Darfield Wastewater Strategy 2016

Prepared for Selwyn District Council

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MWH

BUILDING A BETTER WORLD

QUALITY STATEMENT

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Executive Summary

As Darfield remains one of the largest un-sewered communities in New Zealand, Community and Public Health (CPH) identified a concern that discharge of minimally-treated wastewater to ground from this community may pose an unacceptably high public health risk. In 2014, CPH conducted a three phase investigation to assess the potential risk to public health of minimally treated wastewater.

Carrying forward, Selwyn District Council (SDC) needs to understand the implications of this investigation and define viable servicing options. The purpose of this document is therefore to:

- Review the outcomes and conclusions of the CPH investigation;
- Integrate these outcomes with requirements for managing conveyance, treatment and disposal of wastewater within the Darfield community;
- Evaluate possible options for treatment and disposal of wastewater;
- Evaluate possible conveyance options for the community;
- Consider a possible partial servicing scenario whereby the existing community remains on septic tank treatment and disposal; and
- Recommend viable options and a way forward.

Public Health Risk Assessment

The outcomes of the Public Health Risk assessment conducted by CPH reflects previous investigations undertaken for the servicing of wastewater treatment and disposal within Darfield. Implications for this current wastewater strategy for Darfield revolve around the key issues raised, namely:

- Increased risk to public health associated with clustered / greater density development;
- Poor knowledge / irregular maintenance of septic tanks on private residential properties;
- Minimum property sizes should be enforced if on site treatment is retained;
- Commercial properties / businesses have a greater understanding of their systems and have them serviced more regularly that residential land owners.

Planning and Hydrogeological Review

The Canterbury Land and Water Regional Plan (LWRP) became partially operative in October 2015, superseding parts of the Canterbury Natural Resources Regional Plan (NRRP) and becoming the sole operative regional plan relevant to this proposal. At the time of the previous Darfield and Kirwee Sewerage Scheme Options report in 2012 the regional planning framework was under review. The key change between the 2012 and 2015 rules is the requirement in the LWRP to:

- Meet the nitrogen load limits for the Selwyn Te Waihora sub-region; and
- Adopt the best practicable option for the treatment and discharge of wastewater.

The conditions in Rule 11.5.22 set the expectation that sufficient technical investigations and options evaluations will have been carried out prior to lodging an application for resource consent, such that the achievement of both conditions can be demonstrated.

Where this isn't the case, an application will follow the more difficult pathway of a non-complying activity, where the activity must demonstrate that it is either consistent with the policy framework, or that the environmental effects are minor.

The groundwater quality monitoring (Liquid Earth, 2012) found that there was little indication of contamination likely to be associated with the on-site wastewater disposal in the Darfield area. Both spatial and temporal variations in groundwater quality were thought to be largely associated with other land use activities in the surrounding area. This was further supported by the Public Health Risk assessment conducted by CPH.

For irrigation of treated wastewater to land, the thick layer of unsaturated sediments (gravels) beneath the irrigation field will provide attenuation of microbiological contaminants, however leaching of nitrogen and phosphorous that is not taken up in the root zone, will need to be comprehensively assessed in the consent application for discharge of treated wastewater to land.

Treatment Options

The following representative treatment options were assessed on a technical and Net Present Value basis:

1. **High Quality:** Activated Sludge Plant (ASP) with biological nutrient removal (BNR),
2. **Medium Quality:** lowly loaded Trickling Filter (TF) plant, and
3. **Low Quality:** Waste Stabilisation Pond (WSP).

On the basis of the assumptions used and on servicing the entire Darfield community, the WSP plant (option 3) is recommended as the preferred treatment solution. This is due to the following advantages:

- Lowest capital cost/investment – WWTP
- Lowest NPV cost (excl. consideration of land)
- Ability to stage development
- Lowest OPEX (operator input / energy costs)

The main risk associated with this option is securing and consenting land for irrigation. It would require 4 times more land for irrigation than for the BNR plant option. Further discussion will need to be held to confirm that SDC owned land is available and designated for the end use of treated wastewater effluent irrigation.

The estimated capital cost for the treatment plant, irrigation system and land is $13.9 million. If land is provided to the scheme 'free of charge" then the WSP treatment option offers the lowest overall capital cost for full or partial scheme development at $8.4 million and $3.1 million respectively.

Conveyance Options

The following options were considered on a technical and NPV basis:

- Option 1: Gravity Sewer – decommission septic tank direct connection to gravity sewer reticulation
- Option 2.1: Low pressure sewer system – decommission septic tank, install new pump pot, connect to pressure reticulation
- Option 2.2: STEP system – reline septic tank, install new pump pot, connection to pressure reticulation
- Option 3: Vacuum sewer system – decommission septic tank, gravity connection to pot in berm, connection to vacuum reticulation

Based on the assumptions made within this report, the recommended option for Darfield is a low pressure sewer. The benefits of a low pressure sewer are:

- Lower installed cost than STEP system
- Shallower trenching than gravity system
- More seismically resilient than gravity system
- No ground water infiltration or root intrusion
- Primary treatment/Septic tank pump out costs are eliminated.

The estimated capital cost for the Darfield conveyance system for the existing population is $14.6 million. The cost to develop future collection and conveyance infrastructure is a further $12.3 million, giving total of $26.9 million.

If an option were selected to partially service the Darfield community (approx. 430 lots) then the estimated capital cost of the partial scheme would be $7.8 million.

Recommendations

There are four scenarios under which the following recommendations are made (based on assumptions within this desktop exercise). These are;

- full community development immediately, or
- servicing part of the community (approximately 25%)
- and in each instance, with or without land purchase for land disposal

The recommended community sewerage system for Darfield should is a low pressure sewer system with treatment via a waste stabilisation pond and disposal via irrigation to land designated for disposal of treated wastewater. This is reflected in table and cost estimates below.

The costs below are exclusive of GST and have a -15% to +40% confidence band due to the assumptions used, which is considered appropriate for this stage of the project.

Darfield Conveyance Staging Options Capital Costs

Service Area	Provision for Land	Item	Estimated Cost
Full community development	Full Land Purchase	Treatment Conveyance Total Capital Est. per lot	$13.9 M $26.9 M $40.8 M $23,700
	Land as Free Supply	Treatment Conveyance Total Capital Est. per lot	$8.4 M $26.9 M $35.3 M $20,500
Partial Scheme Development	Full Land Purchase	Treatment Conveyance Total Capital Est. per lot	$4.7 M $7.8 M $12.5 M $29,100
	Land as Free Supply	Treatment Conveyance Total Capital Est. per lot	$3.1 M $7.8 M $10.9 M $25,300

Notes:
1. Per lot development costs for full development are based on 1,720 lots in 2041
2. Per lot development costs for partial development (25%) are based on 430 lots (generally residential)
3. The per lot estimates do not include for financing charges that would otherwise be included in development contributions

Way Forward

The recommendations stated above vary from those defined in the 2012 Darfield and Kirwee Sewerage Options Study. In addition to development of the full community catchment, a partial scheme development proposal has also been considered to meet potential residential and commercial growth. The next stage of this process would be to discuss the outcomes with the key stakeholders, noting that:

- Irrigation to land is considered the most viable option for disposal;
- Refinement will be required of the preferred option(s) and associated capital costs, including layout plans;
- Financing of options will require commentary from SDC financial services;
- Land adjacent to Darfield is owned by SDC and would be considered for irrigation of treated wastewater. How the cost of this land is integrated with the option selected may alter the preferred options.

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APPENDICES

1 Introduction

An assessment was completed by MWH, on behalf of Selwyn District Council (SDC), in November 2012 to assess viable options a community sewerage system to convey, treat and dispose of wastewater in Darfield and Kirwee. The purpose of that assessment was to recommend a way forward for future servicing options.

Since that assessment, the Canterbury District Health Board (CDHB) Community and Public Health (CPH) has raised a concern that discharge of minimally-treated wastewater to ground from Darfield may pose an unacceptably high public health risk. A three stage investigation was conducted culminating in a Public Health Risk assessment (CPH, 2014).

In addition, the Canterbury Land and Water Regional Plan (LWRP) became partially operative (October 2015), superseding parts of the Canterbury Natural Resources Regional Plan (NRRP). The rules defined within this Plan will have a material impact on the decisions reached for the sewerage scheme.

The purpose of this document is to evaluate sewerage options for servicing Darfield with reference to changes within the regional planning environment, outcomes of CPH investigations, and with consideration of partial servicing options within the community.

1.1 Scope

The scope of works for this high-level desktop assessment is as follows:

1. **Document Review:** review of findings of the CPH Public Health Risk assessment and implications for wastewater servicing of Darfield.
2. **Planning Review:** review of planning constraints and hydrogeological review of reports by Pattle Delamore Partners Ltd (PDP) and Liquid Earth.
3. **Servicing Options:** comparison of options for treatment and conveyance for a community sewerage scheme, including high level sizing of components to allow estimation of costs. Options to consider partial scheme development to service commercial areas and future higher density subdivision developments.
4. **Cost Estimates:** comparative project cost estimates for 3 conveyance and 3 treatment options.
5. **Options Report:** summary of the above items and make recommendations for the conveyance, treatment and disposal of wastewater for Darfield.

The scope of this assessment is limited to potential options for a community sewerage scheme for Darfield. It does not include Kirwee as previously assessed under the 2012 Sewerage Scheme Options assessment.

1.2 References

"Darfield and Kirwee Sewerage Scheme Options", MWH, November 2012

"The Potential Hazard On-Site Wastewater Treatment Systems in Darfield and Kirwee. Present to Local Groundwater Quality and Critique of Current Assessment Methods", Dr Lee Burbery, February 2014

"Existing on-site wastewater treatment systems assessment in Darfield", CDHB Community & Public Health, April 2014

"Public health risk assessment of sewage disposal by onsite wastewater treatment and disposal systems in the Darfield and Kirwee Communities", Elaine Moriarty/ Chris Nokes, October 2014

2 Document Review

As Darfield remains one of the largest un-sewered communities in New Zealand, Community and Public Health (CPH) identified a concern that discharge of minimally-treated wastewater to ground from this community may pose an unacceptably high public health risk. In 2014, CPH conducted a three subproject investigation to assess the potential risk to public health of minimally treated wastewater. These subprojects, and key conclusions, are summarised in the following sections. Where applicable, direct quotes have been provided from the associated reports.

2.1 Potential Hazard On-Site Wastewater Treatment Systems

"The Potential Hazard On-Site Wastewater Treatment Systems in Darfield and Kirwee. Present to Local Groundwater Quality and Critique of Current Assessment Methods", Dr Lee Burbery, February 2014

This first subproject was a critical assessment of the groundwater monitoring system presently used to detect contaminant plumes from the onsite system disposal fields. This included a description of the hydrogeology of the area. The following statements and conclusions are drawn from this document:

- The aquifer is heavily impacted by nitrate that derives from the regional agricultural land use onto which impacts from septic tanks are superimposed.
- (evidence) suggests that the local aquifer has 'nitrate issues' before impacts from the Darfield (*and Kirwee*) wastewater disposal fields are even taken into account, with the implication that the regional groundwater system has a limited capacity to dilute nitrate impacts sourced from the clusters of septic tanks in Darfield (*and Kirwee*).
- Conceptually, on-site wastewater treatment operations in Darfield (*and Kirwee*) contribute similar nutrient loads, in terms of nitrogen mass, to the groundwater system as intensive agricultural land uses, notably dairy farming.
- It is helpful to recognise that the current practice of multiple discharges distributed over a broad area promotes the mixing and dilution of impacts in the aquifer. If discharges were focussed at a discrete point such as a centralised effluent disposal field, then unless the system offered advanced treatment to reduce concentrations, the contaminant plume, although narrower, would likely extend further.
- Any initiative to reduce nitrogen loads from wastewater discharges from the Darfield (*and Kirwee*) area would therefore complement the objectives of the CLWRP (*Canterbury Land and Water Regional Plan)* and would help mitigate any risk to public health.

In summary, from the referenced material:

- **at a regional scale**, there is no clear evidence that decentralised treatment systems in Darfield (*and Kirwee*), with their present population densities (Darfield, 5.7 people/ha; *Kirwee 3.7 people/ha),* are greatly affecting overall groundwater quality.
- **at the township scale**, the present population densities may add enough nitrate to the background concentration in the water to exceed nitrate's maximum acceptable value at the water table.
- it is clear that an increase in population density will increase the likelihood of nitrate exceeding its maximum acceptable value given in the Drinking-water Standards for New Zealand 2005 (revised 2008), **in groundwater below the onsite systems, or down gradient from them.**

2.2 Existing on-site wastewater treatment systems

"Existing on-site wastewater treatment systems assessment in Darfield", CDHB Community & Public Health, April 2014

This second subproject involved a sanitary survey undertaken by Community and Public Health (Mulrine 2014). It investigated the operation and maintenance of the onsite systems in the Darfield community. The following statements and conclusions are drawn from this document:

- Many residents had a poor knowledge of their onsite systems. Approximately one-third of residents had not had their onsite tank emptied in the previous five years (2009-2014).
- A little over 29 percent of residents had experienced some sort of system failure which included blockages (leading to the overflow of indoor amenities in some cases), ponding of water, slow draining of indoor amenities and odour.
- Comments from the survey forms from residential respondents included; “would prefer a reticulated system due to potential problems with septic systems in the future”, “there should be a warrant of fitness approach for septic systems”
- With reference to Non-Residential site, high-load businesses (such as food outlets and accommodation providers) were particularly vigilant at having the septic system emptied regularly. Few septic system problems were reported by the interviewees, or observed during the site inspection.

In summary, from the referenced material:

- Greater awareness and proactive maintenance from non-residential land owners compared to residential properties.
- Greater rigour around emptying of the septic tanks on a regular basis by high-load businesses.
- Greater risk of exposure to wastewater on site for residential properties due to irregular/poor maintenance.

2.3 Public health risk assessment

“Public health risk assessment of sewage disposal by onsite wastewater treatment and disposal systems in the Darfield and Kirwee Communities”, Elaine Moriarty/ Chris Nokes, October 2014

This third subproject draws on the findings of the first and second studies to make an assessment of the public health risk presented by the sewage treatment and disposal systems used in Darfield *(and Kirwee).*

Exposure assessment:

Consideration of indirect exposure pathways that could lead to contamination of the town bores shows that a likelihood of exposure through this pathway is very low in the case of Darfield because the cluster of onsite systems is outside the bore’s capture zone. The likelihood of infection by pathogens from the sewage is found to be low.

Exposure to sewage from onsite systems by direct pathways, that is, during system maintenance, or as the result of system failure (ponding or overflow of indoor amenities) is possible.

Conclusions drawn:

- it is unlikely to very unlikely that onsite systems in Darfield contribute to illness in the towns, or properties down-gradient, through drinking-water contamination.
- there is a very low likelihood of residents in the Darfield area becoming ill through indirect exposure to contaminants from the clustered onsite systems. However, it must not be assumed that this finding is applicable to all situations in which onsite systems are clustered.
- the likelihood of exposure to sewage from onsite treatment and disposal systems is not high.
- the implications for future developments; an increase in the density of onsite systems in Darfield will result in an increase in the nitrate concentration in the groundwater beneath the township, exposure through the indirect pathway of drinking-water may lead to an increased likelihood of infection if growth results in onsite systems being established within the capture zones of the community water supply bores, or closer to the bores than what they are now.

Recommendations:

- "To minimise the likelihood of onsite system failure and community residents being exposed to the microbiological hazards in sewage the Selwyn District Council, perhaps in conjunction with Environment Canterbury, should review possible mechanisms for ensuring that onsite systems are properly maintained or redesigned to meet current standards."
- "To maintain the safety of the community drinking-water supplies for Darfield and Kirwee planning by the Selwyn District Council for development of the townships, if onsite sewage treatment and disposal is to be retained, should ensure that onsite systems are not established within the capture zones of public water supply bores. The planning would need to take account of changes in the size of the capture zone resulting from increased water abstraction, and section sizes should be set to include reserve areas for a new disposal field should it be required (see AS/NZS 1547:2012)."

2.4 Implications for the Darfield Wastewater Strategy

The outcomes of the Public Health Risk assessment conducted by CPH reflects previous investigations undertaken for the servicing of wastewater treatment and disposal within Darfield. Implications for this current wastewater strategy for Darfield revolve around the key issues raised, namely:

- Increased risk to public health associated with clustered / greater density development;
- Poor knowledge / irregular maintenance of septic tanks on private residential properties;
- Minimum property sizes should be enforced if on site treatment is retained;
- Commercial properties / businesses have a greater understanding of their systems and have them serviced more regularly than residential land owners.

3 Planning Review

3.1 Introduction

The *Darfield and Kirwee Sewerage Scheme Options* report of November 2012 included a preliminary review of the planning constraints, that MWH identified at that time, in respect of a potential community sewerage scheme to convey, treat and discharge wastewater from the Darfield and Kirwee communities. At the time that report was prepared, the regional planning framework was under review, with the Canterbury Land and Water Regional Plan (LWRP) having been notified in August 2012, to ultimately replace the Canterbury Natural Resources Regional Plan (NRRP) that was operative at that time.

Further, given the early stage of development of the LWRP, there was uncertainty as to how the rules of the plan and specifically the Selwyn Te Waihora Sub-region rules would approach nitrogen discharges. This uncertainty was reflected in the level of planning assessment that could be provided at that time.

This brief planning assessment therefore updates the assessment provided in the 2012 report, taking into account the changes in the regional planning framework noted above.

3.2 Canterbury Land and Water Regional Plan

The LWRP became partially operative in October 2015, superseding parts of the NRRP and becoming the sole operative regional plan relevant to this proposal. The operative portions of the LWRP include the provisions of the Selwyn Te Waihora Sub-region, which were introduced through Plan Change 1 and includes the Darfield area.

The LWRP contains region-wide provisions (objectives, policies and rules) that are consistent with the vision and principles of the Canterbury Water Management Strategy (CWMS). The plan also contains ten sub-region chapters, with the provisions that apply to the Selwyn Te Waihora sub-region contained in Chapter 11. Both the region-wide and sub – region provisions need to be considered, and have been set out and assessed in respect of this proposal below.

3.2.1 Region-wide Rules

The region-wide rules set out in Chapter 5 of the LWRP. The rule that applies to sewerage systems is summarised in Table 1 along with a brief assessment of their application to this proposal. The rule reflects, and is supported by policies 11.4.7 - 8 as set out in the LWRP.

Table 3-1: LWRP General Rules

Rule	Activity	Status	Comment
5.84:	**Using land** for a community wastewater treatment system and **discharging treated wastewater** into or onto land, including where a contaminant may enter water	Discretionary	Both the use of land to establish and operate a WWTP and the discharge of the resulting treated wastewater require resource consent as **discretionary activities**.

3.2.2 Selwyn Te Waihora Sub – region Rules

Chapter 11 of the LWRP contains the policies and rules that specifically relate to activities in the Selwyn Te Waihora Sub – region.

The rules in this section of the LWRP prevail over the region-wide rules. The rules relevant to this proposal are summarised in Table 2, and are supported by policies 11.4.1 – 11.4.5 as set out in the LWRP.

Table 3-2: LWRP Selwyn Te Waihora Sub-region rules

Rule	Activity	Status	Comment
11.5.22:	**Using land** for a community wastewater treatment system and **discharging treated wastewater** into or onto land, including where a contaminant may enter water	Discretionary (conditional)	Both the use of land to establish and operate a WWTP and the discharge of the resulting treated wastewater require resource consent as **discretionary activities if:** 1. The discharge does not exceed the nitrogen load limit of 62 tonnes / year for the sub-region when it is combined with all other lawfully established existing community wastewater treatment systems; and 2. The treatment and discharge processes adopt the best practicable option[1]. Note that the 62 tonnes / year limit is for nitrogen losses from community sewerage systems only, and does not include losses from

[1] The LWRP adopts the definition of 'Best Practicable Option' as per Section 2 of the RMA:
***best practicable option**, in relation to a discharge of a contaminant or an emission of noise, means the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to—*
- *(a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and*
- *(b) the financial implications, and the effects on the environment, of that option when compared with other options; and*
- *(c) the current state of technical knowledge and the likelihood that the option can be successfully applied*

Rule	Activity	Status	Comment
			farming or industrial and trade process, which are subject to separate requirements.
11.5.23:	As above, but where the conditions of Rule 11.5.22 cannot be met	Non-complying.	Both the use of land to establish and operate a WWTP and the discharge of the resulting treated wastewater require resource consent as **non-complying activities** if either condition 1 or 2 (or both) of Rule 11.5.22 cannot be met.

3.3 Selwyn District Plan

The Selwyn District Plan (District Plan) contains provisions including rules that will apply to the development of a future WWTP and disposal area. It is assumed that a WWTP would be developed within rural land, and therefore the provisions of the Rural Volume of the District Plan have been considered. Assuming that any future WWTP would not be established in an area of high landscape, ecological or cultural value, the most likely Rural Volume rules would apply in respect of the land use activity, and buildings and structures. The triggering of such rules are best assessed on a site by site basis as potential plant sites are identified, in order to accurately assess the potential impact of the rules.

Alternatively, the Council as a requiring authority could serve a Notice of Requirement (NoR) on the consent authority to seek to designate the site for wastewater management purposes in the District Plan. Designating land for a defined purpose safeguards it for the primary activity, ensures that no other activity can take place on the site without the approval of the requiring authority, signals the intention of the requiring authority to use land for that purpose, and identifies the status and purpose of the land within the District Plan. It also has the function of setting aside the rules of the District Plan for that activity on that site, enabling greater flexibility in establishing and operating the activity long term than may otherwise be the case. Consequently it is recommended that the District Council designates land to be used for a WWTP rather than seek resource consents for any aspects that needed approval.

3.4 Summary of Rule Changes

The key change between the 2012 and 2015 rules is the requirement in the LWRP to:

- Meet the nitrogen load limits for the Selwyn Te Waihora sub-region; and
- Adopt the best practicable option for the treatment and discharge of wastewater.

The conditions in Rule 11.5.22 set the expectation that sufficient technical investigations and options evaluations will have been carried out prior to lodging an application for resource consent, such that the achievement of both conditions can be demonstrated. Where this isn't the case, an application will follow the more difficult pathway of a non-complying activity, where the activity must demonstrate that it is either consistent with the policy framework, or that the environmental effects are minor.

4 Review of Hydrogeological Constraints

A full review of hydrological constraints was conducted as part of the *Darfield and Kirwee Sewerage Scheme Options* report of November 2012. The sections below summarise the key findings of that review that would have a bearing on this strategy document.

4.1 Hydrogeology

Darfield is underlain by glacial outwash gravels with a thickness of up to 150m. The gravels consist of highly permeable coarse-grained gravel units between reduced permeability units containing a higher proportion of fine-grained material. Groundwater level monitoring records indicate that the depth to the water table is around 80-90 metres beneath Darfield and flows in a south-easterly direction.

4.2 Groundwater Quality

The Liquid Earth (2012) report summarises the groundwater quality for the Darfield area. The report found that there was little indication of contamination likely to be associated with the on-site wastewater disposal in the Darfield area. Both spatial and temporal variations in groundwater quality were thought to be largely associated with other land use activities in the surrounding area. This was further supported by the Public Health Risk assessment conducted by CPH (as summarised in Section 2).

Nitrate concentrations in the area surrounding Darfield ranged from 2.2 to 9.4 g/m^3 during the January 2012 groundwater monitoring. There is no evidence of bacterial contamination of the groundwater. Data provided in Liquid Earth (2012) report can provide the basis for selecting appropriate background groundwater quality values for the assessment of environmental effects and any future modelling.

4.3 Hydrogeological Constraints

The large thickness of unsaturated sediments (gravels) beneath the irrigation field would provide significant opportunity for attenuation of microbiological contaminants. For this reason, microbiological contamination is not considered a significant constraint to land disposal of waste water at these sites.

Nutrients, including nitrate, that are not removed by plant uptake in the root zone, will travel through the unsaturated zone and enter the groundwater system. Background nitrate concentrations as previously recorded in the area are relatively low. However, an increase in nitrate loading to the groundwater system from irrigation of treated wastewater may have potential to increase down gradient nitrate concentrations. The magnitude of this change will depend on the actual treated wastewater nitrogen loads, the amount of nitrogen removed by plant uptake and other factors. It is recommended that the nitrate loading to groundwater be estimated using a nutrient balance model. There is some down gradient groundwater use that may be impacted if waste disposal does increase nitrate loading to the groundwater system.

4.4 Summary

The above hydrogeological assessment can be summarised as follows:

- The groundwater quality monitoring (Liquid Earth, 2012) found that there was little indication of contamination likely to be associated with the on-site wastewater disposal in the Darfield area. Both spatial and temporal variations in groundwater quality were thought to be largely associated with other land use activities in the surrounding area.
- ECan have established within the LWRP controlled limits for leaching of nutrients to groundwater from all sources (refer Section 3). This includes mass limits for nitrogen and phosphorous corresponding to the estimated discharges to groundwater from septic tanks in Darfield.
- For irrigation of treated wastewater to land, the thick layer of unsaturated sediments (gravels) beneath the irrigation field will provide attenuation of microbiological contaminants, however leaching of nitrogen and phosphorous that is not taken up in the root zone, will need to be comprehensively assessed in the consent application for discharge of treated wastewater to land.

5 Extent of Service

There is a consideration being given to the expansion of the existing commercial land development within Darfield, currently zoned as Business 1. The possible expansion of this area is presented in Appendix A as provided by SDC. This area is further highlighted in Figure 5-1.

Figure 5-1 : Darfield Business Zones

The density of development, whether for business activities or residential subdivisions will have a bearing on the configuration of any sewerage scheme considered. For example[2]; a conventional bed / trench disposal field designed in accordance with AS/NZS 1547:2012 for a septic tank to service a 3 bedroom property would require in the order of 50m^2 of disposal area. This would significantly limit the use of open space on each property.

Should septic tank treatment and on site disposal be continued as the principal method for managing wastewater within Darfield then careful consideration will need to be made to the requirements placed on them by ECan resource consent conditions.

As late as 2005[3], ECan was approving resource consents for onsite treatment with specific reference to treated sewage effluent disposal via soakage hole and with a resource consent validity period of 35 years. Some limitations are included on specific consents to limit development to a 2 bedroom unit where the parcel size is small.

Resource consents for recent property development[4] have moved to a revised approach whereby land application for disposal is required within the property envelope. This would typically be via sand filter at a rate of less than 50mm per day per m^2. The validity period has also changed to 15 years meaning more frequent review and submission of revised consent application than previously defined within Darfield.

[2] Clutha District Council, Regulatory Services, "Septic Tank Design Guide"
[3] ECan Consent Reference CRC 052228
[4] ECan Consent Reference CRC 153613

6 Projected Flows and Loads

6.1 Projected Population

Population projections for Darfield have been taken from the table available from the SDC website in the 2015-2025 Long Term Plan and reproduced in Table 6-1. This would equate to a 36% increase in the residential population over the next 25 years.

Table 6-1: Projected Population for Darfield

Year	2016	2019	2021	2026	2031	2036	2041
Population	2,957	3,158	3,360	3,629	3,965	4,301	4,637

The impact of the new Fonterra milk processing plant at Darfield could cause an increase in residents beyond that allowed for population growth projections for Darfield. While there is potential for growth beyond the projections or faster than the projection, the projections have been taken as correct for the purposes of this study.

6.2 Projected Flows and Loads

The flows and loads of wastewater to be treated in a community scheme have been estimated based on the above population projection.

Table 6-2 contains the projected flows and loads for Darfield based on flow parameters specified in Part 6 of the SDC Engineering Code of Practice (February 2012), and per capita load used for the design of the Pines II Wastewater Treatment Plant (WWTP). The loads assume raw wastewater with no septic tanks, which is the worst case load for a possible WWTP. If some septic tanks were retained in a Septic Tank Effluent Pumping (STEP) or Septic Tank Effluent Gravity (STEG) system for all of or parts of the conveyance network, then the loads to the WWTP would be reduced.

Table 6-2: Projected Flows and Loads

Parameter	Unit	2016	Design 2041	Comments	
Flows					
ADWF	m^3/d	660	1,034	220 L/p/d (clause 6.4.3) ADWF: Average Dry Weather Flow	
Peak Diurnal	m^3/d	1,650	2,585	2.5 P/A dry weather diurnal peaking ratio (clause 6.4.1)	
Maximum Flow	m^3/d	3,300	5,170	2.0 x peak diurnal (clause 6.4.2): Maximum Flow (MF) = P/A x SPF x ASF, SPF clause 6.4.2, ASF clause 6.4.3 or 6.4.5	
Loads					
BOD	kg/d	192	301	65g/PE/d	BOD: Biological Oxygen Demand
TSS	kg/d	207	325	70g/PE/d	TSS: Total Suspended Solids
TN	kg/d	38	60	13g/PE/d	TN: Total Nitrogen
TP	kg/d	7.4	11.6	2.5g/PE/d	TP: Total Phosphorous

Notes:
1. Clauses refer to SDC Engineering Code of Practice Feb 2012, Part 6: Wastewater Drainage.

Should a community based sewerage network not be established then the loading rates as defined above would apply to the discharges from each septic tank on an equivalent property by property basis.

7 Treatment and Disposal of Wastewater

7.1 Treated Wastewater Quality Required

The limiting factor for any option considered for a centralised sewerage scheme for Darfield is the ability to dispose of the treated wastewater, either by discharge to a water body or discharge onto, or into, land. As there are no viable options for discharge to a water body near these communities, the disposal of treated wastewater is expected to be by irrigation to land, and the receiving environment will be the soil and gravel zones in the irrigation field and eventual drainage to groundwater.

While a full assessment of environmental effects has not been completed at this stage, an initial assessment has been made and the following sections describe the generally expected requirements for treatment and disposal considering individual quality parameters.

7.1.1 Organic Matter

The loading rate of organic matter (represented by BOD and TSS) irrigated onto the land is seldom limiting and the effects are generally beneficial (NZLTC, 2000). Organic matter present in the effluent assists the soil in retaining moisture and nutrients. Adequate aeration associated with well-drained soils and adequate rest periods, are required to break down organic matter. Because the soils are free draining in the Darfield area, significant breakdown of any remaining organic matter in the discharge can be expected.

Conventional biological treatment will be sufficient to provide reduction of BOD and TSS to acceptable concentrations for irrigation to land. Therefore the concentration of BOD and TSS is not critical.

7.1.2 Microorganisms

Microorganisms include bacteria pathogens which cause illness. They are represented by indicator organisms such as faecal coliforms and E.coli. A key function of wastewater treatment is to reduce the number of microorganisms in order to protect public health.

For irrigation of treated wastewater near Darfield, the concentration of microorganisms in the treated wastewater is not critical because of the thick layer of soil and subsoil prior to the treated wastewater entering groundwater. From the hydrogeological review in Section 4 the depth to groundwater around Darfield is reported as typically 80 to 90 m. Based on published log removal rates, this thickness of soil and gravels overlying the groundwater would provide greater than 8 log removal of pathogens. Faecal Coliform (FC) concentration in raw wastewater is around 10^6 to 10^7 cfu/100ml. Removal of 8 log would reduce this to <1 cfu/100ml, which would comply with the standard for drinking water. Therefore passage through the soil and subsoil zones is sufficient to protect the groundwater without any disinfection of the wastewater, however some disinfection to reduce microorganisms should be provided for health and safety of operators and in case of ponding on the irrigation surface.

Various recycled water guidelines give differing limits for indicator organisms for irrigation of non-food crops, which is similar to the cut and carry operation expected for disposal of treated wastewater. The various limits range from 1,000 cfu/100ml for livestock grazing and from 10,000 cfu/100ml up to biologically treated but undisinfected wastewater (potentially 10^5 to 10^6 cfu/100ml) for irrigation areas that are restricted from public access and for non-food crops (e.g. trees, turf).

The treatment process should therefore provide biological treatment and some pathogen removal. A standard for faecal coliforms in the range of 1,000 to 100,000 cfu/100ml is likely to be acceptable.

7.1.3 Nutrients

New discharge consent applications will require a thorough assessment of the nutrient balance and the mass of nitrogen and phosphorous drainage into groundwater. Consent standards will need to comply with the limits as defined within the LWRP (refer Rule 11.5.22).

The nutrient mass limits that will be applied fall into two categories; that of the localised discharge limits (what can be irrigated to land) and that of the absolute limit for the sub-region from community wastewater systems of 62 tonnes per year.

Previous ECan reports have assumed nutrient drainage to groundwater as follows:

- N applied at 150kg-N/ha/y results in 15% drainage to groundwater
- P applied at >50kg-P/ha/y will all be drained to groundwater (i.e. ≤50kg-P/ha/y was assumed to result in no drainage to groundwater).

The treatment and disposal options considered in this assessment are therefore based on nitrogen loading of 150kg-N/ha/d and use the ECan assumptions noted above to estimate the nitrogen and phosphorous mass leached to groundwater.

While low nitrogen and phosphorous concentrations are advantageous to reduce leaching to groundwater, the mass leached can be further controlled by managing the application rate per hectare. Therefore different levels of treatment can be accommodated, but will result in varying areas of land required for irrigation. Technology that reduces nitrogen and phosphorous will require a smaller area for irrigation, and is expected to provide an easier route to gain discharge consents as the impact on groundwater will be lower. However managing the application rate of nutrients to the land will be a key requirement for any treatment option in order to promote uptake by plants in the root zone and reduce leaching to groundwater.

7.1.4 Summary

The following treated wastewater quality is expected to be required for disposal by irrigation to land in the area of Darfield should a community treatment facility be developed:

- BOD and TSS: provide biological secondary treatment and clarification
- Microorganisms: 10,000 to 100,000 cfu/100ml
- Nutrients:
  - Manage nutrient application to land by providing sufficient land area,
  - Loading rates based on <150kg-N/ha/y and preferably <50kg-P/ha/y.

7.2 Centralised Treatment and Disposal Options

7.2.1 Introduction

The levels of treatment assessed for Darfield are listed below:

1. **High Quality:** Activated Sludge Plant (ASP) with biological nutrient removal (BNR)
2. **Medium Quality:** lowly loaded Trickling Filter (TF) plant, and
3. **Low Quality:** Waste Stabilisation Pond (WSP) or oxidation pond.

Staged upgrades (i.e. multiple units) have been considered as part of this assessment with a view to implementing a gradual transfer from the existing septic tank systems through to a community sewerage scheme. Single unit systems are generally used for small WWTPs due to the additional construction cost of multiple units, however staging may offer an opportunity to defer capital costs.

The status quo option, to remain on septic tanks, is unlikely to be a viable option if new development at a higher density is desired.

Under the LWRP, ECan has set a cap on the nutrient limits for discharge, Darfield is likely to need a community sewerage system in order to allow for the projected population growth from around 2,900 currently to 4,637 in 2041.

7.2.1.1 Option 1 High Quality: BNR plant

A BNR plant would be similar to the Pines I WWTP, which was designed for a design population of 6,000 PE, with inclusion of a centrifuge dewatering plant. It is assumed that sludge would be disposed of to landfill or via the solar drying facility at Pines II WWTP. This option comprises: inlet screen, bioreactor (4-stage Bardenpho), clarifier and UV disinfection. It would provide reduction of BOD, TSS, TN and FC to a high level (see section 7.2.2).

7.2.1.2 Option 2 Medium Quality: TF plant

A TF plant would comprise a lowly loaded TF with a high recycle rate to provide BNR in the biofilm of the TF media. It would use random plastic media similar to other recently constructed TF in New Zealand e.g. Hastings, Tahuna, and Greymouth (completion in 2013). This option comprises an inlet screen, lowly loaded TF, secondary clarifier, UV disinfection and centrifuge dewatering plant. It would provide similar biological treatment to the BNR ASP, but would result in slightly higher BOD, TSS and TN concentrations in the treated wastewater.

7.2.1.3 Option 3 Low Quality: WSP

A WSP plant would have a single facultative pond to provide biological treatment. A maturation pond could be provided to reduce pathogens but the receiving environment does not require this. This option comprises: inlet screen and a single facultative pond. Sludge disposal would be via periodic desludging of the pond. The performance expected is similar to the other options but with higher final BOD, TSS, and TN concentrations. Pathogen removal would be sufficient without UV disinfection.

7.2.2 Expected Performance

Table 6-3 presents the expected treated wastewater quality for each of the treatment options. Each option would provide a slightly different level of treatment with BNR ASP the highest quality through to WSP with the lowest. It should be noted that treatment provided by the WSP, while slightly lower quality than the others, is still removing a high percentage of each parameter.

Table 6-3: Estimated Treated Wastewater Quality (based on annual medians)

Parameter	Unit	Raw Wastewater	OPTION 1: BNR ASP[1]	OPTION 2: TF[2]	OPTION 5: WSP[3]
BOD	g/m^3	250-300	10	20	40
TSS	g/m^3	250-350	10	30	60
TN	$g\text{-}N/m^3$	40-60	<7	15	30
TP	$g\text{-}P/m^3$	8-12	7	7	7
FC	cfu/100ml	10^6-10^7	1,000	1,000	20,000

Notes:

1. Based on performance of the 4-stage Bardenpho process and UV disinfection at the Pines I WWTP.
2. Based on expected performance from a lowly loaded TF with high recycle, secondary clarifier and UV disinfection from unpublished monitoring data.
3. Based on performance data from facultative ponds in New Zealand (Davis-Colley et al 1995, Hickey et al 1989 and unpublished monitoring data).

While each option has varying levels of treatment, particularly for TN, the amount that would be leached to groundwater can be controlled by managing the application rate onto land. Table 6-4 has the estimated irrigation area required for each option based on an application rate of 150 kg-N/ha/y (this rate has been used in order to match the assumed N leaching rate used by ECan in previous reports – leaching rates at different nitrogen application rates were not provided).

Table 6-4: Estimated Irrigation Area and Nutirent Drainage to Groundwater

Parameter	Unit	OPTION 1: BNR ASP	OPTION 2: TF	OPTION 3: WSP
Nitrogen:				
TN Application rate	kg-N/ha/y	150	150	150
Irrigation area required	Ha	18	38	75
Total irrigation block area required[1]	Ha	38	75	132
Estimated TN leached[2]	t/y	0.5	2.8	5.5
Estimated % of proposed TN limit[3]	%	5%	31%	61%
Phosphorous:				
TP Application rate[4]	kg-P/ha/y	150	26	13
Estimated TP leached[5]	t/y	1.6	nil	nil
Estimated % of proposed TP limit	%	57%	0%	0%

Notes:

1. Based on centre pivot irrigation with each unit assumed to be 200m radius
2. Assuming TN leaching of 15% at an application rate of 150kg-N/ha/y based on assumptions in ECan (Draft Oct 2012) Estimating nitrogen and phosphorus contributions to water from discharges of sewage effluent.
3. Proposed TN and TP limits for discharge to groundwater (i.e. leached) estimated from the number of existing lots and the estimated current leaching from septic tanks in the district presented in ECan Report No. R12/18 Barry Loe (2012) Estimating nitrogen and phosphorus contributions to water from discharges that are consented and permitted activities under NRRP.
4. Corresponding TP application rate at TN rate of 150kg-N/ha/y.
5. Assuming all P exceeding 50 kg-P/ha/y is leached to groundwater based on assumptions in ECan (Draft Oct 2012) Estimating nitrogen and phosphorus contributions to water from discharges of sewage effluent.

The BNR plant (option 1) has the smallest land area due to the lower TN concentration. The mass of nitrogen and phosphorous leached to groundwater is estimated to be 5% and 57% of the current estimated mass load to groundwater from septic tanks at Darfield. The other options 2 and 3 would also reduce the current mass load to groundwater. Using the ECan assumptions, the phosphorous would all be taken up in the root zone with no leaching to groundwater for options 2 and 3. This is due to the greater land area required to maintain nitrogen loading at 150 kg-N/ha/d.

7.2.3 Staging Treatment Capacity

Any proposed sewerage scheme could be developed in stages to meet the growth of the Darfield community. The treatment options presented in Section 7.2.1 will have a varying degree of capability to be staged to meet changing population growth rates, particularly where only part of the community may be connected.

Consideration needs to be given to how new development areas may be serviced. Three options will be carried through this assessment, being:

- Status Quo: each property serviced by on site wastewater treatment and disposal;
- Full community servicing: Connection of all properties to new wastewater services;
- Staged service approach: partial scheme development with ability to expand at a later date.

The cost and process efficiencies of the BNR plant will change depending on the amount of flow that is initially connected and the future stages that will be required. The BNR plant approach is best suited to where a large initial flow is connected i.e. development for the wider, existing community. Should the initial flow and loading be low, then the treatment process will not operate efficiently and may compromise the discharge quality.

An advantage of establishing a TF operation on the site over a BNR plant is that it would allow a greater degree of staging. This would involve installing additional TF tanks as population growth occurs to meet demands. The TF process is less likely to be compromised by low flows as compared to BNR.

The most significant cost associated with the development of the WSP process is the earthworks, sealing and waveband. The facultative pond could be designed and constructed in stages, effectively completed as individual cells to meet the growing demands. This would come with additional costs for construction but may provide an interim solution until further consideration is given to the final scale of the connected population.

A hybrid approach could be considered whereby the initial stage of development is serviced by an enhanced WSP system that is set up to be modified and ultimately incorporated as a clarifier for a TF plant meeting full community scheme development. The integration of this approach should be considered at a preliminary design stage as a way to further minimise capital costs.

For the purpose of this assessment it has been assumed that 25% of the Darfield community will be viable to connect as part of an initial stage. This assumes that 70% of all new subdivisions/residential growth will connect to the scheme and that portions of the Darfield commercial centre that wish to connect can do so.

7.2.4 Capital Cost Estimate – Full land purchase

Table 6-5 and **Figure 6-1** present the estimated capital cost for each option. These costs are based on providing treatment for the 2041 projected population within Darfield. The purchase of land for irrigation and the WWTP is a major component and has been provided in addition to the WWTP capital costs.

Contractor preliminary and general costs are considered to be equal between the options and are based on around 10% of the construction cost. The contingency (accounting for uncertainty in scope) and engineering design and monitoring costs (at approx. 12%) are expected to be similar for the two mechanical WWTP options and lower for the WSP option which has simpler design and construction methods . At this stage planning and consenting costs have been excluded, but are likely to be similar between all options.

Table 6-5: Estimated Capital Cost for Options 1 to 3

Item	OPTION 1: BNR ASP (million)	OPTION 2: TF (million)	OPTION 3: WSP (million)
WWTP	$ 4.9	$ 4.2	$ 2.1
Irrigation Equipment	$ 1.2	$ 2.1	$ 4.0
Subtotal	***$ 6.1***	***$ 6.3***	***$ 6.1***
Preliminary & General	$ 0.6	$ 0.6	$ 0.6
Contingency	$ 1.2	$ 1.3	$ 0.9
WWTP Construction Estimate	***$ 7.9***	***$ 8.2***	***$ 7.6***
Land Purchase[1]	$ 1.4	$ 2.7	$ 5.5
Planning and Consents	excl.	excl.	excl.
Engineering Design and Construction Monitoring	$ 0.9	$ 1.0	$ 0.8
Total Project Estimate[2]	**$ 10.2**	**$ 11.9**	**$ 13.9**

Notes:
1. Land purchase cost is estimated from RV+20% of advertised large land blocks in the Darfield area.
2. At this stage, the accuracy of estimates are in the order of -15% to +40% and suitable for comparison between options.

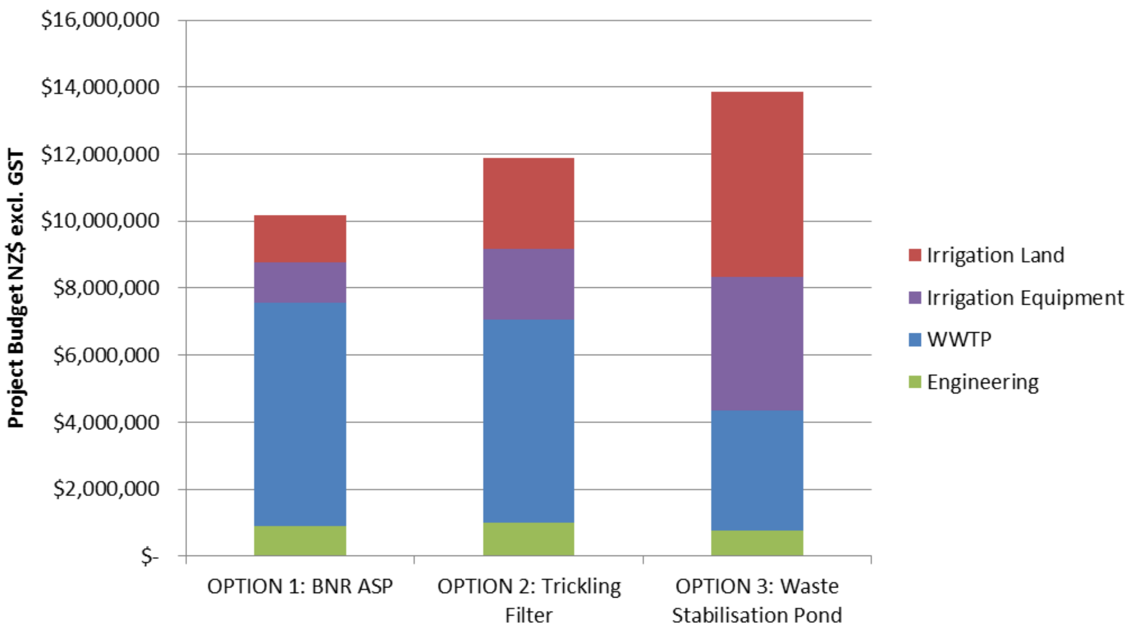


Figure 6-1: Estimated Capital Cost for Options 1 to 3

A partial service approach remains an option for the Darfield community. This could encompass the central business zone and future higher density residential subdivisions. The comparative capital cost estimates in **Table 6-6** and **Figure 6-2** are based on the following assumptions:

- that 25% of the community would be initially connected to a new wastewater scheme;
- trickling filter treatment or a waste stabilisation pond would be most viable for staging;
- the layout would include a potential to expand in the future; and
- that land for irrigation would be purchased/secured as required to meet each stage of growth (noting that Selwyn District Council currently owns 142ha of land in south-eastern Darfield).

Table 6-6: Estimated Capital Cost for Staged Option (25% Development)

Item	OPTION 2: TF		OPTION 3: WSP	
	Full Development (million)	25% Development (million)	Full Development (million)	25% Development (million)
WWTP	$ 4.2	$ 2.0	$ 2.1	$ 1.1
Irrigation Equipment	$ 2.1	$ 0.7	$ 4.0	$ 1.2
Subtotal	***$ 6.3***	***$ 2.6***	***$ 6.1***	***$ 2.3***
Preliminary & General	$ 0.6	$ 0.3	$ 0.6	$ 0.2
Contingency	$ 1.3	$ 0.5	$ 0.9	$ 0.3
WWTP Construction Estimate	***$ 8.2***	***$ 3.4***	***$ 7.6***	***$ 2.8***
Land Purchase[1]	$ 2.7	$ 0.7	$ 5.5	$ 1.6
Planning and Consents	excl.	excl.	excl.	excl.
Engineering Design and Construction Monitoring	$ 1.0	$ 0.6	$ 0.8	$ 0.3
Total Project Estimate[2]	**$ 11.9**	**$ 4.7**	**$ 13.9**	**$ 4.7**

Notes:
1. Land purchase cost is estimated from RV+20% of advertised large land blocks in the Darfield area.
2. At this stage, the accuracy of estimates are in the order of -15% to +40% and suitable for comparison between options.

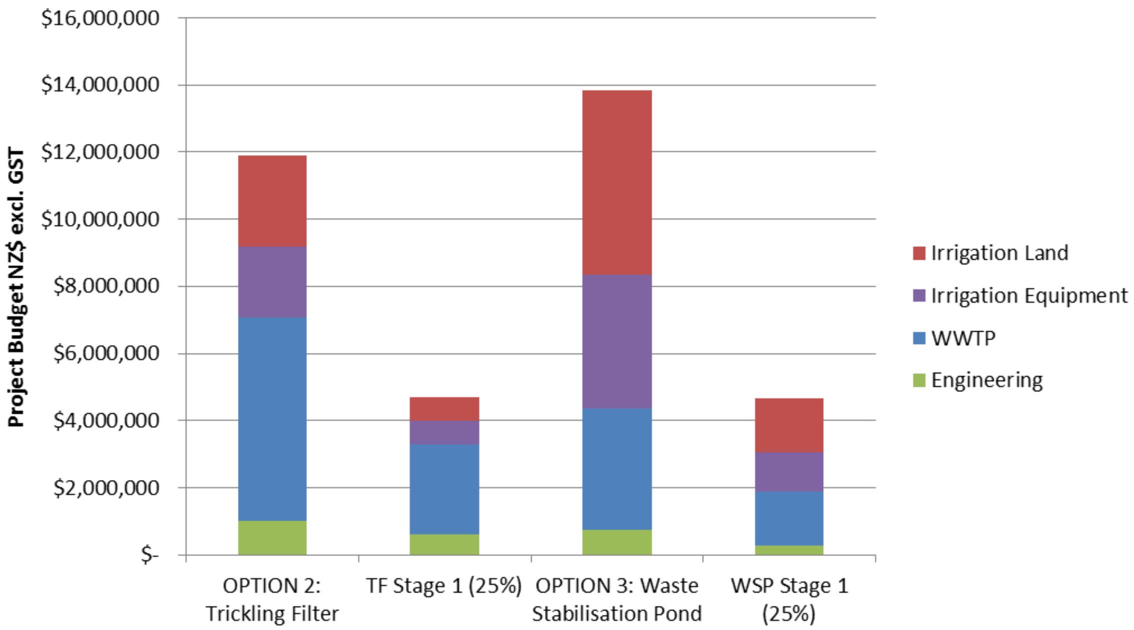


Figure 6-2: Estimated Capital Cost for Staged Option (25% Development)

A risk associated with the staged approach above is that the future land parcels may not be available for purchase and subsequently consented for discharge when the next stage is developed. The Council may wish to remove this risk by purchasing the full parcel of land during stage 1.

7.2.5 Net Present Value Assessment

Table 6-7 and Figure 6-3 contain estimates for operating costs and a simple Net Present Value (NPV) calculation (initial capital in the first year, estimated annualised operation and maintenance costs for the following years, estimated renewal costs of M&E plant after 20 years). Although the WSP has the lowest WWTP capital cost and the lowest operating cost (approximately 60% of option 1), it has a higher overall capital cost due to the large irrigation area required to maintain an application rate of 150 kg-N/ha/y. The NPV shows similar overall costs for each option within the limits of accuracy for the cost estimates.

Table 6-7: Estimated Operating Cost and NPV

Item	OPTION 1: BNR ASP (million)	OPTION 2: TF (million)	OPTION 3: WSP (million)
Estimated Capital Cost	$10.2	$11.9	$13.9
Estimated Operating Cost	$0.6	$0.5	$0.3
Simple NPV (25 Years)			
- 8% discount rate	$17.1	$17.6	$17.2
- 6% discount rate	$18.5	$18.7	$17.9
Simple NPV (50 Years)			
- 8% discount rate	$18.1	$18.4	$17.7
- 6% discount rate	$20.5	$20.4	$18.9

Notes:
1. At this stage, the accuracy of estimates are in the order of -15% to +40% and suitable for comparison between options.
2. The NPV analysis assumes an 8% discount rate.

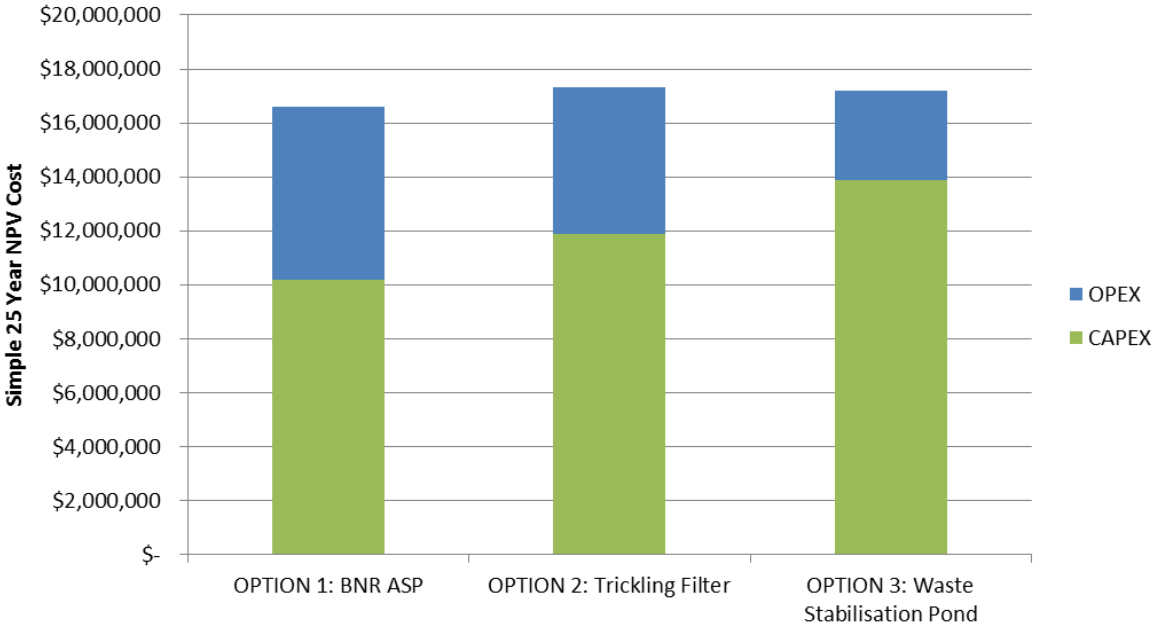


Figure 6-3: Comparison Based on Simple 25 Year NPV, 8% Discount Rate

For the purposes of this document, the Simple 25 Year NPV at 8% discount rate has been adopted for any further assessments.

A similar approach can be taken in the comparison of a single stage development and an initial stage whereby 25% of the capacity is provided. These comparisons are presented in **Table 6-8** and Figure 6-4.

Table 6-8: Estimated Operating Cost and NPV – Single Stage vs Initial Stage

Item	OPTION 2: TF		OPTION 3: WSP	
	Full Development (million)	25% Development (million)	Full Development (million)	25% Development (million)
Estimated Capital Cost	$11.9	$4.7	$13.7	$4.7
Estimated Operating Cost	$0.5	$0.3	$0.3	$0.2
Simple NPV (25 Years)	$17.6	$7.5	$17.2	$6.3

Notes:

1. At this stage, the accuracy of estimates are in the order of -15% to +40% and suitable for comparison between options.

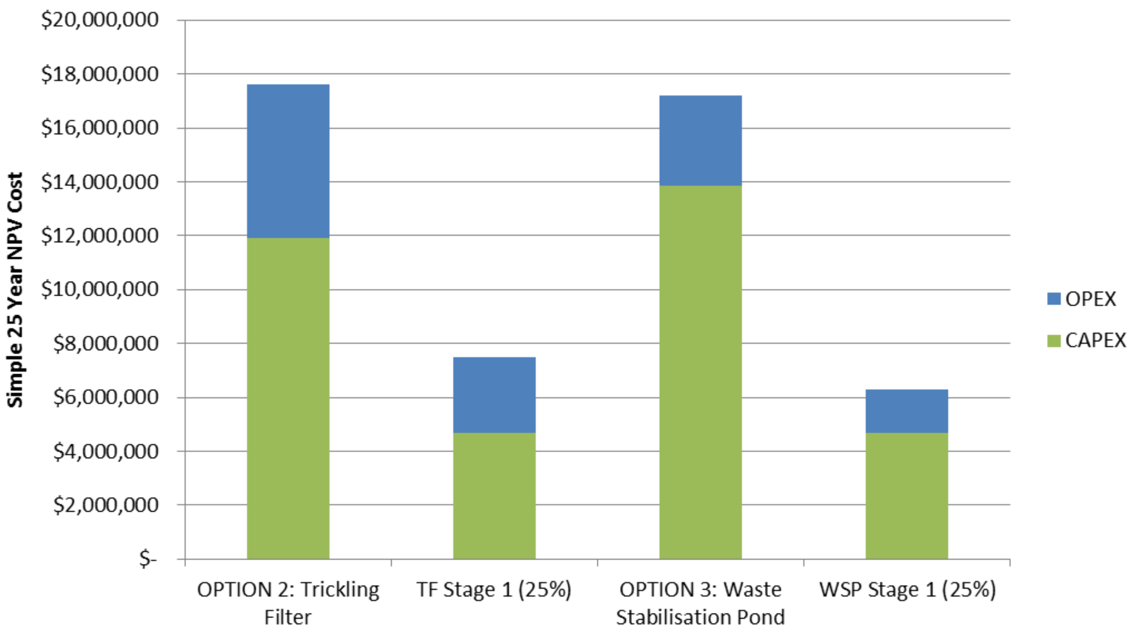


Figure 6-4: Comparison Based on Simple 25 Year NPV – Single Stage vs Initial Stage TF

7.2.6 Capital Cost Estimate – Free supply of land

A significant cost associated with the development of the treatment and disposal options is with land purchase. The parcels of land with the potential for the disposal of treated wastewater effluent, owned by SDC but leased back to current landholder, are presented in Figure 6-5.

Figure 6-5 : Potential Land Disposal Areas

The method for land disposal assumed under this strategy is via centre pivot irrigation. This is an efficient method of irrigating the disposal area although there would remain 'dead' zones in the corner of rectangular blocks. For the 142ha represented in Figure 6-5 and with a pivot to land ratio of 68%, this would equate to approx. 96.5ha of land that can be irrigated. On this basis, there would be sufficient land for disposal under each option and for full service of the community.

If the land was provided free of charge to the scheme then there would be changes to the total scheme costs as presented in **Table 6-9** and **Figure 6-6**.

Table 6-9: Estimated Capital Cost for Options 1 to 3 – Existing Land Provided

Item	OPTION 1: BNR ASP (million)	OPTION 2: TF (million)	OPTION 3: WSP (million)
WWTP	$ 4.9	$ 4.2	$ 2.1
Irrigation Equipment	$ 1.2	$ 2.1	$ 4.0
Subtotal	***$ 6.1***	***$ 6.3***	***$ 6.1***
Preliminary & General	$ 0.6	$ 0.6	$ 0.6
Contingency	$ 1.2	$ 1.3	$ 0.9
WWTP Construction Estimate	***$ 7.9***	***$ 8.2***	***$ 7.6***
Land Purchase[1]	--	--	--
Planning and Consents	excl.	excl.	excl.
Engineering Design and Construction Monitoring	$ 0.9	$ 1.0	$ 0.8
Total Project Estimate[2]	**$ 8.8**	**$ 9.2**	**$ 8.4**

Notes:
1. Land purchase cost is estimated from RV+20% of advertised large land blocks in the Darfield area.
2. At this stage, the accuracy of estimates are in the order of -15% to +40% and suitable for comparison between options.

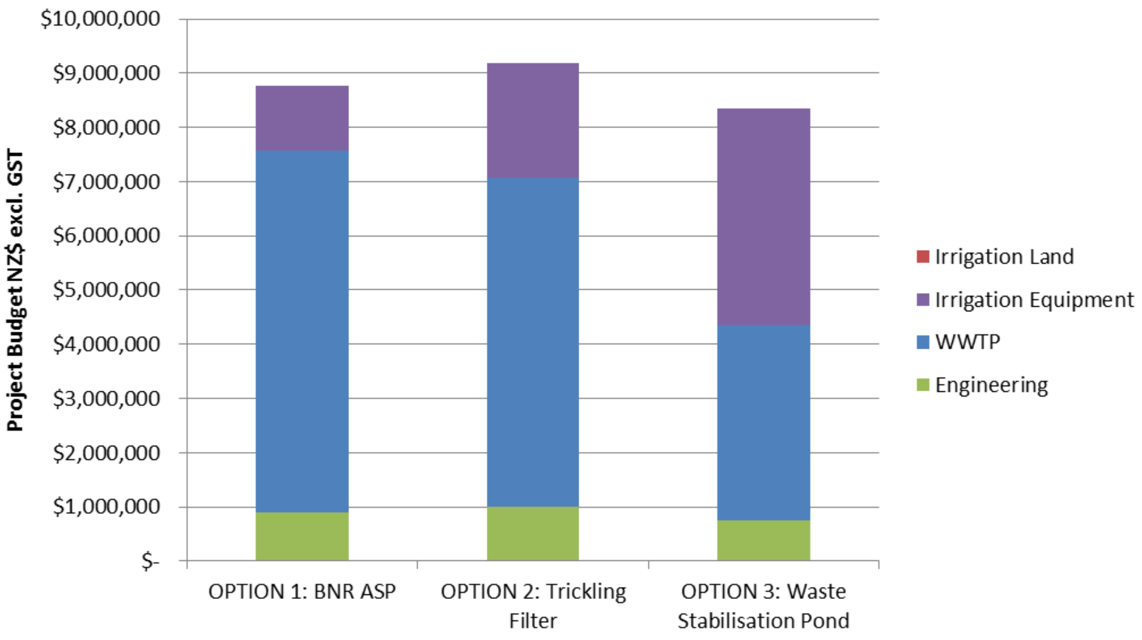


Figure 6-6: Estimated Capital Cost for Options 1 to 3 – Free supply of land

Considering a NPV approach under this scenario (as outlined in Section 7.2.5) would suggest that the preferred solution may swing towards an option if a lower capital and renewal cost for the WWTP.

Table 6-10: Estimated Operating Cost and NPV – Free supply of land

Item	OPTION 1: BNR ASP (million)	OPTION 2: TF (million)	OPTION 3: WSP (million)
Estimated Capital Cost	$8.8	$9.2	$8.4
Estimated Operating Cost	$0.6	$0.5	$0.3
Simple NPV (25 Years)	$15.2	$14.6	$11.7

Notes:
1. At this stage, the accuracy of estimates are in the order of -15% to +40% and suitable for comparison between options.

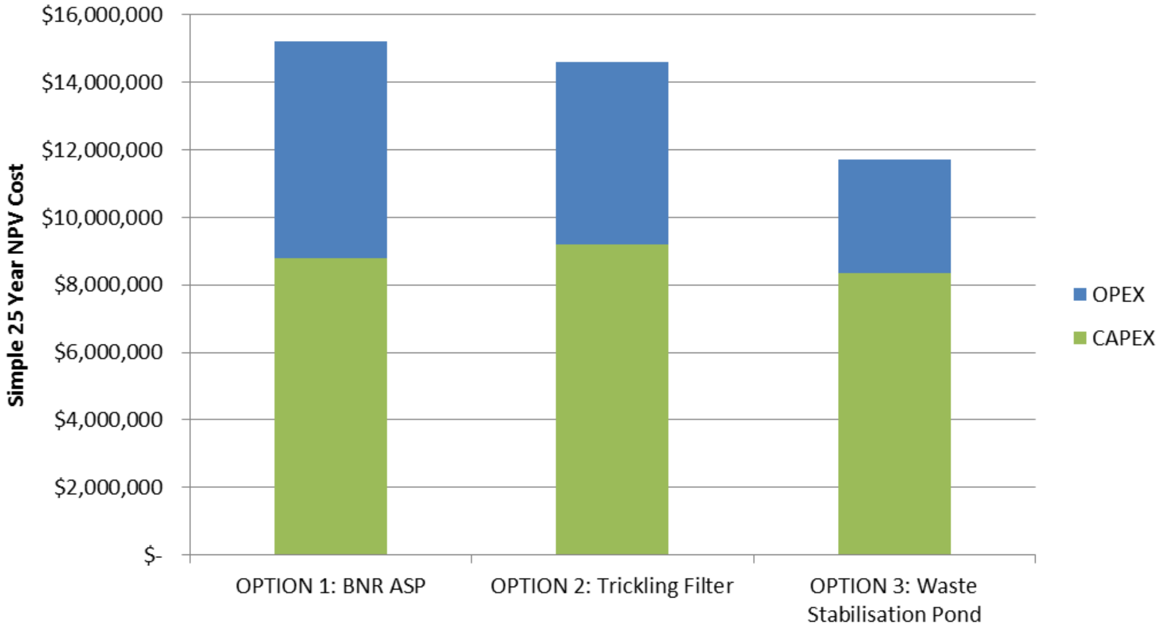


Figure 6-7: Comparison Based on Simple 25 Year NPV - Free supply of land

7.2.7 Discussion

7.2.7.1 Treatment System Options

While the three options presented have varying levels of treatment, they all provide high levels of removal for organic material and microorganisms. The key difference is the level of nitrogen removal which is the basis for the irrigation area and land purchase costs.

The BNR plant (option 1) has the lowest overall capital cost due to the smaller area of land required. The WWTP components ($6.4 million excluding irrigation equipment) and operating cost ($0.6 million) are the highest of the three options, but it has a similar NPV to the other options due to the lower overall capital costs when land and irrigation equipment is considered. It also has the best potential for upgrading to low nitrogen and phosphorus limits, and the only option that could provide significant biological phosphorous removal. Under this approach the nitrogen and phosphorus will be within the current ECan estimates, which are indicative of the future mass limits in the short term.

The TF (option 2) offers intermediate capital and operating costs and is a relatively simple process to operate in comparison to the BNR plant. The TN removal rates under TF will require more land area than for the BNR process and likewise for a TP application rate that results in no leaching of phosphorous to groundwater. TF has an advantage of being able to be cater for greater variance in incoming flows (starting from lower flow rates) and can therefore accommodate a greater level of staging than a BNR process plant.

The WSP (option 3) has the lowest capital and operating costs for the WWTP, 40% and 60% of BNR capital and operating costs respectively. However, the land required for irrigation of treated effluent is far greater due to the relatively high TN concentration. Therefore, including land purchase, this option has the highest capital cost. The viability of this as a preferred option will depend on the availability and accessibility of land for irrigation. Where the land is available and able to be consented/designated through Selwyn District Council ownership then this would smooth the path to implementing this option. If land needs to be sought, purchased and consented through a third party then there would be greater risks that this option may not proceed.

7.2.7.2 Potential Nutrient Limits

The nitrogen and phosphorus mass limits that ECan will impose are defined with the LWRP although how this plan may change, evolve or be interpreted in the future is uncertain at this stage. It has been assumed under this assessment that the land application and leaching rates assumed by ECan in the most recent reports have been incorporated.

The proposed plants would provide limited reduction of phosphorus, but phosphorus removal could be achieved by chemical dosing with any of the options. For option 1 only, biological phosphorus removal could be incorporated. Chemical phosphorus removal requires a clarifier, so a new clarifier and chemical dosing would be required for option 3, but only the chemical dosing equipment would be required for options 1 and 2. The cost for chemical dosing is similar for each type of plant, but the BNR plant has the benefit of being able to incorporate biological phosphorous removal and reducing chemical costs (chemical dosing would be retained as a backup). The BNR plant therefore has an advantage for compliance with potential future phosphorus limits.

7.2.7.3 Scheme Funding

Partial sewerage scheme development for the community would be possible where the conditions are appropriate (i.e. new development is of higher density and adjacent to the treatment and disposal area, commercial buy-in from existing users that may wish to connect). Under this scenario, development contributions would fund the development of the staged scheme. Some allowance for marginal costs funded through Council may need to be made for the potential to expand the infrastructure to eventually encompass the entire community.

The benefit of this approach is that it would principally allow for a “user pays” approach with developer led funding to construct the scheme. The development contributions required from new areas would be partially offset by savings associated with not having a septic tank system installed on site, a Council led discharge consent instead of individual resource consents, and the possibility of providing a greater density/ smaller lot sizes/ therefore a greater number of lots in new subdivisions for sale.

The selection of the preferred solution is largely dependent on the mechanism by which the available land of effluent disposal is considered and costed into the funding model. If the land is provided free of charge to the scheme then the pendulum swings to the selection of the WSP as the preferred approach based on capital cost and on NPV of the treatment process.

7.3 Summary

On the basis of the assumptions used, and on servicing the entire community, there is little to separate the BNR plant (option 1) from the WSP (option 3) as the preferred approach. The estimated NPV costs for each option are very similar, with key differences described in **Table 6-11**:

Table 6-11: Comparison of BNR to WSP treatment

(✓ - where advantage exists over the other option)	OPTION 1: BNR ASP	OPTION 3: WSP
Low Capital Cost - WWTP		✓
Low Capital Cost – Incl. Land	✓	
Quality of Treated Effluent	✓	
Low OPEX		✓
Staging of Development		✓

Given the balance of discussion within the previous section, we would recommend that the WSP approach is selected as the preferred option for Darfield. This is due to the following advantages:

- Lowest capital cost/investment – WWTP
- Lowest NPV cost (excl. consideration of land)
- Ability to stage development
- Lowest OPEX (operator input / energy costs)

The main risk associated with this option is securing and consenting land for irrigation. It would require 4 times more land for irrigation than for the BNR plant option. Further discussion will need to be held to confirm that SDC owned land is available and designated for the end use of treated wastewater effluent irrigation.

If land availability is an issue that cannot be overcome, then we would recommend the BNR plant approach be selected as the first alternative for servicing Darfield as this has the smallest footprint and an estimated NPV cost equivalent to that of the WSP plant.

These recommendations should be confirmed by further investigation and analysis of the assumptions and other costs.

8 Conveyance Options

8.1 Overview

This section describes the main options for collection and conveyance of the wastewater from individual sections to a new central WWTP.

The first part of this looks at the various options available for conveyance within Darfield. For all the options described in the following sections, the approximate total length of sewers required to service the existing extent of Darfield is 23 km. The 2012 Darfield and Kirwee sewerage scheme option investigation concluded that pumping wastewater to the Pines WWTP is not economically viable and therefore this has not been considered further as part of this strategy.

The principal options are also discussed in terms of partial scheme development to service approximately 25% of the community and development of the business/commercial area of Darfield.

8.2 Collection System

As Darfield currently only have on-site septic tanks, any new central treatment system will require a new reticulated conveyance system to be installed.

Three options are outlined in this section:

- Option 1: Gravity Sewer – decommission septic tank direct connection to reticulation, some catchment pump stations,
- Option 2.1: Low pressure sewer system – decommission septic tank, install new pump pot, connect to pressure reticulation
- Option 2.2: Septic Tank Effluent Pump (STEP) system – reline septic tank, install new pump pot, connection to pressure reticulation
- Option 3: Vacuum sewer system – decommission septic tank, gravity connection to pot in berm, connection to vacuum reticulation.

The options listed may require a terminal pump station to lift the wastewater to the WWTP inlet depending on the configuration of the treatment process.

Darfield is located on the Canterbury Plains, in an area that is generally flat but with a gentle fall across the township. This gentle slope could make the township suitable for a gravity collection system. This would be confirmed during concept design. However, as the grades across the township are relatively shallow and also because of seismic events in the area, other sewer reticulation methods have also been considered.

The options have also been compared in terms of operability and seismic resilience as well as capital and operating cost.

8.3 Gravity Sewer

The basis for this system is a network of gravity pipes laid in the street with manholes at regular intervals and changes in direction. However, depending upon the location selected for the treatment plant, it will still require one or more pumps station in the collection network.

The components of this system are:

- Components on individual properties ("on-site components")
  - Decommissioned septic tank
  - Gravity drain from property
- Components common to all properties ("off-site components")
  - Reticulated network – pipework from property boundaries to collector drains, collector drains, inspection ports
  - Lift pump stations (depending upon topography).

Benefits of Gravity Sewers are:

- Fewer "mechanical" components in the system
- Lower Operation and Maintenance (O&M) costs
- Negligible on-going direct costs to homeowner.

Complications of Gravity Sewers are:

- All treatment required at WWTP
- Must be open trenched – more surface disruption
- Deeper pipes typically required
- Difficulty balancing current sizing requirements with future growth
- Frequent manholes required
- Pumping likely to still be required
- Groundwater Infiltration
- Root intrusion to pipe joints (Less likely with modern materials)
- More susceptible to seismic events/differential settlement.

Sizes of the collection mains would be based upon the SDC Engineering Code of Practise and NZS 4404:2010.

8.4 Pressure Pipeline Systems

8.4.1 Lower Pressure Pumped

Low pressure sewers are a system where the effluent from the household gravitates to a small pump station typically located on the homeowner's property. The system uses a high head grinder pump and small diameter pipes, to transport the wastewater to the centralised WWTP

- Components on individual properties (“on-site components”)
  - Decommissioned septic tank
  - Gravity drain from property
  - Grinder pump and pot
  - Pressure sewer to boundary
- Components common to all properties (“off-site components”)
  - Reticulated network – small diameter pressure reticulated sewers, inspection ports, air valves, line valves etc.

Benefits of Low Pressure Sewer are:

- Lower installed cost than STEP system
- Can be directionally drilled – less surface disruption
- Shallower trenching than gravity system
- More seismically resilient than gravity system
- Less ground water infiltration or root intrusion

Complications of Low Pressure Sewers are:

- All treatment required at WWTP
- On-going electricity costs for homeowner
- Occasional pump replacement costs for homeowner
- Risk associated with power outages, requiring mobile pump-out service
- Ownership and maintenance of the pumps (council or privately owned)
- Pigging required to remove solids build up or fats, oils and grease
- Difficulty balancing current sizing requirements with future growth
- More frequent pump replacement than STEP system.

8.4.2 Septic Tank Effluent Pump System

STEP is a system where a pump is located downstream of a septic tank (either in a vault in the septic tank or a separate pump well) and only the liquid is pumped forward for treatment. The solids are retained in the tank for primary treatment and some aerobic digestion. As only liquid is pumped, this means that more efficient pumps can be used and these also tend to have a longer lifespan.

- Components on individual properties (“on-site components”)
  - Repurpose existing septic tank
  - New septic tank
  - STEP pump vault/pit and filter
  - Pressure sewer to boundary
- Components common to all properties (“off-site components”)
  - Reticulated network – pressure reticulated sewers, inspection ports, air valves, line valves etc.

Benefits of STEP system are:

- Primary treatment carried out “on-site” – smaller, centralised treatment plant may be required
- Can be directionally drilled – less surface disruption
- More seismically resilient than gravity system
- No ground water infiltration or root intrusion
- Less likely to require pigging required to remove solids build up or fats, oils and grease.

Complications of STEP system are:

- Risk associated with retrofitting to existing septic tanks (integrity of structure / access)
- Replacement of some septic tanks likely
- Higher installed cost than low pressure sewer
- On-going electricity costs for homeowner
- Occasional pump replacement costs for homeowner
- Risk associated with power outages, requiring mobile pump-out service
- Difficulty balancing current sizing requirements with future growth.

8.5 Vacuum System

With a vacuum sewer system wastewater from the household gravitates to a “pot” located in the road berm, along with flow from 3 or 4 other household. Once the wastewater in the pot reaches a certain level, a valve opens and the contents of the pot are sucked towards the central vacuum unit. The central vacuum unit maintains a negative pressure in the pipe network at all times and only operates occasionally to return the vacuum pressure when it drops due to a valve opening.

- Components on individual properties (“on-site components”)
  - Decommission existing septic tank
  - Gravity sewer to boundary
- Components common to all properties (“off-site components”)
  - Vacuum sewer wet well
  - Reticulated network – pressure reticulated sewers, inspection ports, air valves, line valves etc.

Benefits of Vacuum Sewer are:

- Lower installed cost than STEP system
- Shallower trenching than gravity system
- More seismically resilient than gravity system
- No ground water infiltration or root intrusion
- High velocities provide good scouring of pipe
- “Pot” is located in Council reserve – easy access for maintenance

Complications of Vacuum Sewers are:

- Must be open trenched – more surface disruption
- Less seismically resilient than low pressure sewer
- Pipes must be laid to defined grade by section
- No strong track record in NZ
- All treatment required at WWTP
- On-going power and O&M cost for Council
- Difficulty balancing current sizing requirements with future growth.

8.6 Option Comparison

Table 8-1 summaries the comparison of options.

For this high level assessment, the following key assumptions were made for carrying out the cost estimate:

- Straightforward trenching with little or no services to negotiate
- All work to be carried out as a single contract – reduced rates from economies of scale
- Three yearly pump-out of all septic tanks
- Existing septic tanks require to be decommissioned
- New septic tank installed as part of STEP system
- Gravity system; Annual inspection of the reticulation network, five-yearly repair to the network, and CCTV programme and cleaning of the network once every 20 years

- Two-monthly visual inspection and annual testing of the pump stations
- No costs have been allowed for community consultation
- No costs have been allowed for depreciation
- No costs have been allowed for those associated with obtaining permissions (e.g. NZTA)
- No costs have been allowed for Council in-house costs.

In each instance there is the ability to stage the development of the sewerage scheme. However, this is more economically viable where the initial service area is adjacent to the WWTP. For the purposes of this report it is assumed that subdivisions with higher density housing to be connected to the WWTP meet this criteria.

Table 8-1: Conveyance Options Benefits and Complications Summary

Options	Overview	Benefits	Complications	Summary
Option1: **Gravity**	Conventional gravity collection network – greater number of pump stations in network from Christchurch experience.	• Fewer "mechanical" components in the system • Lower Operation and Maintenance (O&M) costs • Negligible on-going direct costs to homeowner	• All treatment required at WWTP • Must be open trenched – more surface disruption • Deeper pipes typically required • Difficulty balancing current sizing requirements with future growth • Frequent manholes required • Odour problems at manholes • Pumping likely to still be required • Groundwater Infiltration • Root intrusion to pipe joints (Less likely with modern materials) • More susceptible to seismic events/differential settlement	Expensive, given the work required in State Highway and crossing rail tracks. Less suited to low population density areas like Darfield
Option 2.1: **Low Pressure Sewer**	Small pump station located at each property pumping to network and onto treatment plant.	• Lower installed cost than STEP system • Can be directionally drilled – less surface disruption • Shallower trenching than gravity system • More seismically resilient than gravity system • No ground water infiltration or root intrusion • Primary treatment/Septic tank pump out costs are not borne by the Council	• All treatment required at WWTP • On-going electricity costs for homeowner • Occasional pump replacement costs for homeowner • Pigging required to remove solids build up or fats, oils and grease • Difficulty balancing current sizing requirements with future growth • More frequent pump replacement than STEP system	More seismically resilient and able to be installed by directional drilling.

Options	Overview	Benefits	Complications	Summary
Option 2.2: **STEP System**	Small pump station located downstream or in each septic tank at each property pumping to network and onto treatment plant.	• Primary treatment carried out "on-site" – smaller treatment plant required • Can be directionally drilled – less surface disruption • More seismically resilient than gravity system • No ground water infiltration or root intrusion • Less likely to require pigging required to remove solids build up or fats, oils and grease	• Difficult to retrofit to existing septic tanks • Uncertainty on structural integrity of existing septic tanks • Replacement of some septic tanks likely • Higher installed cost than low pressure sewer • On-going electricity costs for homeowner • Occasional pump replacement costs for homeowner • Difficulty balancing current sizing requirements with future growth	More expensive than low pressure sewer due to need to replace septic tanks.
Option 3: **Vacuum Sewer**	Small chamber servicing 3 or 4 properties linked by a network of mains to a central vacuum station. Wastewater then pumped forward to treatment plant.	• Lower installed cost than STEP system • Shallower trenching than gravity system • More seismically resilient than gravity system • No ground water infiltration or root intrusion • High velocities provide good scouring of pipe • "Pot" is located in Council reserve – easy access for maintenance	• Must be open trenched – more surface disruption • Less seismically resilient than low pressure sewer, • Pipes must be laid to a grade • No strong track record in NZ • All treatment required at WWTP • On-going power and O&M cost for Council • Difficulty balancing current sizing requirements with future growth	Pipework must be installed by open trenching and laid to grade, no strong track record in NZ

8.7 Cost of future development

Table 8-2 shows the cost of future collection infrastructure based upon the rates for the existing population pro-rated for the peak future population. This cost does not allow for infill population growth and is based upon a lower future population density.

Table 8-2: Darfield Conveyance Options Capital Costs[1]

Item	Existing (2016 Population)	Future (2041 population)	Total
Option1: Gravity	$17.4 million	$14.6 million	$32.0 million
Option 2.1: Low Pressure Sewer	$14.6 million	$12.3 million	$26.9 million
Option 2.2: STEP System	$18.3 million	$15.4 million	$33.8 million
Option 3: Vacuum Sewer	$13.9 million	$11.7 million	$25.7 million

Notes:
1. Costs include capital works, P&G, design and contingency
2. At this stage, the accuracy of estimates are in the order of -15% to +40% and suitable for comparison between options.

These figures can be compared to a staged solution whereby infrastructure is installed to service 25% of the community as described in Section 7.2.3 (effectively in the order of 430 lots). If this were the case then the following comparison could be drawn as presented in **Table 8-3**, using Option 2.1 Low Pressure as an example for staging costs.

Table 8-3: Darfield Conveyance Staging Options Capital Costs

Item: Option 2.1: Low Pressure Sewer	Existing (2016 Population)	Future (2041 population)	Total
Full community development	$14.6 million	$12.3 million	$26.9 million
Partial Scheme Development			$7.8 million

Notes:
1. Costs include capital works, P&G, design and contingency
2. At this stage, the accuracy of estimates are in the order of -15% to +40% and suitable for comparison between options.

8.8 Option Discussion

The economic evaluation shows that “Option 3 – vacuum sewer” the lowest capital cost. “Option 1 – gravity sewer” typically has the lowest operating cost for full scheme development given the lower levels of pumping required within the system. However, “Option 2.1 – low pressure sewer”, is only marginally more expensive than Option 3 and provides significantly more resilience in seismic events.

STEP system mains are also very resilient in seismic events because the mains are also fully welded and the pipe grade is not critical. Vacuum sewers are fully welded but must be laid to a grade, so are less suitable for use in areas that may experience seismic events.

A STEP system will also initially provide a lower solids load than either the gravity or low pressure sewer system. This could result in a smaller treatment plant, however if the collection system was modified in the future to remove the settling aspect of the tank and all solids are pumped forward (as sometimes happens with STEP systems) then the plant could be undersized for the load. The result of this could be that in the short term (<5 years) that dosing is required at the WWTP. The likelihood of this occurring is beyond the scope of this report.

The Council should also consider the residents opinions of on-going maintenance and costs associated with maintaining the septic tanks and/or pumped systems within their properties. Whilst this may result in a lower capital cost of the system, this will result in the costs, particularly for ongoing operation and maintenance, being transferred to the homeowner. The on-site wastewater systems survey conducted as part of the Public Health Risk assessment (refer Section 2) identified varying levels of understanding and proactive maintenance of the septic tanks systems for private residences.

To varying degrees, all of the options rely upon power to operate the system. This leads to obvious issues with how they operate when there is a power outage. In reality, the experience around the world has been that these events are infrequent, that a combination of homeowner education on the storage available, and back-up generation, is sufficient to mitigate this concern. This risk can be mitigated by an emergency response plan to use a mobile service to pump down the individual pots if power is out for significant periods.

These factors should be considered by the Council when making a decision on the most appropriate system to select.

8.9 Summary

Whilst “Option 2.1 – low pressure sewer” isn’t the overall lowest cost option, we would recommend it be carried forward as the preferred option for the following reasons:

- over-riding factor of seismic resilience;
- lower ongoing operation and maintenance costs compared to Option 3: Vacuum systems;
- flexibility associated with alignment and installation depth; and
- fewer constraints for future connections.

This recommendation is subject to further investigation and analysis of the assumptions and other factors such as community acceptance of such a solution.

The indicative total NPV for this option is in the order of $15.5 million, using a discounting factor of 8% and 25 year horizon. If a staged approach is desired, with 25% of the community connected, then the indicative total NPV for this option is in the order of $8.0 million, using a discounting factor of 8% and 25 year horizon. These are pre-feasibility cost estimates and have a range of accuracy of –15% to +40% (excluding GST). This is considered appropriate for this stage of the investigation.

9 Recommendations

9.1 Introduction

The figures calculated in this report are on the basis of a per lot servicing model up to full development (projected design populations). This includes capital cost estimates for:

- Connection at each lot,
- Conveyance from each site to treatment,
- Wastewater Treatment; and
- Wastewater Disposal.

It is the Council’s policy that the individual development is responsible for meeting the costs of all internal infrastructure i.e. collection and conveyance capital costs within their own development to the boundary of the site. Therefore the total sums as presented in this report may need to be modified when setting development contributions.

The creation of a development contributions strategy has been excluded from this scope of works and would need to be considered with the SDC Planning and Finance team at the next stage of this project. A holistic view will need to be taken to weigh up the savings to the new development areas i.e. the variation costs between a septic tank and disposal field and that of a single on site pump station. The removal of on-site treatment gives an advantage of considering higher density developments.

Any scheme that is introduced will need to meet ECan's requirements of not creating a localised contaminant plume from the development.

9.2 Total Scheme Costs

There are four scenarios under which the following recommendations are made (based on assumptions within this desktop exercise). These are;

- full community development immediately, or
- servicing part of the community (approximately 25%).
- and in each instance, with or without land purchase for land disposal

The recommended community sewerage system for Darfield is a low pressure sewer system with treatment via a waste stabilisation pond and disposal via irrigation to land designated for disposal of treated wastewater. This is reflected in **Table 9-1** and cost estimates below.

The costs below are exclusive of GST and have a -15% to +40% confidence band due to the assumptions used, which is considered appropriate for this stage of the project.

Table 9-1: Darfield Conveyance Staging Options Capital Costs

Service Area	Provision for Land	Item	Estimated Cost
Full community development	Full Land Purchase	Treatment Conveyance Total Capital Est. per lot	$13.9 M $26.9 M $40.8 M $23,700
	Land as Free Supply	Treatment Conveyance Total Capital Est. per lot	$8.4 M $26.9 M $35.3 M $20,500
Partial Scheme Development	Full Land Purchase	Treatment Conveyance Total Capital Est. per lot	$4.7 M $7.8 M $12.5 M $29,100
	Land as Free Supply	Treatment Conveyance Total Capital Est. per lot	$3.1 M $7.8 M $10.9 M $25,300

Notes:
1. Per lot development costs for full development are based on 1,720 lots in 2041
2. Per lot development costs for partial development (25%) are based on 430 lots (generally residential)
3. The per lot estimates do not include for financing charges that would otherwise be included in development contributions

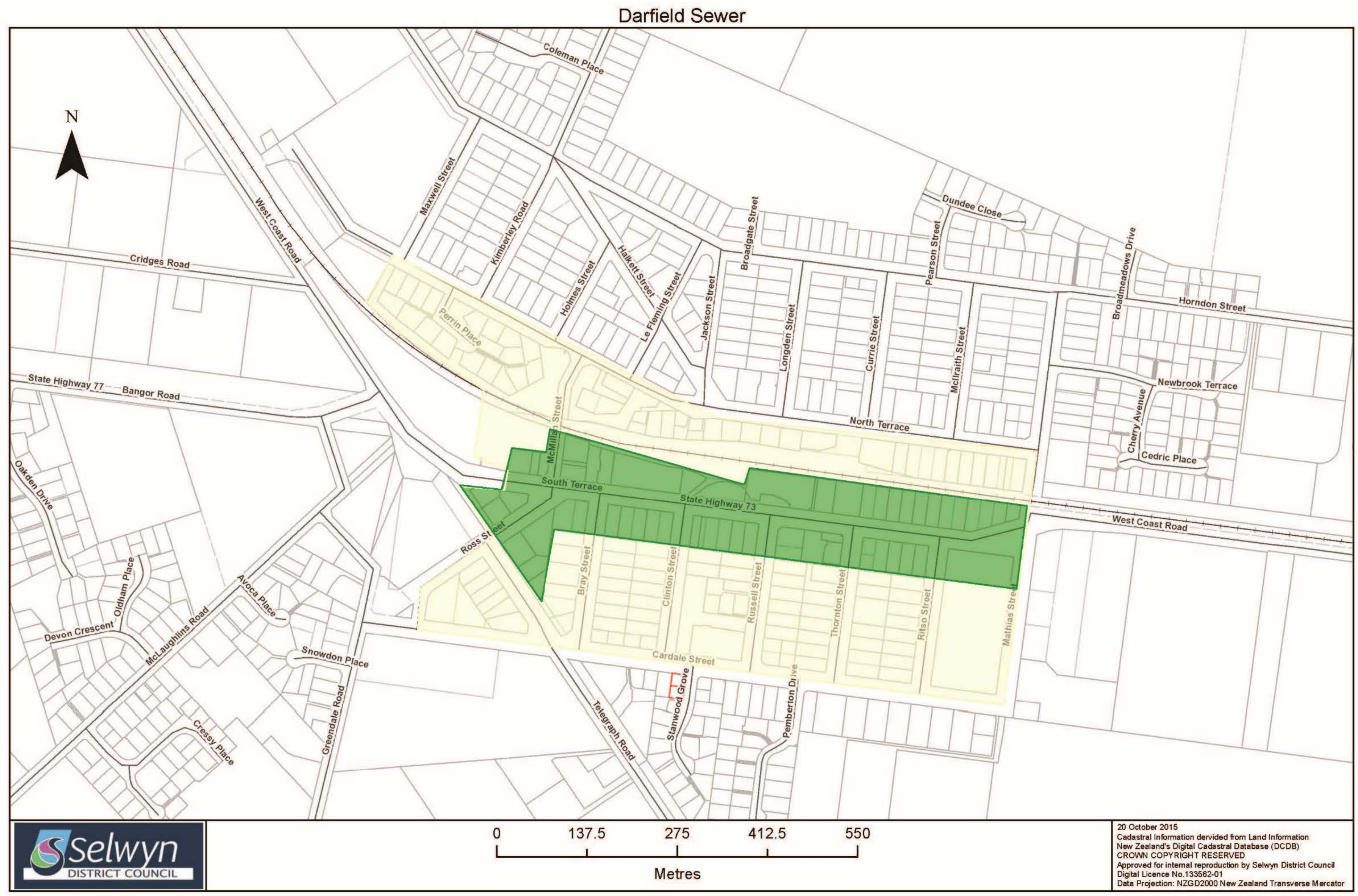
9.3 Way Forward

Development of the full community catchment and a partial scheme development proposal have been considered to meet potential residential and commercial growth. The addition of a partial catchment solution is a deviation from the recommendations defined in the 2012 Darfield and Kirwee Sewerage Options Study, although the full community approach remains the same.

The next stage of this process would be to discuss the outcomes of this strategy with the key stakeholders, noting that:

- Irrigation to land is considered the most viable option for disposal;
- Refinement will be required of the preferred option(s) and associated capital costs, including layout plans;
- Financing of options will require commentary from SDC financial services;
- Land adjacent to Darfield is owned by SDC and would be considered for irrigation of treated wastewater. How the cost of this land is integrated with the option selected may alter the preferred options.

Appendix A Planning Maps


Darfield Sewer
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Kimberley Road
Holmes Street
Halkett Street
Le Fleming Street
Jackson Street
Broadgate Street
Longden Street
Currie Street
Pearson Street
Mcllraith Street
Dundee Close
Broadmeadows Drive
Horndon Street
Newbrook Terrace
Cherry Avenue
Cedric Place
West Coast Road
Cridges Road
Perrin Place
State Highway 77
Bangor Road
North Terrace
McMillan Street
South Terrace
State Highway 73
West Coast Road
Oakden Drive
Ross Street
Oldham Place
Devon Crescent
McLaughlins Road
Avoca Place
Snowdon Place
Bray Street
Clinton Street
Russell Street
Thornton Street
Ritso Street
Mathias Street
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