Annexure 7:

Wastewater Options Infrastructure Report

Kimberley and Broadmeadows Drive

Wastewater Infrastructure Option Report

Prepared for

MERF Agricultural Services Ltd

Prepared by

LOWE Environmental Impact

October 2019

Kimberley and Broadmeadows Drive Wastewater Infrastructure

Option Report

This report has been prepared for the **MERF Agricultural Services** by Lowe Environmental Impact (LEI). No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other parties.

Quality Assurance Statement		
Task	Responsibility	Signature
Project Manager:	Rob Potts	
Prepared by:	Henry van der Vossen	
Reviewed by:	Brian Ellwood & Rob Potts	
Approved for Issue by:	Rob Potts	
Status:	Draft	

Prepared by:

Lowe Environmental Impact
P O Box 29288
Christchurch 8540

| T | [+64] 3 359 3059
| E | office@lei.co.nz
| W| www.lei.co.nz

Ref: 1164.MERF-Wastewater_Infrastructure-191011-Draft2

Job No.: 10661

Date: October 2019

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Overview

MERF Agricultural Services (MERF) are progressing a private plan change for their land in the vicinity of Darfield adjacent to already existing and consented residential activities. This site is located near the corner of Kimberley Road and Horndon Street, Darfield. MERF owns a 14.6 ha title (835350 Lot 4 DP 524058) upon which no dwellings are currently erected. MERF also owns an adjacent 5.4 ha title (835350 Lot 3 DP 524058) to the North.

Parts of the site have been used for many years for grazed pasture and lucerne and before this the site was part of the Selwyn Plantation Board and planted with trees. The trees were subsequently felled in 2009 and the land has since been used for grazing.

The proposal is to re-zone land at North Darfield Living X (with some site specific provisions), to enable development of a number of residential lots, in an area that will cover 14.6 ha. This development will consist of:

- An Aged Care Facility (ACF) (villas plus hospital/hospice), the proposed ACF will be home to 110 residents with an assumed staff of 25 x 2 shifts, and 8 for a 3rd shift. There will be approximately 50-60 beds in the home, including dementia and lifecare units, and approximately 20 independent villas on 400 – 500 m^2 sections;
- 13 Medium Density Lots (MDL), in the 430 - 550 m^2 size range;
- 90 Low Density Lots (LDL), with average lot sizes not less than 650 m^2 ; and
- Reserve spaces.

The 14.6 ha site is part of the Darfield Area 7 Preferred Residential Area, as identified in the Malvern Area Plan. The balance of Darfield Area 7 is proposed as a Future Urban Zone and is not covered in this report.

This report presents options for the treatment and application of wastewater to land to support the private plan change application. Options are outlined for the use of land for land dispersal within the Aged Care Facility (ACF) zone (this includes the medium density lots (MDL) and lower density lots (LDL) for infrastructure services, such as on-site sewage treatment and land discharge. In addition, options for community scale treatment and land application are presented using the additional 5.4 ha land that MERF owns that could be used for wastewater treatment services.

Water supply and stormwater infrastructure are addressed by others.

1.2 Project Scope

Lowe Environmental Impact (LEI) has been engaged by the MERF to provide technical support for wastewater infrastructure for the private plan change and a technical report and assessment of environmental effects to support a discharge to land consent application to Environment Canterbury.

This report provides MERF with wastewater infrastructure options and an assessment of the viability of each option, i.e. is there sufficient resources and land availability for the option to function appropriately. Options for the deferred Future Zone are briefly outlined but with far lesser detail.

This report focuses on technical viability, i.e. can it be done affordably. However, as there is growing concern on nitrate levels in Canterbury aquifers, a brief assessment on nitrogen leaching is included.

This report also includes high-level costings of a number of options from a package plant provider who also provides community systems to show affordability.

The Aged Care Facility (ACF) is an approximately 3 ha site that is expected to have a total of 110 residents, and conservatively assumed staff of 25 in 2 shifts, and 8 for a 3rd shift. It is assumed the ACF will have kitchen and laundry facilities.

The medium density zoning allows for 430 - 550 m^2 sections adjacent to the ACF. There are 13 sections in this zone.

The remaining zone of lower density contains either 1,000 m^2 lots (adjacent to Kimberley Rd), of which there are approximately 19, or minimum 650 m^2 lots, of which there are approximately 71.

2 WASTEWATER MANAGEMENT OPTIONS

2.1 Overview of Wastewater Options

There are four main wastewater treatment plant (WWTP) and discharge options, with a number of sub-options within the main four. The Options and sub-options are:

Option 1 – Individual on-site systems (treatment and dispersal) for LDL to a standard meeting AS/NZS1547. The LDL individual on-site treatment systems have two suitable sub-option methods for the discharge to land:

a) Low Pressure Effluent Dosed (LPED) discharge – via a 30 - 40 m^2 600 mm deep sand trench (to reduce pathogens); or
b) Subsurface drip irrigation, over approximately 240 m^2 area buried 100 to 250 mm deep.

For Option 1, the ACF and MDL wastewater would be centrally collected for treatment, with discharge via subsurface drip irrigation within approximately 0.5 ha of landscaping in the 3 ha ACF area. An overview of Option 1 utlising a STEP reticulation system (see Section 2.3.1) is shown in Figure 2.1 below.

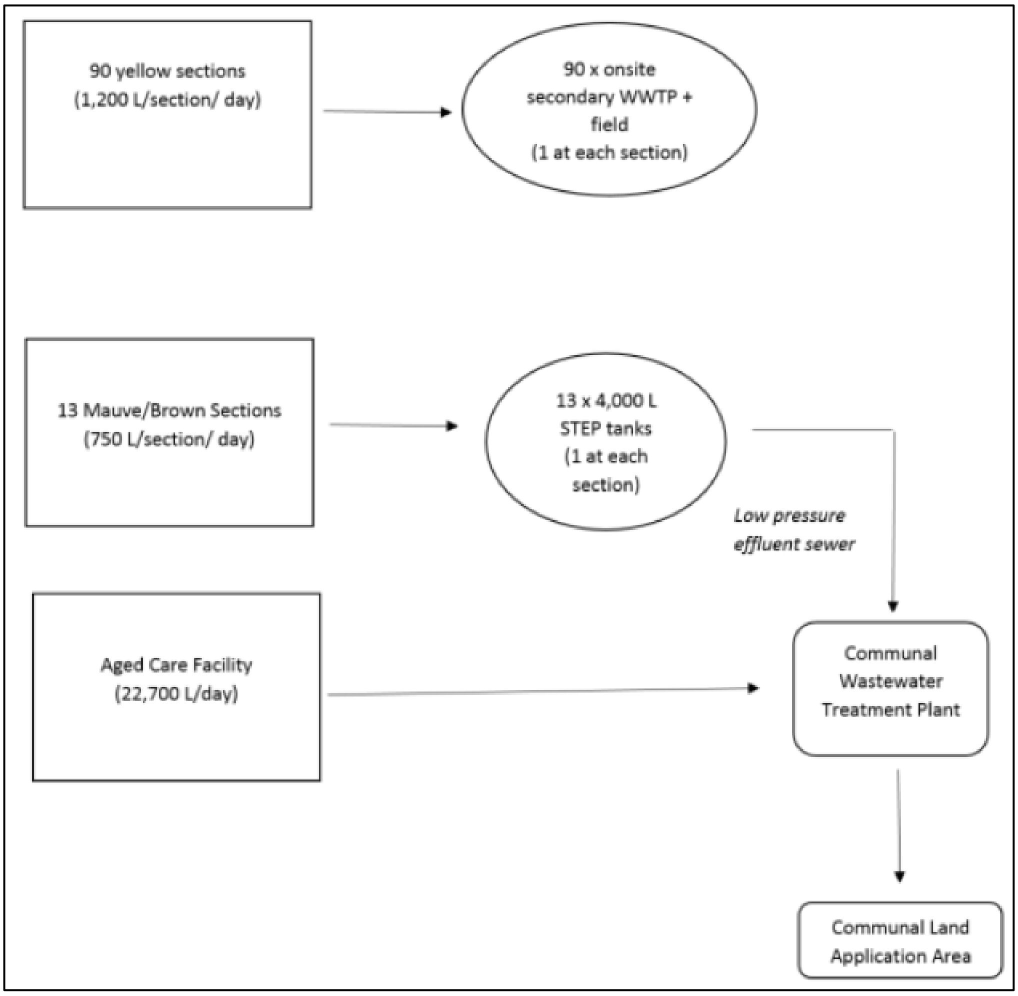

Figure 2.1: Option 1 Overview

Option 2 – LDL with individual on-site WWTPs with the effluent reticulated to a dedicated communal land treatment area. The ACF and MDL would have their wastewater reticulated to a communal WWTP (either sited within the 3 ha ACF as per Option 1, or in the adjacent landholding where the lant treatment area is proposed) and combined with the LDL treated effluent and applied via subsurface drip to a communal land treatment area. The communal discharge land treatment area could either be located within the reserve areas (more area is required as nitrogen removal is less) or on the adjacent 5.4 ha landholding which will be in cut and carry lucerne. An overview of Option 2, also with STEP reticulation is shown in Figure 2.2.

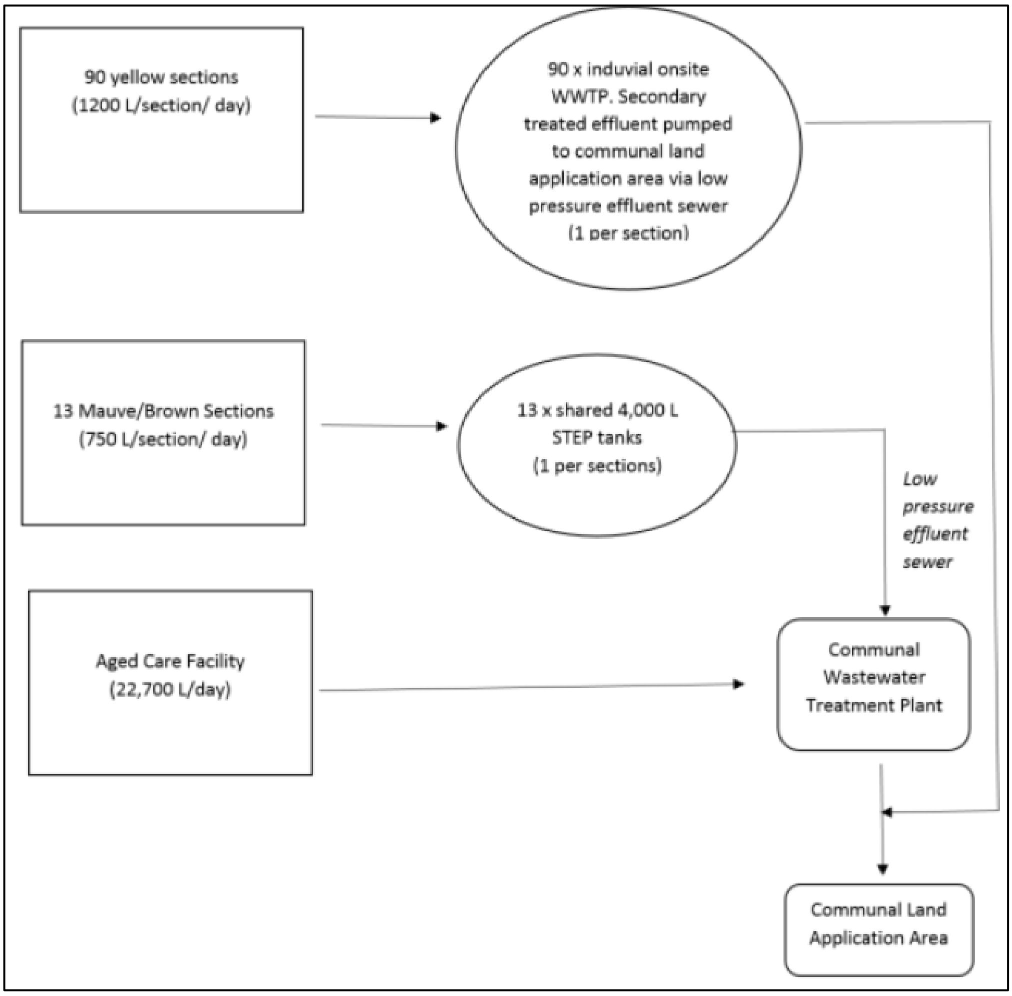

Figure 2.2: Option 2 Overview

Option 3 – All lots and ACF are reticulated to a communal WWTP and a land treatment via subsurface drip on the 5.4 ha of land adjacent to the Plan Change area. An overview, also utilising STEP reticulation is shown in Figure 2.3 below.

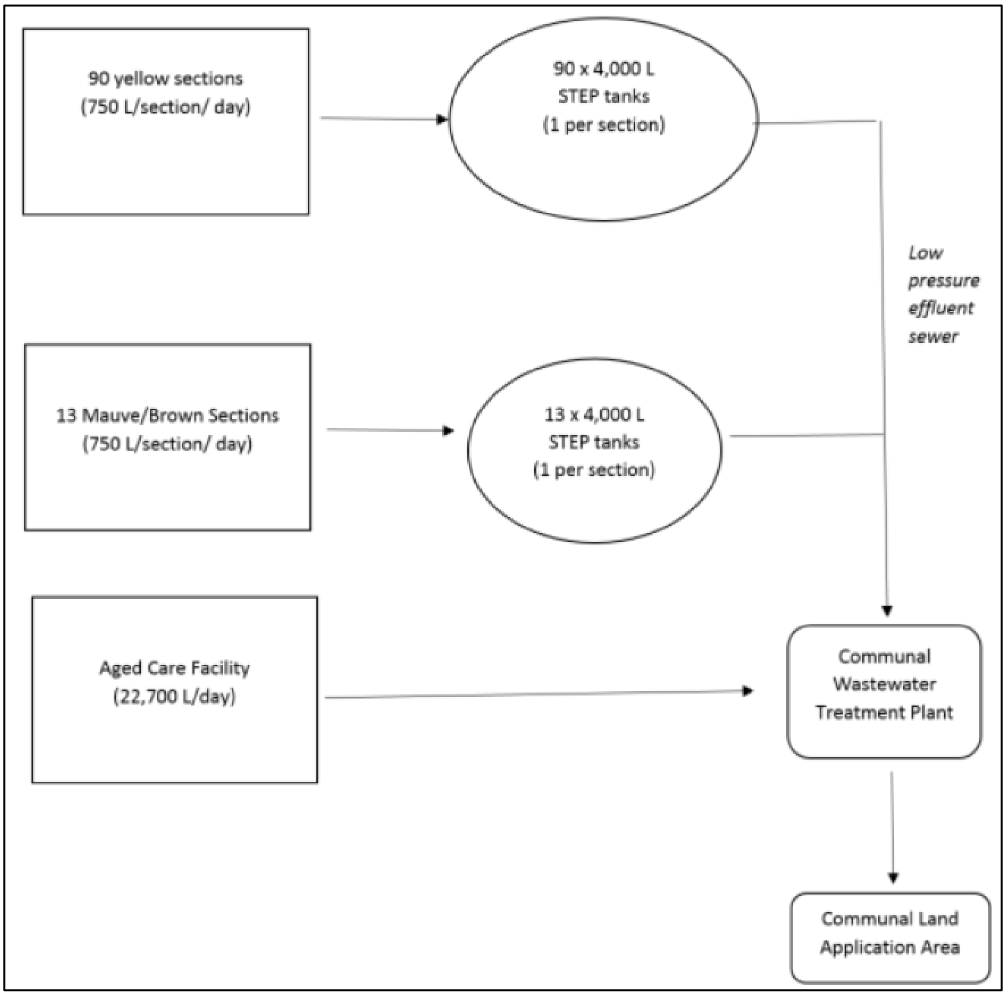

Figure 2.3: Option 3 Overview

Option 4 – All lots and ACF reticulated to SDC owned land and treated in a communal WWTP. This could be a modular plant that SDC can expand as demand dictates. The MERF subdivision could form the start of the district scheme. The layout would be similar to the overview diagram shown for Option 3 above but with the communal WWTP and land treatment area on SDC land.

The current proposal for the SDC WWTP is a pond based system. This type of system is not easily staged, so the MERF development would need to proceed with development of the District Scheme. The District scheme is not within the current LTP, so is unlikely to proceed until after 2034 or later following approvals and design.

2.2 Design Flow Rates and Wastewater Strength

2.2.1 Adopted Flow Rates

To assess the options, differing design flow rates are used due to on-site systems having to be sized for absolute peak loading of the property while communal systems are able to average flows across a number of connections reducing the peak flow rate requiring treatment. The Darfield community has a higher percentage of retired people than most towns, so there is a very high proportion of 1 and 2 people dwellings, e.g. Darfield has 21% of its population over 65 years old, compared to the remainder of Selwyn District of 10.8%, i.e. double the norm. Average household size of Darfield is 2.5 people/house cf Selwyn of 2.9 people/house (Statistics NZ, 2013).

Design flow rates have been calculated using standards relevant for residential/ business activities from AS/NZS 1547:2012 On-site Domestic Wastewater Management for individual on-site systems and NZS4404:2010 Land Development and Subdivision Infrastructure for communal systems. The relevant AS/NZS1547:2012 flow rates for individual on-site systems are outlined in Table 2.1 and NZS4404 in Table 2.2. Rates are shown in Litres/person/day (L/p/d) or Litres/household/day (L/h/d).

Table 2.1: On-site Design Flow Rates AS/NZS 1547:2012

Source	Typical Wastewater Design Flows	
	Reticulated community or a bore-water supply (L/p/d)	Adopted Values
Households with standard fixtures	200	200 L/p/d
Households with standard water reduction fixtures	165	
Households with full water-reduction facilities	145	
Motels/hotels (ACF Residents)		
Visitors	220	180 L/p/d
Non-resident Staff	30	50 L/p/d
1 to 3 Bedrooms	1 to 5 people	1,000 L/d
4 Bedrooms	6 to 7 people	1,200 L/d

Table 2.2: Communal Design Flow Rates NZS 4404:2010

Parameter		
	Range	Adopted Values
No. people per dwelling	2.5 – 3.5	250 L/p/d 750 L/household/d
Average Dry Weather Flow	180 – 250 L/p/d	
Wet Weather Peaking Factor	2.0	1,500 L/household/d
Dry Weather Diurnal Peaking Factor	2.5	For sizing pumps/pipes

Some stormwater infiltration and inflows (I/I) can be expected as the system ages; however, this I/I is significantly less likely in STEP and pressure sewer options (see Section 2.3) with it more appropriate to allow for in gravity sewers. Therefore the flows rates above that include for a peaking factor of 2 to allow for I/I, are considered very conservative. LEI generally allow an additional 30% for wet weather flows for effluent and pressure sewers.

ACF and Medium Density Flows

The calculated flows allow for normal kitchen and on-site laundry operations in the ACF, producing normal domestic type wastewater strength and volumes. For 110 residents plus an assumed 25 staff in 2 shifts, and 8 staff for a 3rd shift, then the adopted design daily volumes, based on 180 L/p/d for residents and 50 L/staff/shift is 22,700 L/day.

It is likely that the MDL's will have smaller houses, however, as these lots are reticulated, the values in NZS4404 have been adopted that are bedroom number independent, i.e. dry weather flow of 750 L/house/d. This gives a further 9,750 L/d to the communal WWTP.

Total flow to treatment of 32.45 m^3/d.

Low Density Lots Individual On-site Treatment

The LDL area for individual on-site treatment are likely to be either 3 or 4 bedroom houses, i.e. 5 to 6 people at 200 L/p/d, giving up to **1,200 L/house/day**.

Low Density Lots Communal Treatment

The LDL area for communal treatment is based on an average of 3 people at 250 L/p/d, **or 750 L/household/day dry weather flow** and **975 L/household/day wet weather flow**.

2.2.2 Wastewater and Effluent Strength

All wastewater, including the ACF is generally only from each lot's on-site toilets, showers, laundry and kitchens with the characteristics of conventional domestic sewage. Therefore, the influent wastewater constituents are expected to have a BOD_5 <400 mg/L, TSS <500 mg/L and TKN: <70 mg/L.

The effluent quality from the WWTP, prior to the land dispersal system, will be dependent on the wastewater treatment plant selected. For both the on-site and communal WWTP options, the expected effluent quality is $cBOD_5$ 20 mg/L, TSS 30 mg/L, total nitrogen of 20 to 30 mg/L, and E.coli 10^4 MPN/100 mls. All wastewater treatment units (on-site and communal) considered in this report can achieve secondary treatment quality, providing a TN reduction of between 60 - 70%, to produce a final effluent TN strength of 20 to 30 mg/L prior to further reduction in the land treatment system.

The soil N and hydraulic loading rate will be dependent on the land dispersal method selected, however, at this early stage of design, a rate of 5 mm/day for drip irrigation and 30 – 40 mm/d for LPED systems, have been adopted.

2.3 Sewer Reticulation Systems

LEI considers there to be three available sewer reticulation options for the MERF wastewater scheme, these are:

1. Sedimentation Tank Effluent Pumping (STEP) system;
2. Sump and grinder pump/progressive cavity pressure sewer system; and
3. Modified gravity system.

These reticulation options are considered for all four main Options. There is no reticulation required for the LDL on-site systems option.

The following sections detail the reticulation options.

2.3.1 System 1 – STEP System

Wastewater from each lot will be collected in a Sedimentation Tank Effluent Pumping (STEP) unit. The STEP system is composed of a tank fitted with an effluent filter and a pumping assembly which will pump liquid waste (effluent only, low solids) to the wastewater treatment system via a low pressure, small diameter sewer network. The primary sedimentation tanks on each property need pumping out on about a 10 – 15 year interval.

Each STEP would be connected to the wastewater effluent sewer main via a boundary kit service connection. This service connection protects the building from back-pressure and allows the building to be isolated from the effluent sewer in an emergency.

The STEP system provides primary treatment and will effectively buffer flows. The effluent main can be a small diameter MDPE pipe and can follow the contour reducing the depth and volume of excavation needed and ensure the pipe stays above groundwater. I/I in these systems should be non-existent, however, as above LEI allows an additional 30% to STEP systems for wet weather flows.

This system has been used with good success in many parts of New Zealand.

2.3.2 System 2 – Sump and Grinder Pump or Progressive Cavity Pump and Pressure Sewer

A pressure sewer system consists of a network of on-lot sumps and either grinder/macerator pumps or progressive cavity pumps that connect to medium pressure pipe mains, which integrate to form a collection system.

This system provides watertight reticulation and is similar to Option 1 in most facets but with primary treatment taking place at the treatment plant. This can have an advantage if advanced nitrogen removal is required as the primary tank in the treatment system can be used as a carbon source for enhanced nitrogen removal in anoxic treatment stages. Maintenance aspects are higher than the STEP system, as the grinder pumps generally require greater maintenance.

2.3.3 System 3 – Modified Gravity

The wastewater is reticulated via gravity, from each building to a central gravity main. This can either feed one or more pump stations (this potentially can be at the WWTP) or if sufficient fall is available, via gravity right to the WWTP primary screen.

This option has no solids removal prior to the treatment plant; thus, pipes need to be larger and laid at sufficient gradient to convey solids to maintain self-cleansing velocities.

The gravity option proposed here is termed a modified system, as it would involve smaller diameter flexible pipe systems with limited manholes compared to conventional systems.

Modified gravity systems can be prone to stormwater ingress because, whilst utilising flexible pipe and fewer manholes over that of a conventional gravity system, the manholes are not completely sealed and therefore can potentially result in wet weather flows entering that require a larger capacity WWTP. However, wet weather flows for modified gravity mains are generally less than conventional gravity systems.

Due to the flat slope of the site, the excavation depths of these pipes to achieve sufficient gravity fall may make this option uneconomic for this application, particularly for Options' 2 and 3 as the off-site communal WWTP is upgradient of the site.

2.4 Wastewater Treatment Plant

2.4.1 Indiviudal On-site

There are numerous options for the individual on-site WWTPs. Only two treatment systems have been considered here but there are many available. The system would have to be certified by the NZ testing facility (OSET) as meeting AS/NZS1547 secondary treatment standard for BOD and TSS. It would also need to meet Grade C or better for nitrogen reduction. These include the following;

1. Recirculating Textile Packed Bed Reactor (rPBR); and
2. Activated Sludge, e.g. Submerged Aerated Filter (SAF).

(1) Recirculating Textile Packed Bed Reactor (rPBR)

The recirculating packed bed reactor is a multiple pass packed bed aerobic wastewater treatment system. The packed bed media is an engineered textile, which has a high void capacity allowing for a large surface area. Wastewater enters a processing tank (recirculating tank) where anaerobic digestion and suspended solids removal can take place. Effluent is then pumped to the secondary treatment chamber where it percolates down through a textile media and is collected in the bottom of a filter pod. This process does not utilise forced aeration. From the filter pod, the flow is split (diverted) between the processing tank and the final discharge.

Recirculating Textile Packed Bed Reactor (rPBR) technology is well established in New Zealand for both on-site and small community systems, giving a high-quality effluent, with low power usage and functions well under fluctuating loads. This type of system is commonly used for community wastewater where a high level of organic treatment, nitrogen reduction and the removal of pathogens are important considerations.

(2) Activated Sludge System (SAF)

The SAF system is a form of the activated sludge process (a wastewater treatment process characterised by a suspended growth of biomass), usually with a floating media to enhance biofilm development and with settlement of solids taking place within a clarifier.

In more detail: Wastewater enters a recirculating (primarily anaerobic) chamber where oxidising bacteria break down suspended solids; the influent is also mixed with returned activated aerated sludge from the clarifying chamber. This mixing stimulates bacteria and enhances the solids digestion. Following primary treatment wastewater enters an aeration chamber which contains submerged media on "bioblocks" (bioblocks allow for an increased surface area). Treated wastewater passes from the aeration chamber to a clarifying chamber in which remaining particles, of suspended solids, settle out of suspension. The suspended solids that sink to the bottom of the chamber are drawn back to the first primary chamber for further processing or removed for disposal off-site.

2.4.2 Communal Sytems

There are also numerous options for communal WWTPs. Only three treatment systems have been considered here but there are many available, including package plants, or bespoke designed plants. The option of reticulating to the Selwyn District Council site could also utilise any of these options, however, the SDC system at this stage is proposed to be a stabilisation pond system, which is not easily staged.

The options include include the following and are summarised in Table 3.3;

(1) Recirculating Textile Packed Bed Reactor (rPBR);
(2) Activated Sludge, e.g. Submerged Aerated Filter (SAF); and
(3) Sequence Batch Reactor (SBR).

(1) Recirculating Textile Packed Bed Reactor (rPBR)

As above for individual on-site systems but at a larger scale. The system is very modular so can be staged as development progresses. The WWTP can be followed by further filtration (125 micron) and UV sterilisation to reduce pathogens, if required.

(2) Activated Sludge System (SAF)

As above for individual on-site systems but at a larger scale. The system is less easy to stage compared to a rPBR but still can be. The WWTP can be followed by further filtration (125 micron) and UV sterilisation to reduce pathogens, if required.

(3) Sequence Batch Reactor (SBR)

In a typical SBR process train, influent wastewater generally passes through screens and grit removal prior to the SBR. The wastewater then enters a partially filled reactor, containing biomass, which is acclimated to the wastewater constituents during preceding cycles. Once the reactor is full, it behaves like a conventional activated sludge system, but without a continuous influent or effluent flow. The aeration and mixing are discontinued after the biological reactions are complete, the biomass settles, and the treated supernatant is removed. Excess biomass is wasted at any time during the cycle. Frequent biomass wasting results in holding the mass ratio of influent substrate to biomass nearly constant from cycle to cycle.

SBR technology generally requires a high level of operator assistance to ensure the system is maintained and operating to a high standard; otherwise, it can be prone to failure and poor effluent quality. SBR's are an aerated technology and therefore require a high power input, significantly exceeding that of an rPBR system; as a result of the high level aerobic microbial activity, a large volume of sludge is produced requiring management and disposal.

An SBR is more suited to larger installations as it is not as modular and cannot be as easily staged as an rPBR system.

Table 2.3: Summary of Wastewater Treatment Options
(3 = Best, 2 = Moderate, 1 = Least Desirable)

Parameter	SBR		SAF		rPBR	
	Description	Score	Description	Score	Description	Score
Capital expenditure	Moderate to High	1	Moderate	2	Moderate	2
Running costs	Moderate to High	2	Moderate to High	2	Low	3
Additional carbon dosing	Unlikely	3	Unlikely	3	Posibly depending on required N conc	1
Power requirement	Moderate	2	Moderate	2	Low	3
Modularity/staging	Poor to moderate	2	Moderate	2	Good	3
Maintenance requirement	Potentially High	2	Potentially High	2	Moderate	3
Sludge production	Moderate	2	Moderate	2	Low	3
Suitable for intermittent flow regimes	Yes, needs buffering	3	Moderate	2	Moderate	2
Noise	Moderate	2	Moderate	2	Low	3
Remote servicing and trouble shooting	Yes	3	Yes	3	Yes	3
Visual impact	Moderate	2	Low	3	Low	3
Operation simplicity	High	1	Moderate	2	Good	3
Anaerobic pre-treatment	Good	3	Good	3	Good	3
Odour production	Moderate	2	Low	3	Low	3
Reliability	Moderate	2	Moderate	2	High	3
Effluent treatment stability	Good	3	Moderate	2	Good	3
Total Score		**35**		**37**		**44**

From Table 2.3, it would appear that a rPBR is likely to be the preferred option, however, the WWTP will be tendered out and tender evaluation attributes taken into account to select a WWTP.

2.5 Available Discharge Options

2.5.1 Statutory Provisions

The proposed wastewater discharge activities have been assessed against Plan Change 7 to the Canterbury Regional Council Land and Water Regional Plan and are considered to be a **discretionary activity** as per Rule 5.9 of the Plan (proposed activities do not fully satisfy Rules 12.A.1.1. to 12.A.1.4 of the Plan).

2.5.2 Land Application Methods

Based on soil type, soil profile, soil permeability, groundwater levels, required treatment outcomes and the potential quality of the effluent from the wastewater treatment plant, it is considered that a number of land application methods could be used for the land application of treated effluent. The most likely for land treatment is subsurface drip irrigation and this could be in combination with low pressure effluent dosed sand trenches for LDL individual on-site discharge. For completeness surface spray irrigation is also discussed.

These options have their advantages and disadvantages as per Table 2.4 below.

Table 2.4: Land Discharge Options

	Advantages	Disadvantages
Subsurface Drip	Is below ground, so no issues with spray drift, freezing, vandalism, public access	Higher cost, distribution efficiency is lower, it is lower than some topsoil profile so nutrient renovation can be lower, harvesting damage if soils are wet
Surface Spray	Lower cost than drip, better distribution performance, utilises the entire rooting depth, is visible so problems easily identified,	Required buffer distances for spray drift and aerosols, needs to be fenced and signage warning public, may need higher quality pathogen removal, harder to harvest around
Low Pressure Effluent Dosing	Low land area requirements	Higher cost than drip if a sand trench, no nutrient reduction via plant uptake

All discharge options are viable. However, Surface Spray irrigation requires greater buffer zones to the site boundary, can have limits on the daily discharge time and a need for filtration and UV treatment, and it may need storage during times of sitting snow or frozen ground, so this method has not been considered further.

2.5.3 Communal Land Treatment Area Management (Subsurface Drip)

An important part of any land application design is choosing the correct vegetation type and maintenance of the established vegetation. Factors to consider when selecting a vegetation type are:

- Short rotation crops;
- Climatic conditions;
- Soil types;
- Environmental constraints;
- Effluent composition;
- Effluent application system;
- Aesthetic requirements; and
- Nutrient and water uptake requirements.

Land use of the communal land treatment area is generally one of the following three methods stated in the order of preference for nitrogen renovation:

1. Cut and Carry;
2. Sheep grazing; and
3. Landscaped areas or cut and leave.

Cut and Carry

"Cut" refers to mowing grass or grass-type crops, tree felling (replanting with juvenile plants) or pruning vegetation back to stimulate regrowth; "carry" refers to removing all dry matter from the site for sale or grazing elsewhere. If vegetation is not removed off-site, biological decay will result in the transfer of nutrients held within the plant back into the soil matrix, with the net plant uptake being zero.

Sheep Grazing

Sheep grazing removes dry matter (and thus nutrients) but recycles some back to the soil store; the net input of nutrients from sheep urine and faeces back to the soil will be less than that eaten by the sheep and turned into meat, wool and energy. Sheep are generally rotated around the site to optimise grazing and vegetation removal. Sheep grazing, however, is not suitable for the LTA within the ACF proposed area but could be used in the off-site block.

Landscaped or Cut and Leave

This option is suitable for the ACF proposed area LTA. Lawn and landscaped areas are managed for aesthetic reasons for which vegetation growth and then removal is not desirable. The net result is limited nutrient removal off-site; the plant life cycle of regeneration and decay will inevitably result in most nutrients taken up by the plants, re-entering the soil matrix during the decay phase. However, plant uptake will slow the rate of nutrient leaching and nitrogen losses occur due to denitrification and in addition, evapotranspiration will reduce hydraulic pressure on the soils.

LTA Management Summary

If main Options 2 or 3 are selected, then an off-site LTA would be selected and that block is proposed to be "Cut and Carry" lucerne.

2.5.4 On-site Discharge Options

There are two main types of on-site discharge options. These are:

1. Discharge into land via rapid infiltration, such as a low-pressure effluent dosing system (LPED) with sand trench; or
2. Apply to land at a lower rate via subsurface drip irrigation.

2.5.5 Discharge to Land via LPED

This option's advantage is a much smaller land area is required than sub-surface drip irrigation. The key disadvantage is there is very limited further reduction in nitrogen in the soil/subsoil system post the WWTP.

Depending on detailed soil analysis of the site, individual on-site systems would likely require 30 – 40 m^2 of LPED and thus it is suitable for all lots. A sand trench would be recommended for enhanced pathogen removal, as one-log reduction per 150 mm of sand can be achieved.

2.5.6 Discharge to Land via Subsurface Drip Irrigation

This option requires a stable WWTP producing low BOD and TSS, as per the recommended systems. Alternatively, further filtration can be provided but this is not recommended for individual on-site systems due to the regular maintenance that is required.

This option's advantages are; a reduction in nitrogen can be achieved through treatment in the soil/plant matrix, and it can provide irrigation to landscape or grass areas in an area that has severe summer soil moisture deficits. The disadvantage is there is a need for larger land area. This method of discharge typically has an application rate of 4 - 5 mm/d, to allow for the nutrient uptake by plants. In some situations, this crop can then be cut and exported to remove nutrients from the site.

Land area requirements for individual on-site systems would be in the order of 240 m^2 for a 4-bedroom house. For communal systems the land area requirements will likely be driven by nitrogen loading.

2.6 Communal Land Treatment

2.6.1 Land Treatment Area (LTA) Identification

Based on the desktop site investigations, on-site test pits (by others), and soil type hydraulic conductivity, the required LTA areas for the various options have been assessed. Three areas have been identified. These are on-site within the 3 ha ACF, or off-site within the 5.4 ha area to the North, or at the SDC site on Creyke Road.

Figure 2.4 shows the three identified areas.

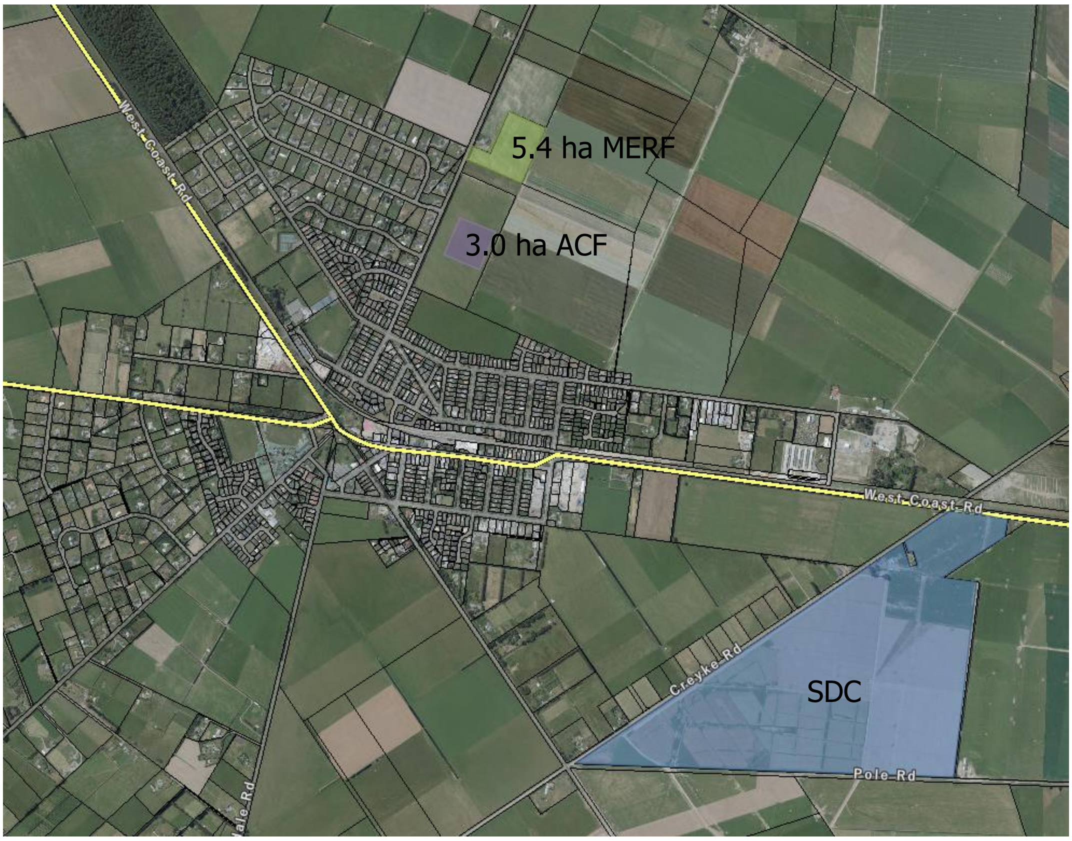

Figure 2.4: Potential Land Treatment Areas

2.6.2 Soil Classification

S-Map Landcare Research

The soil within and around the proposed LTA zone on the MERF site is mapped as a Pallic Firm Brown Soil, well drained Lismore silty loam (Landcare Research, 2019). The S-Map report is attached in Appendix A. Further details can be found in Table 2.5.

Table 2.5: Summary of Soils and Geology within Site

Characteristic	Description	Reference
Surface Geology	Alluvial sediments of the late Pleistocene age.	Fraser Thomas Limited report (2019)
	Flat to very gently undulating land with good drainage/permeability	S-map Soil Report (2019)
Subsurface Geology		
S-map soils description	Lismore Stony Silty Loam. Shallow soil (20 – 45 cm); silty and well drained	S-map Soil Report (2019)
Hydraulic conductivity	Moderate (4 - 72 mm/h) 48 to 1,728 mm/day	S-map Soil Report (2019)

Fraser Thomas Report

Bores on-site were logged by Fraser Thomas on the 1st August 2019, primarily for the foundation design (see Appendix A). The bore logs' location is shown in Figure 3.2. These can be used to look at the depth of the soil across the site and are summarised in Table 2.6.

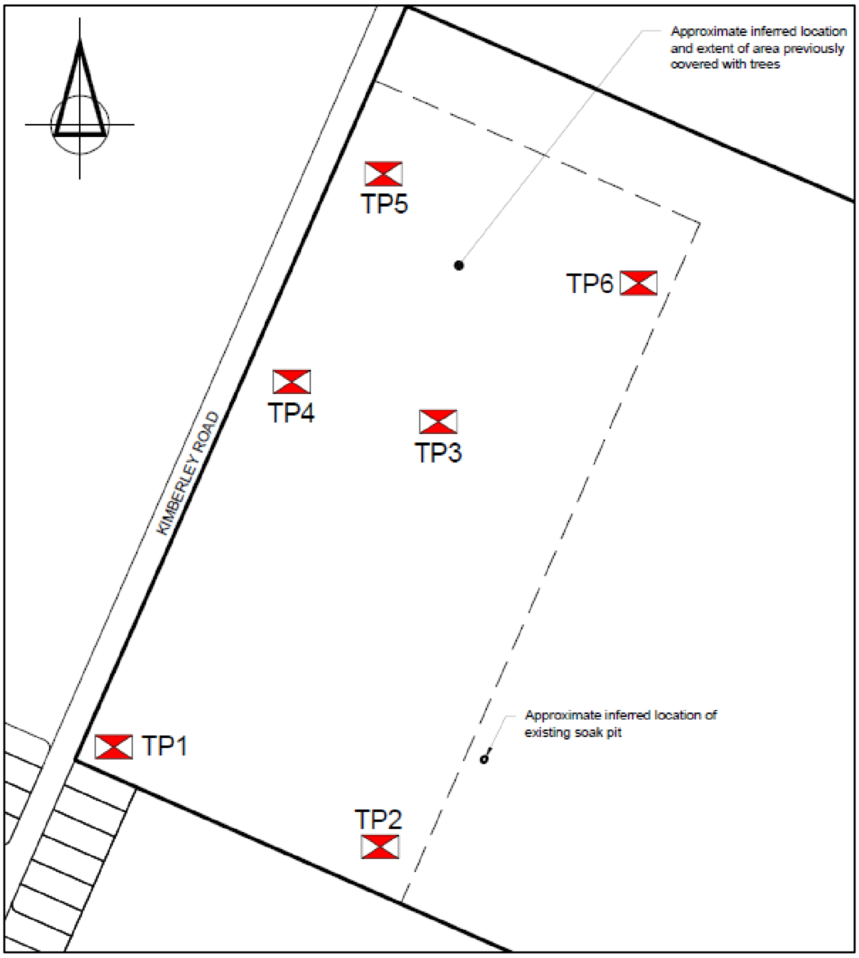

Figure 2.5: Fraser Thomas Bore Logs' Location

Table 2.6: Fraser Thomas Bore Logs (August 2019)

m bgl	TP1	TP2	TP3	TP4	TP5	TP6
0-0.2	Silt, some gravel, dark brown, moist, rootlets (topsoil).	Silt, some gravel, dark brown, moist, rootlets (topsoil).	Silt, some gravel, dark brown, moist, rootlets (topsoil).	Silt, some gravel, dark brown, moist, rootlets (topsoil).	Silt, some gravel, dark brown, moist, rootlets (topsoil).	Silt, some gravel, dark brown, moist, rootlets (topsoil).
0.2-0.3		Silt, gravelly (fine), minor sand (fine, subangular), yellowish brown, hard, moist, low plasticity (alluvial sediments).		Silt, gravelly (fine to medium, subangular to subrounded), minor sand (fine), yellowish brown, hard, moist, non-plastic (alluvial sediments).		
0.3-0.5	Topsoil starts to become gravelly.		Silt, gravelly (fine to medium, subangular to subrounded), minor sand (fine), yellowish brown, hard, moist, low plasticity (alluvial sediments).		Silt, gravelly (fine to medium, subangular to subrounded), minor sand (fine), yellowish brown, stiff, moist, non-plastic (alluvial sediments).	Silt, gravelly (fine to medium, subangular to subrounded), minor sand (fine), yellowish brown, hard, moist, non-plastic, trace rootlets (alluvial sediments).
0.5-0.6				Gravel (fine to coarse, subrounded, grey wacked), sandy (fine to coarse), with cobbles, greyish brown, very dense, moist.		
0.6-0.7	Silt, some sand (fine), trace gravel (fine), yellowish brown, hard, moist (alluvial sediments)	Gravel (fine to coarse, subrounded, greywacke), sandy (fine to coarse), minor cobbles, trace boulders, greyish brown, very dense, moist.			Gravel (fine to medium, subrounded, greywacke), silty, yellowish brown, very dense, moist	
0.7-0.9			Gravel (fine to coarse, subrounded, greywacke), sandy (fine to coarse), trace cobbles, trace boulders, greyish brown, very dense, moist.			Gravel (fine to coarse, subrounded, greywacke), sandy (fine to coarse), greyish brown, very dense, moist.
0.9-1.8					Gravel (fine to coarse, subrounded, greywacke), sandy (fine to coarse), trace cobbles, greyish brown, very dense, moist.	
1.8-1.9	Gravel (fine to course, subrounded greywacke), sand (fine to coarse), trace cobbles, greyish brown, very dense, moist.					
1.8-2.7						
2.7-2.8						
2.8-2.9						
2.9-3.1						

These soils logs show a consistent silt layer with some sands and gravels which are likely to have a soil texture that is representative of Soil Categories 2 and 3 within AS/NZS 1547:2012. Categories 2 and 3 are representative of Loams and Sandy Loams, with a Design Irrigation Rate (DIR) of 4 to 5 mm/d for drip irrigation and 30 - 50 mm/d for LPED trench.

2.6.3 Design Nitrogen Loading

Based on the calculated design flows, the design Nitrogen annual loading has been calculated, as shown in Table 2.7 below. Note that although the individual on-site systems have to be designed for peak hydraulic loading, nitrogen loading can be based on average loading, so the 1,200 L/d for the individual on-site lots, which is based on 6 people per household can be reduced to a similar volums as the communal system.

The final 2 columns give the two individual on-site dispersal options – subsurface drip and LPED.

Table 2.7: Design Nitrogen Loading to Soil System

Wastewater Source	ACF	MDL	LDL (Communal)	LDL (On-site)	LDL (On-site)
Average Daily Dry Weather Flow (m^3/d)	22.7	9.8	67.5	67.5	67.5
Wet weather Flow/Peak Hydraulic (m^3/d)	22.7	12.7	87.8	108	108
Annual flow (m^3/yr)	8,286	3,559	24,638	24,638	24,638
Land Treatment system	Subsurface drip			Drip	LPED
Design treated wastewater N concentration (mg/L)	30			30	
Annual Nitrogen load (kg N/yr)	248	106	739	739	739
LTA area @ 5 mm/day application Drip Or 30 mm/d LPED (m^2)	4,540	2,540	17,560	21,600	3,600
LTA area (m^2)	24,640			240 per lot	40 per Lot
Design Nitrogen loading (kg N/ha/yr)	444			342	2,053
Average Nitrogen load for proposed plan change area of 14.6 ha (kg N/ha/yr)	75			75	75

Based on models developed by LEI in the past for other land treatment schemes, the following can be assumed:

- Soil loss factors that include for denitrification, soil storage, microbe use and volatilisation will be low in summer due to high plant uptake and the relatively free-draining nature of the soils and higher in winter. The summer loss of 10% of N applied is assumed increasing to 20% in the winter months when plant uptake is minimal;
- With main Options 2 and 3, vegetation production is conservatively assumed at 12 t DM/yr, with 90% removed via harvesting, with an average N concentration of 2.5%. This gives 270 kg N/ha/yr removed by harvesting.

Using the above assumptions, a simple nitrogen balance is shown in Table 2.8 below for the communal LTA area with an area of 2.46 ha and with an additional 0.7 ha, giving a 3.16 ha option.

Table 2.8: Nitrogen Leaching from Options' 2 and 3

	Unit	Communal LTA	
Land Area	(ha)	2.46	3.16
Loading scenario	(kg N/ha/yr)	444	346
N removed with Harvesting	(kg N/ha/yr)	270	270
N removed via soil losses	(kg N/ha/yr)	67	52
Theoretical Leaching per ha	(kg N/ha/yr)	107	24
Theoretical Leaching for Site	(kg N/yr)	264	75

Table 3.7 above shows that the communal LTA will have a theoretical leaching mass of between 75 kg and 264 kg N per year that would need to be allowed for within the regional nitrogen allocation. The leaching per hectare of 24 kg N/ha/yr for the 3.216 ha area is in-line with farming practices in the area.

It is recommended that 2.5 to 3.5 ha area is set aside for a communal land treatment area. This is likely to allow WWTPs to produce up to 30 mg/L of nitrogen in their effluent, although the concentration is really only important in the months of April to August.

The individual on-site discharge options of either drip (if there is sufficient land area following house and driveway construction), or LPED (more likely) will result in higher N leaching, as follows:

- The LPED option gives no further nitrogen renovation as the effluent passes through the soil, so the theortetical leaching is the same as the N load from the WWTP, i.e. 739 kg N/yr if all LDL are LPED systems;

- The drip option will have gaseous N losses in the soil system, as per the communal system, but no plant removal allowed for. Theoretical N leaching is therefore 627 kg N/yr if all LDL are drip systems.

The cummulative effects of the nitrogen leaching load on groundwater and where the regional allocation of the community wastewater N load (Table 11i of the Canterbury Land and Water Plan) will be assessed in detail in the discharge consent application to ECan.

3 SHORT AND LONG-TERM OWNERSHIP AND OPERATION

The short and long-term ownership of the wastewater infrastructure has not yet been decided. It is likely that if Option 3 is selected, then the communal scheme is likely only required for short to medium term, as a District scheme for Darfield will likely occur at some time in the next 15 – 20 years. Community treatment options for this development, could be made redundant when a District Scheme is available, however, there is likely to be salvage value for it to be reused elsewhere. Portable systems, such as containerisied or skid mounted systems can therefore be considered favourably, or systems easily removed from within the ground.

Discussions are being held with SDC regarding community infrastructure design standards and ownership. The commentary below is to show that should the developers decide not to vest to Council, or SDC do not wish to take over the asset, then there are other satisfactory outcomes.

A number of Regional Councils have established model conditions to provide certainty that the systems are going to be managed and maintained with future homeownership, as has been the case at Jacks Point in Otago, and in Auckland and Hawkes Bay model conditions.

The model conditions require:

- The consent holder to transfer the consent to a body corporate entity which will own and be responsible for the infrastructure maintenance and operation;
- The constitution of the body corporate requires all lot owners to be equal shareholders and to transfer the shares to purchases when they sell;
- Lot owners must pay any money levied on them by the body corporate and grant a covenant on their property title in favour of the Council; those encumbrances are:

"…recording the obligations of each lot owner in respect of the operation and maintenance of the Wastewater System in accordance with the conditions of this consent, and charging the owner's land with an annual rent charge to ensure performance of the covenants relating to the Wastewater System, such Encumbrance to be enforceable by the Body Corporate/Company against the Lot owner in case of default."

Other Regional Councils have put specific conditions on discharge consents to ensure that environmental effects are limited, as has been used for Kaiuma Park in the Marlborough Sounds.

The Kaiuma Park conditions required:

- In both the discharge consent and the subdivision consent that a Memorandum of Encumbrance (MoE) be entered for all allotments. The discharge consent condition is:

"The Consent Holder shall enter into a covenant in favour of the Council to be registered against the title to each lot recording the obligations of each lot owner in respect of the operation and maintenance of the wastewater treatment system in accordance with the conditions of this consent."

- Other relevant conditions require the wastewater system to be owned, operated and maintained by a services company and that each owner is required to be an equal shareholder in the services company.

- The MoE requires all lot owners to pay the Council $3,200/year, but if in the preceding 12 months, there has been no breach of the landowner obligations for wastewater contained in the covenants, then the annual fee is deemed to have been paid. This provides the economic incentive for each lot owner to undertake their duties and enables the Council to assist the Body Corporate in managing the system if lot owners are not performing their duties to the Body Corporate. The MoE does not waive, cancel or diminish Council's ability under the RMA1991 to take any other enforcement action.

At the Jacks Point, near Queenstown, water supply and wastewater remains in private ownership and is managed by the Body Corporate who since installation have engaged the system designers and builders (Innoflow Technologies) to operate the wastewater system. The Jacks Point discharge consents do not require covenants on titles related to management-related failure, but there are two conditions relating to risk:

- The requirement of an Operations and Management (O&M) Manual, outlining a schedule of maintenance, timing, monitoring procedures, contingency plans, dealing with malfunctions and reporting; and

- The consent holder is required to enter into a maintenance service contract with a suitably qualified person, who is required to operate and service in accordance with the O&M Manual.

However, the Jacks Point subdivision consents from QLDC require a consent notice to be lodged against all titles relating to the wastewater system. This requires all owners to install the on-site (STEP) components of the decentralised system when seeking building consent, as per below.

"The consent holder shall provide evidence to the Council of a responsible body (management group) which will undertake responsibility for the maintenance of the infrastructure including the private roads, water reservoir and associated network, stormwater reticulation, sewage reticulation (including primary sewage treatment tanks located on individual lots) and discharge fields (including regular monitoring and maintenance in accordance with the recommendations of the system designer of the individually owned primary treatment tanks) and open space. The management group shall also be responsible for the ongoing monitoring of the water supply to ensure that it continues to comply with the Drinking Water Standard for New Zealand 2005. Details of maintenance and operation of all infrastructure shall also be provided by the consent holder."

Discussions with SDC will address these options and their preference. In summary, there are a number of mechanisms available to Council to ensure the wastewater infrastructure, if it remains in private ownership, is managed accordingly.

4 OPTION COST ANALYSIS

The four main options are detailed in Section 3.

A package plant treatment plant provider (Innoflow Technologies Ltd) was approached for the prefeasibility costing of the main wastewater treatment plant (WWTP) and discharge options. These options are summarised in Tables 5.1 to 5.5.

Table 4.1: Option 1 - Cost Assessment

	Cost	Requirement
LDL On-site Treatment and LTA	$ 20,000	AdvanTex AX20 system and 240 m² of drip field at each section
MDL	$ 13,200	4,000 L STEP tanks and boundary kit at each section (this cost will be slightly lower for a grinder sewer system)
ACF	$ 354,470	Communal Reticulation, Wastewater Treatment Plant & Land Application Area for Aged Care Facility and MDL
Total cost	$ 2,326,070	

Note that the LDL individual on-site systems with LPED and sand trench would be an additional $3,000/lot over the subsurface drip option.

Table 4.2: Option 2 - Cost Assessment

	Cost	Requirement
LDL On-site Treatment	$ 19,000	A AdvanTex AX20 system at each section plus boundary kit. Reticulated to communal LTA
MDL	$ 13,200	4,000 L STEP tanks and boundary kit at each section (this cost will beslightly lower for a grinder sewer system)
MERF (ACF Off-site communal)	$ 490,270	Communal Reticulation, Wastewater Treatment Plant for ACF and MDL and Land Application Area for ACF, MDL and LDL
Total cost	$ 2,371,870	

Table 4.3: Option 3 - Stage 1 - Cost Assessment

Stage 1	Cost	Requirement
LDL	$ 13,200	20 lots with 4,000 L STEP tanks and boundary kit at each section (this cost will be slightly lower for a grinder sewer)
MDL	$ 13,200	4,000 L STEP tanks and boundary kit at each section (this cost will be lower for a grinder sewer)
Communal WWTP and LTA for ACF, MDL and LDL off-site)	$ 485,950	Communal Wastewater Treatment Plant and LTA for ACF, MDL and 20 LDL
Total cost	$ 921,550	

Table 4.4: Option 3 - Stage 2 - Cost Assessment

Stage 2	Cost	Requirement
LDL	$ 13,200	35 lots with 4,000 L STEP tanks and boundary kit at each section (this cost will be slightly lower for a grinder sewer)
MDL	$ -	No development in this Stage
Expansion of Community WWTP and LTA	$ 215,985	Expansion of Communal Wastewater Treatment Plant and LTA for further 35 LDL
Total cost	$ 677,985	

Table 4.5: Option 3 - Stage 3 - Cost Assessment

Stage 3	Cost	Requirement
LDL	$ 13,200	35 lots with 4,000 L STEP tanks and boundary kit at each section (this cost will be slightly lower for a grinder sewer)
MDL	$ -	No development in this Stage
Expansion of Community WWTP and LTA	$ 215,985	Expansion of Communal Wastewater Treatment Plant and LTA for further 35 LDL
Total cost	$ 677,985	

A summary of the options and indicative costs that have been considered for the development of the 14.6 ha MERF site are presented below.

Option 1 will allow the costs of wastewater treatment and discharge to be deferred to the purchaser of the LDL Lots and the STEP tank and boundary kit for the MDL. This cost will be $20,000 per LDL and $13,200 per MDL. The WWTP and reticulation for the ACF and the MDL will be funded by MERF at the cost of $355,500.

Option 2 will allow the costs of wastewater treatment to be deferred to the purchaser of the LDL Lots and the STEP tank and boundary kits for the MDL. This cost will be $19,000 per LDL and $13,200 per MDL. The WWTP and reticulation for the ACF and the MDL and reticulation and the communal land treatment for all lots will be funded by MERF at the cost of $490,000.

Option 3 will have a higher upfront cost to MERF with only the STEP tank and boundary kit cost deferred to the purchaser. This cost will be $13,200 for all the LDL and the MDL Lots. The reticulation, communal WWTP and land treatment will be funded by MERF at a full cost of $836,000, or can be staged in three steps in the order of $486,000, $216,000, and $216,000.

Option 4 will have much the same costs as Option 3, assuming there is no charge by SDC to utlise the land in Creyke Rd. However, the reticulation costs increase from $45,000 to $260,000, based on $50/m plus a PC sum of $50,000 for jacking under SH73 and the main west coast railway.

The cost estimates from Innoflow Technologies are attached in Appendix D. It is important to note not all option combinations have been costed. The estimates for the on-site systems are for the lower cost subsurface dripper line. Likewise, the cost for a STEP system has been included in the base estimates, and the estimated costs will be slightly less for a grinder/progressive cavity pump system.

5 FUTURE DEFERRED ZONE

The future deferred zone has not been analysed in any detail. It is likely to be deferred until the District Scheme is available.

Should it progress sooner, then it could be added to the communal WWTP and LTA in Option 3. Based on approximately 300 lots, then an additional 5.8 ha of land would be required for a LTA. This could partially be accommodated in the MERF owned land to the North and within an area of the Future Urban Zone that could subsequently be developed at a later stage; or within adjoining land to the north of the Future Urban Zone, also owned by the owner of the Future Urban Zone.

6 RECOMMENDATIONS

Based on the environmental conditions within the Darfield vicinity, it is considered that all options presented for the sewage collection, wastewater treatment and effluent discharge, are viable and a discharge consent likely to be procured for all options.

However, MERF want to proceed with the option that has least environmental effect and likely to be accepted by all stakeholders and have therefore decided to apply for discharge consent for Option 3, with a communal WWTP and subsurface cut and carry LTA on the adjacent 5.4 ha lot. This has the infrastructure in-place for connection to a Council run scheme in the future.

7 REFERENCES

Fraser Thomas Limited report, September 2019. Proposed Plan Change Darfield Preferred Development Area 7 (Malvern Area Plan) Geotechnical Investigation Report.

Landcare Research, 2019. https://smap.landcareresearch.co.nz

Statistics New Zealand, 2013. http://archive.stats.govt.nz/Census/2013-census/profile-and-summary-reports/quickstats-about-a-place.aspx?request_value=14889&parent_id=14888&tabname=&p=y&printall=true

8 APPENDICES

Appendix A: Location Map
Appendix B: S-Map Soils Assessment
Appendix C: Fraser Thomas Bore Logs

APPENDIX A

Location Map

APPENDIX B

S-Map Soils Assessment

APPENDIX C

Fraser Thomas Bore Logs