



Kaeo Wastewater Treatment Plant

Land Disposal Options Assessment

DRAFT

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REPORT INFORMATION AND QUALITY CONTROL

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Executive Summary

This report provides the results of an assessment to identify potential sites for land disposal of treated wastewater from the Kaeo wastewater treatment plant (Kaeo WWTP). The work has been completed using geographic information systems (GIS) to identify potentially suitable sites along with a multi-criteria analysis to shortlist potentially suitable sites for a future detailed assessment.

This report assumes an average annual wastewater flow to the WWTP of 171 m³/day in 2026 which is the estimated year of commissioning of any land-based disposal infrastructure. An average hydraulic loading rate of 1.14 – 4.14 mm/day was determined based on the soil drainage classes present in Kaeo and the indicative permeability rate associated with clay loam soils. Based on these assumptions, a minimum total area of 7.1 hectares of land is required for disposal to land which includes a 50% buffer to allow for future growth, adequate distance from surroundings, and a storage pond. Due to high levels of rainfall and resulting stormwater infiltration in Kaeo, the maximum flow from the WWTP is much larger than the average flow. To deal with high flows it is recommended that 28 Ha be used for irrigation and a buffer.

GIS mapping using data sets from FNDC, Northland Regional Council (NRC) and other online sources were used. Based on these data sets, it can be confirmed that there are numerous feasible options for land disposal within 5 km of the WWTP. The sites identified as a shortlist were largely located to the south of the WWTP.

Upon review of the top 10 sites, it was found that the best option was too close to potential nearby dwellings. Therefore, it would require subsurface drip irrigation as opposed to the cheaper method of spray irrigation which has meant that the second ranked site was instead identified as the preferred theoretical site.

Site specific economic analysis has been achieved for option 3 by Beca which has been included as Appendix A. This analysis gives a high-level estimate of \$6.2M with an uncertainty range of \$4.4M – \$9.3M.

1. Introduction

The Kaeo WWTP discharges treated wastewater into the Kaeo River which flows into the Whangaroa Harbour. FNDC is currently in the process of renewing the resource consent authorising the discharge, which expires on 31st October 2022. Policy D.4.3 of the Proposed Regional Plan for Northland (Appeals Version – August 2019) sets out that an application for resource consent to discharge municipal wastewater to water will generally not be granted unless, among other things, a discharge to land has been considered and found not to be economically, environmentally, or practicably viable.

The purpose of this report is to provide an initial desktop feasibility assessment and a high-level cost estimate for land disposal of wastewater from the Kaeo WWTP. This will enable a determination of land disposal practicability and feasibility in accordance with Policy D.4.3.

Kaeo township and the surrounding area is known to be flood prone land with clay soils that are not very conducive to discharge to land. However, this desktop study identified numerous options and has ranked the top ten using a multi-criteria analysis to identify which site should be used to base an economic analysis on.

2. Methodology

To establish the feasibility of land disposal areas, GIS software was used to initially screen site suitability by excluding land areas that failed critical criteria. This first-class exclusion zone was initially developed for the area of interest (AOI) based on the following criteria:

- 20m proximity from all lakes and rivers.
- 20m proximity from all land not designated rural production, general coastal or minerals.
- Total area for land designated as minerals.
- Total area for flood susceptible land.
- Total area for 50-year coastal flooding and erosion predictions.
- Slope > 12°.
- Soil drainage classes 0 – 1.

These criteria were developed based on established best practice, considering previous similar studies in the Far North [note reference] and engineering advice provided by Beca as part of a pre-draft review process.

A long list of sites was then created by ranking each site using the criteria and weighting shown in Table 1 below.

Table 1: Long List Criteria

| Criteria | Weighting |
|--|-----------|
| Highest Average Hydraulic Loading Rate | 33.0% |
| Distance from Wastewater Treatment Plant | 25.0% |
| Lowest Average Slope | 17.0% |
| Total Available Area for Discharge | 17.0% |
| Regularity of Site | 8.0% |

Lastly, the long list underwent a multi-criteria analysis (MCA) process in which qualitative measures are assessed as shown in Table 2 below. This process allows for the remaining sites to be ranked based on their suitability for land disposal so that the highest ranked can be taken forward for further analysis. Cultural consideration can not be made by staff and therefore will be made in collaboration with tangata whenua should a land owner agree to further investigations being conducted at a later date.

Table 2: MCA Criteria

| Criteria | Weighting |
|--|-----------|
| Long List Score | 40% |
| Proximity to archaeological sites of significance | 20% |
| Statutory Considerations (SNA, Wetlands) | 20% |
| Existing Land Use (Land Cover, Aerials, LINZ Land Use) | 20% |

The analysis was achieved using the datasets found in Table 3 to conduct the exclusion zones and criteria analysis referenced above.

Table 3: Spatial Data Sets used to Identify Land Disposal Constraints

| GIS Dataset | Source |
|---|----------------------------|
| District Plan Zones | Far North District Council |
| Slope | LENZ ² |
| MfE river flows | LINZ ¹ |
| Northland Flood Susceptible Land | Northland Regional Council |
| Marae | Te Puni Kokiri Maps |
| NZAA Registered Sites | Far North District Council |
| SNA's | Far North District Council |
| Bore sites | Northland Regional Council |
| Parcel Search (Property Ownership Type) | Far North District Council |
| NZLRI SOIL | LRIS Portal ³ |
| LCDB v5.0 | LRIS Portal |

- 1 LINZ topo1:50,000 map data
- 2 Slope data layer used in the creation of Land Environments of New Zealand (LENZ) classification
- 3 Identified as the same layer used in NRC Soil Map Viewer

3. Land Disposal Methods

The work of Tonkin + Taylor (2019) in Ahipara suggests that the methods for land disposal from wastewater treatment plants are limited by volume, soil quality, and level of treatment prior to disposal.

Four potential land disposal methods have been identified for consideration:

- Soil Aquifer Treatment (SAT)
- Soil Moisture Discharge Methods (SM)
- Slow Rate Irrigation (SR)
- Combined Land and Water Discharge (CLWD)

Soil Aquifer Treatment (SAT)

According to the USEPA Process Design Manual for Land Treatment of Municipal Wastewater Effluents, (2006) soil aquifer treatment allows for higher loading rates than the other options which would significantly reduce the area required for disposal. However, this method requires high permeability soils which are free draining and require a fine level of pre-disposal filtration to operate effectively.

The area surrounding the Kaeo WWTP contains a mixture of sandstone and greywacke soils which vary from poorly drained to well-draining. These soils are likely to not have the drainage level required to consider SAT however further investigations would need to take place to be sure.

Effluent exiting the Kaeo WWTP also contains algae and other solids which can lead to clogging of the disposal system and result in runoff. For SAT to be viable, the pre-disposal treatment would need to meet a suitable standard to prevent clogging and runoff from occurring. Current pre-disposal treatment would not meet this standard and therefore SAT would only be considered in combination with upgrades to the treatment process.

Investigation into treatment requirements and costing of upgrades required to reach those requirements would need to be completed before SAT disposal could be considered. It is recommended that this is done should land disposal be carried forward as an option following this report.

Soil Moisture Discharge Methods (SM)

Soil moisture discharge methods are designed to minimize losses to groundwater following the disposal to land. This method requires a significantly larger land area than other disposal methods. For this reason, it would only be considered if on-site investigations deemed it necessary due to the potential health risk present in the event treated wastewater would flow into groundwater used by the public.

Slow Rate Irrigation (SR)

Slow rate irrigation is a method where treated wastewater effluent is applied at a low loading rate over an extensive area of land as determined by USEPA (2006). Application rates typically vary between 3 and 5 mm/d according to Tonkin + Taylor (2019). The effluent applied will soak into the upper soil layers where some is lost to evapotranspiration. When the storage capacity of moisture in the soil is exceeded, the effluent will percolate and be lost via soakage. Application methods for SR are spray irrigation (fixed

sprinkler or k-line system), and pressure compensating drip irrigation, either laid on the surface or buried within the topsoil layer (100 to 150 mm depth).

Effluent from the Kaeo WWTP is not suitable for the pressure compensating drip irrigation system due to the required small diameter effluent emitters. The wastewater being discharged contains algae that will quickly clog the emitters and compromise the operation. This was the reason the system was not further considered for the Ahipara WWTP land disposal options assessment (Tonkin + Taylor, 2019). Therefore, drip irrigation would only be considered if pre-disposal treatment of total suspended solids (TSS) was improved.

SR systems need to be developed to avoid run-off from the disposal area with all effluent being disposed of via soakage or evapotranspiration. Therefore, irrigation will need to cease during times of high soil moisture content when chances of runoff are high. Detailed investigations would be required to determine when irrigation should cease for each site. Effluent produced at such a time would need to be stored in a storage pond. Comparison sites indicate a requirement of 2 – 6 months of storage capacity is required if 100% discharge to land is pursued. Whangamata which uses a precipitation index irrigation scheme requires a 3-month storage pond, whilst a land disposal system in Mangawhai requires 6 months of storage.

SR is most suitable on land slopes up to 10° however, it can work on slopes up to 20° if drainage class is suitable. The drainage class within the area of interest allows slopes greater than 10° to be considered, however the additional runoff risk requires further investigation. For the purpose of this analysis, sites with less than 12° have been considered for disposal in accordance with the land disposal report for Kohukohu by Daniel, J. (2020). This report identified that slopes above 12° pose a greater risk of runoff and erosion issues.

Most contaminants within wastewater effluent are removed in the first few meters of soil, with finer soils resulting in a greater removal rate. Some nitrogen may be removed through nitrification on the surface of the soil, however, once it has entered the soil will move freely through the soil profile when it becomes entrained with water. This can lead to nitrogen loading downstream, the effects of which should be considered when finding an appropriate site for land disposal.

Slow rate irrigation is considered the most appropriate method for this desktop analysis.

Combined Land and Water Discharge (CLWD)

Using SR in a combined land and water discharge should also be considered where the land disposal would be considered as a 'side-stream' treatment to the current set-up; that is, flows that are to be directed to land disposal would undergo a separate treatment process to the flows that would be discharged to water. The benefits of a side-stream arrangement are that the capital investment required for land disposal can potentially be reduced owing to the differing treatment requirements for land disposal discharge to water. This would allow for discharge to water when the land discharge site is unable to accept treated wastewater due to soil moisture conditions. It is also noted that at least 20% of the flow is required to go through the ponds to keep them 'alive'. Therefore, it would be ideal for the wastewater to flow through the current system before either being discharged to land or surface water depending on soil moisture conditions.

4. Flow Summary:

Total flow data for the period between 1st January 2017 and 31st Dec 2020 has been collated for analysis. Table 4 below identifies the average, median, 90th percentile, maximum, and average dry weather flows for 2021 (current year), 2026 (estimated first year of operation should the option be taken forward), and 2043 (final year of population forecast data).

Table 4: Kaeo Wastewater Inflows (Jan 2017 – Dec 2020)

| Parameter | 2021 | 2026 | 2043 |
|--|------|------|------|
| Average Flow (m ³ /day) | 165 | 171 | 195 |
| Median Flow (m ³ /day) | 128 | 133 | 151 |
| 90 th Percentile Flow (m ³ /day) | 294 | 305 | 347 |
| Maximum Flow (m ³ /day) | 1274 | 1320 | 1503 |
| Average Dry Weather Flow (m ³ /day) | 79 | 82 | 94 |

The inflow to the treatment plant was used to determine the amount of discharge the land would be required to handle due to the outflow being unreliable over the years. The flows recorded have been historically compliant with the average dry weather flow limit of 360 m³/day.

Soil Drainage Class

Drainage classification is of fundamental importance to land disposal feasibility assessment. It allows for an indicative soil permeability to be determined based on the preliminary soil permeability as per the guidelines of NZS1547 (2012).

To compare the potential sites with the underlying soil, a drainage class assessment was undertaken using the following method:

- NZLRI Soil (2010) layer imported from LRIS portal. This layer forms the basis for the Northland Regional Councils (NRC) soil viewer.
- Using the soil factsheets supplied by NRC, the types of soils found in the AOI were assigned with a drainage class between 0 (No drainage) – 5 (Very well drained). Some of these soils had a range of drainage classes that were averaged out so that a single value could be attributed to them. (e.g. Omu Clay Loam (OM) has a drainage class between 2 – 4 so would become a 3).
- The assigned drainage classes were then applied to the imported layer which exists as polygons on the map. These polygons often had 2 – 3 soils attributed to them and so an average drainage class was used with it being rounded to the nearest whole number.

The output from the above assessment is set out in Figure 1 below.

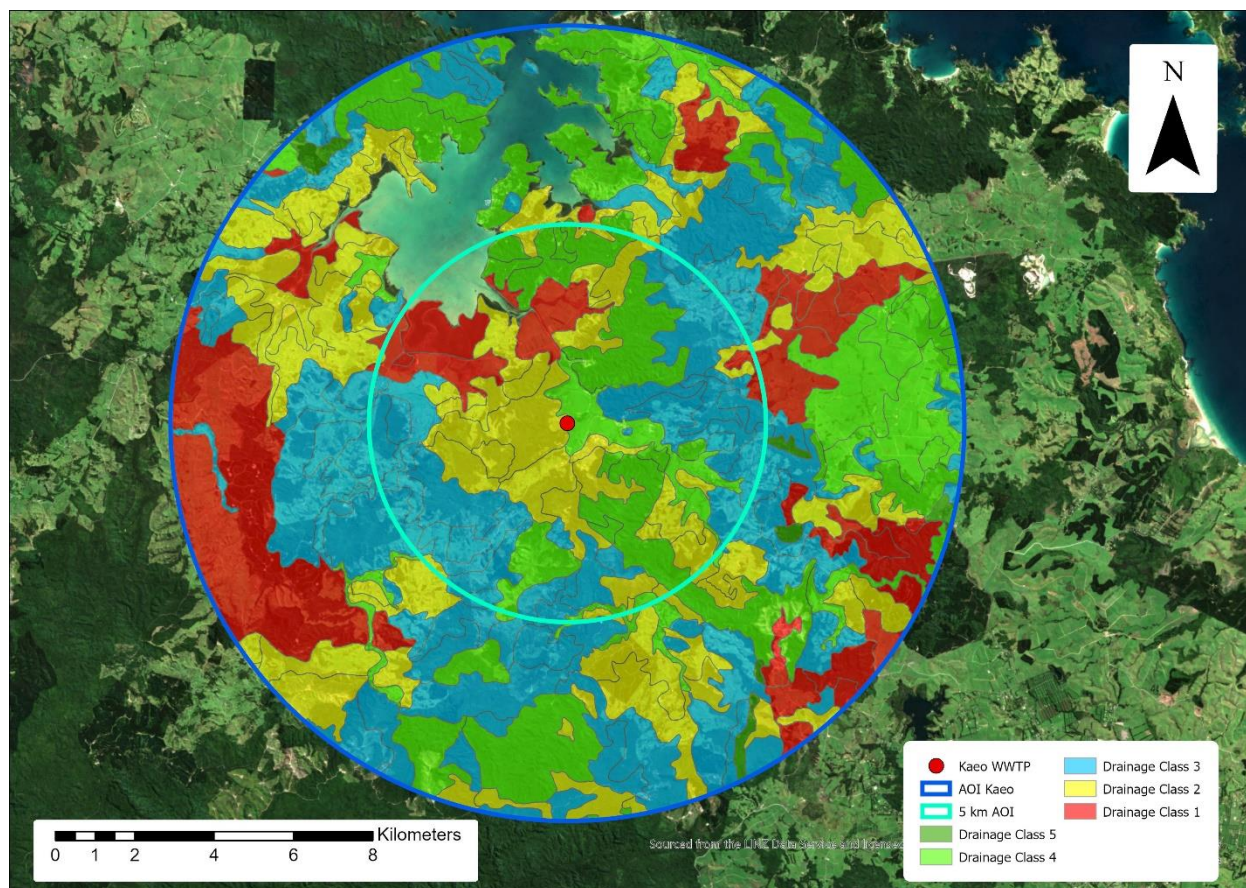


Figure 1: Soil Drainage Classes

For the purposes of this analysis a high-level approach was used to give an indicative drainage class that could be associated with the underlying soil as a comparison tool for potential sites. On-site testing to confirm the drainage of the soil would need to be carried out in the event any options are taken forward for further consideration.

5. Groundwater considerations

NRC does not currently monitor groundwater in the Kao area, and no groundwater investigations have been undertaken by FNDC. Therefore, onsite investigations will need to be undertaken to determine groundwater levels and flows relative to the site selected for disposal. Registered bores can be found in the Kao AOI and there will likely also be unconsented bores in the area. The proximity of any known bores will need to be identified if any of the options are further investigated. It can be assumed that any bore onsite of an option which is implemented will be decommissioned unless appropriate buffer distances can be accommodated within the irrigation system design.

It is vital that a flow path be charted for the treated wastewater once it has been disposed to land so that FNDC can be confident that it will not turn into an environmental or public health risk. This can be achieved using well-placed bores which are monitored to establish flow rates, depth, and direction. It is important

that this monitoring accurately reflect yearly flows and so should be done for the period of at least one year though winter months where the flows will be highest.

6. Hydraulic Loading Rate Design Basis

Following the method used by Jacobs (2020) the hydraulic loading rate has been determined based on an estimated percolation rate, average annual rainfall, and the average annual evapotranspiration for Kaero. Annual rainfall and evapotranspiration data used is NIWA Cliflo data from the nearest stations which document that data. Rainfall was taken from the Kaero Northland site (Network Number: A53071) and evapotranspiration was taken from the Kerikeri Ews site (Network Number: A53191).

The preliminary design for soil permeability is determined using NZS1547 (2012) which provides a broad estimate of between 60 – 120 mm/day for massive clay loam land disposal systems. This range was used to differentiate the drainage classes being considered (2 – 5) as in Table 6 below.

Table 6: Soil Permeability

| Drainage Class | Preliminary Soil Permeability (mm/day) |
|----------------|--|
| 2 | 60 |
| 3 | 80 |
| 4 | 100 |
| 5 | 120 |

An example of this method can be found in Table 7 below which finds a hydraulic loading rate of 4.32 mm/d for areas with a drainage class of 5. Therefore, this result is the best possible case for the area of interest and is only slightly outside the range of 3 – 5 mm/d suggested by Tonkin + Taylor (2019) for land disposal for the Ahipara WWTP.

The hydraulic loading rate found for drainage class 2 is 1.32 mm/day which is below the range considered by Tonkin + Taylor (2019). Due to the imperfectly draining nature of the class this was considered appropriate.

Table 7: Hydraulic Loading Rate Example

| Parameter | Units | Value | Comment |
|---|---------|-----------|--|
| Soil Type | - | Clay Loam | NRC Managing NZ Soils Fact Sheet Viewer |
| Soil Permeability (Preliminary Design) | mm/day | 120 | Category 4, Table 5.2 NZS1547 (2012) |
| Design Safety Factor | % | 5 | USEPA (2006) |
| Design Annual Percolation Rate | mm/day | 6 | Soil Permeability x Design Safety Factor |
| Annual Rainfall | mm/year | 1460 | NIWA (Average from past 4 years) |

| | | | |
|----------------------------------|---------|------|---|
| Annual Evapotranspiration | mm/year | 782 | NIWA (Average from past 4 years) |
| Hydraulic Loading Rate | mm/day | 4.14 | Percolation – Rainfall + Evapotranspiration |

7. Land Disposal Design Basis

Using the values reported for the average daily flow and the hydraulic loading rate, total land disposal area requirements can be calculated. These land area requirements are reported in Table 8 for drainage class 2 and 5 to show the range considered for sizing the land disposal system. The total land requirement includes a 50% buffer to account for a storage pond, and potential growth of irrigated area. A 50% buffer has been used to accommodate for the low area requirement for land disposal present due to the low average discharge flow.

A comparison has also been included in Table 8 below to show the difference between 2026 and 2043 requirements based on assumed wastewater flows in 2043. The 50% buffer is added in addition to the exclusion zones applied as detailed in section 9 of this report.

Table 8: Total Area Required for Land Disposal

| Parameter | Units | Drainage Class 2 | Drainage Class 5 |
|--|---------------------|-------------------------------|-------------------------------|
| Average Daily Flow (2026) | m ³ /day | 171 | 171 |
| Average Daily Flow (2043) | m ³ /day | 195 | 195 |
| Hydraulic Loading Rate | mm/day | 1.14 | 4.14 |
| Irrigated Area (2026) | Ha | 14.5 | 4.1 |
| Irrigated Area (2043) | Ha | 17.1 | 4.7 |
| Irrigation Application Method | | Spray | Spray |
| 50% Buffer Area (2026) | Ha | 7.2 (0.25 * (Irrigated Area)) | 2.1 (0.25 * (Irrigated Area)) |
| 50% Buffer Area (2043) | Ha | 8.6 (0.25 * (Irrigated Area)) | 2.4 (0.25 * (Irrigated Area)) |
| Total Land Area Required (2026) | Ha | 21.7 | 6.2 |
| Total Land Area Required (2043) | Ha | 25.7 | 7.1 |

8. First-class Exclusion Process

A first-class exclusion zone has been initially developed in Arc GIS Pro for the area of interest based on the following criteria:

- 20 m proximity from all lakes and rivers.
- 20 m proximity from all land not designated rural production, general coastal or minerals.
- Total area for land designated as minerals.
- Total area for flood susceptible land.
- Total area for 50-year coastal flooding and erosion predictions.
- Slope > 12°.
- Soil drainage classes 0 – 1.

Based on these criteria, a desktop GIS analysis was conducted by first creating a 10 km buffer boundary around the Kao WWTP. FNDC District Plan zones were included to determine the zoning associated within the AOI. Figures 3 - 7 below show the area of the zones being excluded from further analysis as according to the criteria above.

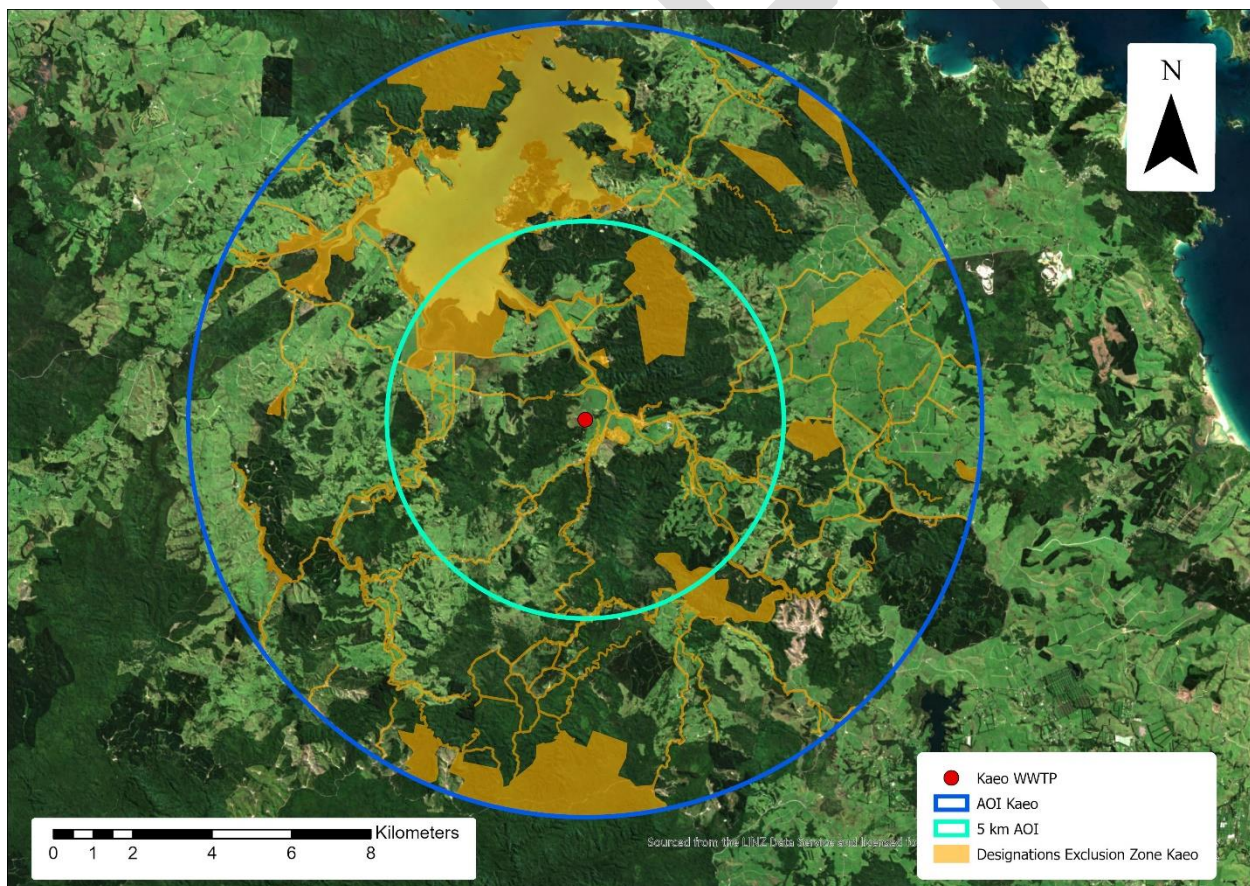


Figure 3: Land Designation

Using this zoning data, all land not zoned as either rural production or general coastal was given a 20m buffer which acts as the designation exclusion zone. The exception to this rule was the minerals zone as

it was deemed that this zoning does not require the same degree of separation due to the anticipated land use not being sensitive to the land disposal activity.

The lines stretching across the AOI is land designated as roads which have also been considered part of the exclusion zone.

River lines were then produced using data from LINZ TOPO50 NZ River Centerlines and given a buffer of 20 m as per the exclusion criteria. The output is depicted in Figure 4 below. Rivers/streams are widespread over the AOI and act as a considerable constraint compared to the other exclusion criteria.

The flood plains were also considered a total exclusion zone and have been included in Figure 4. Because no flood modeling has been completed within the surrounding catchment, the Northland Regional Council Flood Susceptible Land data was used to demarcate 100-year floodplains. It has been used as an exclusion zone due to the potential damage/contamination that could be caused in the event of a flood.

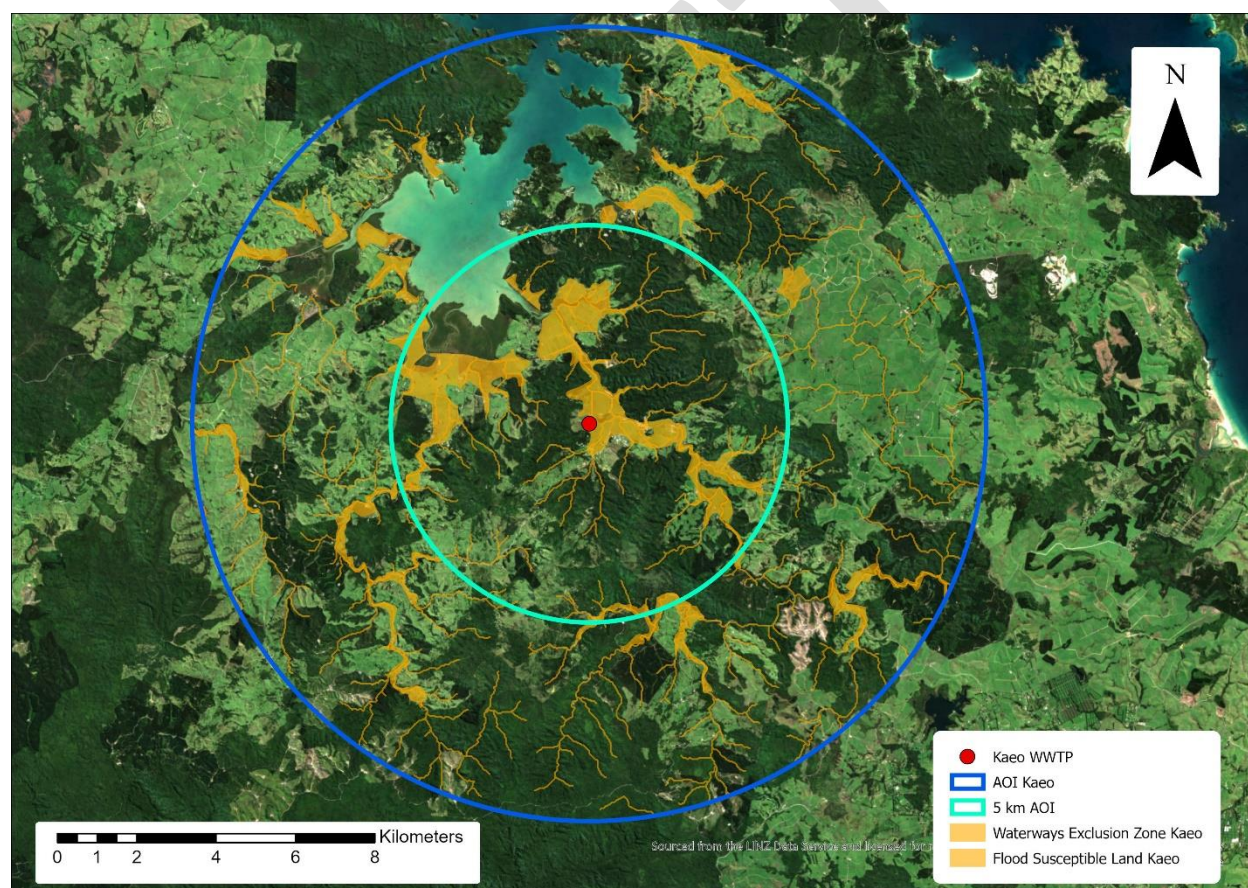


Figure 4: River, Lake, and Flood lands Exclusion Zone

Rivers are spread out across the AOI and have a significant impact on where land disposal can be applied. Flood susceptible land follows the river lines and extends out onto low lying land.

Slopes greater than 12° have been added as an exclusion zone due to the propensity for runoff to be produced from these slopes. Data from LENZ was used first to project the slope data based on a 25m

digital elevation model fitted to 20m digital contour data as seen in Figure 5 below. Following this, the areas above 12° were added to the exclusion zone.

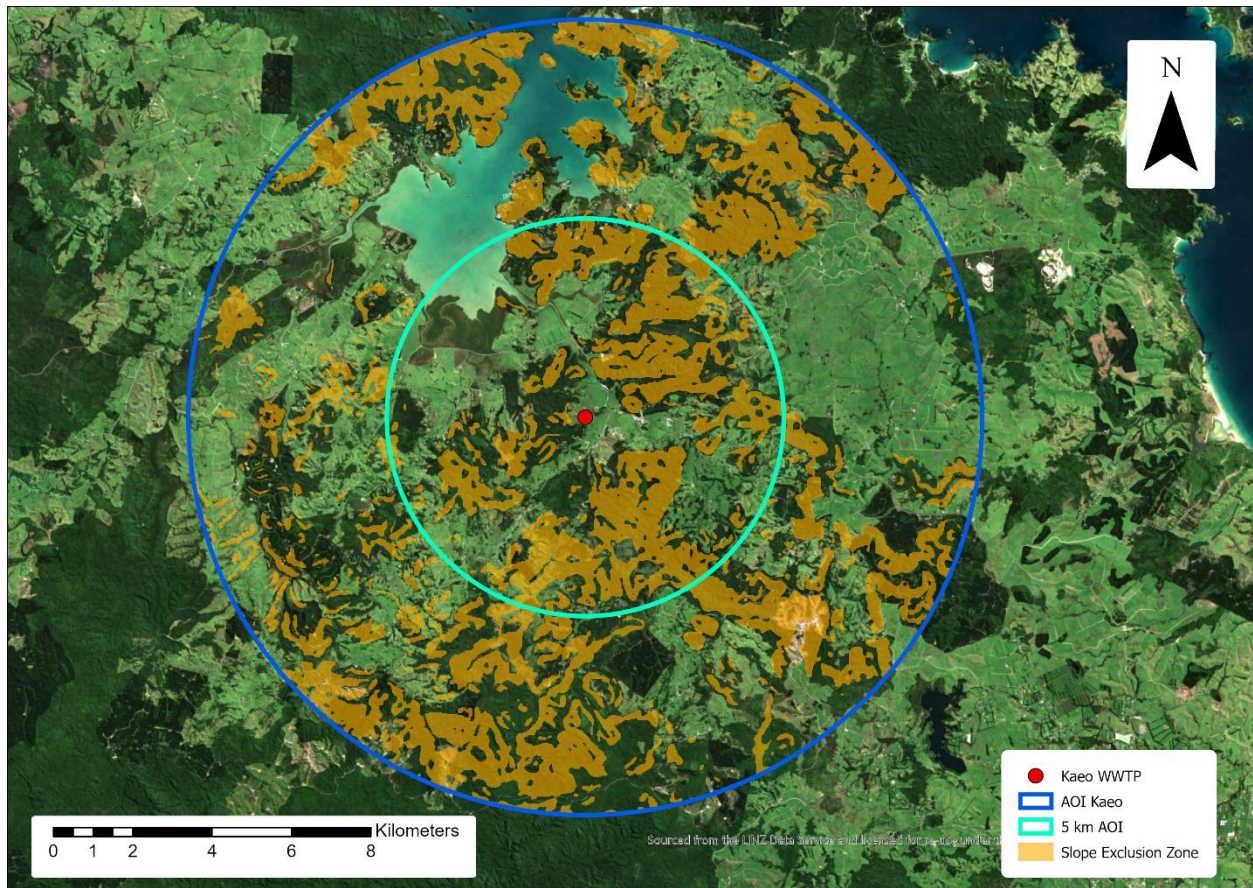


Figure 5: Slope Exclusion Zone

Slopes greater than 12° were found in high quantity throughout the AOI. This is a significant amount of area unavailable for land disposal.

As can be seen in Section 5 of this report, the soil drainage map allows for classes 0 – 1 to be excluded from further consideration. This is shown as an exclusion zone in Figure 6 below.

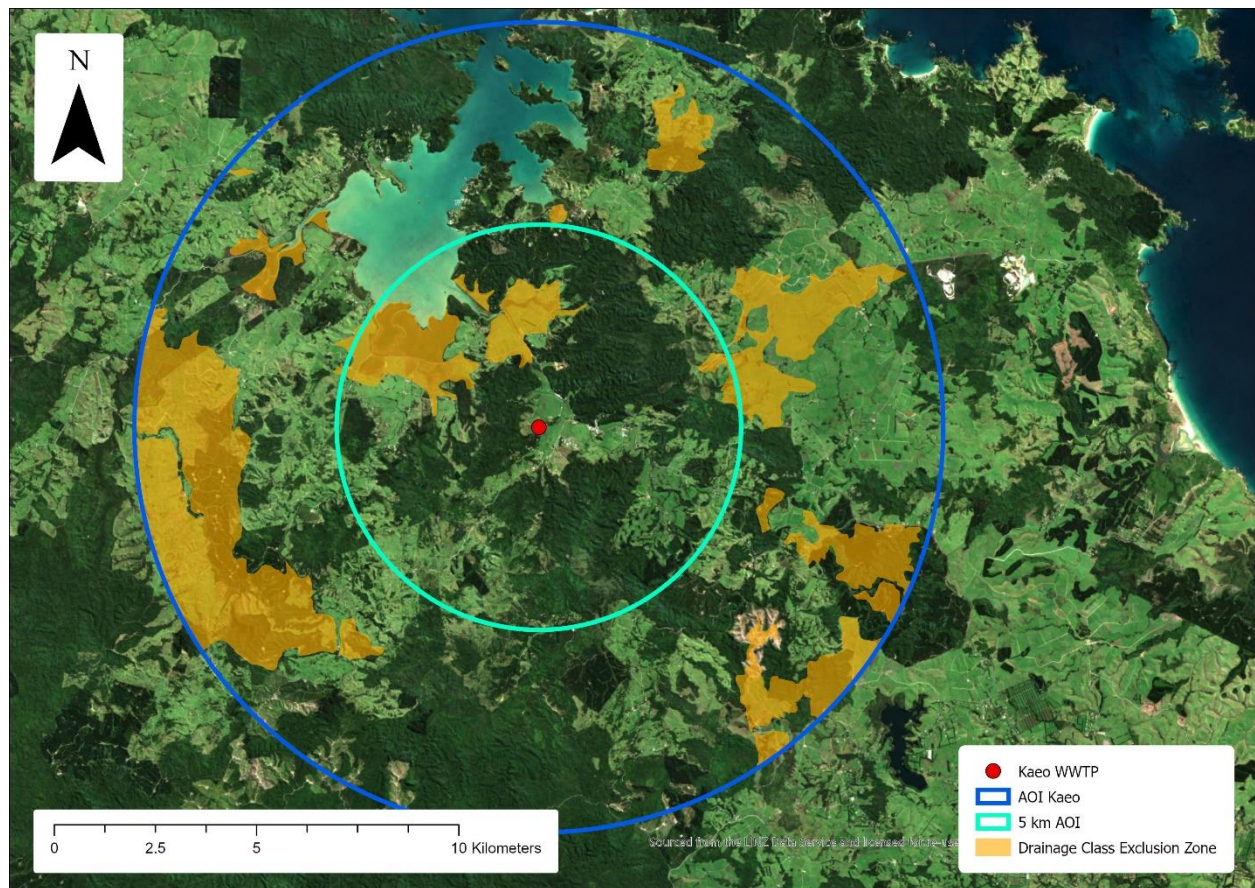


Figure 6: Soil Exclusion Zone

As can be seen, most of the land within the AOI is at a high enough drainage class to be considered for disposal of land. This is due to the large presence of sandstone and greywacke soils which dominate the area and generally have a drainage class between 2 (inconsistent) and 4 (well-draining).

Based on all the first-class exclusions a complete exclusion zone could then be formed as per Figure 7 below.

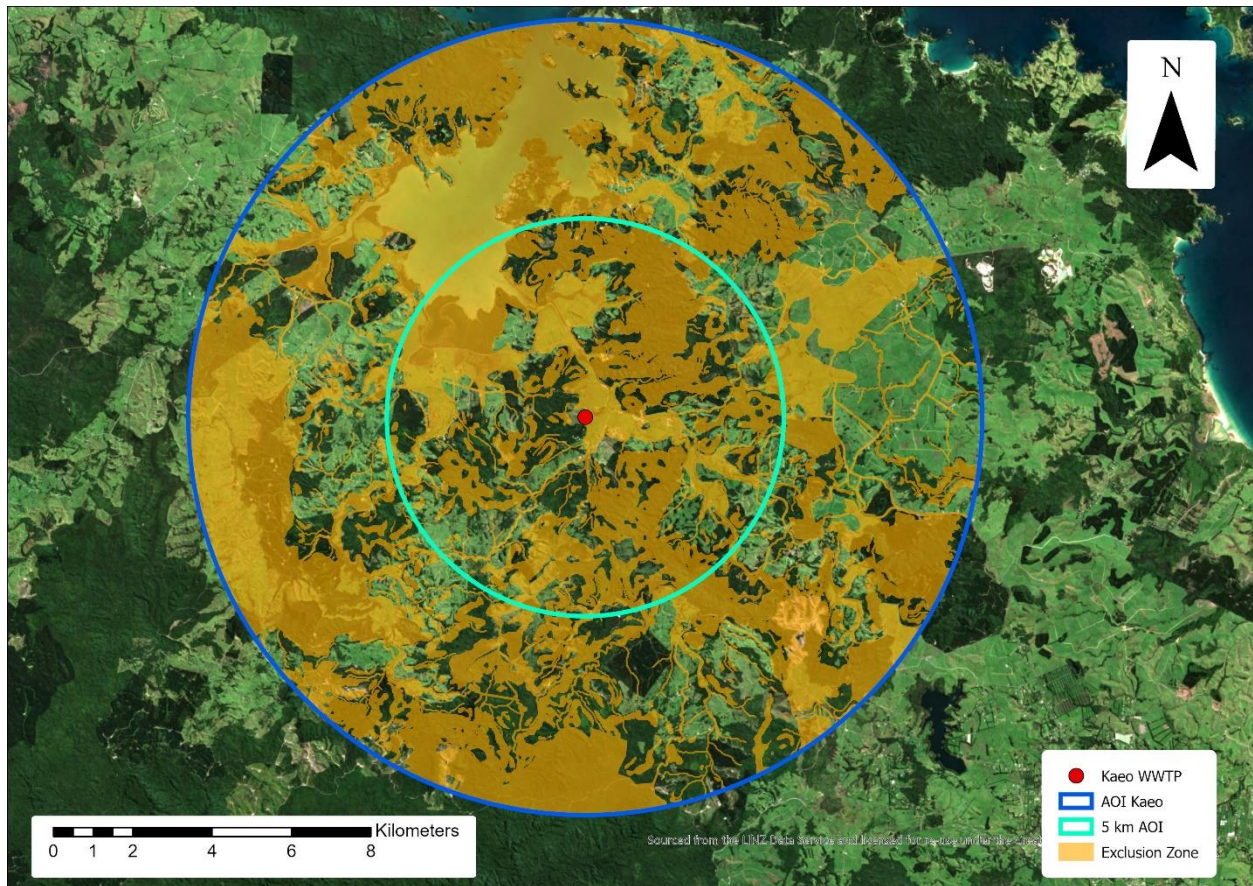


Figure 7: Total Exclusion Zone

As seen, most of the land with the AOI is currently excluded from further considerations due to the above criteria. However, given the relatively small amount of land required for land disposal in Kao there are still plenty of options to be considered.

This is shown below where using the total exclusion zone layer, the available land can be shown as in Figure 8.

Coastal flooding and erosion have been determined by NRC at 50 and 100-year intervals. The 100-year zones hold a 5% probability however, and so the 50-year zones have been used instead which have a 66% likelihood. These zones did not add to the exclusion zone area beyond what is already was. Maps for these layers can be supplied on request.

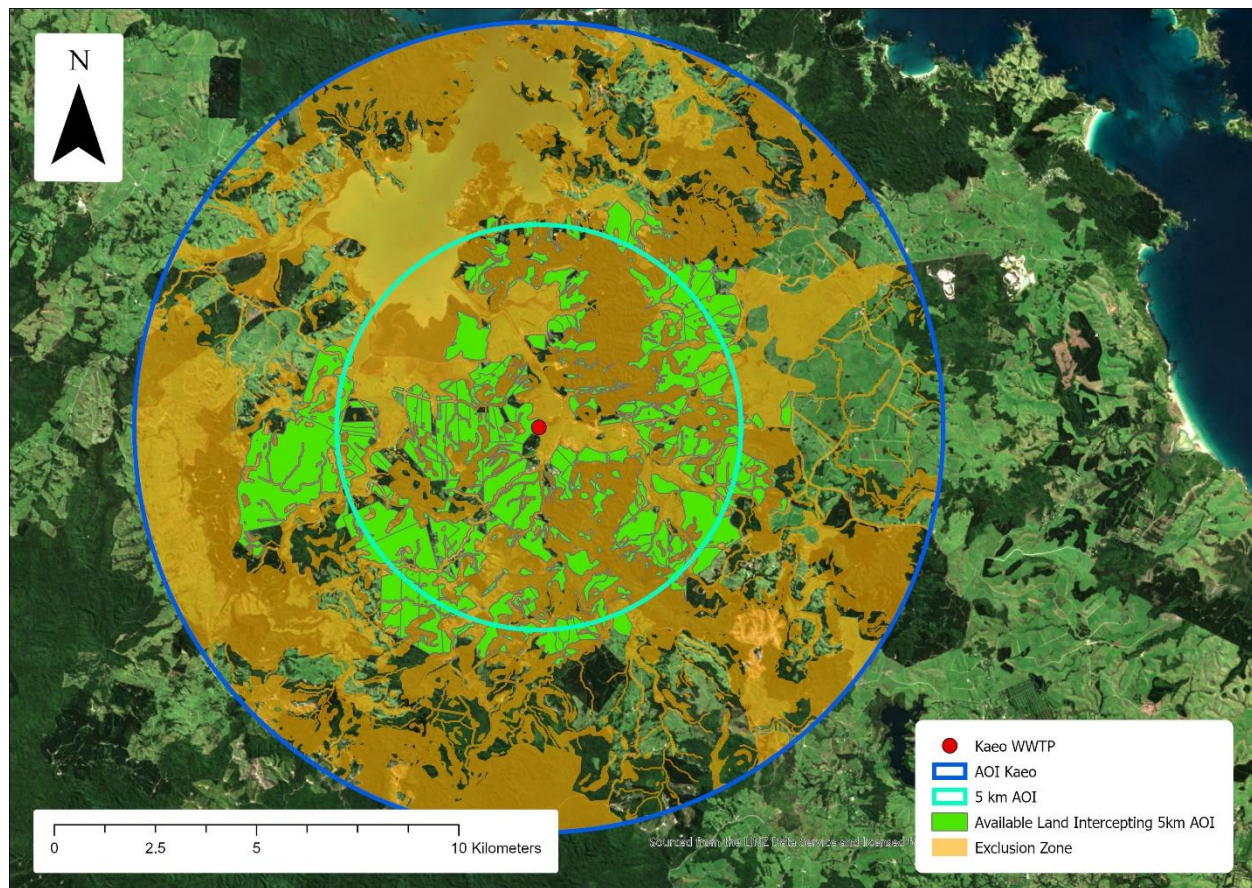


Figure 8: Available Land

The land parcels located outside the exclusion zone were processed using GIS software (ArcMap Pro) to remove small parcels and those that are deemed unusable, in addition to merging land parcels in common ownership. The methodology for this processing is outlined below:

- Available land data initially cleaned of any land parcel area below 1 Ha.
- Additional cleaning of remaining data with parcel intents labelled ROAD, HYDRO, etc. which hold unusable land for disposal.
- Parcel properties are merged based on ownership and proximity. This is done so that total land available from a single owner/ownership group can be used providing that the parcel properties are close together.
- Any land remaining with less than 4.1 Ha is excluded due to being less than the lowest disposal area requirement calculated.

This process has provided an extended list of options which can be further considered for their potential as land disposal sites. In this case there were 113 remaining sites of interest within 5km and therefore available sites further out than that were not included in further analysis. The number of sites is further refined into a long list using the qualitative method detailed in section 10 of this report.

9. Long List Development

The long list was created using the criteria shown in Table 9 below. This initial method of ranking the potential sites was purely quantitative in nature.

Table 9: Long List Criteria

| Criteria |
|--|
| Highest Average Hydraulic Loading Rate |
| Distance from Wastewater Treatment Plant |
| Lowest Average Slope |
| Total Available Area for Discharge |
| Regularity of Site |

The long list criteria were determined as follows:

- The resulting 113 sites found in the first-class exclusion process were joined with the underlying soil drainage data using the union tool in Arc GIS Pro. This allowed for the drainage classes of each option to be analyzed.
- Multiple soil drainage class polygons underlined each option and therefore a percentage was developed to show how much of each option contained each drainage class. To achieve this analysis, the available land area information was extracted from Arc GIS Pro and transferred to Excel. Here, the total area of each option was first found by summing the areas for all associated drainage class polygons. This allowed for the area of each drainage class to be given a percentage value for the area they make up of an option in relation to its total area.
- To come up with a numerical field that can be ranked, the percentage values of each drainage class are multiplied by its associated hydraulic loading rate (as calculated in section 6 of this report). This gives each option an indicative hydraulic loading rate which can then be used to score the drainage level of each option.
- Distance from the wastewater treatment plant was scored depending on proximity of the sites. An option which was within 5km would score 1 where an option within 1km would score 5.
- The average slope of each option was calculated in Excel using the AVERAGE function for all soil polygons found within an option. This gives an indicative value for the slopes on-site for each option and allows for them to be scored against each other to find the options with the lowest average slope.
- Lastly, the regularity is calculated by using the ratio $\text{AREA}:\text{Perimeter}^2$. This means that cuts within the available areas produced from exclusion criteria result in a lower regularity as they raise the perimeter of the polygons in Arc GIS Pro. However, it was decided that regularity would not be included in this assessment due to it counteracting larger sites from being considered. This is due to them being more likely to have rivers, pockets of high slope, or some other exclusion zone running through them and splitting up the area.

Using the output from the above analysis, scores can be set up for each of the long list criteria based on where an option sits for a certain criterion in relation to the other options. Percentiles were then used to

create 10 possible scores for each criterion based on the results found for all 113 options. An example of this is shown in Table 10 below which details how options are scored for their total available area.

Table 10: Total Available Area Scoring

| Percentile | Score |
|----------------------|-------|
| Below 10% | 1 |
| Below 20%, Above 10% | 2 |
| Below 30%, Above 20% | 3 |
| Below 40%, Above 30% | 4 |
| Below 50%, Above 40% | 5 |
| Below 60%, Above 50% | 6 |
| Below 70%, Above 60% | 7 |
| Below 80%, Above 70% | 8 |
| Below 90%, Above 80% | 9 |
| Above 90% | 10 |

The scoring for each of the criterion were then used to develop the long list using the weightings shown in Table 11 below. Hydraulic loading rates were considered the most important factor for considering land disposal and therefore got a highest weighting. Distance to the wastewater treatment plant has been proven as a significant factor in the cost of implementation and therefore was weighted accordingly. As slopes above 12° were excluded earlier this was deemed a less important criterion though it is noted that the lower the slope on-site, the better it is for land disposal and therefore it was included. Total available area allows for more options to be considered at the site but due to the small area needed for land disposal in Kaeo was given a low weighting.

Table 11: Long List Weighting

| Criteria | Weighting |
|--|-----------|
| Highest Average Hydraulic Loading Rate | 33.0% |
| Distance from Wastewater Treatment Plant | 25.0% |
| Lowest Average Slope | 17.0% |
| Total Available Area for Discharge | 17.0% |
| Regularity of Site | 8.0% |

The weightings for each of the criteria were then multiplied by the associated score for each option to develop an overall ranking for each site. Based on this ranking, the top 10 sites were taken forward for further analysis using a multi-criteria analysis (MCA) which considered qualitative information. These 10 sites are included in Appendix B alongside the information used for the MCA. It is important to note that this does not rule out the remaining 113 options from consideration. Should the options taken forward prove unviable then additional sites from the available land list can be taken forward based on their ranking to be considered further.

Also included in Appendix B is the total available land in hectares. All sites identified have an available area of at least 7 Ha and therefore can support land disposal provided they have adequate soil drainage. This will need to be determined using on-site investigations which test the soils at key locations.

10. Multi-Criteria Analysis

A multi-criteria analysis (MCA) has been carried out to further rank the top 10 sites from the long list options. The MCA considers four additional criteria as shown in Table 11 below. The initial weighting of the criteria is as below, however, numerous different weighting scenarios were considered in a sensitivity analysis.

On top of the criteria listed in Table 12, bore locations and property ownership type (Public, Private, Maori) were found for each site. It was deemed that any bores onsite could be closed off before implementation of land disposal and therefore not considered in the MCA. Ownership type was excluded from the MCA and was instead set for later consideration should any sites be taken forward. However, in this case all 11 sites are on private freehold land.

Treaty settlement land was also considered following the MCA to identify if the proposed land was settled. None of the land being considered is settled, however, discussion with local iwi will need to take place to appropriately define whether each site is culturally acceptable for use.

Table 12: MCA Criteria

| Criteria | Weighting |
|--|-----------|
| Long List Score | 40% |
| Proximity to archaeological sites of significance | 20% |
| Statutory Considerations (SNA, Wetlands) | 20% |
| Existing Land Use (Land Cover, Aerials, LINZ Land Use) | 20% |

The initial long list ranking for each of the options was first recognized as a factor which needed to be considered due to its importance in site selection.

Impacts that the options could have on cultural sites and values is an important consideration which will not be included in the MCA due to it needing to be assessed in partnership with mana whenua. However, local marae and known sites of significance have been mapped in preparation for those discussions. Instead, archaeological sites of significance identified by NZAA have been used to identify the potential importance of the land area as a determinant for ease of consent.

Lastly, the existing land use has been determined by using the land cover database (LCDB), and locations of Significant Natural Areas (SNA) in the AOI. This was then verified using aerial photography with Photoblique. As with the drainage class, the land cover database is joined with the available land using a union in GIS and a percentage calculated for how much of the option is covered by certain types of land (e.g. High Production Exotic Grassland). SNA's are found in FNDC's geodatabase and if they cross one of the long-listed options, their impact on the usage of the site is determined and scored appropriately.

Considerations of any wetlands are also included in the land use category.

The results of this analysis can be seen below in Figures 9 – 10. Figure 9 shows the results of the chosen weighting from Table 12, where Figure 10 shows the variance exhibited by the sensitivity analysis in which differing weightings were compared. A score of 5 would represent a maximum score, whilst a score of 0 represents a minimum score for both figures.

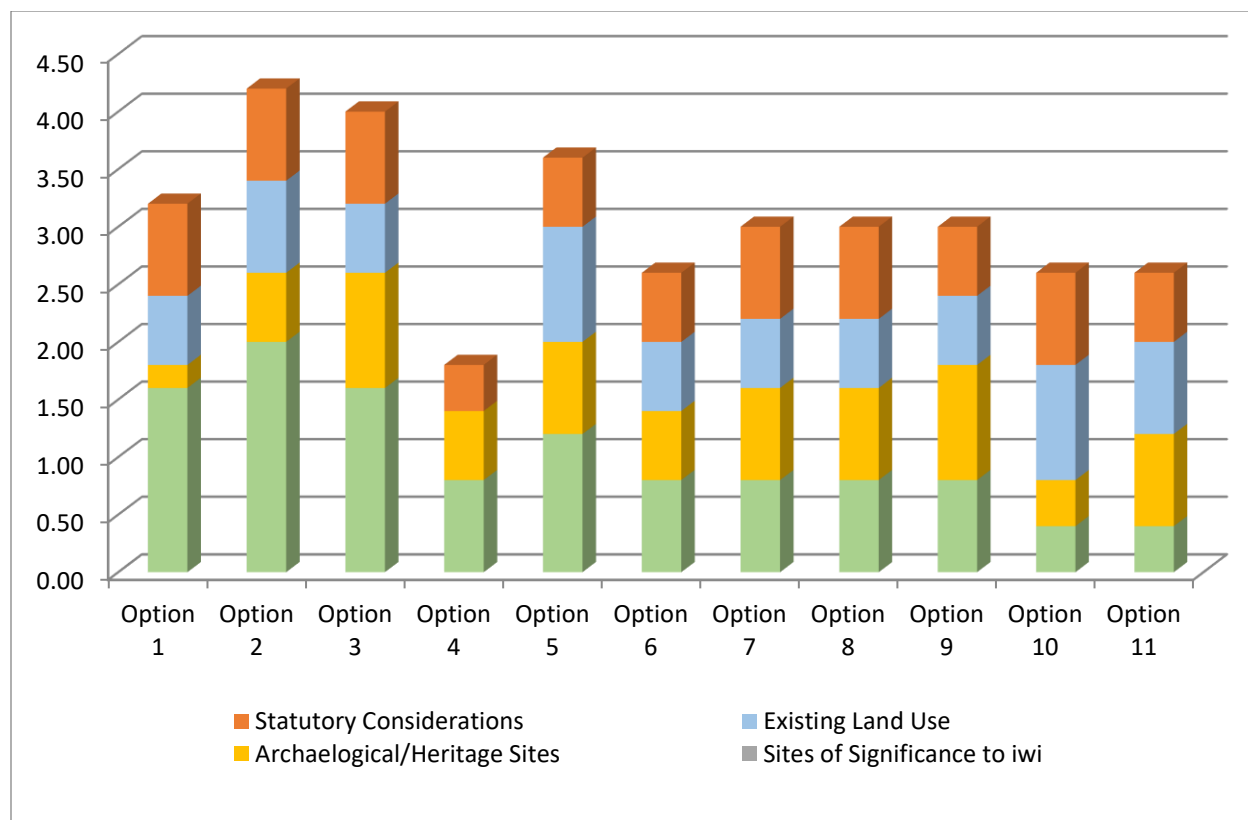


Figure 9: MCA Results

Option 2 was the top option and therefore investigated further in preparation for economic analysis. This investigation found that there were multiple dwellings with 150m of the site which would place restrictions on the method of disposal that would increase costs. It was decided instead to conduct the economic analysis on option 3 upon investigation finding it did not deal with the same issue.

The economic analysis provides FNDC a cost estimate to develop a wastewater discharge to land scheme (with -35% to +50% margin of error) to go to the community and council with. Discussion with the community and elected members as well as a rating impact assessment of the estimated cost will determine if land disposal is economically viable.

For more detail on the options displayed in Figure 9 above, see Appendix B for the sites location and long list ranking scores such as hydraulic drainage rates, and total available area for disposal.

All other options which were considered in the long list are still viable and should be considered in order of rank should the top 11 sites above prove unviable for land disposal. Should this be the case, then an MCA will be conducted from the next ten options from the long list to be investigated.

A sensitivity analysis was also conducted as below in Figure 10 to confirm the original findings.

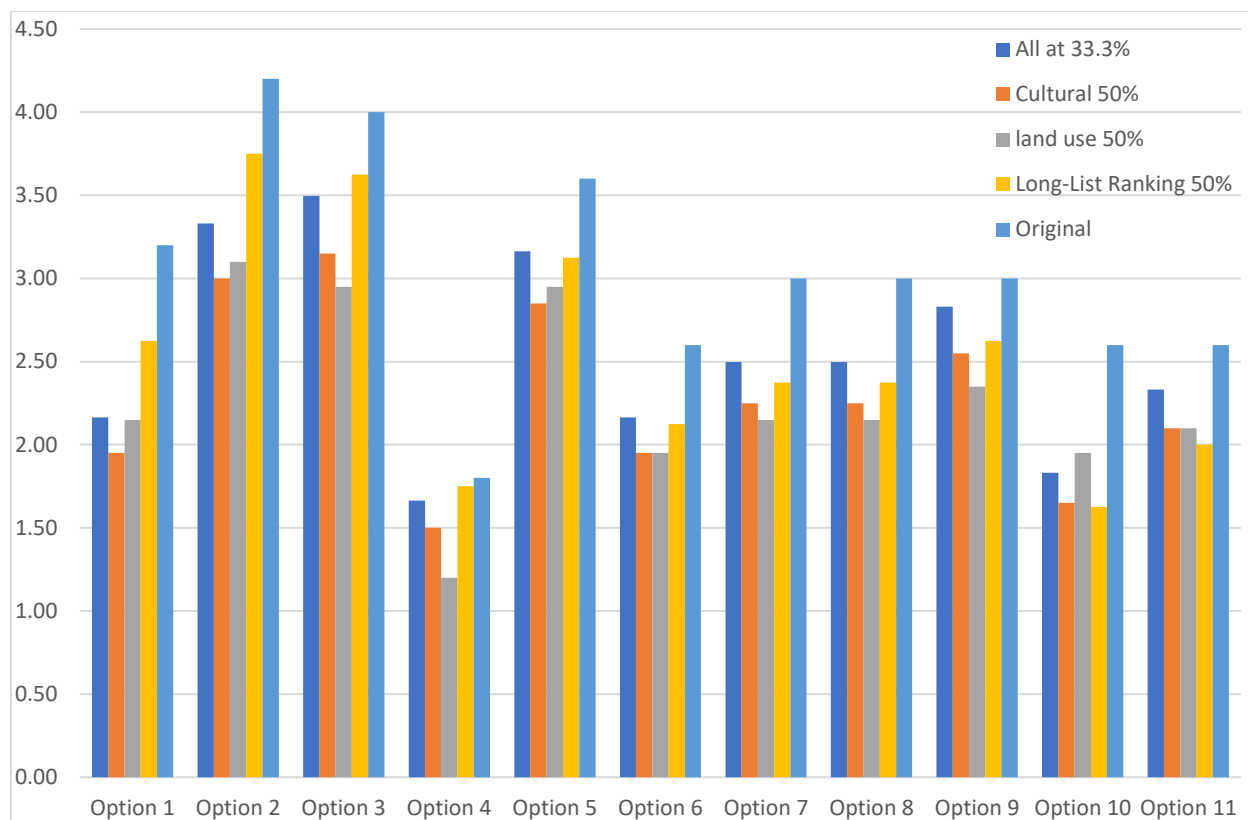


Figure 10: MCA Sensitivity Analysis

From this graph a consistent trend can be seen across the various scenarios indicating that the original weighting is reputable. This gives confidence in the original weighting results and allows for the scoring to be followed up on for further investigations should that be supported by council.

11. Closing Remarks

The Kaeo high-level economic analysis has been included as Appendix A which includes site specific costing prepared for option 3 in this report. The costing does not include land purchase or potential upgrades required by the Kaeo WWTP to discharge to land. Community engagement will be imperative to develop the relationships over time to properly consider land disposal as a viable option.

The high-level economic analysis can enable us to determine a cost estimate for establishing a wastewater discharge to land scheme for Kaeo. The cost estimate can then be used to estimate the rating impact of such a scheme. Estimated costs of a project are often criteria for determining whether a project should go ahead. While the costs for this project are relatively high, further investigation into the option of wastewater disposal to land may be warranted when considering other criteria such as cultural and community preference.

If the option of wastewater discharge to land for Kaeo is to be progressed, the next steps include engagement with mana whenua and specific landowners to identify a preferred site or sites for on-site testing. On-site testing will seek to validate findings from the desktop analysis and investigate any

unforeseen issues with the sites. Upon selection of preferred site that meets technical, cultural and landowner approval, a concept scheme design can be developed that includes an assessment of potential environmental effects of the proposed activity. Costs will also need to be revised and updated based upon the results of the concept design, which can then be taken to council again for a decision on whether a land disposal scheme should be implemented for the township of Kaeo.

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