Whitehead & Associates
Environmental Consultants

Craig Favelle
c/- Aprajita Gupta
hdb Planning Pty Ltd
Re: 245 Station Lane,
Lochinvar NSW 2312
(via email)

Ref: 3706_WMR_001

5 June 2024

On-site Wastewater Management Report for Change of Use at 245 Station Lane, Lochinvar NSW

Whitehead & Associates Environmental Consultants Pty Ltd (W&A) were engaged by Craig Favelle (the Owner) to prepare an On-site Wastewater Management Report (WMR) for the change of development use at 245 Station Lane, Lochinvar NSW (the Site). The Site, identified as Lot 80 in DP1003006, is approximately 3.1ha in area, and zoned RU2 (rural landscape) under the Maitland LEP (2011).

Development at the Site consists of a heritage listed dwelling (Clifton House), detached loft, Coach House, and studio located in the northwest of the property. Other improvements include detached metal storage sheds and landscaping. Potable water is provided by tank (roof) water supply, and no reticulated sewer service is available (or anticipated).

It is understood that the Owner proposes to submit a Development Application (DA) to Maitland City Council (Council) to formalise the change of use for two (2) buildings at the Site. The Coach House has been converted to a one (1) bedroom residential dwelling, with the studio converted to a one (1) bedroom ‘eco-tourism’ accommodation unit.

The Site is bound by the Northern Railway to the north, private property to the east, Old North Road to the south, and Station Lane to the west. A majority of the Site consists of managed pasture, with mature vegetation in the development area and adjacent the southwest property boundary. A dam is located in the southern portion of the Site, with multiple ornamental ponds in proximity to the development area. A drainage feature links these surface water features, with some drainage directed towards the adjacent property to the east. The Site is mapped as potentially containing Acid Sulphate Soils (ASS) at depth (Class 5), and is identified as moderately bushfire prone throughout (vegetation category 3).

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. Recommendations are provided regarding the suitability of the existing OSSM system, as well as any upgrade requirements to ensure compliance with the relevant standards and guidelines currently enforced by Council, as follows:

- Maitland City Council (2020), *On-site Sewage Management Policy*;
- NSW Ministry of Health (2016), *Sewage Management Facility Vessel Accreditation Guideline* (NSW Health, 2016);

- Standards Australia / Standards New Zealand (2012), *On-site Domestic Wastewater Management* (*AS/NZS 1547:2012*); and
- NSW Department of Local Government (1998), *Environmental & Health Protection Guidelines: On-site Sewage Management for Single Households* (NSW DLG, 1998).

1 Author Statement

This WMR was prepared by Connor Morton. Connor is an Environmental Consultant with W&A, holding a B. EnvSc. and Mgmt. from the University of Newcastle (2019). Connor has completed the On-site Wastewater Management professional short-course with the Centre for Environmental Training (CET) and has completed many WMRs across the Port Stephens, Hunter, Central Coast, and MidCoast regions.

2 Introduction

The following table summarises information relating to the property investigated.

Feature	Description
Site Address	245 Station Lane, Lochinvar NSW
Lot / DP	Lot 80 DP1003006
Local Government Area	Maitland City Council
Land Zoning	RU2 (rural landscape)
Lot Size (ha)	3.1
Development	Change of use for the Coach House to a one (1) bedroom residential dwelling, and studio to a one (1) bedroom 'eco-tourism' accommodation unit
Potable Water Supply	Tank (roof) water supply
Reticulated Sewer Connection Available	No

3 Site and Soil Assessment

The Site investigation was undertaken by Connor Morton of W&A on 3 May 2024. The following tables present the results of the site and soil investigations 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 NSW DLG (1998).

SITE ASSESSMENT			
Parameter	**Data/ Observation**	**Reference**	**Classification/ Outcome**
Climate	Temperate climate with median annual rainfall of 795.2mm; minimum of 34.7mm (August) and a maximum of 75.8mm (March).	BoM Station 061014	Minor limitation

<table>
<tr><th colspan="5">SITE ASSESSMENT</th></tr>
<tr><th>Parameter</th><th colspan="2">Data/ Observation</th><th>Reference</th><th>Classification/ Outcome</th></tr>
<tr><td></td><td colspan="2">Mean annual evaporation of 1,477.5mm.
Potential evaporation exceeds rainfall for all months of the year.</td><td>SILO Point Data (-32.7, 151.45)</td><td></td></tr>
<tr><td colspan="3">Land Application Area (LAA) Sizing</td><td colspan="2" rowspan="4">As per AS/NZS 1547:2012, and NSW DLG (1998) procedures

N/A</td></tr>
<tr><td colspan="2">Hydraulic sizing attached:</td><td>Yes</td></tr>
<tr><td colspan="2">Nutrient balance (annual) attached:</td><td>Yes</td></tr>
<tr><td colspan="2">LAA sizing attached:</td><td>Yes</td></tr>
<tr><td colspan="2">Wet weather storage requirement:</td><td>N/A</td><td colspan="2"></td></tr>
<tr><td colspan="3">Flooding</td><td rowspan="4">The Site is not flood impacted (LEP, 2011)</td><td rowspan="4">Minor limitation</td></tr>
<tr><td colspan="2">LAA above 5% AEP flood level:</td><td>Yes</td></tr>
<tr><td colspan="2">LAA above 1% AEP flood level:</td><td>Yes</td></tr>
<tr><td colspan="2">Electrical components above 1% AEP flood level:</td><td>Yes</td></tr>
<tr><td>Exposure</td><td colspan="2">The available effluent management area (EMA) consists of open pasture, providing high exposure.</td><td colspan="2">Minor limitation</td></tr>
<tr><td>Slope and Aspect</td><td colspan="2">Slopes of 7% – 10% within the available EMA.
Northern aspect located in the south of the Site, with a north-western aspect within the east.</td><td colspan="2">Moderate limitation</td></tr>
<tr><td>Landform</td><td colspan="2">Linear planar to linear divergent.</td><td colspan="2">Minor limitation</td></tr>
<tr><td>Run-on and Seepage</td><td colspan="2">Run-on from the adjacent property to the east was observed in proximity to BH3. No run-on observed in the remaining available EMA. No upslope seepage observed at the Site.
Stormwater and run-on from upslope areas must be directed away from the proposed LAA (refer Section 9.1).</td><td colspan="2">Moderate limitation</td></tr>
<tr><td>Erosion Potential</td><td colspan="2">No erosion evident within the available EMA.
Address potential concerns using erosion and sediment controls during construction and revegetation of LAA using turf or other suitable groundcover as appropriate (refer Section 9.2).</td><td colspan="2">Minor limitation</td></tr>
<tr><td>Site Drainage</td><td colspan="2">Areas of poor drainage observed in proximity to surface water features and shaded areas; however, these areas are located outside the available EMA.</td><td colspan="2">Moderate limitation</td></tr>
</table>

SITE ASSESSMENT			
Parameter	**Data/ Observation**	**Reference**	**Classification/ Outcome**
	Moderate to good drainage observed in the available EMA.		
Fill	No fill observed during the Site inspection.	Minor limitation	
Groundwater	No shallow groundwater (GW) encountered during the soil survey. NSW Office of Water GW bore registry indicates that there no registered bores located within 250m of the Site.	Minor limitation	
Surface Water Features	A dam is located in the south of the Site, with multiple ornamental ponds in proximity to the development area. A drainage feature links these surface water features, with some drainage directed towards the adjacent property to the east. A table drain is identified along the western property boundary (refer Figure 1).	Major limitation	
Buffers Applicable			
Domestic GW bores (250m):	N/A		
Permanent rivers and creeks (100m):	N/A		
Intermittent waterways and other waters (40m):	Yes	Achievable, however strict application significantly limits available EMA. Risk based buffer reductions proposed, with mitigation (refer to Section 8.5).	
Lot boundaries, buildings, and swimming pools (3m if EMA downslope-6m if EMA upslope):	Yes	Achievable	
Limiting horizon (GW, bedrock etc.) (>0.6m):	Yes	Achievable	
In-ground water tanks (4m)	Yes	Achievable	
Other sensitive receptors:	N/A		
Surface Rock	None identified at the Site.	Minor limitation	
Available EMA	Approximately 5,780m^2 of available EMA is identified at the Site, with reduced buffers to surface water features based on a risk analysis.	Minor limitation	
Concluding Remarks Slope, run-on, and site drainage poses a moderate limitation to OSSM at the Site; however, these constraints will be mitigated through conservative treatment / LAA selection, location, design, and installation (refer Sections 7 and 8).			

SITE ASSESSMENT			
Parameter	**Data/ Observation**	**Reference**	**Classification/ Outcome**
Standard buffer distances to the surface water features (intermittent waterways and other waters) can be achieved at the Site; however, strict application creates unfavourable available EMA at the Site >150m upslope of the development area with a 16m increase in elevation. A reduced buffer of 20m to surface water features is proposed. To support a reduction in the applied setbacks, a risk assessment and viral die-off modelling were undertaken to demonstrate that OSSM is sustainable (refer Section 8.5).			

SOIL ASSESSMENT (physical)			
Parameter	**Data/ Observation**	**Reference**	**Classification/ Outcome**
Soil Depth	800mm – ≥1,200mm.	Moderate limitation	
Soil Profile	**BH1:** A: 0mm – 200mm, moderately structured to massive, dark brown, medium clay (Cat 6). B: 200mm – 800mm, massive, strong brown, heavy clay (Cat 6). **BH2:** A: 0mm – 100mm, moderately structured, strong brown, medium clay (Cat 6). B: 100mm – 1,000mm, massive to weakly structured, reddish brown to brown, medium clay (Cat 6). **BH3:** A: 0mm – 100mm, moderately structured, very dark grey, medium clay (Cat 6). B: 100mm – 1,200mm, massive, dark brown to brown, medium clay (Cat 6). **BH4:** A: 0mm – 100mm, moderately structured, very dark grey, medium clay (Cat 6). B: 100mm – 1,200mm, massive to weakly structured, dark brown to brown, medium clay (Cat 6). Borehole locations shown in Figures 1 – 3, Appendix A, Soil borelogs presented in Appendix B.		
Depth to Water Table	Shallow water table not encountered. Mottling observed in subsoils (>500mm) indicating restricted vertical drainage within soils during periods of high rainfall and extended wet weather.	Moderate limitation	

SOIL ASSESSMENT (physical)

Parameter	Data/ Observation	Reference	Classification/ Outcome
Coarse Fragments (%)	<10% (<20mm).	Minor limitation	
Soil Permeability	<0.06m/day (inferred).	Massive Cat 6 subsoil	Major limitation
Emerson Aggregate Class (EAT)	Topsoil: 7 – 8 (negligible). Subsoil: 2(1), 5, and 7 (slightly unstable and dispersive).	Moderate limitation	
Soil Landscape	The Site is located on the Lochinvar (lv) soil landscape. **<u>Lochinvar (lv):</u>** Undulating rises with elevation ranging from 20m-80m. Local relief is around 20m, with slope gradients of 4%-6%. Average slope lengths are 800m-1,000m. Drainage lines occur at 400m-800m intervals. Soils generally consist of hardsetting light sandy clay loam to silty clay loam, underlain by sandy to medium clay.	Soil Landscapes of the Singleton 1:250 000 Sheet (Kovac M. and Lawrie J.M., 1991)	
	The Site is also mapped on the North Eelah (ne) soil and land resources unit, exhibiting similar characteristics to the Lochinvar soil landscape. Therefore, published soil chemistry results for the North Eelah landscape has been used (sodicity, fertility, and p-sorption capacity).	Soil Landscapes of the Newcastle 1:100 000 Sheet (L.E. Matthei, 1995)	

Concluding Remarks

Topsoil, restricted vertical drainage, soil permeability, and soil stability / dispersion (EAT) limitations present moderate to major constraints to OSSM at the Site.

Restricted vertical drainage and low soil permeability will be mitigated through conservative treatment / LAA selection, location, design, and installation (refer Sections 7 and 8). Topsoil and soil stability / dispersion limitations can be mitigated through soil improvement measures (refer Section 9.3).

SOIL ASSESSMENT (chemical)

Parameter	Data/ Observation		Reference	Classification / Outcome
pH	4.3 – 6.2	Slightly to extremely acidic	Moderate to Major limitation	
EC (EC_e)	0.35 – 6.21	Non-saline to moderately saline	Minor to Moderate limitation	

SOIL ASSESSMENT (chemical)				
Parameter	**Data/ Observation**		**Reference**	**Classification / Outcome**
ESP (%)	1.0	Non-sodic	ne7 Soil Landscapes of the Newcastle 1:100 000 Sheet (L.E. Matthei, 1995)	Minor limitation
CEC (me/100g)	35.8	High fertility		Minor limitation
P-sorption (mg/kg)	432 (~7,260kg/ha)	High		Minor limitation

Concluding Remarks

The acidity (pH) and salinity (EC) of the Site soils poses a moderate constraint to OSSM.

Acidity did not appear to impact groundcover growth during the Site investigation. Salinity limitations were only identified in subsoils; therefore, mitigation has been deemed unnecessary. If necessary, soil improvement measures may be employed to mitigate future concerns (refer Section 9.3.1).

General notes on the soil chemistry parameters above are attached as Appendix E.

4 Development Components

The following section outlines the development components of the Site. Capacities have been confirmed by the Owner, and have been used to assess the Equivalent Population (EP) of each development component. All components are located in the northwest of the Site.

Clifton House: The Clifton House is a two (2) storey residential dwelling located adjacent the western property boundary, consisting of six (6) bedrooms. No alterations are proposed for the dwelling. The dwelling contains WCs, basins, kitchen, shower, and bath.

Loft: The loft is a two (2) storey building located directly east of the Clifton House, and contains a study within the upstairs area. This has been considered as a potential bedroom, and is included in this assessment. No alterations are proposed for the loft. The loft contains a kitchen and laundry.

Coach House: The Coach House is located to the south of the Clifton House, and previously served as a garage. The Coach House currently serves as a residential dwelling, containing one (1) bedroom. The dwelling contains a WC, basin, kitchen, shower, and laundry.

Studio: The Studio is located to the east of the Coach House, and contains one (1) bedroom. The Studio currently serves as an eco-tourism accommodation unit, providing short term accommodation to guests. The Studio contains a WC, basin, kitchen, and shower.

5 Wastewater Generation

5.1 Wastewater Quantity

Wastewater generation at the Site is from WC, basin, kitchen, shower, bath, and laundry facilities, with potable water provided by tank (roof) water supply.

An occupancy rate of two (2) EP for first two (2) bedrooms and one (1) EP for each bedroom thereafter has been applied for residential components, with a rate of two (2) EP per bedroom for eco-tourism accommodation unit.

A higher reticulated (mains) flow allowance has been adopted for the eco-tourist accommodation unit to account for typically higher water use associated with short-term accommodation. The following table summarises the assumed hydraulic load from each development component.

Parameter	Value	Comment/Source
Existing Dwelling + Loft		
No. Bedrooms	7	6-bedroom dwelling + 1-bedroom loft
EP	9	(2-bedrooms x 2EP) + (5-bedrooms x 1EP)
Flow Allowance (L/EP/day)	120	Table H1 of *AS/NZS 1547:2012* for 'residential premises with tank water supply'
Design Hydraulic Load (L/day)	1,080	9EP x 120L/person/day
Coach House		
No. Bedrooms	1	As per Owner information
EP	2	1-bedrooms x 2EP
Flow Allowance (L/EP/day)	120	Table H1 of *AS/NZS 1547:2012* for 'residential premises with tank water supply'
Design Hydraulic Load (L/day)	240	2EP x 120L/person/day
Eco-tourist Accommodation		
No. Bedrooms	1	As per Owner information
EP	2	1-bedroom x 2EP
Flow Allowance (L/EP/day)	150	Table H1 of *AS/NZS 1547:2012* for 'residential premises with reticulated water supply'
Design Hydraulic Load (L/day)	300	2EP x 150L/person/day

The Site has a combined design hydraulic load of 1,620L/day.

5.2 Wastewater Quality

The contaminants in sanitary 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 at the Site is expected to be of 'typical' domestic nature, with combined wastewater; blackwater (toilet) and greywater (kitchen, laundry, shower, and bath) streams. As such, untreated wastewater is expected to have characteristics similar to that described in the following table; which incorporates information taken from NSW DLG (1998).

Parameter	Loading	Greywater %	Blackwater %
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

6 Existing OSSM System

The existing OSSM system servicing the Site is described in this section, with the layout presented as Figure 1 of Appendix A.

Greywater generated at the Site is drains to a stormwater drainage system directed off-site; with blackwater draining to a septic tank directly north of the loft.

The septic tank was found to be in poor structural condition, with an internal diameter of 1.5m, a standing water level of 1.5m, providing an 'effective' volume of 2,650L. No baffle was observed in the tank, with weak scum and sludge layers present. A vitrified clay T-junction was observed within the outlet of the tank, with no T-junction installed on the inlet.

NSW Health (2016) requires septic tank capacities to be sized to provide (minimum) 24-hours of settling volume and an allowance for accumulation of sludge. The guideline requires a minimum sludge accumulation allowance of 1,550L with an assumed de-sludge frequency of four (4) years, as per the following calculation.

Sludge Allowance + Daily Flow = Tank Capacity

Based on the septic tank volume, the available treatment capacity of the tank is 1,100L (2,650L – 1,550L). Therefore, the tank has insufficient capacity to manage the hydraulic loads generated from the Site.

No LAA was identified at the time of the Site visit; however, it is assumed that effluent is disposed to a subsoil absorption bed in the north of the Site in proximity to the ornamental pond to the east of the Clifton House.

6.1 Recommendation

Given the non-compliant discharge of greywater and the poor condition of the undersized septic tank, it is recommended that a new OSSM system be installed at the Site.

The redundant septic tank must be decommissioned in accordance with best practice procedures, as outlined in NSW Health Advisory Note 3, with the existing LAA 'abandoned in place'.

https://www.health.nsw.gov.au/environment/domesticwastewater/Documents/adnote3.pdf

7 Proposed Wastewater Treatment

Given the identified Site constraints, specifically slowly permeable subsoils, the number of treatment and LAA options considered suitable are limited. 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.

Therefore, a minimum effluent quality standard of 'secondary treatment' (with disinfection) is recommended for the Site.

7.1 Proposed Wastewater Treatment

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 (STS) in NSW. The system selected must hold such an accreditation for treatment of up to 2,000L/day. Appropriate secondary treatment technologies include (but are not limited to) the following:

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

A detailed list of suitable NSW Health accredited STSs 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 STS', or can be installed as an add-on by the system supplier. A disinfection unit must be installed with the chosen system. Domestic systems typically use one or a combination of the following disinfection methods:

- Ultra violet irradiation; and / or
- Chlorination.

Final system selection will be the responsibility of the Owner; however, selection and installation of the system must follow Council requirements and the recommendations provided within this WMR.

7.1.1 Treated Effluent Quality

Table 14 of NSW DLG (1998) describes the minimum effluent quality standard for STSs, and have been reproduced in the following table.

Parameter	Loading
Biochemical Oxygen Demand	≤20mg/L
Suspended Solids	≤30mg/L
Faecal Coliforms	≤30cfu/100mL
Total Nitrogen	≤30mg/L
Total Phosphorus	≤10mg/L

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

7.2 System Siting

The exact positioning of the proposed STS 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 system installation.

All plumbing and drainage works must be completed in accordance with the National Construction Code, which incorporates the Plumbing Code of Australia.

7.3 System Operation and Management

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

8 Proposed Effluent Management

This section describes the Site's capability for effluent management and provides design details, including sizing of the required LAA. As detailed in Section 7, secondary treatment (with disinfection) is considered the most appropriate wastewater treatment option.

8.1 LAA Options

W&A have considered the suitability of various land application systems in relation 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 range of effluent land application options considered and presents recommendation for the preferred approach to be used in conjunction with the proposed STS.

Land Application Option	Suitable	Reasoning
Conventional Absorption Trenches / Beds	No	Not supported due to slowly permeable soils (*AS/NZS 1547:2012*).
ETA Beds	Possible	Considered suitable; however, discounted due to substantial construction cost and availability of more appropriate alternatives.
Mounds		
Surface Irrigation	Possible	Considered suitable; however, discounted due to slope limitations (7% – 10%) presenting an increased runoff risk to surface waters located within the standard buffers.
Subsurface Irrigation	Yes	Considered suitable as effluent is able to be applied high in the soil profile, maximising evapotranspiration and vegetation uptake.

Subsurface irrigation (SSI) is considered the most suitable effluent management method for the Site. A description of the proposed SSI LAA, required setbacks, and sizing are presented in the following sections.

8.2 Subsurface Irrigation

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.

8.3 LAA Sizing

Water and nutrient balance modelling were undertaken to determine the necessary size of the LAA required to manage the proposed hydraulic and nutrient loads from the Site. 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 NSW DLG (1998). These calculations determine 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 requirements to enable nutrients to be assimilated by the soils and vegetation. The nutrient balance used generally follows the NSW DLG (1998) procedure, 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 hydraulic load	L/day	1,620	Refer Section 5.1
Precipitation	mm/month	Median monthly	BoM Station 061014
Pan evaporation	mm/month	Mean monthly	SILO Point Data (-32.7, 151.45)
Retained rainfall	Unitless	0.8	Conservative assumption that 80% of rainfall remains on-site and infiltrates the soil
Crop factor	Unitless	0.6-0.8	Annual value for grasses (adjusted for seasons)

Parameter	Units	Value	Comments
Design loading rate	mm/day	2	Based on Table M1 *AS/NZS 1547:2012* for irrigation in Cat 6 soils
Effluent total nitrogen concentration	mg/L	≤30	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	≤10	Target effluent quality following secondary treatment, from Table 14 NSW DLG (1998)
Soil phosphorus sorption capacity	mg/kg	432	Refer Section 3
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	Recommended design life for system (NSW DLG, 1998)
Results			
Hydraulic balance		869	
Nitrogen balance		546	
Phosphorus balance		576	

Based on the hydraulic and nutrient modelling outcomes, the hydraulic load is the limiting factor for sizing the required LAA. Therefore, a minimum LAA of 870m^2 (rounded) is required to service the Site.

8.4 Installation and Detail

A detailed irrigation design is beyond the scope of this WMR. The design should be prepared by the nominated irrigation installer for submission with the Section 68 application to Council and before installation of the irrigation system.

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. PCSD typically needs an operating pressure at the emitter of 10m – 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 0.8m apart in clay soils and roughly parallel to prevent insufficient effluent distribution. SSI shall be installed at a depth of 100mm – 150mm in good quality topsoil as per *AS/NZS 1547:2012* (Note 2, Table M1). Due to topsoil limitations at the

Site, it is recommended that of organic material is incorporated into the proposed LAA prior to installation (refer Section 9.3.2).

General specifications for the proposed SSI LAA is as follows:

- Effluent must be applied evenly across the 870m^2 LAA;
  - This can be achieved by way of a hydraulic sequencing valve (indexing valve or similar) to appropriately sized, nominally three (3) zones of 290m^2 would be appropriate;
  - Care should be taken to ensure that the valve is installed at or above the maximum LAA elevation to prevent poor operation due to back-pressure;
- Driplines are to be buried within a minimum 100mm – 150mm depth below the 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 (nominally 120µm) disc filter must 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);
- A flush main should be installed to periodically clean-out the irrigation lines to prevent soil particles being sucked into the lines at the end of pump cycles as pipelines depressurise and ensure effective long-term performance;
  - Either manual or automatic flush valves may be used, with flush water directed back to the treatment system or to a manual flush valve box installed at the terminal end of each zone. Valve boxes should installed with 50mm – 100mm pea gravel base and lilac lids level with ground surface;
- Air release valves will be installed at the high points in individual irrigation zones to ensure that any entrained air pockets are automatically released; and
- An 'as-built' schematic layout of the OSSM system (treatment and LAA) shall be provided to Council and the system Owners upon completion.

Figure 4 in Appendix A provides a schematic representation of a SSI system. Specialist advice must be obtained for designing and installing the irrigation system.

8.5 Buffers

Buffer distances are recommended to provide a form of mitigation against unidentified hazards and reduce potential pathways of human and environmental exposure. The following (minimum) environmental buffers are required for SSI land application systems, based on Table 5 of NSW DLG (1998):

- 250m from domestic GW bores;
- 100m from permanent watercourses;
- 40m from intermittent watercourses and other waters;
- 6m if area up-gradient and 3m if area down-gradient of driveways, swimming pools, property boundaries, and buildings;
- 4m from in-ground water tanks; and
- 0.6m vertical separation from hardpan or bedrock.

All of the required buffers can be achieved at the Site; however, the strict application of buffers to surface water features (intermittent waterways and other waters) creates unfavourable available EMA at the Site >150m south of the development area with a ~16m increase in elevation.

In order to provide favourable available EMA at the site, a reduced buffer distance of 20m is proposed to surface water features. To support this, a risk assessment and viral die-off modelling have been provided in the following section to confirm the adequacy of available buffers.

8.5.1 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 the proposed LAA design to support a reduction in the recommended buffer distance:

- Secondary treated effluent (with disinfection) with contractual service agreement;
- Deep (1,200mm) Category 6 soils;
- Proposed LAA upslope of sensitive features;
- Moderate rainfall area (<800mm/year);
- Proposed subsurface (SSI) application method in gently sloped (~7%) landscape with good drainage;
- Proposed LAA sized by monthly hydraulic water and annual nutrient balance; and
- Entire property located above the 1 in 20 year flood level.

AS/NZS 1547:2012 recommends a setback distance range of 15m (low risk) – 100m (high risk) for surface water features. Based on the analysis the proposed OSSM presents a 'low risk' to surface water features, with a recommended setback range of 15m – 30m. Therefore, the proposed setback of 20m has been applied to surface water features.

8.5.2 Viral Die-off Modelling

Viral die-off modelling has been used to support the reduction in setbacks to surface water features. 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 (Cromer *et al*. 2001); and
- Cooler temperatures allow viruses to reside longer in the soil and hence provide potentially greater travel distances. GW temperatures based on the assumption of 11.8°C (SILO Point Data -32.7, 151.45 mean minimum temperature).

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 (°C)	11.8
Days Required for Viral Reduction Level	40
Porosity of Soil (decimal)	0.47
K_{sat} (m/day)	0.06
Groundwater Gradient (%)	3.5
Depth to GW (m)	1.2
Horizontal distance travelled in GW (m)	0.1

Viral die-off modelling demonstrates that with secondary treatment (with disinfection), 100% pathogen reduction within the soil is expected to occur within 0.1m from the installed LAA boundary. Therefore, a reduction in contaminants to background levels will be achieved within the adopted setbacks before reaching any sensitive receptors.

8.6 LAA Positioning

Available areas for effluent application are shown in Figures 2 and 3 of Appendix A as ‘Available EMA’. These areas exclude the adopted buffer distances as detailed in Sections 8.3 and 9. The required LAA can be located anywhere within the available EMA. A nominal location for the SSI LAA is shown in Figure 3 of Appendix A.

Access onto the LAA by vehicles and grazing animals can damage the soil conditions and irrigation infrastructure. Therefore, it is recommended that the LAA be appropriately fenced to restrict access, reducing the risk of damage.

9 Mitigation Measures

9.1 Stormwater Management

The performance of LAAs (and potentially treatment systems) can be adversely affected if stormwater is allowed to run onto these areas. A stormwater diversion device should be designed and constructed to collect, divert and dissipate collected run-on away from the proposed LAA. The structure 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 Figure 5 of Appendix A. 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.

9.2 Vegetation Establishment

The existing groundcover (managed lawn) at the Site is considered sufficient for effluent application.

It is recommended to establish and maintain a vegetated buffer around the LAA. 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 LAA once fully grown. It is important that the LAA receives maximum exposure to sun and wind to maximise evapotranspiration.

To maximise assimilation of effluent-borne nutrients within the LAA, vegetation clippings should be removed from the LAA and mulched elsewhere on-site for use on 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 of clippings in the general waste bin, or green waste bin collection service, if provided.

9.3 Soil Improvement

9.3.1 Soil Chemistry

Given that Site soils are identified as acidic and slightly unstable and dispersive; they may be susceptible to impaired vegetative growth and impaired permeability. 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 calcium minerals is a recognised way of reducing the effects of soil instability and dispersion. It does this by supplying calcium to the affected soil and thereby elevating calcium concentrations with respect to sodium.

Typically, gypsum would be the preferred soil amendment; however, given the identified acidity concern a 50:50 application of gypsum and lime may be more suitable for the Site. Both gypsum and lime are 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 necessary to incorporate the amendment into the subsoil prior to construction of the land application system. This can be done by shallow ripping of the natural soil to 200mm and applying the 50:50 gypsum / lime. A suitable gypsum / lime application rate of approximately 0.2kg/m^2 is recommended.

9.3.2 Topsoil Material

To improve the topsoil material at the Site, it is recommended that 50mm of organic mulch / topsoil material is incorporated into the proposed LAA footprint prior to installation. This can be done by shallow ripping of the natural soil to 200mm, incorporating the organic material (as well as the recommended soil amendments in Section 9.3.1), and levelling of the surface prior to installation of the SSI LAA.

10 Acid Sulfate Soils

Council mapping indicates the Site is located within a Class 5 acid sulphate soil (ASS) risk zone (LEP, 2011). Work carried out in this zone may require development consent, including an ASS Management Plan, under the following conditions:

> *Class 5 – Works within 500m of adjacent Class 1, 2, 3, or 4 land that is below 5m AHD and by which the watertable is likely to be lowered below 1m AHD on adjacent Class 1, 2, 3, or 4 land.*

Any excavation works require for the proposed OSSM system will occur above 66m AHD, as per available DEM data. No water table was identified during the soil investigation. SSI laterals are to be laid on the soil surface and covered with 0.1m of topsoils material, with an assumed excavation depth of 1.8m – 2m for the proposed STS (based on commonly available tank sizes).

Therefore, a maximum excavation elevation of 64m AHD (66m AHD – 2m AHD) is expected. Encountering ASS or lowering the water table below 1m AHD is considered unlikely. Based on preliminary investigation, it is assumed that ASS management measures are not likely to be required.

11 Conclusions and Recommendations

This completes our assessment of the Site capability for sustainable OSSM in relation to the proposed change of use at 245 Station Lane, Lochinvar NSW. Specifically, W&A recommend the following:

- The existing septic tank should be decommissioned in accordance with NSW Health Advisory Note 3;
- Wastewater generated will be treated to a ‘secondary’ standard within an appropriately sized, NSW Health accredited, secondary treatment system (with disinfection);
- Secondary treated effluent will be reused on-site via a SSI LAA of 870m^2;
    - The SSI LAA is to be split into three (3) zones of 290m^2, with distribution achieved by a hydraulic indexing valve (or similar);
- The LAA should be designed and installed by an experienced professional, taking into account the expected flows and other recommendations contained within this report;
- A gypsum / lime application rate of approximately 0.2kg/m^2 should be applied to the proposed LAA prior to installation;
- 50mm of organic material (mulch / topsoil) should be incorporated into the proposed LAA prior to installation;
- The proposed LAA must be located within the available EMA specified to comply with adopted setbacks;
- Suitable vegetation such as turf must be established over the LAA immediately after installation; and
- Livestock and vehicles must be prevented from entering the designated LAA.

Yours Sincerely,

Connor Morton

Environmental Consultant
Whitehead and Associates Environmental Consultants Pty Ltd

Appendix A

Figures

Figure 1: Site Plan Showing Existing OSSM

Job 3706: 245 Station Lane, Lochinvar NSW - WMR

N

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0 20 40 m
(Approx Scale)

Revision	001
Drawn	CM
Approved	MS

Figure 2: Site Plan Showing Layout and Available EMA

Job 3706: 245 Station Lane, Lochinvar NSW - WMR

N

Whitehead & Associates
Environmental Consultants

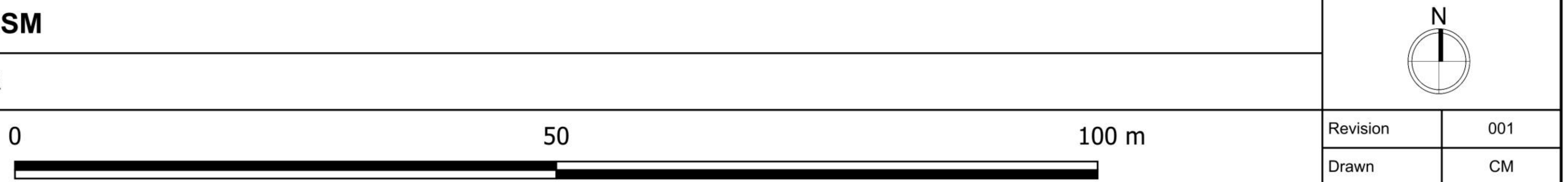
0 20 40 60 80 m

(Approx Scale)

Revision	001
Drawn	CM
Approved	MS

Figure 3: Site Plan Showing Proposed OSSM

Job 3706: 245 Station Lane, Lochinvar NSW - WMR



Whitehead & Associates Environmental Consultants

Revision	001
Drawn	CM
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.

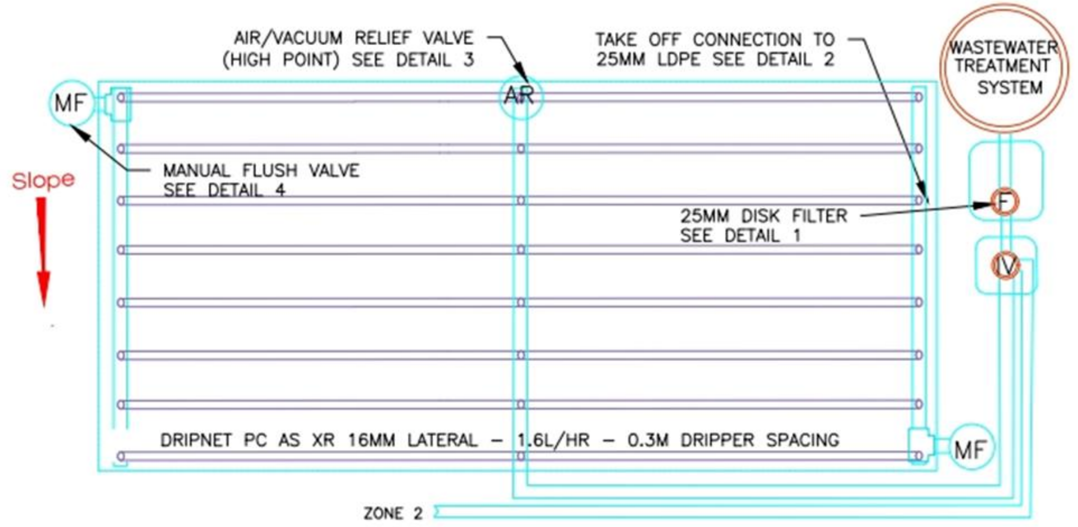
A Total application area = 852m2. Four zones of 213m2 each.

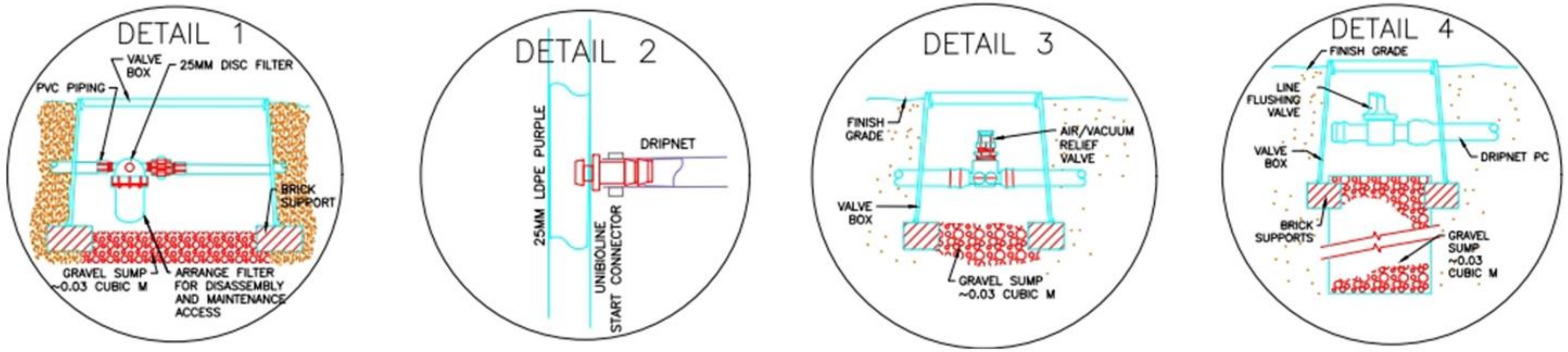
B Each zone is fed by a central distribution manifold with return flushing manifolds on the outer ends, each with a flush valve. An air/vacuum relief valve is located at the high point in each zone.

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.

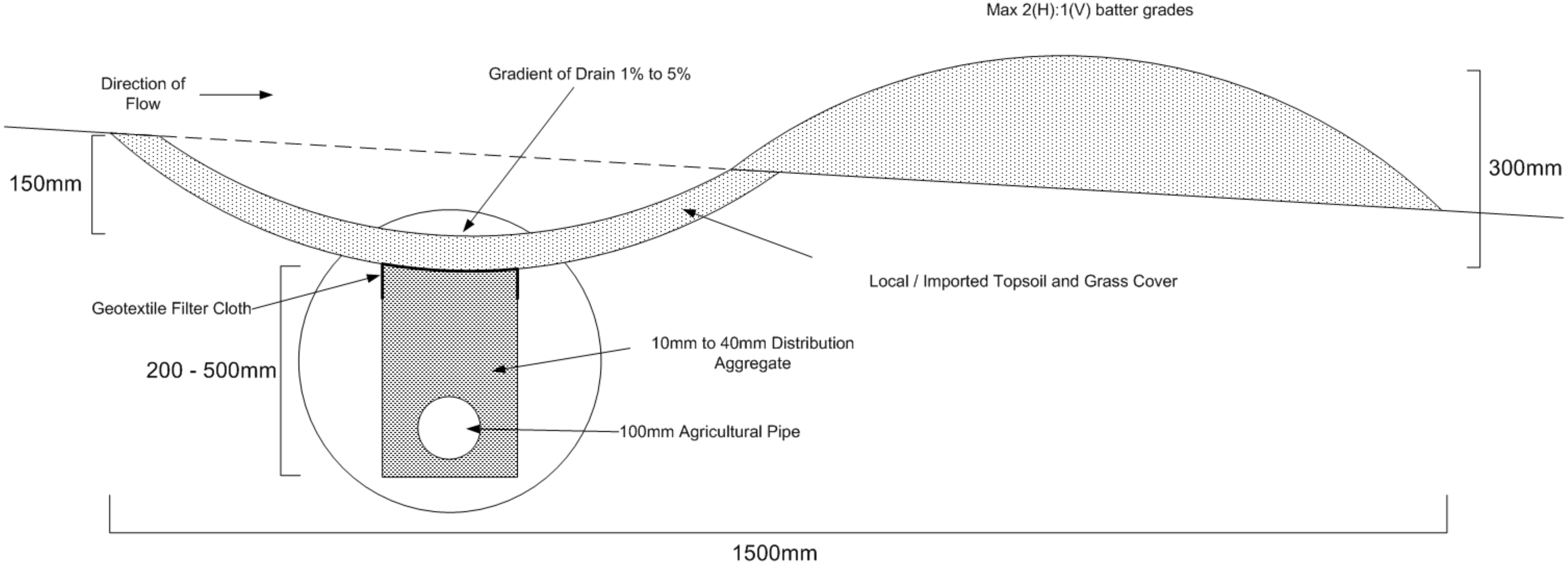




Courtesy: Netafim Australia Pty Ltd

W **Whitehead & Associates** **Environmental Consultants**	*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 4: Standard Drawing, Subsurface Irrigation**

Cross Section: Upslope Diversion Drain



Whitehead & Associates Environmental Consultants	**FIGURE 5:** **STANDARD DRAWING OF AN UPSLOPE DIVERSION DRAIN**	Project: 3706 Drawn: CM Approved: MS Scale: NTS

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
LFS - Loam fine sandy
SiL - Silty loam

MC - Medium clay
HC - Heavy clay

Parent material (weathered)

Soil Bore Log

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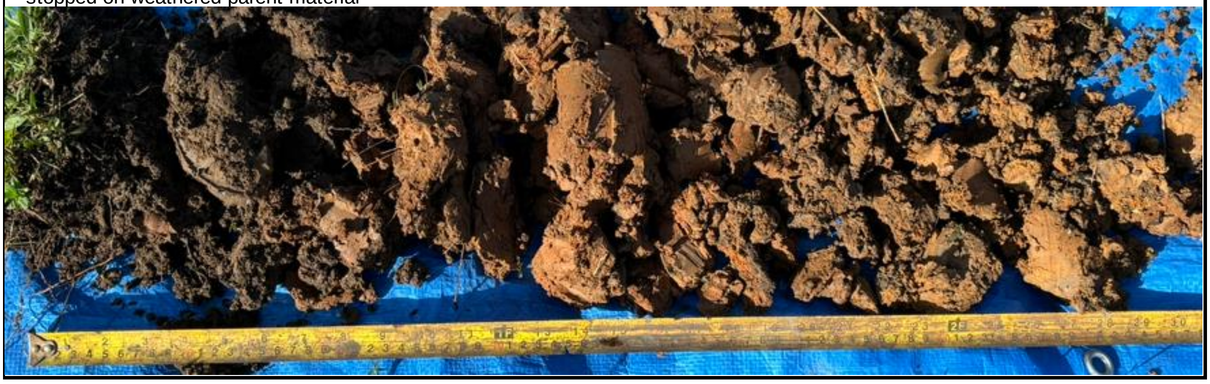
Client:	Craig Favelle	**Test Pit No:**	**BH1**
Site:	245 Station Lane, Lochinvar NSW	Excavated/logged by:	CM
Date:	3 May 2024	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

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		BH1/1	A1	MC	Moderate	Dark brown	Nil	< 2%	2-6mm	M	
0.2		BH1/2	A2	MC	Massive	Dark brown	Nil	2 - 10%	2-6mm	SM	
0.3		BH1/3	B	HC	Massive	Strong brown	Nil	2 - 10%	6-20mm	SM	
0.4											
0.5											
0.6							Orange Gley (moderate)				
0.7											
0.8											

- stopped on weathered parent material



Soil Bore Log

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Client:	Craig Favelle	**Test Pit No:**	**BH2**
Site:	245 Station Lane, Lochinvar NSW	Excavated/logged by:	CM
Date:	3 May 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	MC	Moderate	Strong brown	Nil	< 2%	2-6mm	SM	
0.2		BH2/2	B1	MC	Massive	Reddish brown	Nil	2 - 10%	6-20mm	SM	
0.3											
0.4											
0.5											
0.6											
0.7											
0.8											
0.9		BH2/3	B2	MC	Weak	Brown	Nil	2 - 10%	6-20mm	SM	
1.0											

- stopped on weathered parent material

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Craig Favelle	**Test Pit No:**	**BH3**
Site:	245 Station Lane, Lochinvar NSW	Excavated/logged by:	CM
Date:	3 May 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	MC	Moderate	Very dark grey	Nil	< 2%	2-6mm	M	
0.2		BH3/2	B1	MC	Massive	Dark brown		2 - 10%	6-20mm	SM	
0.3							Orange (minor)				
0.4											
0.5		BH3/3	B2	MC	Massive	Brown	Orange Gley (moderate)	2 - 10%	6-20mm	SM	
0.6											
0.7											
0.8											
0.9											
1.0											
1.1											
1.2											

- stopped on weathered parent material

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	Craig Favelle	**Test Pit No:**	**BH4**
Site:	245 Station Lane, Lochinvar NSW	Excavated/logged by:	CM
Date:	3 May 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	MC	Moderate	Very dark grey	Nil	< 2%	2-6mm	SM	
0.2–0.4		BH4/2	B1	MC	Massive	Dark brown	Nil	2 - 10%	6-20mm	SM	
0.5–1.2		BH4/3	B2	MC	Weak	Brown	Orange (minor)	2 - 10%	6-20mm	D	

- stopped on weathered parent material

Job 3706: 245 Station Lane, Lochinvar 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	100	MC	7	Negligible	n/a	6.2	Slightly acid	46	0.35	Non-saline	
	BH1/2	200	MC	5	Slight	n/a	6.1	Slightly acid	47	0.35	Non-saline	
	BH1/3	800	HC	5	Slight	n/a	5.1	Strongly acid	92	0.53	Non-saline	
	BH2/1	100	MC	8	Negligible	n/a	4.8	Very strongly acid	59	0.44	Non-saline	
	BH2/2	800	MC	5	Slight	n/a	4.8	Very strongly acid	143	1.07	Non-saline	
	BH2/3	1000	MC	2(1)	Mod-High	n/a	4.8	Very strongly acid	532	3.99	Slightly saline	
	BH3/1	100	MC	7	Negligible	n/a	4.9	Very strongly acid	59	0.44	Non-saline	
	BH3/2	400	MC	5	Slight	n/a	4.6	Very strongly acid	145	1.09	Non-saline	
	BH3/3	1200	MC	5	Slight	n/a	4.3	Extremely acid	828	6.21	Moderately saline	
	BH4/1	100	MC	7	Negligible	n/a	4.5	Very strongly acid	62	0.47	Non-saline	
	BH4/2	400	MC	7	Negligible	n/a	5.1	Strongly acid	185	1.39	Non-saline	
	BH4/3	1200	MC	5	Slight	n/a	5.5	Strongly acid	122	0.92	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

Soil Landscapes of the Newscatle 1:100 000 Sheet (L.e. Matthei, 1995)

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
ne7	0.2-1.4	35.8	H		n/a		n/a		n/a		n/a	1.0	NS	432	H

Notes:- (also refer Interpretation Sheet 2)

n/a
n/t

Appendix C

Water and Nutrient Balance

Irrigation Area Water Balance & Storage Calculations

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Job 3706: 245 Station Lane, Lochinvar NSW

INPUT DATA

Design Wastewater Flow	Q	1,620	L/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	870	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	0.8	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Rainfall Data	Branxton (Dalwood Vineyard) [061014]			Median Monthly data (1863 - 2024)
Evaporation Data	SILO Point Data (-32.7, 151.45)			Mean Monthly data (1984 - 2024)

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	72.1	74.0	75.8	48.5	44.2	47.0	34.8	34.7	36.3	47.0	58.3	65.8	72.1	74.0	75.8	48.5	44.2	47.0	**795.2**
Evaporation	E		mm/month	187.6	147.8	129.7	94.4	69.2	55.9	65.6	91.9	121.5	152.9	166.8	194.4	187.6	147.8	129.7	94.4	69.2	55.9	**1477.5**
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	150.1	118.2	90.8	56.7	41.5	33.6	39.4	55.1	85.0	122.3	133.4	155.5	150.1	118.2	90.8	56.7	41.5	33.6	**1081.5187**
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	212.1	174.7	152.8	116.7	103.5	93.6	101.4	117.1	145.0	184.3	193.4	217.5	212.1	174.7	152.8	116.7	103.5	93.6	**1812.0**
INPUTS (GAINS)																						
Retained Rainfall	RR	RxRC	mm/month	57.68	59.2	60.64	38.8	35.36	37.6	27.84	27.76	29.04	37.6	46.64	52.64	57.68	59.2	60.64	38.8	35.36	37.6	**510.8**
Effluent Irrigation	W	(QxD)/L	mm/month	57.7	52.6	57.7	55.9	57.7	55.9	57.7	57.7	55.9	57.7	55.9	57.7	57.7	52.6	57.7	55.9	57.7	55.9	**680.1**
Inputs		RR+W	mm/month	115.4	111.8	118.4	94.7	93.1	93.5	85.6	85.5	84.9	95.3	102.5	110.4	115.4	111.8	118.4	94.7	93.1	93.5	**1190.9**
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	-96.7	-62.9	-34.4	-22.0	-10.4	-0.1	-15.8	-31.6	-60.1	-89.0	-90.9	-107.1	-96.7	-62.9	-34.4	-22.0	-10.4	-0.1	
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	325	396	545	624	737	869	683	562	419	342	331	305	325	396	545	624	737	869	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: **869** 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

Nutrient Balance

Whitehead & Associates
Environmental Consultants

Job 3706: 245 Station Lane, Lochinvar NSW

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 576 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	1,620	L/day	Crop N Uptake	260	kg/ha/yr	which equals	71.23	mg/m²/day
Effluent N Concentration	30	mg/L	Crop P Uptake	30	kg/ha/yr	which equals	8.22	mg/m²/day
% Lost to Soil Processes (Geary & Gardner 1996)	0.2	Decimal	Phosphorus Sorption					
Total N Loss to Soil	9,720	mg/day	P-sorption result	432	mg/kg	which equals	7,258	kg/ha
Remaining N Load after soil loss	38,880	mg/day	Bulk Density	1.4	g/cm³			
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	546	m²
Phosphorus	576	m²

Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)

Nominated LAA Size	870	m²
Predicted N Export from LAA	-8.43	kg/year
Predicted P Export from LAA	-3.01	kg/year
Phosphorus Longevity for LAA	96	Years
Minimum Buffer Required for excess nutrient	0	m²

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	870	m²			
Daily P Load	0.0162	kg/day	→ Phosphorus generated over life of system	295.65	kg
Daily Uptake	0.0071507	kg/day	→ Phosphorus vegetative uptake for life of system	0.150	kg/m²
Measured p-sorption capacity	0.72576	kg/m²			
Assumed p-sorption capacity	0.363	kg/m²	→ Phosphorus adsorbed in 50 years	0.363	kg/m²
Site P-sorption capacity	315.71	kg	→ Desired Annual P Application Rate	8.924	kg/year
			which equals	0.02445	kg/day
P-load to be sorbed	3.30	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

Buffer Risk Assessment

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Viral Die-off Modelling

Job 3706: 245 Station Lane, Lochinvar NSW					*AS/NZS 1547:2012* Table R1 and R2 Buffer Distance Justification																	
Site Feature	Constraint Scale				Risk Assessment									Revised Risk Assessment								Available Buffer (m)
	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	
	Microbial Quality of Effluent	Secondary treated effluent (with disinfection) and Contractual Service Agreement	Primary treated effluent (no disinfection)	Secondary treated effluent (with disinfection) and Contractual Service Agreement	**Low**	✓	1		0		0			✓	1		0		0			
	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 down gradient; high rainfall; high resource / environmental value	Category 6 soils; surface water feature across slope and downslope of proposed LAA; moderate rainfall area (<800mm pa); and low resource value	**High**		0		0	✓	3		Monthly hydraulic and annual nutrient modelling used to size LAA.		0	✓	2		0	Conservative LAA location and design		
	Slope	0-6% (surface effluent application), 0 -10% (subsurface effluent application)	>10% (surface effluent application), >30% subsurface effluent application	~7% for subsurface (SSI) application	**Low**	✓	1		0		0			✓	1		0		0			
Surface Water 15m (low) - 100m (high)	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 permanent water feature	**High**		0		0	✓	3	**Moderate (<=17)**	Monthly hydraulic and annual nutrient modelling used to size LAA.		0	✓	2		0	Conservative LAA location and design	**Low (<=10)**	15-30
	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 a elevated, sloping landscape with good drainage observed within the available EMA	**Moderate**		0	✓	2		0				0	✓	2		0			
	Flood Potential	Above 1 in 20 year flood contour	Below 1 in 20 year flood contour	Entire property located above the 1 in 20 year flood level	**Low**	✓	1		0		0			✓	1		0		0			
	Application Method	Drip irrigation or subsurface application of effluent	Surface / above ground application of effluent	Subsurface (SSI) application	**Low**	✓	1		0		0			✓	1		0		0			

Beavers, Cromer, Gardner Viral Dieoff Model
Job 3706: 245 Station Lane, Lochinvar 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 (^oC)	11.8	From BOM
Order of magnitude reduction	3	3 order of magnitude required for secondary treatmen
Days required for viral reduction	**40**	(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 =	40	days
Effective porosity of soil (fraction)	P =	0.47	
Saturated hydraulic conductivity	K =	0.06	m/day
Groundwater gradient	I =	3.5%	
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 =**	**0.1**	**m**

Notes:

Porosity (P): Worst case assumption for medium clay soil (Hazelton & Murphy, 2007).
Ksat (K): Assumed average Ksat of 0.06m/day for massive medium clay.
Groundwater gradient (I): Assumed groundwater gradient of 3.5% (half of surface slope value).
Vertical drainage (d_v): Assumed 1.2m of unsaturated flow before reaching groundwater.

f = 1 - pb/ps
f = porosity
pb = (bulk density of soil)g/cm^3 ← Table 2.18 (Hazelton & Murphy, 2007)
ps = 2.65g/cm^3 ← Seciton 2.4.1 average specific gravity of soil particles (Hazelton & Murphy 2007)

pb =	1.4
ps =	2.65
f =	0.47

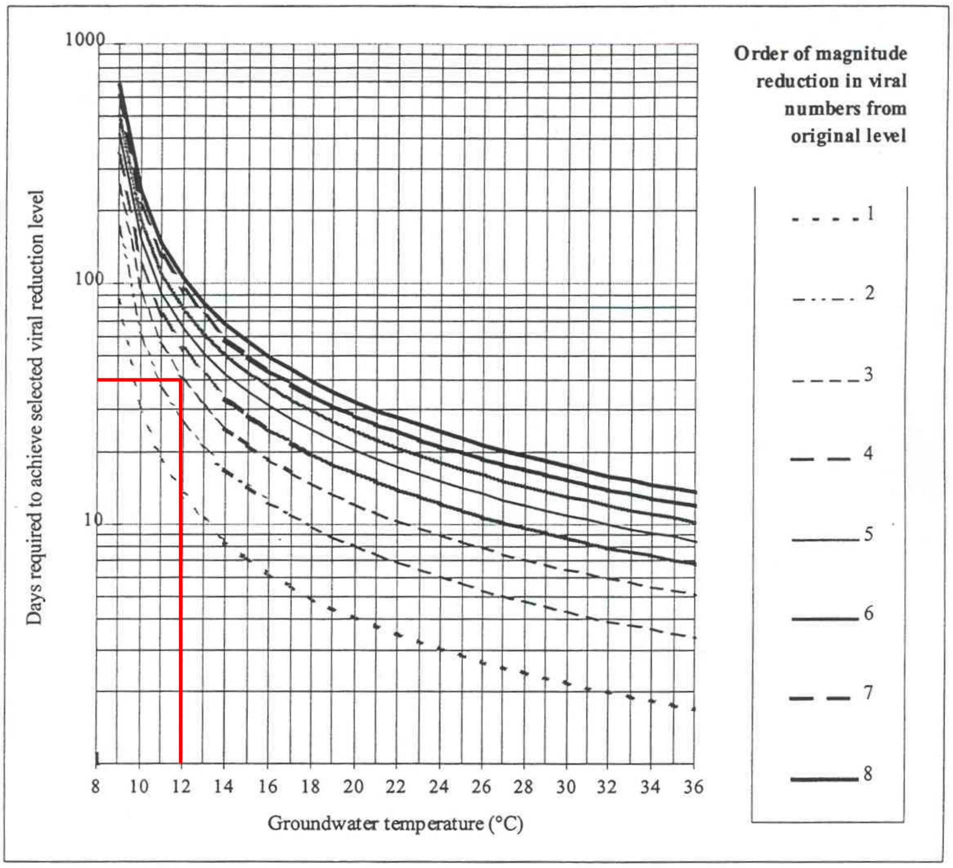

Figure 1. Relationship between Groundwater Temperature and Viral Die-Off Time for Various Order-of-Magnitude Reductions in Viral Numbers

(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 soils 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.