On-site effluent management study

Lot 3 in the proposed subdivision of 172 Spring Hill Road,
Springhill NSW 2800

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1. Summary

Proposed development and situation	A rural-residential lot requires evaluation for suitability of on-site application of effluent from a proposed new residential dwelling. This report describes the assessment and recommends a suitable effluent treatment and application system.
Investigation	A site assessment and soil assessment were undertaken using the Australian Standard 1547, *On-site domestic wastewater management*, and the Environment and Health Protection Guidelines, *On-site sewage management for single households* (1998), Department of Urban Affairs and Planning, as guidelines. Suitable wastewater application systems, sizing and location for the site are recommended. The evaluation is based on a proposed dwelling with four bedrooms.
Type of land application and **treatment** systems considered best suited to the site	The recommended system is • **Surface irrigation with an irrigation area of 488 square metres.** Gypsum should be applied to the application area during construction. • **Secondary wastewater treatment system** accredited by NSW Health.
Location	The location of the effluent application area is identified in Appendix 1.
Notes	Construction of the treatment and application systems should be according to AS1547 and Sydney Catchment Authority guidelines, Designing and Installing On-site Wastewater Systems (2019). Gypsum should be applied to the application area during construction and annually to maintain permeability. Secondary treatment systems require regular maintenance to ensure effective operation. Maintenance scheduling should be undertaken in accordance with manufacturers and NSW Health guidelines. The water balance is calculated using full water saving devices such as dual flush toilets (6/3litre water closets), water reduction cycles on dishwashers, aerator faucets fitted to taps, front loader washing machines and water reducing shower heads. A maintained grass sward is the recommended vegetation over the irrigation area. Appendix 4 is a checklist of do's and don'ts to ensure correct operation of the wastewater system. Gypsum should be applied every two years to maintain permeability.

2. Introduction

A rural-residential lot requires evaluation for on-site application of effluent from a proposed new residential dwelling. A site and soil assessment were undertaken on 3 June 2022. Boreholes were drilled to 1.0m depth and soil samples collected for analysis. This report describes the site and soil investigation and recommends a suitable effluent treatment and application system.

3. Scope

A site assessment and soil assessment were undertaken using Australian Standard 1547, *On-site domestic wastewater management*, Sydney Catchment Authority (SCA) guidelines, *Designing and Installing On-site Wastewater Systems (2019)* and the Environment and Health Protection Guidelines, *On-site sewage management for single households* (1998), Department of Urban Affairs and Planning, as guidelines. Suitable wastewater application systems, sizing and location for the site are recommended.

4. Site information

Address of site	Lot 3 in the proposed subdivision of 172 Spring Hill Road, Spring Hill NSW 2800
Local Government	Cabonne Shire Council
Client	Ian Stewart
Size	Approximately 2.0ha
Location, shape, layout	A plan of the relevant areas of the site and proposed effluent application area is described in Appendix 1.
Photograph(s) attached	Yes
Intended water supply	Rainwater Reticulated water supply Bore/Groundwater
Development	New residential dwelling
Expected wastewater flows	Number of bedrooms – 4 Number of persons – 5 Flows per person – 120 litres/person **Total** expected wastewater flow is 600 litres/day Flows are calculated using full water saving devices such as dual flush toilets (6/3 litre water closets), water reduction cycles on dishwashers, aerator faucets fitted to taps, front loader washing machines and water reducing shower heads. Re-calculation of the hydraulic balance and application area is required for dwellings containing a differing number of potential bedrooms.
Local experience of on-site management systems nearby	All systems are known to work satisfactorily in the locality providing they are adequately designed and maintained.

Setting	This lot is in a rural setting where the average dwelling density is less than 1 dwelling per 2ha and therefore less than the 1 per 0.4 hectares required for groundwater protection (Geary & Gardner 1996, Land Management for Urban Development, Australian Society of Soil Sciences, Qld).
Current land-use	Grazing
Climate	Summers are warm to hot and winters are cold with little or no effective evaporation. Rainfall is distributed evenly throughout the year with an average annual rainfall of 832mm and pan evaporation of 1,335mm (Bureau of Meteorology, Orange).

5. Site assessment

Work undertaken	**Details**
Date	03 June 2022
Details	Site inspection, borehole drilling to 1.0m depth or refusal, soil sampling and analysis
Weather on day and preceding week	Overcast, windy, >25mm rain in preceding week

Site feature	**Assessment**	**Limitation**
Vegetation	Grasses, plantain, clover, broadleaved weeds	Minor
Flood potential: 1 in 20 year 1 in 100 year	 Nil Nil	Minor
Exposure Site aspect Shelter belts Topographical feature or structure	High East Nil Nil	Minor
Slope	1-3% in application area	Minor
Landform	Mid-slope	Minor
Run-on and seepage: Comment	Run-on and sub-surface seepage is expected to be moderate. Diversion banks are required to divert flows from upslope sources.	Moderate
Erosion potential: Erodibility and erosion hazard	The topsoil and subsoil have a low erodibility. Erosion hazard is low and is reduced when vegetated.	Minor

Site drainage	Moderate. Mottled clays identified from 600mm.	Moderate
Fill	Nil	Minor
Groundwater: Level of protection Bores and wells in the area and their purpose	One groundwater bore is located within 100m of the recommended application area. The bore (GW058711) is located approximately 95m southwest of the recommended application area. The standing water level (SWL) of the bore is 12.0m. Water bearing zones (WBZ) were from 46.0m to 55.0m. Four groundwater bores are located within 500m of the recommended application area. The Sydney Catchment Authority recommends a draw-down analysis using an appropriate methodology such as Cromer *et. al* 2001 be undertaken when an effluent application area is located within 100m of a bore used for domestic consumption. The Cromer methodology was applied to the bore as calculated in Appendix 5. Bore characteristics were conservatively estimated from data of existing bores in the locality. A minimum buffer distance of 25m is required around the bore. This buffer distance is available. No impact on groundwater is expected from the application of effluent to the site.	Minor
Surface water: Permanent waters, streams, lakes *(Recommended buffer distance 100m)* Other waters, intermittent waterways *(Recommended buffer distance 40m)*	Nil Two dams approximately 50m south and one dam approximately 50m northwest. A drainage line is present in the western section of the lot.	Minor
Buffer distances from recommended application area to: Boundary premises *(Recommended buffer distance 6-12m)* Swimming pools *(Recommended buffer distance 6-12m)* Buildings *(Recommended buffer distance 6-12m)*	 >6m Nil >6m	Minor

Area required for application system(s): Area available (including buffers):	63m^2 minimum area required for trench systems. 488m^2 minimum area required for irrigation systems. Potential application area of approximately 1,500m^2 available (Appendix 1).	Minor
Surface rocks, rock outcrops	Surface rocks and rock outcrops were identified scattered across the site.	Moderate
Geology	The site is within the Spring Hill Soil Landscape. This soil landscape occupies a large area south and south-east of Orange. Krasnozems are dominant soils. Yellow Podzolic soils occur on the lower slopes with Yellow Solodic soils in drainage lines. The geological unit is tertiary volcanics from Mount Canobolas. Parent rock consists of basalt flows which are separated by volcanic ash forming layers of clay and slate. Parent material consists of in situ materials or colluvium derived from Tertiary volcanics (eSPADE v2.2).	Minor
Environmental concerns: Native plants intolerant of phosphorous High water table Water way/wetland Community water storage	 Nil Nil None nearby None nearby	
Site stability: Is expert assessment necessary	No, not expected to affect system performance	Minor

6. Soil assessment

Soil was assessed on site on 3 June 2022 by borehole construction to a depth of 1.0 metres or drill refusal with a ute mounted hydraulic corer.

The soil profile was described, and representative samples collected for the determination of physical and chemical properties. Soil physical property measurements undertaken included Emerson aggregate test (dispersion description), texture, colour, pH, and salinity (ECe). The laboratory tests for physical properties were undertaken by Envirowest Testing Services and results are presented in the following table.

Depth (mm)	Description	Sampled (mm)	Texture group	Moisture	Emerson aggregate test*	pH (1:5 water)	ECe dS/m
Test hole 1							
0-200	Dark grey silty clay loam	100	ZCL	W	5	7.0	0.69
200-600	Dark greyish brown silty clay with fine gravels and abundant ironstone gravels	600	ZC	W	3	6.8	0.60
600-1000	Brown silty clay with coarse sand to fine gravels, abundant ironstone gravels to nodules, red mottles and heavily mottled grey clays	900	ZC	M	5	6.5	0.68
1000	End of hole at investigation depth						
Test hole 2							
0-200	Grey silty clay loam with fine to coarse sand	100	ZCL	M	3	6.4	0.17
200-600	Yellowish brown light clay with heavily mottled grey clays	600	LC	M	5	6.8	0.15
600-1000	Yellowish brown silty clay with trace coarse sand, abundant ironstone gravels and weathered rock inclusions	900	ZC	W	5	6.6	0.15
1000	End of hole at investigation depth						

M=Moist, D=Dry, W=Wet *1= highly dispersive (slakes, complete dispersion), 2= moderately dispersive (slakes, some dispersion), 3= slightly dispersive (slakes, some dispersion after remoulding), 4= non-dispersive (slakes, carbonate or gypsum present), 5= non-dispersive (slakes, dispersion in shaken suspension) 6= non-dispersive (slakes, flocculates in shaken suspension), 7= non-dispersive (no slaking, swells in water), 8= non-dispersive (no slaking, does not swell in water).

Site feature	Assessment	Limitation
Depth to bedrock	Greater than 1,000mm in recommended application area *(600mm below application base recommended)*	Minor
Depth to high water table	Greater than 1,000mm in recommended application area *(600mm below application base recommended)*	Minor
Coarse fragments	Gravels identified throughout the soil profile	Minor
Bulk density	Good (estimated)	Minor
pH	Satisfactory *(4.5-8.5 optimum range)*	Minor
Salinity	Non-saline *(<4.0 dS/m desirable threshold)*	Minor
Phosphorus sorption capacity *(SCA, 2012)*	6,500 kg/ha estimated	Minor
Nutrient balance	Water is not expected to move off site, nutrients will be utilised by the vegetation and stored in the soil. The subsoil is a moderately drained silty clay to light clay that will immobilise moderate quantities of nitrogen (in ammonium and organic forms) as derived from primary treatment systems.	Minor
Cation exchange capacity	Moderate (estimated). Will provide adequate retention of nutrients for plant growth.	Minor
Dispersiveness (Emerson aggregate test)	Slightly dispersive to non-dispersive silty clay loam topsoil over a slightly dispersive to non-dispersive silty clay to light clay subsoil. Regular application of gypsum is recommended at the rate of 1kg per square meter of application area.	Minor
Soil structure	Strongly structured	Minor

Soil texture and permeability category	Clay loam CL (100mm) Light clay LC (600mm)	Minor

7. System selection

7.1 Estimation of land application areas from hydraulic loadings

Rainfall water balance and land application area calculations are presented in Appendix 3 and are summarised in the following table. Design flow rates for the dwelling are 600L/day based on the use of water saving features. Wet weather storage areas included in the water balance utilise the storage capacity of the soil. The design application rate was determined from Tables L1, M1, N1 in AS1547 using the permeability classification of the subsoil.

Factors Affecting Design Loading and Sizing	**Design application rate (AS1547) (mm/day)**	**Size required for effluent application**
Hydraulic loading for different application systems - Surface/sub-surface irrigation - Absorption/ Evapotranspiration trench	 3 8	 488m^2 63m^2
Notes	The proposed loading will provide for leaching of salts out of the root zone and prevent the soil from becoming sodic. The proposed infiltration rates will protect the catchment against off-site nutrient movement.	

7.2 Centralised sewerage systems

Consideration of connection to a centralised sewerage system Approximate distance to nearest feasible connection: Potential for future connection to centralised sewerage: Potential for future connection to reticulated water:	 >500m high / medium / low / already connected high / medium / low / already connected

7.3 Suitability of application systems

Application system	**Treatment system**	**Site limitations of the application system**	**Modifications to mitigate constraints**	**Suitability**
Absorption system	Septic tank	Moderately drained subsoil Surface rock and rock outcrops	Nil	No
Evapotranspiration system	Septic tank	Moderately drained subsoil Surface rock and rock outcrops	Nil	No
Surface irrigation	Secondary	Slightly dispersive topsoil Surface rock and rock outcrops	Regular application of gypsum Ensure wastewater is applied to the soil	Yes
Sub-surface irrigation	Secondary	Slightly dispersive topsoil Surface rock and rock outcrops	Regular application of gypsum Ensure wastewater is applied to the soil	Yes

7.4 System recommendation

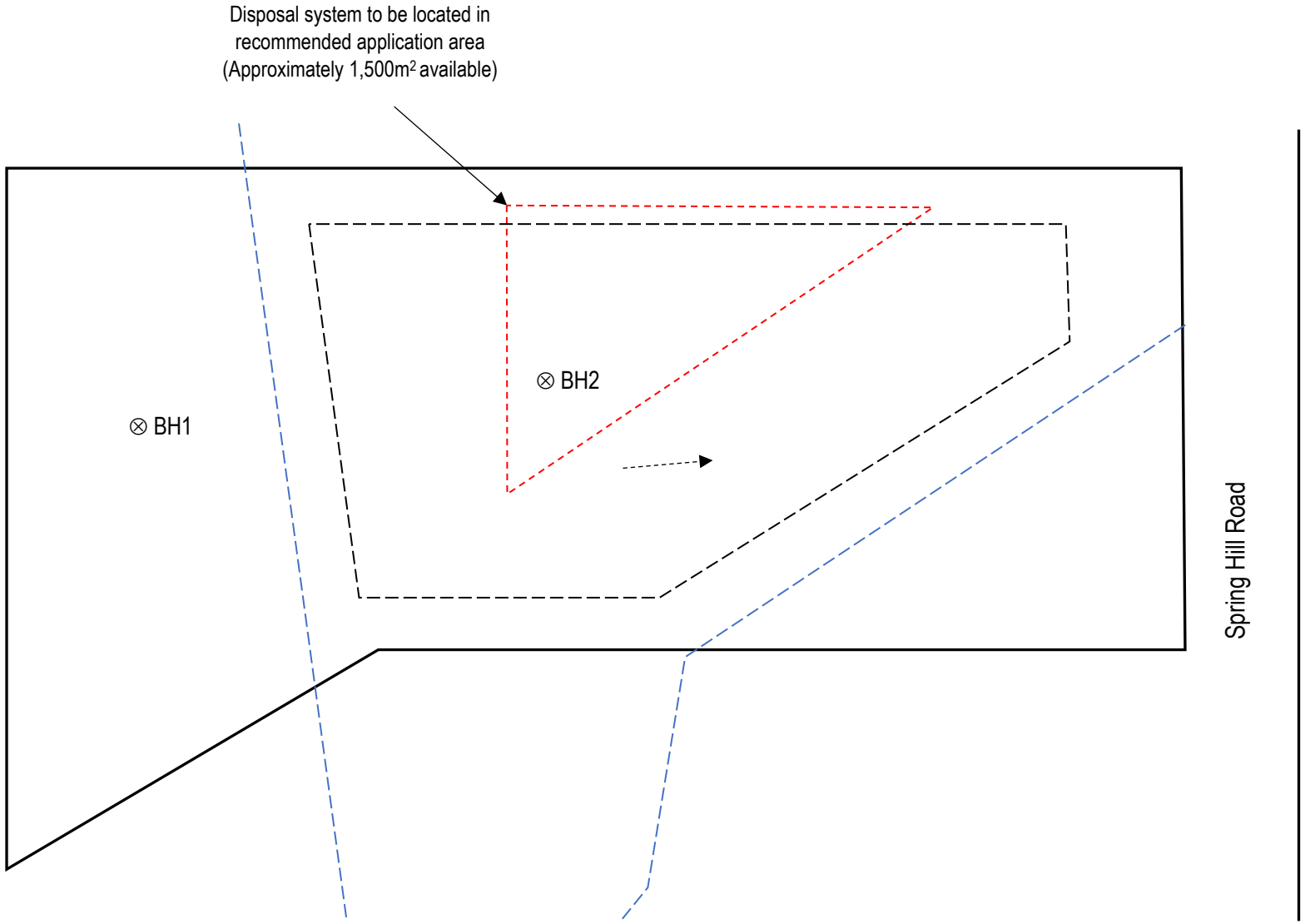
Type of land application and **treatment** systems considered best suited to the site	The recommended system is • **Surface irrigation with an irrigation area of 488 square metres.** Gypsum should be applied to the application area during construction. • **Secondary wastewater treatment system** accredited by NSW Health.
Location	The location of the effluent application area is identified in Appendix 1.
Notes	Construction of the treatment and application systems should be according to AS1547 and Sydney Catchment Authority guidelines, Designing and Installing On-site Wastewater Systems (2019). Gypsum should be applied to the application area during construction and annually to maintain permeability. Secondary treatment systems require regular maintenance to ensure effective operation. Maintenance scheduling should be undertaken in accordance with manufacturers and NSW Health guidelines. The water balance is calculated using full water saving devices such as dual flush toilets (6/3litre water closets), water reduction cycles on dishwashers, aerator faucets fitted to taps, front loader washing machines and water reducing shower heads. A maintained grass sward is the recommended vegetation over the irrigation area. Appendix 4 is a checklist of do's and don'ts to ensure correct operation of the wastewater system. Gypsum should be applied every two years to maintain permeability.

8. General comments

Are there any specific environmental constraints?	Wastewater should be evenly applied over the application area.
Are there any specific health constraints?	Restrict access to people and stock as recommended in AS1547 and summarised in Appendix 4.
Any other comments?	The topsoil is capable of supporting plant growth that will optimise evapotranspiration and wastewater usage.

9. Report limitations and intellectual property

This report has been prepared for the use of the client to achieve the objectives given the clients requirements. The Australian Standard 1547, *On-site domestic wastewater management*, and the Environment and Health Protection Guidelines, *On-site sewage management for single households* (1998) Department of Urban Affairs and Planning, have been used as guidelines in this report. Where system limitations or uncertainties are known, they are identified in the report. No liability can be accepted for failure to identify conditions or issues which arise in the future and which could not reasonably have been predicted using the scope of the investigation and the information obtained. No guarantee can be made that the wastewater system will achieve all performance criteria because of operational factors and the inherent variable and unpredictable nature of the soil. All components of the wastewater system have a limited life.



Legend

⊗	Borehole	▭	Proposed building envelope
⇢	Slope	▭	Recommended application area (Approximately 1,500m² available)
———	Lot boundary	- - -	Drainage line

Approximate Scale 1: 1100

0 11 22 44m

Appendix 1. Aerial image and borehole location		
Lot 3 in the proposed subdivision of 172 Spring Hill Road Spring Hill NSW		
	Envirowest Consulting Pty Ltd	
Job: R14501e3	Drawn by: TS	Date: 22/06/2022

Appendix 2. Photograph of the recommended application area

Looking east over the recommended application area

Appendix 3a. Monthly water balance to determine the wastewater application area required for Irrigation systems

Design wastewater flow	Q	L/day	600	120	L/person/day	5	persons
Design percolation rate	R	mm/wk	21	3	mm/day		
Land area	L	m2	130				
Effective precipitation	EP		0.9	(10% runoff)			

Parameter	**Symbol**	**Formula**	**Units**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**total**
days in month	D		days	31	28	31	30	31	30	31	31	30	31	30	31	365
Precipitation	P		mm/month	61.3	86.4	45.9	36.2	47.7	79.7	76.3	86	76.2	81.9	83.6	70.6	832.2
Evaporation	E		mm/month	216	157	137	94	51	41	38	51	81	114	152	203	1335
Crop factor	C		-	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	10.8
Inputs																
Effective Precipitation	EP		mm/month	55.17	77.76	41.31	32.58	42.93	71.73	68.67	77.4	68.58	73.71	75.24	63.54	749
Effluent irrigation	W	QXD/L	mm/month	143.1	129.2	143.1	138.5	143.1	138.5	143.1	143.1	138.5	143.1	138.5	143.1	1685
Inputs		P+W	mm/month	198.2	207.0	184.4	171.0	186.0	210.2	211.7	220.5	207.0	216.8	213.7	206.6	2433
Outputs																
Evapotranspiration	ET	ExC	mm/month	194.4	141.3	123.3	84.6	45.9	36.9	34.2	45.9	72.9	102.6	136.8	182.7	1202
Percolation	B	R/7xD	mm/month	93.0	84.0	93.0	90.0	93.0	90.0	93.0	93.0	90.0	93.0	90.0	93.0	1095
Outputs		ET+B	mm/month	287.4	225.3	216.3	174.6	138.9	126.9	127.2	138.9	162.9	195.6	226.8	275.7	2297
Storage	S	(EP+W)-(ET+B)	mm/month	-89.2	-18.3	-31.9	-3.6	47.1	83.3	84.5	81.6	44.1	21.2	-13.1	-69.1	
Cumulative storage	M		mm	0.0	0.0	0.0	0.0	47.1	130.4	214.9	296.5	340.7	361.9	348.8	279.7	

Storage	V	largest M	mm	361.9
		Soil storage	mm	372.0
		Storage required	mm	-10.1
		VxL/1000	m^3	**-1.3**
Irrigation area			m^2	**130**

	water holding capacity	depth (mm)	Totals(mm)
Topsoil	34%	200	68
Subsoil	38%	800	304
			372

Appendix 3b. Estimation area requirement from organic matter and nutrient balances (Irrigation systems)

Estimated effluent flow	(Q)	600	L/day
Soil depth		1	m

Organic matter balance

BOD (C)	20	mg/L
treated wastewater flow rate (Q)	600	L/day
critical loading rate of BOD (Lx)	300	mg/m^2/day
land area required (A)	0	m^2
	4.0	

Nitrogen balance

nutrient concentration	37	mg/L
treated wastewater flow rate	600	L/day
critical loading rate of nutrient	50	mg/m^2/day
land area required (A)	**444**	m^2

Determination of nitrogen critical loading rate

Nitrogen load (kg/year)	8.1	kg/year			
Loss 20% denitrification	6.5	kg/year			
Load to soil	146.0	kg/ha/year	assumed irr. area	44 4	m2
Vegetation usage	200.0	kg/ha/year	from table		
Residual (potential leaching)	-54.0	kg/ha/year			

Typical nitrogen uptake (Myers et al. 1984)		
Pastures	300 kg/ha/year	82 mg/m2/day
Pine	350 kg/ha/year	96 mg/m2/day
Eucalypts	180 kg/ha/year	49 mg/m2/day

Phosphorus balance

Phosphorus sorption capacity per metre=		6,500	kg/ha	
Phosphorus sorption capacity of profile=		6,500	kg/ha	
Soil factor		0.33		
Critical loading=		3	mg/m^2/day	
P concentration*=		12	mg/L	
P adsorbed=	phosphorus sorption capacity x soil factor	2145		
		0.2145	kg/m^2	
Puptake=	critical loading x days/year x	50	year s	
		54750		
		0.0548	kg/m^2	
Pgenerated=	total phosphorus concentration x wastewater volume in	50	year s	
		131400000		
		131	kg	
	Pgenerated / (Padsorbed + Puptake)			
Land area required	**488.0**	**m^2**		

Appendix 4. Checklist for effective management of wastewater systems

Domestic wastewater system

DO

- Check household products for suitability of use with a septic tank or secondary treatment tank.
- Conserve water, prolonged period of high water use can lead to application area failure. For optimum operation, avoid daily and weekly surges in water flows. Spas are not recommended.
- Scrape cooking dishes and plates prior to washing to reduce solid load.
- Maintain the system with regular servicing as per the manufacturer's instructions.

DON'T

- Dispose of excessive solid material, fats, lint or large water volumes into drains.

Land application area

- Construct and maintain diversion drains around the top-side of the application area to divert surface water.
- The application area should be a grassed area, which is maintained at 10-30cm height.
- The area around the perimeter can be planted with small shrubs to aid transpiration of the wastewater.
- Ensure run-off from the roof or driveway is directed away from the application area.
- Periodic application of gypsum may be necessary to maintain the absorptive capacity of the soil.
- **Do not** erect any structures or paths on the land application area.
- **Do not** graze animals on the land application area.
- **Do not** drive over the land application area.
- **Do not** plant large trees that shade the land application area thereby reducing transpiration of water.
- **Do not** let children or pets play on the land application area.
- **Do not** extract untreated groundwater for potable use.

Appendix 5. Buffer distances for bores

The recommended buffer distance for on-site effluent management systems to groundwater wells is 100m. One bore is located 95m southwest and downslope from the recommended application area. The size of the buffer distance from the bores can be reduced by determining the separation distance required between the bore and an on-site application system.

The separation distance is the distance required between a bore and a land application system to prevent contamination of the bore with effluent that may enter the bore. The separation distance is determined from the radius of influence of a bore plus the setback distance.

The radius of influence of a bore can be calculated from the aquifer and bore hydraulic characteristics as an application of the viral die-off method of Cromer *et al*. (2004). The viral die-off method estimates the time required for viruses in the contaminated water to be inactivated (reduced to acceptable number by natural mortality processes) as they move down gradient in the groundwater. The distance travelled during the travel time is the setback distance. Darcy's law is used to estimate the travel time.

The model for estimating the setback distance is:

$dg = (t\text{-}dv.P/K) / (P/K.\ i)$

where:
d_g = setback distance (m)
t = time (days)
d_v = vertical distance to water table (m)
P = porosity of fraction (decimal)
K = hydraulic conductivity (m/day)
i = groundwater gradient (fraction)

The model for estimating the radius of influence of a water bore is:

$r = 1.5[(KHt/S)^{0.5}]$ *which is reasonably valid for* $t=Kt/SH \geq 1$

where:
r= radius of influence
K= aquifer permeability (m/day)
H= initial thickness of the water (m) in the fully penetrating bore
t= time of pumping (t, days)
S= specific yield (S fraction, dimensionless)

A land application system should not be located within the maximum radius of influence of a bore. Additionally, the appropriate separation distance is the radius of influence of the bore plus the setback distance for viral die-off when application systems are located up gradient of the bore. The application system will be located up gradient of the bore 95m southwest of the application area therefore the radius of influence plus the calculated setback distance is the appropriate buffer distance.

No impact from the application of effluent is expected on the bore. Bores surrounding the site are unconfined aquifers.

An assessment of potential impacts on non-confined aquifers was undertaken by modelling. The viral die-off method of Cromer *et al.* (2004) was used to calculate the radius of influence and subsequently the minimum separation distance required to the well.

Viral die off time was estimated to be a reduction in order of magnitude of 3 at a groundwater temperature of 9.6°C equivalent to 100 days. This is expected to be a conservative estimate in viral die-off.

The model parameters for estimating the radius of influence of the water bore were:

K= aquifer permeability (m/day) = 0.5
H= initial thickness of the water (m) in the fully-penetrating bore = 12.0m
t= time of pumping (t, days) = 110
S= specific yield (S fraction, dimensionless) = 4.547

The radius of influence was subsequently calculated to be 18 metres.

The model parameters for measuring the setback distance of the groundwater bore were:

t= time (days) = 100
d_v= vertical distance to water table (m) = 12.0
p= porosity of fraction (decimal) = 0.2
k= Hydraulic conductivity (m/day) = 0.5
i= groundwater gradient (fraction) = 0.03

The calculated setback distance was subsequently calculated to be 7 metres.

The appropriate separation distance is the radius of influence plus the calculated setback distance, which is subsequently calculated to be 25m.

A buffer distance of 25 metres is therefore required around the bore.