Hihi Wastewater Treatment Plant

Land Disposal Options Assessment

September 2021

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 Hihi wastewater treatment plant (Hihi 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 45 m^3/day in 2025 which is the estimated year of commissioning of any land-based disposal infrastructure. An average hydraulic loading rate of 1.32 – 4.32 mm/day was determined based on the soil drainage classes present in Hihi and the indicative permeability rate associated with clay loam soils. Based on these assumptions, a minimum total area of 1.6 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.

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 all located to the south of the final discharge point at the end of the constructed wetlands.

The top two options found in this report are both within 3 km of the final discharge point and hold enough area to discharge to land and hold a storage pond for wet winter months when soils are high in water content.

Site specific economic analysis has been achieved for these top two sites by Beca which has been included as Appendix A. This analysis gives a high-level estimate to the cost of implementing land disposal at the two preferred sites for presentation to the community and the council. Should costs prove acceptable, engagement with site owners will begin to establish the likelihood of sale and onsite investigations into the soil, groundwater, and wastewater quality will take place.

1. Introduction

The Hihi WWTP discharges treated wastewater into an unnamed tributary of Hihi Beach. FNDC is currently in the process of renewing the resource consent authorising the discharge, which expires in November 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 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 Hihi WWTP. This will enable a determination of land disposal practicability and feasibility in accordance with Policy D.4.3.

Important to note is that upgrades to the Hihi WWTP have been considered numerous times over the past 10 years. Most recently, a membrane reactor (MBR) was taken before council in March 2021. This option was not supported by council however, due to the high costs and lack of community engagement involved in the decision. FNDC are currently undertaking a new options assessment in collaboration with the community of Hihi to establish a preferred option to take before council.

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.

The AOI for land disposal in Hihi was initially set out as a 10km radius from the final discharge point. However, due to the number of practicable sites this was reduced to a 5km radius. 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 Total Available Area	17.0%
Highest Average Hydraulic Loading Rate	50.0%
Lowest Average Slope	33.0%

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.

Table 2: MCA Criteria

Criteria	Weighting
Long List Rank	35%
Potential effects on Maori cultural sites (impacts on cultural values and sites)	25%
Distance to WWTP	20%
Existing Land Use (Land Cover, Statutory Considerations, SNA's)	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 sandy soils which are free draining and require a fine level of pre-disposal filtration to operate effectively.

Typically, SAT is used when free draining sandy soils are present which is not the case in Hihi. The area surrounding the Hihi WWTP contains a mixture of young, mature, and old semi-volcanic soils which vary from poor up to excessively well-draining as discussed in section 5 of this report.

Effluent exiting the Hihi 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 Hihi 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 3 – 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. Hihi WWTP currently makes use of a constructed wetland as a final treatment process before it is discharged to the stream. If a combined approach was taken forth then an investigation into the impact on the constructed wetland would be needed.

4. Flow Summary:

Flow data for the period between 1st January 2017 and 31st Dec 2020, which includes both residential and industrial wastewater, has been collated for analysis. Figure 1 below shows the inflows and outflows of the treatment plant as well as the final discharge flows post constructed wetlands. As can be seen there is some missing data and periods of time where the outflows from plant and final discharge have been used interchangeably.

The high flows on this graph match rainfall events which suggest there is infiltration. If this infiltration could be reduced, then the land area requirement for land disposal could be reduced.

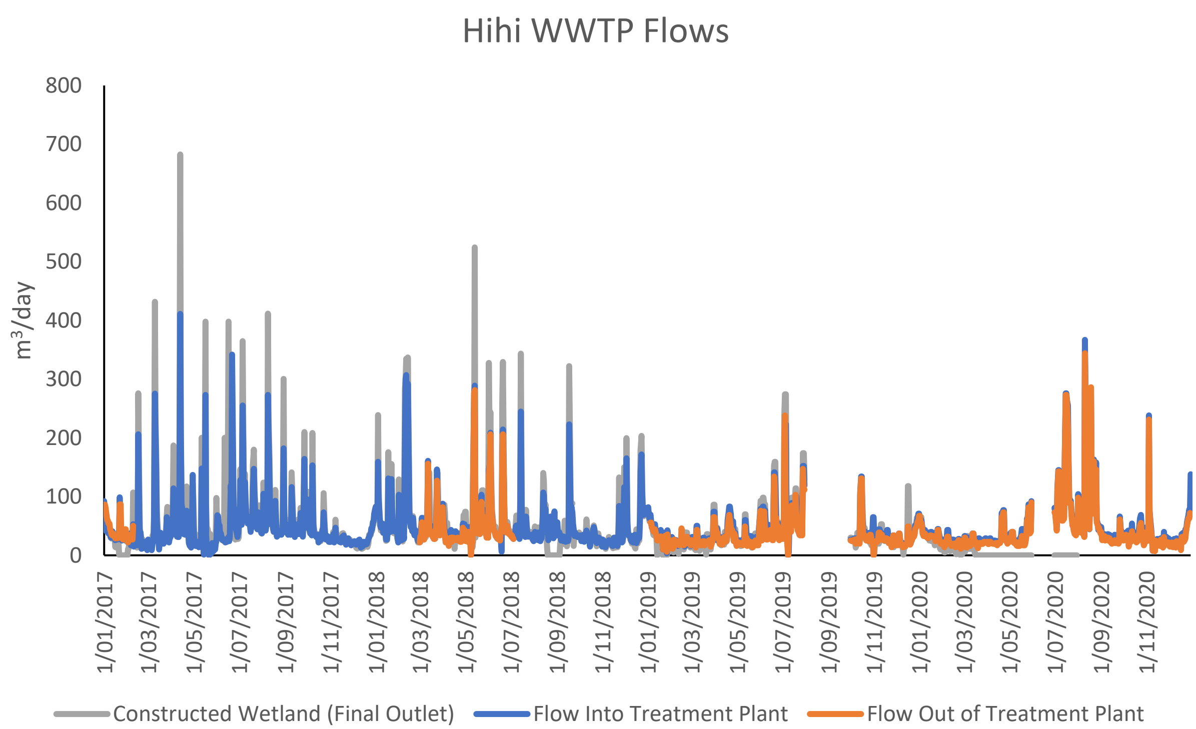

Figure 1: Hihi WWTP Flows

Table 4 below identifies the average, median, 90th percentile, maximum, and average dry weather flows for 2020 (current year), 2025 (estimated first year of operation should the option be taken forward), and 2055 (final year of maximum consent duration).

Table 4: Hihi Wastewater Constructed Wetland Flows (Jan 2017 – Dec 2020)

Parameter	2021	2025	2055
Average Flow (m3/day)	44	45	57
Median Flow (m3/day)	32	33	41
90th Percentile Flow (m3/day)	83	85	108
Maximum Flow (m3/day)	683	697	885
Average Dry Weather Flow (m3/day)	29	30	38

The final discharge point which flows out of the constructed wetland (CWL) and into the unnamed tributary of Hihi Beach has been used to determine the flow rate that would be disposed to land. Stormwater infiltration is currently a major issue in Hihi with the WWTP taking on up to 8 times the average flow during heavy rainfall events. The maximum flow discharged from the constructed wetlands is double the maximum outflow from the plant and indicates that the CWL is also susceptible to heavy rainfall.

This will impact the design considerations that depend on maximum flow such as pipe sizing and pump specifications required.

5. Soil Drainage Class

Drainage classification is of fundamental importance to land disposal at a high level. 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 2 below. As can be seen, the higher draining soils in close proximity to the final outlet are to the east of the AOI. These soils are predominantly young, mature, and old semi-volcanic soils which are well draining. Specific soil types include large areas of Rangiuru clay and Mangonui clay in the well-draining area east of the final outlet.

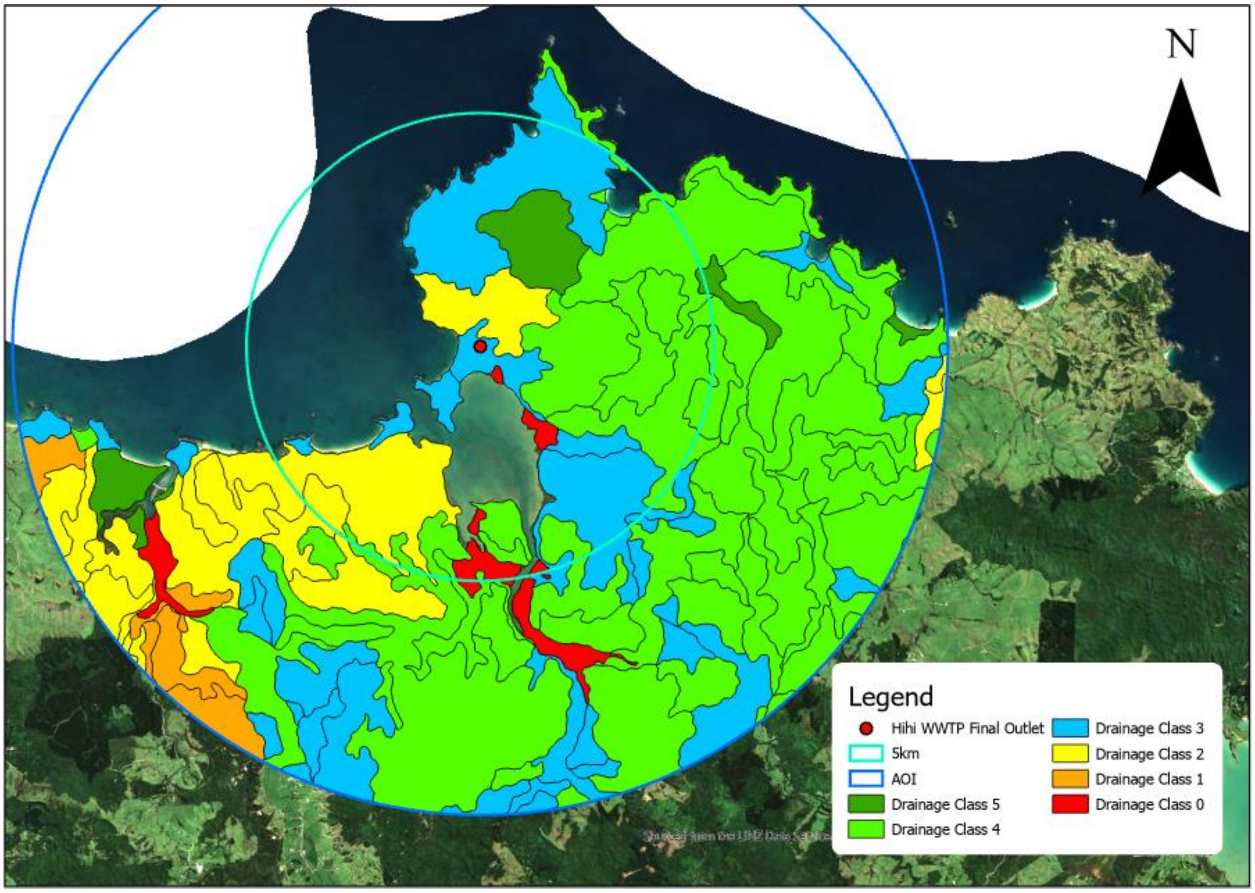

Figure 2: Soil Drainage Classes

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.

6. Groundwater considerations

NRC does not currently monitor groundwater in the Hihi area, and no groundwater investigations have been achieved by FNDC. Therefore, onsite investigations will need to be achieved to determine groundwater flows relative to the site selected for disposal.

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 are the most important.

7. 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 Hihi. Annual rainfall and evapotranspiration data used is NIWA Cliflo data from the nearest stations which document that data.

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	1538	NIWA (Average from past 5 years)
Annual Evapotranspiration	mm/year	926	NIWA (Average from past 5 years)
Hydraulic Loading Rate	mm/day	4.32	Percolation – Rainfall + Evapotranspiration

8. 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. High stormwater infiltration also means that more land may be required to account for heavy rainfall events in the form of a storage pond.

A comparison has also been included in Table 8 below to show the difference between 2025 and 2055 requirements based on assumed wastewater flows in 2055. 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 (2025)	m^3/day	45	45
Average Daily Flow (2055)	m^3/day	57	57
Hydraulic Loading Rate	mm/day	1.32	4.32
Irrigated Area (2025)	Ha	3.4	1.0
Irrigated Area (2055)	Ha	4.3	1.3
Irrigation Application Method		Spray	Spray
50% Buffer Area (2025)	Ha	1.7 (0.25 * (Irrigated Area))	0.6 (0.25 * (Irrigated Area))
50% Buffer Area (2055)	Ha	2.2 (0.25 * (Irrigated Area))	0.7 (0.25 * (Irrigated Area))
Total Land Area Required (2025)	Ha	5.1	1.6
Total Land Area Required (2055)	Ha	6.5	2.0

9. 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 Hihi 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.

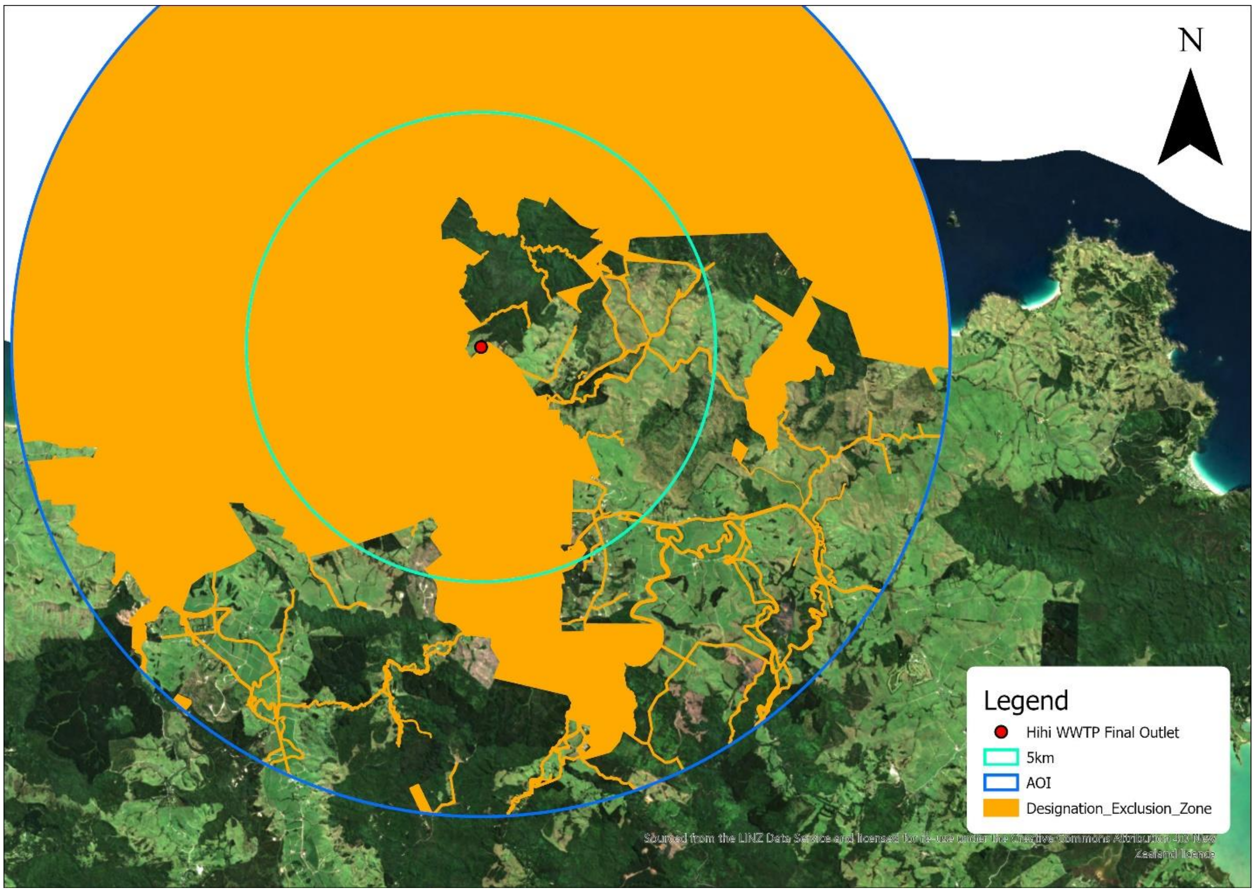

Figure 3: Land Designation

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 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.

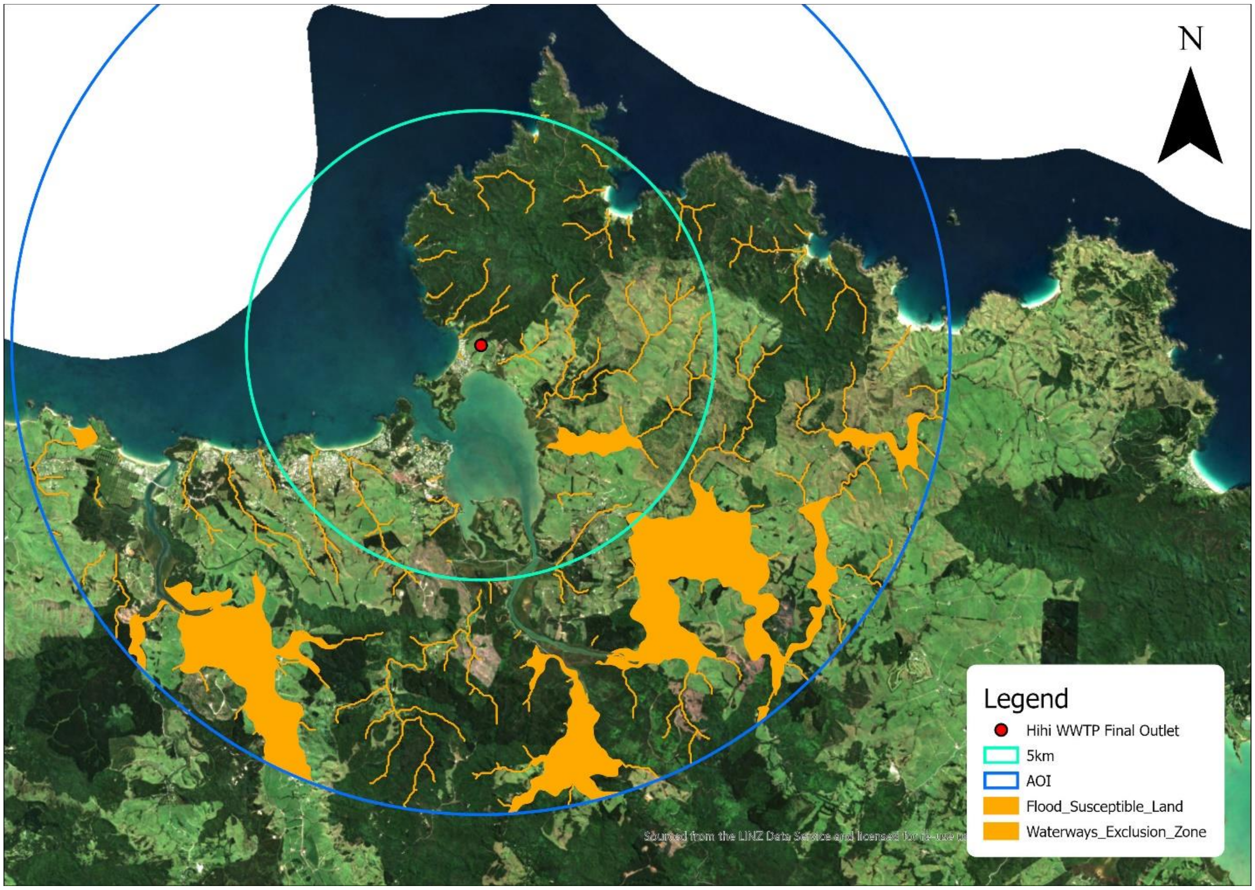

Figure 4: River, Lake, and Flood lands Exclusion Zone

Rivers are spread out across the AOI and have a significant impact on where land disposal can be applied. Flood susceptible land, however, resides exclusively to the south portion of the AOI and is mostly outside of the 5km radius being considered.

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.

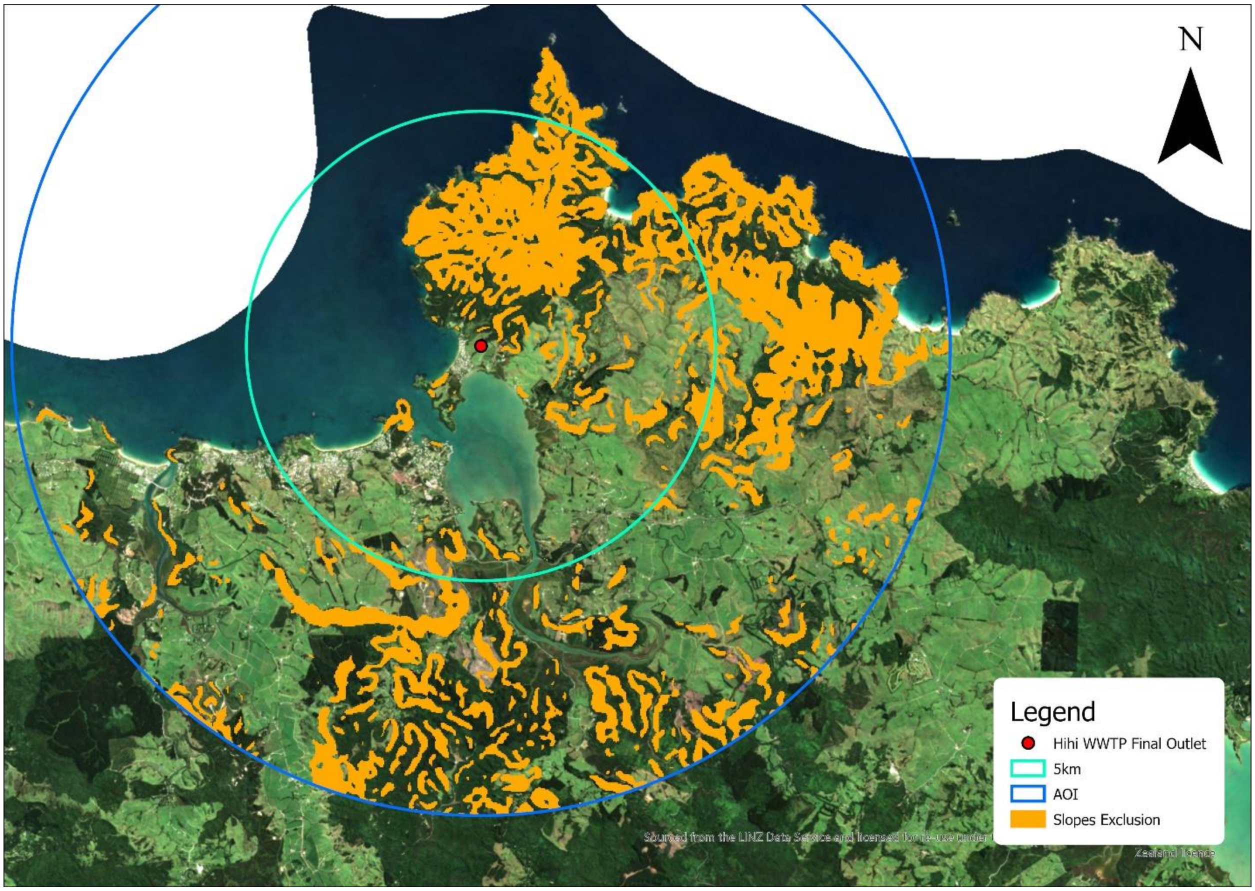

Figure 5: Slope Exclusion Zone

Slopes greater than 12° were found in high quantity to the north and east of the discharge point. Sporadic cases can also be seen to the south and west portions of the AOI, but these are mainly outside of the 5km radius being considered. 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 which matches well with the flood susceptible land due to the alluvial soils found in that area.

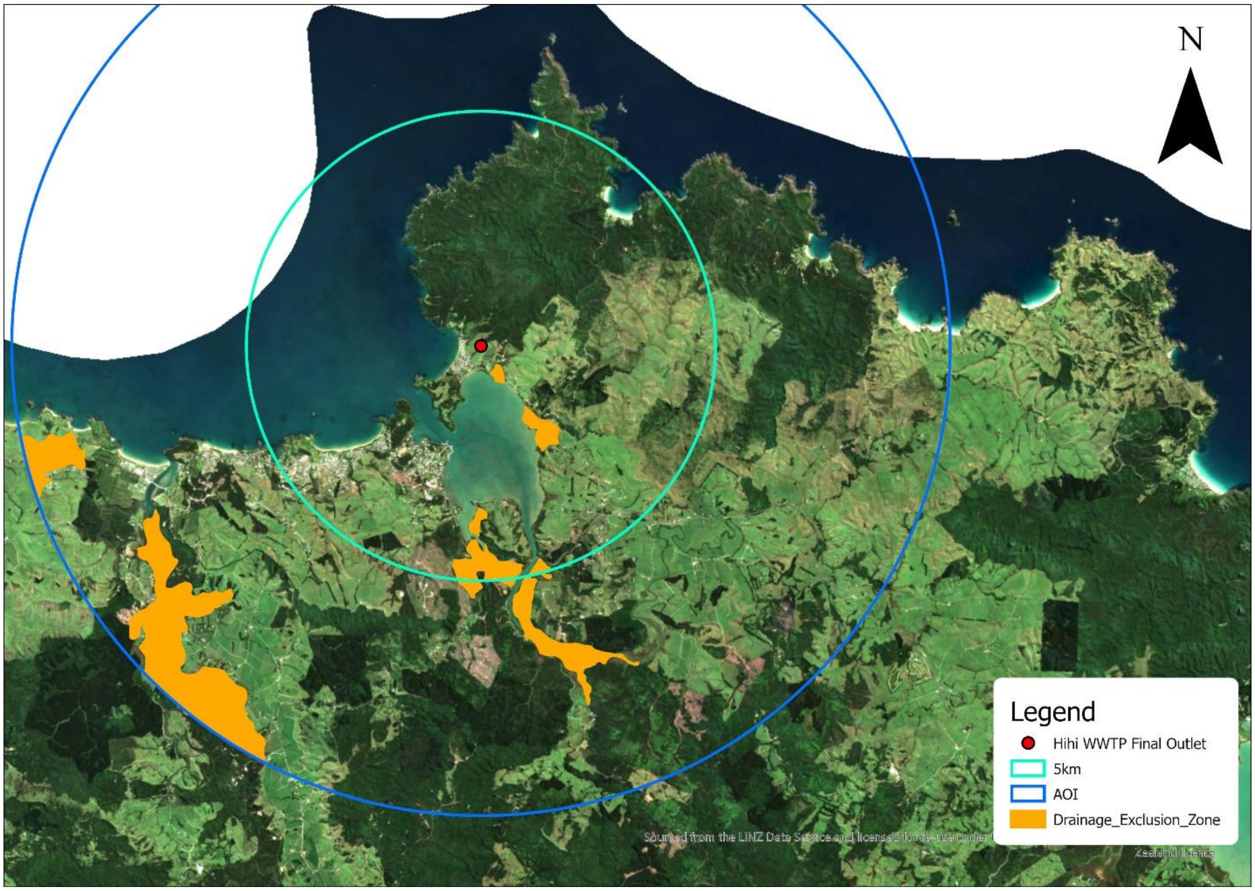

Figure 6: Soil Exclusion Zone

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 young to old semi-volcanic 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.

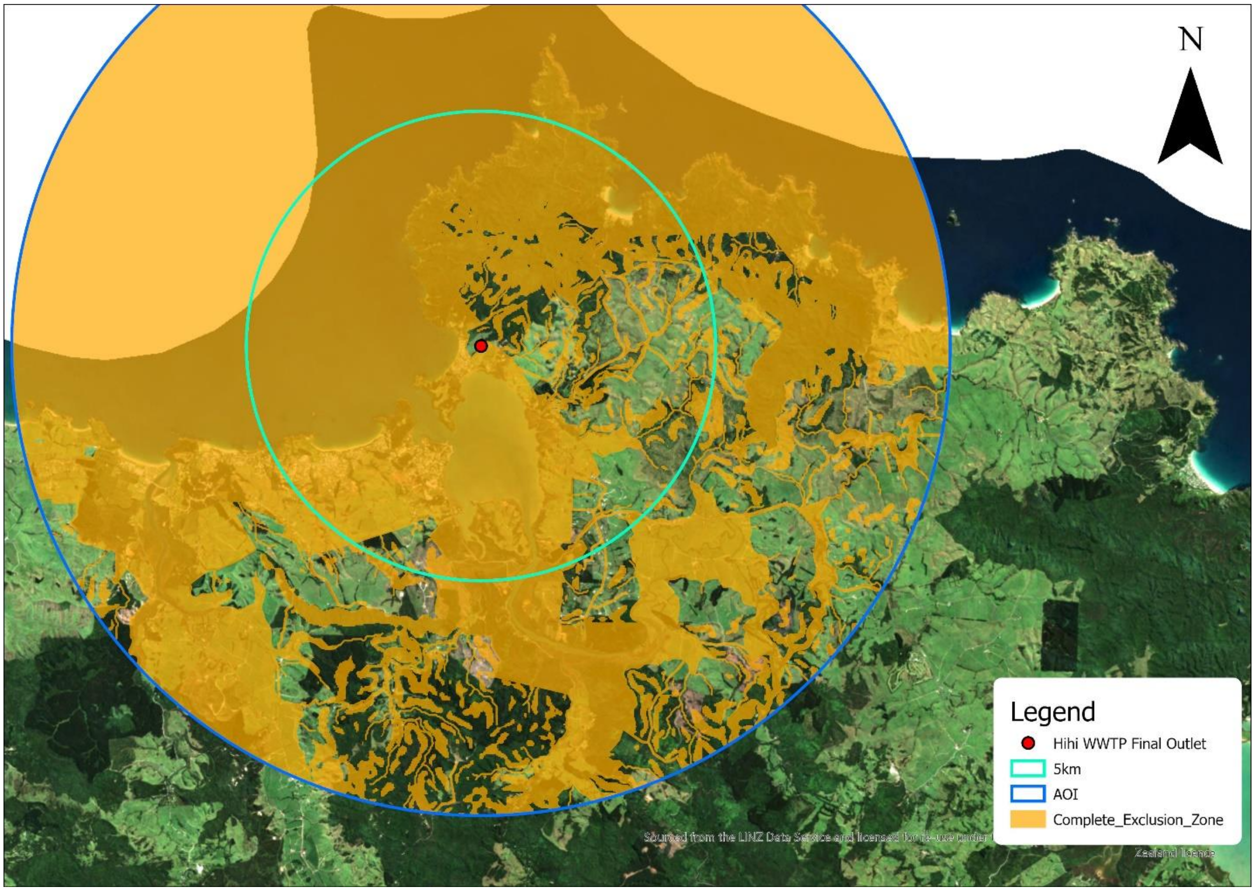

Figure 7: Total Exclusion Zone

As seen, most of the land with the AOI is currently excluded from further considerations due to the above criteria. However, given the small amount of land required for land disposal in Hihi 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.

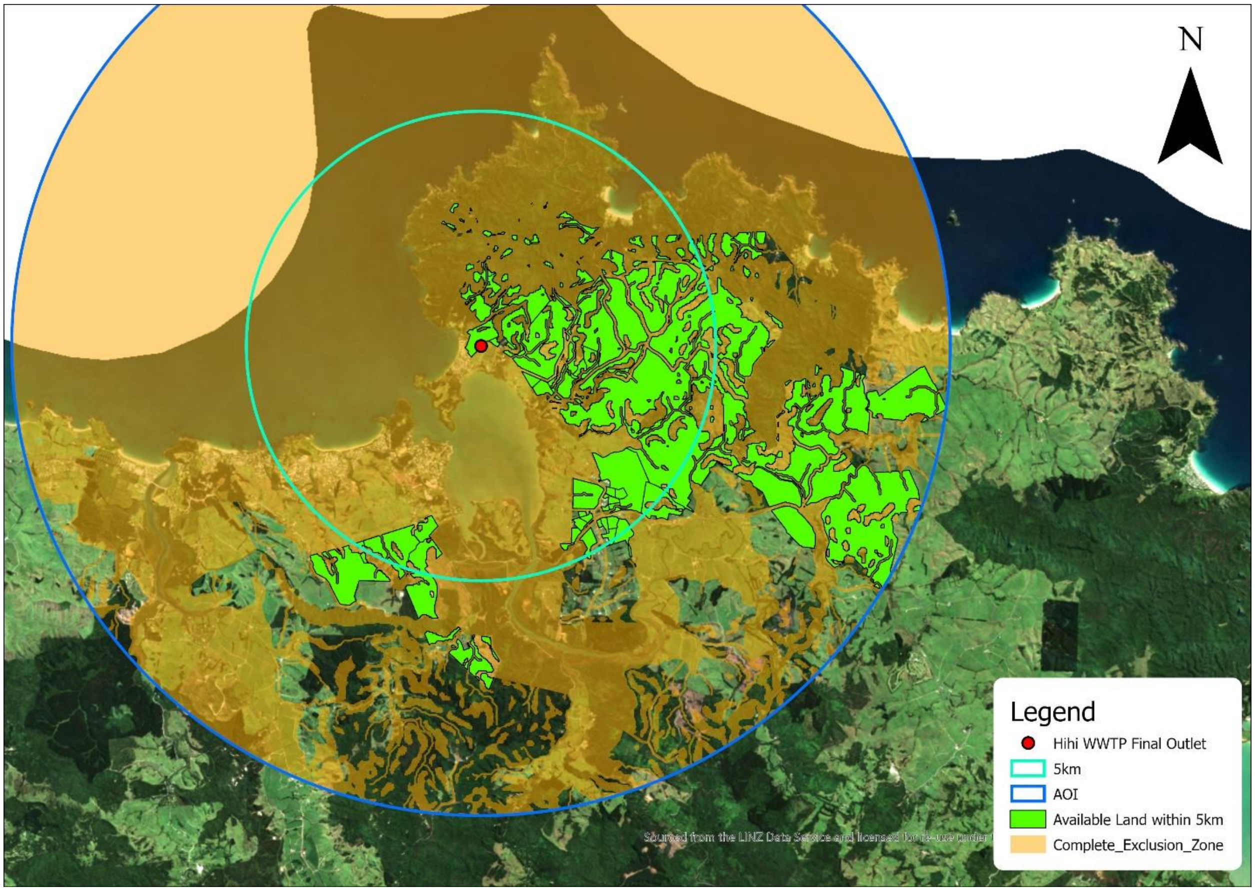

Figure 8: Available Land

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 0.1 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 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 40 remaining sites of interest. The number of sites is further refined into a long list using the qualitative method detailed in section 10 of this report.

10. 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
Total Available Area
Average Hydraulic Loading Rate
Average Slope

The long list criteria were determined as follows:

- The resulting ~60 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.
- The average slope of each option was calculated in Excel using the AVERAGE function for all soil polygons found within a site. 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.

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 40 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 factors for considering land disposal and therefore received a higher weighting. 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 Hihi was given the lowest weighting.

Table 11: Long List Weighting

Criteria	Weighting
Highest Total Available Area	17%
Highest Average Hydraulic Loading Rate	50%
Lowest Average Slope	33%

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 50 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 1 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.

11. Multi-Criteria Analysis

Finally, a multi-criteria analysis (MCA) has been carried out to further rank 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 10 sites are on private freehold land.

Treaty settlement land was also considered following the MCA as an unlikeliness in the purchasing or use of the land. This is for both commercial and cultural redress treaty settlement land.

Table 12: MCA Criteria

Criteria	Weighting
Long List Rank	35%
Potential effects on Maori cultural sites (impacts on cultural values and sites)	25%
Distance to WWTP	20%
Existing Land Use (Land Cover, Statutory Considerations, SNA's)	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 was deemed an important consideration. This was achieved by locating all marae and NZAA sites within a range of 500 m of each site and evaluated the level of its cultural significance. An example of this is that one of the options held a marae at its center and would therefore show significant risk from a cultural perspective and would score low. However, this is an initial evaluation only, and a separate evaluation will have to be undertaken for any sites taken beyond the scope of this report. The additional evaluation will need to incorporate an engagement process with local iwi.

Distance to the wastewater treatment plant has been included to allow for cost differences in reticulation, as cost has not been included as a criterion in the MCA. This is due to an economic analysis being conducted by BECA for the Hihi land disposal report which has been deemed appropriate to use for this report given the similarities between the assessments.

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.

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.

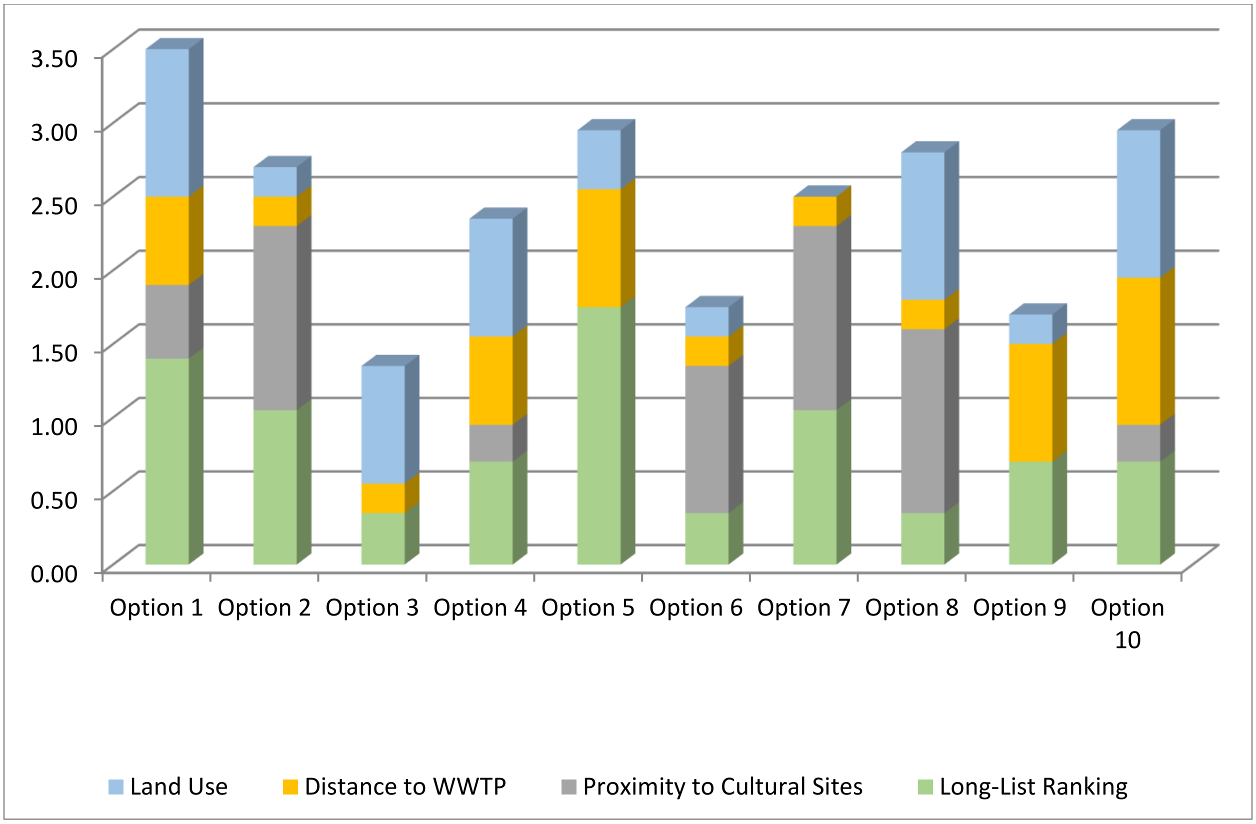

Figure 9: MCA Results

Figure 9 shows that option 1 is the clear 1st preference for land disposal. This is due to its large land area which consists largely of high producing exotic grassland, ideal for land disposal. However, this land was identified as cultural redress land as part of a treaty settlement and therefore has been lowered in preference due to the associating difficulty with gaining use of the land.

The second and third preferred options are 10 and 5 respectively which both scored well in everything but cultural impact due to nearby Pa sites. These sites have been identified as the preferred sites and will be used for site specific economic analysis to be undertaken by Beca. This will result in a high-level assessment of the cost for disposal to land in Hihi and allow for it to be considered by council for a decision on further investigations.

All other options are viable and should be considered in order of rank should the sites above prove unviable for land disposal. Detailed accounts of each of the ten sites can be found in Appendix B.

Should none of these sites presented be viable for disposal to land, 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.

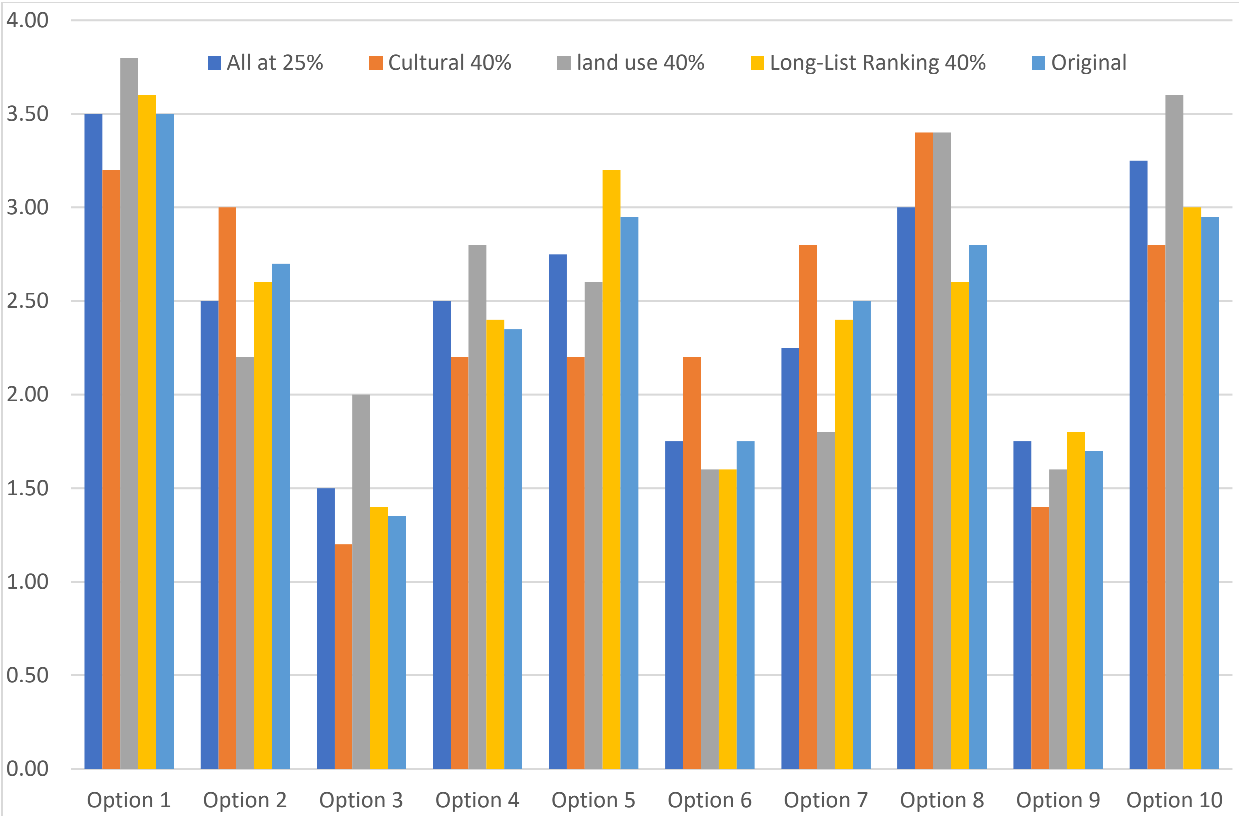

Figure 10: MCA Sensitivity Analysis

From this graph a consistent trend can be seen across the various scenarios indicating that the original weighting is reasonable. 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.

12. Closing Remarks

The Hihi high-level economic analysis has been included as Appendix A which includes site specific costing undertaken for the top 2 ranked sites from this report. It is important to note that both these sites are privately owned but have a Pa located onsite and others in close proximity. Community engagement will be imperative to develop the relationships over time to properly consider land disposal as a viable option. Option 10 is much larger than option 5 however and includes 3 separate titles which makes a partial much easier. All three titles are large enough on their own to support disposal to land from the Hihi WWTP.

This analysis will be a determining factor for the potential development of a land disposal system at the Hihi WWTP. If the cost is too high for consideration, then the process of investigating the different options will stop here. However, if it is decided that the option is viable then negotiations will begin with the site owners. On-site testing will also be carried out to confirm the desktop analysis and investigate any unforeseen issues with the sites. This will include an assessment of potential environmental effects of the proposed treated wastewater discharge regime. Costs will also need to be revised and updated based upon the results of further technical and environmental investigations.

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