MWH
BUILDING A BETTER WORLD

REPORT

Darfield and Kirwee Sewerage Scheme Options

Prepared for Selwyn District Council

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QUALITY STATEMENT

PROJECT MANAGER	PROJECT TECHNICAL LEAD
Warren Biggs	A. Mitchell

PREPARED BY		
C. McKenzie, A. Mitchell, I. Oldfield, S. East	[signature]	22/11/2012
CHECKED BY		
S Bishop	[signature]	22/11/2012
REVIEWED BY		
C Mellish	[signature]	22/11/2012
APPROVED FOR ISSUE BY		
Shane Bishop	[signature]	22/11/2012

CHRISTCHURCH
Hazeldean Business Park, 6 Hazeldean Road, Addington, Christchurch 8024
PO Box 13-249, Armagh, Christchurch 8141
TEL +64 3 366 7449, FAX +64 3 366 7780

Executive Summary

In October 2012, Selwyn District Council (SDC) commissioned MWH to provide a high level desktop assessment for a community sewerage system for conveyance, treatment and disposal of wastewater in Darfield and Kirwee. The purpose of this report is to summarise the initial assessment for a community scheme and recommend a way forward for future servicing options.

Darfield and Kirwee are two of the larger un-sewered communities in the Selwyn District. The current combined population is around 3,050 and is projected to grow to 5,500 people in 2036 and then slowly reduce due a predicted decline in the number of occupants per house.

Currently, wastewater treatment and disposal is via individual septic tank systems with subsurface disposal fields. The status quo option, to remain of septic tanks, is outside the scope of this report which was to assess options for a community sewerage scheme. However, MWH consider that it is unlikely that septic tanks will be an acceptable long term solution as the community grows because it would result in an increase in the discharge of nitrogen and phosphorous to groundwater, which Canterbury Regional Council (ECan) is expected to cap at current levels. ECan is currently developing the mass limits, and is expected to confirm these and the approach for implementation of the limits during 2013.

Treated Wastewater Quality Required

The limiting factor for any option considered for the servicing of Darfield & Kirwee 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 an assessment of environmental effects has not been completed at this stage, an initial assessment was made and the following level of treatment is expected to be required for disposal via irrigation to land:

- BOD and TSS: provide biological secondary treatment and clarification
- Microorganisms: faecal coliform concentration of 10,000 to 100,000 cfu/100ml
- Nutrients:
  - Currently ECan is expected to cap nutrient leaching to estimated current levels
  - Manage nutrient application to land by providing sufficient land area
  - Loading rates based on <150kg-N/ha/y and preferably <50kg-P/ha/y.

Planning and Hydrogeological Review

MWH completed a planning and hydrogeological assessment which can be summarised as follows:

- The NRRP[1] and LWRP[2] are relevant to the proposed treatment and disposal of treated wastewater to land.
- Schedule 8 of the LWRP, although not currently written, will set limits for the nitrogen and phosphorus discharge for different underlying land uses.
- Recent 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 and Kirwee areas. Both spatial and temporal variations in groundwater quality were thought to be largely associated with other land use activities in the surrounding area.
- However, ECan will tightly control leaching of nutrients to groundwater from all sources. This is expected to include mass limits for nitrogen and phosphorous corresponding to the estimated current discharge to groundwater from septic tanks in Darfield and Kirwee. If this is implemented then it would require a reduction in nutrients to groundwater to allow for population growth (i.e. improved treatment of wastewater would be required).
- 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.

[1] Natural Resources Regional Plan (NRRP)
[2] Land and Water Regional Plan (LWRP)

Treatment Options

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

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

If ECan require the nutrient discharge to be maintained at current levels then it is possible that Kirwee could remain on septic tanks because no growth is projected. However, the population of Darfield is expected to approximately double, so an improvement in treatment would be required and this is likely to require a community sewerage system.

Based on the assumptions made within this report, the recommended treatment option for Darfield, and Kirwee if desired, is an activated sludge plant with biological nutrient removal. This type of plant has the following advantages:

- Low nutrient concentrations in treated wastewater – this offers the best potential for meeting initial and future long term nutrient limits.
- Smallest land area required for irrigation – resulting in lower overall capital cost, depending on land availability and purchase price.
- Similar overall NPV cost, when land area for irrigation is considered, to other lower level treatment options.

The estimated capital cost for the treatment plant, irrigation system and land is $10.6 million.

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, and Kirwee if desired, 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 $13.4 million and Kirwee being $7.4 million for collection and conveyance to Darfield. The cost to develop future collection and conveyance infrastructure is $20.7 million; this cost is exacerbated by a decrease of population density along with the additional population growth.

Recommendations

Based on the assumptions made in this desktop assessment, MWH recommends that the preferred option for a community sewerage system for Darfield, and Kirwee if desired, should be a low pressure sewer system with treatment via an activated sludge plant with biological nutrient removal and disposal via irrigation to land designated for disposal of treated wastewater. This is a high level recommendation and is subject to further investigation and analysis.

Assuming Kirwee is included, the estimated total capital cost for the project is $51.9 million resulting in an expected cost per lot of $21,500 based upon a 2036 lot number of 2,400.

With Kirwee excluded the estimated total capital cost for the project is $43.1 million resulting in an expected cost per lot of $21,000, based upon a 2036 lot number of 2,050.

These costs 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.

Way Forward

There are a number of unresolved or uncertain issues which will have significant impact on the way forward for a Darfield, and possibly Kirwee, community sewerage scheme. The key issues include:

1. Potential ECan district wide nitrogen and phosphorous limits on discharge to groundwater, and potential nitrogen and phosphorous land application limits based on underlying land use – ECan is currently developing these limits and they are expected to be released during 2013. These potential limits, and how ECan will implement them, are key to the level of treatment required and whether septic tanks could be a viable option for Darfield, at this point it is expected that a higher level of treatment is required and that this is best provided by a community treatment plant.
2. Key stakeholders have not been consulted on options available – this report is a good initial step for possible sewerage conveyance and treatment options to be discussed. Irrigation to land is considered the only viable option for disposal.

The suggested way forward is as follows:

- Engage with key stakeholders on conveyance and treatment options
- Further refine the preferred option(s) and associated capital costs
- Development of financing options for the scheme.

Selwyn District Council
Darfield and Kirwee Sewerage Scheme Options

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1 Introduction

1.1 Background

In October 2012, Selwyn District Council (SDC) commissioned MWH to provide a desktop assessment for a community sewerage system for conveyance, treatment and disposal of wastewater in Darfield and Kirwee. The purpose of this report is to summarise the assessment and recommend a way forward for future servicing options.

Darfield and Kirwee are two of the larger un-sewered communities (combined population ~3,050) in the Selwyn District. Treated wastewater disposal is to ground via individual septic tank system. This is unlikely to be an acceptable long term solution as the community grows because it would result in an increase in the discharge of nitrogen and phosphorous to groundwater[3]. The last technical appraisal of sewerage options for Darfield was completed in February 2004 by MWH, which compared on-site septic tank disposal and community sewerage systems.

Since the 2004 MWH report, PDP Limited has modelled the impact of Darfield and Kirwee wastewater discharges on groundwater quality (July 2011), and Liquid Earth Limited has also undertaken and reported on groundwater monitoring.

Also since the completion of the 2004 report, ECan has released the proposed Natural Resources Regional Plan (NRRP) has been adopted and will be superseded by the Land and Water Regional Plan (LWRP) during 2013.

1.2 Scope

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

1. **Planning Review:** review of planning constraints and hydrogeological review of recent reports by PDP and Liquid Earth.
2. **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.
3. **Cost Estimates:** comparative project cost estimates for 3 conveyance and 3 treatment options.
4. **Options Report:** summary of the above items and make recommendations for the conveyance, treatment and disposal of wastewater for Darfield and Kirwee.

The scope of this assessment is limited to potential options for a community sewerage scheme for Darfield and Kirwee.

[3] The Canterbury Regional Council (ECan) is expected to cap nitrogen and phosphorus at the estimated current mass of nitrogen and phosphorous discharged to groundwater. ECan is currently developing the mass limits, and is expected to confirm these and the approach to implementing them during 2013.

2 Planning Review

2.1 Introduction

MWH has reviewed the NRRP and LWRP (section 2.2), and the recent PDP groundwater modelling report and the Liquid Earth groundwater quality reports (section 2.3).

2.2 Review of Planning Constraints

There are currently two Regional Plans that must be considered when assessing the planning constraints for any work conducted within the Canterbury Region. The first is the Natural Resources Regional Plan (NRRP), which is the operative Regional Plan for Canterbury. The second is the proposed Land and Water Regional Plan (LWRP) which was notified in August 2012 and will supersede the NRRP once the submissions process is complete (expected to be mid 2013). The proposed activity, disposal of treated wastewater to land, has been assessed under the rules of both plans.

2.2.1 Natural Resources Regional Plan (NRRP)

Rule WQL14 deals with the discharge of treated wastewater to land from a community wastewater system. The proposed activity would be classed as a restricted discretionary activity if the discharge to land was sited in an area that complied with all the conditions of the rule (attached in Appendix A). In particular Condition 2 states that the discharge shall not occur within the Community Drinking Water Supply Protection Zone. The activity is classed as a prohibited activity if this condition cannot be met and therefore no resource consent can be granted. Discretion is reserved primarily to ensure that ground and surface water quality are protected.

2.2.2 Land and Water Regional Plan (LWRP)

The proposed activity can be split into two parts when assessed under the rules of the proposed LWRP. Rule 5.62 states that the use of land for a community wastewater system and the discharge of treated wastewater onto or into land is a discretionary activity. As with the NRRP the discharge of treated wastewater into a Community Drinking Water Supply Protection Zone is a prohibited activity.

The Section 32 Report for the LWRP states that the control of nutrients is the single most significant change from the NRRP position. The Canterbury Regional Council (ECan) has introduced a set of rules which control the loss of nitrogen from land used for a 'farming activity'. Farming activity has currently not been defined and therefore there is some uncertainty in regards to whether this proposal, to treat and dispose of municipal wastewater, will fall under these rules. The use of the land irrigated with treated wastewater is likely to control whether these rules will be applied to this activity. For the purposes of this assessment it is assumed that any discharge will need to comply.

ECan has split the Canterbury Region into Nutrient Allocation Zones, based on the water quality of these catchments. Green zones meet water quality outcomes, orange zones are classed as at risk and red zones are areas where water quality guidelines are not met. Darfield is situated in the Selwyn – Waihora Nutrient Allocation Zone which is classed red. This means that ECan considers water quality outcomes are not currently being met in this area. It is likely that future restrictions on nitrogen and phosphorous loads will restrict nitrogen and phosphorous leaching to below that which is currently occurring for all activities within the allocation zone in an effort to improve the degraded water of this area.

Until 1 July 2017 any farming activity in this area which existed before 11 August 2012 is a permitted activity, if a record of nitrogen loss is kept using OVERSEER™. Until 1 July 2017 any *change* (refer to definitions Appendix A in farming activity is a permitted activity so long as the conditions of Rule 5.42 are met. These conditions include monitoring nitrogen loss using OVERSEER™ and preparing a Farm Environment Plan. A *change* in farming activity in the proposed activity area that does not comply with these conditions is a non-complying activity (refer to Appendix A for a full set of conditions). From 1 July 2017 the use of land for a farming activity is a permitted activity if all the conditions of Rule 5.46 are met. Condition 2 of Rule 5.46 states that the average annual loss of nitrogen shall not exceed the rate outlined in the relevant farming activity in Schedule 8 (Schedule 8 has not currently been prepared). From 1 July 2017 any farming activity which does not meet Condition 2 and is in an area zoned red will be a non-complying activity. It is expected that any activity classed non-complying will be difficult to obtain resource consent for and ECan has indicated any such activity will be publicly notified.

If the irrigation of wastewater onto land as part of this activity is considered under the farming activity rules it is expected that levels of nitrogen leaching will be tightly controlled. However, moving to a community wastewater treatment system from the current on site systems will significantly reduce the total quantity of nitrogen leached within this area, and this can be used to demonstrate the positive groundwater quality outcomes from the proposed system[4].

2.3 Review of Hydrogeological Constraints

A review of previous reports related to the assessment of effects on groundwater from wastewater disposal at Darfield and Kirwee was undertaken. Appendix B contains the full review which is summarised here. The review included the following reports:

1. Darfield Sewerage Options Technical Appraisal (MWH, 2004a)
2. Kirwee Sewerage Options Technical Appraisal (MWH, 2004b)
3. Modelling the Impacts of Darfield and Kirwee Wastewater Discharges on Groundwater Quality (PDP, 2011)
4. Darfield/Kirwee Groundwater Monitoring February 2012 Update (Liquid Earth, 2012)[5]

The hydrogeological review is briefly summarised in the sections below.

2.3.1 Hydrogeology

Both Darfield and Kirwee are underlain 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 around 75 metres beneath Kirwee. Groundwater flows in a south-easterly direction.

2.3.2 Groundwater Quality

The Liquid Earth (2012) report summarises the groundwater quality for the Darfield and Kirwee area. The report found that there was little indication of contamination likely to be associated with the on-site wastewater disposal in the Darfield and Kirwee areas. Both spatial and temporal variations in groundwater quality were thought to be largely associated with other land use activities in the surrounding area.

Nitrate concentrations in the area surrounding Darfield and Kirwee ranged from 2.2 to 9.4 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.

2.3.3 Summary of Previous Modelling

There are considerable differences in the calculated plume extents between the MWH and PDP modelling. A detailed review of the modelling, to identify the reasons for the differences, has not been undertaken at this stage of the assessment. After this preliminary review there does not appear to be any reason to value the validity of the results of one of these reports over the other.

Neither model incorporates the design flows and loads that are now relevant for Darfield and Kirwee. In addition, these models do not consider the nitrogen removed from the system due to plant growth and removal that would be part of any irrigation proposal. However, this is consistent with the ECan assumption that septic tank discharges are below the root zone and therefore all nutrients drain to groundwater.

For a consent application for discharge of treated wastewater to land, the modelling would need to be repeated, to include the design flow and loads and incorporate estimated nitrogen and phosphorous uptake in the root zone for above ground irrigation.

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[4] This position is further supported by recent correspondence between Ecan and SDC defining the potential limits that may be placed on nitrogen and phosphorous discharges to groundwater from municipal wastewater treatment facilities in the Selwyn District.

[5] Darfield/Kirwee groundwater monitoring reports from 2008 and 2009 (SKM) and 2011 (Liquid Earth) were sighted but not included in the review as 2012 report provides a summary of these previous reports (including those from 2006) and a discussion of temporal changes in groundwater quality.

2.3.4 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 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 waste water 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.

2.4 Summary

The above planning and hydrogeological assessment can be summarised as follows:

- The NRRP[6] and LWRP[7] are relevant to the proposed treatment and disposal of treated wastewater to land.
- Schedule 8 of the LWRP, although not currently written, will set limits for the nitrogen and phosphorus discharge for different underlying land uses.
- Recent 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 and Kirwee areas. Both spatial and temporal variations in groundwater quality were thought to be largely associated with other land use activities in the surrounding area.
- However, ECan will tightly control leaching of nutrients to groundwater from all sources. This is expected to include mass limits for nitrogen and phosphorous corresponding to the estimated current discharge to groundwater from septic tanks in Darfield and Kirwee. If this is implemented then it would require a reduction in nutrients to groundwater to allow for population growth (i.e. improved treatment of wastewater would be required).
- 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.

[6] Natural Resources Regional Plan (NRRP)
[7] Land and Water Regional Plan (LWRP)

3 Projected Flows and Loads

3.1 Projected Population

Population projections for Darfield and Kirwee have been taken from the table available from the SDC website in October 2012 and reproduced in Table 3-1.

Table 3-1: Projected Population for Darfield and Kirwee

Year	2011	2016	2019	2021	2026	2031	2036	2041
Darfield	2,176	2,304	2,552	2,797	3,474	4,371	4,715	4,605
Kirwee	871	855	854	858	855	834	814	796
Total	**3,047**	**3,159**	**3,406**	**3,655**	**4,329**	**5,205**	**5,529**	**5,401**

These projections are based on the 2008 BERL estimates for the Selwyn District. Therefore the projections have no allowance for additional growth due to the earthquakes in 2010 and 2011. However some additional growth that could be expected in Eastern Selwyn towns of Lincoln, Prebbleton and Rolleston following the earthquakes is less likely in Darfield and Kirwee which are further outside Christchurch.

The impact of the new Fonterra milk processing plant at Darfield could cause an increase in residents beyond that allowed for growth in the population projection for Darfield and Kirwee. 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.

3.2 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. The population peaks in 2036 when the maximum number of lots is expected to be reached. This has been taken as the design year. Following this, the number of people per house is expected to decline leading to a lower population after 2036.

Table 3-2 contains the projected flows and loads for Darfield and Kirwee 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 3-2: Projected Flows and Loads

Parameter	Unit	2016	Design 2036	Comments
Flows				Population peaks in 2036
ADWF	m³/d	704	1,232	220 L/p/d (clause 6.4.3)
Peak Diurnal	m³/d	1,760	3,080	2.5 P/A dry weather diurnal peaking ratio (clause 6.4.1)
Maximum Flow	m³/d	3,520	6,160	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	208	364	65g/PE/d
TSS	kg/d	224	392	70g/PE/d
TN	kg/d	42	73	13g/PE/d
TP	kg/d	80	140	2.5g/PE/d

Notes:

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

4 Treatment and Disposal of Wastewater

4.1 Treated Wastewater Quality Required

The limiting factor for any option considered for the servicing of Darfield & Kirwee 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.

4.1.1 BOD and TSS

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/Kirwee area, significant breakdown of any remaining organic matter in the discharge can therefore be expected to occur.

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

4.1.2 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 2.3 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.

4.1.3 Nutrients

ECan are currently in the process of developing mass limits for discharge of nitrogen and phosphorus into groundwater in the Selwyn and wider Canterbury plains. New discharge consent applications will require a thorough assessment of the nutrient balance and the mass of nitrogen and phosphorous drainage into groundwater.

The nutrient mass limits that will be applied will be uncertain until the ECan LWRP is finalised in 2013. However, recent 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.

4.1.4 Summary

The following treated wastewater quality is expected to be required for disposal by irrigation to land in the area of Darfield:

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

4.2 Treatment and Disposal Options

4.2.1 Introduction

The levels of treatment assessed for Darfield and Kirwee are listed below:

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

Staged upgrades (i.e. multiple units) have not been considered as the current population of 3,050 is greater than 50% of the ultimate design population in 2041 of 5,600, and single unit systems are generally used for small WWTP due to the additional construction cost of multiple units.

The status quo option, to remain on septic tanks, is unlikely to be a viable option if new development is desired. MWH consider that it is unlikely that septic tanks will be suitable if/when ECan introduce limits on nitrogen and phosphorus as improved treatment is expected to be required to allow for population growth without exceeding the nitrogen and phosphorous limits.

On the basis that ECan will cap nutrient limits at the current level, Darfield is likely to need a community sewerage system in order to allow for the projected population growth from around 2,200 currently to 4,700 in 2036 (population is predicted to decline after 2036 due to projected decline in the number of residents per house). However, Kirwee could possibly remain on septic tanks as its population is projected to slightly decline over the next 30 years from around 870 currently to 800 people in 2041 and the Liquid Earth (2012) report states that the groundwater monitoring data had little indication of contamination likely to be associated with the on-site wastewater disposal.

For the purposes of this report, a consideration has been made assuming that Kirwee is to be upgraded to a community sewerage system for comparison. However, it is possible that it could remain on septic tanks if desired and the costs presented for treatment and conveyance could be reduced accordingly.

4.2.1.1 Option 1 High Level: BNR plant

A BNR plant would be similar to the existing Pines I WWTP, which was designed for a design population of 6,000 PE, with 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 4.2.2).

4.2.1.2 Option 2 Medium Level: 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 a 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.

4.2.1.3 Option 3 Low Level: 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.

4.2.2 Expected Performance

Table 4-1 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 4-1: 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 existing performance of 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 4-2 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 recent reports – leaching rates at different nitrogen application rates were not provided).

Table 4-2: 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	21	45	90
Total irrigation block area required[1]	Ha	42	90	180
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 and Kirwee. 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.

4.2.3 Capital Cost Estimate

Table 4-3 presents the estimated capital cost for each option. The purchase of land for irrigation and the WWTP is a major component and has been provided additional to the WWTP capital costs. Contractor preliminary and general costs are considered to be equal between the options and are based on around 5% of the construction cost. The contingency (accounting for uncertainty in scope) and engineering design and monitoring costs 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 4-3: Estimated Capital Cost for Options 1 to 3

Item	OPTION 1: BNR ASP (million)	OPTION 2: TF (million)	OPTION 3: WSP (million)
WWTP	$ 5.5	$ 4.4	$ 2.0
Irrigation Equipment	$ 1.2	$ 2.1	$ 4.0
Subtotal	***$ 6.7***	***$ 6.5***	***$ 5.8***
Preliminary & General	$ 0.4	$ 0.4	$ 0.3
Contingency	$ 1.0	$ 1.0	$ 0.9
WWTP Construction Estimate	***$ 8.1***	***$ 7.9***	***$ 7.0***
Land Purchase[1]	$ 1.5	$ 3.2	$ 6.3
Planning and Consents	excl.	excl.	excl.
Engineering Design and Construction Monitoring	$ 1.0	$ 0.9	$ 0.8
Total Project Estimate[2]	**$ 10.6**	**$ 12.0**	**$ 14.1**

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.

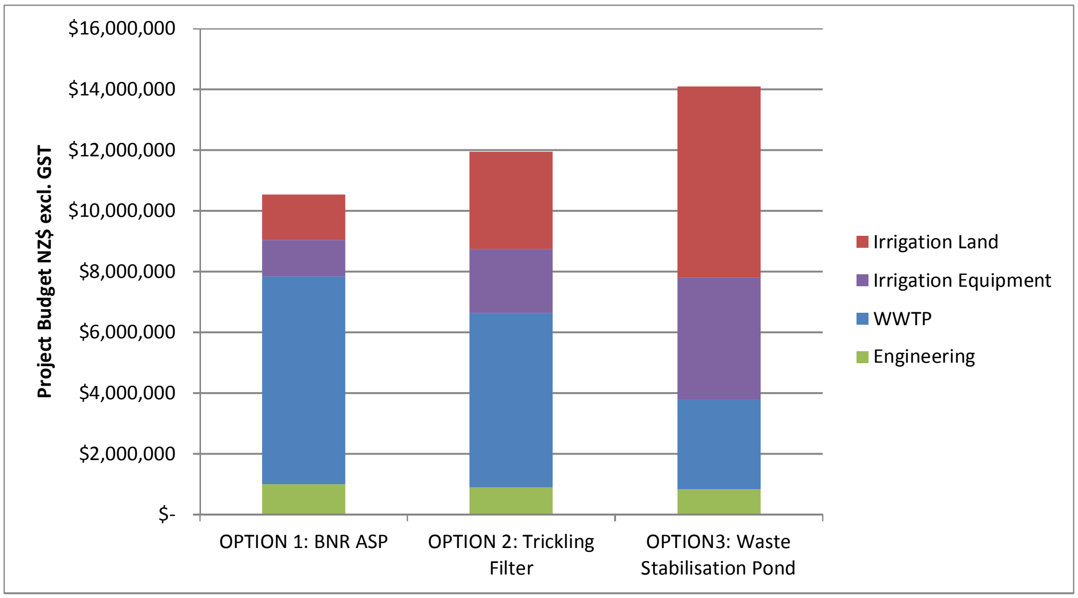

Figure 4-1: Capital Cost Comparison

Table 4-4 and Figure 4-2 contain estimates for operating costs and a simple Net Present Value (NPV) calculation (initial capital in the first and estimated annualised operation and maintenance costs for the following 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 4-4: Estimated Operating Cost and NPV

Item	OPTION 1: BNR ASP (million)	OPTION 2: TF (million)	OPTION 3: WSP (million)
Estimated Capital Cost	$10.5	$12.0	$13.7
Estimated Operating Cost	$0.5	$0.4	$0.3
Simple NPV (25 Years)	$15.2	$15.8	$15.5

Notes:

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

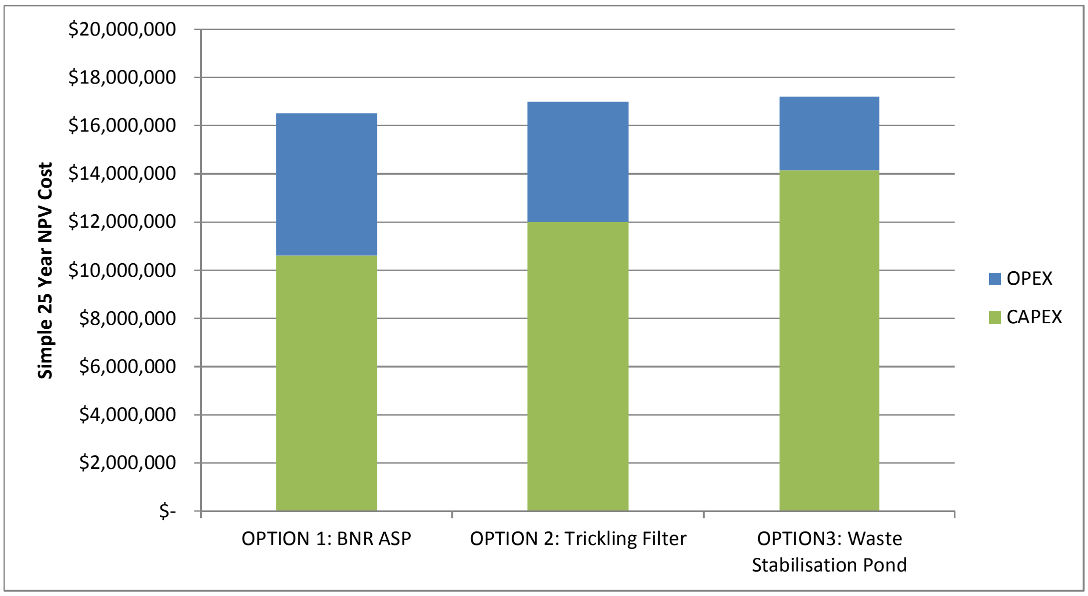

Figure 4-2: Comparison Based on Simple 25 Year NPV

4.2.4 Discussion

4.2.4.1 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 ($5.5 million) and operating cost ($0.5 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 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. It is therefore the best option to comply with the more stringent nitrogen and phosphorus limits expected. The initial assessment shows 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 results in an intermediate area of land required and at a TP application rate that results in no leaching of phosphorous to groundwater (according to the assumptions used by ECan).

While the WSP (option 3) has the lowest capital and operating costs, 40% and 60% of BNR capital and operating costs respectively, the area of land needed due to the relatively high TN concentration is prohibitively large and would result in additional capital costs of approximately $10 million, making this option the most expensive in terms of overall capital cost. Therefore the WSP (option 3) is unlikely to be feasible due to the nitrogen application limits (note while the loading could be increased to maintain the current mass of nitrogen to groundwater, this is true of all the options and the WSP option will require around 4 times the land area compared to the BNR plant (option 1).

4.2.4.2 Potential Nutrient Limits

The potential nitrogen and phosphorus mass limits that ECan will impose are relatively uncertain at this stage. Part of the uncertainty is the potential for leaching of nitrogen and phosphorus at varying application rates to land. The impacts of the potential limits are outside the scope of this assessment; however the land application rates and leaching assumed by ECan in the most recent estimates 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 a clear advantage for compliance with potential future phosphorus limits.

4.3 Summary

On the basis of the assumptions used, the BNR plant (option 1) has the lowest capital and NPV costs despite having the highest WWTP capital cost and highest operating and maintenance costs. This is due to the reduced area of land required for irrigation and the subsequent cost savings in land purchase and irrigation equipment. The BNR plant has the best potential for meeting potential nutrient limits, particularly lower cost biological phosphorus removal.

At this stage, the recommended treatment option for Darfield, and Kirwee if desired, is option 1 BNR plant. This recommendation should be confirmed by further investigation and analysis of the assumptions and other costs. This type of plant has the following advantages:

- Low nutrient concentrations in treated wastewater
- Smallest land area required for irrigation
- Lowest NPV cost when land area is considered.

5 Conveyance Options

5.1 Overview

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

The first part of this looks at the various options available for conveyance within Darfield. As discussed earlier in the report, maintaining a status-quo for Kirwee mean there is no requirement for a conveyance system. The collection system costs for Darfield could be pro-rated for Kirwee to indicate a cost for a collection system if required.

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.

This section also considers the potential for pumping the wastewater to the Pines WWTP.

5.2 Collection System

As Darfield and Kirwee 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
- 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.

All options will require a terminal pump station to lift the wastewater to the WWTP inlet. Current thinking with gravity sewers in Christchurch is to have steeper shorter sections that have a greater number of pump stations, this will mean that the “gravity” option may still require pump stations and the associated on-going power costs as well as maintenance.

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 detailed design. However, as the grades across the township are relatively shallow and also because of the recent 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.

The main options available are considered below.

5.3 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
- 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.

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

5.4 Low Pressure Pumped/STEP

5.4.1 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 pit
    - 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
- Primary treatment/Septic tank pump out costs are not borne by the Council.

Complications of Low Pressure Sewers are:

- 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.

5.4.2 STEP 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”)
  - Decommission 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 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:

- 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.

5.5 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 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.

5.6 Pumping to Pines WWTP

Given the large wastewater treatment facility already in place at Pines, the option of pumping to the new plant has also been considered.

Kirwee is approximately 100m higher than and 19km from the new Pines WWTP, with Darfield a further 9km and another 50m higher.

The advantages of this option are:

- Centralised treatment
- No additional discharge consents required.

Disadvantages of this option are:

- Additional capital cost at Pines WWTP
- Septicity issues due to long transit times
- Higher capital cost
- Technical issues associated with pumping downhill
- Earlier upgrades required at Pines WWTP – associated capital contributions required.

A breakdown of costs for this option is included in Table 5-1:

Table 5-1: Estimated Capital Cost for Pumping to Pines WWTP

Item	Description	Capital Cost (million)	OPEX
Darfield Pump Station	Pump Wastewater from Darfield to Pines	$0.6	$6,000
Kirwee Pump Station	Pump wastewater from Darfield and Kirwee and Pump to Pines	$0.7	$7,000
Pipeline from Darfield to Kirwee	280 OD HDPE – 9 km	$2.4	$2,000
Pipeline from Kirwee to Pines	315 OD HDPE – 19 km	$6.1	$1,0000
Connection to Pines WWTP	Cost to upgrade treatment plant for additional flow	$4.3	$180,000
Construction Estimate		$14.1	
Simple NPV (25 years)		$16.0	

Notes:

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

The above costs do not include collection with Darfield or Kirwee, nor operating costs. The capital cost of this option is significantly more than those based upon treatment around Darfield. The operational expenditure is also likely to be more due to the need for two large pump stations, a long pipeline and the additional treatment at Pines WWTP.

This option has not been considered further.

5.7 Option Comparison

Table 5-2 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.

Table 5-2: Conveyance Options Benefits and Complications

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 and Kirwee
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

5.8 Cost of future development

Table 5-3 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 5-3: Darfield Conveyance Options Capital Costs[1]

Item	Existing	Future (2036 – Peak population)	Total
Option1: Gravity	$15.8 million	$24.4 million	$40.1 million
Option 2.1: Low Pressure Sewer	$13.4 million	$20.7 million	$34.1 million
Option 2.2: STEP System	$16.9 million	$26.0 million	$42.9 million
Option 3: Vacuum Sewer	$12.7 million	$19.6 million	$32.4 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.

5.9 Option Discussion

The economic evaluation shows that “Option 3 – vacuum sewer” the lowest capital cost and “Option 1 – gravity sewer” has the lowest operating cost. However, “Option 2.1 – low pressure sewer”, is only marginally more expensive 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 also 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 additional 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 within their properties. Whilst this may result in a lower capital cost of the system, this will result in the costs being transferred to the homeowner.

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 so infrequent, that a combination of homeowner education on the storage available, and back-up generation, is sufficient to mitigate this concern.

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

5.10 Summary

Whilst “Option 2.1 – low pressure sewer” isn’t the overall lowest cost option, the minor additional cost and over-riding factor of seismic resilience means that it is recommended option for collection and conveyance. This recommendation is subject to further investigation and analysis of the assumptions and other factors.

The indicative total NPV for this option is in the order of $14.3 million, using a discounting factor of 8% and 25 year horizon. This is a pre-feasibility cost estimate and has a range of accuracy of –15% to +40% (excluding GST). This is considered appropriate for this stage of the investigation.

6 Recommendations

6.1 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.

6.2 Total Scheme Costs

Based on the assumptions made in this desktop assessment, MWH recommended that the community sewerage system for Darfield, and Kirwee if desired, should be a low pressure sewer system with treatment via an activated sludge plant with biological nutrient removal and disposal via irrigation to land designated for disposal of treated wastewater.

Assuming Kirwee is included, the estimated total capital cost for the project is $51.9 million resulting in an expected cost per lot of $21,500 based upon a 2036 lot number of 2,400.

With Kirwee excluded the estimated total capital cost for the project is $43.1 million resulting in an expected cost per lot of $21,000, based upon a 2036 lot number of 2,050.

These costs 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.

7 Way Forward

There are a number of unresolved or uncertain issues which will have significant impact on the way forward for a Darfield, and possibly Kirwee, community sewerage scheme. The key issues include:

1. *Potential ECan district wide nitrogen and phosphorous limits on discharge to groundwater, and potential nitrogen and phosphorous land application limits based on underlying land use* – ECan is currently developing these limits and they are expected to be released during 2013. These potential limits, and how ECan will implement them, are key to the level of treatment required and whether septic tanks could be a viable option for Darfield, at this point it is expected that a higher level of treatment is required and that this is best provided by a community treatment plant.
2. *Key stakeholders have not been consulted on options available* – this report is an initial step for possible sewerage conveyance and treatment options to be discussed. Irrigation to land is considered the only viable option for disposal.

The suggested way forward is as follows:

- Engage with key stakeholders on conveyance and treatment options
- Further refine the preferred option(s) and associated capital costs
- Development of financing options for the scheme.

Appendix A Review of Planning Constraints

Review of Planning Constraints

There are currently two Regional Plans that must be considered when assessing the planning constraints for any work conducted within the Canterbury Region. The first is the Natural Resources Regional Plan (NRRP), which is the operative Regional Plan for Canterbury. The second is the proposed Land and Water Regional Plan (LWRP) which was notified in August 2012 and will supersede the NRRP once the submissions process is complete. The proposed activity has been assessed under the rules of both plans.

2.1 Natural Resources Regional Plan (NRRP)

Rule WQL14 deals with the discharge of treated sewage effluent to land from a community wastewater system. The proposed activity would be classed as a restricted discretionary activity if the discharge to land was sited in an area that complied with all the conditions of the rule (attached in Appendix X). In particular condition two states that the discharge shall not occur within the Community Drinking Water Supply Protection Zone. The activity is classed as a prohibited activity if this condition cannot be met and therefore no resource consent can be granted. Discretion is reserved primarily to ensure that ground and surface water quality are protected.

2.2 Land and Water Regional Plan (LWRP)

The proposed activity can be split into two parts when assessed under the rules of the proposed LWRP. Rule 5.62 states that the use of land for a community wastewater system and the discharge of treated wastewater onto or into land is a discretionary activity. As with the NRRP the discharge of treated wastewater into a Community Drinking Water Supply Protection Zone is a prohibited activity.

The Section 32 Report for the LWRP states that the control of nutrients is the single most significant change from the NRRP position. The Canterbury Regional Council has introduced a set of rules which control the loss of nitrogen from land used for a ‘farming activity’. Farming activity has currently not been defined and therefore there is some uncertainty in regards to whether this proposal will fall under these rules. The use of the land irrigated with treated wastewater is likely to control whether these rules will be applied to this activity.

Environment Canterbury has split the Canterbury Region into Nutrient Allocation Zones, based on the water quality of these catchments. Green zones meet water quality outcomes, orange zones are classed as at risk and red zones are areas where water quality guidelines are not met. Darfield is situated in the Selwyn – Waihora Nutrient Allocation Zone which is classed red. This means the Canterbury Regional Council considers water quality outcomes are not currently being met in this area. It is likely that future restrictions on nitrogen loads will restrict nitrogen leaching to below that which is currently occurring for all activities with the allocation zone in an effort to improve the degraded water of this area.

Until 1 July 2017 any farming activity in this area which existed before 11 August 2012 is a permitted activity, if a record of nitrogen loss is kept using OVERSEER. Until 1 July 2017 any *change* (refer to definitions Appendix X) in farming activity is a permitted activity so long as the conditions of Rule 5.42 are met. These conditions include monitoring nitrogen loss using OVERSEER and preparing a Farm Environment Plan. A *change* in farming activity in the proposed activity area that does not comply with these conditions is a non-complying activity (refer to Appendix X for a full set of conditions). From 1 July 2017 the use of land for a farming activity is a permitted activity if all the conditions of Rule 5.46 are met. Condition 2 of Rule 5.46 states that the average annual loss of nitrogen shall not exceed the rate outlined in the relevant farming activity in Schedule 8. (Schedule 8 has not currently been prepared). From 1 July 2017 any farming activity which does not meet condition 2 and is in an area zoned red will be a non-complying activity. It is expected that any activity classed non-complying will be difficult to obtain resource consent for and the Canterbury Regional Council has indicated any such activity will be public notified.

If the irrigation of wastewater onto land as part of this activity is considered under the farming activity rules it is expected that levels of nitrogen leaching will be tightly controlled. Moving to a community wastewater treatment system from the current on site system is likely to significantly reduce the total quantity of nitrogen leached within this area however and this can be used to demonstrate the positive groundwater quality outcomes from the proposed system.

Appendix B Review of Hydrogeological Constraints

A review of previous reports related to the assessment of effects on groundwater from waste water disposal at Darfield and Kirwee was undertaken. The review included the following reports:

- Darfield Sewerage Options Technical Appraisal (MWH, 2004a)
- Kirwee Sewerage Options Technical Appraisal (MWH, 2004b)
- Modelling the Impacts of Darfield and Kirwee Wastewater Discharges on Groundwater Quality (PDP, 2011)
- Darfield/Kirwee Groundwater Monitoring February 2012 Update (Liquid Earth, 2012)[1]

Hydrogeology

Both Darfield and Kirwee are underlain 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 around 75 meters beneath Kirwee. Groundwater flows in a south-easterly direction.

Groundwater quality

Groundwater quality for the Darfield and Kirwee area is summarised in the Liquid Earth (2012). The report found that there was little indication of contamination likely to be associated with the on-site wastewater disposal in the Darfield and Kirwee areas. Both spatial and temporal variations in groundwater quality were thought to be largely associated with other land use activities in the surrounding area.

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

Previous modelling

Darfield Sewerage Options Technical Appraisal (MWH, 2004a) and Kirwee Sewerage Options Technical Appraisal (MWH, 2004b)

MWH prepared 3D numerical groundwater models for both sites using MODFLOW. The modelling provides estimates of the extent of the contamination plume for the various disposal and flow scenarios examined.

For both sites it was found that faecal coliform contamination would not extend beyond the boundary of the discharge areas. This is due to the significant attenuation that occurs in the thick unsaturated zone.

The modelled nitrate plume at Kirwee was 3.8km for current flows and loads and 4.5km for design flows and loads (both using septic tank discharge).

The modelled nitrate plume[2] at Darfield was 2.9km for current flows and loads and 3.5km for design flows and loads (both using septic tank discharge). The modelled nitrate plume when

[1] Darfield/Kirwee groundwater monitoring reports from 2008 and 2009 (SKM) and 2011 (Liquid Earth) were sighted but not included in the review as 2012 report provides a summary of these previous reports (including those from 2006) and a discussion of temporal changes in groundwater quality.
[2] Plume length was considered the distance required for groundwater quality to attenuate to the NZDWS nitrate-N guideline value of 11.3mg/L.

using a community sewerage scheme and irrigation disposal was 0.5, 0.75 and 2.0km for current, design and ultimate flow and load scenarios when using oxidation pond treatment. Is a BNR process was used the contaminant plume would not extend beyond the discharge areas.

Many of the parameters used in the modelling were estimated or inferred and may not reflect actual conditions encountered at the sites. This may lead to over or underestimation of the resultant plume extents. The plume lengths are also dependent on the background nitrate concentration used. If a higher background nitrate concentration was used, groundwater nitrate concentrations would require greater distances to attenuate to the NZDWS of 11.3mg/L than shown in the table above.

Modelling the Impacts of Darfield and Kirwee Wastewater Discharges on Groundwater Quality (PDP, 2012)

This report uses an analytical modelling approach to estimate the potential impacts of the current and future wastewater discharges. A future community sewerage scheme was then modelled using a simple mixing model approach.

The modelled nitrate plume3 at Kirwee extended up to 225m for current flows and loads. Design flows and loads were not modelled.

The modelled nitrate plume at Darfield extended up to 40m for current flows and loads. For design flows and loads (using septic tank discharge) the plume length did not change, but its width doubled.

The impact of a community sewerage scheme was modelled using a simple mixing model. For Kirwee it was estimated that the down gradient nitrate-N concentration after complete mixing to 10 meters would be 4.2mg/L. For Darfield it was estimated that the down gradient nitrate-N concentration after complete mixing to 10 meters would be 8.2mg/L.

Summary of previous modelling

There are considerable differences in the calculated plume extents between the MWH and PDP modelling. A detailed review of the modelling, to identify the reasons for the differences, has not been undertaken at this stage of the assessment. After this preliminary review there does not appear to be any reason to value the validity of the results of one of these reports over the other.

Neither model incorporates the design flows and loads that are now relevant for Darfield and Kirwee. In addition, these models to not consider the nitrogen removed from the system due to plant growth and removal that would be part of any irrigation proposal.

Hydrogeological constraints

The large thickness of unsaturated sediments provides 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. Conservative contaminants, including nitrate, that are not removed by plant uptake, will travel through the unsaturated zone and enter the groundwater system. Background nitrate concentrations in the area are relatively low, however; an increase in nitrate loading to the groundwater system may have potential to increase down gradient nitrate concentrations. The magnitude of this change will be depend on the actual waste water 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.

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[3] Plume length was considered the distance required for groundwater quality to attenuate to the NZDWS nitrate-N guideline value of 11.3mg/L.

Appendix C Cost Estimates

Treatment Cost Estimate

	OPTION 1: BNR ASP	OPTION 2: Trickling Filter	OPTION3: Waste Stabilisation Pond
Inlet Screen	incl.	$300,000	$160,000
Biological Treatment	$4,800,000	$3,200,000	$1,600,000
Dewatering Plant	$650,000	$650,000	n/a
UV Disinfection	incl.	$200,000	n/a
Irrigation Equipment	$1,200,000	$2,100,000	$4,000,000
Sub Total	$6,700,000	$6,500,000	$5,800,000
Preliminary and General	$400,000	$400,000	$300,000
Contingency	$1,000,000	$1,000,000	$900,000
Construction Cost Estimate	$8,100,000	$7,900,000	$7,000,000
Irrigation Land Purchase ($36,000/ha)	$1,500,000	$3,200,000	$6,300,000
Planning and Consents	excl.	excl.	excl.
Engineering Design and Construction Monitoring	$1,000,000	$900,000	$840,000
Total Project Budget Estimate	$10,600,000	$12,000,000	$14,140,000

Collection Cost Estimate (Existing)

	OPTION 1: Gravity	OPTION 2.1: Low pressure sewer	OPTION 2.2: STEP system	OPTION 3: Vacuum sewer
Darfield lots (Existing)	805	805	805	805
Collection chambers/pump stations	8	805	805	220
Approximate total pipe length (km)	23	23	23	23
Average pipe installation Rate ($/m)	360	70	70	160
Installation Sub Total	**$11,300,000**	**$10,100,000**	**$12,620,000**	**$8,900,000**
Preliminary and General	$1,100,000	$1,000,000	$1,300,000	$900,000
Contingency	$1,700,000	$1,500,000	$1,900,000	$2,200,000
Construction Cost Estimate	**$14,100,000**	**$ 12,600,000**	**$15,900,000**	**$12,000,000**
Planning and Consents	excl.	excl.	excl.	excl.
Engineering Design and Construction Monitoring	$1,700,000	$800,000	$950,000	$720,000
Total Project Budget Estimate	**$15,800,000**	**$13,400,000**	**$16,850,000**	**$12,720,000**

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