FREEMAN COOK ASSOCIATES / PTY LTD

7 Virginia Heights, Otamatea, Whanganui, 4501

Mob: 02102384482

Email: freeman@freemancook.com.au

Website: www.Freemancook.com.au

LOADING FROM ON-SITE WASTEWATER MANAGEMENT AND CUMULATIVE EFFECTS SPRINGHILL SUBDIVISION EVALUATION REPORT

Client:	Development Nous Limited Hastings
Project:	Springhill Subdivision
Location:	Corner of State Highway 50 and 612 Wakarara Road, Ongaonga
Prepared by:	Professor Freeman J Cook, Environmental Physicist, Freeman Cook and Associates Pty LTD
Date	24 September 2021

Contents

Introduction

This report has been prepared by Professor Freeman J Cook for Development Nous Limited. It is a report considering the proposed loading of the site and cumulative effects in terms of nutrients, water (hydraulic) and bacteriological arising from domestic wastewater systems associated with the proposed 312 lot subdivision of the site, compared to the present farmed loadings. It is based on a desk top study of relevant information from various sources and scheme plan supplied by Development Nous Limited.

The intent of this report is to provide expert advice in response to wastewater loading questions raised by Central Hawke's Bay District Council (the Council) and their engineering consultant for the proposed subdivision. This report has only assessed in a general sense the loading of wastewater on the site from management options provided in the Preliminary On-site Wastewater Management Site Evaluation Report (Cook, 2021).

The report is only for the Overall Scheme Layout Plan drawing number H20210003-CO10 and all comments and recommendations are solely with reference to that Plan.

Sources of Information

The Sources of information used in this assessment are listed below:

- Development Nous Limited
- Cook (2021)
- Hawkes's Bay Regional Resource Management Plan (HBRRMP, 2015)
- Manaaki Whenua Landcare Research S-Maps (https://soils.landcareresearch.co.nz/soil-data/s-map-and-s-map-online/)
- NIWA Cliflo (https://cliflo.niwa.co.nz/)
- Google Earth Pro
- Scientific literature (see references)

Background

As part of the overall assessment of the application for subdivision consent, the following commentary was provided by Stantec as the Council's engineering consultant following their assessment of the preliminary report (Cook, 2021).

"*The report notes that as groundwater is greater than 2m below the surface that no impact on groundwater would seem likely. However due to the scale of the development and the rapid permeability of some sub-soils, especially for the northern half of the development area, this should be considered in more detail. Note NZS4404:2010 requires on-site wastewater treatment and disposal to be designed in accordance with AS/NZS 1546 and AS/NZS1547. Under NZS1547:2012 some of the site soils would be considered category 1 and 2 (gravels and sands and sandy loams). Category 1 & 2 soils have limitations with soil treatment capacity rather than hydraulic capacity that govern loading rates to minimise environmental impacts. Potential short-circuiting through these soils and low nutrient retention that potentially will impact on groundwater should be addressed. In addition the separation to the stream may need to be greater with the rapid permeability if this fed from groundwater at the site or further downstream. Specialist design for distribution techniques will also be required at the design stage. Consideration should be given to the minimum level of treatment (nutrient removal and disinfection) for on-site systems considering the* *cumulative effect of the overall development on groundwater. The sensitivity of groundwater or proximity to existing groundwater takes has not been considered in the reports provided.*"

Subsequent to the Stantec assessment, the Council has advised the Applicant that the cumulative effects of wastewater have been identified through Council's community consultation as a matter of concern.

In response to the stated community concerns, the Applicant has revised the scope of the subdivision application to require all future wastewater systems to incorporate tertiary treatment by way of UV or similar disinfectant. While pathogens would generally be expected to be consumed within the active soil layer, particularly across the large individual lot areas, the tertiary treatment level has been offered to assist in allaying the community concerns.

Phone discussion between Mr Wayne Hodson of Stantec and Dr Freeman Cook on 10 September 2021 sought to expand upon the Stantec assessment commentary and clarified the basis of the Stantec review. Mr Hodson suggested that additional information discussed during the phone conversation, such as the basic nutrient and hydraulic loading calculations, should be submitted to Council for his review.

This report was commenced with the intention of explaining the additional information discussed in the 10 September phone conversation and to provide greater understanding of the overall conclusion that the 220ha site can readily accommodate the on-site domestic wastewater discharges arising from the proposed 312 lot subdivision. However, prior to the completion of this report, the Council has issued a s92(2) request for agreement by the Applicant to the commissioning of a report to assess potential cumulative effects arising from the domestic wastewater discharges. This request was followed by detail of the proposed scope of reporting.

This scope of this report has been expanded to include the additional points of the scope of the report proposed to be commissioned by the Council.

This report is based on the revised application scope requiring all future development lots to provide tertiary standard domestic wastewater treatment, by way of a final stage UV or similar disinfectant treatment prior to the discharge of the treated wastewater to purpose formed dispersal fields.

The matters raised by the Council's engineering comments are addressed by way of assessment of the loading for each of the soil types against the related discharge to ground method.

The additional matters raised by the proposed additional report scope are addressed through specific discussion. However, no minimum standards for discharge are recommended, as these are obviated by way of the overall recommendation for treatment systems to comprise tertiary treatment and discharge by way of subsurface drip irrigation with resulting negligible effects that do not necessitate further assessment.

This report provides comparison assessment of the proposed domestic discharge against the discharge from beef cattle, which were the stock grazing site during a site inspection on 12 August 2021.

The report findings have also been compared to the general conclusions of Council's own investigation of the proposed Takapau township wastewater treatment plant and associated discharge to land (Lowe Environmental Impact, 2021). This system seeks to provide for the discharge of 250 houses to 30ha of land via oxidation pond treatment with a daily application rate of 29 mm day^{-1}. This is obviously a significantly greater intensity of discharge than the 312 household discharge across 220ha proposed with a daily application of 4 mm day^{-1} in the Springhill application.

Site Information

The proposed development site is located at the intersection of State Highway 50 and Wakarara Road, Ongaonga, as shown in in figure 1. The site is within the jurisdiction of the Central Hawke's Bay District Council and Hawke's Bay Regional Council, with respective planning and discharge rules and standards set out in the Central Hawke's Bay District Plan and the Regional Resource Management Plan.

The 220ha site is generally rectangular in shape with a length of approximately 2000 m and width of 1000 m. The site is currently held in pasture for sheep and beef grazing.

The surrounding rural land is utilised for a variety of grazing and irrigated production, and this pattern of use is evident in the aerial photograph at Figure 1.

The Waipawa River is located 1.2 km to the north of the site, flowing generally west to east. The Tukituki River, again flowing generally west to east is located 5 km to the south of the site. The site separation to these rivers obviates the need for any further consideration of effects from the development systems.

The township of Ongaonga is located 3km to the south of the site. This township is not serviced by Council utilities, and houses are reliant on onsite wastewater discharge and a combination of roof water and bore water for domestic purposes. There are limited HBRC well and water permit records for Ongaonga.

Figure 1. Site location outline with the black line, sited on the corner of Wakarara Road and State Highway 2.

The land is the subject of a resource consent application to Central Hawke's Bay District Council for subdivision to form 312 rural lots. All lots exceed the minimum 4,000m^2 area applicable to Rural Zone subdivision, ranging from 4010m2 to 1.5ha with a median lot size of 5895 m^2. The lot layout of the proposed scheme plan is shown in figure 3.

All lots are larger than the 2500 m^2 minimum land area for wastewater discharge with no more than advanced primary treatment as a permitted activity pursuant to Rule 37 Condition a of the Hawke's Bay Regional Resource Management Plan (HBRRMP).

Topography

The proposed development is located on land with a slope of less than 5% and generally less than 1%. A prominent ephemeral water channel traverses the southern end of the site, serving as a drain during rain events before continuing under State Highway 50 at Chestermans Bridge (figure 2). A second defined ephemeral channel traverses the southwestern corner of the site, before connecting to the main channel. The channel appears to drain water from the site rapidly and was observed to be dry within 48 hours of rain event on 12 August 2021.

Assessment is based on the requirement that wastewater systems installed in proximity of **this ephemeral waterway will provide a minimum of 20m separation between the dispersal field and the water channel to accord with Rule 37e of the HBRRMP.**

Figure 2. Photograph showing Chestermans Bridge (left panel) and of the ephemeral drain (right panel).

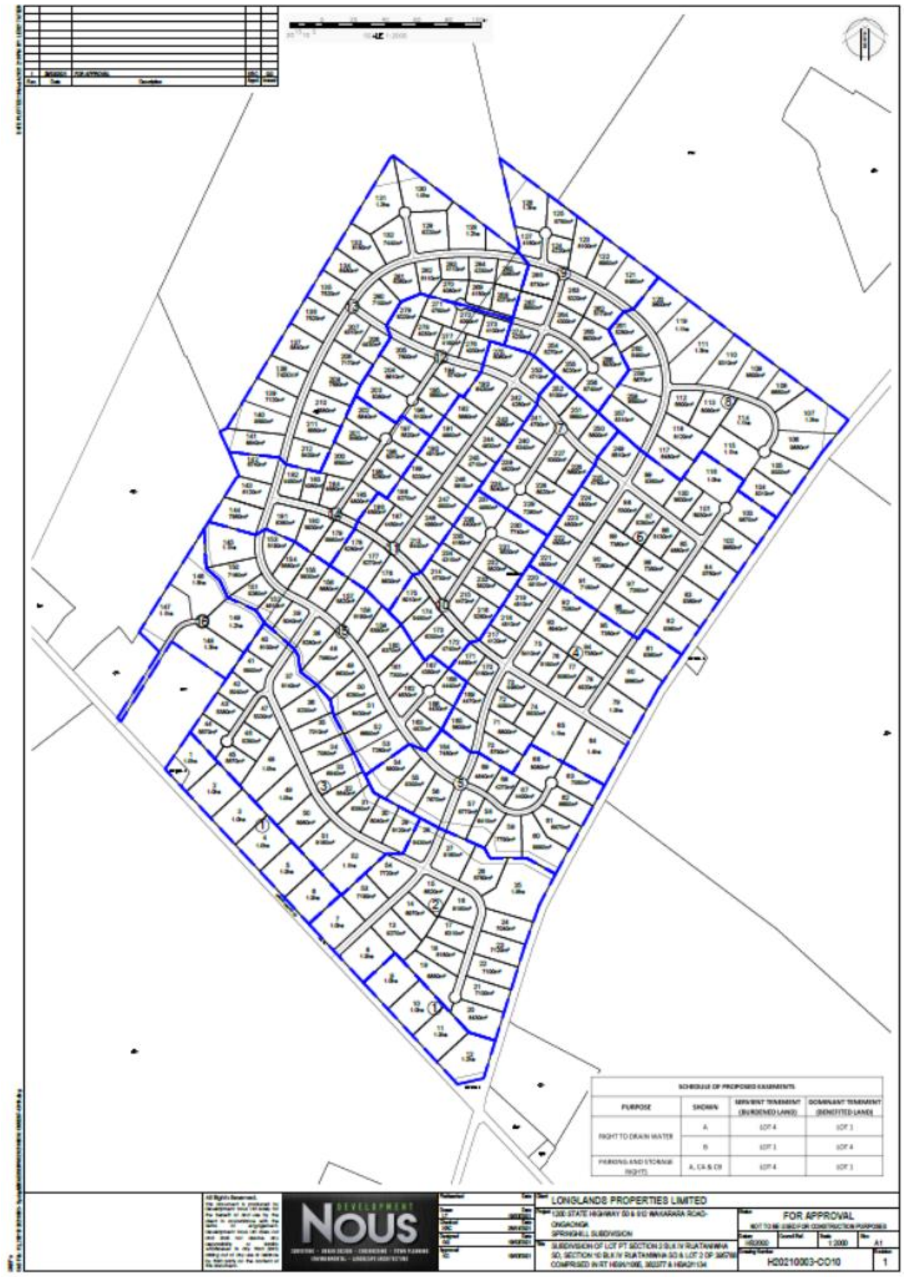

Figure 3. Proposed Scheme Plan

Soil

The site has three soil types as described by the Manaaki Whenua Landcare Research soil resource S-Map; Bushgate_14a.1, Mangatewai_3a.1 and Tararu_6a.1. The proposed development area is shown on the soil map in figure 4.

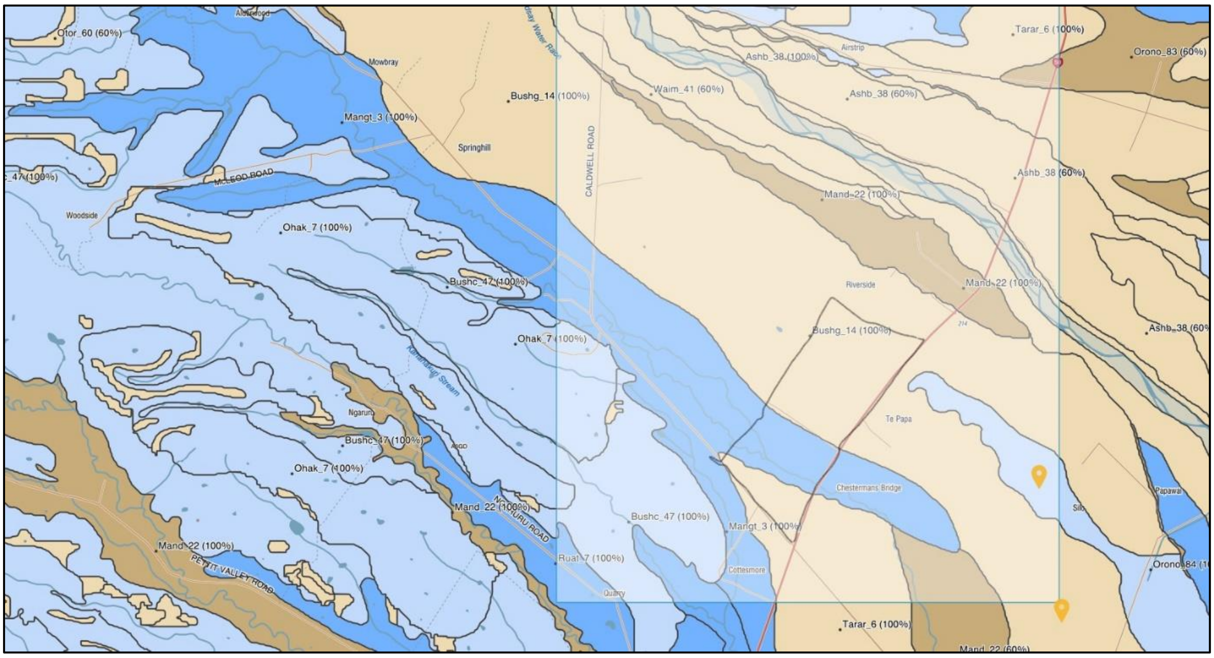

Figure 4. Soil map from S_MAPS with the general area of the proposed development outline in the black rectangular area.

The soils on this site consist of the Bushgate over the northern two thirds of the area. The Tararu soil covers a triangular area to the southeast and the balance of the site is the Mangatewai soil (in blue on map).

Bushgate soil

The Bushgate soil has a loamy topsoil for the top 30 cm with rapid to moderate permeability and rapid permeability in the gravel below this (Appendix 1). Lots on this soil could reasonably utilise any of the primary disposal methods of trenches, beds or subsoil irrigation.

Mangatewai soil

The Mangatewai soil has a loamy topsoil with rapid to moderate permeability but the preponderance of gravel below a depth of 0.4 m is considered a restriction and the permeability is only described as moderate to slow (Appendix 1). Lots on this soil could use subsurface drip irrigation.

Tararu soil

The Tararu soil has a loamy topsoil with rapid to moderate permeability and a good depth of loamy soil to 0.55 m. The gravel below 0.55 m is considered to have a moderate permeability (Appendix1). Lots on this soil could reasonably utilise any of the three disposal methods but given the depth of loamy soil subsoil, subsurface drip irrigation would be preferable in this semi-arid climate.

Soil Physical properties

Using the data from S-Maps on texture and available water capacity, the soil water retention properties were determined for each soil and layer using Carsel and Parrish (1988), as implemented in the HYDRUS1D code (Šimůnek et al., 2008). The permeabilities were taken from the S-Map data sheets (Appendix 1) and the data is presented in Table 1.

Table 1. Soil physical properties used in HYDRUS1D model. θ_s and θ_r are respectively the saturated and residual volumetric water contents, α is a parameter related to the air entry pressure of the soil, n is shape factor and K_s is the saturated hydraulic conductivity.

Soil	Depth (m)	θ_r ($m^3\ m^{-3}$)	θ_s ($m^3\ m^{-3}$)	α (m^{-1})	n (-)	K_s ($m\ s^{-1}$)
Bushgate	0 - 0.15	0.50	0.065	2.50	1.90	$2.08x10^5$
	0.15 - 0.30	0.46	0.065	6.00	1.89	$1.23x10^5$
	0.30 – 0.50	0.50	0.078	2.50	1.90	$1.23x10^5$
	0.50 – 1.00	0.50	0.078	2.50	1.90	$2.08x10^5$
Mangatewai	0 - 15	0.45	0.065	3.00	1.90	$2.08x10^5$
	0.15 - 0.30	0.42	0.065	6.00	1.89	$1.23x10^5$
	0.30 – 0.40	0.35	0.078	3.60	1.90	$2.85x10^6$
	0.40 – 1.00	0.22	0.078	4.20	1.90	$2.85x10^6$
Tararu	0 - 15	0.48	0.065	2.50	1.90	$2.08x10^5$
	0.15 - 0.30	0.49	0.065	6.00	1.89	$1.23x10^5$
	0.30 – 0.40	0.31	0.078	6.00	1.56	$1.23x10^5$

Climate

This local area can be described as semi-arid. Climate data is available from Waipukurau airport for the period from 29/3/1972 to 1/1/1988, a duration of 5761 days. The total rainfall in this period was 13012 mm and the reference evapotranspiration (ET_0) was 16841 mm (calculated using FAO-56 (Allen et al., 1998)) giving a potential moisture deficit of 3829 mm.

The ET_0 is the potential evapotranspiration for a short grass sward so no crop factor was required. The leaf area index was taken as > 3, which would be the case for a healthy sward and the split between soil evaporation and transpiration calculated with $0.25ET_0$ and $0.75ET_0$ respectively (Sutano et al. 2012).

The rainfall and ET_0 for the time period are shown in figure 5. The ET_0 shows a distinct annual cycle while the rainfall is a more random pattern (figure 5).

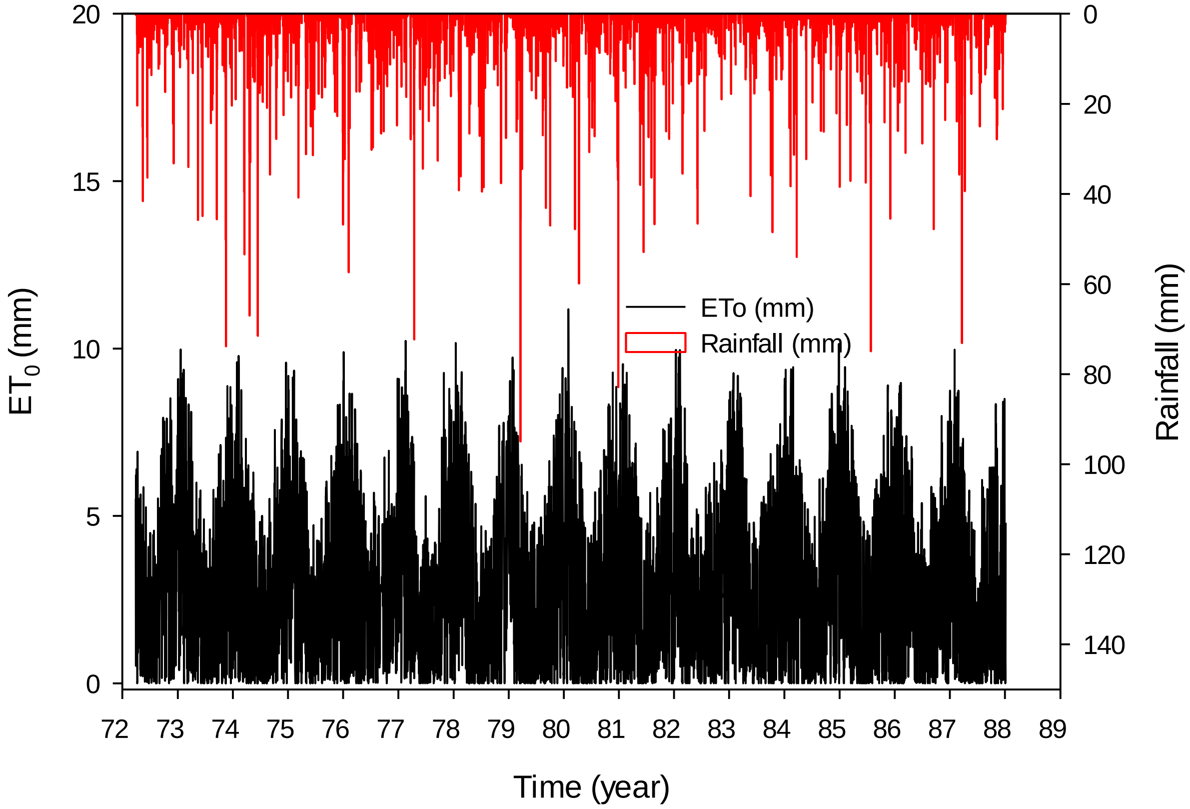

Figure 5. Rainfall and ET_0 for 16 years at Waipukurau Aero site. Data from NIWA (Cliflo)

HYDRAULIC LOADING

The water balance without wastewater irrigation was calculated for all three soils to give the background drainage and loading to the subsoil using the HYDRUS1D model (Šimůnek et al., 2008). HYDRUS1D is a universally accepted numerical solution for the transport of water in porous media. The wastewater was added to the rainfall with 4 mm day^{-1} for the dripper and 20 mm day^{-1} for the beds and trenches. This is likely to be the upper limit of the wastewater as it is unlikely that these flows will occur every day.

Bushgate soil

The cumulative drainage, transpiration and soil evaporation for all three simulations (dryland, dripper and beds/trenches) is shown in figure 6. The soil evaporation and transpiration were the same for dripper and bed/trench simulations. Since the loading was the same for beds and trenches only one simulation was required for both of these treatments.

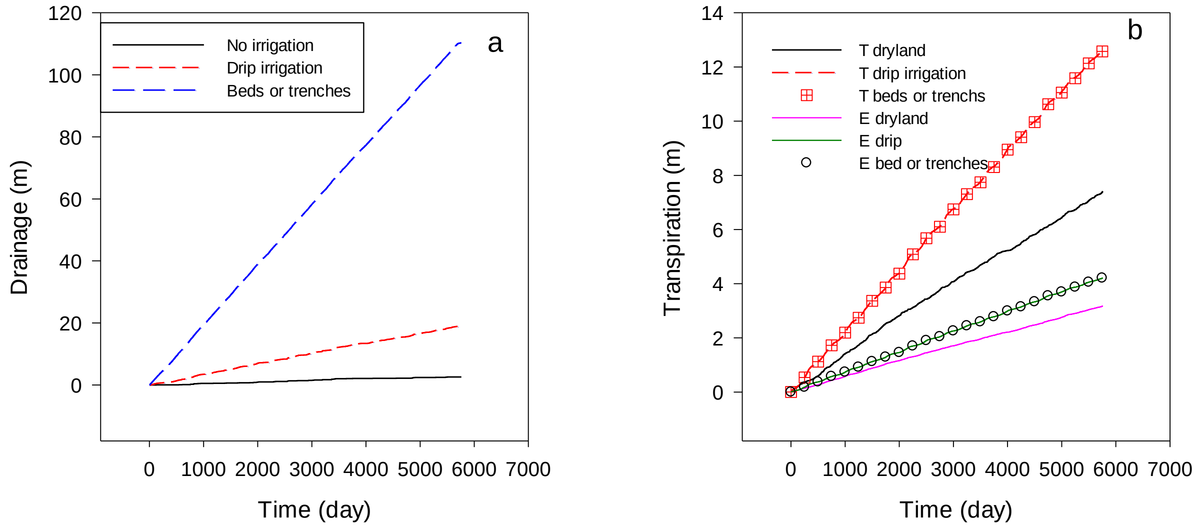

Figure 6. Simulated cumulative a) drainage and b) transpiration (T) and evaporation (E) for dryland, dripper and beds or trenches treatments for Bushgate soil. Note the transpiration was virtually the same for the dryland and dripper treatments.

The cumulative drainage over the whole period was 2.58, 19.14 and 110.30 m respectively for the dryland, dripper and beds or trenches simulations respectively. The area average hydraulic loading can then be calculated from areas of the different land use components, which are given in Table 2. The average hydraulic loading (*H*) was calculated by:

$$H = \left(L_d A_d + L_i A_i + L_r A_r\right) / \left(A_d + A_i + A_r\right) \quad (1)$$

L_d is the dryland hydraulic loading rate (mm day^{-1})

L_i is the wastewater irrigated area hydraulic loading rate (mm day^{-1})

L_r is the roof hydraulic loading rate (mm day^{-1})

A_i is the wastewater irrigation area (ha)

A_r is the roof area (ha)

$A_d = A_t – (A_i + A_r)$ is the dryland area (ha)

A_t is the total area of Bushgate soil (147 ha)

The roof area was estimated as 300 m^2 per lot (Jason Kaye pers. comm.) with the water from this captured into rainwater tanks for domestic use.

Table 2. Component and average hydraulic loading to Bushgate soil area of Springhill development.

Component	Area (ha)	Component hydraulic loading rate (mm day^{-1})	Average Hydraulic loading rate (mm day^{-1})
Dryland	147	0.45	0.45
Dripper	5.62	3.32	0.54
Beds	0.16	19.1	0.63
Trenches	0.12	19.1	0.59
Roofs	6.24	0	0

The Hantush (1967) was used to see if the increased loading in Table 2 would have a significant effect on the watertable. The change in watertable height is shown in figure 7 and shows that after 16 years the water table change compared to that of the dryland situation is 0.26, 0.51 and 0.39 m for drippers beds and trenches respectively. This is a worst case scenario as the watertable height is the maximum calculated at the middle of the area of Bushgate soil and Hantush's solution assume that no discharge to a surface waterway occurs and here the Waipawa river will be an eventual discharge point. At the edge of the area there is minimal watertable rise of < 0.1 m in all irrigation treatments.

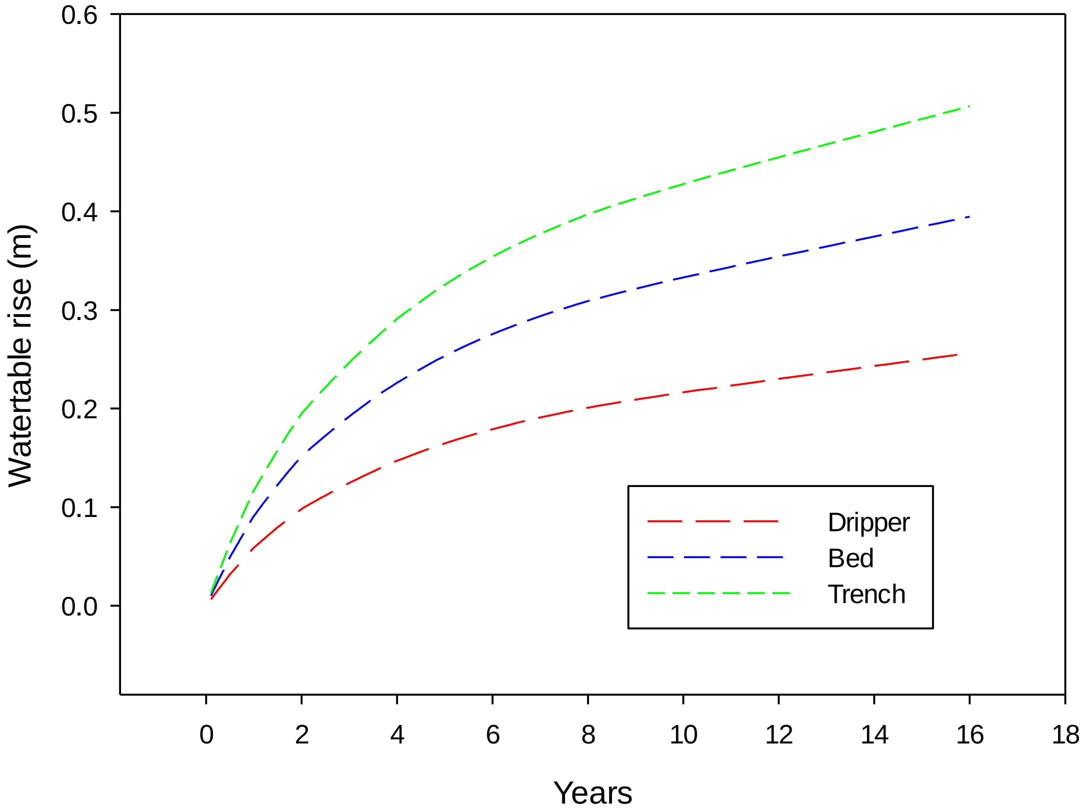

Figure 7. Maximum watertable rise with time at the midpoint of the Bushgate soil area compared to the dryland treatment calculated using Hantush (1967).

For the Bushgate soil there is only a minor change in the average hydraulic loading with the wastewater systems suggested in Cook (2021) and watertable rise is expected to be of no concern.

Tararu soil

The cumulative drainage and transpiration for all three simulations (dryland, dripper and beds/trenches) is shown in figure 8. The soil evaporation and transpiration were the same for the dripper and bed/trench simulations.

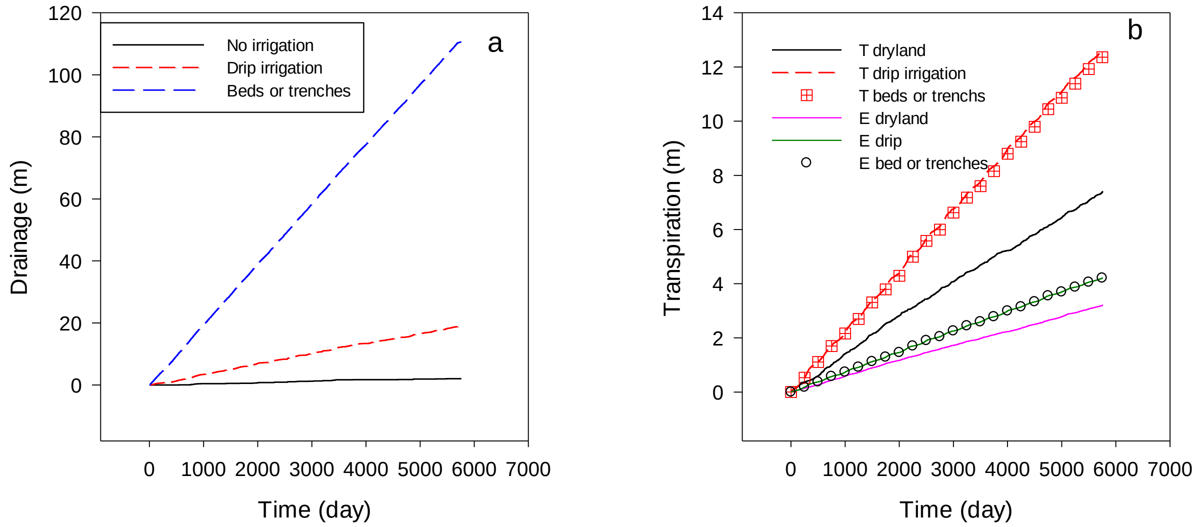

Figure 8. Simulated cumulative a) drainage and b) transpiration for dryland, dripper and beds or trenches treatments for Tararu soil. Note the transpiration was virtually the same for the dryland and dripper treatments.

The cumulative drainage over the whole period was 2.04, 19.06 and 110.58 m respectively for the dryland, dripper and beds or trenches simulations respectively. These values for the cumulative drainage are similar to those for the Bushgate soil. The areas and hydraulic loadings for the different components are given in Table 3. The average hydraulic loading (H) was calculated with eqn (1) with A_t is the total area of Tararu soil (24 ha).

The roof area was estimated as 300 m^2 per lot (Jason Kaye pers. comm.) with the water from this captured into rainwater tanks for domestic use.

Table 3. Component and average hydraulic loading to Tararu soil area of Springhill development.

Component	Area (ha)	Component hydraulic loading rate (mm day^{-1})	Averaqe Hydraulic loading rate (mm day^{-1})
Dryland	24	0.35	0.35
Dripper	0.92	3.31	0.45
Beds	0.025	19.2	0.54
Trenches	0.020	19.2	0.50
Roofs	1.02	0	0

The Hantush (1967) was used to see if the increased loading in Table 3 would have a significant effect on the watertable. The change in watertable height is shown in figure 9 and shows that after 16 years the water table change compared to that of the dryland situation is 0.10, 0.19 and 0.15 m for drippers beds and trenches respectively. This is a worst case scenario as the watertable height is the maximum calculated at the middle of the area of Tararu soil and Hantush's solution assume that no discharge to a surface waterway occurs and here the Waipawa river will be an eventual discharge point. At the edge of the area there is minimal watertable rise of < 0.04 m in all irrigation treatments. The lower levels of watertable rise for the Tarau soil are in part due to the small area the drainage loading is occurring on.

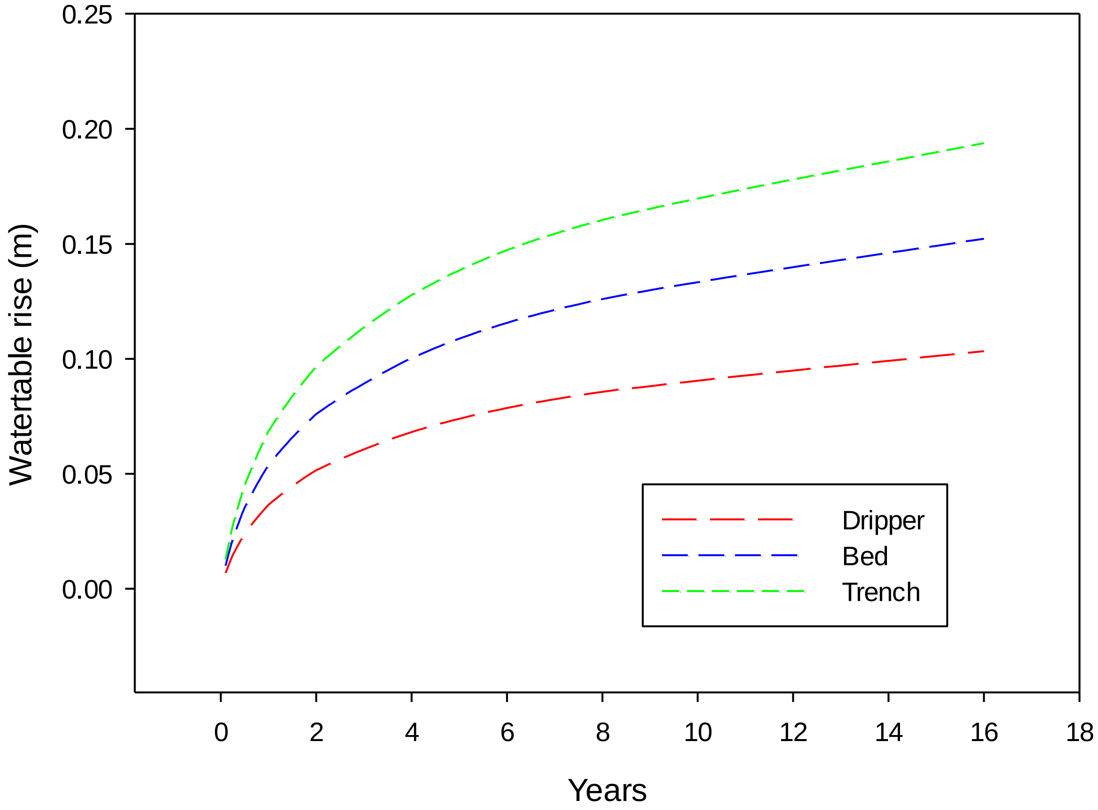

Figure 9. Maximum watertable rise with time at the midpoint of the Tararu soil area compared to the dryland treatment calculated using Hantush (1967).

For the Tararu soil there is only a minor change in the average hydraulic loading with the wastewater systems suggested in Cook (2021) and watertable rise is expected to be of no concern.

Mangatewai soil

Only subsurface drip irrigation was recommended by Cook (2021) for the Mangatewai soil. The cumulative drainage, transpiration and soil evaporation for dryland and dripper simulations is shown in figure 10.

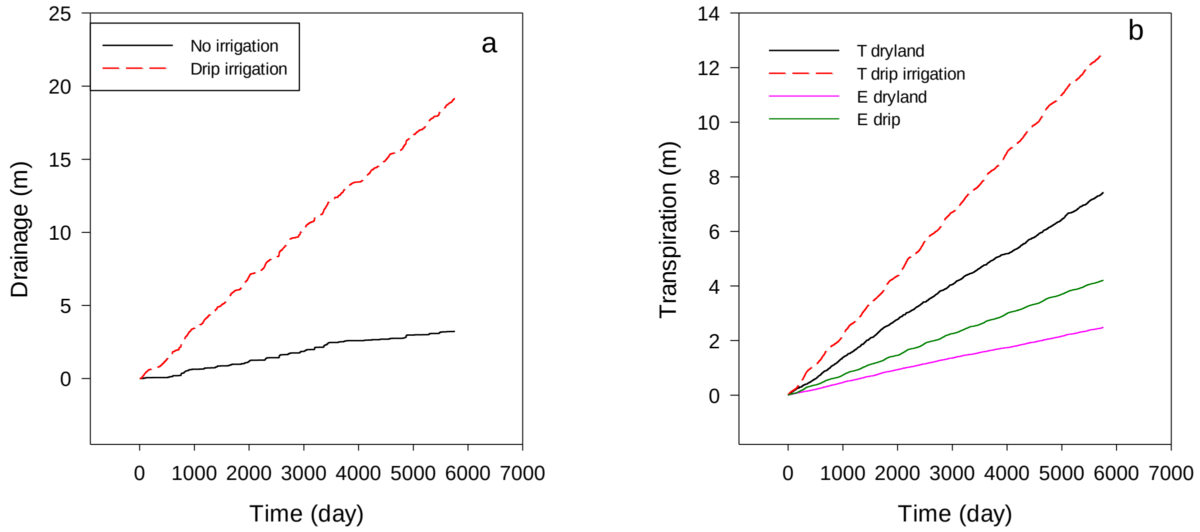

Figure 10. Simulated cumulative a) drainage and b) transpiration for dryland, dripper and beds or trenches treatments for Tararu soil. Note the transpiration was virtually the same for the dryland and dripper treatments.

The cumulative drainage over the whole period was 2.48 and 19.15 respectively for the dryland and dripper simulations respectively. These values for the cumulative drainage are similar to those for the Bushgate and Tararu soil. The areas and hydraulic loadings for the different components are given in Table 3. The average hydraulic loading (*H*) was calculated with eqn (1) with A_t is the total area of Mangatewai soil (49 ha).

The roof area was estimated as 300 m^2 per lot (Jason Kaye pers. comm.) with the water from this captured into rainwater tanks for domestic use.

Table 3. Component and average hydraulic loading to Mangatewai soil area of Springhill development.

Component	Area (ha)	Component hydraulic loading rate (mm day^{-1})	Averaqe Hydraulic loading rate (mm day^{-1})
Dryland	49	0.56	0.56
Dripper	1.88	3.32	0.64
Roofs	2.08	0	0

The Hantush (1967) was used to see if the increased loading in Table 3 would have a significant effect on the watertable. The change in watertable height is shown in figure 11 and shows that after 16 years the water table change compared to that of the dryland situation is 0.23 m for the drippers respectively. This is a worst case scenario as the watertable height is the maximum calculated at the middle of the area of Tararu soil and Hantush's solution assume that no discharge to a surface waterway occurs and here the Waipawa river will be an eventual discharge point. At the edge of the area there is minimal watertable rise of < 0.04 m in all irrigation treatments. The lower levels of watertable rise for the Tarau soil are in part due to the small area the drainage loading is occurring on.

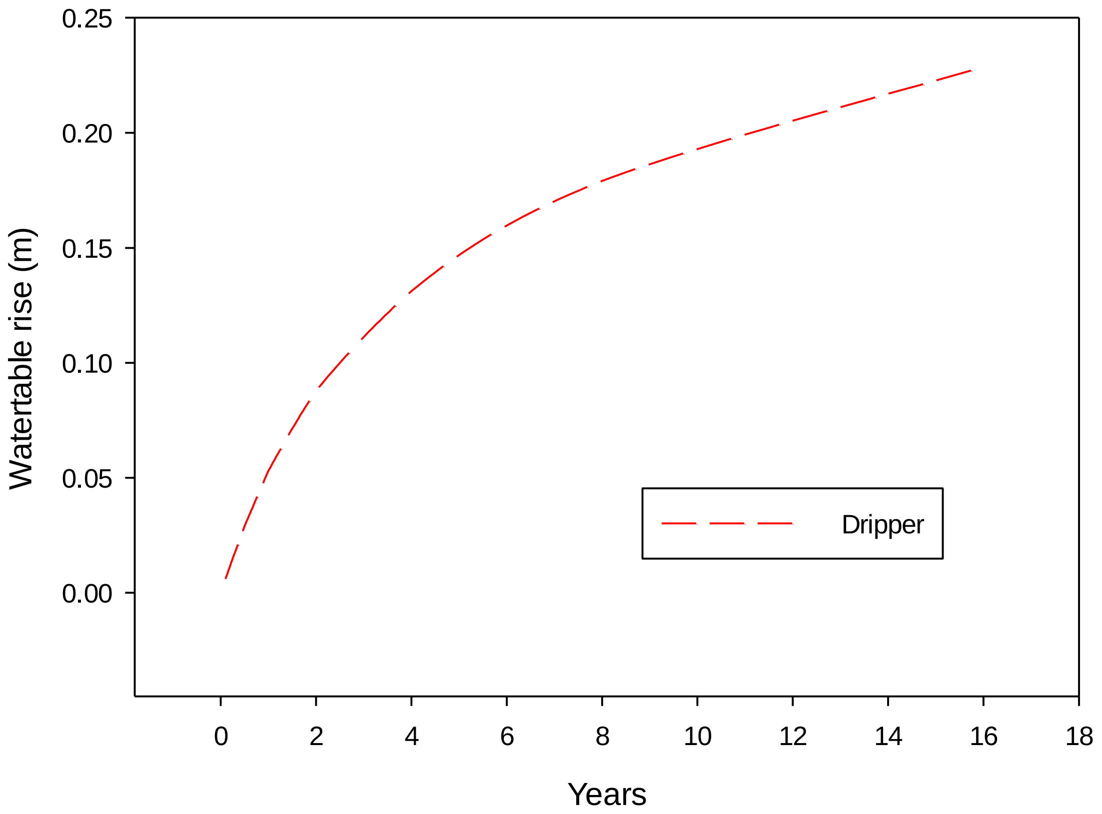

Figure 11. Maximum watertable rise with time at the midpoint of the Mangatewai soil area compared to the dryland treatment calculated using Hantush (1967).

For the Mangatewai soil there is only a minor change in the average hydraulic loading with the wastewater system suggested in Cook (2021) and watertable rise is expected to be of no concern.

Hydraulic Loading Impact on Surface Water

There is an ephemeral stream that runs through this site, so no disposal areas can be within 20 m of this on Lots that abut this creek. The simulations indicated that no runoff would arise from any of the design scenarios, so no impact on surface water flow to the ephemeral stream is anticipated.

The Waipawa river is over 1 km from the northern edge of the development. Given the small changes in groundwater calculated no impact is expected on the river from this development.

Hydraulic Loading Impact on Groundwater

The ground water at this site is at greater than 2 m below the soil surface (Initia Geotechnical Specialists, 2021) which is greater than the required depth below the discharge depth 0.6 m (HBRRMP Rule 37 Condition J). No impact on groundwater would seem likely from this development. Given the groundwater assessments done using the Hantush (1967) model will overestimate the groundwater rise no impact is anticipated from this development.

NUTRIENT LOADING

The nutrient loading to the soils will be driven by the nutrient concentration in the wastewater. For septic tank systems the output of nitrogen is mainly in the form ammonium. Being positively charged ammonium will be retarded in its transport through the soil. By nitrification the ammonium will be converted to nitrate which is a readily transported nutrient. In the process of nitrification and denitrification some nitrogen will be converted to nitrous oxides and dinitrogen which will be lost to the atmosphere. Parfitt et al. (2008) estimated this to be 17% of the nitrogen inputs in Hawke's Bay. The denitrification loss based on Parfitt et al. (2008) would be 74.5 kg-N ha^{-1} yr^{-1}. The other major loss will be plant uptake with the nitrogen content of grasses in the range of 2.5 to 3% of dry matter.

Dryland: Present landuse

The pasture production has been estimated by Mills et al. (2021) to 16.9 kg_DM mm^{-1} yr^{-1} which would give the dryland grass productivity at Springhill as 13,932 kg_DM ha^{-1} yr^{-1}. At a nitrogen (N) concentration of 2.5% this would give an N uptake of 348 kg_N ha^{-1} yr^{-1}.

Using an uptake of 2 kg_DM day^{-1} (Beef + Lamb, 2012) for cattle this would give a stocking rate of 19 cows ha^{-1}. However, according to Nobel (1985) the potential stocking rate for this land would be 32 su ha^{-1} which given average of 4 su per cow would give 8 cows ha^{-1}, which to be conservative is what we have utilised in the comparison analysis. It is noted that 8 stocking units per hectare is defied by the HBRRMP as a Low Intensity Farming System. The amount of nitrogen excreted each day in feces and urine was tabulated by Reed et al. (2015) and is given below in Table 4.

Table 4. Total nitrogen excreted daily by cattle: mean and standard deviation from Tables 1 and 2 in Reed et al, (2015).

Stock	**Total Nitrogen (g_N day^{-1}) Table 1**		**Total Nitrogen (g_N day^{-1}) Table 2**	
	Mean	SD	Mean	SD
Lactating cows	432	145	455	109
Heifers and dry cows	143	54	170	27.1
Steers	105	44.9	106	28.6

In calculating the amount of nitrogen excreted per cow per day the value of 143 g_N day^{-1} (Reed et al., 2015) was used as this a moderate level compared to that of lactating cows but not as low as that of steers. Using this value results in a loading of 418 kg_N ha^{-1} yr^{-1}. This is a reasonable alternative site use and is provided as a base for comparison with the wastewater irrigated options.

The plant uptake plus the denitification losses of 71 kg_N ha^{-1} yr^{-1} gives a total of 419 kg_N ha^{-1} yr^{-1} which is equivalent the input from excreta. If the stocking rate is increased to 10 cows per ha the input increases to 522 kg_N ha^{-1} yr^{-1} while the output increase (due to denitrification) to 437 kg_N ha^{-1} yr^{-1} giving an excess of 85 kg_N ha^{-1} yr^{-1}.

Cows produce on average 29.5 kg of faeces a day (https://fergusonfoundation.org/lessons/cow_in_out/cowmoreinfo.shtml) with a phosphorus content of 0.8 kg ton^{-1} (Barnett, 1994). With 8 cows per ha this gives a phosphorus loading of 69 kg_P ha^{-1} yr^{-1}, which will be used as the basis for comparison with the wastewater irrigation options. The excretion of phosphorus in urine by cows is 1-1.4 g day^{-1} (Lovendahl and Sehested, 2015) which for 8 cows per ha gives an annual input of 3 kg_P ha^{-1} yr^{-1}. This gives a total input without fertiliser additions of 72 kg_P ha^{-1} yr^{-1}.

The pasture uptake is calculated to be 70 kg_P ha^{-1} yr^{-1}, almost in equilibrium with the input from feaces and urine. Over the whole area (220 ha) we would estimate a possible accumulation of 2 kg_P ha^{-1} yr^{-1}. These loading calculations are predicated on the 8 cow per ha modest stocking rate basis. If the number of cows per ha increases to 10, the excess phosphorus increases to 26 kg_P ha^{-1} yr^{-1}.

Note no fertiliser additions have been considered in these calculations.

Dripper

From the volume of wastewater and using the upper limit of the ammonium concentration given in the TP58 of 30 gm^{-3} and an annual application of 394 m^{3} yr^{-1} the nitrogen loading would be 438 kg-N ha^{-1} yr^{-1}. This is only 20 kg_N ha^{-1} yr^{-1} greater than the present landuse if the stocking rate is 8 cows per ha and 84 kg_N ha^{-1} yr^{-1} less than if 10 cows per ha.

The irrigation options will not have a water deficit, so will have a maximum grass production which we set at a conservative value of 17,000 kg_DM mm^{-1} yr^{-1}. On this basis the dripper nitrogen uptake would be 425 kg-N ha^{-1} yr^{-1} and when combined with the denitrification is 499 kg-N ha^{-1} yr^{-1}, which is greater than the input.

The phosphate concentration in wastewater given is between 7-20 g m^{-3}. For drip irrigation the wastewater will have to be filtered to prevent blockage of the drippers. This will remove much of the phosphorus from the wastewater, so 7 g m^{-3} will be used as the wastewater concentration, but it will probably be less than that. The phosphate loading will be 102 kg_P ha^{-1} yr^{-1}. The uptake of phosphate by grasses is 0.5% of dry matter (DM). The uptake of phosphate by the plant will be 85 kg_P ha^{-1} yr^{-1}. This could result in a potential accumulation of phosphate in the soil with time, although Vazquez-Montiel et al. (1996) found that the excess phosphate was removed by soil processes. This calculation assumes that the houses are occupied by 6 people continuously, which is unlikely, so the loading is a worst case scenario. The land area in drippers means that the total excess phosphate loading to the area is 17 kg_P ha^{-1} yr^{-1} or if spread over the whole 49 ha of Mangatewai soil giving an average loading of 0.65 kg_P ha^{-1} yr^{-1} compared to the present land use of 2 and 26 kg_P ha^{-1} yr^{-1} for stocking rates of 8 and 10 cows per ha respectively.

Any nitrogen reaching the groundwater is likely to be attenuated by denitrification within a short distance downstream (Collins et al. 2017, Simth and Duff, 1988).

It is further noted that background reporting by BECA (2021, p18) supporting Central Hawke’s Bay District Council’s proposed Takapau wastewater treatment plan, which has a higher loading, suggested “limited phosphorus would be leached from the site through the groundwater.”

The nutrient loading for the dripper system is unlikely to be any worse and is possibly better than the present land use.

Beds

The mass of nitrogen applied to the beds is the same as that for the drippers but the area it is applied to is less with 3 beds 1 m wide and spaced 1 m apart. There will be some sorptive adsorption into the 1m spacing between the beds but after the initial wetting this sorption will reduce. Thus, we are presenting the worst case scenario with the nutrients only being applied to the area of the beds receiving wastewater (75 m^2). This will result in a nitrogen loading of 1577 kg-N ha^{-1} yr^{-1}. The plant uptake will be the same as for the dripper of 425 kg-N ha^{-1} yr^{-1} and the denitrification (2 kg_N yr^1) 268 kg-N ha^{-1} yr^{-1}, give a net accumulation of 883 kg-N ha^{-1} yr^{-1}. However, on a total mass basis across the 220 ha given that beds are only for the Bushgate and Tararui soils (171 ha) the net mass is 461 kg_N yr^{-1} accumulating and/or leaching to the groundwater. When this mass is divided by the area of 171 ha the rate of accumulation and/or leaching is 9.4 kg-N ha^{-1} yr^{-1}. By comparison for the present land use with a stocking rate of 8 or 10 cows per ha the excess across the 220 ha area would be 0 kg_N yr^{-1} and 85 kg-N ha^{-1} yr^{-1} respectively. BECA (2021) suggested that the Takapau wastewater treatment site a mass of nitrogen loss of 2097 kg yr^{-1} would occur based on OVERSEER modelling. This may be an underestimate given the simplifications in OVERSEER (The Foundation for Arable Research, 2013) and such use of OVERSEER is not recommended (Parliamentary Commissioner for the Environment, 2018). However, given the estimated nitrogen load to the groundwater for the 30 ha area at the wastewater treatment site this would result in a loading of 70 kg_N ha^{-1} yr^{-1}. BECA (2021) suggested that this could be denitrified in the groundwater (Collins et al., 2017). The loading here at Springhill would be an order of magnitude less than what has been proposed by The Council for the Takapau wastewater treatment site.

The annual mass of phosphorus added using a concentration of 20 g m^{-3} (as filtering will be minimal) is 7.9 kg per bed or the equivalent of 1051 kg_P ha^{-1} yr^{-1}. Grass uptake will only be 85 kg_P m^{-2} yr^{-1}, so there will be an accumulation of phosphorus in the beds of 966 kg_P ha^{-1} yr^{-1}. This a high loading rate, however, when spread over the 171 ha of Bushgate and Tararu soils this would be equivalent to 6 kg_P ha^{-1} yr^{-1}.

The use of beds compared to using drippers represents a greater risk of nitrogen transport to groundwater, but this is no worse than the present landuse. The phosphorus loading is high and this may represent a long term risk. However, BECA (2021) found that the present phosphorus loading of the Takapau wastewater discharge into the Makaretu river was attenuated by 400 m downstream from the discharge point. It will also take a considerable time (and distance) for the phoshorous to travel through the groundwater to the Waipawa River or Tukituki River.

Trenches

The mass of nitrogen applied to the beds is the same as that for the drippers but the area it is applied to is less with 8 beds 0.3 m wide and spaced 1 m apart. There will be some sorptive adsorption into the 1 m spacing between the trenches but after the initial wetting this sorption will reduce. Thus, we are presenting the worst case scenario with the nutrients only being applied to the area of the beds receiving wastewater (60 m^2). This will result in a nitrogen loading of 197 g-N m^{-2} yr^{-1}. The plant uptake will be the same as for the dripper of 425 kg-N ha^{-1} yr^{-1} and the denitrification 355 kg-N ha^{-1} yr ^{1}, gives a net accumulation of 760 kg-N ha^{-1} yr^{-1}. However, on a total mass basis across the 220 ha given that beds are only for the Bushgate and Tararu soils (171 ha) the net mass is 10 kg_N yr^{-1} accummulating and/or leaching to the groundwater. By comparison for the present land use with a stocking rate of 8 or 10 cows per ha the excess across the 220 ha area would be 0 kg_N yr^{-1} and 85 kg-N ha^{-1} yr^{-1} respectively. Again, compared to the Takapau wastewater site this is an order of magnitude less nitrogen loading.

The annual mass of phosphorus added using a concentration of 20 g m^{-3} (as filtering will be minimal) is 1314 kg_P ha^{-1} yr^{-1}. Grass uptake will only be 85 kg_P ha^{-1} yr^{-1}, so there will be an accumulation of 1229 kg_P m^{-2} yr^{-1}. This a high loading rate, however, when spread over the 171 ha of Bushgate and Tararu soils this would be equivalent to 7 kg_P ha^{-1} yr^{-1}.

The use of trenches compared to using drippers represents a greater risk of nitrogen transport to groundwater but this is no worse than the present landuse. The phosphorus loading is high and this may represent a long term risk. However, BECA (2021) found that the present Takapau wastewater discharge into the Makaretu river was attenuated by 400 m downstream from the discharge point. It will also take a considerable time for the phosphorous to travel through the groundwater to the Waipawa River or Tukituki River.

Nutrient Loading Impact on Surface Water and Groundwater

As no runoff was generated in the modelling of the wastewater disposal areas no impact of the nutrient loading on surface water is likely.

There is no nutrient impact from the dripper irrigated system for nitrogen and the phosphate accumulation would be less than the present landuse. The beds and trenches have increased with nitrogen loading with 9.3 and 10 kg_N ha^{-1} yr^{-1} respectively. The present landuse is likely to have similar nitrogen loading rates to the groundwater of between 2 and 17 kg_N ha^{-1} yr^{-1} (Thomas et al. 2005) and for a stocking rate of 10 cows per ha this could be as great as 85 kg_N ha^{-1} yr^{-1}. However, with wastewater there is a high dissolved carbon content so that Smith and Duff (1988) found the nitrogen level was negligible 350 m downstream in an aquifer that was receiving leaching from wastewater. The distance to the surface water body (Waipawa River) is over 1 km away, so no impact is anticipated from the nitrogen loading.

The amount of phosphorus applied in the wastewater is very high for the beds and trenches and we suggest that subsurface drip wastewater irrigation be used in preference to beds and trenches. The subsurface drip irrigation requires filtering of the wastewater to prevent clogging of the emitters. This will substantially reduce the phosphate concentration of the discharged wastewater, so no impact on groundwater or surface water is anticipated.

BACTERIOLOGICAL LOADING

The population of the development area has been calculated as 6 people per lot which for the 312 lots gives 1872 people. At a stocking rate of 8 cows per ha for 220 ha this gives 1760 cows. Foote et al. (2015) states that the bacteriological output per cow is 14 times that of a person. The equivalent number of people to give the same bacteriological load would be 24640. Thus, the total load to the area will be greatly reduced and the impact from the bacteriological load will be low.

Following the nutrient loading results the wastewater is assumed to be applied by subsurface drip irrigation on all soils. This gives a total area for wastewater disposal of 312x270= 8.4 ha. The intensity of the bacteriological load using a person as 1 load is then 1872/8.4 = 222. For the cows the intensity is 24640/220 = 112. This means that the intensity of the bacteriological loading in the wastewater irrigated areas will be approximately double that of the present landuse, while the total loading across the 220 ha will be 0.075.

Tertiary treatment (disinfection) of the wastewater has been agreed to for the wastewater which means that the bacteriological loading will be orders of magnitude less than the present land use.

HBRC Proposed Cumulative Effects Report Scope

We understand that discussion of the application between CHBDC and HBRC has resulted in a request from CHBDC to commission an external report considering the cumulative effects of wastewater discharge, with a proposed scope of the study subsequently provided. For clarity, we have not been a party to these discussions and are not aware of the matters discussed, having only been advised of the Stantec review and invited to discuss wastewater further with the locally based Stantec engineer, Wayne Hodson.

The discussion with Mr Hodson covered some of the points raised in the proposed report scope with the concluding suggestion that the discussed details were submitted for his consideration. The additional points raised in the proposed report scope are addressed in this section. This is based on the recommendation that all systems provide tertiary treatment (disinfection) and are discharged by way of subsurface drip irrigation (with associated filtering of discharge).

Impact on downgradient bores and groundwater quality, with reference to Conditions h (no increase to pathogenic organisms in any surface water body) and k (shall not result in a breach of Drinking Water Quality Standards for New Zealand (2008) of Rule 37 of the HBRRMP. Risk to any future bores within the proposed lots.

As set out in the assessment provided in this report, disinfection of the wastewater before discharge to the soil is proposed, so the bacteriological load will be minimal and not down grade bores and groundwater quality,

The Drinking Water Quality Standards for New Zealand were revised in 2018 to supersede the 2008 standards. These standards reference nitrate (short term) and nitrite (long term and short term). The standards do not specify a MAV for phosphorous. The proposed wastewater treatment and discharge methodology will readily ensure compliance with the MAVs for the specified constituents.

Following the setback required by the HBRRMP, the treated wastewater discharge would not be expected to compromise the ability for homes to install groundwater bores, provided these were at appropriate depth (as is already required by the HBRRMP requirement for bores to be efficient).

Potential Impact on freshwater bodies of nutrients and microbial pathogens.

Loading rates have been calculated in the above assessment. Nutrient loading will be negligible and less than agricultural use. Pathogen loading will be negligible and several orders of magnitude below rural use due to tertiary treatment.

Recommended minimum standards for on-site wastewater systems

As stated above, no further minimum (or maximum) standards are recommended beyond those set out in the HBRRMP Rule 37 conditions. The dispersed arrangement of the wastewater discharge across 220ha along with the tertiary treatment and subsurface drip irrigation application ensures that no offsite impacts are anticipated.

Ability to achieve compliance with HBRRMP Rule 37 conditions h and k.

As set out above, the resulting low intensity of discharge through the dispersal across 220ha, the level of treatment and the application methodology are such that compliance with Rule 37 h and k is expected on both an individual and cumulative basis.

Additional Information Required

Subject to the securing of the proposed wastewater treatment level and discharge methodology by way of consent notice or similar, there is no additional information necessary to support the wastewater assessment.

SUMMARY/CONCLUSIONS

This report considers the hydraulic, nutrient and bacteriological loading to the Springhill development. The results suggest that:

1. There is unlikely to be any impact of the onsite wastewater disposal to surface or groundwater by subsurface drip irrigation (SDI), beds or trenches.
2. The nutrient loading indicates that phosphorus would accumulate in the disposal areas where beds and trenches were used but SDI would not cause an increase in nutrient loading compared to the present landuse.
3. The bacteriological loading showed that the total load to the site would be greatly reduced by the change from cattle grazing to housing but the intensity of loading in the wastewater SDI areas would be double that of the present land use. Thus, tertiary treatment (disinfection) to decrease any risk is considered worthwhile.
4. **It is recommended that subsurface drip irrigation be used and that the wastewater be filtered and disinfected before discharge. This will result in no cumulative impacts to the land and is likely to improve the groundwater compared to the present land use of cattle grazing.**

Professor Freeman J Cook

Principal Scientist/Director

B.Sc, Dip. Agric. Sci., M.Phil (Massey University); PhD (University of Technology Sydney)

Fellow of the Modelling and Simulation Society of Australia and New Zealand

American Geophysical Union, member

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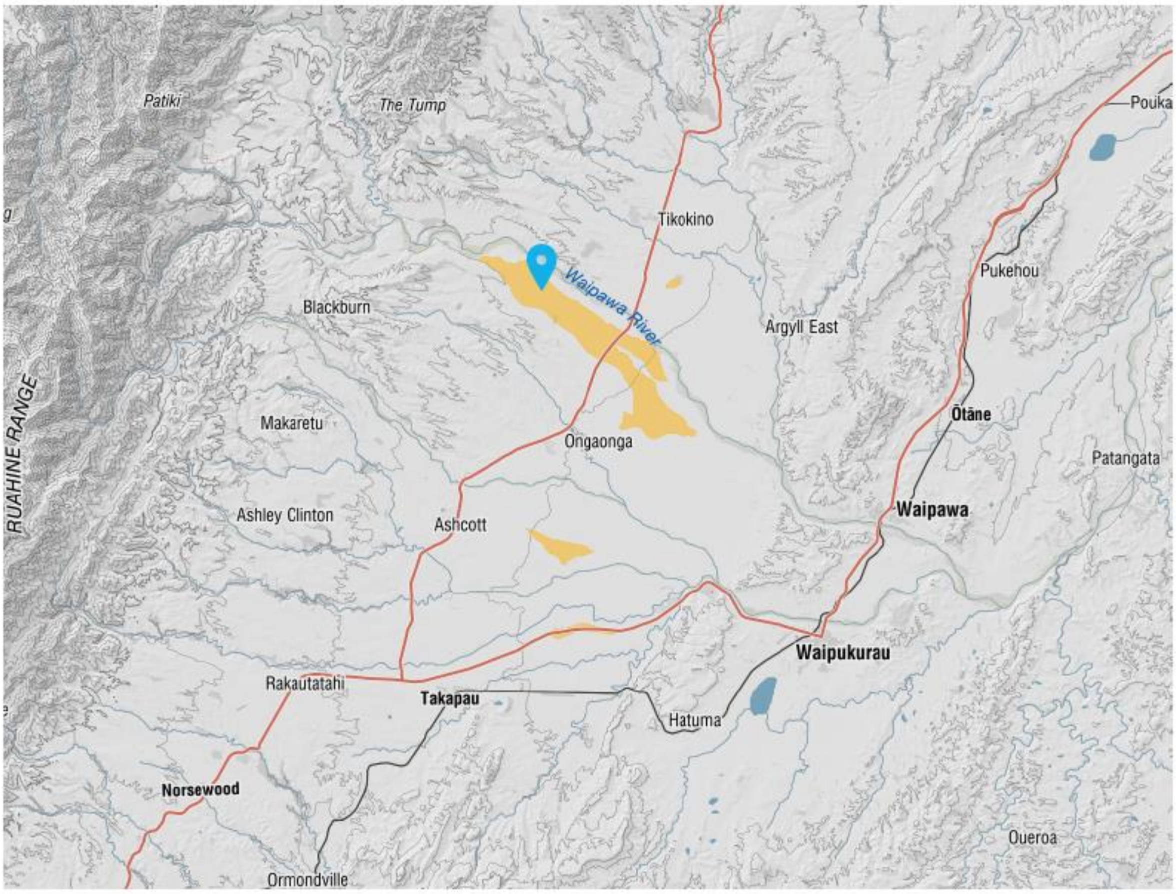
Appendix 1. Soil data

Bushgate Soil

Soil map unit factsheet

Report generated: 10/04/2021 from https://smap.landcareresearch.co.nz/maps-and-tools/app/?url=/print-soil-map-unit-factsheet/&gislayer=HawkesBay&soilmapuc=rt_SHB_1000008&pinCoordinate=1890314.3911806059%2C5583138.852209832

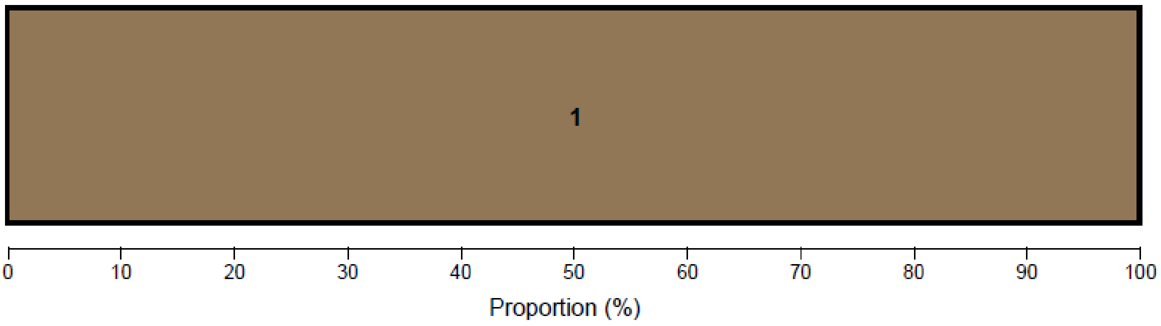
Areas with HawkesBay\rt_SHB_1000008 map unit code are shown on the map below. A soil map unit is a collection of areas that have the same soils (i.e. siblings) in the same proportion.



Map contains data sourced from LINZ. Crown Copyright Reserved

Proportion of siblings in this map unit

Graph is coloured according to the NZSC soil order of each sibling within this map unit.



Sibling

1: Bushgate_14a.1 (100%)

Soil Order

Brown

Soil properties of the siblings within the soil map unit

This table shows the details of the soil siblings within the map unit. The profile available water (Paw) is a measure of the capacity of the soil sibling to store water to a depth of 1 metre. Click the links below to find out more about each item:

Soil Order, Drainage Class, Depth Class

No.	Smap name	Proportion (%)	Depth	Texture	Drainage class	PAW (mm)	Order
1	Bushgate_14a.1	100	Shallow	silt	Well drained	111.8	Brown

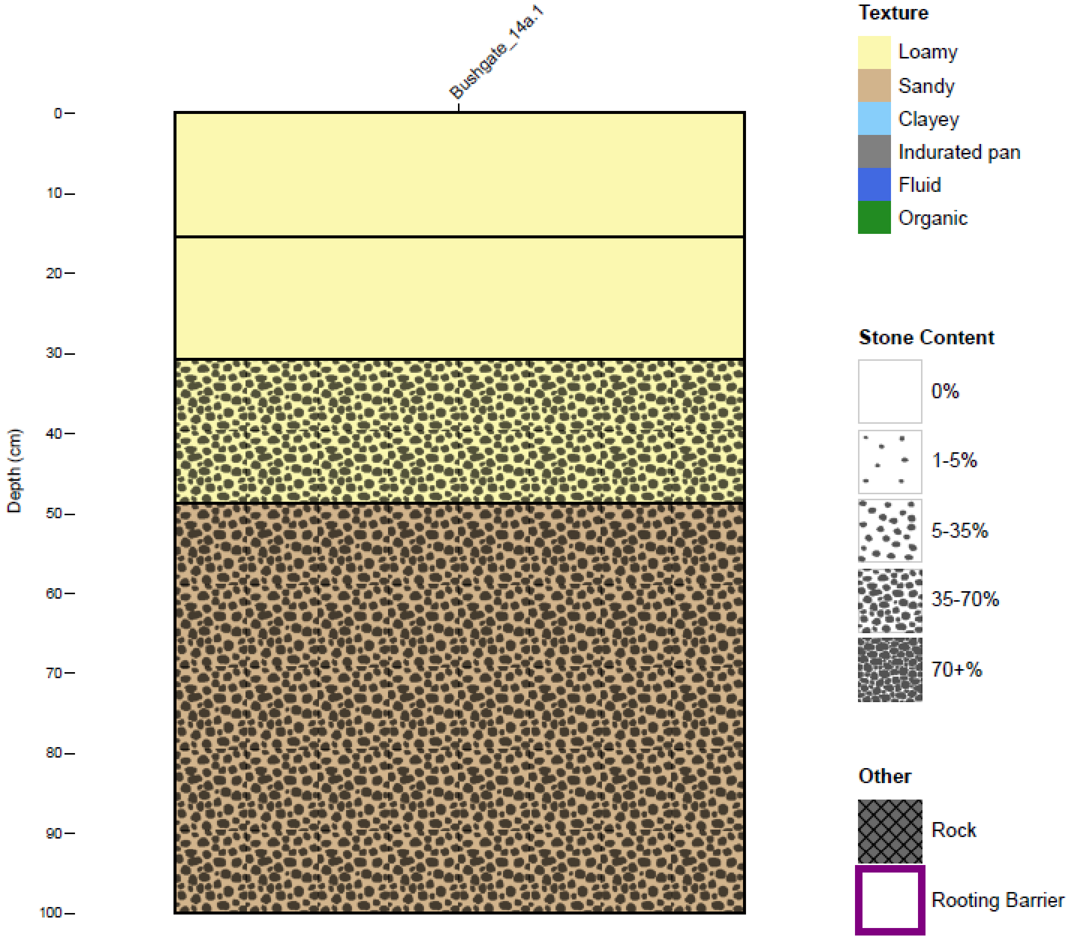
Soil Survey

This soil mapunit was mapped within the following soil survey:

Survey Title: Survey of the Ruataniwha Plains (Elwyn Griffiths, Malcolm Reeves, Sharn Hainsworth)
Survey Scale: 50000
Survey Date: 2004
Origin: legacy update major
Map Unit Delineation Method: Hand-drawn
Map Unit Labelling Method: Observations
Sibling Base Property Classification Method: Observations
Description: Mapping based on adequate to good supporting layers and observations in a mod to highly predictable landscape. Or mapping that could be Excellent but has not been statistically verified or reviewed.
Map Unit Description:

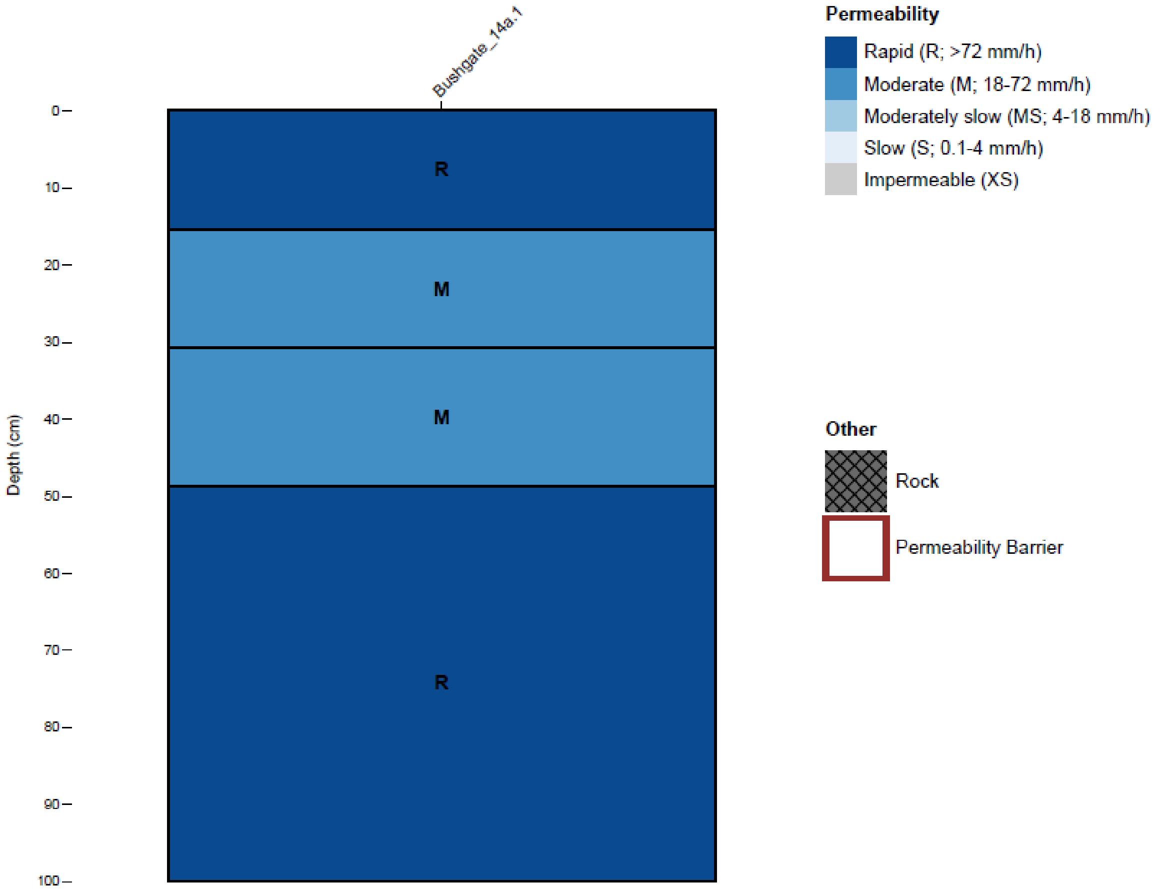
Texture graph

This graph shows the texture profile of the siblings found in the map unit. Each horizon is coloured according to its texture.



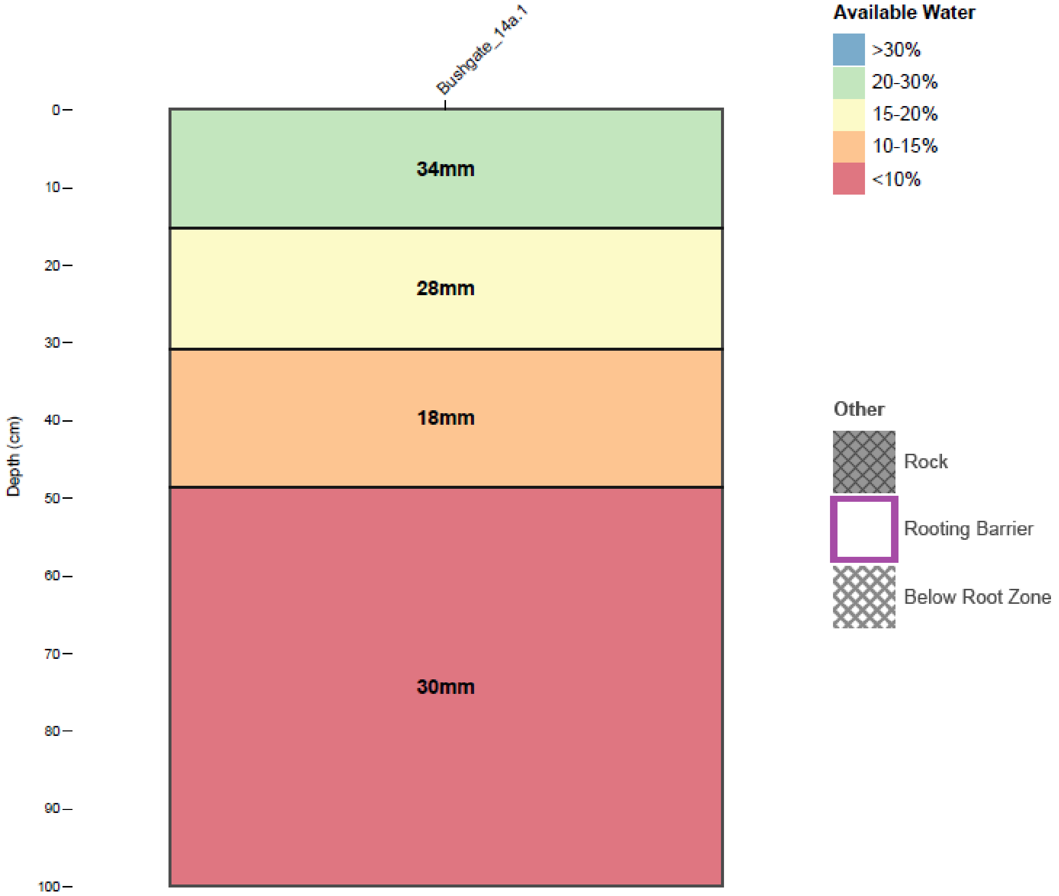
Permeability graph

This graph shows the permeability profile of the siblings found in the map unit. Each horizon is coloured according to its permeability. Click here for more information on permeability.



Available Water Graph

This graph shows the available water profile of the siblings found in the map unit. This is capacity of the soil to hold water that is available to plants. Each horizon is coloured according to its percent available water content. Click here for more information on available water.



About this publication

- This information sheet describes the typical average properties of the specified soil map unit.
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Landcare Research

Mangatewa soil

Soil map unit factsheet

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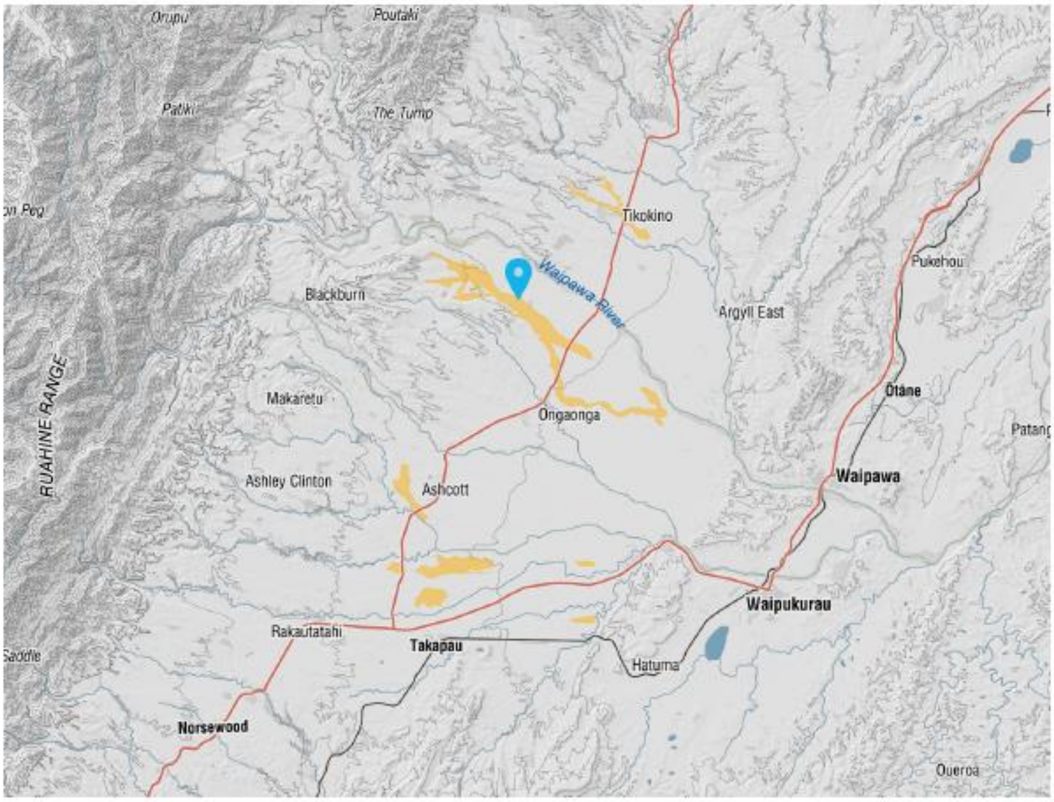
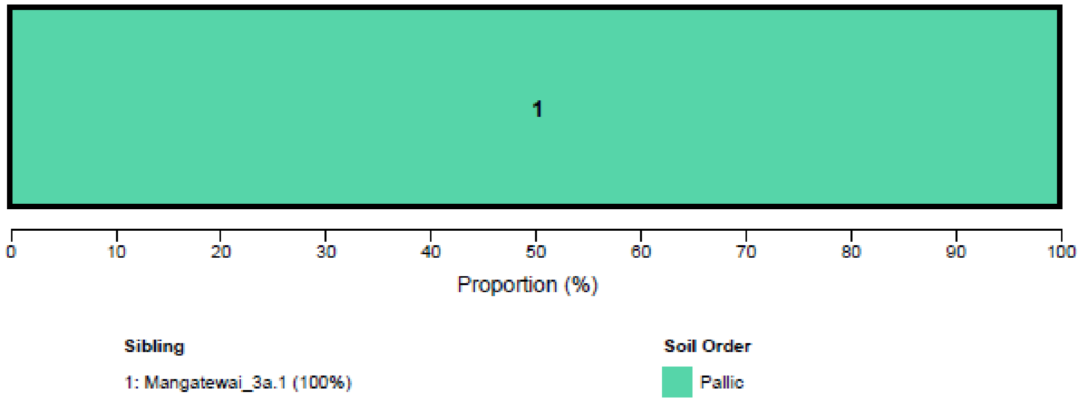
Areas with HawkesBay\rt_SHB_1000032 map unit code are shown on the map below. A soil map unit is a collection of areas that have the same soils (i.e. siblings) in the same proportion.



Map contains data sourced from LINZ. Crown Copyright Reserved

Proportion of siblings in this map unit

Graph is coloured according to the NZSC soil order of each sibling within this map unit.



Soil properties of the siblings within the soil map unit

This table shows the details of the soil siblings within the map unit. The profile available water (Paw) is a measure of the capacity of the soil sibling to store water to a depth of 1 metre. Click the links below to find out more about each item:

Soil Order, Drainage Class, Depth Class

No.	Smap name	Proportion (%)	Depth	Texture	Drainage class	PAW (mm)	Order
1	Mangatewai_3a.1	100	Shallow	silt	Poorly drained	63	Pallic

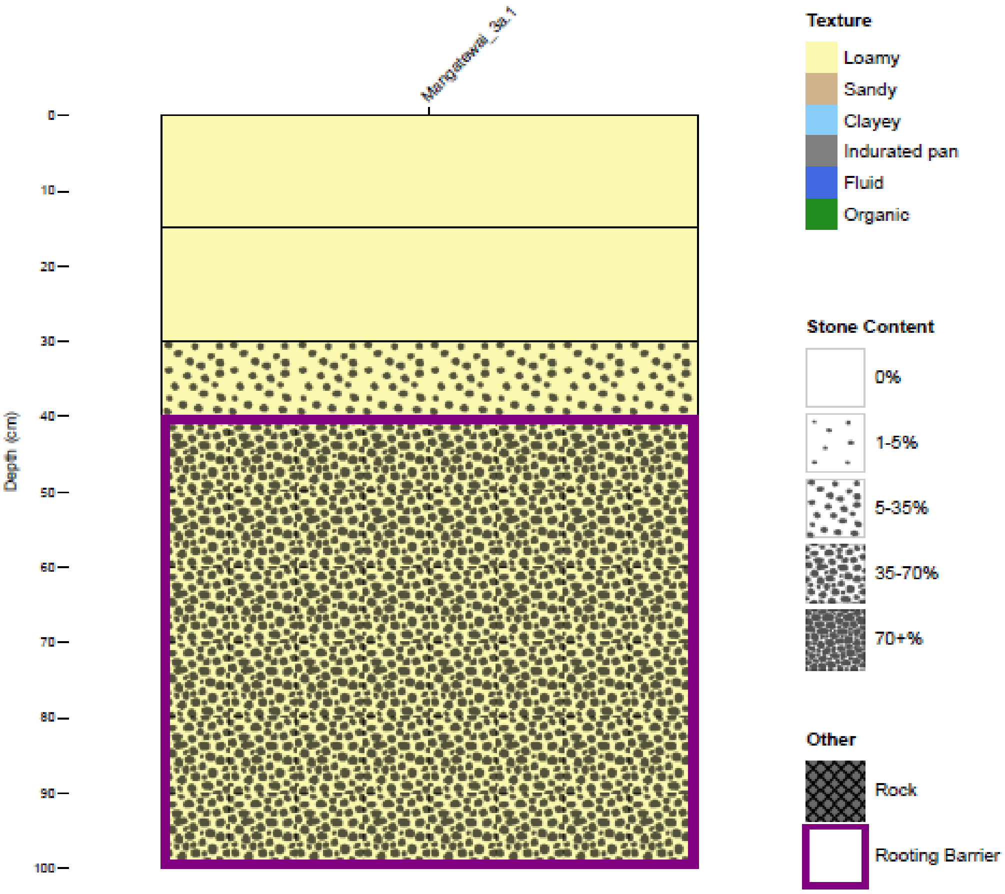
Soil Survey

This soil mapunit was mapped within the following soil survey:

Survey Title: Survey of the Ruataniwha Plains (Elwyn Griffiths, Malcolm Reeves, Sharn Hainsworth)
Survey Scale: 50000
Survey Date: 2004
Origin: legacy update major
Map Unit Delineation Method: Hand-drawn
Map Unit Labelling Method: Observations
Sibling Base Property Classification Method: Observations
Description: Mapping based on adequate to good supporting layers and observations in a mod to highly predictable landscape. Or mapping that could be Excellent but has not been statistically verified or reviewed.
Map Unit Description:

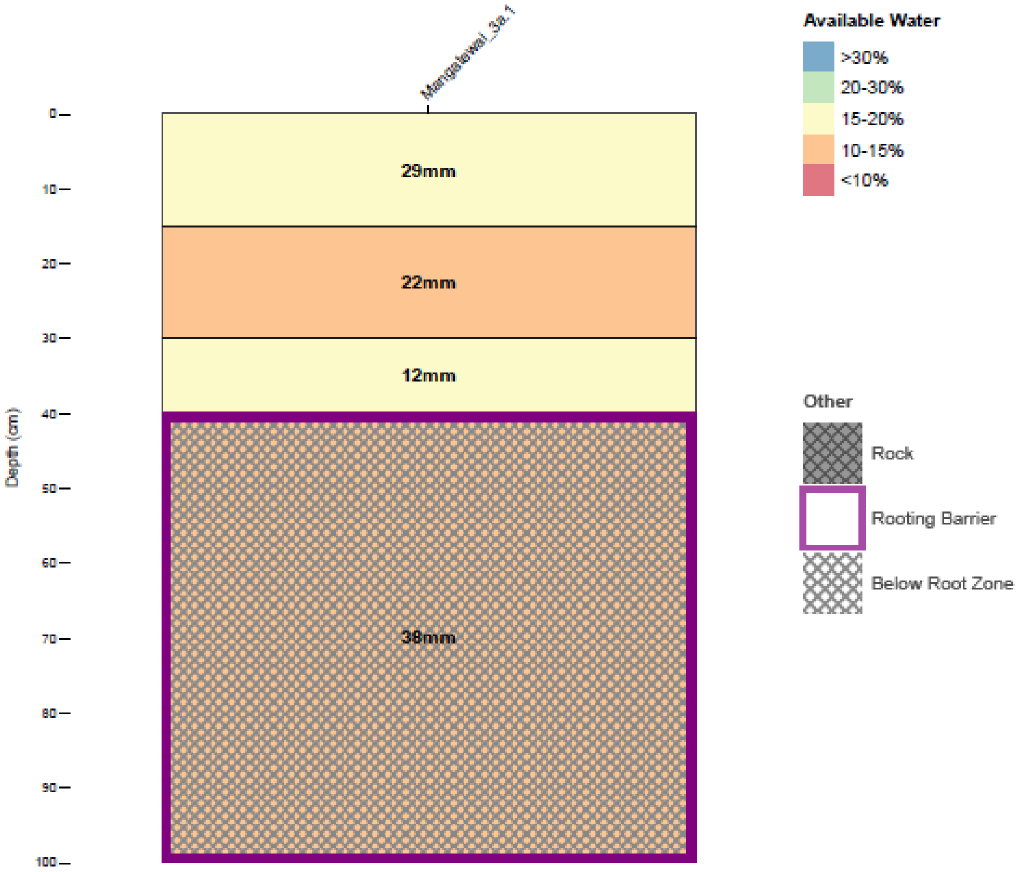
Texture graph

This graph shows the texture profile of the siblings found in the map unit. Each horizon is coloured according to its texture.



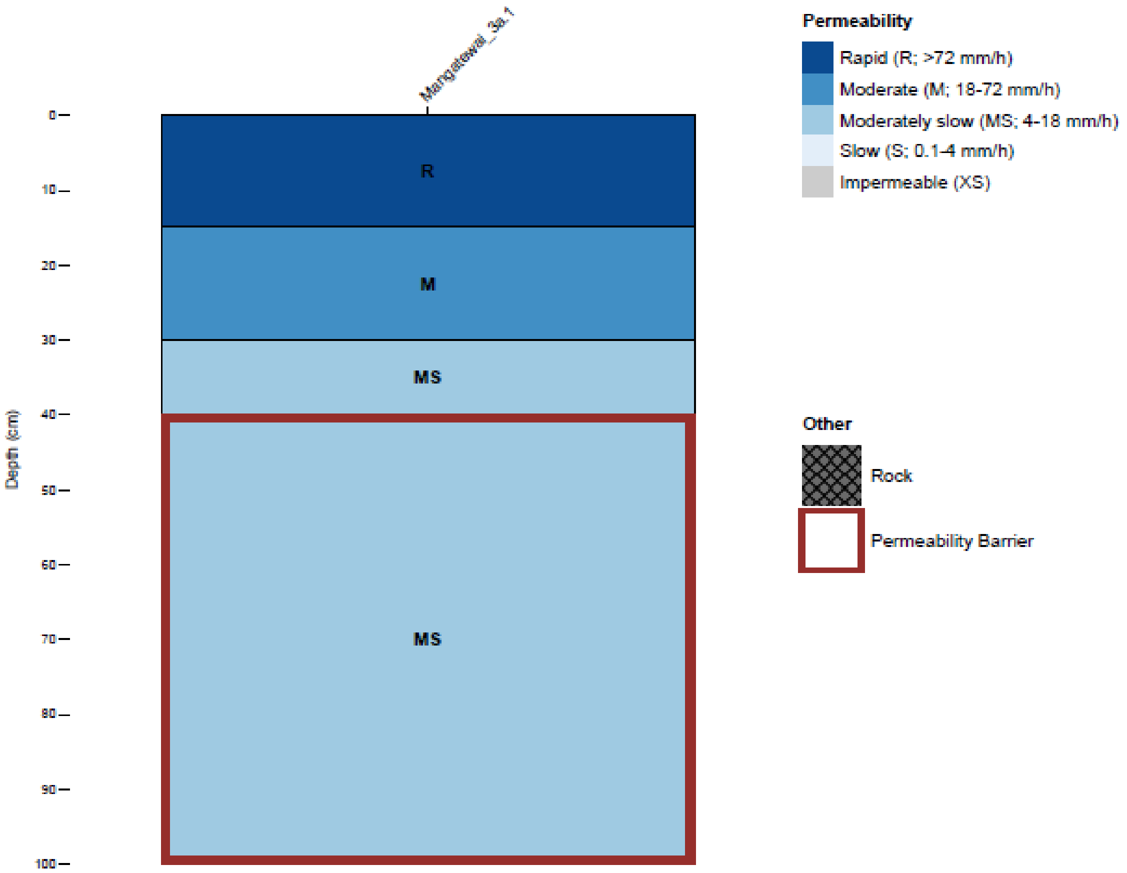
Available Water Graph

This graph shows the available water profile of the siblings found in the map unit. This is capacity of the soil to hold water that is available to plants. Each horizon is coloured according to its percent available water content. Click here for more information on available water.



Permeability graph

This graph shows the permeability profile of the siblings found in the map unit. Each horizon is coloured according to its permeability. Click here for more information on permeability.



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Tararu soil

Soil map unit factsheet

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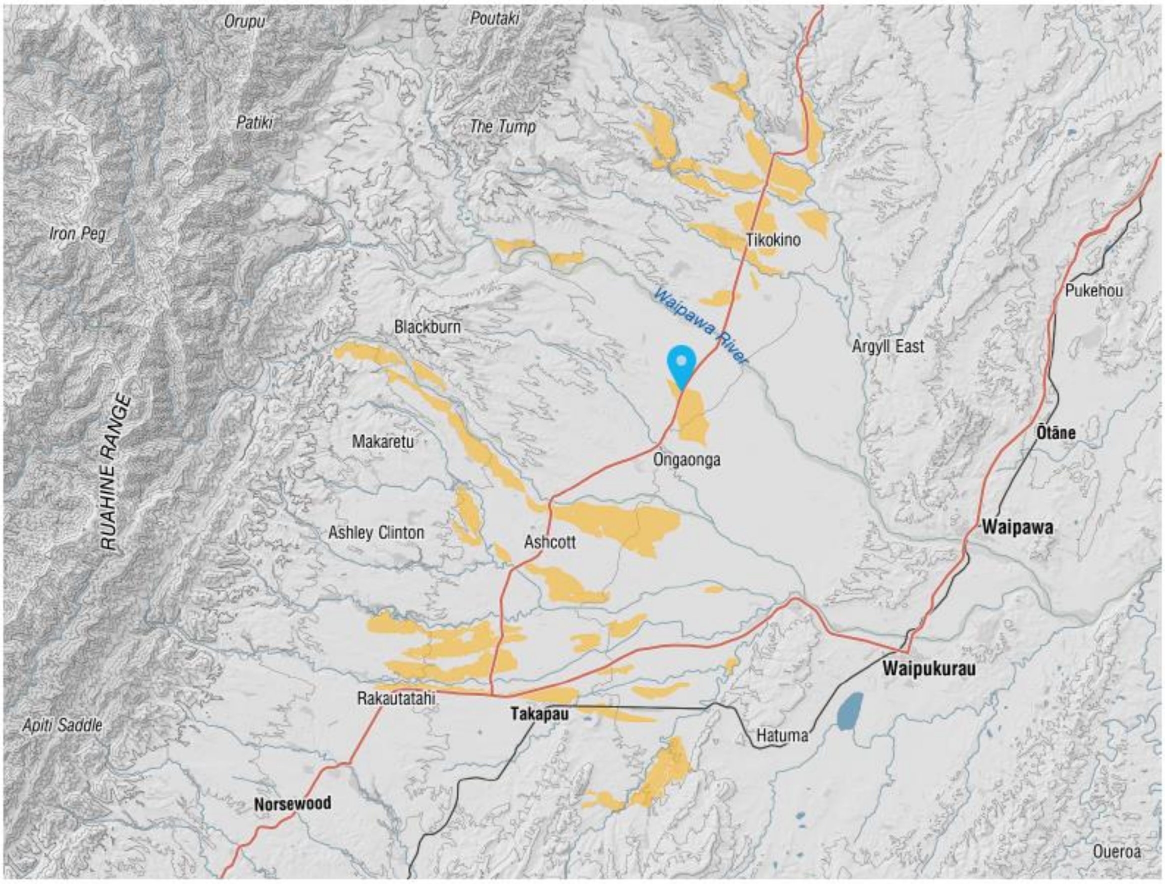
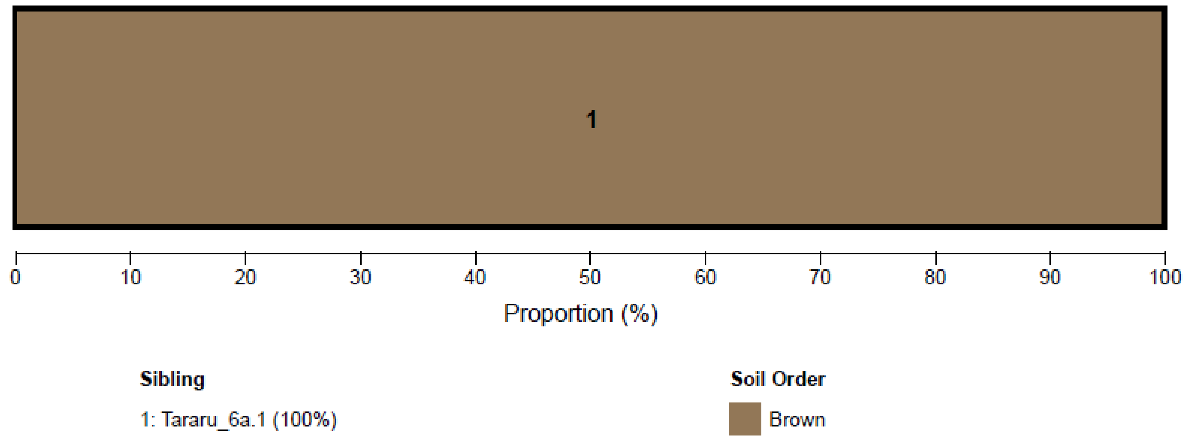
Areas with HawkesBay\rt_SHB_1000058 map unit code are shown on the map below. A soil map unit is a collection of areas that have the same soils (i.e. siblings) in the same proportion.



Proportion of siblings in this map unit

Graph is coloured according to the NZSC soil order of each sibling within this map unit.



Soil properties of the siblings within the soil map unit

This table shows the details of the soil siblings within the map unit. The profile available water (Paw) is a measure of the capacity of the soil sibling to store water to a depth of 1 metre. Click the links below to find out more about each item:

Soil Order, Drainage Class, Depth Class

No.	Smap name	Proportion (%)	Depth	Texture	Drainage class	PAW (mm)	Order
1	Tararu_6a.1	100	Moderately Deep	silt	Well drained	144	Brown

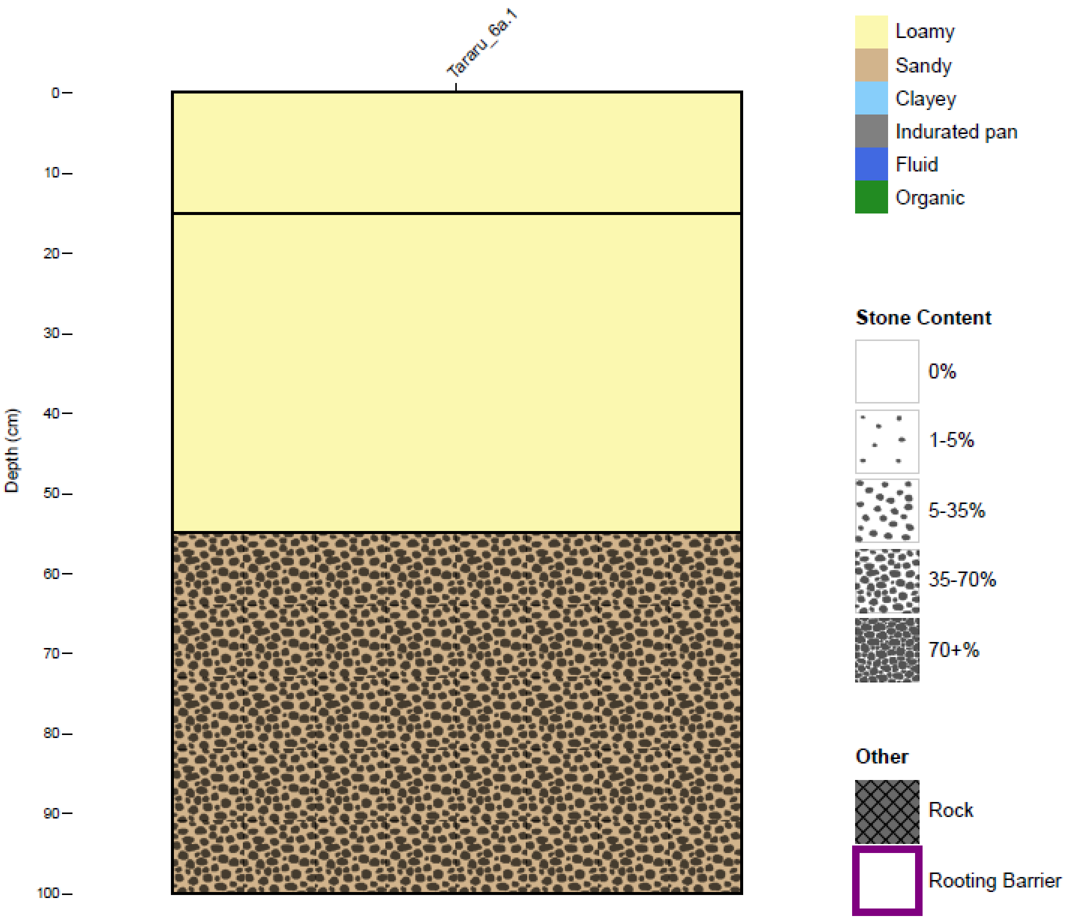
Soil Survey

This soil mapunit was mapped within the following soil survey:

Survey Title: Survey of the Ruataniwha Plains (Elwyn Griffiths, Malcolm Reeves, Sharn Hainsworth)
Survey Scale: 50000
Survey Date: 2004
Origin: legacy update major
Map Unit Delineation Method: Hand-drawn
Map Unit Labelling Method: Observations
Sibling Base Property Classification Method: Observations
Description: Mapping based on adequate to good supporting layers and observations in a mod to highly predictable landscape. Or mapping that could be Excellent but has not been statistically verified or reviewed.
Map Unit Description:

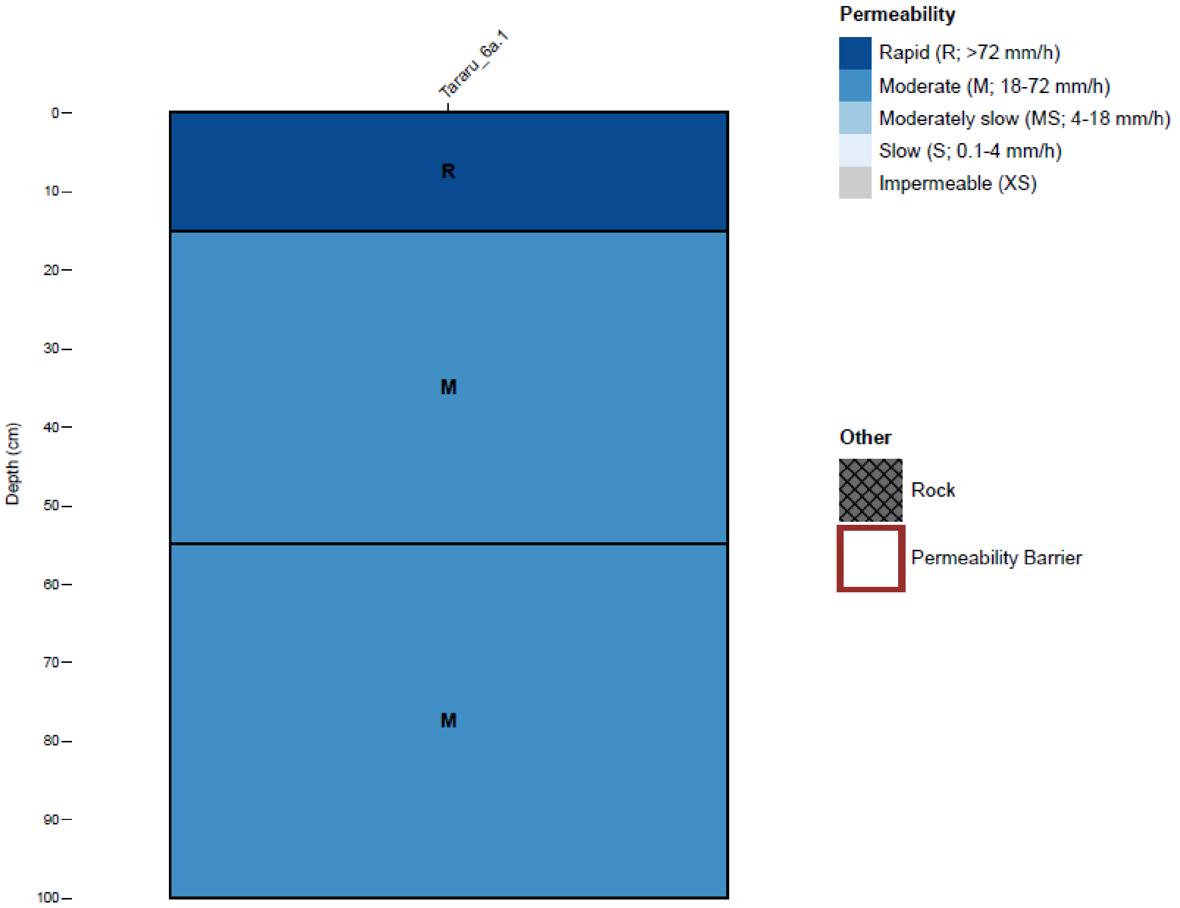
Texture graph

This graph shows the texture profile of the siblings found in the map unit. Each horizon is coloured according to its texture.



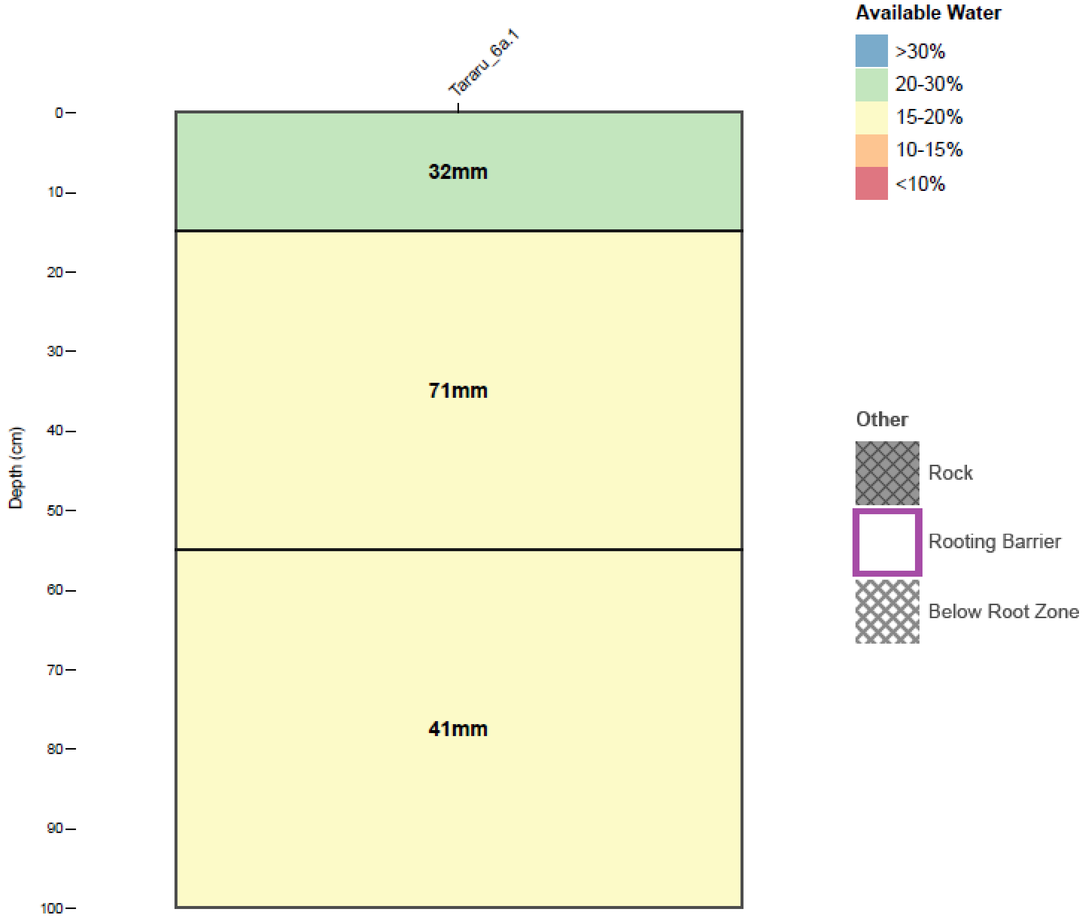
Permeability graph

This graph shows the permeability profile of the siblings found in the map unit. Each horizon is coloured according to its permeability. Click here for more information on permeability.



Available Water Graph

This graph shows the available water profile of the siblings found in the map unit. This is capacity of the soil to hold water that is available to plants. Each horizon is coloured according to its percent available water content. Click here for more information on available water.



About this publication

- This information sheet describes the typical average properties of the specified soil map unit.
- For further information on individual soils, contact Landcare Research New Zealand Ltd
- Advice should be sought from soil and land use experts before making decisions on individual farms and paddocks.
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