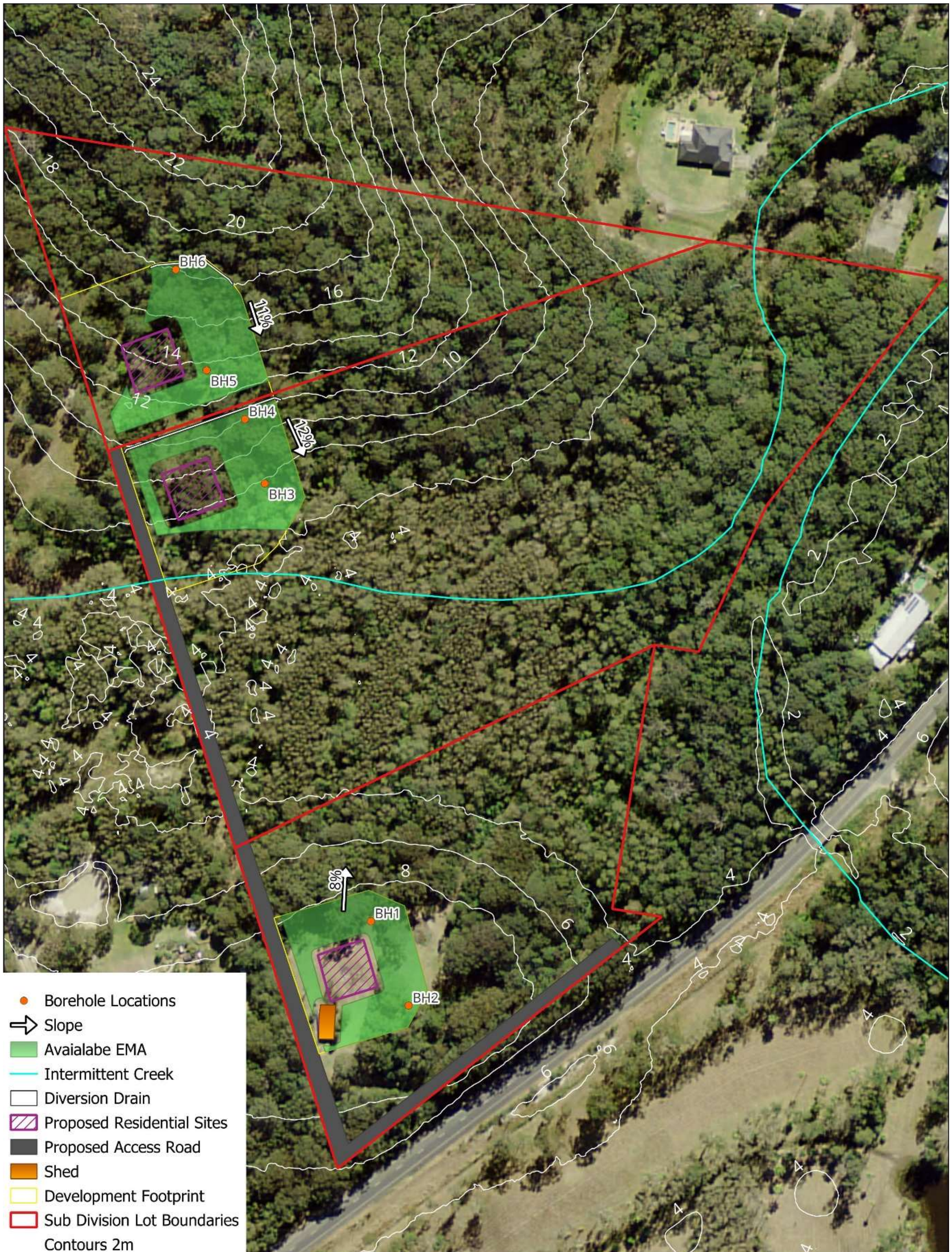


Figure 2: Site Plan Showing Proposed Subdivision OSSM

Job Number 3703: WMR for proposed 3-lot subdivision at 3611 The Lakes Way, Charlotte Bay NSW

Whitehead & Associates
Environmental Consultants

0 25 50 75 100 125 150 175 200 m
(Approx Scale)

N

Revision	001
Drawn	ED
Approved	MS

NOTES

Design for long lateral runs on relatively uniform slope.

An earth bank diversion drain must be constructed upslope of each zone to divert stormwater run-on.

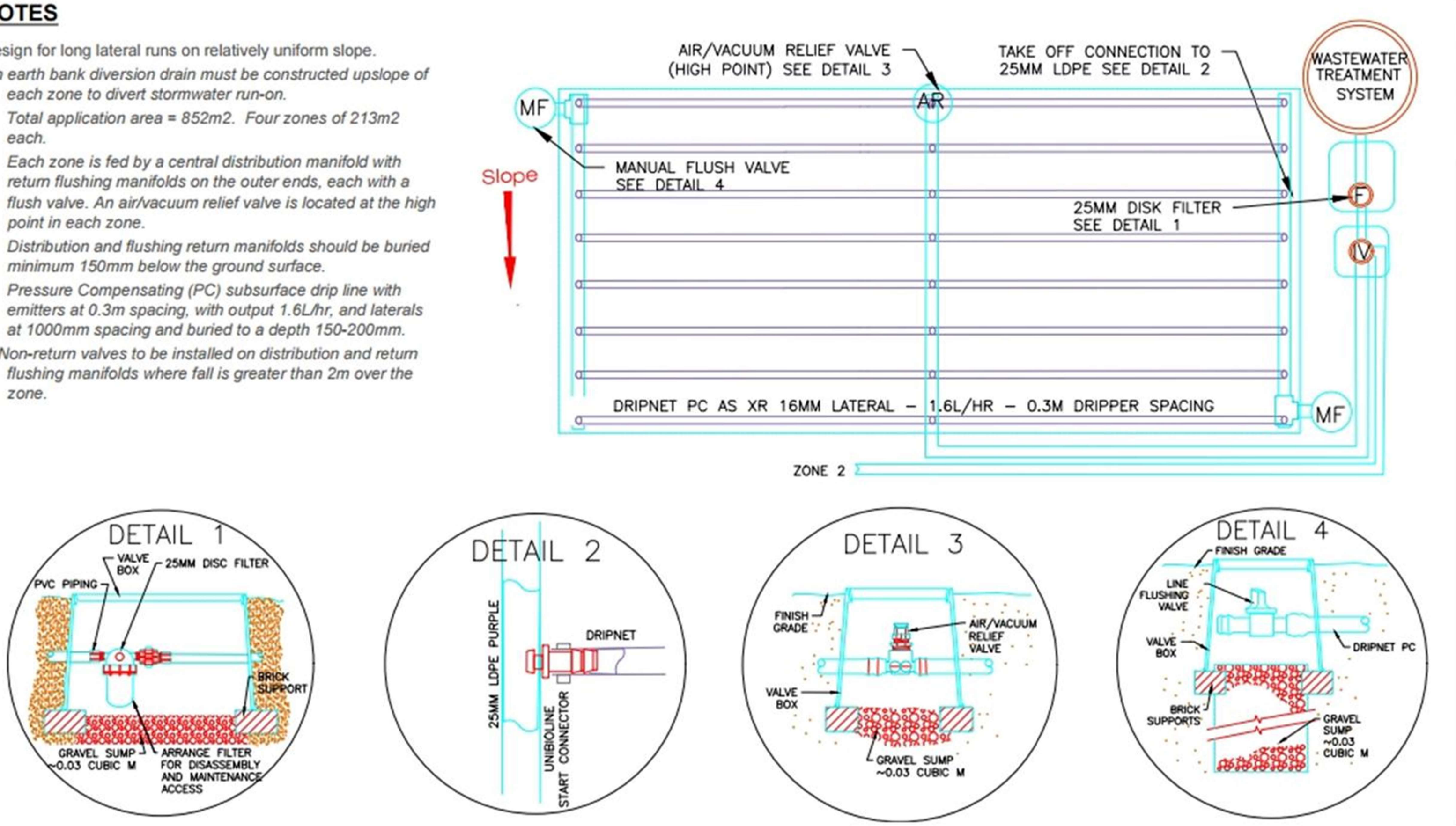
A Total application area = 852m2. Four zones of 213m2 each.

B Each zone is fed by a central distribution manifold with return flushing manifolds on the outer ends, each with a flush valve. An air/vacuum relief valve is located at the high point in each zone.

C Distribution and flushing return manifolds should be buried minimum 150mm below the ground surface.

D Pressure Compensating (PC) subsurface drip line with emitters at 0.3m spacing, with output 1.6L/hr, and laterals at 1000mm spacing and buried to a depth 150-200mm.

E Non-return valves to be installed on distribution and return flushing manifolds where fall is greater than 2m over the zone.



Courtesy: Netafim Australia Pty Ltd

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This standard design has been based on a generic area for irrigation based on typical conditions. It does not eliminate the need for a site and soil evaluation to be carried out or any additional consideration of site specific issues. It should be used as a generic guide only.

Figure 3: Standard Drawing, Subsurface Irrigation

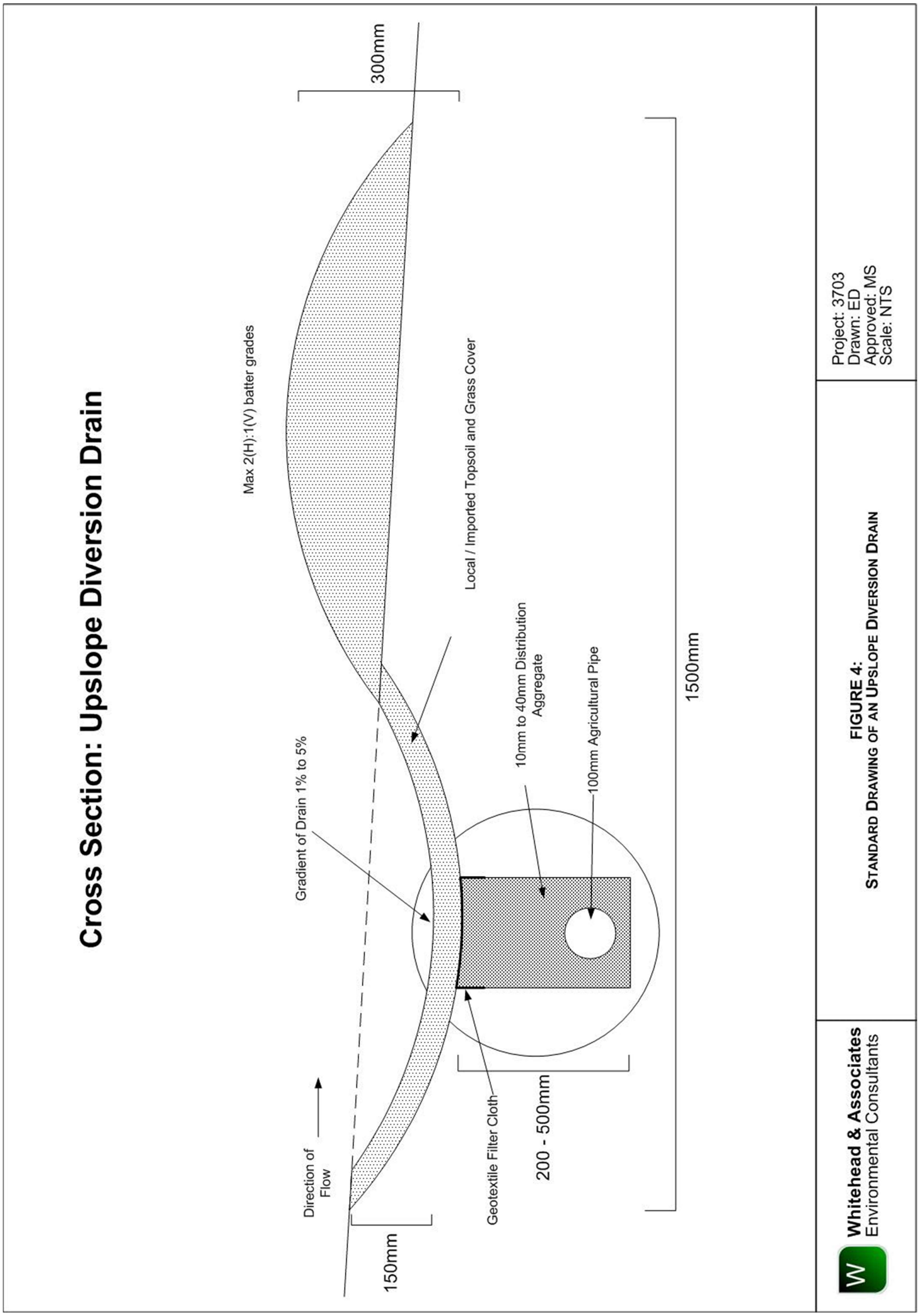

FIGURE 4:
STANDARD DRAWING OF AN UPSLOPE DIVERSION DRAIN

Appendix B

Soil Borelogs and Laboratory Results

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Key to Soil Borelogs

Symbols

W	Watertable depth	●	Sample collected
X	Depth of refusal		

Moisture condition

D	Dry
SM	Slightly moist
M	Moist
VM	Very moist
W	Wet / saturated

Graphic Log and Textures

S - Sand
LS - Loamy sand
CS - Clayey sand

CL - Clay loam
SCL - Sandy clay loam
SiCL - Silty clay loam

Gravel (G)

SL - Sandy loam

LC - Light clay
SC - Sandy clay

Parent material (stiff)

L - Loam
FSL - Fine sandy loam
SiL - Silty loam

MC - Medium clay
HC - Heavy clay

Parent material (weathered)

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	Brett Philips	**Test Pit No:**	**BH1**
Site:	3611 The Lakes Way, Charlotte Bay	Excavated/logged by:	E.D
Date:	18 July 2024	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1–0.2		BH1/1	A	CL	Moderate	Black	NA	< 2%	2-6mm	SM	
0.3–0.9		BH1/2	B1	MC	Weak	Gray	NA	< 2%	2-6mm	D	
1.0–1.2		BH1/3	B2	MC	Weak	Light Grey	Orange	< 2%	2-6mm	D	

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	Brett Philips	**Test Pit No:**	**BH2**
Site:	3611 The Lakes Way, Charlotte Bay	Excavated/logged by:	E.D
Date:	18 July 2024	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1		BH2/1	A	CL	Moderate	Black	NA	< 2%	2-6mm	SM	
0.2											
0.3			B1	MC	Weak	Grey	NA	< 2%	2-6mm	D	
0.4											
0.5											
0.6		BH2/2									
0.7											
0.8											
0.9											
1.0			B2	MC	Weak	Light Grey	Orange	< 2%	2-6mm	D	
1.1		BH2/3									
1.2											

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Brett Philips	Test Pit No:	BH3
Site:	3611 The Lakes Way, Charlotte Bay	Excavated/logged by:	E.D
Date:	18 July 2024	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1		BH3/1	A	CL	Moderate	Black	NA	< 2%	2-6mm	D	
0.2											
0.3			B1	MC	Weak	Grey	NA	< 2%	2-6mm	D	
0.4											
0.5		BH3/2									
0.6											
0.7			B2	MC	Weak	Light Grey	Orange	< 2%	2-6mm	D	
0.8											
0.9		BH3/3									
1.0											
1.1											
1.2											

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	Brett Philips	**Test Pit No:**	**BH4**
Site:	3611 The Lakes Way, Charlotte Bay	Excavated/logged by:	E.D
Date:	18 July 2024	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1		BH4/1	A	CL	Moderate	Black	NA	< 2%	2-6mm	D	
0.2											
0.3			B1	MC	Weak	Grey	NA	< 2%	2-6mm	D	
0.4		BH4/2									
0.5											
0.6			B2	MC	Weak	Light Grey	Orange	< 2%	2-6mm	D	
0.7											
0.8											
0.9		BH4/3									
1.0											
1.1											
1.2											

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	Brett Philips	**Test Pit No:**	**BH5**
Site:	3611 The Lakes Way, Charlotte Bay	Excavated/logged by:	E.D
Date:	18 July 2024	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
		BH5/1	A	CL	Moderate	Black	NA	< 2%	2-6mm	D	
0.1			B1	MC	Weak	Grey	NA	< 2%	2-6mm	D	
0.2											
0.3		BH5/2									
0.4											
0.5											
0.6											
0.7			B2	MC	Weak	Light Grey	NA	< 2%	2-6mm	D	
0.8											
0.9		BH5/3									
1.0											
1.1											
1.2											

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	Brett Philips	Test Pit No:	BH6
Site:	3611 The Lakes Way, Charlotte Bay	Excavated/logged by:	E.D
Date:	18 July 2024	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1		BH6/1	A	CL	Moderate	Black	NA	< 2%	2-6mm	D	
0.2		BH6/2	B1	MC	Weak	Grey	NA	< 2%	2-6mm	D	
0.3											
0.4											
0.5											
0.6		BH6/3	B2	MC	Weak	Light Grey	Orange	< 2%	2-6mm	D	
0.7											
0.8											
0.9											
1.0											
1.1											
1.2											

Job 3703: 3611 The Lakes Way, Charlotte Bay NSW

Sheet 1 - Soil Sampling Schedule and Results of pH, EC and Emerson Aggregate Test Analysis

Site	Sample Name	Sample Depth (mm)	Texture Class	EAT [1]	Rating [2]	pH f [3]	pH 1:5 [4]	Rating	EC 1:5 (µS/cm)	ECe (dS/m) [5]	Rating	Other analysis [6]
BH1	1/1	200	CL	3(2)	Slight	n/a	5.25	Strongly acid	28	0.24	Non-saline	
	1/2	900	MC	1	Very High	n/a	3.50	Extremely acid	13	0.10	Non-saline	
	1/3	1200	MC	3(2)	Slight	n/a	2.75	Extremely acid	38	0.29	Non-saline	
BH2	2/1	200	CL	3(2)	Slight	n/a	2.92	Extremely acid	15	0.13	Non-saline	
	2/2	900	MC	3(2)	Slight	n/a	2.65	Extremely acid	72	0.54	Non-saline	
	2/3	1200	MC	3(2)	Slight	n/a	2.52	Extremely acid	179	1.34	Non-saline	
BH3	3/1	200	CL	3(1)	Slight	n/a	3.00	Extremely acid	14	0.12	Non-saline	
	3/2	600	MC	2(2)	High	n/a	2.89	Extremely acid	20	0.15	Non-saline	
	3/3	1200	MC	3(2)	Slight	n/a	2.64	Extremely acid	42	0.32	Non-saline	
BH4	4/1	200	CL	3(2)	Slight	n/a	2.9	Extremely acid	11	0.09	Non-saline	
	4/2	550	MC	3(2)	Slight	n/a	2.8	Extremely acid	15	0.11	Non-saline	
	4/3	1200	MC	1	Very High	n/a	3.2	Extremely acid	30	0.23	Non-saline	
BH5	5/1	50	CL	3(2)	Slight	n/a	3.6	Extremely acid	21	0.18	Non-saline	
	5/2	600	MC	2(2)	High	n/a	3.4	Extremely acid	11	0.08	Non-saline	
	5/3	1200	MC	1	Very High	n/a	3.7	Extremely acid	20	0.15	Non-saline	
BH6	6/1	100	CL	3(2)	Slight	n/a	3.8	Extremely acid	16	0.14	Non-saline	
	6/2	500	MC	1	Very High	n/a	3.5	Extremely acid	14	0.11	Non-saline	
	6/3	1200	MC	3(3)	Moderate	n/a	3.1	Extremely acid	19	0.14	Non-saline	

Notes:- (also refer Interpretation Sheet 1)

n/a not available
n/t not tested
[1] The modified Emerson Aggregate Test (EAT) provides an indication of soil susceptibility to dispersion.
[2] Ratings describe the likely hazard associated with land application of treated wastewater.
[3] pH measured in the field using Raupac Indicator.
[4] pH measured on 1:5 soil:water suspensions using a *Hanna Combo* hand-held pH/EC/temp meter.
[5] Electrical conductivity of the saturated extract (Ece) = $EC_{1:5}$(µS/cm) x MF / 1000. Units are dS/m. MF is a soil texture multiplication factor.
[6] External laboratories used for the following analyses, if indicated:

- CEC (Cation exchange capacity)
- Psorb (Phosphorus sorption capacity)
- Bray Phosphorus
- Organic carbon
- Total nitrogen

SALIS Report: WEL/96/37/446(1)

Sheet 2 - Results of External Laboratory Analysis

Name	Depth (m)	CEC (me/100g)	Rating	Ca (mg/kg)	Rating	Mg (mg/kg)	Rating	Na (mg/kg)	Rating	K (mg/kg)	Rating	ESP (%)	Rating	P-sorp. (mg/kg)	Rating
	0.7 - 1	17.3	M	100	VL	192	M	92	M	78	VL	14.8	SS	823	VH

Notes:- (also refer Interpretation Sheet 2)

n/a
n/t

SALIS Report: WEL/94/37/265(1)

Sheet 2 - Results of External Laboratory Analysis

Name	Depth (m)	CEC (me/100g)	Rating	Ca (mg/kg)	Rating	Mg (mg/kg)	Rating	Na (mg/kg)	Rating	K (mg/kg)	Rating	ESP (%)	Rating	P-sorp. (mg/kg)	Rating
	0.45 - 0.9	29.0	H	4140	VH	1548	VH	2185	VH	1092	VH	20.7	SS	376	MH

Notes:- (also refer Interpretation Sheet 2)

n/a
n/t

Sample Code: WEL/96/37/446(1) Upper bound: 0.70 Lower bound: 1.00

Name	Value	Unit of measure
15F1_CA [Exchangeable Ca - 0.01M (AgTU)+, no pretreatment]	0.5	cmol/kg
15F1_K [Exchangeable K - 0.01M (AgTU)+, no pretreatment]	0.2	cmol/kg
15F1_MG [Exchangeable Mg - 0.01M (AgTU)+, no pretreatment]	1.6	cmol/kg
15F1_NA [Exchangeable Na - 0.01M (AgTU)+, no pretreatment]	0.4	cmol/kg
15F2_AL [Exchangeable Al - 0.01 M AgTU+]	13	cmol/kg
15F3_CEC [Cation exchange capacity - 0.01 M AgTU+]	17.3	cmol/kg
2B1 [As received moisture content]	4.4	%
3A1 [EC of 1:5 soil/water extract]	0.04	dS/m
4A1 [pH of 1:5 soil/water suspension]	4.7	pH
4B1 [pH of 1:5 soil/0.01M CaCl2 extract - direct, no stir]	3.9	pH
504.02_FC [Field Capacity, SWC pressure plate]	44.6	
504.02_PWP [Permanent Wilt Point, SWC pressure plate]	26.2	
505.99 [Water repellence field method]	0	
513.98 [Emerson aggregate test SCS method]	6	
514.99 [Dispersion percentage]	1	%
515.01 [Dry aggregate distribution]	72	
516.01_CL [Non-dispersed PSA clay]	0	%
516.01_CS [Non-dispersed PSA coarse sand]	16	%
516.01_FS [Non-dispersed PSA fine sand]	44	%
516.01_GR [Non-dispersed PSA gravel]	1	%
516.01_SI [Non-dispersed PSA silt]	39	%
517.99_CL [PSA clay - hydrometer]	72	%
517.99_CS [PSA coarse sand - hydrometer]	2	%
517.99_FS [PSA fine sand - hydrometer]	8	%
517.99_GR [PSA gravel - hydrometer]	1	%
517.99_SI [PSA silt - hydrometer]	17	%
518.99 [Volume expansion]	16	
550.01 [Unified Soil Classification System (lab)]	CL	
6A1 [Organic carbon - Walkley & Black]	0.6	%
9E1 [Fluoride-extractable P (Bray 1-P) - manual colour]	1	mg/kg
9I1 [Phosphate sorption index]	823	

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

Report generated on 11/07/2024 at 12:16 PM

Sample Code: WEL/94/37/265(1) Upper bound: 0.45 Lower bound: 0.90

Name	Value	Unit of measure
15F1_CA [Exchangeable Ca - 0.01M (AgTU)+, no pretreatment]	20.7	cmol/kg
15F1_K [Exchangeable K - 0.01M (AgTU)+, no pretreatment]	2.8	cmol/kg
15F1_MG [Exchangeable Mg - 0.01M (AgTU)+, no pretreatment]	12.9	cmol/kg
15F1_NA [Exchangeable Na - 0.01M (AgTU)+, no pretreatment]	9.5	cmol/kg
15F2_AL [Exchangeable Al - 0.01 M AgTU+]	0	cmol/kg
15F3_CEC [Cation exchange capacity - 0.01 M AgTU+]	29	cmol/kg
2B1 [As received moisture content]	6.5	%
3A1 [EC of 1:5 soil/water extract]	9	dS/m
4A1 [pH of 1:5 soil/water suspension]	7.5	pH
4B1 [pH of 1:5 soil/0.01M CaCl2 extract - direct, no stir]	7.1	pH
504.02_FC [Field Capacity, SWC pressure plate]	55.5	
504.02_PWP [Permanent Wilt Point, SWC pressure plate]	24.5	
513.98 [Emerson aggregate test SCS method]	5	
514.99 [Dispersion percentage]	9	%
515.01 [Dry aggregate distribution]	88	
516.01_CL [Non-dispersed PSA clay]	0	%
516.01_CS [Non-dispersed PSA coarse sand]	9	%
516.01_FS [Non-dispersed PSA fine sand]	34	%
516.01_GR [Non-dispersed PSA gravel]	0	%
516.01_SI [Non-dispersed PSA silt]	57	%
517.99_CL [PSA clay - hydrometer]	41	%
517.99_CS [PSA coarse sand - hydrometer]	9	%
517.99_FS [PSA fine sand - hydrometer]	26	%
517.99_GR [PSA gravel - hydrometer]	0	%
517.99_SI [PSA silt - hydrometer]	24	%
518.99 [Volume expansion]	24	
550.01 [Unified Soil Classification System (lab)]	OL	
6A1 [Organic carbon - Walkley & Black]	3.47	%
9E1 [Fluoride-extractable P (Bray 1-P) - manual colour]	8	mg/kg
9I1 [Phosphate sorption index]	376	

Appendix C

Water and Nutrient Balance Modelling

Irrigation Area Water Balance & Storage Calculations

Whitehead & Associates
Environmental Consultants

Site address: 3611 The Lakes Way, Charlotte Bay NSW

INPUT DATA

Design Wastewater Flow	**Q**	1,050	**L/day**	5-bedroom dwelling (7EP) reticulated water supply (150L/person/day)
Design Irrigation Rate	**DIR**	2.0	**mm/day**	Litres/m²/day - based on Table M1 AS/NZS 1547:2012 for secondary effluent with Cat 6 soils
Available Land Application Area	**L**	2,300	**m²**	Used for iterative purposes to determine storage requirements for nominated areas
Crop Factor	**C**	0.6-0.8	**unitless**	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Runoff Coefficient	**RC**	0.7	**unitless**	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Rainfall Data	BOM Station 060028			Median Monthly data (114 years)
Evaporation Data	Silo data (-32.35, 152.5)			Mean Monthly data (60 years)

Soil Category (AS1547:2012)	DIR	Units
Gravels and Sands (1)	5	mm/day
Sandy Loams (2)	5	mm/day
Loams (3)	4	mm/day
Clay Loams (4)	3.5	mm/day
Light Clays (5)	3	mm/day
Medium to Heavy Clays (6)	2	mm/day

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Days in Month	D		days	31	28.25	31	30	31	30	31	31	30	31	30	31	31	28.25	31	30	31	30	365.25
Rainfall	R		mm/month	73.7	85.2	119.1	109.6	126.2	113.3	109.2	77.9	58.9	67.6	74.8	71.1	73.7	85.2	119.1	109.6	126.2	113.3	1086.6
Evaporation	E		mm/month	172.2	135.9	120.8	90.2	67.9	57.3	65.5	90.8	119.1	145.3	154.3	177.3	172.2	135.9	120.8	90.2	67.9	57.3	1396.5
Crop Factor	C			0.80	0.80	0.70	0.60	0.60	0.60	0.60	0.60	0.70	0.80	0.80	0.80	0.80	0.80	0.70	0.60	0.60	0.60	
OUTPUTS (LOSSES)																						
Evapotranspiration	ET	ExC	mm/month	137.8	108.8	84.5	54.1	40.7	34.4	39.3	54.5	83.4	116.2	123.4	141.8	137.8	108.8	84.5	54.1	40.7	34.4	1018.90182
Percolation	B	DIRxD	mm/month	62.0	56.5	62.0	60.0	62.0	60.0	62.0	62.0	60.0	62.0	60.0	62.0	62.0	56.5	62.0	60.0	62.0	60.0	730.5
Outputs		ET+B	mm/month	199.8	165.3	146.5	114.1	102.7	94.4	101.3	116.5	143.4	178.2	183.4	203.8	199.8	165.3	146.5	114.1	102.7	94.4	1749.4
INPUTS (GAINS)																						
Retained Rainfall	RR	RxRC	mm/month	51.59	59.64	83.37	76.72	88.34	79.31	76.44	54.53	41.23	47.32	52.36	49.77	51.59	59.64	83.37	76.72	88.34	79.31	760.62
Effluent Irrigation	W	(QxD)/L	mm/month	14.2	12.9	14.2	13.7	14.2	13.7	14.2	14.2	13.7	14.2	13.7	14.2	14.2	12.9	14.2	13.7	14.2	13.7	166.7
Inputs		RR+W	mm/month	65.7	72.5	97.5	90.4	102.5	93.0	90.6	68.7	54.9	61.5	66.1	63.9	65.7	72.5	97.5	90.4	102.5	93.0	927.4
STORAGE CALCULATION (Δ)																						
Storage Remaining from Previous Month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the Month	S	(RR+W)-(ET+B)	mm/month	-134.1	-92.7	-49.0	-23.7	-0.2	-1.4	-10.7	-47.8	-88.4	-116.7	-117.4	-139.9	-134.1	-92.7	-49.0	-23.7	-0.2	-1.4	
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Maximum Storage for Nominated Area	N		mm	0.0																		
Storage Volume required	V	(NxL)/1000	m³	0.0																		
LAND AREA REQUIRED FOR ZERO STORAGE			m²	220	281	515	842	2,264	2,091	1,311	525	308	249	240	211	220	281	515	842	2,264	2,091	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: 2,264 m²

This value is based on the worst month of the year, so the balance overestimates the area/storage requirements and is therefore conservative for all other months

Northern and Middle Lots

Nutrient Balance

Whitehead & Associates
Environmental Consultants

Site address: 3611 The Lakes Way, Charlotte Bay NSW

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 411 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	1,050	L/day	Crop N Uptake	260	kg/ha/yr	which equals	71.23	mg/m^2/day
Effluent N Concentration	30	mg/L	Crop P Uptake	30	kg/ha/yr	which equals	8.22	mg/m^2/day
% Lost to Soil Processes (Geary & Gardner 1996)	0.2	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	6,300	mg/day	P-sorption result	376	mg/kg	which equals	6,317	kg/ha
Remaining N Load after soil loss	25,200	mg/day	Bulk Density	1.4	g/cm^3			
Effluent P Concentration	10	mg/L	Depth of Soil	1.2	m			
Design Life of System	50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal			

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer			Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)		
Nitrogen	354	m^2	Nominated LAA Size	2,264	m^2
Phosphorus	411	m^2	Predicted N Export from LAA	-49.67	kg/year
			Predicted P Export from LAA	-17.26	kg/year
			Phosphorus Longevity for LAA	-242	Years
			Minimum Buffer Required for excess nutrient	0	m^2

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	2,264	m^2			
Daily P Load	0.0105	kg/day	→ Phosphorus generated over life of system	191.625	kg
Daily Uptake	0.0186093	kg/day	→ Phosphorus vegetative uptake for life of system	0.150	kg/m^2
Measured p-sorption capacity	0.63168	kg/m^2			
Assumed p-sorption capacity	0.316	kg/m^2	→ Phosphorus adsorbed in 50 years	0.316	kg/m^2
Site P-sorption capacity	715.10	kg	→ Desired Annual P Application Rate	21.094	kg/year
			which equals	0.05779	kg/day
P-load to be sorbed	-2.96	kg/year			

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,
- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Southern Lot

Nutrient Balance

Whitehead & Associates
Environmental Consultants

Site address: 3611 The Lakes Way, Charlotte Bay NSW

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 354 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	1,050	L/day	Crop N Uptake	260	kg/ha/yr	which equals	71.23	$mg/m^2/day$
Effluent N Concentration	30	mg/L	Crop P Uptake	30	kg/ha/yr	which equals	8.22	$mg/m^2/day$
% Lost to Soil Processes (Geary & Gardner 1996)	0.2	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	6,300	mg/day	P-sorption result	823	mg/kg	which equals	13,826	kg/ha
Remaining N Load after soil loss	25,200	mg/day	Bulk Density	1.4	g/cm^3			
Effluent P Concentration	10	mg/L	Depth of Soil	1.2	m			
Design Life of System	50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal			

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer		
Nitrogen	354	m^2
Phosphorus	228	m^2

Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)		
Nominated LAA Size	2,264	m^2
Predicted N Export from LAA	-49.67	kg/year
Predicted P Export from LAA	-34.26	kg/year
Phosphorus Longevity for LAA	-529	Years
Minimum Buffer Required for excess nutrient	0	m^2

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	**2,264**	m^2				
Daily P Load	0.0105	kg/day	→	Phosphorus generated over life of system	191.625	kg
Daily Uptake	0.0186093	kg/day	→	Phosphorus vegetative uptake for life of system	0.150	kg/m^2
Measured p-sorption capacity	1.38264	kg/m^2				
Assumed p-sorption capacity	0.691	kg/m^2	→	Phosphorus adsorbed in 50 years	0.691	kg/m^2
Site P-sorption capacity	1565.24	kg	→	Desired Annual P Application Rate	38.097	kg/year
				which equals	0.10438	kg/day
P-load to be sorbed	-2.96	kg/year				

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,
- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Appendix D

Risk Analysis

Project: 3703	3611 The Lakes Way, Charlotte Bay, NSW				AS1547:2012 Table R1 and R2 Buffer Distance Justification																		
		Constraint Scale			Risk Assessment									Revised Risk Assessment								Adopted Buffer Distance	
Site Feature	Site Constraint Items of Concern	Low Constraint	High Constraint	Applicable Constraint	Risk Assessment	Low (1)		Moderate (2)		High (3)		Risk Rating	Mitigation Measures	Low (1)		Moderate (2)		High (3)		Risk Justification	Revised Risk Rating	Available Buffer (m)	Minimum Acceptable Buffer (m)
Surface Water 15m (low) - 100m (high)	Microbial Quality of Effluent	Secondary treated effluent (with disinfection) and Contractual Service Agreement	Primary treated effluent (no disinfection)	Secondary treatment with disinfection	**Low**	✓	1		0		0	**Moderate (<15)**		✓	1		0		0	Maintain (minimum) secondary treatment with disinfection	**Low (<10)**	**20m to intermittent watercourses as per AS/NZS 1547:2012**	15-30
	Surface Water	Category 1 to 3 soils no surface water down gradient within 100m; low rainfall area	Category 4 to 6 soils permanent surface water <50m down gradient; high rainfall; high resource / environmental value	Category 6 soil; proposed LAA 20m from downgradient intermittent water course; annual evaporation exceeds rainfall (rainfall = ~1,086mm pa , evaporation = ~1,396)	**High**		0		0	✓	3		Monthly (hydraulic) modelling used to size LAA to limit surface surcharge of effluent		0	✓	2		0	LAA conservatively sized.			
	Slope	0-6% (surface effluent application), 0 -10% (subsurface effluent application)	>10% (surface effluent application), >30% subsurface effluent application	Slope ~12% in LAA; subsurface (absorption system) effluent land application method	**Moderate**		0	✓	2		0				0	✓	2		0	Absorption system located on slope ≤12%			
	Position of Land Application Area in Landscape	Downgradient of surface water, property boundary, recreational area	Upgradient of surface water, property boundary, recreational area	Proposed LAA upgradient of surface water	**High**		0		0	✓	3		Subsurface LAA to be located in low slope (<12%) area of EMA.		0	✓	2		0	Proposed LAA location as far away as possible (>20m) from sensitive receptor			
	Drainage	Category 1 to 2 soils; gently sloping area	Category 6 soils; sites with visible seepage; moisture tolerant vegetation; low lying area	Category 6 soils in an elevated, sloping landscape with good drainage observed within LAA	**Moderate**		0	✓	2		0		Address soil drainage and structural constraints. Install cut-off drain upslope of LAA to intercept run-on.	✓	1		0		0	Soil improvement measures and drainage controls to increase stability and drainage properties.			
	Flood Potential	Above 1 in 20 year flood contour	Below 1 in 20 year flood contour	Proposed LAA above 1 in 20 year flood contour	**Low**	✓	1		0		0			✓	1		0		0	Proposed LAA above flood prone area			
	Application Method	Drip irrigation or subsurface application of effluent	Surface / above ground application of effluent	Subsurface application	**Low**	✓	1		0		0			✓	1		0		0	LAA option of subsurface (absorption system) application			

Beavers, Cromer, Gardner Viral Dieoff Model
Job 3703: 3611 The Lakes Way, Charlotte Bay NSW

Whitehead & Associates
Environmental Consultants Pty Ltd

Step 1	Use Figure 1 in Cromer *et al.* (2001) (reproduced below) to determine days travel time using groundwater temperature* and a selected order of magnitude reduction.

** If mean groundwater temperature is unavailable, mean daily air temperature can be used in most cases.*

Groundwater Temperature (°C)	13.5	From BOM station
Order of magnitude reduction	3	3 order of magnitude required for secondary treatment
Days required for viral reduction	**29**	(from Figure 1, below)

Step 2	Calculate the predicted travel distance using Equation 4 from Cromer *et al.* (2001). $Dg = (t-d_v.P/K)/(P/K.I)$

Time in days	t =	29	days
Effective porosity of soil (fraction)	P =	0.47	
Saturated hydraulic conductivity	K =	0.06	m/day
Groundwater gradient	I =	12.0%	
Vertical drainage before entering groundwater	d_v =	1.2	m

See notes below for description of values

Setback Distance	**Distance travelled in groundwater**	d_g =	**0.3**	**m**

Notes:

Porosity (P): Assume clay subsoil - typical bulk density (BD) of 1.4, typical specific gravity (SG) of 2.65 (Hazelton & Murphy 2007). Therefore, total porosity = 1 - (1.4/2.65) = 0.47.

Ksat (K): Assumed average Ksat of 0.06m/day for weakly structured medium clay

Groundwater gradient (I): Assumed groundwater gradient of 12% (~ surface slope value).

Vertical drainage (d_v): Assumed 1.2m of unsaturated flow before reaching groundwater.

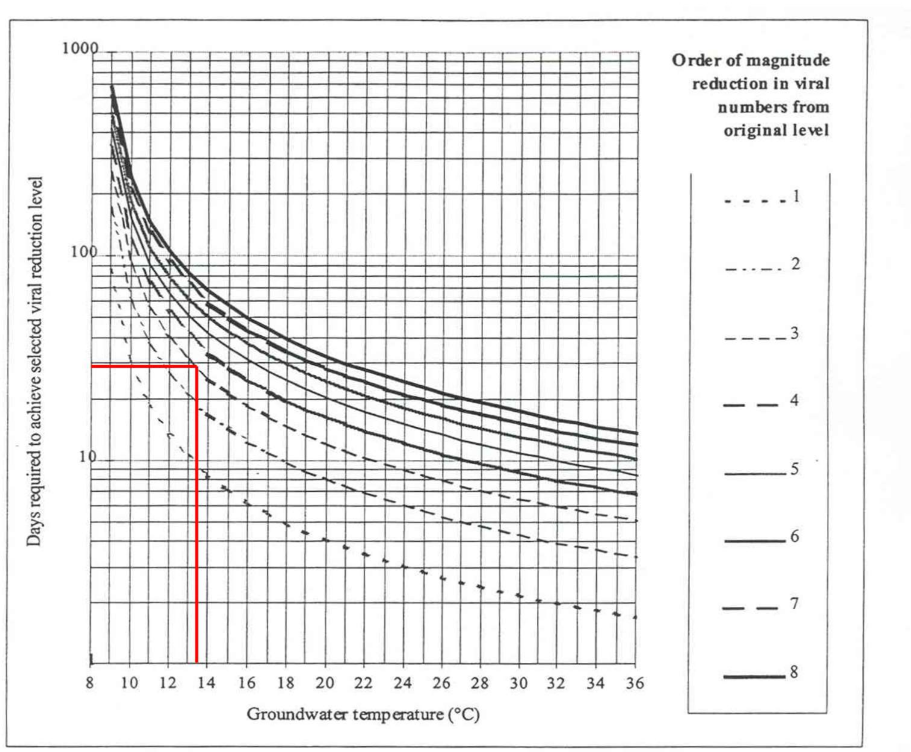

Figure 1. Relationship between Groundwater Temperature and Viral Die-Off Time for Various Order-of-Magnitude Reductions in Viral Numbers

(Figure 1 taken from Cromer et al., 2001)

Appendix E

General Notes

Soil Physical Properties / Chemistry

pH

This test is used to determine the acidity or alkalinity of native soils. pH is measured on a scale of 0 to 14, with 7 being neutral. Results below 7 are considered acid, while those above 7 are alkaline. For land application of effluent, soil with a pH of 4.5 to 8.5 should typically pose no constraints. Soil pH affects the solubility and fixation of some nutrients; this in turn reduces soil fertility and plant growth. By correcting soil pH beneficial plant growth is improved, assisting in the assimilation of nutrient and improving evapotranspiration of effluent. Most Australian soils are naturally acidic.

Electrical Conductivity

Electrical conductivity (EC) is a measure of a soil or soil/water extracts ability to conduct an electrical current. It is used as an indirect measure of a soil's accumulation of water-soluble salts, mainly of sodium, with minor potassium, calcium and magnesium. High EC within a land application area reflects general soil salinity and is undesirable for vegetation growth. The tolerance of vegetation species to soil salinity varies among plant types. Typically, EC readings of <4dS/m pose no constraints. There are a number of measures available to counter high soil EC values for land application of effluent; however, the most important measure relates to the conservative selection of application rates and appropriate application area sizing.

Emerson Aggregate Test

The Emerson Aggregate Test (EAT) is a measure of soil dispersibility and susceptibility to erosion and structural degradation. It assesses the physical changes that occur in a single ped of soil when immersed in water, specifically whether the soil slakes and falls apart or disperses and clouds the water. Dispersive soils pose limitations to on-site sewage management because of the potential loss of soil structure when effluent is applied. Soil pores can become smaller or completely blocked, causing a decrease in soil permeability, which can lead to system failure.

Cation Exchange Capacity

The cation exchange capacity (CEC) is the capacity of the soil to hold and exchange cations (positively charged molecules). Because some soils have a dominant negative charge, they can adsorb cations. Soils bind cations such as calcium, magnesium, potassium and sodium, preventing them from being leached from the soil profile and making them available as plant nutrients. CEC is a major controlling agent for soil structural stability, nutrient availability for plants and the soils' reaction to fertilisers and other ameliorants. A CEC of greater than 15 cmol+/kg or me/100g is recommended for land application systems. Adding organic matter (compost/humus) to soil can greatly increase its CEC.

Exchangeable Sodium Percentage

The exchangeable sodium percentage (ESP) is an important indicator of soil sodicity, which affects soil structural stability and overall susceptibility to dispersion. Sodic soils tend to have a low infiltration capability, low hydraulic conductivity, and a high susceptibility to erosion. When sodium dominates the exchangeable cation complex, soil structural stability declines significantly. Soil ESP is considered acceptable for effluent application areas when it is below 5%, marginal between 5% – 10% and limiting >10%. The ESP of application area soils can be improved by the measured application of calcium (lime/gypsum).

Phosphorus Sorption Capacity

Phosphorus sorption (P-sorption) capacity is a direct measure of a soils ability to adsorb phosphorus. Phosphorus is an important plant nutrient and is the limiting available nutrient in many aquatic environments. Excess phosphorus can increase the production of nuisance vegetative growth such as algae. The P-sorption capacity of the soil in an effluent application area relates to its ability to assimilate the phosphorus in the wastewater for the design life of the application area. P-sorption values greater than 400mg/kg is considered acceptable for land application of effluent, while values below 150mg/kg present a constraint.