Attachment 6:

Additional Information from the Applicant on Alternatives (29/10/2020)

INVESTIGATION	Alliance Mataura Plant Wastewater Treatment and Disposal Alternatives Assessment	**PROJECT**	Discharge Options and Treatment Alternatives Further Assessment
CLIENT	**Alliance Group Limited**	**PROJECT NO**	AJ903230
CLIENT CONTACT	Doyle Richardson	**PREPARED BY**	Luke Wilkinson, Azam Khan
CLIENT WORK ORDER NO/ PURCHASE ORDER		**SIGNATURE**	
		DATE	28 October 2020

Introduction

Alliance Group Limited lodged an application to re-consent the wastewater discharge to the Mataura River for their beef processing plant in Mataura. As part of this application PDP prepared an assessment of the treatment and discharge options available to Alliance Mataura (May, 2019). This report identified the preferred option (option 1C) for the future discharge was a staged upgrade approach that would result in the biological treatment of all the wastewater prior to continued discharge to the river. This assessment has undergone a technical review by Environment Southland (carried out on behalf of the Council by 4Sight Consulting) and further information and clarification was sought in that report to further address why land treatment and/or discharge to the Gore District Council wastewater system as trade waste have been discounted as practicable alternatives. It was also raised during the review that more consideration be given to alterative treatment processes that could be used as part of a treatment upgrade option.

This technical memo has been prepared to address the trade discharge and treatment alternatives matters. Further consideration of land treatment is addressed separately with further assessment of land discharges reported elsewhere.

This memo details the further assessment that has been undertaken of the trade waste discharge options and sets out why such options are not practicable. Further explanation is also provided in this technical memo as to why other potential treatment alternatives were discounted.

Trade Waste Discharge Further Assessment

Two possible trade waste discharge locations were identified in the 4Sight report:

- Gore Wastewater Treatment Plant (WWTP).
- Mataura WWTP.

Both treatment plants are operated by Gore District Council (GDC) and are currently undergoing a reconsenting process.

General Issues with Trade Waste Discharge

Due to the high strength nature of the wastewater generated at the Alliance Mataura plant there are constraints and issues that must be considered and addressed, such as the following:

- High strength wastewater will turn anaerobic and generate an objectionable odour if retained in a pumped rising main for too long. This is a recognised issue being experienced with the Mataura Valley Milk trade waste discharge to the Gore Industrial Hub WWTP.

- The construction of a pump station and long pipeline will be required.
- The trade waste discharge will increase the flow and load into the municipal plants by a significant percentage, therefore a major upgrade of the municipal WWTP would be required.
- Both WWTPs under consideration result in a discharge to the Mataura River, therefore even if the plants wastewater is discharged into the Gore District Council wastewater system the final discharge location of the wastewater will be the river.

Discharge to Mataura WWTP

The Mataura WWTP processes (mostly) domestic wastewater from the Mataura township. The predicted future (2050) average flow to the Mataura WWTP is 895 m^3/d (Gore and Mataura WWTP Options Assessment - Harrison Grierson, 2020). The average wastewater volume of wastewater generated by the Alliance Mataura plant is 3,488 m^3/d, with a peak discharge of around 8,000 m^3/d. Clearly, the volumes of wastewater generated at the Mataura Plant are significantly greater than (over 300%) the municipal wastewater volume and will overwhelm the domestic wastewater treatment system. Thus, if Alliance was to discharge its wastewater to the Mataura WWTP it is highly likely that a new dedicated WWTP would need to be constructed to enable the treatment of the trade waste to an acceptable standard for discharge to the river. It is therefore not considered of any benefit to construct a new treatment plant at the Mataura WWTP that includes domestic wastewater site rather than the Alliance Mataura plant site. In addition to the establishment of a new wastewater treatment plant, further challenges arise with mixed domestic/industrial wastewater to manage the sludge generation that requires disposal. There will be an additional cost of the conveying the wastewater from the Alliance Mataura site to the Mataura WWTP with a dedicated pipeline at a cost of around $1M + GST.

Discharge to Gore WWTP

The Gore WWTP processes domestic and trade derived wastewater from the Gore township (including from the Mataura Valley Milk (MVM) processing plant, Blue Sky Pastures and Silver Ferns Farms Waitane Plant). The wastewater from MVM plant is pumped through a dedicated pipeline and is treated in a separate Industrial Hub wastewater treatment facility. Other main trade waste discharges form part of the normal sewerage system into Gore WWTP.

The predicted future (2050) average dry weather flow to the Gore WWTP is 8,792 m^3/d, including trade wastes (Gore and Mataura WWTP Options Assessment - Harrison Grierson, 2020). The average wastewater volume of wastewater generated by the Alliance Mataura plant is 3,488 m^3/d, with a peak discharge of around 8,000 m^3/d. If the Mataura Plant wastewater were to be discharged to the Gore WWTP a significant upgrade would be necessary to the Industrial Hub part of the wastewater treatment facility to handle the higher volumes and loads. This upgrade would need to be carried out at the Gore WWTP site as well as at the Alliance Mataura site. If the Plant's wastewater were to be conveyed to the Gore WWTP it is likely that treatment at the Alliance site will be required to mitigate against the threat of odour being generated in the pipeline. Currently, PDP understands that there is continued risk of odour generated at the Gore WWTP with the acceptance of partially treated wastewater from MVM.

The following treatment options to enable a trade waste discharge to Gore WWTP have been identified:

- No treatment at Alliance Mataura, upgrade of pumping facilities and upgrade of capacity at Gore WWTP. As indicated above, this could lead to a significant risk of odour generation.
- Treatment for biochemical oxygen demand (BOD) removal at Alliance Mataura to reduce odour risk and upgrade capacity at Gore WWTP to handle increased flow and total nitrogen (TN) load. Gore WWTP may not achieve required TN removal due to lack of carbon source for biological reduction of oxidised nitrogen (denitrification) when discharges from Mataura Valley Milk plant is not available, so a

dedicated carbon dosing system may need to be installed as part of the Gore WWTP upgrade which would increase capital and particularly operating costs.

- Full treatment at Alliance Mataura (to level proposed in option 1C) and increase in hydraulic capacity at Gore WWTP to allow for re-aeration of treated wastewater and discharge.

Further detail on the assessment of the discharge to Gore trade waste options is provided in Table 1, attached at the end of this memo.

Feasibility of Trade Waste Discharge to Gore WWTP

During the Gore WWTP reconsenting BPO assessment conducted by Harrison Grierson, a replacement biological nitrogen removal (BNR) treatment plant with continued discharge to the river was identified as the best practicable option. It is noted that land discharge was also considered but was not considered practicable, predominantly due to technical (soils and suitable land availability) and financial feasibility criteria, similar to the same technical constraints faced with the Alliance Mataura discharge. The options assessment was based on a BNR achieving a treated wastewater total nitrogen concentration of 10 - 20 mg/L. This is similar to the level of treatment proposed in the previous Alliance Mataura options assessment which is included as part of the application before the Council. This means that even if the Alliance Mataura wastewater is discharged via trade waste to the Gore WWTP it would need to undergo a similar level of treatment as currently identified for Alliance Mataura (option 1C). Thus, no additional environmental benefits would accrue as the wastewater would be treated to the same extent as is proposed by Alliance in the application. However, this discharge option would incur an additional cost (capital costs estimated to be in the order of $5M +GST) above the costs identified for on-site treatment and is considered an impractical step to achieve similar outcomes. There is likely to be high operating costs as Alliance Mataura will contribute to nearly 50% of the combined flows to the Gore WWTP. It is also noted that a discharge via the Gore WWTP may result in the change of receiving environment that could contribute to additional measurable effects that are currently not present in that stem of the river reach.

Based on the assessment of the available options and the identified best practicable option for Gore WWTP, a trade waste discharge to Gore WWTP does not offer additional benefit when compared to the currently proposed approach at Alliance Mataura. Pursuing this option will incur additional capital and operating costs to the wastewater management at Alliance Mataura with increases in new capital expenditure for reticulation and trade wastes charges, as well as management of biosolids generation that may be impacted with domestic wastewater. The handling of biosolids from the site WWTP could be simpler as there are less regulation and restrictions placed on their disposal than compared to biosolids produced from the treatment of human waste. There is also an additional operating costs risk associated with a trade waste discharge, as both Mataura and Gore WWTP are undergoing reconsenting it is not known what level of discharge quality will be acceptable for continued discharges and further upgrades may be required for the treatment and disposal therefore budgeting to allocate fund for the required upgrades becomes difficult particularly if more extensive upgrades are required at Gore WWTP in the shorter term.

Trade Waste Discharge Summary

The assessment of discharges to trade waste were discounted because it was assessed to be not the best practicable option for the management of the wastewater generated at the Alliance Mataura site.

A trade waste discharge to Gore WWTP is not likely to provide a long-term reduction in contaminant load to the river when compared to option 1C.

A trade waste discharge to Mataura WWTP is also not likely to provide a long-term reduction in contaminant load to the river when compared to option 1C. It is also a less suitable option compared to a discharge to Gore

WWTP due to the lower capacity of the plant and Gore WWTP already accepting some large trade waste discharges.

Treatment Alternatives Evaluation

During the initial options assessment for Alliance Mataura, PDP evaluated potential treatment upgrade alternatives, there were generally discounted in favour of activated sludge process. This was due to a number of factors such as the company's familiarity with activated sludge systems, the high pH nature of the DAF treated wastewater, and the high concentrations of the wastewater.

The following treatment alternatives were considered:

- Anaerobic treatment
- Activated sludge system and clarifier
- Sequencing Batch Reactor (SBR)
- Membrane Bioreactor (MBR)
- Emerging technologies, such as Membrane Aerated Biofilm Reactor (MABR) or Moving Bed Biofilm Reactor (MBBR)

Anaerobic Treatment

Anaerobic treatment of high strength wastes is an efficient approach to take, particularly with respect to minimising aeration energy and reducing sludge production. This type of treatment is utilised at the Alliance Lorneville plant, however, large reactors are required for meat processing wastewater to provide for efficient removal of solids and oil & grease.

Anaerobic treatment is effective at treating the BOD load in wastewater but not the nitrogen load, therefore this is generally used as a pre-treatment for high strength waste streams with further activated sludge treatment for nitrogen removal downstream. Anaerobic treatment was not considered suitable for Alliance Mataura because of the existing pre-treatment facilities using dissolved air flotation (DAF), that utilises sulphuric acid for the removal of proteins and a considerable amount of BOD. Having a large amount of sulphates in the wastewater will result in a significant amount of hydrogen sulphide gas generated as a result of anaerobic processes requiring comprehensive management controls for the biogas generated from anaerobic treatment processes. In addition, the DAF plant removes a substantive amount of BOD load, therefore when targeted nitrogen removal processes are put in place, there will be an unbalanced supply of internal carbon to drive the biological nitrogen removal processes.

In the event, the existing DAF treatment processes are mothballed, then anaerobic treatment may need to be considered to reduce the amount of solids, oil & grease and oversupply of BOD to the downstream BNR processes. A separate chemical treatment for phosphorus will then need to be put in place to replace the DAF-in-series system.

Activated Sludge System and Clarifier

This is a common treatment system used across New Zealand and at other Alliance sites, the larger lagoons used in this type of system are particularly useful for buffering peaks in high strength waste production. Other newer technologies are able to use smaller reactors which can be beneficial in terms of space saving but means the process is very susceptible to spikes in wastewater concentrations or pH. This is of particular concern at Alliance Mataura due to the high pH DAF treatment used for phosphorus removal and spikes in ammoniacal nitrogen that may inhibit nitrogen removal processes. Based on the greater resilience of the activated sludge lagoon system and that this is a system that Alliance are already familiar with, this was selected as a preferred treatment option. It is also noted that with effective DO and pH control, activated sludge lagoons can achieve effective nitrogen removal, comparable with other systems.

SBR

An SBR would be expected to have similar treatment performance to the activated sludge lagoon system and would have a similar level of resilience to the lagoon as well. An SBR was not considered as the preferred option in the options assessment due to the larger treatment volume and aeration capacity required for their operation, the system will only be in aeration mode for a maximum of 4 hours out of every 6, therefore 50% additional peak capacity is required compared to a standard lagoon system. SBRs also usually decant treated wastewater over only 1 hour every 6 hours, this generates significant peaks in treated wastewater, requiring large decant buffer to reduce the rate of discharge to the Mataura River.

MBR

As stated above, an MBR uses a smaller treatment volume than a typical lagoon or SBR, therefore is more susceptible to spikes in wastewater concentration and pH, this is seen as a significant disadvantage for an MBR system. Additionally, due to the nature of the processing occurring in the main site, the wastewater contains a high amount of animal hair fibres, as well as oil and grease. Membrane filtration of wastewater containing hair fibres is not recommended, this will increase the frequency of membrane backwashes and replacement, and the risk of solids breakthrough. Given that the site utilises DAF-in-series system for phosphorus removal with hydrated lime used as a catalyst for precipitation, high concentrations of calcium in MBR system is likely to cause blockage and reduce the membrane flux.

Emerging Technologies

Some emerging technologies were mentioned in the 4sight review report as process options that should have been considered, PDP did not regard these as suitable alternatives. An MBBR uses a sand media to both filter the wastewater and to act as a growth medium for the biofilm, having a sand media is not suitable for such a high strength wastewater, especially with high concentrations of Oil & grease. The sand media would blind extremely quickly due to the high solids concentration in the wastewater, leading to ineffective treatment and very frequent washing and replacement of the media. Overall, this is considered as only being suitable as a tertiary polishing treatment for discharges that require very low nitrogen concentrations.

MABRs are still a relatively new technology that is uncommon in New Zealand. PDP did not consider that it was appropriate to develop a new technology, when there is risk of discharges to the Mataura River with poor levels of treatment due to an unreliable technology, and considered that a reliable activated sludge technology would provide the required treatment performance, operational simplicity and resilience.

PDP considered a wide range of treatment upgrade options that are commonly utilised in the meat industry as well as for the dairy industry that are simple to operate and provide for the highest levels of resilience.

For Alliance Mataura site, the most appropriate option post existing DAF treatment system would be to select an activated sludge lagoon and clarifier system, based on its proven ability to provide good levels of treatment and provide resilience to handling peak wastewater loads.

sufficient for use by PDP in preparing the memorandum. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

Table 1: Summary of Further Assessment of Trade Waste Discharge to Gore WWTP			
Option Description	**Risks and Issues (Compared to preferred option 1C)**	**Estimated Capital Cost**	**Comments**
- Continued DAF treatment only at Alliance Mataura. - Upgrade to capacity at Gore WWTP (could be separate trade waste treatment process).	- High risk of odour generation at Gore WWTP due to anaerobic conditions in pipeline. - Significant upgrade of capacity at Gore WWTP required, which would be funded by Alliance. - Potential adverse effects of the discharge moved further upstream in the catchment.	Total - $18.5M Pumping and Pipeline - $5.5M Treatment[4] - $11.5M Indirect Project Costs (Design/Consenting) - $2M	Increased capital cost for no reduction in river effects, compared to preferred option 1C. Risk of odour unlikely to be accepted by GDC.
- Treatment for BOD removal at Alliance Mataura to reduce odour risk. - Upgrade capacity at Gore WWTP to handle increased flow and TN load.	- Investment in two treatment plants required. - Removal of BOD may lead to a carbon shortage at the Gore plant for denitrification, leading to higher TN concentration in the wastewater or expensive carbon dosing requirement. - Potential adverse effects of the discharge moved further upstream in the catchment.	Total - $20M Pumping and Pipeline - $5.5M Treatment[4] - $12.5M Indirect Project Costs (Design/Consenting) - $2M	Increased capital cost for no reduction in river effects, compared to preferred option 1C.
- Full treatment at Alliance Mataura (to level proposed in option 1C). - Increase in hydraulic capacity at Gore WWTP.	- Higher hydraulic load to Gore WWTP, may reduce treatment efficiency. - Cost contribution to upgrade hydraulic capacity of Gore WWTP still required. - Potential adverse effects of the discharge moved further upstream in the catchment.	Total - $21M Pumping and Pipeline - $5.5M Treatment[4] - $13.5M Indirect Project Costs (Design/Consenting) - $2M	Increased capital cost for no reduction in river effects compared to preferred Option 1C.

Notes:

1. *Cost estimated prepares to +40%/-20% level of accuracy.*
2. *Cost are in NZD and do not include GST.*
3. *Cost estimates based on same assumptions as set out in the main options assessment report.*
4. *Treatment costs includes treatment upgrades at Alliance Mataura and Gore WWTP sites.*

PATTLE DELAMORE PARTNERS LTD

Alliance Mataura Plant Wastewater Treatment and Disposal Alternatives Assessment – Re-assessment of Land Discharge Options

Alliance Group Limited

Alliance Mataura Plant Wastewater Treatment and Disposal Alternatives Assessment – Re-assessment of Land Discharge Options

Prepared for

Alliance Group Limited

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Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Alliance Group Limited. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

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1.0 Introduction

Alliance Group Limited lodged an application to re-consent the wastewater discharge to the Mataura River for their beef processing plant in Mataura. As part of this application PDP prepared an assessment of the treatment and discharge options available to Alliance Mataura. In that report, it was identified that the preferred option for the future discharge was a staged upgrade approach that would result in the biological treatment of all the wastewater prior to continued discharge to the Mataura River.

As part of the consenting process, a technical review by 4Sight on behalf of Environment Southland was carried out. The review has sought further investigation and feasibility of land-based discharge as part of the alternatives considered by Alliance in establishing the best practicable option for managing the plant's wastewater discharge.

As was set out within the application, Alliance considered a range of land discharge options as alternatives to discharging treated wastewater to the Mataura River. As a note, a comprehensive assessment was also undertaken in 2004 as part of the assessment prior to granting of existing consent. The outcomes at that time determined that limitations within soils to continually accept wastewater for land treatment was the key limiting factor.

This report provides further evidence as to the practical difficulties inherent in discharging the plant's wastewater to land.

2.0 Response to 4Sight Review for Land-Based Discharge

There are various matters that have been raised to provide further clarification in relation to consideration of land-based discharge.

Table 1 provides a summary of the responses and the detailed analysis to support the response is further assessed in this report.

Table 1: Responses to Commentary on Land Discharge Review

Review Report Section	Review Comment Description	Response
4.2	Full (year-round) land disposal options were not given more consideration	Full disposal to land would require irrigation over winter when soils already have a high moisture content. Over long periods in winter the ground would be unsuitable for irrigation. Processing at the plant does not decrease over winter so almost full wastewater flows would need to go to land which is regarded to be impractical due to risks such as storage overflow, runoff and increase nitrogen leaching.
5.1	Further consideration should be given to a year-round land discharge to remove the discharge from the river.	Further assessment of the feasibility of a year-round discharge to land is provided in this report. PDPs comments around higher level of adverse effects are based on the high risk of runoff into local small streams running through the irrigation site and due to elevated nitrogen leaching into groundwater which is considered to be strongly hydraulically connected to the river.
5.2	More consideration should be given to a seasonal land discharge. Can a similar reduction in load to the river be achieved by a seasonal land discharge and a treatment upgrade?	The PDP report submitted as part of the application stated a similar reduction in TN load to the river for a seasonal discharge (Options 4A and 5A - 70%) and a treatment upgrade (Option 1C – 68%), see section 5.1.1. Option 5A (zero grazed option) is the more favourable land option than 4A (dairy farm irrigation) which has a higher capital cost and NPV estimate than option 1C. It was noted in the original PDP report that the wastewater cannot be stored due to the odour risk. Therefore, some discharge to the river will occur during summer during wet weather. This therefore reduces the estimated reduction in load to the river below the 70% stated in the report. Therefore, a seasonal discharge will not achieve an improved reduction in load to the river when compared to a treatment upgrade of a similar cost.

3.0 Revisit of Land Discharge Assessment

As was set out within the application, Alliance considered a range of land discharge options as alternatives to discharging treated wastewater to the Mataura River. This report provides further evidence sought by 4Sight as to the practical difficulties inherent in discharging the plant's wastewater to land as opposed to the current proposal to discharge to the Mataura River.

Following the 4Sight technical review, a revisit of the practicalities of any land-based treatment system has been undertaken. The initial assessment of the long-list options and the short-listed options was comprehensive, and this re-assessment uses that original work as a basis for further assessment.

A key consideration for the design of land-based treatment systems is the ability of the soils encountered on available land to accept wastewater on a continued basis. Without suitable soils being available to accept wastewater, land-based disposal options are severely constrained. Where the soils are determined to be suitable for long-term acceptance of wastewater, then other constraints need to be assessed. In the previous assessment, it was determined that the soils on the farmland in the vicinity of the plant were not suitable for long-term acceptance of wastewater for land treatment. This was based on the soils work undertaken in 2004 and more recently on the updated soils database for the area.

However, following the 4Sight technical review additional assessment is provided that builds on the long-list options and the shortlisted land discharge alternatives, described in PDP report "*Alliance Mataura Plant Wastewater Treatment and Disposal Alternatives Assessment – May 2019*". This assessment is directed at addressing the questions raised by 4Sight. Some numerical figures quoted may slightly differ from the original report due to the time that has elapsed since the original report was prepared and the further depth of assessment undertaken, particularly in relation to the soil moisture modelling.

3.1 Comparison to other Industrial Site Land Treatment Systems in Southland

It is acknowledged there are some significant industrial sites in the Southland region that operate either a land only and/or a dual discharge system. The two examples considered are Fonterra Edendale and Blue Sky Pastures.

For Fonterra Edendale, the site has a dual discharge system with access to a land treatment system having an annual hydraulic loading of around 200 mm and wet/winter discharges to surface water. The average daily discharge volume during the peak season is estimated at around 10,000 m^3/d onto nearly 800 ha of irrigated land. During wet conditions and generally in winter, the treated wastewater is discharged to the Mataura River when stream flows are above 40 cumecs and subject to the soil conditions reaching field capacity.

For Blue Sky Pastures, there are low levels of processing (sheep and bovine rendering) in winter months and the land treatment system is entirely operated as a zero grazed pasture (cut & carry operations with crop exported from the site). The maximum daily volume discharged is 1,000 m^3/d onto 80 ha of irrigated land. There has been continued hydraulic loading issues and high nitrogen application onto land over many years. Because of the substantial nutrient loading onto land, Blue Sky Pastures has recently undertaken a comprehensive wastewater treatment system upgrade to reduce the amount of nitrogen discharged onto land as well as the risks of odour from primary treated wastewater. Blue Sky Pastures is also seeking access to additional land to reduce the hydraulic loading onto the existing land during wet and winter periods.

It must be noted that for both Fonterra Edendale and Blue Sky Pastures, the soils that are subject to land treatment have better drainage characteristics than those that exist around the Mataura Plant. They drain better and can accept wastewater at more times of the year than the Mataura soils. For example, the Fonterra Edendale land treatment system allows for around 500 mm annual soil drainage to maintain adequate land treatment system capacity.

In addition, it is important to note that the nature of the operations at Alliance Mataura make a land discharge only scheme more challenging and problematic than both of the examples referred to above. This is predominantly due to continued “near peak” winter processing at the plant. Typically, dairy and meat processing plants experience a decrease in processing rates over winter, with commensurate decreases in the amount of wastewater generated requiring disposal. The Alliance Mataura plant does not experience a decrease in processing rates during the winter or wetter months. This is shown in Figure 1 and Figure 2 which provide weekly processing numbers for 2019 and 2018 respectively. Notably, these figures show that processing rates tend to peak during the winter months.

Seasonally reduced processing at some sites, such as the examples mentioned above can allow the discharge of wastewater to land over winter to occur because the volumes involved and therefore irrigation rates are much lower. It should be noted that for Fonterra Edendale, the direct discharge to the Mataura River is allowed during conditions when soil moisture levels exceed field capacity and the river flows are above a threshold flow. This means that the hydraulic capacity of the land is not exceeded, including during the wetter, cooler months when evapotranspiration rates are very low.

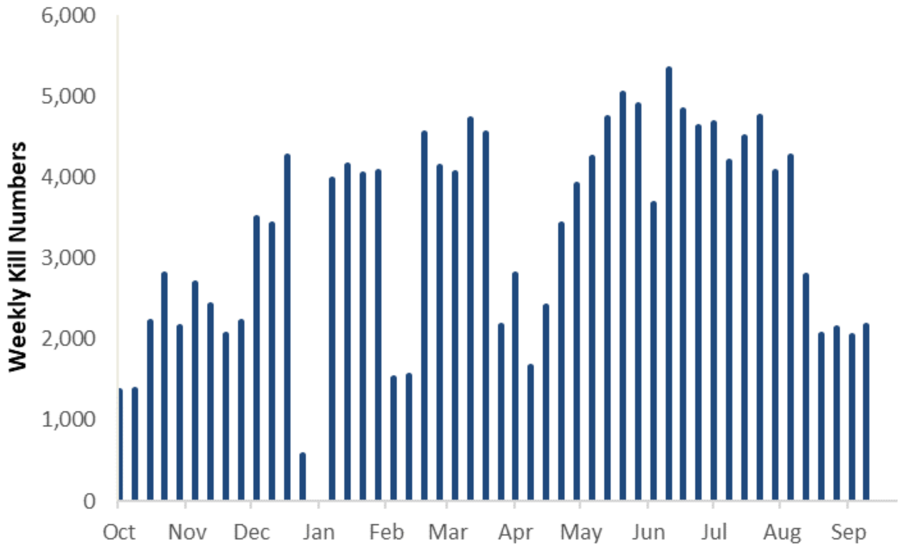

Figure 1: Alliance Mataura 2019 Season Weekly Cattle Processing Numbers

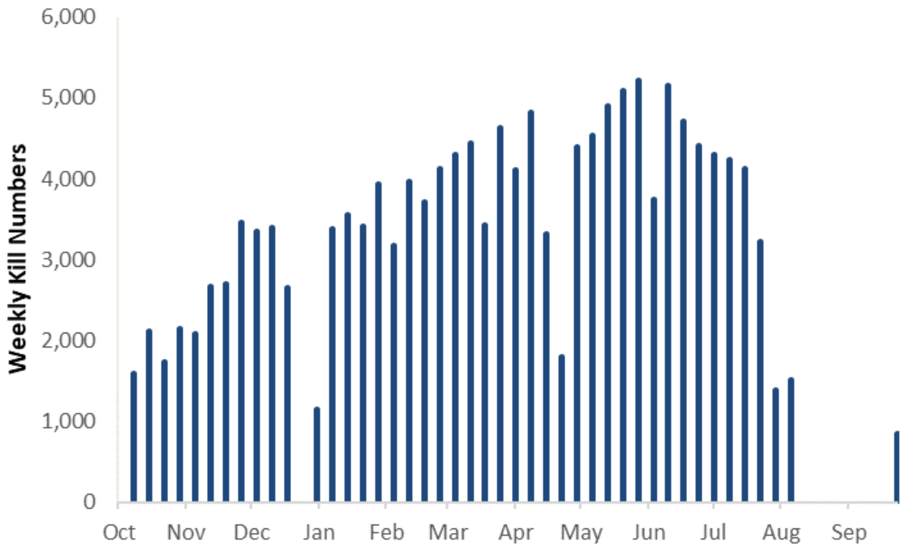

Figure 2: Alliance Mataura 2018 Season Weekly Cattle Processing Numbers

3.2 Previous Investigations

PDP has based this assessment on the following assumptions and previous investigations.

3.2.1 Land Cost Assumptions

PDP has conducted an assessment of the value of the land surrounding Mataura that would need to be purchased for a land treatment scheme at Mataura. This was based on recent sales in the area (within 30 km from the plant) and current real estate listings for land parcels larger than 50 ha.

Land prices were found to fall in the range $20,000 per hectare to $33,000 per hectare (excl GST). Due to the infrequency of suitably sized parcels being listed for sale, the land is likely to be purchased from land-owners without a need to sell their land, therefore a 20% premium has been added to the land prices to account for this. This premium pricing for land parcels has been experienced for land in the Waikato region where land treatment system expansion was required onto neighbouring farmland from an existing system.

The area of land required to be purchased is assumed to be 50% more than the actual required irrigation area to account for land that is likely to unsuitable for irrigation within the landholding.

As a conservative approach to estimating the cost of the land required for the land discharge scheme the highest reported land price was adopted as the basis of the cost estimates ($33,000/ha), the 20% premium was then added to this price to calculate the land cost used in this assessment of $40,000/ha of land parcel.

It is noted that the previous assessment utilised a value of $70,000 per hectare of actual irrigable land. The initial assessment was slightly conservative, with assumed market behaviour at the time of purchase. Using the $40,000 per hectare land prices and applying the setback/non-irrigated area allowance of 1.5, then the unit pricing for irrigated land is estimated at $60,000 per hectare. This difference in pricing does not materially change the ranking of options that was undertaken in our earlier reporting.

3.2.2 The 2004 Report

As indicated earlier, PDP has previously completed an assessment of the feasibility of a land discharge for the Alliance Mataura site, see "*Re-evaluation of Land Based Wastewater Disposal Options, June 2004*. PDP", this is included as Appendix B. This report concluded that there were significant practical difficulties associated with the disposal options considered. The primary reason for reaching this conclusion was that there is a very limited amount of land available, with suitable soil types in the Mataura area that would enable the irrigation of wastewater in the volumes required and during the times of the year when the Plant was processing. The 2004 investigation report was informed by a soil suitability assessment conducted by SoilWork Ltd (November 2003). The SoilWork report detailed the particular soil properties on land around the Mataura Plant and is included as Appendix C.

The soils assessment investigation showed that the soil drainage was the key determining factor in determining whether there was available land to enable year-round wastewater irrigation. Soil drainage is particularly important during winter irrigation when evapotranspiration contributes very little to reducing the moisture content of the soil (which is particularly the case in Southland). The SoilWork report found that there was very little suitable area for the irrigation of wastewater in the area around Mataura. Whilst some possible sites were identified these were generally held in small holdings and there was not enough land consolidated in large enough holdings to enable a practicable land-based option to be found. None of these findings have changed in the intervening period.

3.3 Year-round Irrigation Issues

Year-round irrigation is made difficult due to the requirement to irrigate during the wetter winter months. Issues that arise due to winter irritation that must be managed include:

- Oversaturation of soils making farm operation difficult and leading to pugging/compaction of soils and damage to the soil structure.
- Ponding and runoff of the irrigated wastewater, causing nutrients to runoff into surface water bodies.
- Low crop growth rates, reducing nutrient uptake and leading to greater leaching of nutrients to groundwater.
- Greater infiltration and therefore leaching to groundwater, caused by heavier rain events when soil moisture is already elevated.

Due to these reasons, year-round land discharge system is not feasible without additional measures put in place to manage the environmental effects. To manage adverse effects on the irrigated land and receiving environment caused by winter irrigation there are three options available:

- Place stringent limits on the amount of wastewater irrigated during the winter months, standard practice would be to use an irrigation depth limit of 50 mm/month. This will then increase the irrigation area required.
- Store the wastewater to be irrigated over the winter months in a large storage facility, for irrigation during drier months.

In order to manage the inability to undertake winter irrigation, the alternate approach is to utilise a dual discharge system to remove the requirement to irrigate during winter. This option was shortlisted for further assessment in the original PDP alternatives consideration.

3.4 Further Assessment of Land Discharge Options

In order to respond to the 4Sight report referred to above, PDP has reconsidered the range of viable and shortlisted land treatment options, including the dual discharge option and assessed them against other environmental factors in addition to the initial, screening which was primarily based on soils information. These options include:

1. Seasonal Irrigation (dual discharge) with no further wastewater treatment (Equivalent to shortlist option 5A in original assessment).
2. Year-round irrigation with prior biological nitrogen removal (BNR) treatment and winter storage (Option 3B).
3. Seasonal Irrigation (dual discharge) with prior BNR treatment (Option 5B).

The assessment of these options has been summarised in Table 2.

The land discharge options have taken into account soil moisture balance assessment to determine the required irrigation areas and storage requirements. The following assumptions were made for all the land discharge options:

- Maximum daily application depth of 5 mm, to prevent runoff;
- Minimum irrigation rotation interval to maximise land discharge;
- Irrigation will not occur if rainfall is greater than 25 mm/d even when there is soil moisture capacity;
- Irrigation will not occur if the soil moisture is above the saturation limit for the soil; and
- An additional 50% allowance above the required irrigation area must be purchased to account for the provision of buffer distances to neighbours and areas unsuitable for the installation of irrigators.

In order to provide for assurance of sustainable land treatment system further nutrient leaching assessment was undertaken based on the irrigation regime assessed. The increase in nitrogen leaching due to the irrigation is provided in Table 2. Further detail of the data and assumptions used in for the Overseer modelling is provided in Appendix A.

Table 2: Summary of Further Assessment of Land Discharge Options

Option	Description	Risks and Issues	Estimated Leaching Rate and Nitrogen Loading Rate	Estimated Capital Cost	Comments
Seasonal Irrigation (Dual Discharge) – No Further Treatment *Equivalent to option 5A in the original assessment shortlist*	- 160 ha solid-set irrigation scheme[6]. - 240 ha total land purchase. - 6,000 m^3 wastewater storage pond (sized for 1 day of wastewater storage at peak flows). - No additional wastewater treatment. - No irrigation May – September.	- Increased capital cost when compared to other discharge options previously considered. - There is still a discharge to the river with associated environmental effects. - No reduction in the nutrient load to the river over winter. - Risk of odour generation due to the irrigation of poorly treated wastewater, either by the wastewater turning anaerobic and producing odour as it is pumped to the irrigation site or after it is irrigated. - Discharge to the river will still be required during summer wet periods as wastewater cannot be stored due to odour potential. - Likely that multiple land parcels required to be purchased to make up the required 240 ha, making a suitable land area difficult to find.	Leaching - 45 kg N/ha/yr Loading – 348 kg N/ha/yr	Total - $23M Land Purchase - $10M Reticulation/Irrigation System – $11M Indirect Project Costs - $1M	Nitrogen leaching rate unlikely to be acceptable due to adverse effects, based on comparison to generally accepted leaching rates from agricultural land. No reduction in contaminant load to the river over winter, see main report shortlist option 4A. Exceeds assumed nitrogen loading limit.[4] This could be managed by improving the level of wastewater treatment with additional treatment stages or increasing the size of the irrigation scheme.
Year-round Irrigation – Biological Nutrient Treatment (Winter Storage) – Option 3B	- 160 ha solid-set irrigation scheme[6]. - 240 ha total land purchase. - 380,000 m^3 wastewater storage pond. - Wastewater treatment to reduce odour risk from storage, similar level to option 1C. - No irrigation May – September.	- Large capital cost when compared to other discharge options previously considered. - A large dam to store all the wastewater generated during winter processing would be required. The storage dam is required to store all wastewater over the winter period so it does not have to be irrigated, the treatment provided sufficiently reduces the odour risk from this. - Prevention of fugitive contamination from wildlife (birds and ducks), and algal growth risks. - Winter irrigation still may be required to prevent storage dam overflow, leading to risk of increased leaching and runoff. - Increased irrigation rates over summer to allow the discharge of stored wastewater, may lead to higher leaching and runoff. - Multiple land parcels required to be purchased to make up the required 240 ha, making a suitable land area difficult to find.	Leaching - 25 kg N/ha/yr Loading – 159 kg N/ha/yr	Total - $52M Land Purchase - $10M Treatment Upgrade - $14M Reticulation/Storage/Irrigation System – $25M Indirect Project Costs (Design/Consenting) - $3M	Capital investment is significant and much higher than other options assessed. Requirement to still irrigate occasionally over winter will cause high risk of adverse effects due to increased runoff, leaching and soil damage. Nitrogen loading could be managed by improving the level of wastewater treatment with additional treatment stages or increasing the size of the irrigation scheme.

Table 2: Summary of Further Assessment of Land Discharge Options					
Option	**Description**	**Risks and Issues**	**Estimated Leaching Rate and Nitrogen Loading Rate**	**Estimated Capital Cost**	**Comments**
Seasonal Irrigation (Dual Discharge) – Biological Nutrient Treatment – Option 5B	- 160 ha solid-set irrigation scheme[6]. - 240 ha total land purchase. - 30,000 m^3 wastewater storage pond (sized for 5 days of wastewater storage at peak flows). - Biological nutrient removal wastewater treatment, similar level to option 1C. - No irrigation May – September.	- Increased capital cost when compared to other discharge options previously considered. - There is still a discharge to the river with associated environmental effects. - Discharge to the river may still be required during summer wet periods to prevent storage pond overflow. - Multiple land parcels required to be purchased to make up the 240 ha required, making a suitable land area difficult to find.	Leaching - 14 kg N/ha/yr Loading – 110 kg N/ha/yr	Total - $37M Land Purchase - $10M Treatment Upgrade - $14M Reticulation/Irrigation System – $11M Indirect Project Costs (Design/Consenting) - $2M	Capital investment is significant and much higher than other options assessed.

Notes:

1. *Cost estimated prepares to +40%/-20% level of accuracy.*
2. *Land purchase assumed at $40,000 per hectare of pastoral farmland. An allowance of 1.5 times the actual irrigable area for total farmland has been allowed for.*
3. *Cost are in NZD and do not include GST.*
4. *Cost estimates based on same assumptions as set out in the main options assessment report.*
5. *Nitrogen Loading limit of 150 kg N/ha/yr, assumed limit is based on Rule 16C and 50 of the Environment Southland Regional Water Plan (2010) and rule 5.5.2 of the Environmental Southland Regional Effluent Land Application Plan (1998, updated May 2014).*
6. *Increase in area from shortlist assessment (135 ha) due to more detailed soil moisture balance assessment.*

3.5 Land Discharge Assessment Findings

Both the 2004 assessment and the assessment undertaken by PDP as part of the resource consent application have shown that there is very little suitable land available around Mataura for the establishment of a comprehensive land discharge scheme. For the land that could be utilised, other factors including long conveyance distances and a high risk of runoff render such options to be impracticable.

The key constraints that contribute to the discounting of the establishment of a reliable comprehensive land treatment system includes:

i. The soils that would allow sustainable wastewater irrigation are unsuitable in the vicinity of the processing plant.

ii. There is a risk of significant direct run-off and potential high nitrogen leaching if the identified land is utilised on an ongoing basis.

iii. Winter irrigation is not practicable and use of large winter storage facilities increases a level of risk in relation to management of nutrient levels in the stored treated wastewater, odour and would incur considerable additional capital cost to the management option identified in the application as comprising the best practicable option.

iv. Dual discharge options present considerable difficulties due to the fact that the Mataura Plant processes during winter and winter processing rates are high. Wastewater management would necessitate prior treatment and the obtaining of suitable irrigable land which adds a significant capital cost to the management option identified in the application as comprising the best practicable option.

4.0 References

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Rankin, A.R, Bruce, J. G. (date unknown). *Farming in Southland*. Accessed on 25 September 2020 via: https://www.grassland.org.nz/publications/nzgrassland_publication_1549.pdf

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Appendix A

Overseer Modelling Assumptions and Data

Methodology

Land treatment system (LTS) nutrient modelling was carried out for four (4) potential land treatment system options. These were:

1. Year-round irrigation of untreated wastewater (63 g TN/m^3, 6 g TP/m^3) to 360 ha of pastoral land.
2. Year-round irrigation of treated wastewater (20 g TN/m^3, 6 g TP/m^3) to 360 ha of pastoral land.
3. Irrigation from October to June of untreated wastewater (63 g TN/m^3, 6 g TP/m^3) to 160 ha of pastoral land as part of a dual discharge system.
4. Irrigation from October to June of treated wastewater (20 g TN/m^3, 6 g TP/m^3) to 160 ha of pastoral land as part of a dual discharge system.

A theoretical farming operation was developed based on review of aerial photographs in the local region. This theoretical farm was used to determine per hectare leaching rates for the irrigation system based on the expected per hectare loading rates. This farming operation comprised of:

- 170 ha of pasture that was suitable for both grazing and cropping for winter feed.
- 50 ha of pasture that was marginal and used for grazing only. This land was generally steeper slopes and near permanent or intermittent streams.
- 6 ha of pine forestry.

A baseline farming operation (background farm) without irrigation or nitrogen fertiliser was set up. Based on standard sheep stocking and production information provided in Ministry of Agriculture and Forestry (2009) this farm was stocked with 2,900 RSU of sheep, with 6.5 kg of greasy wool production per RSU. A single pasture cropping event was allowed for in January to provide for winter stock feed. This resulted in pastoral production of 9,870 – 9,958 kg DM/ha/yr, which is reasonable for a farm without nitrogen fertiliser use in Southland (DairyNZ, 2020).

Maintenance fertiliser rates for phosphorus established through overseer were applied, and no nitrogen fertilisers were applied.

The baseline farm spans the following soil types; in order of dominance: Aparima (Apar_7a.1), Craigdale (Craig_3a.1), Heretaunga (Heret_47a.1), Wyndham (Wynd_9a.1), Otaraia (Otari_3a.1). The soil nutrient test results were assumed to be within optimum levels for sedimentary soils.

Irrigation rates (mm/month) and nitrogen and phosphorus application rates (kg/ha/month) were applied to the background farm on the pasture that was suitable for both grazing and cropping for winter feed only. These irrigation rates and nitrogen and phosphorus application rates were based on the design concentrations for the BPO assessment and the soil moisture modelling complete for the options for each of the options.

Expected pastoral return on the nitrogen applied was determined on a monthly basis, based on DairyNZ (2012). This was the basis against which the sheep farm was intensified. Intensification was via an increase in stock numbers, an increase in fodder crop area, and adjusting the relative productivity of each block so that only the LTS pasture production increased to match the expected return.

Table 3: Overseer Modelling Summary

Parameter	Background	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Dominant Farming Operation	Sheep grazing	Sheep grazing	Sheep grazing	Sheep grazing	Sheep grazing
Pasture Area for Grazing and Cropping Winter Feed	170 ha	170 ha	170 ha	170 ha	170 ha
Pasture Area for Grazing (Steep/Marginal Land)	50 ha	50 ha	50 ha	50 ha	50 ha
Fodder Crop Area (rotates through grazing and cropping area only) [1]	15 ha	18 ha	17 ha	20 ha	17 ha
Forestry Area (Pine)	6 ha	6 ha	6 ha	6 ha	6 ha
Total Farm Area	**230 ha**	**230 ha**	**230 ha**	**230 ha**	**230 ha**
Stocking Rate [2]	2,900 RSU	3,500 RSU	3,425 RSU	4,050 RSU	3,100 RSU
Pasture Production [3]	9,870 – 9,958 kg DM/ha/yr	9,929 – 12,729 kg DM/ha/yr	9,925 – 12,406 kg DM/ha/yr	9,969 – 15,337 kg DM/ha/yr	9,971 – 10,383 kg DM/ha/yr
Nitrogen Leaching	10 kg N/ha/yr	31 kg N/ha/yr	25 kg N/ha/yr	45 kg N/ha/yr	14 kg N/ha/yr
Phosphorus Leaching	0.6 kg P/ha/yr	0.7 kg P/ha/yr	1 kg P/ha/yr	0.8 kg P/ha/yr	0.7 kg P/ha/yr

Notes:

1. *Fodder crop area was determined from stocking rate based on 5 ha swedes/1000 RSU (Rankin & Bruce, date unknown).*
2. *Stocking rate was set to achieve pasture production equivalent to the estimated pasture growth response to nitrogen expected on a seasonal basis as outlined in DairyNZ (2012). The pasture response assumed was 6 kgDM/kgN May – June, 12.5 kgDM/kgN July – September, 20 kgDM/kgN October – February, 7.5 kgDM/kgN March – April.*
3. *Pasture production is determined through Overseer based on stocking rates and crop production. However, stocking rates were iterated to achieve pasture production that would be expected from the nitrogen applied as wastewater.*

Table 4: Overseer Modelling Input Data

	Year-round Untreated			Year-round Treated			Dual Discharge Untreated			Dual Discharge Treated		
Month	**Irrigation (mm/month)**	**Total Nitrogen Load (kg/ha/month)**	**Total Phosphorus Load (kg/ha/month)**	**Irrigation (mm/month)**	**Total Nitrogen Load (kg/ha/month)**	**Total Phosphorus Load (kg/ha/month)**	**Irrigation (mm/month)**	**Total Nitrogen Load (kg/ha/month)**	**Total Phosphorus Load (kg/ha/month)**	**Irrigation (mm/month)**	**Total Nitrogen Load (kg/ha/month)**	**Total Phosphorus Load (kg/ha/month)**
January	41	26	2	93	19	6	93	59	6	93	19	6
February	35	22	2	81	16	5	79	50	5	79	16	5
March	41	26	2	93	19	6	91	58	5	91	19	6
April	46	29	3	101	20	6	101	63	6	101	20	6
May	51	32	3	0	0	0	4	2	0	4	0	0
June	33	21	2	0	0	0	0	0	0	0	0	0
July	16	10	1	0	0	0	0	0	0	0	0	0
August	6	4	0	0	0	0	0	0	0	0	0	0
September	0	0	0	109	22	7	0	0	0	0	0	0
October	20	13	1	110	22	7	46	29	3	46	9	3
November	29	18	2	113	23	7	65	41	4	65	13	4
December	32	20	2	93	19	6	72	45	4	72	14	4
Annual Total	**350**	**220**	**21**	**793**	**159**	**48**	**552**	**348**	**33**	**552**	**110**	**33**

Appendix B

Re-evaluation of Land Based Wastewater Disposal Options Report

Re-evaluation of Land Based Wastewater Disposal Options

Prepared for
Alliance Group Limited, Mataura

June 2004

Quality Control Sheet

TITLE	**Re-evaluation of Land Based Wastewater Disposal Options**
CLIENT	Alliance Group Limited – Mataura
VERSION	Final
DATE	8 June 2004
JOB REFERENCE	AJ90307
SOURCE FILE(S)	AJ90307R001 AJ90307W001 AJ90307S001 AJ90307S007 AJ90307D001

Prepared by

SIGNATURE

Andrew Sussex   Roanna Stewart   Azam Khan

Directed, reviewed and approved by

SIGNATURE

Alan D. Pattle

Limitations:

The report has been prepared for Alliance Mataura, according to their instructions, for the particular objectives described in the report. The information contained in the report should not be used by anyone else or for any other purposes.

Executive Summary

Preliminary

Alliance Mataura is investigating the feasibility of land and wetland treatment options for part of the treated wastewater volume currently discharged into the Mataura River. The waste stream that is being investigated includes green effluent streams that are generated from the combined beef processing, sheep processing and rendering operations at their processing facilities.

Following previous environmental investigations and proposals for the upgrade of the existing wastewater treatment facilities, separation of specific effluent streams that contain higher nutrient loads has either already occurred or are programmed to be completed in this years off-season maintenance period. The separated effluent streams are now identified as the “green effluent stream” and is typically around 1,800 m^3/d.

This report has been prepared to re-evaluate the preliminary feasibility and approximate estimates of cost for disposal of this green wastewater onto land. It has been commissioned in response to a meeting of submitters in March 2004 as part of the discharge to Mataura River resource consents programme. Land disposal would be used under varying conditions of wastewater treatment for times when the Mataura River flow is below 40 m^3/s (cumecs).

Under a land based treatment scenario, the green waste stream would be separately conveyed to a dedicated treatment section of the existing chemically assisted dissolved air flotation (DAF) treatment plant. This report investigates the options for the disposal of either acid phase treated (for the removal of proteins and solids) or lime phase treatment (to assist in the removal of dissolved reactive phosphorus) for irrigation options including grazed pasture, plantation forest or wetland treatment.

Selection Criteria

Selection criteria and preliminary design of land disposal options have been based on nutrient and hydraulic loading limits appropriate for sustainable land use and soil limitations. Selection of soil properties and potential irrigation areas was based on the findings of the report carried out by SoilWork Limited (November 2003). Limitations on irrigation methods were primarily based on hydraulic application rates, while nutrient loading was primarily based on land use activity.

The Options

Several potential land disposal options have been identified. These involve combinations of varying treatments levels (untreated, acid phase DAF treated and lime phase DAF treated) with various disposal methods. The disposal methods involve alternatives of irrigation hardware (travelling and fixed irrigation systems), land use options (grazed, cut and carry, and forest), and in one case wastewater discharge to the Mataura River after wetland treatment. The key objectives of this investigation were to complete a technical and economic analysis of each option and comment on the associated feasibility and risks.

Three options were short listed based on their technical feasibility:

a) **Wetland Treatment** is the most economically feasible option, but still requires the discharge of the final treated wastewater to the Mataura River. It has capital cost of just under $4M (excluding GST). The wetland treatment would be undertaken in conjunction with use of the existing dissolved air flotation (DAF) treatment plant followed by an upgraded lime phase DAF process for phosphorus removal, and a biological nutrient removal system. The wetlands would be around 7 - 9 ha with surface flow configuration and would require to be operated on a continuous basis. However, the addition of the wetland treatment would provide an aesthetic improvement only.

If wetland discharge is not acceptable then the capital costs would rise to $7M - $9M for:

b) **Grazed Pasture Irrigation of Lime Phase** effluent (adjusted downwards to suitable pH) as a bolt-on system following treatment of the green waste stream in the existing DAF treatment plant (both acid and lime phases). The wastewater would be irrigated onto about 284 ha of grazed (sheep or beef) pasture. Wastewater would be applied utilising a pod irrigation system such as K-line.

c) **Grazed Pasture Irrigation of Acid Phase** effluent (adjusted upwards to suitable pH) as a bolt-on system following treatment of the green waste stream in the existing DAF treatment plant (acid phase). After neutralising the pH, the wastewater would be irrigated onto about 350 ha of grazed (sheep or beef) pasture. The wastewater would be applied utilising a pod irrigation system such as K-line.

Costs Comparison

Each of the options has been costed for both capital and anticipated operational costs. A summary of the associated land area requirements and associated capital and operating costs is provided in the table below. Whilst, he plantation forest land disposal option is not considered to be economic a summary of the costs are provided in the table below.

Summary of Scenario Disposal Options and Associated Costs

	Grazed Pasture – SRI (200 N)	Plantation – SRI (150 N)	Wetlands with N Removal
Scenario 1: Acid Phase			
Total Area Required (ha)	351	702	7
Total Cost	$9M	$26.9M	$3.6M
Land Purchase Cost	$4.6M	$9.1M	$91K
Development Cost	$4.4M	$17.8M	$3.5M
Annual O & M Cost	$140K	$338K	$200K
Scenario 2: Lime Phase			
Total Area Required (ha)	284	568	9
Total Cost	$7.0M	$22.4M	$3.8M
Land Purchase Cost	$3.7M	$7.4M	$117K
Development Cost	$3.3M	$15M	$3.7M
Annual O & M Cost (	$119K	$310K	$201K

Notes:

1. *Untreated green wastewater land disposal is not a feasible option due to high nitrogen loading rates.*
2. *Cut and Carry systems were not costed as they were not considered feasible due to factors including; hydraulic limitations at feasible nutrient loads, limitations in irrigation method with sustainable instantaneous irrigation application rates, uncertainty as to potential for a saleable harvested crop.*
3. *Land areas for irrigation options are all assumed to be within 5 km of the plant site.*
4. *Areas required for plantation options are potentially too large to be realistically sourced within the area available.*

Key Factors Affecting Feasibility

A number of key factors have been identified for the various options with the most significant of these being:

1. **Land Availability:** Purchase of adequate land areas and easements required for access to suitable irrigation sites is a significant issue for the viability of the irrigation options.

2. **Soil limitations:** Many parts of the potential areas contain soils that may not be suitable for year round irrigation and/or have low permeability requiring irrigation methods with low instantaneous application rates. The SoilWork (November 2003) report identifies potential areas for irrigation, however, site specific studies are recommended for proving the hydraulic potential of individual soil types in the actual areas that would be irrigated.

3. **Significant Capital Costs**: The capital costs for land disposal options for slow rate irrigation either on pasture or in the forest are significant compared to the capital works costs associated with the continued discharge into the Mataura River after further biological wastewater treatment and land assisted treatment through wetlands.

Recommendations

In the event that “land disposal” options continue to be considered for the disposal of part of the treated wastewater following upgrading of the existing DAF-based wastewater treatment system to remove DRP, then the following actions are recommended:

1. **Investigation of land availability and options for purchase**: Identification of suitable properties in the prospective irrigation areas.
2. **Site specific soil studies in potential future irrigation areas:** Determine acceptable long term design parameters in terms of hydraulic loading constraints, irrigation rates and return period.
3. **Detailed costing analysis of preferred option:** Revise and refine costings for the scheme options.

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Appendices

1.0 Introduction

1.1 General Background

Alliance Group Limited operates a combined sheep and beef processing plant (Alliance Mataura) in Mataura. In addition to the slaughter and further processing of the animals, the plant has ancillary by-products processing divisions that involve processing in the fellmongery, pelthouse (pelts and hides), and rendering.

As a result of the various processing divisions, effluent is generated that requires significant physical and chemical treatment in the on-site chemically assisted dissolved air flotation (DAF) based wastewater treatment plant prior to the discharge into the Mataura River.

Alliance Mataura has applied for resource consents in December 2003 for the continued discharge of up to 14,400 m^3/d treated wastewater into the Mataura River. Whilst establishing that continued discharge into the Mataura River is the most practicable option, Alliance Mataura has responded to submissions by agreeing to re-evaluate land disposal options to determine their feasibility, especially during low river flows.

In order to allow discharge into the Mataura River, Alliance Mataura has determined through its consultative process prior to the resource consent application that a key constraint for continued discharge was the level of dissolved reactive phosphorus (DRP) in the treated wastewater. Therefore, the main investigations and proposals for the upgrade of the existing wastewater treatment facilities have focussed on the separation of specific effluent streams that contain higher amounts of DRP and the subsequent removal of DRP via the double pH-adjustment method in the existing DAF based wastewater treatment plant. The separated effluent streams are now identified as “green effluent streams” and were typically around 3,600 m^3/d prior to recent changes in site operations and further waste reduction initiatives undertaken by Alliance Mataura.

Preliminary investigation of land disposal options (SoilWork, 2003) identified that the soils in and around the Alliance Mataura processing plant are generally unsuitable for a high hydraulic application as the soils are often of low permeability. The SoilWork[1] report also identified that irrigation systems would become nitrogen-limited as the volume is reduced. Consequently, the resource consent application lodged in December 2003 proposed enhanced treatment to reduce DRP levels rather than land based options. Since then, submitters to the application have suggested that the land uses other than pastoral farming should be considered (wetlands and plantation forestry in particular). Alliance Mataura responded by commissioning a more detailed assessment of all three options.

[1] SoilWork Limited (2003). *Preliminary Assessment of Suitabilities of Local Soils for Wastewater Irrigation*. Consultancy Report prepared by SoilWork Limited for Alliance Group Ltd – Mataura. November 2003.

Since the preparation of the preliminary soils report by SoilWork[2], Alliance Mataura has identified opportunities to reduce the volume of green effluent streams through various methods. The recent closure of the casings department has assisted in this respect. This meant that will be a substantial reduction in the volume of high strength green effluent streams once separation is complete. The volume of this effluent is estimated to be around 1,800 m^3/d prior to treatment.

One of the key concerns that the submitters to the application have identified is that there is evidence that the discharge has been contributing to nuisance growth in the Mataura River during extended periods of low flow.

Given that the volume of the “green effluent stream,” can be reduced, Alliance Mataura is revisiting the investigation of the feasibility of land based treatment methods including pastoral and plantation forest irrigation, as well as wetland based treatment which still requires final discharge back into the Mataura River.

Alliance Mataura has engaged Pattle Delamore Partners Limited (PDP) to determine the preliminary feasibility and approximate estimates of cost for disposal the “green effluent streams” wastewater onto land under varying conditions of wastewater treatment for times when the Mataura River flow is below 40 m^3/s (cumecs).

1.2 Scope of Report

This investigation examines the options for irrigation of the treated, partially treated and untreated green components of the wastewater onto land, only when the river flow is low (less than 40 m^3/s). For river flows above 40 m^3/s the green wastewater is assumed to be discharged with the other plant wastewater after treatment to remove dissolved reactive phosphorus as currently proposed by Alliance Mataura.

The specific matters covered in this investigation include:

1. Determination of suitable pastoral land areas and plantation forest land areas for slow rate irrigation;
2. Evaluation of the wetland requirements for the removal of contaminants following substantial treatment in a Biological Nutrient Removal (BNR) plant for continued discharge into the Mataura River;
3. Provision of cost estimates for both treated and untreated green effluent stream to allow comparison with other treatment and disposal options previously evaluated by Alliance Mataura;
4. Assessment of the practicability of land disposal and recommendations for further investigations.

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[2] SoilWork Limited (2003). *Preliminary Assessment of Suitabilities of Local Soils for Wastewater Irrigation*. Consultancy Report prepared by SoilWork Limited for Alliance Group Ltd – Mataura. November 2003.

2.0 Green Effluent Streams

2.1 Green Effluent Separation

Alliance Mataura is currently planning on-site physical works to provide separation of "green" waste streams. The green waste streams are typically high in contaminants including organic matter (biochemical oxygen demand), nitrogen, phosphorus, oil and grease and micro-organisms. The green waste streams generally comes from operations involving stock yard washing, truck wash, gut cutting operations and rendering plant.

The separation works undertaken have identified other additional non-green waste streams that would need to be separated further to allow a lower volume of total green waste streams produced. Alliance Mataura would then treat this component of the total wastewater separately within the existing dissolved air flotation (DAF) wastewater treatment plant to the rest of the wastewater. For this investigation, the volume of green wastes identified is at 1,800 m^3/d, this amount being the likely green waste stream volume after complete separation of the green waste streams.

Alliance Mataura is proposing to upgrade their existing dissolved air flotation (DAF) wastewater treatment plant to include the removal of dissolved reactive phosphorus (DRP) prior to the discharge of treated meat processing wastewaters into the Mataura River. The separated green waste stream will undergo an acid phase DAF treatment (removal of proteins) and subsequent alkaline phase DAF treatment to remove dissolved reactive phosphorus. This upgraded treatment process is proposed to be applied to the green wastewater stream prior to its disposal for some of the options discussed in this report ("lime phase treated green wastewater").

2.2 Green Effluent Characteristics

During the waste surveys, Alliance Mataura has identified the likely green waste stream characteristics and the likely loads following treatment in the existing DAF for the green waste stream following acid phase and alkaline phase treatment.

For this investigation of the land disposal options, Alliance Mataura have identified that the likely wastewater characteristics of the land disposed effluent would be similar to that determined in the waste surveys. The wastewater characteristics provided in Table 1 show that the untreated green waste streams from the survey. The acid and lime phase effluent characteristics is based on the removal efficiencies obtained during the recent pilot plant trials[3] undertaken by Alliance Mataura. "Acid Phase" is the wastewater output after the first stage of DAF treatment, similar to the effluent type produced after the full-scale DAF treatment facilities at the site, and "Lime Phase" is the wastewater output following the proposed second stage of DAF treatment as occurred during the recent trials for phosphorus removal.

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[3] PDP (2004). *DAF Pilot Plant Trials for the Removal of Contaminants from Green Waste Streams*. Pattle Delamore Partners Limited Consultancy Report for Alliance Mataura. (June 2004).

Table 1: Green Effluent Stream Expected Effluent Characteristics

Parameter	Untreated	Acid Phase	Lime Phase
Biochemical oxygen demand (BOD_5)	1,483	359	199
Total Kjeldahl nitrogen (TKN)	486	202	126
Total phosphorus (TP)	66	37	11.3
Dissolved reactive phosphorus (DRP)	40	26.5	0.9

Notes:

1. *All units in g/m^3.*
2. *The effluent characteristics based on waste survey for untreated and the acid phase and lime phase characteristics based on the removal efficiencies determined in the pilot plant trials undertaken by Alliance Mataura on the green effluent stream. The acid phase effluent is the result of the initial acidified effluent and the lime phase is the final treated effluent after DRP has been removed.*
3. *The wastewater characteristics have been obtained from pilot scale DAF trials during March – April 2004 (Trial outcomes reported separately).*

The pH of the primary DAF treatment (acid phase) is around a pH of 3 to 4 pH units, compared to the second stage lime phase DAF wastewater, which has a pH of around 9.5 to 10 pH units.

2.3 Effluent Quality for Land Disposal Requirements

The proposed DAF treatment upgrade involving a second stage of DAF treatment with lime addition for phosphorus removal is primarily for the benefit of reducing DRP for continued surface water discharge. If irrigation of treated green wastewater was to occur, the need for the green waste stream to undergo the second phase of DAF with lime treatment can be minimised, as phosphorus in the treated wastewater would be a useful nutrient to land if the load is kept to a reasonable level.

However, if treatment stops after the first stage of DAF treatment (acid phase) the wastewater is likely to be too acidic for continued land disposal. The low pH of the first phase DAF wastewater would require pH correction by lime addition to a more neutral pH (at least 6.5) for irrigation. The addition of lime to do this pH adjustment would provide an additional cost, however, the total volume of wastewater is less than if complete lime phase treatment is carried out as the amount of whitewater (air saturated water used in the DAF) does not form part of the treated effluent stream (covered in Section 3.2) thus reducing pumping and irrigation costs.

In comparison, if secondary DAF (lime treated) wastewater was irrigated pH correction from 10 to a more sustainable value suitable for irrigation of around 8.5 or less would be relatively easy through inclusion of a small volume of pH 4 DAF effluent from the non-green wastewaters stream. The wastewater volume for the lime treated DAF wastewater is higher (approximately 3,050 m^3/d), but it has a lower nitrogen and phosphorus load, requiring less land area for disposal overall.

The untreated effluent has a high BOD_5 (as well as COD), nitrogen and phosphorus concentrations. While the irrigation of this water may be feasible based on nitrogen and phosphorus levels alone (at least to grazed pasture systems and forest options), the effects of high BOD_5 on the soil and the potential for odour make irrigation of this wastewater uncertain. The microbiological load of this wastewater is also expected to be significantly higher than the treated wastewater, leading to a higher risk in irrigation with regard to possible stock and public health issues associated with spray drift. While it is possible to reduce microbiological population through ultraviolet disinfection (UV), these types of treatment require reasonable water clarity and application of UV is unlikely to be effective. Typical irrigation areas required for untreated effluent are shown in the calculations below, however, this option is not recommended over irrigation of either the partially or fully treated green wastewater.

3.0 River Flow and Land Disposal Implications

3.1 Mataura River Flow

Mataura River flow data was obtained from Environment Southland to determine likely numbers of irrigation days for the condition of river flow less than 40 m^3/s. A probability distribution of flows provided by Environment Southland for the Mataura River flows at Tuturau (approximately 6 km downstream of the discharge point) for the period 1 January 1983 to 1 January 2004 shows that the river is below 40 m^3/s for 27% of the time (approximately 99 days per year on average). While this is true for the entire data set from 1983 to 2004, the actual number of days in any single year when flows fall below 40 m^3/s are more relevant to determining likely frequency that might be encountered in the future. The variability of this number of days is also important.

Table 2 shows the actual number of days historically over the dataset when the flow has been below 40 m^3/s for each year on record.

Table 2: Mataura River Flow Frequency Below 40 Cumecs

Year	Number of days per year	Year	Number of days per year
1983	15	1994	30
1984	28	1995	107
1985	153	1996	77
1986	108	1997	52
1987	64	1998	106
1988	105	1999	139
1989	181	2000	108
1990	211	2001	128
1991	68	2002	98
1992	88	2003	192
1993	52		

Notes: *1. Data supplied by Environment Southland May 2004.*

As can be seen in Table 2, there is considerable variability in the actual number of days when river flow is less than 40 m^3/s, and the average number determined from the flow probability distribution (99 days) is often well exceeded. For example, approximately 10% of all years have 185 or more flow days $<40\ m^3/s$.

3.2 Wastewater Flow Volumes and Predicted Loads

The number of processing days per season is around 195 (191 in the 2001/2 season). However, the number of days of processing in the November to May period is lower, at around 165 days, based on the 2001/2002 season. Because the river flow is unlikely to be below 40 m^3/s outside the November to May period (based on inspection of a selected period of historical flow data (1996 to 1998)), using the maximum number of days of processing inside the period of lower flows makes a reasonable design basis for calculating possible annual flows sent to irrigation. From the Mataura River, flow records (at Tuturau), approximately 14% of years on record have more than 165 days when river flow is less than 40 m^3/s (capturing nearly 87% of the days when river is below 40 m^3/s).

Therefore, for preliminary design purposes it is appropriate to use 165 days of irrigation for the irrigation area sizing, as this is a realistic estimate of possible irrigation days that may be required. Because 165 days of irrigation is close to the total processing days per year the costs of irrigating all year round would be similar, and hence this option is not considered separately.

Based on wastewater flow surveys undertaken by Alliance Mataura the green wastewater flow could be reduced to around 1,800 m^3/d. This flow figure is used for preliminary design purposes for all irrigation days for the untreated green wastewater flow. The DAF treatment introduces approximately 30% extra water flow in the dissolved air input (whitewater). Thus the flow from the first phase of DAF treatment (acid phase) will be 2,340 m^3/d, and from the second phase of DAF treatment (lime phase), the flow increases to 3,042 m^3/d.

From the river flow and production data discussed in Section 3.1 above, the assumed number of irrigation days (165) and the predicted daily flow give an annual irrigation volume of 501,930 m^3 assuming irrigation of lime treated (2 DAF phases) green wastewater.

If partially treated (first phase of DAF only) green wastewater was irrigated, a lower volume of irrigation is required, at approximately 386,100 m^3 annually, assuming irrigation only occurs when the river is less than 40 m^3/s. Some pH adjustment is required for this option, which has assumed to not affect the annual volume noticeably.

If untreated green wastewater was irrigated, an even lower volume of irrigation is required, at approximately 297,000 m^3 annually, assuming irrigation of green wastewater only occurs when the river is less than 40 m^3/s.

The above flows and the nutrient concentrations based on the waste surveys and pilot plant removal assessment, the likely annual loads are shown in Table 3.

Table 3: Estimate of Annual Flows and Loads for Irrigation

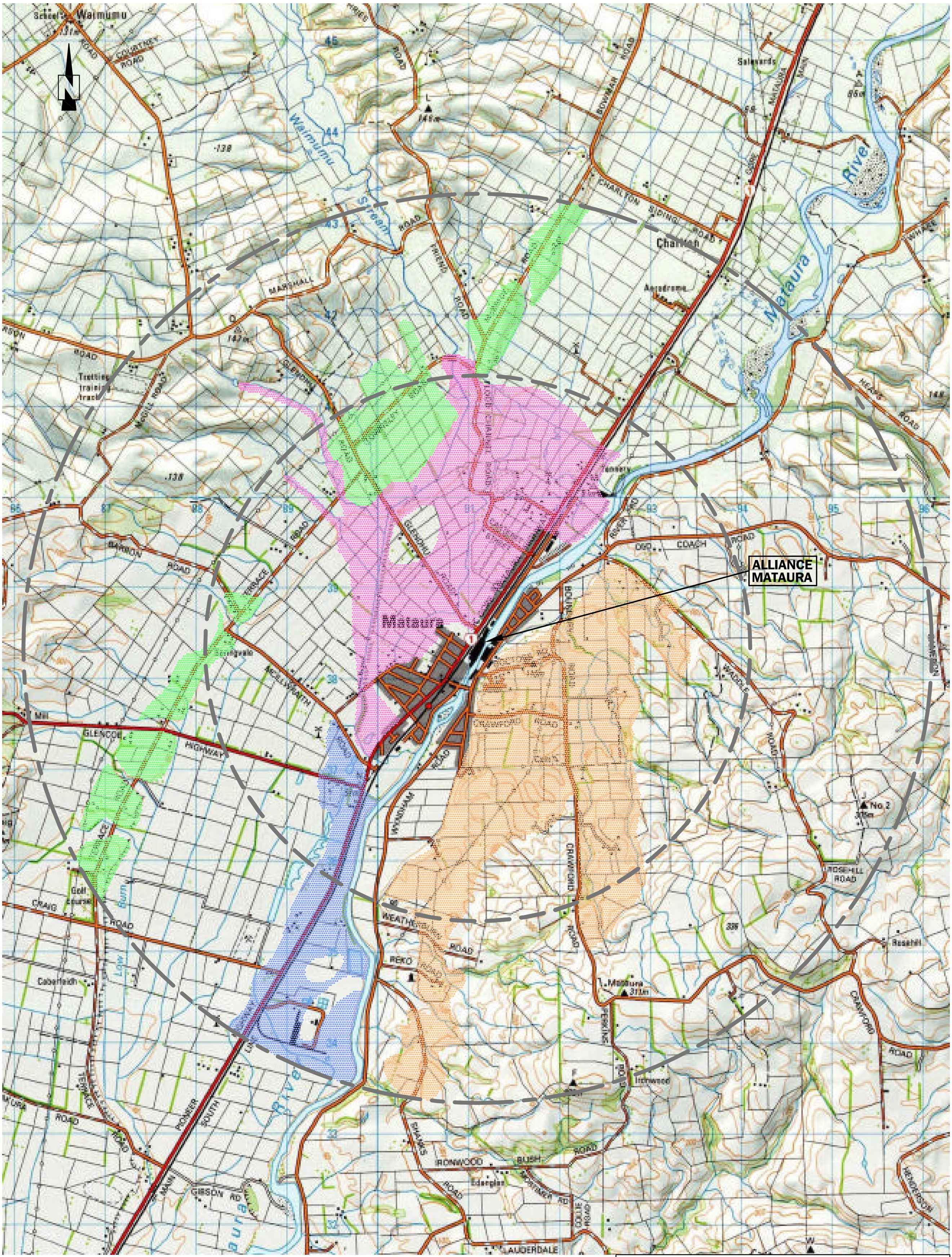
Treatment Level	Flow (m^3/yr)	Nitrogen load (kg/yr)	Phosphorus load (kg/yr)
Untreated Green	297,000	144,375	19,635
Post Acid Phase	386,100	78,045	14,190
Post Lime Phase	501,930	63,195	5,775

Notes: *1. The post lime phase is after the acid phase as described to enable DRP removal.*
2. Loads calculated from waste surveys and pilot plant removal efficiencies.
3. The irrigation days are estimated to be around 165 days when the river is likely to be below 40 m^3/d.

Whilst, the annual nitrogen load from the untreated green effluent stream is calculated at 144 tonnes, well above the previous preliminary estimates of 98 tonnes (based on 2003 - 2004 season) provided in the SoilWork report, this calculated annual load is a reasonable design estimate for feasibility investigation. The actual loads may vary season to season depending on the stock numbers, however, the design is based on the likely nitrogen production of 795 kg/d from green waste streams for the full processing period of 165 days (132 tonnes) between November and May and allowing for a contingency load of 10% (13 tonnes). The actual annual load required for land disposal would also be determined from the number of actual days the Mataura River flow is below 40 m^3/s and could be well above 165 days as shown in the long-term data in Table 2.

4.0 Land Disposal Options and Sizing

Given the limitations of soil type, soil physical and chemical properties, topography and other constraints considered in the SoilWorks Limited 2003 report (Appendix 1), as well as maintaining land treatment systems within 5 km of the Alliance Mataura plant , areas for potential irrigation were considered within “Area 1”, “Area 3” and “Area 4” as defined by SoilWorks (see Figure 1). Possible land uses of the irrigated area considered are discussed below followed by the advantages and disadvantages of the various application technologies.



Notes:

1. Soils identification based on SoilWork Ltd Report : Preliminary Assessment of Suitabilities of Local Soils for Wastewater Irrigation, November 2003.
2. Wetlands would be potentially located in Area 2. Potential irrigation areas are located primarily within Area 3 and part of Area 1.

KEY

- 3 km Radius from Alliance Mataura Plant
- 5 km Radius from Alliance Mataura Plant
- Area 1: ~310 ha of Tuturau, Edendale & Arthurton soils
- Area 2: ~140 ha of Ardlussa & Charlton soils
- Area 3: ~ 500 ha of Makarewa soils
- Area 4: ~ 550 ha of Tuturau soils

APPROX. SCALE 1:60,000 (A4)

Figure 1: POTENTIAL LAND DISPOSAL AREAS FOR ALLIANCE MATAURA WASTEWATER

4.1 Land Use Options and Limitations

For each option of land disposal considered it was assumed that Alliance Mataura would purchase the necessary land at current market values. With the higher daily volume generated, wastewater irrigation to company owned land is desirable over privately owned land in the longer-term due to its provision of certainty regarding continued access to the land, and reducing third party risk to Alliance Mataura in the case of unforeseen incidents related to the wastewater disposal process or other downstream effects (e.g. potential unforeseen negative effects on soils, or conflicts over land management such as the grazing rotation, meshing with irrigation events and maintenance of appropriate stock withholding periods.

4.1.1 Grazed Pasture (Beef and Sheep)

The existing land use is for grazed pasture, and continuing the land use represents the least cost in irrigation site development. However, given the long term uncertainties of continued acceptance of industrial wastewater irrigation onto dairy farmland, Alliance Mataura has considered that the areas required for irrigation would need to be converted to either sheep or dry stock beef grazing.

Irrigation methods have some impact on farm layout, in terms of fencing and access for the irrigation equipment. Even more significant controls on irrigation of grazed land come with the requirements from stock withholding periods. The stock withholding period is the time required for stock to be kept off the irrigated land following an irrigation event in order to allow natural processes such as UV light exposure and drying out to render any potential microbiological components of the wastewater harmless to stock. Irrigated grass also may be unpalatable to stock if grazed too close to an irrigation event. Typically a 7 day withholding period would be expected, thus making the return period for irrigation events greater than 7 days.

Irrigation outside summer months introduces further constraints on some soils such as the Makarewa soil type, the dominant type found in Area 3 (SoilWork, 2003). Outside summer months these gley soils (typically with restricted drainage and a high groundwater table) could be likely to become pugged and suffer structural damage with cattle walking on areas of higher moisture content due to irrigation. The river flow irrigation constraint (irrigation when the river is <40 m^3/s) means that irrigation is likely to occur both during summer (December to March), and in November, April and May. The months outside of the mid-summer period are of greater potential for soil moisture problems. The soils such as the Edendale and Tuturau soils that make up much of Area 1 and Area 4 are generally better drained and more suitable to irrigation, although some parts are non-contiguous. Some of Area 1 has been assumed to be utilised for irrigation, and there is probably some scope for directing irrigation to these Area 1 soils at the less favourable times of the season, thereby reducing effects on the poorer soils in Area 3. Area 4, which consists predominantly of Tuturau soils contains significant areas of well drained soils however is undulating with slopes up to 8° and non-contiguous.

Land area requirements for grazed pasture irrigation are considered to be limited by a combination of nutrient loading and hydraulic constraints. For raw wastewater the land area required is greater due to nutrient loading but not as constrained by hydraulic concerns. For partially treated and lime treated DAF wastewater the hydraulic constraints increase due to increasing annual volume for disposal, while at the same time having lower total nutrient loads due to increased treatment. Based on a preliminary assessment the hydraulic loads should be acceptable, however, the lime treated DAF wastewater load is at the upper end of acceptable limits for hydraulic load[4] based on acceptable return periods if irrigation depth is limited to around 25 mm per event.

Based on a nitrogen load limit, the areas required for irrigation are outlined in Table 4. The nitrogen load of 300 kg N/ha/year was selected as it is likely to be the maximum sustainable nitrogen load for grazing without excessive nitrogen leaching to groundwater. While other consents issued from Environment Southland have higher nitrogen load limits for grazed pasture (up to 350 kg N/ha/yr) the hydraulic loading rates associated with these higher nitrogen loading rates are not acceptable for the soils considered in this investigation. Given large areas of soils with restrictive drainage capabilities and high water tables within the potential irrigation area, an increased hydraulic load is less likely to be feasible (if a higher nitrogen load was applied). Similarly, increasing the treated/partially treated wastewater nitrogen load from 300 kg N/ha/yr means the phosphorus load increases to less sustainable amounts.

Table 4: Land Area Requirements for Grazed Pasture Irrigation

Treatment Level	Net Irrigation Area (ha)	Hydraulic Load (mm/yr)	Nitrogen Load (kg/ha/yr)	Phosphorus Load (kg/ha/yr)
Acid Phase	260	114	300	42
Lime Phase	210	238	300	27

Notes: 1. *No detailed water balance modelling has been undertaken at this stage to confirm expected feasibility of the hydraulic loads. The Acid and Lime DAF treated hydraulic load is likely to be at the upper end of acceptable hydraulic loading based on return periods.*

2. *Irrigable Land Area above is actual land irrigated without allowance for buffer zones and tracks, water courses etc. An allowance of 35% above net area is undertaken for costing analysis to allow for buffers.*

At this pre-feasibility stage the effects of potassium in the wastewater have not been evaluated. However, it should be kept in mind that with some wastewaters, high potassium can be limiting over nitrogen through the potential for pasture imbalances and subsequent risk of metabolic disorders in grazing animals. Similarly, wastewater with high sodium content (in relation to calcium and magnesium) can lead to soil structural changes and reduction in permeability. Whilst the pelt house effluent is generated at the plant, this waste stream does not form part of the green wastes streams and therefore

[4] SoilWork Limited (2003) recommends no more than 20 to 25 mm application depth per irrigation event.

sodium levels (although not evaluated as part of this study) would not be expected to be high for this type of wastewater.

Therefore, based on the above assessment and limitations, grazed pasture irrigation, at least of the partially treated or lime phase treated DAF wastewater, is considered technically feasible provided the right irrigation methods are utilised (see Section 4.2). (Irrigation of raw wastewater is not recommended due to the reasons outlined in Section 5.1). The likely gross area required for this option would be in excess of 480 ha.

4.1.2 Cut and Carry Pasture

Cut and carry operations irrigate a crop (often pasture) at a higher nitrogen loading than for grazed systems. Typically cut and carry pasture systems are irrigated at 400 kg N/ha/yr and higher. The higher nitrogen load is achieved through plant uptake and regular harvesting to effectively move the nitrogen off site in the crop (as opposed to grazed systems where most of the nitrogen uptake in the pasture is returned to the land via the stock). Harvesting of grass can occur three to five times annually and suitably accessible land and soil moisture conditions are required for this to occur successfully.

Cut and carry systems are not considered appropriate for the Alliance Mataura situation for the following reasons:

1. At the nitrogen loading rates that would be utilised for cut and carry operations, the corresponding hydraulic loading rate is limiting for treated and partially treated options. Therefore, with an increase in area to meet hydraulic constraints, the area required becomes close to that required for the grazed operations, making grazing the preferred option, (by reducing the expense of harvesting operations while maintaining the profitability of using the land for farming). The acid phase treatment option comes closer to being feasible hydraulically, however, the phosphorus load is likely to be unsustainable. Cut and carry of raw wastewater is considered inappropriate for the reasons outlined in Section 2.3.

2. Suitable low instantaneous rates of irrigation required for the majority of the irrigation area soils are less appropriate with cut and carry systems, apart from fixed solid set irrigation, however, this option is less economically feasible than other systems and methods (e.g. pod irrigation to grazed land).

3. Potential markets for sales of cut and carry pasture are uncertain.

4.1.3 Forestry

Forest irrigation is limited by the nitrogen loading rate of 150 kg N/ha/yr which in turn requires a significantly large area for effluent disposal, e.g. 520 ha required for Acid Phase treated wastewater disposal. Despite this fact forest irrigation has several advantages over other systems.

1. The wastewater is generally isolated from the public or contact with stock due to the shelter provided by the trees.

2. There are minimal constraints on when areas can be irrigated, e.g. no restrictions such as pasture due to stock withholding times or other land use activities.
3. Hydraulic loading is the lowest of all options.
4. Solid-set irrigation hardware can be utilised to apply relatively low instantaneous application rates.
5. Low operator requirements for operation (e.g. no irrigators to shift).
6. Relatively low technology hardware with non-specialist repair and maintenance and possibility for some automation of sprinkler blocks.

The potential disadvantages of such systems are:

1. Relatively high cost for establishment and long term (e.g. 27 years for *Pinus Radiata*) before investment is realised in terms of tree harvesting.
2. Irrigation equipment except for buried mainlines is required to be removed from areas to be logged. (Probably not a significant issue for new establishment, but could be a factor if existing forest used.)
3. Potential nutrient flushing during harvesting and fire risk.
4. Unknown market conditions at the time of harvesting.

A summary of loadings and irrigable land required for the forest irrigation options is presented in Table 5. Further evaluation of the effects of high strength BOD_5 effluent on the individual soil types to be irrigated would be required before progressing with raw wastewater irrigation activities.

Table 5: Land Area Requirements for Forest Irrigation

Treatment Level	Irrigable Land Area Required (ha)	Hydraulic Load (mm/yr)	Nitrogen Load (kg/ha/yr)	Phosphorus Load (kg/ha/yr)
Acid Phase	520	57	150	21
Lime Phase	421	119	150	14

Notes: *1. No detailed water balance modelling has been undertaken at this stage to confirm expected feasibility of the hydraulic loads.*

2. Irrigable Land Area above is actual land irrigated without allowance for buffer zones and tracks, water courses etc. An allowance of 35% above net area is undertaken for costing analysis to allow for buffers.

4.1.4 Wetlands

Wetland treatment of wastewater from Alliance Mataura would not be appropriate for untreated green wastewater due to the BOD_5 and nutrient loads involved. For the partially treated and lime treated options, additional nitrogen removal would also be required to reduce nitrogen to a level that can be further renovated by the wetland. The effectiveness of a wetland system in terms of nitrogen removal is that, unless the wetland plants are harvested, ultimately there is very little net removal of nitrogen from the river system. The wetland plants do remove some nitrogen, however, the plants will eventually die and then slowly release this nitrogen back into the water. The timing of the nitrogen release back into the river is over a long time period and not necessarily at times of low flow in the river, however, in terms of net nitrogen renovation the wetland system performs poorly compared to the other options. Wetland systems are also not perceived to be “land treatment” systems as the final discharge is back to surface water.

A modified activated sludge type of wastewater treatment plant like a Sequencing Batch Reactor (SBR) type process (biological nutrient removal) would be required for nitrogen removal utilising a combination of anaerobic and aerobic treatment system that treated wastewater after the existing DAF treatment system or after an upgraded lime DAF treatment system. This additional treatment system represents significant extra costs and operational demands.

During previous discussions between Alliance Mataura and submitters, it was suggested that the Mataura Township sewage treatment plant (oxidation ponds) could be upgraded and discharged into wetlands prior to discharge into the Mataura River. This volume of wastewater generated from the Mataura oxidation pond is about 900 m^3/d. This would require an additional 1 – 2 ha of wetland area in addition to that required by Alliance Mataura.

Provided an additional organic matter and nitrogen removal treatment system was built the areas required are shown in Table 6.

Table 6: Land Area Requirements for Wetland Treatment

Treatment Level	With N Removal - Total Area Required (ha)
Acid Phase	7
Lime Phase	9

Notes: *1. Area determined by the maximum allowable hydraulic load limit (100 L/m^2/day).*

The main benefits of establishing a wetland system is to polish the effluent to reduce total suspended solids and provide a marginal increase in dissolved oxygen in the discharged treated wastewater. In New Zealand, the use of wetlands have generally been for community level sewage treatment plant systems and provide an aesthetic improvement of the wastewater treatment system prior to discharge to surface water in order to satisfy cultural needs.

The disadvantage of the use of wetlands is that it generally reduces the microbial quality of the treated wastewater as there is a substantial increase in bird life in the wetlands. For Southland climate conditions a significant amount of wetland plant die-off may occur during the winter months, significantly reducing the treatment performance.

Since the wastewater discharged from Alliance Mataura has a low level of total suspended solids and reduced microbial contaminants, the use of the wetlands would be of aesthetic improvement, rather than as a treatment alternative.

4.2 Irrigation Methods and Limitations

Methods of irrigation considered for use at Mataura are:

1. Centre Pivot Irrigation
2. Lateral Move
3. Travelling rotating-boom irrigators (Briggs type)
4. Solid Set Irrigation
5. Pod irrigation (e.g. K-line irrigation)

There are a number of factors in considering the selection of an irrigation system for the Alliance Mataura wastewater, beyond the obvious limiting factors of available area, soil type and location, including capital and operating costs and desired operational requirements/commitments. Some of the relevant factors for each irrigation method are discussed below.

4.2.1 Centre Pivot and Lateral Move Irrigation

Centre Pivot irrigation is a moving irrigation system which rotates around a fixed point. This method generally has a high capital cost (being the most technologically complex), but also has a low labour requirement compared to other travelling irrigation systems. Traditionally used for fresh water irrigation, Centre Pivot irrigators are now being used for wastewater disposal due to low labour requirements, high uniformity of distribution, water efficiency (for fresh water) and the combined functions of irrigation and wastewater disposal through a single system. Wastewater disposal may be conducted through the centre pivot span or alternatively via additional sprinklers positioned on top of the irrigator fed from a supply line slung beneath the main Centre Pivot truss.

Lateral move irrigation systems use a similar irrigation truss structure as Centre Pivot systems, however instead of travelling in a circle, they travel in straight lines. Like Centre Pivot systems, Lateral Move systems also have high capital costs and generally have low labour requirements. However, they do require greater labour input than centre pivots but are more efficient with use of available land. Water supply for Lateral Move irrigators may be through a flexible hose dragged behind the irrigator or from an open channel ditch system.

Centre Pivot or Lateral Move wastewater disposal to land for Alliance Mataura however is not considered a desirable option due to the following factors:

1. The shapes of the land areas available and the dissected nature of much of the areas with either streams or changes in suitable/unsuitable soil types mean that these types of systems are less viable because they require contiguous large areas to operate in.

2. Because of the rotary nature of centre pivots, significant re-fencing is required in order to keep animals separate from spray zones. Depending on the speed and return period of the irrigator, maintaining suitable stock withholding periods while coordinating stock rotation with irrigation rotations can require complex management of the system.

3. Instantaneous application rates can be high at the outside end of the centre pivot booms due to the relatively fast travel time of the outer end compared with the centre. In general, most travelling irrigators will apply water at higher instantaneous application *rates* to achieve the same total application *depth* over an area, compared to fixed systems or systems that provide a greater instantaneous coverage (i.e. a larger area sprayed at any one time). On the flatter areas, where centre pivots would traditionally be better suited, the soils are generally of lower permeability (e.g. the Makarewa soils) and are less able to receive high instantaneous application rates without ponding occurring.

4. The possible exception to the above points would be if a suitably large area of Area 1 Edendale soils was identified as having sufficient infiltration characteristics and a large enough contiguous area for a single centre pivot. It is likely that a combination of irrigation methods would still be required to dispose all the wastewater.

4.2.2 Rotary Boom Irrigation

Rotary Boom Irrigation is a travelling spray irrigation system. The system consists of a large boom intermittently spaced with sprinklers which moves along an irrigation block by winching to a fixed anchor block. Smaller rotary booms are also available with one sprinkler jet at each end of the boom. The smaller machines can cover smaller, harder to access areas, and can operate on steeper slopes than the larger booms (which are limited to relatively flat or even gradient land). Commonly used in the dairy industry, rotary boom irrigation is cost efficient and relatively easy to operate and manage with relatively low technology. However, the instantaneous application rates typically applied by rotary boom irrigators are too great for lower permeability soils. Therefore because of the expected infiltration capacities of the Makarewa soils, this irrigation method is not likely to be feasible over much of the available irrigation area. Potentially some of Area 1 and Area 4 may be suitable for small travelling boom irrigators, and parts of Area 3 may be suitable in summer, however, having more than one irrigation system used on the same area (at different times of the year) increases capital cost and increases management requirements. Provided soil permeability allows use of travelling boom irrigators they can be a more economical capital cost solution, however, they have higher operational costs (operator time) compared to centre pivots or fixed irrigation systems (solid set) due to shorter run times and the requirement for regular set-up and moving between irrigation runs.

4.2.3 Solid Set Irrigation

This irrigation system uses impact sprinklers typically set on risers at around 1.2 m height above ground. The entire area irrigated is covered by the sprinklers (i.e. they are not moved). This type of system is most commonly used in forestry and non grazed situations. Provided pipe freezing and land use restraints are not issues (for example in a forest, and provided local climate temperature extremes are not an issue), the pipe work can be laid above ground to lower installation costs. Some use has been made in grazed situations in New Zealand, however the sprinklers require mounting on substantial risers to prevent damage from stock (e.g. each sprinkler mounted on a fence post or similar large diameter wooden pole). The main features of the solid set irrigations systems are:

1. Its ease of operation and relatively simple management, with a low labour requirement (no irrigators to shift), and its ability to irrigate any chosen area without having to be concerned with irrigator set up (or stock withholding issues if in a forest or cut and carry operation). There are also possibilities for partially automating a solid set irrigation system (at increased cost).

2. The relatively low instantaneous application rates achievable using this type of system enabling irrigation of soils of lower permeability.

3. Cut and carry systems can use this type of irrigation system as long as the sprinkler layout is designed to not adversely affect harvesting operations, e.g. appropriate sprinkler spacing and well buried laterals and supply pipes.

4. Although this option has higher capital costs, it has low operational costs compared to most moveable travelling irrigator systems (e.g. towable rotary booms).

4.2.4 Pod Irrigation

Pod irrigation is a flexible hose line sprinkler irrigation system. It is used predominantly in the dairy and meat works industries, this system has minimal development and capital costs, but is labour intensive compared to Centre Pivot, Lateral move or Rotary Boom systems. The main features of pod irrigation system are:

1. Pod Irrigation operates on either a 12-hour or 24-hour shift period. Used increasingly for effluent disposal (currently used at the Alliance Lorneville and Alliance Makarewa Meat Processing Plants), this system maximises the use of available land for effluent disposal through being able to irrigate unusual shapes and relatively small discrete areas. A significant benefit of this system is that the instantaneous application rate from the system is low (between 2 – 4 mm/hr) and therefore it may be used in locations with poorly drained soils. There are currently two different pod irrigation systems available on the market, namely “K-Line” and “Le Pod”. Both operate on the same principles and basic design. The standard system consists of ‘lines’ which are made up of 10 sprinklers housed in ‘pods’ on a length of PE pipe at 15 m intervals. This line is attached to a riser in the centre of the paddock and is moved on a daily basis in a structured format to ensure a uniform irrigation application over the complete block.

2. Pod irrigation is operated at low pressures with relatively low spray height, decreasing the potential for off site spray drift in comparison with larger and higher pressure travelling irrigator systems.
3. Pod irrigation is relatively simple technology and repairs are more easily undertaken by non-specialist operators than on some of the more advanced irrigation systems.
4. A pod irrigation system for the effluent disposal from the Makarewa plant would involve the development of the land (depending on the level of effluent treatment) into appropriately sized (approximately 5 ha) irrigation blocks. Operation of the system would be managed on a 24 hour shift system with the lines of sprinklers being moved daily.
5. The pod irrigation method is recommended for irrigation of grazed pasture, but is potentially unsuitable for a cut and carry operation with long grass making towing of the lines difficult. The pod irrigation system is unable to be used for forest options as it can not be easily moved between rows of trees.

5.0 Land Disposal Options Costing Analysis

Approximate cost estimates (excluding GST) have been made for the options discussed above. Costs are “ball park” (±30%) estimates only and would require revision during detailed design.

Operating and Maintenance Costs (O&M Costs) have been calculated as a percentage of the capital cost. The rates used for the calculations are: 1% for civil works, 0.5% for pipeline, 5% for mechanical and electrical components and between 1.5 – 2.5% for irrigation plant depending on whether the irrigation is a fixed or shift system. For biological nutrient removal plant, additional O&M costs for plant operation are calculated.

5.1 Untreated Green Disposal Options

Land disposal of untreated green effluent is not viable due to the high nitrogen concentration and therefore large disposal area required and it is not applicable for wetland treatment as a phosphorus removal mechanism (i.e. DAF treatment would still need to be undertaken).

5.2 Acid Phase Disposal Options

Land disposal of the acid phase effluent stream requires a significantly large disposal area due to the nigh nitrogen loading in the effluent. The acid phase disposal options for grazed pasture and plantation irrigation requires 350 ha and 700 ha of land respectively (includes additional 35% land area on top of net area). Wetland treatment and eventual river disposal of the treated wastewater, requires 7 ha of land. The plantation disposal area required is significant and therefore would be located up to 5 km away from the Alliance Mataura Plant, while the grazed pasture disposal may be conducted within a 4 km radius of the plant and the Wetland development within a 3 km radius.

Table 7: Acid Phase Disposal Options – Sizing and Costs Summary

Description of Itmes	Grazed Pasture – SRI (300 N) ($'000s)	Plantation – SRI (150 N) ($'000s)	Wetlands with BNR Plant ($'000s)
Land Purchase	4,561	9,122	91
Land Development	634	1,221	-
Pump Station(s) & Rising Main	1,402	2,055	554
Biological Nutrient Removal Plant	-	-	1,223
Irrigation System	348	7,796	-
Surface Flow Wetlands	-	-	591
Irrigation Storage Lagoon	175	175	-
Consents and easement	256	1,125	237
Engineering and Design	854	2,444	295
Contingency	734	2,963	580
Total Capital Costs (excl GST)	**9,000**	**26,900**	**3,570**
Annual O&M (excl GST)	**141**	**338**	**200**

Notes:

1. *Wetland influent is >35mg/L nitrogen concentration and therefore a separate nitrogen removal system is required (included in costings).*
2. *Cut and Carry systems were not costed as they were not considered feasible due to factors including; being hydraulically limited at feasible nutrient loads, limitations in irrigation method with sustainable instantaneous irrigation application rates, uncertainty as to potential for a saleable harvested crop.*
3. *SRI = Slow Rate Irrigation; BNR = Biological Nutrient Removal.*
4. *Land development includes fencing, roading, pasture/forest establishment.*

5.3 Lime Phase Disposal Options

Land disposal of the lime phase effluent stream although requiring less land area than the untreated green effluent disposal and Acid Phase irrigation disposal (with the exception of the wetland option) still requires a significant area of land. The Lime Phase disposal options for Grazed Pasture and Plantation Irrigation requires 284 ha and 568 ha of land respectively (including buffers). Wetland treatment and eventual river disposal of the lime phase effluent is also an option, which requires only 9 ha of land. The plantation disposal area required is significant and therefore would be located up to 5 km away from the Alliance Mataura Plant, while the Grazed Pasture disposal may be conducted within a 4 km radius of the plant and the Wetland development within a 3 km radius.

Table 8: Lime Phase Disposal Options – Sizing and Costs Summary

Description of Items	Grazed Pasture – SRI (300 N) ($'000s)	Plantation – SRI (150 N) ($'000s)	Wetlands with BNR Plant ($'000s)
Land Purchase	3,694	7,388	117
Land Development	516	989	-
Pump Station(s) & Rising Main	939	2,055	554
Biological Nutrient Removal Plant	-	-	1,223
Irrigation System	282	6,315	-
Surface Flow Wetlands	-	-	726
Irrigation Storage Lagoon	175	175	-
Consents and easement	191	953	250
Engineering and Design	672	2,031	314
Contingency	555	2,504	613
Total Capital Costs (excl GST)	**7,025**	**22,410**	**3,800**
Annual O&M (excl GST)	**119**	**310**	**221**

Notes:
1. *Wetland influent is >35mg/L nitrogen concentration and therefore a separate nitrogen removal system is required (included in costings).*
2. *Cut and Carry systems were not costed as they were not considered feasible due to factors including; being hydraulically limited at feasible nutrient loads, limitations in irrigation method with sustainable instantaneous irrigation application rates, uncertainty as to potential for a saleable harvested crop.*
3. *SRI = Slow Rate Irrigation; BNR = Biological Nutrient Removal.*
4. *Land development includes fencing, roading, pasture/forest establishment.*

6.0 Summary and Recommendations

6.1 Summary

1. The land disposal options identified include slow rate pastoral and forestry irrigation of either acid phase or lime phase treated effluent. The wetland treatment option is considered as a polishing system for suspended solids for continued surface water disposal after treatment in a biological nutrient removal (BNR) plant.

2. The key constraints identified for the slow rate irrigation systems have been nutrient (especially nitrogen) loading.

3. For pastoral based slow rate irrigation, cut and carry (zero grazing) option is considered not feasible because the hydraulic loading rate becomes limiting to satisfy the higher nutrient loading and therefore the land area required for cut & carry option becomes similar to that for grazed pasture, providing very little economic advantage to pursue cut & carry operations. In addition, the method of irrigation for this system substantially increased the land disposal costs in comparison to the grazed pastoral system.

4. The land disposal of up to 1,800 m^3/d untreated green waste stream is not considered viable because of higher nitrogen loads and other factors including stock health effects, spay drift, microbial contaminants, high organic matter in the effluent stream and the likely community non-acceptance of land disposal of untreated effluents.

5. The total gross area requirements for pastoral grazed option are 284 ha for up to 3,050 m^3/d lime phase treated effluent increasing to 350 ha for up to 2,340 m^3/d acid phase treated effluent.

6. The total gross are required for forestry based disposal would be a minimum of 568 ha for lime phase treated wastewater increasing to 702 ha for acid phase treated wastewater.

7. The wetlands utilised for both level of DAF treated wastewater is not likely to exceed 9 ha. However, the utilisation of wetlands would require establishment of a biological nutrient removal (BNR) wastewater treatment system to reduce nitrogen to lower levels as the wetlands would not remove much nitrogen. The wetlands would reduce total suspended solids but may contribute to an increase in microbial contaminants. The final discharge would still be to surface water.

8. The capital including land purchase (CAPEX) and annual operating (OPEX) costs (excluding GST) for the land disposal options investigated are as follows:

   i. $9M (CAPEX) and $140,000 per annum (OPEX) for acid phase treated effluent disposed onto grazed pasture;

   ii. $7M (CAPEX) and $119,000 per annum (OPEX) for lime phase treated effluent disposed onto grazed pasture;

   iii. $27M (CAPEX) and $338,000 per annum (OPEX) for acid phase treated effluent disposed onto plantation forest;

   iv. $22M (CAPEX) and $310,000 per annum (OPEX) for lime phase treated effluent disposed onto plantation forest;

   v. $3.6M (CAPEX) and $200,000 per annum (OPEX) for acid phase treated effluent disposed via the wetlands after biological nitrogen removal;

   vi. $3.8M (CAPEX) and $200,000 per annum (OPEX) for lime phase treated effluent disposed via the wetlands after biological nitrogen removal.

6.2 Practicability of Land Based Treatment System

Based on the capital costs alone, the land disposal options are not considered feasible, as the costs are well above that expected for the establishment of a biological wastewater treatment system to enable treatment of the green waste streams to a high degree prior to continued discharge into the Mataura River.

For example, for the wetland treatment option, the BNR treatment plant treating DAF treated effluent is expected to be around $1.9M – $2.5M (excluding GST) depending on the proximity to the existing plant. The wastewater characteristics of the discharge from a biological nutrient removal plant is likely to be a very high quality allowing continued discharge into the Mataura River even during extended periods of low river flow.

The utilisation of wetlands relies entirely on a substantial biological wastewater treatment system prior to the wetlands to treat the wastewater prior to discharge through land-assisted treatment. Therefore, if the direct discharge to Mataura River is accepted *per se*, then the use of the wetlands becomes an aesthetic feature of the treatment system. In addition, the wetlands may become a part of nuisance with increase in wild life and subsequent degradation of the discharged water quality into the Mataura River with respect to microbial contaminants.

Based on technical feasibility alone, the land based disposal option that has merit would be the disposal of lime phase treated wastewater on sufficient land in Area 1 and Area 3 identified in this report subject to acceptable hydraulic loading capacities of the soils.

Whilst, the land disposal of DAF treated effluent may be technically feasible onto a maximum of 350 ha of grazed pasture, there are significant constraints in obtaining large parcels of land with suitable soil characteristics to make the land disposal option as feasible bolt-on solution to the existing discharge.

This report has assessed the technical and financial requirements for a number of options for the land disposal of treated green waste streams. The lowest cost option, wetland treatment (Capex $4M) still relies on discharging the final treated wastewater to the Mataura River. Alliance Mataura considers that the establishment of a wetland based treatment system provides no real advantage in terms of a land disposal system because the final discharge is still into the Mataura River. Alliance Mataura recognises that this may not satisfy the expectations of some of the submitters.

6.3 Recommendations

In the event that land based options continue to be considered for disposal of the treated green streams then it is recommended that site investigations be undertaken to identify:

i. Actual suitable sites for irrigation;

ii. Suitable soils and the areas available at each potential irrigation site;

iii. Hydraulic properties of the soils including infiltration rates;

iv. Easement and access requirements; and

v. Landowner interest in property sale in the relevant areas.

GREEN WASTE STREAM NUTRIENT CALCULATION
File Ref: AJ90307S007
Date: 04/06/2004 by RSS
chked AJS/AK

Table 1: Biochemical Oxygen Demand

Source	*Estimated Flow (m3/d)*	*BOD Conc (mg/m3)*	*BOD Load (kg/d)*
Rendering Plant (post Mini-DAF)	388	2000	776
Ovine Gut Cutter	70	4250	298
Sheepyards	40	-	761
Truck Wash	47	-	
Bovine Gut Cutter	392	1270	498
Cattle Yards	559	168	94
TOTAL	1496		2426
10% Contingency for BOD Load			**2669**
20% Contingency for Estimated Flow	**1795**		

DAF Treatment Removal	BOD Load (Flow in) *(kg/d)*	Removal Efficiency *(%)*	BOD Load (Flow out) *(kg/d)*
Raw Phase	-	-	**2669**
Acid Phase	2669	68	**841**
Lime Phase	841	28	**604**

Table 3: Phosphorus

Source	*Estimated Flow (m3/d)*	*P Conc (g/m3)*	*P Load (kg/d)*
Rendering Plant (post Mini-DAF)	388	-	24
Ovine Gut Cutter	70	487	34
Sheepyards	40	-	24
Truck Wash	47	-	
Bovine Gut Cutter	392	56	22
Cattle Yards	559	7.3	4
TOTAL	1496		108
10% Contingency for P Load			**119**
20% Contingency for Estimated Flow	**1795**		

DAF Treatment Removal	P Load (Flow in) *(kg/d)*	Removal Efficiency *(%)*	P Load (Flow out) *(kg/d)*
Raw Phase	-	-	**119**
Acid Phase	119	27	**86**
Lime Phase	86	60	**35**

Table 2: Nitrogen

Source	*Estimated Flow (m3/d)*	*N Conc (mg/m3)*	*N Load (kg/d)*
Rendering Plant (post Mini-DAF)	388	1013	393
Ovine Gut Cutter	70	686	48
Sheepyards	40	-	233
Truck Wash	47	-	
Bovine Gut Cutter	392	160	63
Cattle Yards	559	105	59
TOTAL	1496		795
10% Contingency for N Load			**875**
20% Contingency for Estimated Flow	**1795**		

DAF Treatment Removal	N Load (Flow in) *(kg/d)*	Removal Efficiency *(%)*	N Load (Flow out) *(kg/d)*
Raw Phase	-	-	**875**
Acid Phase	875	46	**473**
Lime Phase	473	19	**383**

Table 4: Dissolved Reactive Phosphorus

Source	*Estimated Flow (m3/d)*	*DRP Conc (mg/m3)*	*DRP Load (kg/d)*
Rendering Plant (post Mini-DAF)	388	25.8	10
Ovine Gut Cutter	70	418	27
Sheepyards	40	-	11
Truck Wash	47	-	
Bovine Gut Cutter	392	41	16
Cattle Yards	559	3.6	2
TOTAL	1496		66
10% Contingency for DRP Load			**72**
20% Contingency for Estimated Flow	**1795**		

DAF Treatment Removal	DRP Load (Flow in) *(kg/d)*	Removal Efficiency *(%)*	DRP Load (Flow out) *(kg/d)*
Raw Phase	-	-	**72**
Acid Phase	72	14	**62**
Lime Phase	62	96	**3**

Summary of Effluent Nutrient Concentrations Used for this Assessment

Characteristic	**Raw Phase**	**Acid Phase**	**Lime Phase**
Volume (m3/d)	1800	2340	3042
BOD (g/m3)	1483	359	199
TKN (g/m3)	486	202	126
TP (g/m3)	66.0	36.9	11.3
DRP (g/m3)	40.1	26.5	0.9

Summary of Effluent Nutrient Loads Used for this Assessment

Characteristic	**Raw Phase**	**Acid Phase**	**Lime Phase**
Volume (m3/d)	1800	2340	3042
BOD (kg/d)	2669	841	604
TKN (kg/d)	875	473	383
TP (kg/d)	119	86	35
DRP (kg/d)	72	62	3

Indicative Cost Estimates

Job	ALLIANCE MATAURA	Prepared by:	RSS
Name	PRE-FEASIBILITY LAND DISPOSAL	Quantities:	RSS
		Date:	04/06/04
		Checked:	AJS
		Approved:	AK
File:	AJ90307S002		

Item	Description	Unit	Qty	Rate	Amount
Option 1 - Acid Phase Effluent Disposal onto Grazed Pasture					
A	***Capital Costs***				
A.1	Land Purchase	ha	351	13,000	4,560,800
A.2	Land Development (incl fencing & capital items)	LS	1	634,141	634,100
A.3	Irrigation Mainline				
	- *Pipe*	m	8500	110	935,000
	- *Thrusting under road/rail*	No	5.5	8,000	44,000
A.4	Irrigation System				-
	- *Aboveground hardware: K-lines*	No	1117	110	122,900
	- *Aboveground hardware: risers*	No	208	60	12,500
	- *Underground hardware*	m	20465	9	180,100
	- *Installation*	LS	1	32,484	32,500
A.5	Storage Lagoon	m^3	7000	25	175,000
A.6	Pump Stations (2 farm locations and 1 at plant)				-
	- *Pumps/Variable Speed Drives*	LS	6	25,500	153,000
	- *Pump Housing*	LS	3	20,000	60,000
	- *Civil Works*	LS	3	50,000	150,000
	- *Telemetry*	LS	3	5,000	15,000
	- *Electrical Systems*	LS	3	15,000	45,000
	Sub-Total (Excl. GST)				**$7,119,900**
	Consents and easements (10%)	LS	1	10%	256,000
	Engineering Costs (15%)	LS	1	12%	854,000
	Contingency (20%) Total	LS	1	20%	734,000
	Capital Cost Total (Excl. GST)				**$8,964,000**
B	***Operating Costs***				
	General Site Maintenance	LS	1	$2,261	$2,260
	Irrigation Mainline	LS	1	$4,895	$4,900
	Irrigation System	LS	1	$4,285	$4,290
	Storage Pond	LS	1	$1,750	$1,750
	Pump Station Infrastructure	LS	1	$12,750	$12,750
	Pump Station Operator	LS	1	$50,000	$50,000
	Pump Station - Electricity	kWh	643,389	$0.10	$64,300
	Annual Operating Cost Total (Excl. GST)				**$140,250**

Indicative Cost Estimates

Job Name	**ALLIANCE MATAURA** **PRE-FEASIBILITY LAND DISPOSAL**	Prepared by: Quantities: Date:	RSS RSS 04/06/04
		Checked:	AJS
		Approved:	AK
File:	AJ90307S002		

Item	Description	Unit	Qty	Rate	Amount
Option 2 - Acid Phase Effluent Disposal onto Plantation					
A	***Capital Costs***				
A.1	Land Purchase	ha	702	13,000	9,121,600
A.2	Irrigation Mainline				
	- *Pipe*	m	14000	110	1,540,000
	- *Thrusting under road/rail*	No	11.5	8,000	92,000
A.3	Irrigation System				
	- *Aboveground hardware: Solid Set*	ha	520	15,000	7,796,300
A.4	Plantation Costs				
	- *Initial Development*	ha	520	1,900	987,500
	- *Fencing*	km	52	4,500	233,500
A.5	Storage Lagoon	m^3	7000	25	175,000
A.6	Pump Stations (2 farm locations and 1 at plant)				
	- *Pumps/Variable Speed Drives*	LS	6	25,500	153,000
	- *Pump Housing*	LS	3	20,000	60,000
	- *Civil Works*	LS	3	50,000	150,000
	- *Telemetry*	LS	3	5,000	15,000
	- *Electrical Systems*	LS	3	15,000	45,000
	Sub-Total (Excl. GST)				**$20,368,900**
	Consents and easements (10%)	LS	1	10%	1,124,737
	Engineering Costs (15%)	LS	1	12%	2,444,278
	Contingency (20%) Total	LS	1	20%	2,963,277
	Capital Cost Total (Excl. GST)				**$26,902,000**
B	***Operating Costs***				
	Plantation Maintenance and Management	LS	1	$33,135	$33,100
	Irrigation Mainline	LS	1	$8,160	$8,200
	Irrigation System	LS	1	$116,944	$116,900
	Storage Pond	LS	1	$1,750	$1,750
	Pump Station Infrastructure	LS	1	$12,750	$12,750
	Pump Station Operator	LS	1	$50,000	$50,000
	Pump Station - Electricity	kWh	1,153,245	$0.10	$115,300
	Annual Operating Cost Total (Excl. GST)				**$338,000**

Indicative Cost Estimates

Job Name	**ALLIANCE MATAURA** **PRE-FEASIBILITY LAND DISPOSAL**	Prepared by: Quantities: Date:	RSS RSS 04/06/04
		Checked:	AJS
		Approved:	AK
File:	AJ90307S001		

Item	Description	Unit	Qty	Rate	Amount
Option 3 - Acid Phase Wetlands					
A	***Capital Costs***				
A.1	Land Purchase	ha	7	13,000	91,000
A.2	Irrigation Mainline				
	- Pipe	m	3000	110	330,000
	- Thrusting under road/rail	No	3	8,000	24,000
A.3	Wetland				
	- Cell development	No	10	30,000	312,000
	- Planting	ha	3	40,000	124,800
	- Associated Pipework	LS	1	154,000	154,000
A.4	Biological Treatment				
	- Anaerobic Pond	m^3	15600	25	390,000
	- SBR	m^3	15600	25	390,000
	- Aerators	No	5	42,000	210,000
	- Mixers	No	3	15,000	45,000
	- Electrical works	LS	1	100,000	100,000
A.5	Post SBR Buffer Storage Lagoon	m^3	3500	25	87,500
A.6	Pump Stations				
	- Pumps/Variable Speed Drives	LS	2	20000	40,000
	- Pump Housing	LS	2	10000	20,000
	- Civil Works	LS	2	10000	20,000
	- Telemetry	LS	2	10000	20,000
	- Electrical Systems	LS	2	50000	100,000
	Sub-Total (Excl. GST)				**$2,458,300**
	Consents and easements (10%)	LS	1	10%	236,730
	Engineering Costs (15%)	LS	1	12%	294,996
	Contingency (20%) Total	LS	1	20%	579,805
	Capital Cost Total (Excl. GST)				**$3,570,000**
B	***Operating Costs***				
	Wetland Maintinance	LS	1	$5,908	$5,900
	Biological Treatment System Maintenance	LS	1	$23,300	$23,300
	Mainline	LS	1	$1,770	$1,800
	Storage Pond	LS	1	$875	$875
	Pump Station Infrastructure	LS	1	$8,200	$8,200
	Pump Station Operator	LS	1	$50,000	$50,000
	Pump Station - Electricity	kWh	217,185	$0.10	$21,700
	Aerators - Electricity	kWh	876,000	$0.10	$87,600
	Annual Operating Cost Total (Excl. GST)				**$199,375**

Indicative Cost Estimates

Job	ALLIANCE MATAURA	Prepared by:	RSS
Name	PRE-FEASIBILITY LAND DISPOSAL	Quantities:	RSS
		Date:	04/06/04
		Checked:	AJS
		Approved:	AK
File:	AJ90307S001		

Item	Description	Unit	Qty	Rate	Amount
Option 4 - Lime Phase Effluent Disposal onto Grazed Pasture					
A	***Capital Costs***				
A.1	Land Purchase	ha	284	13,000	3,694,000
A.2	Land Development (incl fencing & capital items)	LS	1	515,901	515,900
A.3	Irrigation Mainline				
	- *Pipe*	m	5500	110	605,000
	- *Thrusting under road/rail*	No	6.5	8,000	52,000
A.4	Irrigation System				-
	- *Aboveground hardware: K-lines*	No	905	110	99,600
	- *Aboveground hardware: risers*	No	168	60	10,100
	- *Underground hardware*	m	16576	9	145,900
	- *Installation*	LS	1	26,311	26,300
A.5	Storage Lagoon	m^3	7000	25	175,000
A.6	Pump Stations (2 farm locations and 1 at plant)				
	- *Pumps/Variable Speed Drives*	LS	4	$25,500	102,000
	- *Pump Housing*	LS	2	$20,000	40,000
	- *Civil Works*	LS	2	$50,000	100,000
	- *Telemetry*	LS	2	5,000	10,000
	- *Electrical Systems*	LS	2	15,000	30,000
	Sub-Total (Excl. GST)				**$5,605,800**
	Consents and easements (10%)	LS	1	10%	191,174
	Engineering Costs (15%)	LS	1	12%	672,690
	Contingency (20%) Total	LS	1	20%	555,121
	Capital Cost Total (Excl. GST)				**$7,025,000**
B	***Operating Costs***				
	General Site Maintenance	LS	1	$1,945	$1,940
	Irrigation Mainline	LS	1	$3,285	$3,290
	Irrigation System	LS	1	$3,471	$3,470
	Storage Pond	LS	1	$1,750	$1,750
	Pump Station Infrastructure	LS	1	$8,500	$8,500
	Pump Station Operator	LS	1	$50,000	$50,000
	Pump Station - Electricity	kWh	500,144	$0.10	$50,000
	Annual Operating Cost Total (Excl. GST)				**$118,950**

Indicative Cost Estimates

Job Name	**ALLIANCE MATAURA** **PRE-FEASIBILITY LAND DISPOSAL**	Prepared by: Quantities: Date:	RSS RSS 04/06/04
		Checked:	AJS
		Approved:	AK
File:	AJ90307S001		

Item	Description	Unit	Qty	Rate	Amount
Option 5 - Lime Phase Effluent Disposal onto Plantation					
A	***Capital Costs***				
A.1	Land Purchase	ha	568	13,000	7,388,000
A.2	Irrigation Mainline				
	- Pipe	m	14000	110	1,540,000
	- Thrusting under road/rail	No	11.5	8,000	92,000
A.3	Irrigation System				
	- Aboveground hardware: Solid Set	ha	421	15,000	6,314,600
A.4	Plantation Costs				
	- Initial Development	ha	421	1,900	799,800
	- Fencing	km	42	4,500	189,200
A.5	Storage Lagoon	m^3	7000	25	175,000
A.6	Pump Stations (2 farm locations and 1 at plant)				
	- Pumps/Variable Speed Drives	LS	6	$25,500	153,000
	- Pump Housing	LS	3	$20,000	60,000
	- Civil Works	LS	3	$50,000	150,000
	- Telemetry	LS	3	5,000	15,000
	- Electrical Systems	LS	3	15,000	45,000
	Sub-Total (Excl. GST)				**$16,921,600**
	Consents and easements (10%)	LS	1	10%	953,359
	Engineering Costs (15%)	LS	1	12%	2,030,594
	Contingency (20%) Total	LS	1	20%	2,503,509
	Capital Cost Total (Excl. GST)				**$22,410,000**
B	***Operating Costs***				
	Plantation Maintenance and Management	LS	1	$26,838	$26,800
	Irrigation Mainline	LS	1	$8,160	$8,200
	Irrigation System	LS	1	$94,718	$94,700
	Storage Pond	LS	1	$1,750	$1,750
	Pump Station Infrastructure	LS	1	$12,750	$12,750
	Pump Station Operator	LS	1	$50,000	$50,000
	Pump Station - Electricity	kWh	1,153,245	$0.10	$115,300
	Annual Operating Cost Total (Excl. GST)				**$309,500**

Indicative Cost Estimates

Job Name	**ALLIANCE MATAURA** **PRE-FEASIBILITY LAND DISPOSAL**	Prepared by: Quantities: Date:	RSS RSS 04/06/04
		Checked:	AJS
		Approved:	AK
File:	AJ90307S001		

Item	Description	Unit	Qty	Rate	Amount
Option 6 - Lime Phase Wetlands					
A	***Capital Costs***				
A.1	Land Purchase	ha	9	13,000	117,000
A.2	Irrigation Mainline				
	- Pipe	m	3000	110	330,000
	- Thrusting under road/rail	No	3	8,000	24,000
A.3	Wetland				
	- Cell development	No	13	30,000	390,000
	- Planting	ha	4	40,000	156,000
	- Associated Pipework	LS	1	180,000	180,000
A.4	Biological Treatment				
	- Anaerobic Pond	m^3	15600	25	390,000
	- SBR	m^3	15600	25	390,000
	- Aerators	No	5	42,000	210,000
	- Mixers	No	3	15,000	45,000
	- Electrical works	LS	1	100,000	100,000
A.5	Post SBR Buffer Storage Lagoon	m^3	3500	25	87,500
A.6	Pump Stations				
	- Pumps/Variable Speed Drives	LS	2	20000	40,000
	- Pump Housing	LS	2	10000	20,000
	- Civil Works	LS	2	10000	20,000
	- Telemetry	LS	2	10000	20,000
	- Electrical Systems	LS	2	50000	100,000
	Sub-Total (Excl. GST)				**$2,619,500**
	Consents and easements (10%)	LS	1	10%	250,250
	Engineering Costs (15%)	LS	1	12%	314,340
	Contingency (20%) Total	LS	1	20%	613,418
	Capital Cost Total (Excl. GST)				**$3,798,000**
B	***Operating Costs***				
	Wetland Maintenance	LS	1	$7,260	$7,300
	Biological Treatment System Maintenance	LS	1	$23,300	$23,300
	Mainline	LS	1	$1,770	$1,800
	Storage Pond	LS	1	$875	$875
	Pump Station Infrastructure	LS	1	$8,200	$8,200
	Pump Station Operator	LS	1	$50,000	$50,000
	Pump Station - Electricity	kWh	217,185	$0.10	$21,700
	Aerators - Electricity	kWh	876,000	$0.10	$87,600
	Annual Operating Cost Total (Excl. GST)				**$200,775**

Appendix C

Preliminary Assessment of Suitability of Local Soils for Wastewater Irrigation Report

SoilWork Ltd

Professional Soil Consultants

Alliance Group Ltd
Mataura
Southland
New Zealand

PRELIMINARY ASSESSMENT OF SUITABILITIES OF LOCAL SOILS FOR WASTEWATER IRRIGATION

November 2003

P.B. Greenwood

CONTENTS

SUMMARY

As part of a process of consent renewal for the discharge of wastewater from the Mataura Plant, SoilWork Ltd was commissioned by Alliance Group Ltd to conduct preliminary assessments of land disposal. Those assessments comprised initial work on the suitability of local soils for wastewater discharge (December 2002), and on the practicality of irrigating all Mataura Plant wastewater (April 2003) or only ‘green stream’ wastewater (August 2003).

A ‘desktop’ screening and subsequent field screening were used to provide an initial assessment of the potential suitabilities of approximately 90 individual areas of land near Mataura for wastewater irrigation. The land areas comprised various combinations of soils and topography, and all were within a 5 km radius of the Alliance Mataura Plant.

The screenings included assessments of the soils for factors such as internal drainage, preferential flow, water retention capacity, and susceptibility to structural degradation. Topography of each land area was also considered. These factors strongly influence the incidence of nitrate leaching, ponding, runoff, seepage, and waterlogging. The assessments, however, were based on existing information in published and unpublished reports and in SoilWork databases. Soil inspections are required to confirm the results of this work.

Four areas with potentially suitable soils and topography were identified.

1. An area of approximately 310 ha that comprises several non-contiguous areas of land with Tuturau, Edendale, and Arthurton soils. Most of this area is likely to be well drained and suitable for wastewater irrigation, but some occurs on dissected hill land. It is located at least 2 km distant from the plant and is elevated by approximately 20-30 m. Further evaluation is required to estimate the topographically-suitable area.

2. An undulating area of well drained Ardlussa soils dissected by imperfectly drained Charlton soils. There is approximately 140 ha within this area. The degree of dissection and proportion of imperfectly drained soils vary widely and require further assessment. The nearest part of this area is also located approximately 2 km from the plant, but the area is not elevated.

3. A large, relatively flat, area (approximately 500 ha) of Makarewa soils adjacent to the Mataura Plant. These soils are often poorly drained and are usually imperfectly drained. However, because their drainage status

varies between locations this area is considered as potentially suitable depending on the results of inspections of soil profiles. This area is close to the Mataura Plant and is not elevated.

4. A large area (approximately 550 ha) of dissected hill land that contains significant areas of well drained, undulating (<8^{o} slope) Tuturau soils. The areas of these soils that have suitable slope are non-contiguous, and are elevated (approximately 40-140 m above the plant). Topographically suitable areas need to be determined.

From this initial assessment of soil suitabilities, there are no clearly suitable areas. There are, however, areas that are potentially suitable, but require further assessments to better determine their overall suitabilities. Some occur on dissected hill land and comprise non-contiguous areas of suitable, but elevated, soils. Others comprise relatively flat, non-elevated areas of marginally suitable soils or of suitable soils in non-contiguous areas. Further assessments are therefore necessary if these areas are to be considered for wastewater irrigation.

Following the soil suitability work, preliminary assessments were made of the practicability of full irrigation of the Mataura Plant wastewater, and of irrigation of all of that wastewater for part of each processing season (i.e. of irrigating all wastewater all of the time, and all wastewater some of the time). These assessments were based on estimates of hydraulic loadings and the resultant potentials for irrigation of wastewater onto soils within a 5 km radius of the plant.

If the soils to be used are all well suited to wastewater irrigation, it is estimated that approximately 700-850 ha of land is required for full irrigation depending on wastewater quality (i.e. treated vs untreated wastewater). If the soils are only moderately suitable, however, approximately 850-1100 ha is required. It is likely that there is insufficient land that is well suited to this wastewater irrigation option, therefore land within a 5 km radius of the Mataura Plant is considered to be unsuitable for full irrigation of all wastewater from that plant.

For part irrigation (i.e. irrigating all wastewater some of the time), minimum river flow ‘triggers’ of 40 m^3/s and 20 m^3/s were used as the basis of irrigation scheduling. Under these scenarios, all of the wastewater would be irrigated whenever river flow dropped below 40 m^3/s or 20 m^3/s.

The results of the 40 m^3/s river flow ‘trigger’ assessment showed that approximately 800-900 ha of land is required. That area is only 20-25% less than would be required for full irrigation, and it is likely that there is insufficient suitable land within a 5 km radius of the Mataura Plant.

An assessment of the 20 m^3/s river flow scenario indicated that an area of at least 500 ha would be required for wastewater irrigation in order to minimise the risks of ponding and runoff. Both well suited and moderately suited soils can be used, and there are sufficient areas of such soils within a 5 km radius of the Mataura Plant. In 70% of all years only 260 ha of this land would be required for the discharge of only 10% of the annual volume of wastewater but, for the remaining years, there are moderate risks of ponding and runoff if only this smaller area of land is used. Further soil water modelling is required to confirm this preliminary assessment.

A preliminary assessment of irrigating only a 'green' wastewater stream from the Mataura Plant was also conducted. The green stream contains high concentrations of phosphorus, nitrogen, and micro-organisms, and is expected to comprise approximately 8% of the full wastewater volume.

With such a low proportion of the full wastewater volume in the green stream, annual hydraulic loading is very low compared with irrigation of all wastewater. Consequently, nitrogen loading is the limiting factor with irrigation of the green stream. Because this stream is expected to have a high nitrogen concentration, however, the risk of nitrate leaching and/or nitrogen runoff is high on most soils identified as being potentially suitable within a 5 km radius of the plant.

The risk of nitrate leaching can be reduced by diluting the high-N wastewater or by applying very small volumes of the green stream wastewater at each irrigation event. The latter practice would be difficult and/or costly.

Without diluting the wastewater or irrigating with very small volumes, approximately 75-380 ha of land would be required for green stream irrigation that would be limited to river flow trigger scenarios of 20 m^3/s or 40 m^3/s. This restriction occurs because large areas of soils suitable for high nitrogen loadings per irrigation event are probably not available within a 5 km radius of the plant.

Under the 20 m^3/s trigger scenario, irrigation would take place on up to approximately 75 days (average 19 days) per season. This would require 75-150 ha of land depending on whether nitrogen was applied at 150 kg/ha/yr or 300 kg/ha/yr. Under the 40 m^3/s trigger scenario, irrigation would take place on up to approximately 150 days (average 85 days) per season. This would require 190-380 ha of land.

Irrigation of the green stream would also be limited to annual nitrogen loadings of 300 kg/ha or less even if a 'cut and carry' system is employed to enhance nitrogen removal. A field assessment of potentially suitable land would need to be conducted to confirm this option.

1 INTRODUCTION

1.1 BACKGROUND

As part of a process of consent renewal for the discharge of wastewater from the Mataura Plant, Alliance Group Ltd requested initial assessments of land disposal. The first of these was commissioned in December 2002, and was a preliminary assessment of the suitability of local soils for wastewater discharge.

Following that work, initial assessments of the practicality of irrigating all Mataura Plant wastewater, and of irrigating only 'green stream' wastewater were then commissioned in April 2003 and August 2003 respectively.

This report presents these three preliminary assessments.

1.2 FACTORS CONSIDERED IN THIS REPORT

The following soil factors and other relevant information were used in this report:

- *soil types and their distributions* (from existing soil maps and descriptions in various published and unpublished reports);
- *soil properties* (from existing published and unpublished data);
- *topographic and other constraints to irrigation* (from published data and general field assessments);
- *meteorological data* (daily evapotranspiration and rainfall data for an average year (in terms of drainage) and a ten percentile wet year (i.e. a year wetter than 90% of others) were taken from a 17 year period at Gore);
- *wastewater volumes and expected nitrogen concentrations* (data from the Mataura Plant in 2001-2002 and predictions for the 2003-2004 season were forwarded by Alliance staff).

These factors were initially used to identify any potentially suitable areas within a 5 km radius of the Mataura Plant for irrigation of wastewater. The radius was chosen by Alliance Group staff. They were then used for initial assessments of the practicality of irrigating all wastewater, and of irrigating just the 'green stream' wastewater, within that 5 km radius.

2 WASTEWATER IRRIGATION

2.1 DESCRIPTION

The primary objective of slow rate irrigation is to apply wastewater in such a manner that as much of it as possible is retained within the root zone, mainly of pastures. Wastewater retained within that zone undergoes biological breakdown, and the nutrients thus released are available for plant uptake. The water applied with wastewater is lost from the soil mainly by evapotranspiration, with any excess being transmitted through the soil profile and lost by drainage. Overall, wastewater treatment in the soil occurs through a combination of biological and chemical transformations, adsorption by soil particles, uptake and loss of water and nutrients by plants, and by filtration through soil pores.

If wastewater is transmitted below the root zone (the zone of most biological activity), constituents and breakdown products can then be leached from the soil profile with drainage of excess water. Losses then occur from the soil to underground aquifers.

If wastewater is applied to soils with poor infiltration or internal drainage characteristics, seepage, runoff, and ponding of the wastewater can occur.

The occurrences of leaching, seepage, runoff, and ponding, and the rates at which they occur, are dependent on a number of important soil factors. Those factors are used, in this preliminary assessment, to identify potentially suitable areas for irrigation of Mataura Plant wastewater.

2.2 RELEVANT SOIL PROPERTIES

Soil properties such as depth, texture, and structure, determine the amount of water that can enter and be retained within a particular soil, and also the rate of transmission of excess water through that soil. Water balances, drainage characteristics, and consequent leaching losses of wastewater constituents, are therefore strongly dependent on those properties. Wastewater irrigation systems should be matched as closely as possible to those properties to minimise leaching, runoff, and ponding.

Soils with high water holding capacities (e.g. deep silt loam soils) are able to store large quantities of wastewater. Because leaching occurs in response to movement of excess water from the soil, other soils with lower water holding capacities are less suitable for wastewater irrigation.

Soil structure (i.e. the nature of the arrangement of soil particles, aggregates, and pores) determines the water transmission characteristics of a soil through its influence on the number, size, and continuity of large soil pores. The latter are largely air-filled at the upper drained limit but, when further water is received, are the pathways for rapid downward transport of excess water through the soil.

In some soils, continuous fissures or channels can result in 'preferential flow' of wastewater. With irrigation, wastewater can enter the continuous channels and then move rapidly through the soil. Because there is little opportunity for the wastewater to be retained within the root zone, plants cannot take up wastewater nutrients, and high leaching losses are likely to occur.

Overall, the suitability of any particular soil for slow rate irrigation of wastewater, depends mainly on the following factors:

- inherent soil permeability and any preferential flow characteristics;
- infiltration rate and hydraulic conductivity;
- susceptibility to structural deterioration and ability to recover from damage;
- water retention characteristics.

In addition, the slope of the soil surface is important. Under wastewater irrigation, steep topography can result in seepage, runoff, and ponding of wastewater.

In relation to those factors, the following parameters were used in the first screening (Section 3.2) to exclude unsuitable land areas from selection as a possible wastewater irrigation sites:

- soil depth less than 45 cm to bedrock or gravels *(indicates high potential for leaching, seepage, ponding, and runoff)*;
- soil texture peaty *(indicates high water table and waterlogging)*, clayey *(indicates low permeability and slow hydraulic conductivity)*, or sandy *(indicates too-rapid water transmission and low water retention capacity)*;
- poor internal drainage *(indicates high potential for soil damage, waterlogging, runoff, ponding, and seepage)*;
- a preferential flow characteristic *(indicates high potential for leaching and seepage)*;
- low water retention capacity *(indicates high potential for leaching and a requirement for a very large area of land)*;
- slopes greater than 15 degrees *(indicates high potential for runoff, seepage, and ponding)*.

For slope, a maximum value of 10 degrees has previously been issued as a general guideline (NZLTC, 2000). With suitable, well-structured soils, however, slopes of up to approximately 15 degrees are considered suitable.

3 SELECTION OF POTENTIALLY SUITABLE SOILS

3.1 SELECTION AREA

The boundary of the selection area (a 5 km radius from the Mataura Plant) is shown in Figure 3.1. The area, including townships, roads, and waterways, comprises approximately 7,850 ha.

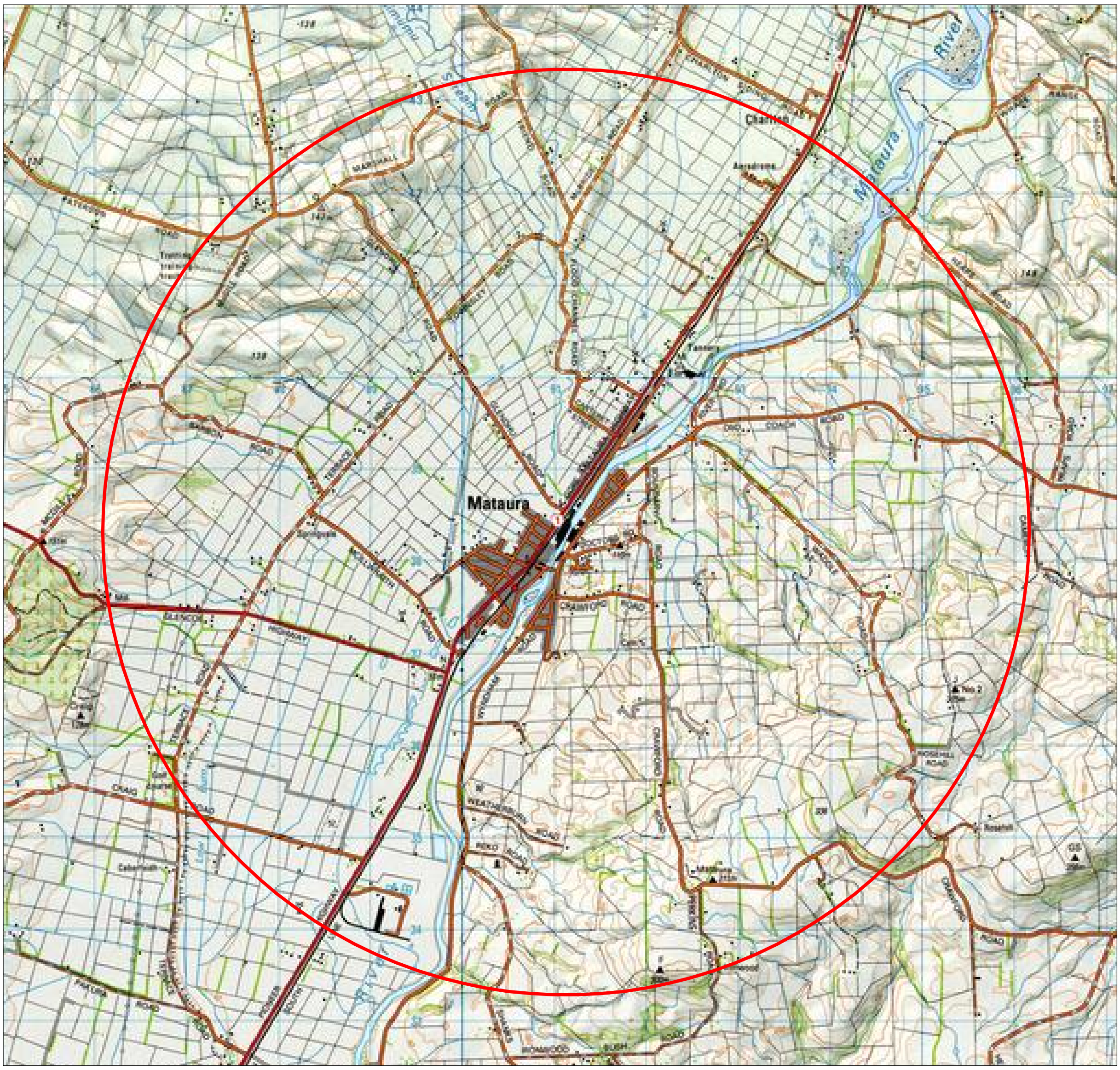


Figure 3.1:
Area for selection of potential irrigation sites.

3.2 SOIL SELECTIONS – INITIAL SCREENING

Locations of various soil areas within the selection area were determined using existing information (published and unpublished reports, and SoilWork data). A list of all soils identified, together with their landform locations, is given below.

- Ardlussa (Terrace, floodplain)
- Arthurton (Terrace)
- Charlton (Terrace, floodplain)
- Craigdale (Hill, downlands)
- Edendale (Terrace)
- Ferndale (Downland, terrace)
- Fleming (Terrace)
- Gore (Terrace)
- Howe (Floodplain)
- Jacobstown (Floodplain)
- Kaiwera (Hill)
- Kuriwao (Hill)
- Makarewa (Floodplain)
- Mandeville (Downland)
- Mataura (Floodplain)
- Otaraia (Hill, downlands)
- Oteramika (Hill, terrace)
- Pukemutu (Hill, terrace)
- Riversdale (Floodplain)
- Tokanui (Hill)
- Tuturau (Terrace)
- Tyneholm (Hill)
- Waikoikoi (Hill, terrace)
- Woodlands (Hill, terrace)
- Wyndham (Downland, terrace)

Information on various properties of these soils (as described in Section 2.2) was then used to select individual areas of land that are potentially suitable for wastewater irrigation. Data from a range of published and unpublished reports, and SoilWork sources, were used for specific soil profile information. Approximately 90 individual areas of land containing the individual soils listed above, and various mixtures of those soils, were assessed for selection.

Areas excluded from the initial selection comprised soils with high potential for preferential flow, leaching, seepage, ponding, or runoff; soils with significant inherent restrictions to internal drainage; soils with low water retention capacity; and soils readily susceptible to structural degradation and with slow recovery characteristics after damage. Soils with slopes greater than 15° (hilly soils) were also excluded.

A map of the areas selected as potentially suitable after this initial screening is given in Figure 3.2.

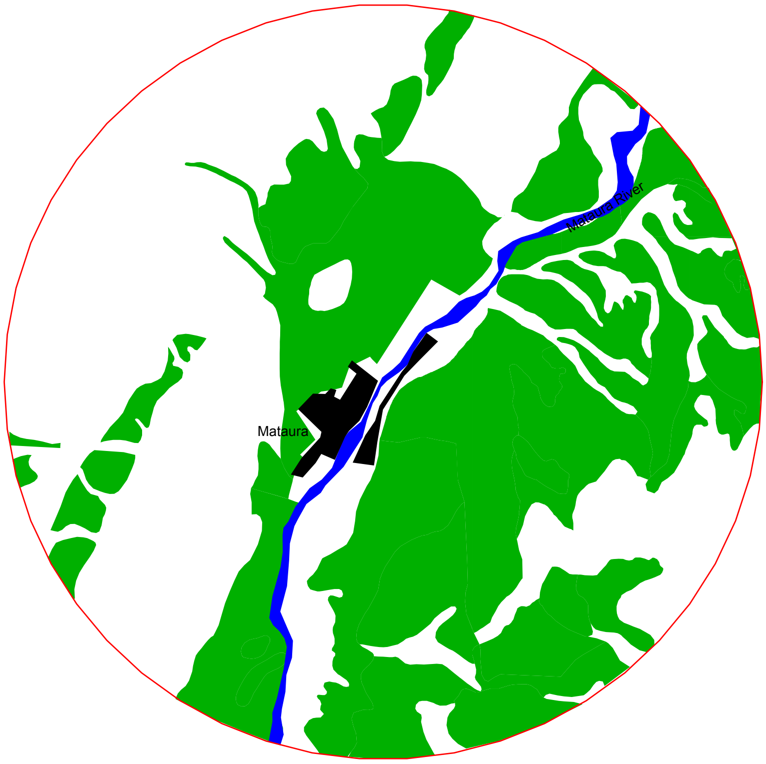


Figure 3.2:
Areas selected in the initial screening as potentially suitable for wastewater irrigation.

The areas of land initially selected as potentially suitable for irrigation comprise approximately 3,190 ha. That area is approximately 40% of the total area screened. It consists of the following soils:

- Ardlussa
- Arthurton
- Charlton
- Craigdale
- Edendale
- Ferndale
- Makarewa
- Mataura
- Otaraia
- Tokanui
- Tuturau
- Tyneholm
- Woodlands
- Wyndham

Areas initially selected include mixtures of soils where one of those (the least dominant) is considered to be unsuitable. They also include soils with marginal or unknown drainage characteristics, and soils that occur on slopes of 8^o–15^o. Although slopes should not usually exceed 10^o for wastewater irrigation, slopes of up to 15^o may be satisfactory with suitable, well-structured soils.

A second screening was then conducted to more fully evaluate the potential suitability of areas that were selected in the initial screening. For this second screening, relevant land characteristics were evaluated with a general field assessment to identify constraints to wastewater irrigation. The results of the second screening are given in the following section.

3.3 SOIL SELECTIONS – FIELD SCREENING

The areas selected as potentially suitable in the initial screening, together with boundaries and identification numbers for each, are shown in Figure 3.3.

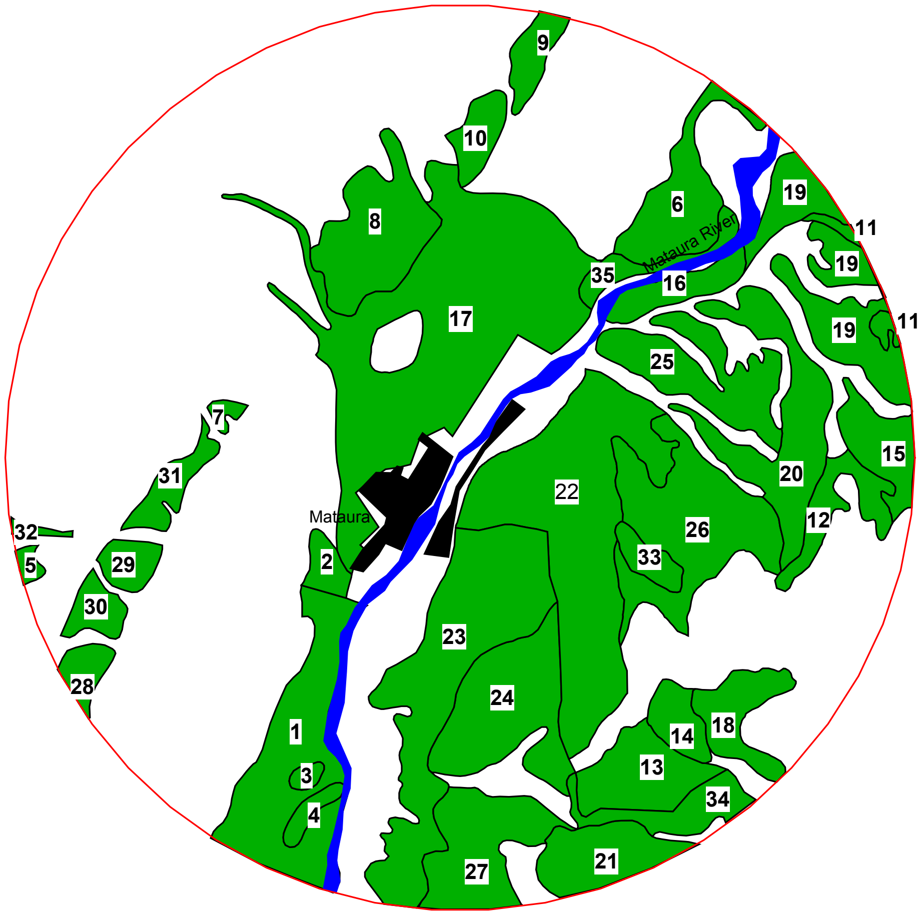


Figure 3.3:
Identifications of areas initially selected as potentially suitable for wastewater irrigation.

Relevant information for each of the areas shown in Figure 3.3, together with recommended suitabilities for wastewater irrigation, are given in Table 3.1. The soil types for each area are taken from previous soil surveys and have not been confirmed by field investigation.

Table 3.1:
General characteristics, and recommended suitabilities, of areas shown in Figure 3.3.

AREA NUMBER	CHARACTERISTICS[1]	SUITABIILTY[2]
1&2	Ardlussa and Charlton soils. Well drained areas dissected with many areas of imperfectly drained soils. Significant contiguous areas of well drained soils exist in the southern part of this zone.	Parts potentially suitable
3&4	Ardlussa soils. Well drained, but lower water retention capacities than in areas 1&2. Potentially high leaching risk.	Unsuitable
5	Very small area of imperfectly drained Arthurton and rolling Woodlands soils. Topography, drainage, and size limitations.	Unsuitable
6	Charlton and Fleming soils. A complex of imperfectly and poorly drained soils. Drainage limitions.	Unsuitable
7	Small area of Edendale soil. Well drained but small size. Potentially suitable if it can be combined with adjacent areas (28-31)	Potentially suitable
8-10	Complexes of Edendale and imperfectly drained Arthurton soils. High proportion of area (approx 80%) is estimated to be suitable.	Parts potentially suitable
11&12	Imperfectly drained Ferndale soils on rolling topography. Drainage and topography limitations.	Unsuitable
13&15	Imperfectly drained Ferndale and well drained but only moderately deep Craigdale soils on mostly rolling dissected hill land. Only small non-contiguous undulating areas. Drainage, water retention, and topography limitations.	Unsuitable
14	Imperfectly drained Ferndale soil. This area is dissected by steep gullies and natural drainage channels. Drainage and topography limitations.	Unsuitable
16	A narrow strip of Makarewa soil immediately adjacent to the Mataura river. This area receives seepage from adjacent hills and appears to be imperfectly to poorly drained. Drainage and flood risk limitations.	Unsuitable
17	A large, mostly flat to gently undulating, area of Makarewa soils. The drainage status of this soil varies between areas, but is usually imperfect to poor. This soil would not usually be recommended unless other, better drained, soils are present within any particular wastewater irrigation area. The drainage status of cannot be properly determined without field examinations.	Potentially (marginally) suitable.
18	A complex of Otaraia and Craigdale soils on undulating and rolling land. Topography, water retention capacity limitations.	Unsuitable
19	A mixture of rolling Otaraia, rolling and imperfectly drained Ferndale, and rolling Tuturau soils. Topography and drainage limitations.	Unsuitable

20	An area of Otaraia soils on dissected hill land. Small undulating areas exist but are non-contiguous. Topography limitation.	Unsuitable
21	A mixture of Tokanui and Tyneholm soils on rolling dissected hill land. There are small undulating areas. Some areas have low water retention capacity and high leaching risk.	Unsuitable
22&23	A large area of Tuturau soils on rolling dissected hill land. Most of the area is rolling with smaller areas that are undulating. The latter are non-contiguous but suitable for use. The areas of these are undetermined.	Parts potentially suitable
24-27	An area of well drained Tuturau and imperfectly drained Wyndham soils on rolling dissected hill land. Topography and drainage limitations.	Unsuitable
28-30	Areas of undulating, well drained Tuturau soils on dissected hill land. There are significant parts with suitable topography but the areas of these are undetermined.	Parts potentially suitable
31	A mixture of undulating, well drained Tuturau and Edendale soils on hill land that is more strongly dissected than Areas 28-30.	Parts potentially suitable
32	A small area of Woodlands soil. This area is well drained but is very small and not contiguous with other larger areas.	Unsuitable
33	An area of rolling Wyndham soils. Topography and drainage limitations.	Unsuitable
34	An area of rolling Wyndham and Craigdale soils. Topography, drainage, and water retention capacity limitations.	Unsuitable
35	A small area of moderately deep and imperfectly drained Mataura, and sandy Howe soils. Drainage and water retention capacity limitations.	Unsuitable

[1] characteristics are derived from various published and unpublished soil reports, SoilWork data, and a general field assessment. On-farm assessments are required for confirmation of soil types and drainage characteristics.
[2] recommendations are based on general topographic assessments and unconfirmed soil properties. On-farm confirmations are required for further definition of suitabilities.

3.4 FINAL SOIL SELECTIONS

The areas in Table 3.1 that were assessed as potentially suitable after the second screening are shown in Figure 3.4. With aggregations of similar areas, four potentially suitable areas that have distinctly different soils and topographic features are shown.

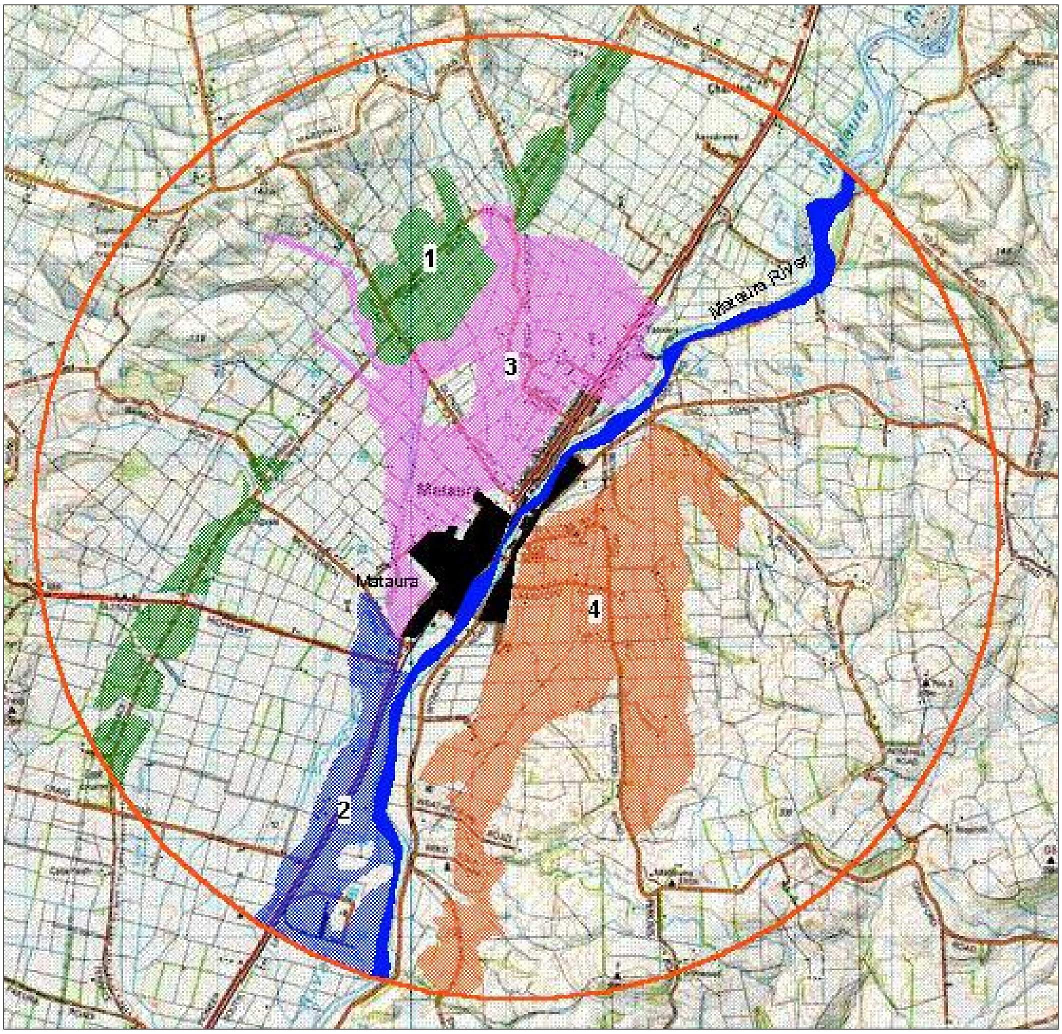


Figure 3.4:
Areas selected in the second screening as potentially suitable for wastewater irrigation.

The four potentially suitable areas shown in Figure 3.4 are described below.

AREA ONE

This area comprises several smaller non-contiguous areas of Tuturau, Edendale, and Arthurton soils. Excluding major features (e.g. roads) it totals approximately 310 ha. Except for the small areas of Arthurton soils, most of this area is likely to be well drained and suitable for wastewater irrigation. Some of the area, however, occurs on dissected hill land, and further evaluation would require estimates of the topographically-suitable area. Factors to be considered in further evaluations are the non-contiguous nature of the total area over a significant distance (approximately 9 km), and the elevation of the area above the Mataura plant (approximately 20-30 m).

The nearest part of this area is approximately 2 km from the plant. That part (approximately 120 ha of contiguous land) comprises an area of Edendale soil that is well suited to wastewater irrigation but also some areas (approximately 20%) of Arthurton soils that are imperfectly drained. The two soils could, however, be used together, as are the Makarewa and Waikiwi soils at the Makarewa plant.

AREA TWO

This is an area of well drained Ardlussa soils dissected by imperfectly drained Charlton soils. The degree of dissection and proportion of imperfectly drained soils vary widely over the area, but are lowest to the south. However, the MDF plant occupies part of the southern area. Overall, there is approximately 140 ha potentially suitable but a portion of this is occupied by Charlton soils.

Area 2 is also approximately 2 km from the Mataura plant, but is not elevated. It does however contain a number of small holdings on the outskirts of Mataura and is dissected by SH1.

AREA THREE

This is a large, mostly flat, area (approximately 500 ha) of Makarewa soils adjacent to the Mataura plant. These soils are often poorly drained and are usually imperfectly drained. However, because their drainage status varies between locations, this area is considered as potentially suitable depending on the results of soil profile inspections. If such inspections showed this area to be imperfectly to poorly drained overall, it should be classified as unsuitable unless it is combined with another area containing well drained soils, or unless it is used for limited irrigation. The latter includes using a low hydraulic loading (applying wastewater to a larger area of land than would be used with a more suitable soil, or applying only small volumes of wastewater), or irrigating only when soil water conditions are suitable (i.e. ensuring that the water retention capacity is not significantly exceeded).

Area 3 is close to the Mataura plant and is not elevated but, like Area 2, it contains a number of small holdings on the outskirts of Mataura near the plant.

AREA FOUR

This is a large area (approximately 550 ha) of dissected hill land that contains significant areas of well drained, undulating (<8^{o} slope) Tuturau soils. The areas of these soils with suitable slope, however, are non-contiguous and occur over a large distance (approximately 6 km). Their areas (ha) need to be determined if this area is considered further.

Area 4 is on the opposite side of the river to the Mataura plant, and is elevated (approximately 40-140 m).

3.5 RECOMMENDATIONS

From this preliminary assessment of soil suitabilities, no clearly suitable areas were evident. There are, however, areas that are potentially suitable, but require further assessments to better determine their overall suitabilities. The following work is recommended for any such further assessments:

- determination of the approximate areas required for irrigation using a water balance, climatic information, and wastewater data;
- assessment of topographically suitable areas in the zones that contain non-contiguous areas of suitable soils on dissected hill land (using existing aerial photographs from Environment Southland);
- field inspections of soils that are considered, at this stage, to be marginally suitable (either on farms or on suitable areas that can be identified outside of farms).

4 PRELIMINARY ASSESSMENT OF IRRIGATION OF ALL MATAURA PLANT WASTEWATER

4.1 PARAMETERS

This work involved preliminary assessments of the practicability of full irrigation of the Mataura Plant wastewater, and of irrigation of all of that wastewater for part of each processing season (i.e. of irrigating all wastewater all of the time, and all wastewater some of the time). These assessments were based on estimates of hydraulic loadings and the resultant potentials for irrigation of wastewater onto soils within a 5 km radius of the plant.

The parameters and data used for these assessments are given below.

1. Gore meteorological data was used because data from that site is comprehensive enough for reasonable water balance estimates, and is considered to be sufficiently representative of Mataura. Daily evapotranspiration and rainfall data for an average year (in terms of drainage) and a ten percentile wet year (i.e. a year wetter than 90% of others) were taken from a 17 year period.
2. Wastewater volumes from the Mataura Plant in the 2001-2002 season were used. This data was forwarded by Kevin Lehrke (Alliance, Mataura).
3. All estimates were made on a monthly basis.
4. For part irrigation (i.e. irrigating all wastewater some of the time), Environment Southland Mataura river flow summaries (at Tuturau) were used. Alliance Group Ltd instructed that minimum river flows of 40 m^3/s and 20 m^3/s were to be used as the basis of irrigation scheduling under the ‘part irrigation’ regimes.

4.2 FULL IRRIGATION (IRRIGATING ALL WASTEWATER ALL OF THE TIME)

For an acceptable amount of additional drainage under a wastewater irrigation scheme in this area (from experience and measurements of hydraulic loading, drainage and leaching under such schemes), it is estimated that full irrigation of all of the Mataura Plant wastewater would require approximately 700 to 1100 ha of land. This is based on non-irrigated drainage estimates of approximately 250 mm and 400 mm in an average year and a wet year respectively. The variation in required land areas occurs with wastewater and soil quality variables.

If the soils to be used are all well suited to wastewater irrigation (using the soil properties described in Section 2.2), approximately 700-850 ha of land is required depending on wastewater quality (i.e. treated vs untreated wastewater). If the soils are only moderately suitable, however, approximately 850-1100 ha is required.

Within a 5 km radius of the Mataura Plant, an irrigation area of this magnitude will require the inclusion of a significant proportion of moderately suitable soils. Overall, therefore, it is estimated that approximately 900-1000 ha is required for full wastewater irrigation. However, because some operational flexibility is always required to manage hydraulic and nutrient loadings on large wastewater irrigation areas, especially where not all soils are well suited to such irrigation, estimates of required land areas should err on the conservative side. Consequently, based on hydraulic loading, it is estimated that approximately 1,100 ha is required for full irrigation in this area.

Using a Mataura wastewater nitrogen concentration (100 g/m^3) supplied by Kevin Lehrke, estimated nitrogen loading on an irrigated area of 1,100 ha would be approximately 150 kg N/ha/yr with untreated wastewater. It is therefore apparent that hydraulic loading is the limiting factor in land area determinations.

Based on the areas of potentially suitable (well suited and moderately suited) soils identified in Section 3, it is likely that there is insufficient land that is well suited to this wastewater irrigation option. Based on this preliminary investigation, therefore, land within a 5 km radius of the Mataura Plant is considered to be unsuitable for full irrigation of all wastewater from that plant. Further investigation of land treatment as an option for discharge of all wastewater is not warranted.

4.3 PART IRRIGATION (IRRIGATING ALL WASTEWATER SOME OF THE TIME)

Twenty years of daily Mataura River flow records were used in assessing this option in which irrigation of all Mataura Plant wastewater would occur whenever river flow fell below either 40 m^3/s or 20 m^3/s.

Flow data shows that, during the processing season, river flow is less than 40 m^3/s and 20 m^3/s, on average, for 85 days and 19 days respectively. Wastewater irrigation would therefore occur on those days. The data also shows, however, that there is considerable variability from year to year. Over a twenty year period, the number of days when irrigation would occur using the 40 m^3/s and 20 m^3/s ‘trigger’ values is approximately 15-148 days and 0-77 days respectively. Thus, although using the 20 m^3/s trigger, for example, results in an average requirement for wastewater irrigation on only 19 days per season, that requirement may be as high as 77 days. The percentages of years when irrigation would be required for various numbers of days based on the two flow triggers are given in Table 4.1.

Table 4.1:
Percentages of years when irrigation is required for various numbers of days each season using the two river flow 'triggers'.

Trigger flow	*Number of days when irrigation is required using the irrigation triggers (days per processing season)*				
	0-20 days	*20-40 days*	*40-60 days*	*>60 days*	
20 m^3/s	***70%***	***15%***	***5%***	***10%***	
	0-30 days	*30-60 days*	*60-90 days*	*90-120 days*	*>120 days*
40 m^3/s	***15%***	***15%***	***20%***	***30%***	***20%***

USING A 40 M^3/S RIVER FLOW TRIGGER

Under this scenario, all of the wastewater would be irrigated whenever river flow dropped below 40 m^3/s. On average, irrigation would be required on approximately 85 days per season but, as Table 4.1 shows, it would be required for more than 120 days in 20% of all years. The maximum number of days irrigation would be needed could be as high as approximately 150 days in a season.

Overall, therefore, the land area required for this scenario must accommodate wastewater irrigation for approximately half of the number of days that irrigation would occur with full irrigation (i.e. it must accommodate 120-150 days per season, compared with 227 days per season with full irrigation). River flow data shows that those irrigations could be required at any time throughout the processing season.

Although only approximately half of the total wastewater produced by the Alliance Plant would need to be irrigated under this scenario, the land area required cannot be reduced proportionally. This occurs because hydraulic loading per irrigation is an important parameter in moist areas such as this when irrigation may be required any time between November and August, and also with soils that are only moderately suited to wastewater irrigation. For Mataura, a significant proportion of the area that could potentially be used would comprise moderately suitable soils. Under these circumstances, if daily hydraulic loadings are high, significant ponding and runoff of wastewater will occur.

It is considered that, for irrigation in this area during approximately half of the processing season (but at any time during the season), daily hydraulic loading should not exceed 20-25 mm/day. Irrigation return time should not be less than approximately 15-16 days. These parameters have been investigated previously on a range of soils and with various types of wastewater and, although they require further definition for this combination of wastewater and soils, it is considered that they are satisfactory approximations for this preliminary assessment.

Using the more conservative of those hydraulic loading parameters, approximately 800-900 ha of land is required for this irrigation scenario. That area is only 20-25% less than would be required for full irrigation.

It is considered that there is insufficient land suitable for this wastewater irrigation option, and further investigation of part irrigation using a 40 m^3/s river flow 'trigger' is not warranted.

USING A 20 M^3/S RIVER FLOW TRIGGER

With this irrigation scenario, all of the wastewater would be irrigated whenever river flow dropped below 20 m^3/s. On average, irrigation would only be required on approximately 19 days per season, but the data in Table 4.1 shows that it would be required for more than 40 days per season in 15% of all years, and for more than 60 days per season in 10% of all years. The maximum number of days irrigation would occur is approximately 80 days in a processing season.

Overall, therefore, this scenario must accommodate approximately 60 days of wastewater irrigation (with the full daily volume of wastewater) per season. The river flow records indicate that most irrigations would be required between January and April inclusive, but some would also be necessary in November, December, and May.

For wastewater irrigation during only short dry periods each year, deficit irrigation (to restore soil water deficits) can be used to minimise the occurrence of ponding or runoff in only moderately suitable soils. To assess the opportunity for this, daily river flow records for the days when flow was less than 20 m^3/s were compared with soil water content on the same days during the 1998-99 season. The latter information was available from previous soil water modelling work in the area. The 1998-99 season was chosen because water modelling data was available and because, during that year, irrigation of wastewater would have been required for 58 days using the 20 m^3/s river flow trigger.

The water modelling data showed that significant soil water deficits corresponded with river flows below 20 m^3/s. Based on those deficits, approximately 70 mm of wastewater could have been irrigated on the first day of low river flow without significant risk of ponding or runoff. Low river flows then continued for almost 50 consecutive days.

An area of only 16 ha would have been required for that initial day's wastewater irrigation. Using an irrigation return time of 16 days, fifteen further daily irrigations could have been conducted on similar areas of land. For the first 16 days of irrigation, therefore, a total area of approximately 256 ha would have been required.

From the 17th day, however, a second cycle of wastewater irrigation would have been required. Based on existing water modelling data, however, only approximately 35 mm of wastewater could have been applied each day of that cycle if risks of ponding or runoff were to be minimised on moderately suitable soils. That irrigation cycle would therefore have required a total area of approximately 500 ha.

With continuing low river flows, a further consecutive wastewater irrigation cycle would have been required that year. Because of significantly reduced soil water deficits, however, only approximately 25 mm of wastewater could have been applied each day to minimise the risk of ponding or runoff. An area of approximately 700 ha would have been necessary to complete that final irrigation cycle.

This preliminary case study of wastewater irrigation using a 20 m^3/s river flow trigger in 1998-99, shows that 500-700 ha of land would be required to minimise the risk of wastewater ponding or runoff. Irrigating in this manner requires a land area approximately 45-65% of that required for full irrigation, but only results in irrigation of 25% of all of the wastewater. Overall nitrogen loading would be approximately 80 kg N/ha/yr.

During the processing season, only approximately three wastewater irrigations need to be accommodated using this part irrigation scenario (20 m^3/s river flow trigger). Land areas smaller than 500-700 ha could be used, and/or a shorter irrigation return interval could be employed, whilst maintaining a low to moderate nitrogen loading, and avoiding soil impacts. Because of high daily hydraulic loadings, however, and because some of the area that would be used would be only moderately suited to wastewater irrigation, there would be a moderate risk of ponding and/or runoff during the second and third irrigation cycles. The river flow records show that two irrigation cycles would be required in 30% of all years while three cycles would be required in 15% of all years. For the remainder of the years, only one irrigation cycle is likely to be necessary, and the total land area required could be reduced to approximately 260 ha.

Overall, it is estimated that an area of at least 500 ha is required for this irrigation scenario in order to minimise the risks of ponding and runoff of wastewater. Both well suited and moderately suited soils can be used, and there are sufficient areas of such soils within a 5 km radius of the Mataura Plant. In 70% of all years, however, only 260 ha of this land would be required for the discharge of only 10% of the annual volume of wastewater but, for the remaining years, there are moderate risks of ponding and runoff if only this smaller area of land is used.

If such a wastewater irrigation regime (using a 20 m^3/s river flow 'trigger') is considered, further soil water modelling should be conducted to confirm this preliminary assessment.

5 PRELIMINARY ASSESSMENT OF IRRIGATION OF 'GREEN STREAM' MATAURA PLANT WASTEWATER

5.1 PARAMETERS

For this assessment, the practicability of irrigating only a 'green' wastewater stream from the Mataura Plant was considered. That green stream contains high concentrations of phosphorus, nitrogen, and micro-organisms. Alliance Group staff advised that it would be expected to comprise approximately 8% of the full wastewater volume.

The parameters and data used for this preliminary assessment are given below.

1. Gore meteorological data was used (refer to Section 4).
2. Predicted Mataura Plant green stream wastewater volumes, together with expected nitrogen concentrations, for the 2003-2004 season were used (from Alliance Group staff, Appendix I).
3. All estimates were made on a monthly basis.
4. For part irrigation (i.e. irrigating all of the green stream some of the time), Environment Southland Mataura river flow summaries (at Tuturau) were used in the same manner as in Section 4. Alliance Group Ltd instructed that minimum river flows of 40 m3/s and 20 m3/s were to be used as the basis of irrigation scheduling under the 'part irrigation' regimes.

5.2 HYDRAULIC LOADING

With only 8% of the full wastewater volume in the green stream (approximately 121,600 m^3 annually), annual hydraulic loading is low compared with irrigation of all wastewater (Section 4).

For an acceptable amount of additional hydraulic loading of the soils in this area (from experience and measurements of hydraulic loading, drainage and leaching under similar soils in Southland), it is estimated that full irrigation of the green stream would require approximately 40-60 ha of land. The variation in required area occurs with soil quality variables.

With irrigation whenever river flow dropped below 40 m^3/s, wastewater irrigation would be required for approximately 120-150 days per season (Section 4.3). For this scenario, it is estimated that approximately 25-35 ha of land is required for acceptable hydraulic loading and profile drainage. When the river 'trigger' flow is reduced to 20 m^3/s, the required land area is similarly reduced, to 10-15 ha.

Overall, therefore, the land areas required for irrigation of the green stream (10-60 ha) are small when based on hydraulic loading. There are sufficient areas of suitable soils within a 5 km radius of the Mataura Plant.

5.3 NITROGEN LOADING

Compared with the full wastewater stream used for the assessment described in Section 4, the green stream contains a high concentration of nitrogen. Whereas the nitrogen concentration of the full wastewater stream was earlier estimated to be 100 g/m^3 (Section 4.2), the green wastewater stream is likely to contain 805 g N/m^3 (K. Lehrke, Alliance Group Ltd). Based on that latter concentration, land areas required for nitrogen loading scenarios of 150 kg N/ha/yr, 300 kg N/ha/yr and 450 kg N/ha/yr are given in Table 5.1.

Table 5.1:
Land areas (ha) required for irrigation of the green stream under various nitrogen loading scenarios.

WASTEWATER GREEN STREAM IRRIGATION SCENARIO	WASTEWATER NITROGEN LOADING (kg/ha/yr)		
	150	300	450
Full irrigation	650	330	220
Irrigation at a 40 m^3/s river flow trigger	380	190	130
Irrigation at a 20 m^3/s river flow trigger	150	75	50

Most of the areas of land within a 5 km radius of the plant that, in Section 3.4, were identified as being potentially suitable for wastewater irrigation, probably aren't suitable for a nitrogen loading of 450 kg/ha/yr (or for the associated microbial loading) without a considerable risk of leaching or runoff of nitrogen. This occurs because the soils there are likely to have a medium to high leaching risk and/or a medium risk of runoff with a high nitrogen loading. Even using a nitrogen removal management system such as 'cut and carry', or predominantly silage, the maximum nitrogen loading will probably need to be restricted to approximately 300 kg/ha/yr or less. The approximate areas required for this vary between 75 ha and 650 ha (Table 5.1). This estimate, however, requires confirmation with daily water modelling and local groundwater information.

The hydraulic loadings associated with green stream irrigation of 150 kg N/ha/yr and 300 kg N/ha/yr are only 18.5 and 36 mm/yr respectively. On an annual basis, these are negligible in this area. Because of this, however, it is likely that most, if not all, of the annual wastewater nitrogen loading would be applied at a single wastewater irrigation event.

Such an irrigation regime significantly increases the risk of transmission of large amounts of nitrogen below the root zone. Although much of that nitrogen would be organic, subsequent mineralisation and nitrification are likely to result in significant leaching of nitrate nitrogen. A similar scenario has been experienced with other wastewater irrigation, and resulted in an accumulation of subsoil nitrogen. That, in turn, resulted in significant nitrate leaching irrespective of current pasture, fertiliser, and wastewater management.

To reduce the significant risk of nitrate leaching with irrigation of high-N wastewater, dilution of the nitrogen concentration could be considered, or applications of very small amounts of wastewater at each irrigation event could be conducted. Both of these practices reduce the amount of nitrogen that would be applied at each irrigation, and therefore also decrease the risk of nitrate leaching. The latter practice of applying very small amounts of wastewater per irrigation, however, is likely to be difficult to achieve without high costs of irrigation equipment and/or operation.

Without implementing practices that reduce the amount of nitrogen applied at each irrigation, it is likely that green stream irrigation possibilities would be limited to the 40 m^3/s and 20 m^3/s river flow scenarios using annual nitrogen loadings of 300 kg/ha or less. These would require between approximately 75 ha and 380 ha of land that should be managed using a cut and carry system. This restriction occurs because large areas of soils suitable for high nitrogen loadings per irrigation event are probably not available within a 5 km radius of the plant.

The existence of smaller areas of such soils suitable for irrigation of part of the high-N green stream using the 40 m^3/s and 20 m^3/s river flow scenarios requires a field assessment of potentially suitable land that was identified in Section 3.4.

5.4 RECOMMENDATIONS FOR 'GREEN STREAM' IRRIGATION

In summary, nitrogen loading is the limiting factor with irrigation of the green wastewater stream. Because this stream is expected to have a high nitrogen concentration, the risk of nitrate leaching and/or nitrogen runoff is high on most soils identified in Section 3.4 as being potentially suitable for wastewater irrigation within a 5 km radius of the plant.

The risk of nitrate leaching can be reduced by diluting the high-N wastewater or by applying very small volumes of the green stream wastewater at each irrigation event. The latter practice would be difficult and/or costly.

Without diluting the wastewater or irrigating with very small volumes, approximately 75-380 ha of land would be required for green stream irrigation that would be limited to river flow trigger scenarios of 20 m^3/s or 40 m^3/s. Irrigation would also be limited to annual nitrogen loadings of 300 kg/ha or less even if a 'cut and carry' system is employed to enhance nitrogen removal. A field assessment of potentially suitable land would need to be conducted to confirm this option.

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APPENDIX I

EXPECTED GREEN STREAM VOLUMES AND COMPOSITION (KEVIN LEHRKE, ALLIANCE GROUP LTD)

Mataura Plant

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August 13, 2003

Phil Greenwood
SoilWork Ltd
PO Box 5908
Dunedin

Dear Phil,

IRRIGATION OF 'GREEN' STREAMS

In our quest for reducing inputs of dissolved, reactive phosphorus into the Mataura River we have come to view plant effluent in terms of 'green' streams and 'non-green' streams. The 'green' streams are characterised by high levels of phosphorus and micro-organisms, and they also contain a significant level of nitrogen. They originate from operations that deal with paunch and gut contents such as the truckwash, stockyard washings, paunch contents and gut-cutter effluent.

From data collected in 2002 and 2003 it was estimated that about 36% of the effluent was 'green'. However, we have identified opportunities to reduce this volume down to about 8%, primarily by separating the non-green stock-wash water from the 'green' stockyard floor washings, which will eliminate the dilution effect of the stock-wash water. The engineering works to achieve separation are currently in progress, but they will not be completed until next year.

I estimate that, post-separation, most of the phosphorus will be contained in the relatively small volume of about 958 m^3/day (at the peak of the season) and I would like to assess whether irrigation of the smaller volume could be a realistic option for us. Therefore, I would appreciate it if you could repeat the desk-top exercise outlined in your letter of 8 April, 2003 using the figures of 958 m^3 and 771 Kg N. per day as shown in the attached Table 1. You will appreciate the meat processing industry is seasonal and monthly effluent data from the 2002-03 season is shown in the attached Table 2.

The objectives of this exercise are firstly to establish the land area that would be required for irrigating the green streams all of the time; secondly to establish the land area that would be required for irrigating the green streams at river flow triggers of 40 m^3/s and 20 m^3/s; and thirdly to indicate whether suitable land is located within close proximity to the plant. It is intended as a 'broad-brush' exercise to assess whether irrigation of 'green' streams is technically feasible. If so, we intend to make an economic assessment of irrigation to compare to some of the effluent treatment options that are available to us for river discharge.

Please contact me if you would like to discuss this further, or if you require any additional information to make the assessment.

Yours Sincerely,

Kevin Lehrke
Site Environmental Manager

TABLE 1: ESTIMATED FUTURE 'GREEN' VOLUMES

'Green' Targets	May 2002 Survey			Peak in 2003	Expected in 2003/04
	TP	TKN	Vol	Vol	Vol
	Kg/day	Kg/day	m^3/day	m^3/day	M^3/day
Truckwash	24	173	~ 115	~ 115	**~ 80**
Sheepyard & tunnel washdowns			~ 90	~ 90	**~ 45**
Sheepwash			1721	1732	**0**
Lamb paunch contents	31	34	65	~ 78	~ 78
Casings stripping machine	18	153	346	~ 253	~ 253
Cattleyard washings	5	63	130	130	**~ 130**
Cattlewash			610	620	**0**
Cattle paunch contents	24	67	422	~ 438	**~ 222**
Rendering stickwater	11	12	147	~ 150	~ 150
Ovine dewatering	9	82			
Bovine dewatering	16	187			
Total	***138***	***771***	***3646***	***~ 3606***	***~ 958***
Total Effluent	*146*	*~ 1600**	*10 230*	*11 430*	*11 430*
Proportion of 'Green'	*95 %*	*~ 48%*	*36 %*	*32 %*	*8 %*

*2003 data

TABLE 2: ESTIMATED N. LOAD OF FUTURE 'GREEN' STREAMS

	2002 - 03	2003 - 04	
	Effluent Produced (m^3)	**Predicted 'Green' assuming 8% (m^3)**	**Predicted Nitrogen based on 805 g/m^3 (Kg)**
November	46 800	3744	3014
December	113 150	9052	7287
January	197 011	15 760	12 687
February	224 011	17 920	14 426
March	283 940	22 715	18 286
April	238 345	19 068	15 350
May	234 731	18 778	15 116
June	148 730	11 898	9578
July	32 750	2620	2109
August	Off - season	Off – season	Off – season
September	Off - season	Off – season	Off – season
October	Off - season	Off – season	Off – season
TOTAL	**1 519 468**	**121 557**	**97 853**