Raglan Wastewater Treatment Plant Discharge Options – Assessment of Land Irrigation

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Prepared for

Watercare Services Limited

January 2021

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Quality Control Sheet

TITLE	Raglan Wastewater Treatment Plant Discharge Options – Assessment of Land Irrigation
CLIENT	Watercare Services Limited
VERSION	Draft V6
ISSUE DATE	14 January 2021
JOB REFERENCE	A03532200
SOURCE FILE(S)	A03532200R001_LA&DBIAssessment DRAFT V6.docx

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Executive Summary

The Raglan wastewater treatment plant (WWTP) is owned by Waikato District Council (WDC) and operated by Watercare Services Limited (WSL). Treated wastewater has historically been discharged to the marine environment under a marine discharge consent, which expired in February 2020. Currently, legal operation of the discharge continues as the status quo for treatment and 100% marine outfall discharge under a short term 3 year consent application, lodged early in November 2019 with the Waikato Regional Council (WRC).

A new long term consent is required and changes to the present discharge method are being investigated. The final solution will need to be the Best Practicable Option (BPO) that balances environmental, cultural and financial effects, provided within a 35-year consent (or longest time frame obtainable). To identify a BPO, several options are being explored, which comprise discharge options to land and/or water.

Pattle Delamore Partners Ltd (PDP) has been engaged by WSL, as part of the Technical Adviser team, with Beca Limited as the lead technical adviser, to complete technical assessment works in relation to land treatment options required for the consenting project. Land treatment and Deep Bore Injection (DBI) were both identified by PDP as potential discharge solutions within a long list of discharge options of treated wastewater. DBI was discounted once short listed options were finalised.

<u>Long List Assessment</u>

Four potential land treatment options were investigated, including deficit and non-deficit irrigation, with and without an alternative winter marine disposal option (dual discharge). Soil moisture models, developed for each option, indicate that the following irrigation areas and storage volumes are required for the proposed 35 year consent term:

- Non-deficit, all year round: 90 ha - 190 ha, 150,000 m^3 of storage;
- Non-deficit, dual discharge: 80 ha - 110 ha, 20,000 m^3 of storage;
- Deficit, all year round: 260 ha – 570 ha, 300,000 m^3 – 400,000 m^3 of storage;
- Deficit, dual discharge: 220 ha - 240 ha, 20,000 m^3 of storage.

A weighted attribute, GIS based, assessment (WAA) was conducted to identify potential irrigation areas within a 10 km radius of the Raglan WWTP. The assessment considered usable area, topography, landuse, district plan zoning, distance from the WWTP and land ownership. 40 preferred sites were identified on the south side of Raglan Harbour, with varying irrigable areas. To enable a non-deficit irrigation option, 2 to 4 of the assessed land parcels will theoretically be required. To enable a deficit irrigation option, 4 to 11 of the assessed land parcels would theoretically be required. The two non-deficit schemes progressed

to the short listed options due to the smaller land area and storage area requirements.

Short List Assessment

Selected short listed options include:

- Non-deficit irrigation to land – 100% irrigation.
- Non-deficit irrigation to land with an alternative marine discharge.

For the short listed options, theoretical cluster sites have been assessed to identify potential combined irrigation areas that could form part of a complete single location system.

For the non-deficit, 100% irrigation to land, 4 irrigation clusters were identified, within the 10 km radius assessment area, with the optimum location situated south of the treatment plant, near Te Hutewai Rd. There are a number of incised valleys in this location which could provide for large storage dams. Land-uses that could operate under the irrigation system, for the identified cluster sites, would likely include a combination of forestry for steeper slopes and cut and carry pasture based fodder crops for lesser sloped areas, such as ridges and valleys.

For the non-deficit irrigation option with an alternative discharge solution (marine), the required land area is slightly less than the area required for the 100% irrigation option. The reason for this is that the marine discharge will accommodate wastewater volumes during wetter winter months when greater land areas (and storage volumes) are required to avoid oversaturating soils. For the reduced area, 5 theoretical irrigation clusters have been identified. Similar to the 100% irrigation option, the properties along Te Hutewai Rd are likely to be the optimum location (subject to landowner consultation).

The rough order cost for the three short listed land treatment options are:

- Option 1 – Non-deficit 100% to land: $47 M
- Option 2 – Non-deficit with alternative discharge: $22M
- Option 3 – Non-deficit to public land with alternative discharge $5.5M

If these short listed options are to progress further, identified key knowledge gaps and key inputs which need to be incorporated into progressing land treatment as a potential discharge option or part-option, are:

- Legislation and regional planning review to solidify position on any regulatory aspects that may influence any land treatment option.
- Iwi consultation and involvement, particularly to assist in identifying any culturally sensitive areas that should be excluded from further land treatment consideration.

- Initial stakeholder / landowner consultation re: potential interest in either working with WSL collaboratively or land sale/lease possibilities.
- Detailed field investigation to assess general soil types and permeability confirmation at sites where there is landowner interest.
- Initial land treatment concept design with size and application method, including very rough order costing on concept option.

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1.0 Introduction

The Raglan wastewater treatment plant (WWTP) is owned by Waikato District Council (WDC) however, in 2019, operation of the plant and management of the treated wastewater disposal was transferred to Watercare Services Limited (WSL). Treated wastewater has historically been discharged to the marine environment under a marine discharge consent, which expired in February 2020. Currently legal operation continues as the status quo for treatment and 100% marine outfall discharge under a short term 3 year consent application lodged early in November 2019 with the Waikato Regional Council (WRC).

A new long-term discharge consent is required and changes to the present discharge method are being investigated alongside re-use options. The final solution will need to be the Best Practicable Option (BPO) that balances environmental, cultural and financial effects, provided within a 35-year consent (or longest time frame obtainable). To identify a BPO, several options are being explored, which comprise discharge options to land and/or water.

Beca (lead technical advisor) and WDC commenced work toward a long-term consent in March 2019, where an alternative agency was engaged to provide land-irrigation technical advice. Investigations conducted for consenting were previously managed by WDC, however, the responsibility for obtaining consents for discharges from the plant have now been transferred to WSL. Work undertaken up to the transfer of responsibilities included several technical, environmental and engineering investigations. A short-list of seven concept options was identified and engagement with the community and mana whenua undertaken.

Upon transition from WDC to WSL a project re-focus occurred which established a WSL preference to engage Pattle Delamore Partners Ltd (PDP) as specialists for the land treatment-based activities, with Beca remaining as the lead technical expert for the consent application preparation. In terms of land-treatment options, work up to the transition of WDC water services to Watercare included a long list options assessment which was refined to focus on one site on Maungatawhiri Rd for land disposal with winter marine discharge. Due to compressed timeframes associated with lodging the new consent applications, the ability for progressing productive engagement with the required property owner was not able to be progressed sufficiently. Upon transition, the intention was to re-new such discussions as part of any short listed disposal methodology. As such, a high-level revisit of the suitability of several sites was needed, which may support any additional discussions with property owners and operators, depending on suitability for discharge.

PDP has been engaged by WSL as part of the Technical Adviser team to complete technical assessment works in relation to land treatment options required for the consenting project. Land treatment has been identified as a potential discharge option. The purpose of this report is to provide a high level review of this discharge applicability within the Raglan area, as a long list option, and to progress towards identifying potential sites for short listed land treatment option assessment.

1.1 Data Sources

Key externally obtained data sources and resources used within this work package are:

- Digital land zoning and designation data (Waikato District Council);
- Digital topographic data (Waikato Regional Council);
- Digital regional soil drainage maps (LINZ and S-MAP);
- Digital regional geological maps (GNS);
- Digital land cover data (LINZ);
- Rainfall and evaporation data (NIWA);
- Registered bore information from Waikato Regional Council including geological/drillers log descriptions; and
- Groundwater and surface water takes, and allocation limits (Waikato Regional Council).

2.0 Land Treatment

Land treatment is the irrigation of wastewater (generally pre-treated/treated) to land, with the purpose of supporting a land use (crop) and with the soil and crop providing further treatment of the wastewater with water and nutrient uptake. Application of dried, dewatered or wet biosolids to land is also captured under land treatment, though is not assessed in this case. Any residuals from land treatment can migrate diffusely to groundwater and/or surface water receptors.

2.1 Land Treatment Scenarios

The following four possible scenarios were initially considered:

- Non-deficit irrigation - 100% to land all year round, at rates exceeding soil moisture demand;
- Non-deficit irrigation with alternative discharge - seasonal irrigation with alternative discharge i.e. marine discharge, during wetter season (late autumn to early spring);
- Deficit irrigation with storage - 100% to land when soil moisture levels require irrigation;
- Deficit irrigation with alternative discharge – seasonal irrigation with alternative discharge i.e. marine discharge, during wetter season.

For a non-deficit irrigation system treated wastewater is irrigated to land all year round, with storage required for periods when soils risk saturation or runoff. This type of system allows for soils to be irrigated above field capacity which is the moisture content held in soils after excess water has drained away. Irrigating soils above field capacity therefore induces downward drainage and leaching of nutrients to groundwater generally occurs.

For a deficit irrigation system, treated wastewater is only irrigated to land when soil moisture levels require additional moisture, up to field capacity, and therefore no downward drainage takes place. This generally occurs during late spring to early autumn when drier conditions benefit from water application. A deficit system requires a large storage capacity during the wetter winter months, or alternatively can be managed with an alternative discharge i.e. marine discharge or discharge to surface water.

In land treatment systems, nutrients in the treated wastewater are captured in the soil, biologically and chemically broken down, and up taken by vegetation stimulating growth and providing further treatment of the applied wastewater. The assimilative capacity of the system is dependent on soil characteristics, plant type and environmental conditions.

2.1.1 Soil Moisture Model

A soil moisture model (SMM) was run to identify approximate irrigable land area requirements and storage volumes for all four scenarios. The SMM models the daily effects on soil moisture under different operating constraints.

The model uses a water mass balance within the void space in the topsoil. The void space is based on the anticipated characteristics of the soil type and is defined by the sum of the wilting point (%),the profile (plant) available water (PAW) (%) (the void space between the wilting point and the field capacity), and the macroporosity (%), which is the void space above field capacity and before saturation.

A daily soil moisture content is determined from the previous days soil moisture plus rainfall and irrigation and less potential evapotranspiration (PET), infiltration to groundwater, runoff and interception.

Figure 1 summarises the soil water storage and the various factors that influence the soil moisture content. Water is stored in the pores of the soil and starts to infiltrate to groundwater once field capacity is reached. The saturation point is when all the pores in the soil are full with water, ponding and runoff start to occur at this point. The wilting point is defined as the amount of water in a soil that a plant requires before it starts to wilt. Below this point evapotranspiration will not occur.

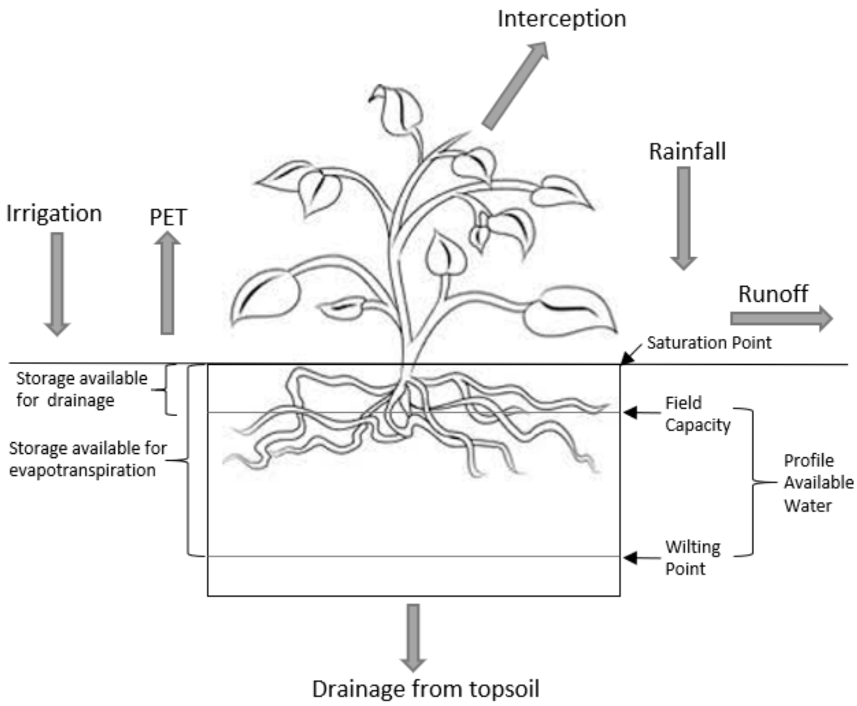

Figure 1: Soil moisture storge schematic

The following assumptions were used in the SMM:

- Rainfall and Potential Evapotranspiration (PET) – daily rainfall and PET data was downloaded from the National Climate Database (2020) for a ten year period (2006 – 2015). The 'Raglan, Karioi' station (agent no 2027) was used as the source of data for rainfall and the 'Hamilton, Ruakura 2 Ews' station (agent no 26117) was used as the source of data for PET. These stations are approximately 2.5 km and 40.5 km from the Raglan WWTP, respectively;
- Daily wastewater volume was the projected average daily flow in the year 2055 (35 years) of 1,957 m^3/d;
- Irrigation does not occur if rainfall exceeds 50 mm/day and the maximum irrigation event is 50 mm;
- Storage is uncovered and affected by evaporation and rainfall;
- The maximum irrigable soil moisture content is:
  - Halfway between field capacity and saturation for a non-deficit system;
  - Field capacity for a deficit system;
- For the non-deficit system and deficit system with alternative discharge, the model assumes 20,000 m^3 (approximately 10 days) of storage;
- Runoff only occurs when soils are at saturation and interception is negligible;
- The soil parameters were based off three dominant moderately drained & well drained soils in the Raglan area.
- To take into account wet soil conditions, the models assume a saturated drainage rate of 10mm/d and an average unsaturated (k_{-40}) drainage rate of 1 mm/d (ranging from 0 mm/d to 2 mm/d).

Based on the soil moisture model assumptions, Table 1 summarises the irrigable land area requirements for each land treatment scenario.

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Table 1: Land Area Requirements for Various Land Treatment Scenarios

Scenario	Land Area (ha)	Storage (m^3)	Annual Irrigation Depth (mm)
Non-Deficit Irrigation	90 - 190	150,000	440 - 800
Non-deficit irrigation with Alternative Discharge	80 - 110	20,000	510 - 770
Deficit Irrigation with Storage	260 – 570	300,000 – 400,000	210 - 320
Deficit Irrigation with Alternative Discharge	220 - 240	20,000	240 - 260

2.2 Raglan Soil Assessment Summary

PDP undertook field investigations on 21 and 22 July 2020 in Raglan to assess general soil types and permeability in the area to identify potential for wastewater irrigation in Raglan.

A number of sites in the area were visited based on availability and granted permission from property owners. The investigations involved walking over the site, taking soil augers for soil identification, and taking soil cores for permeability testing. PDP engaged Landcare Research soil scientist Malcolm McLeod to assist with the investigations and provide a summary of the soil types present (see Appendix B).

The following locations (see Figure 2) are a mix of public and private land and were used to create an understanding of the general soil types in the Raglan area:

- Wainui Reserve
- Raglan Airstrip
- Raglan Golf Course
- 276 Maungatawhiri Road
- 15 Te Ahiawai Road
- 343 Te Hutewai Road
- Fertiliser Airstrip, Te Hutewai Road

It is noted that testing at the Raglan Airstrip was for knowledge building only as it is understood that the site is reserved for other future uses. Additionally, it is noted that a large section of the Wainui Reserve is designated as Maori Area of Significance and as such is unlikely to be available for land treatment.

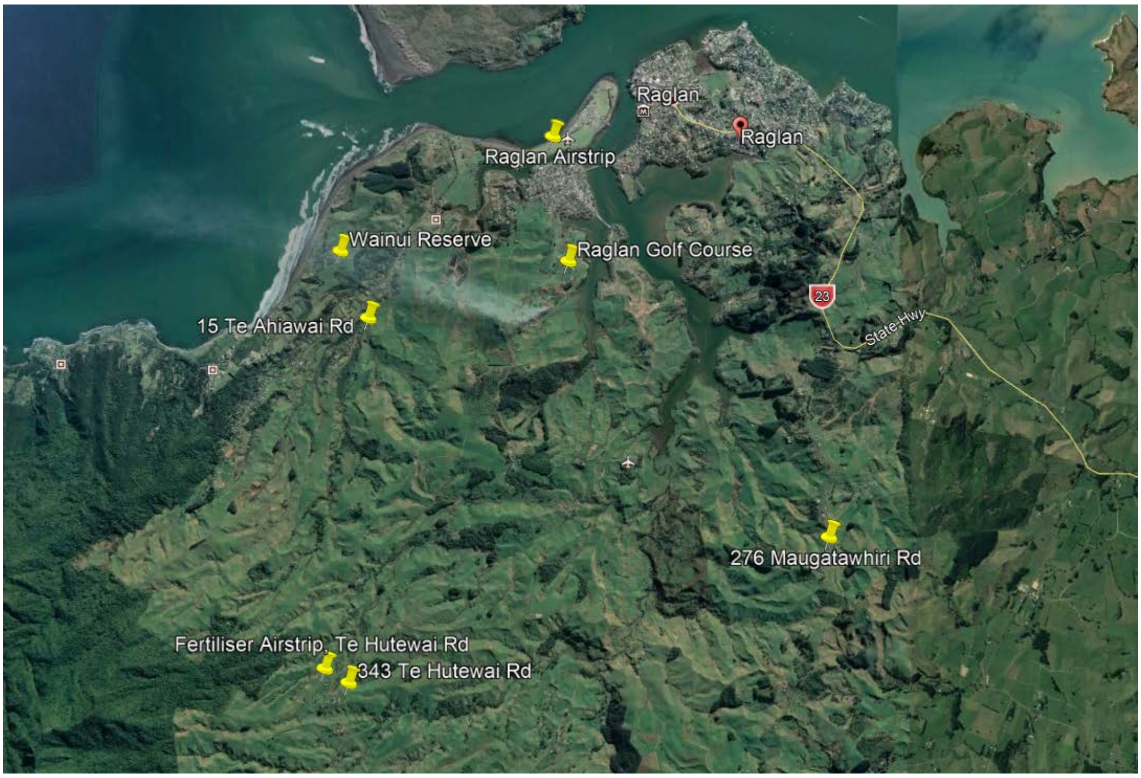

Figure 2: Soil Sampling Locations

The site assessments were undertaken when the soil conditions were wet, following an extended period of rain. This provided an opportunity to observe the performance of the soils under wet conditions which is advantageous as it is important to understanding the soils performance under irrigation to avoid damaging the structure via oversaturation. Soil cores were taken from topsoil and subsoil layers to test for hydraulic conductivities at each assessed site. The purpose of hydraulic conductivity testing is to gain an understanding of the pore size distribution within the soil and the soils ability to transmit water.

In general, there were three main soil types assessed, consisting of:

- Soils with limiting clay layers, in the sites immediately south of Raglan, including the golf course, Wainui Reserve and Te Ahiawai Road,
- Freer draining loamy soils, further south of Raglan (Upper Te Hutewai Rd), and.
- Sandy soils, under the Raglan Airfield.

The soils identified as having limiting clay layers would require high levels of irrigation management to avoid saturated conditions inducing runoff and ponding. Fine manganese concretions and paler colours in these soils indicate wet soil conditions in the upper part of the soil during part of the year. While mapped as 'moderately well drained' on SMAP the soils encountered would behave more similar to 'imperfectly drained soils', limiting soakage capacity, due to the lower, limiting clay layer. The areas observed were generally hilly and low permeability in the clayey subsoils could lead to lateral flow within the soil.

Loamy soils were encountered at both sites on Te Hutewai Road and soil colouring indicates there is no rapid changes in permeability, therefore irrigated wastewater would move uniformly to depth. These soils were judged to have medium to high P-retention indicating they would absorb phosphorus from the treated wastewater reducing the chance of run-off.

Sandy soils were encountered at the Raglan Airstrip. Sandy soils have high infiltration rates but are limited in their ability to absorb chemical contaminants entrained in treated wastewater.

The soil types, which are likely to be better for land treatment are the moderately well drained soils that can manage irrigation better during wet periods, but allow sufficient retention of water to adsorb nutrients.

The level of treatment provided by the existing wastewater treatment plant with filtration is sufficient for irrigation of these soils, provided that the application rate is in keeping with the hydraulic capacities of the soils and the nutrient removal capacity of the land use system.

2.2.1 Soil Hydraulic Conductivity

Undisturbed soil cores of the topsoil and subsoil were collected at each location and analysed for saturated hydraulic conductivity (K_{sat}), unsaturated hydraulic conductivity (K_{-40}) and bulk density. Table 2 summaries the results of the sampling.

Table 2: Hydraulic Conductivities in Raglan Area

Site	Topsoil/Subsoil	K_{sat} (mm/h)	K_{-40} (mm/h)	Bulk Density (g/cm^3)
Wainui Reserve, site 1	topsoil	29	19	0.85
	subsoil	40	37	1.1
Wainui Reserve, site 2	topsoil	3	1	1.02
	subsoil	5	4	1.13
Raglan Airstrip	topsoil	127	84	1.29
Raglan Golf Course	topsoil	647	117	0.83
	subsoil	693	51	0.94
276 Maungatawhiri Road	topsoil	35	6	0.87
	subsoil	289	108	1.05
15 Te Ahiawai Road	topsoil	63	11	0.97
	subsoil	2	1	1.05
343 Te Hutewai Road, site 1	topsoil	15	8	0.6
	subsoil	289	141	0.66
343 Te Hutewai Road, site 2	topsoil	11	4	0.69
	subsoil	647	262	0.56
Fertiliser Airstrip, Te Hutewai Road	topsoil	231	12	0.63
	subsoil	404	182	0.58

Notes:

1. *Sampling was carried out by PDP staff on 21 – 22 July 2020.*
2. *Laboratory testing carried out by Landcare Research Soil Physics Laboratory.*

Low subsoil saturated and unsaturated hydraulic conductivities at Wainui Reserve and Te Ahiawai Road confirm observations of underlying clay layers with limited permeability. A high saturated hydraulic conductivity was recorded at the Raglan Golf Course, however, this is possibly due to cracks in the sample as the distribution between K_{sat} and K_{-40} is relatively large.

The subsoils at Te Hutewai Road demonstrated higher subsoil saturated hydraulic conductivities and unsaturated hydraulic conductivities indicating soils with increased permeability. The rates are in excess of typical irrigation rates of 5 mm/hr. The distribution between saturated and unsaturated hydraulic conductivity in these soils indicate a good distribution of pore sizes.

The subsoils at Maungatawhiri Road demonstrated a saturated hydraulic conductivity and unsaturated hydraulic conductivity in the lower range encountered at Te Hutewai Road. These soils were judged to have a lower overall permeability on inspection(see Appendix B).

2.3 Land Application Area Scoping Assessment

A custom Weighted Attribute Analysis (WAA) tool was developed by PDP to provide a high-level, wide ranging assessment of potential land treatment sites within the Raglan area. The assessment was designed to be predominantly technical in nature, and therefore deliberately excludes direct assessment of capital and operational costs, as well as social and cultural aspects at this stage.

2.3.1 Physical Extent of Assessment

The physical extent of the assessment area was selected in association with the project team and covers a 10 km radius from the Raglan WWTP in all directions (refer to Figure 3).

The assessment area encompasses a wide range of physical terrain, environmental settings, and land uses within the region. PDP consider the assessment area as comprehensive and representative for the region, and deliberately constructed so as not to exclude potentially favourable portions of the region.

KEY :

- RAGLAN WATEWATER TREATMENT PLANT
- ASSESSMENT AREA

SOURCE:
1. TOPOGRAPHICAL INFORMATION DERIVED FROM LINZ DATA.

NO.	REVISION	DATE	APP.
A	ISSUE		

FOR DISCUSSION
13/01/2021

CLIENT :

Watercare
An Auckland Council Organisation

PROJECT :

RAGLAN WWTP DISCHARGE OPTIONS

TITLE :

LAND APPLICATION TECHNICAL ASSESSMENT AREA

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SCALE : 1:100,000 (A3)

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METRES

PROJECT NO. :	FIGURE NO. :	REVISION :
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Parcel boundaries were overlaid across the assessment area and parcels adjacent to each other with the same Certificate of Title were grouped as one effective parcel. The quantitative assessment was run for every parcel. The aim of this approach was to provide an overall suitability ranking for each parcel of land to enable suitable properties to be identified.

Overall, the assessment is intended to provide high-level assessment of potential land treatment properties in a holistic, quantitative and transparent manner for the entire search area.

2.3.2 Fatal Flaw Assessment

A 'fatal flaw' assessment identified areas within the assessment area that are considered incompatible with land treatment. These are:

- Incompatible land zoning – essentially; urban/residential, commercial, industrial zoned land, and other including living zones, Maioro Mining, Pa, Village and Wetland conservation;
- Land Slope - Slopes greater than 30%.

Areas comprised partly or completely of any of the above, were excluded from further assessment. The remaining land is termed the 'useable land area'.

2.3.3 Weighted Attribute Analysis

The assessment involves use of a WAA on the remaining parcels to quantitatively rank potential suitability for land treatment against a prescribed criterion. The scoring criteria comprises of seven primary aspects:

- Useable Land Area
- Physical Suitability (Slope and Soil Drainage)
- Distance from WWTP
- District Zoning
- Existing Land Use
- Land Ownership

Geospatial data was obtained from data source providers, and automated GIS 'scripts' were developed and utilised to provide consistent data for each parcel. The scripting of the raw data assessment allowed for these very large data set to be handled efficiently i.e. compared to a manual assessment. Geospatial data used as input to the WAA is presented on Figure 4 (land zoning), Figure 5 (land slope), Figure 6 (soil drainage), and Figure 7 (land cover).

The geospatial data was quantitatively evaluated for each criterion at each parcel. The outcome was calculated as a numeric ranking score within a range of 5 (best) to 1 (worst). Each criterion was then weighted based on its perceived importance to land treatment suitability. The WAA Methodology is summarized in Appendix A.

KEY :

- RAGLAN WATEWATER TREATMENT PLANT
- ASSESSMENT AREA
- ASSESSMENT PARCEL

ZONES

- BUSINESS / VILLAGE BUSINESS
- COASTAL
- COUNTRY LIVING
- INDUSTRIAL; LIGHT INDUSTRIAL
- LIVING
- RESIDENTIAL / RURAL-RESIDENTIAL
- PA
- RECREATION
- RURAL

SOURCE:
1. TOPOGRAPHICAL INFORMATION DERIVED FROM LINZ DATA.
2. DISTRICT PLAN INFORMATION DOWNLOADED FROM WRC OPEN DATA PORTAL ON 27/03/2020

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LAND ZONING IN ASSESSMENT AREA

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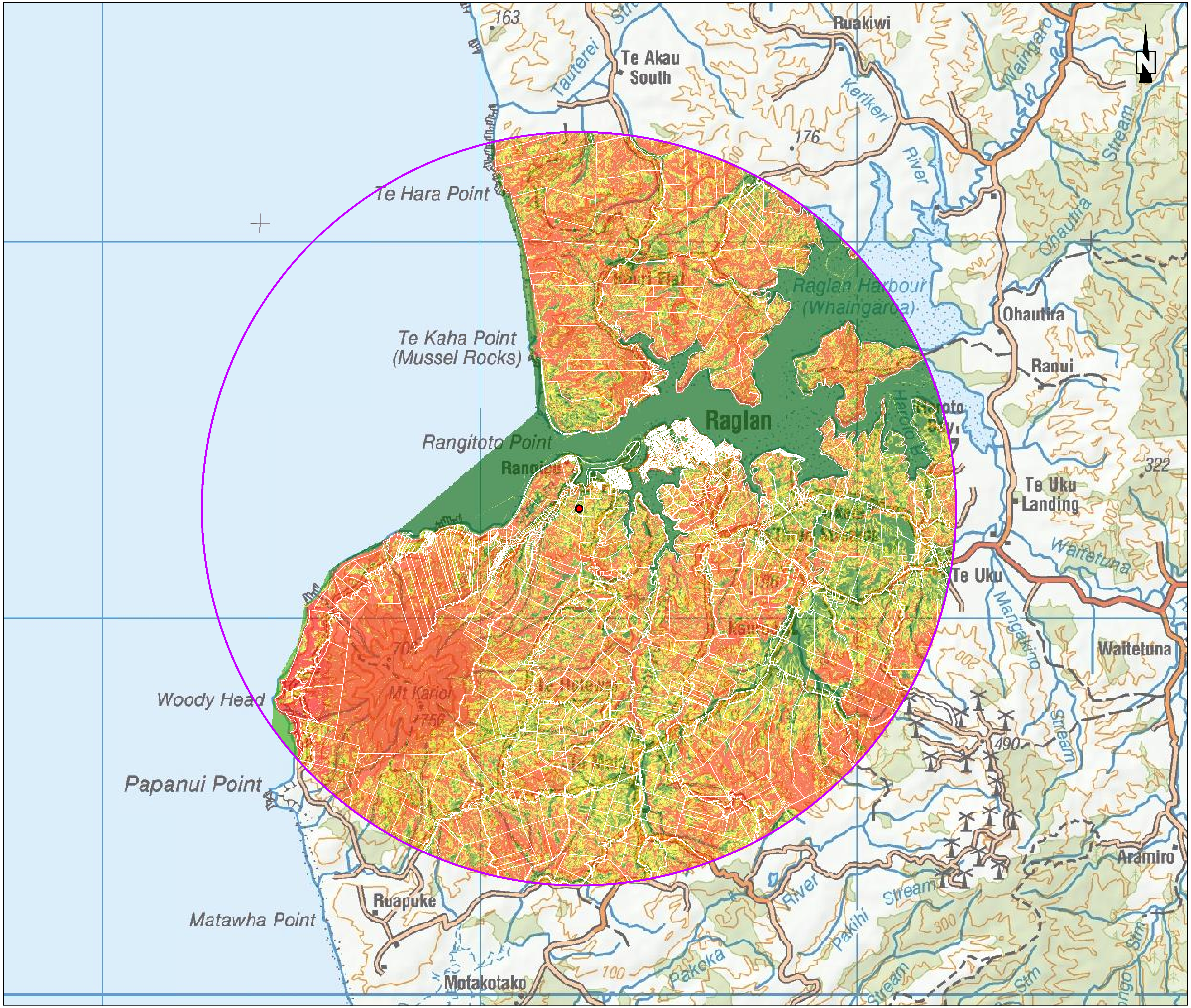

KEY :

- RAGLAN WATEWATER TREATMENT PLANT
- ASSESSMENT AREA
- ASSESSMENT PARCEL

PERCENT SLOPE

- 0 - 5%
- 5 - 10%
- 10 - 15%
- 15 - 20%
- 20 - 25%
- 25 - 30%
- >30%

SOURCE:
1. TOPOGRAPHICAL INFORMATION DERIVED FROM LINZ DATA.
2. SLOPES GENERATED FROM DTM PROVIDED BY Waikato REGIONAL COUNCIL 2012.

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PROJECT : RAGLAN WWTP DISCHARGE OPTIONS

TITLE : LAND SLOPE IN ASSESSMENT AREA

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PROJECT NO. :	FIGURE NO. :	REVISION :
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KEY :

- RAGLAN WATEWATER TREATMENT PLANT
- ASSESSMENT AREA
- ASSESSMENT PARCEL

SOIL DRAINAGE

- POORLY DRAINED
- MODERATELY WELL DRAINED
- WELL DRAINED

SOURCE:
1. TOPOGRAPHICAL INFORMATION DERIVED FROM LINZ DATA.
2. LINZ SOIL DRAINAGE LAYER (AUG 2018) SUPPLIED BY LANDCARE RESEARCH UNDER LANDCARE DATA USE LICENSE LINK: http://lris.scinfo.org.nz/license/landcare-data-use-licence-v1/
DATA REPRODUCED WITH THE PERMISSION OF LANDCARE RESEARCH NEW ZEALAND LIMITED.

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CLIENT :
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PROJECT :
RAGLAN WWTP DISCHARGE OPTIONS

TITLE :
SOIL DRAINAGE CHARACTERISTICS IN ASSESSMENT AREA

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SCALE : 1:100,000 (A3)

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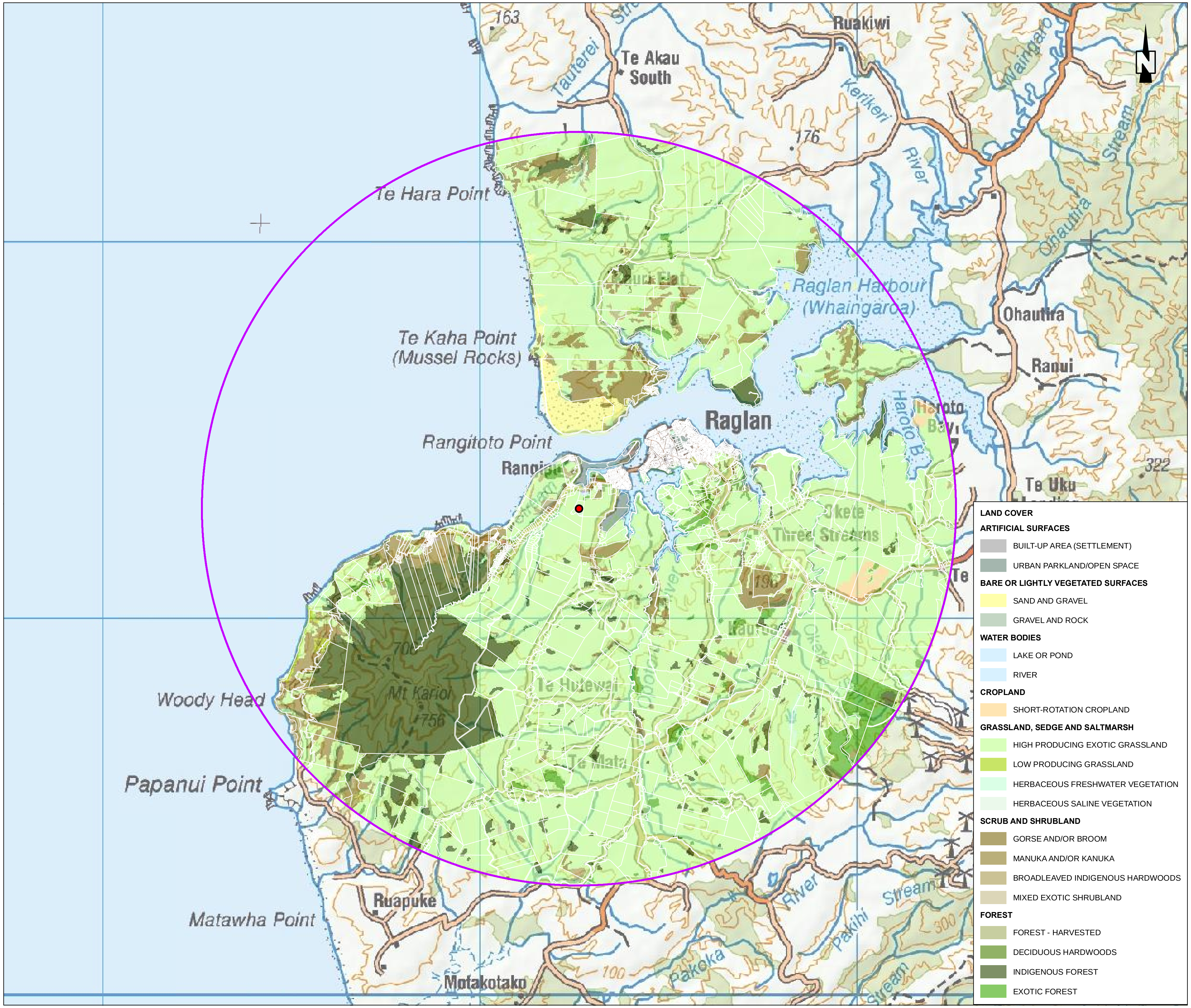

KEY :
- RAGLAN WATEWATER TREATMENT PLANT
- ASSESSMENT AREA
- ASSESSMENT PARCEL

SOURCE:
1. LAND COVER DATA SUPPLIED BY LANDCARE RESEARCH (LRIS PORTAL), DATED 07/02/2020.
2. TOPOGRAPHICAL INFORMATION DERIVED FROM LINZ DATA.

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CLIENT :
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PROJECT :
RAGLAN WWTP DISCHARGE OPTIONS

TITLE :
LAND COVER IN ASSESSMENT AREA

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SCALE : 1:100,000 (A3)
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2.4 Land Treatment Assessment Results and Suitable Area Selection

The full results of the land treatment WAA assessment are presented visually based on a scale of suitability in Figure 8.

The WAA was used to identify the top 40 parcels suitable for land treatment in the assessment area (see Figure 9). Areas that are on the northern side of Raglan Harbour were excluded, primarily due to the potential challenges with installing a pipeline across the Raglan Harbour. Areas within the Waikato 2070 Raglan growth nodes were excluded due to projected development in these areas. Areas were also checked for high risk hazards of coastal inundation and coastal erosion. One of the parcels (WAA Rank #11) was flagged to be marginally within a sensitive area to coastal inundation, but was not excluded due to the small area of land that would be potentially impacted.

For the 40 selected parcels, Table 3 summarises the irrigable areas for each parcel which has been determined based on the slope adjusted areas to account for lower irrigation rates over steeper areas. A 30% allowance for non-irrigable areas such as buffer zones from property boundaries, separation from waterways, and separation from dwellings etc, has been made.

For a land treatment option to proceed several parcels will likely be required. For the non-deficit scenarios 2 - 4 parcels are required. For the deficit scenario, which is not a short-listed discharge option, at least 4 to 11 parcels would theoretically be required. Consideration needs to be given to the location of each parcel as it is more practical in terms of infrastructure to have them near or adjoining other sites.

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Table 3: Usable Areas of WAA Top 40 Parcels

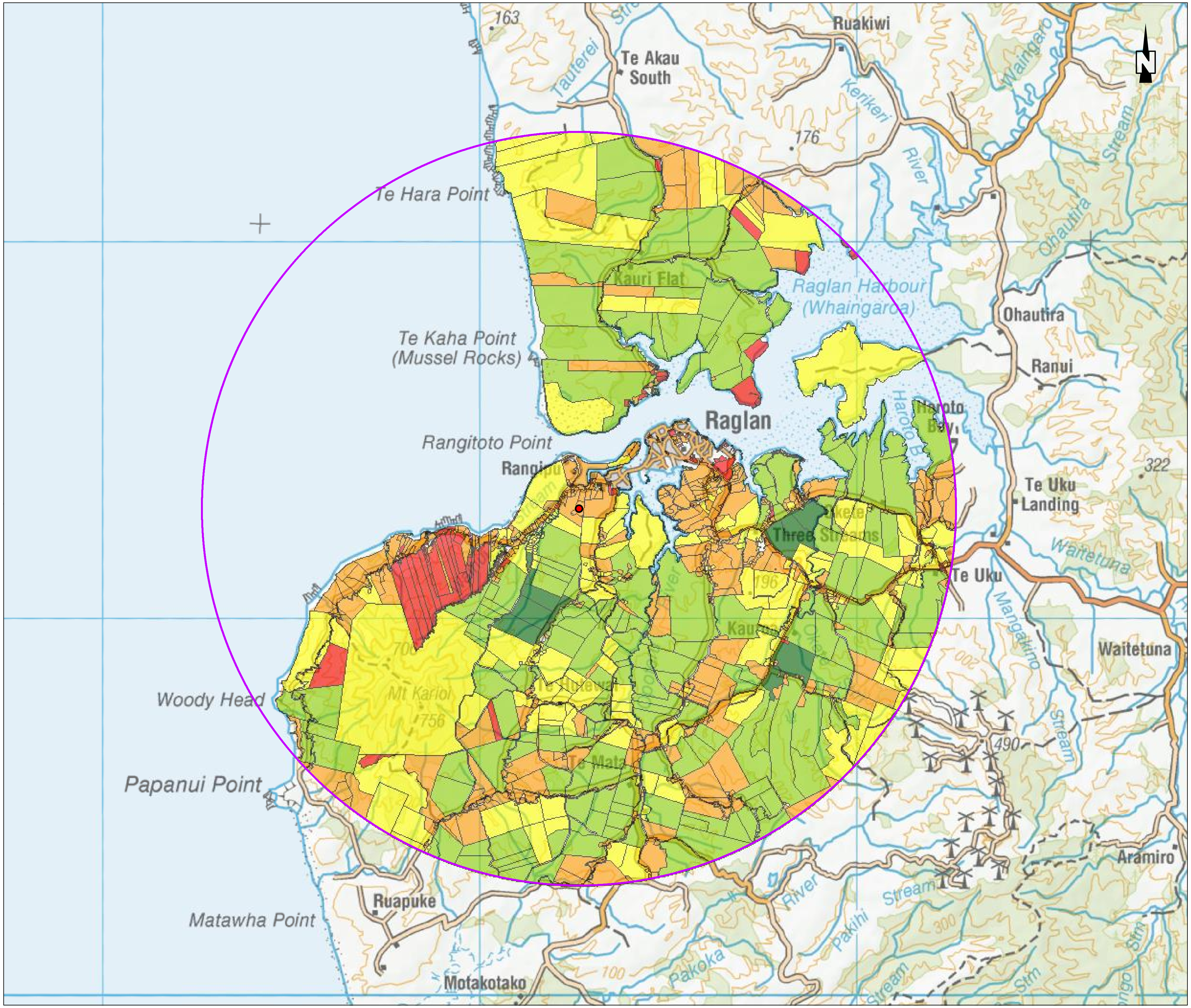
WAA Rank	Number of Parcels	Slope Adjusted Area[1] (ha)	Irrigable Area[2] (ha)
1	2	83	58
2	7	67	47
3	3	77	54
4	2	117	82
5	2	77	54
6	3	91	64
7	8	63	44
8	3	66	46
9	2	38	27
10	6	48	34
11	6	77	54
12	2	103	72
13	4	61	43
14	5	103	72
15	6	72	50
16	5	79	55
17	4	66	46
18	2	62	43
19	7	122	85
20	4	68	48
21	3	66	46
22	8	56	39
23	3	49	34
24	2	45	31
25	2	53	37
26	1	85	60
27	2	71	50

Table 3: Usable Areas of WAA Top 40 Parcels

WAA Rank	Number of Parcels	Slope Adjusted Area[1] (ha)	Irrigable Area[2] (ha)
28	4	71	50
29	3	65	46
30	6	61	43
31	2	27	19
32	9	104	73
33	8	54	38
34	3	58	41
35	5	59	41
36	2	56	39
37	1	78	55
38	1	53	37
39	5	64	45
40	4	41	29

Notes:

1. *Based on the WAA slope weighted areas.*
2. *30% allowance for buffer zones and non-irrigable areas.*



KEY :

- RAGLAN WATEWATER TREATMENT PLANT
- ASSESSMENT AREA

LAND TREATMENT WAA ASSESSMENT RESULTS

- 1-3
- 3-3.5
- 3.5-4
- 4-4.5
- 4.5-5

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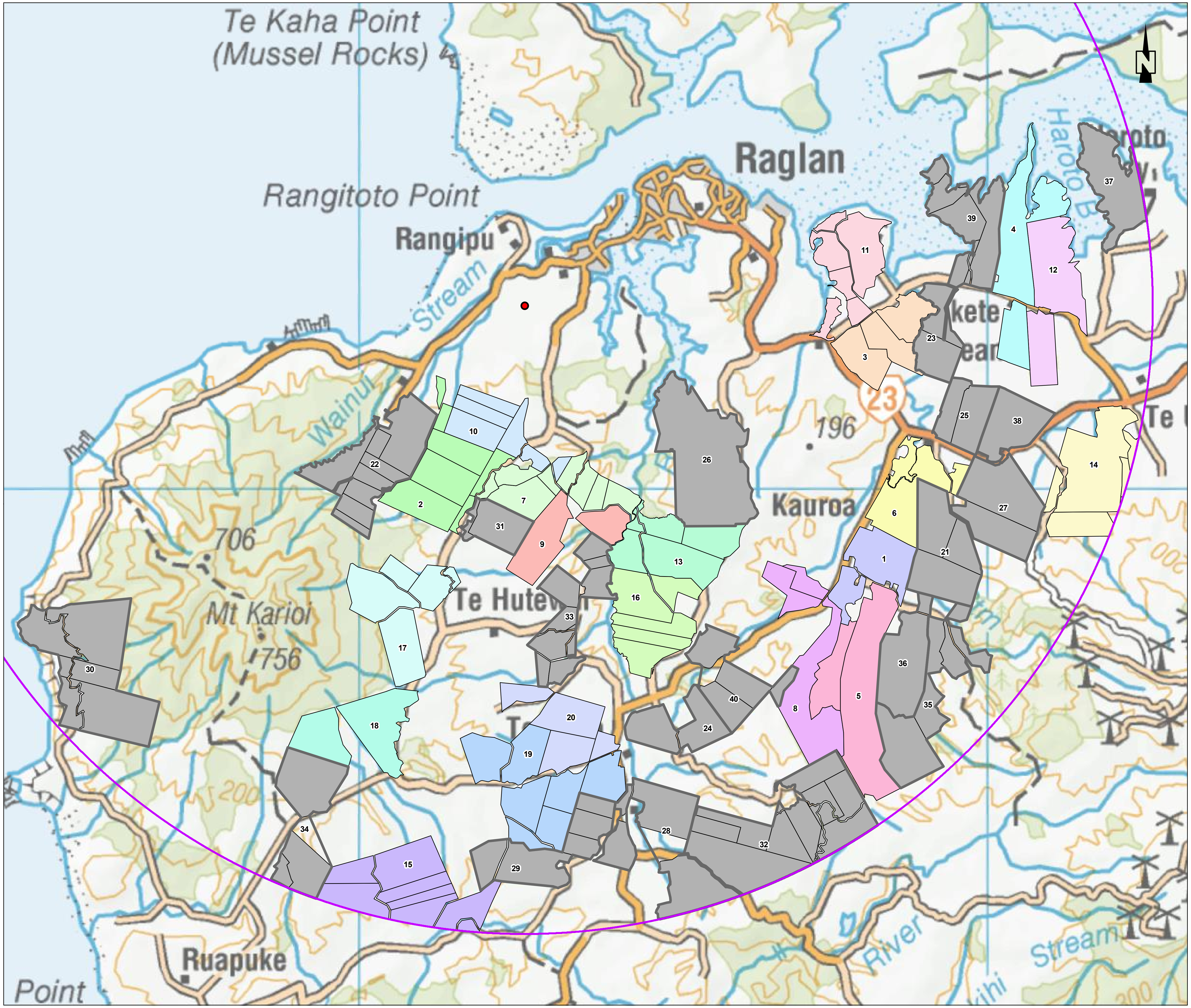

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ASSESSMENT AREA

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A03532200	9	A

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2.5 Land Treatment Wastewater Quality

Aside from hydraulic limitations, land treatment systems are often limited by nutrient loading rates. Key nutrients for consideration in assessing wastewater irrigation rates include nitrogen, phosphorus and sodium. Whether a system will be hydraulically limited or nutrient loading limited is site specific and dependent on a number of factors including soil characteristics (drainage and soil type), topography and wastewater quality.

Depending on the land use, nitrogen loading for land treatment systems generally range from 150 kg TN/ha/yr for a grazed or forestry system, through to approximately 400 to 500 kg TN/ha/yr for a cut and carry system. Based on grazed or forestry systems, an average nitrogen concentration in the wastewater of approximately 18 g TN/m^3 to 30 g TN/m^3 would be required, for a hydraulic loading rate of approximately 500 mm/yr to 800 mm/yr.

Depending on the land use, the phosphorus loading could typically range between 30 kg TP/ha/yr to 40 kg TP/ha/yr, with an average phosphorus concentration ranging from 4 g/m^3 to 8 g/m^3.

Sodium levels are generally not an issue for municipal wastewater irrigation systems in areas of elevated rainfall and no significant trade waste sources, however, lime addition can be required to manage sodium levels if they increase in the soils over time.

While the required wastewater nutrient levels have been approximated above, for a land treatment system, the allowable nutrient loading rates will need to be assessed against nutrient leaching potential and potential effects on the receiving environment. Given the topography and soil types in the area, requiring large irrigation areas to manage hydraulic loading, it is likely that the hydraulic loading capacity of the soils will be the key limiting factor. However, for higher hydraulic loading rates for non-deficit, all-year round options, nutrient loads could be elevated, potentially requiring landuse changes or additional nitrogen removal at the treatment plant to manage nutrient loads.

3.0 Assessment of Short-Listed Options

From the long list assessment of land treatment and deep bore injection options, the short-listed options selected for further assessment are:

- Non-deficit irrigation to land – 100% irrigation.
- Non-deficit irrigation to land with an alternative discharge solution (marine).

Deficit irrigation options were excluded from further assessment due to the large land areas required and the large number of properties that would be required to be included in a land treatment scheme. Deficit irrigation only occurs when soil moisture conditions require additional irrigation and as such large irrigation areas are required to manage the treated wastewater along with large storage areas for when irrigation cannot occur (particularly for wetter winter months). Due to the large number of parcels that would be required in Raglan for a deficit system it is considered impractical as an option. Therefore, the two non-deficit irrigation systems have been short listed for further consideration.

Deep bore injection was initially included as a short listed option, however it was later excluded from further consideration due to a poor response from consultees during the initial consultation process.

This section provides further assessment of the potential implementation options for the short listed options.

3.1 Non-deficit irrigation - 100% to land all year round

A non-deficit irrigation system with irrigation to land all year round would require a land treatment area in the order of 90 – 190 ha, which would require 2 – 4 parcels to be obtained. For practical purposes parcels in close proximity to each other are desired to minimise infrastructure requirements.

3.1.1 Potential Irrigation Locations

Table 4 summarises several theoretical parcel clusters (A-D) that could be used for the land treatment scheme. These are also displayed visually in Figure 10. Cluster A is closest to the WWTP which would decrease the pumping infrastructure requirements however, more parcels are required due to smaller usable land areas and greater slopes in this area.

The underlying soils of Cluster A are likely to be similar to the freer draining loamy soils observed in this area during the site visit discussed in Section 2.2. As indicated on SMAP, similar soil types may be present at Cluster D. Clusters B and C are indicated to have areas of poorly drained soils which could potentially reduce the allowable irrigation volumes at these sites.

Table 4: 100% Non-Deficit Irrigation Potential Land Treatment Combined Parcels

Cluster	WAA Ranking Numbers	Combined Usable Area
A	2, 7, 9, 10	152
B	1, 5, 6	176
C	4, 12	154
D	19, 20	133

If a non-deficit, year round land treatment option progressed property clusters identified in Table 4 provide optimum scenarios. An advantage of Cluster A would be a single rising main from the treatment plant.

When considering public land for irrigation of wastewater there is insufficient area available within the assessed areas to enable a feasible non-deficit irrigation system on public land alone. Irrigation of the Wainui Reserve is theoretical only as much of the land is designated a Maori Area of Significance and has high public use and therefore could potentially account for only a small fraction of the overall waste stream.

3.1.2 Storage Options

A storage volume in the order of 150,000 m^3 is required for this option, to prevent the need to irrigate during periods of high rainfall and saturated soil conditions. Storage would generally be managed by drawing down storage levels during the drier summer period and then utilising the storage facility during the wetter winter periods. The storage area could be provided by a dam at the irrigation site.

With the undulating nature of the Raglan area many opportunities exist for valleys to be utilised for this purpose. Clusters A, B and D all have incised valleys which may offer the opportunity for conceptual storage.

3.1.3 Land Use and Irrigation type

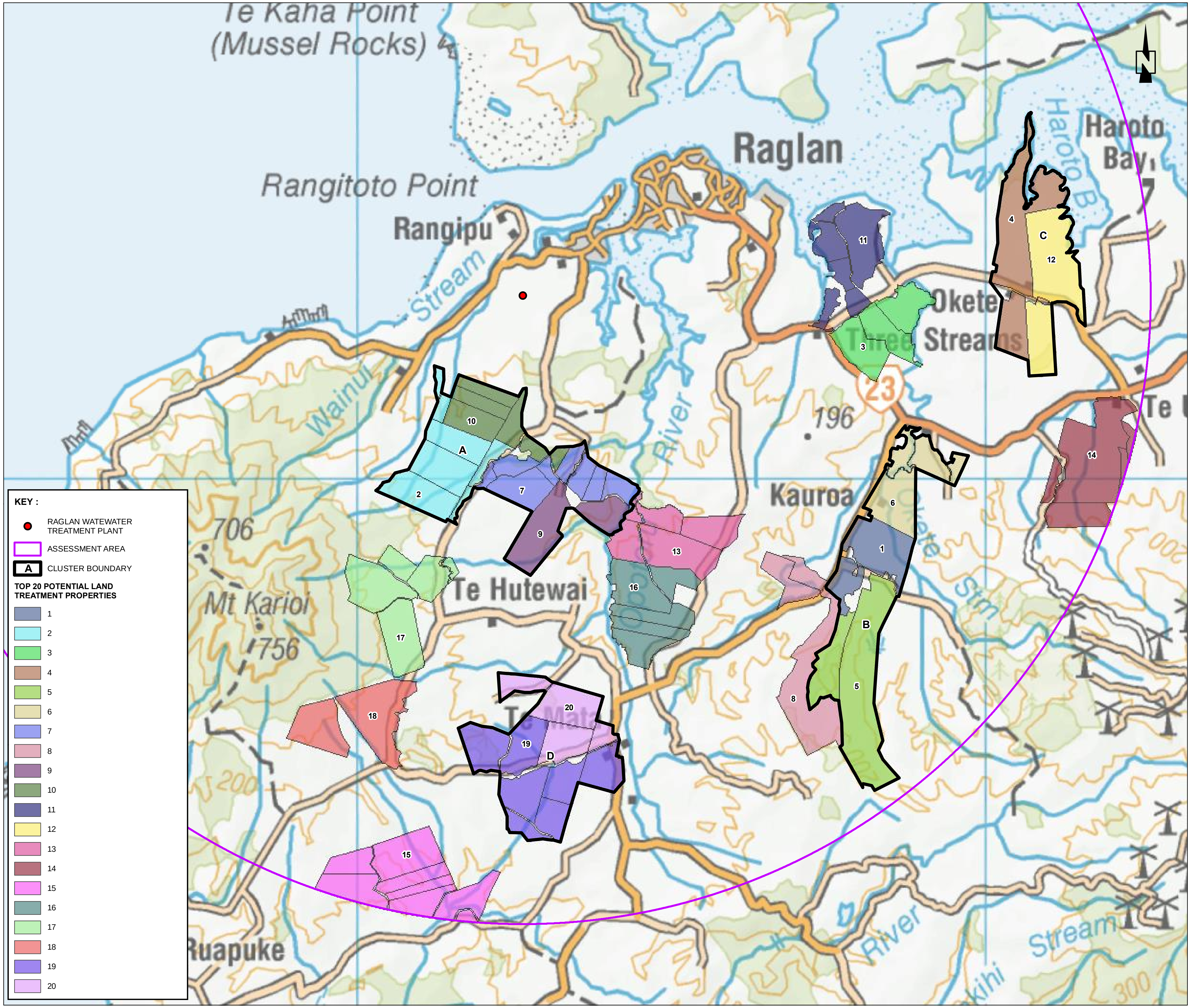
There are a variety of landuse options that could be implemented at the land treatment sites including pastoral grazing, non-consumptive crops, cut and carry, forestry and non-contact consumptive crops. These are discussed in more detail in Raglan Landuse Assessment report no. A03532200R002 (PDP, 2020a). Examples of land treatment schemes that incorporate land use variations include Taupo sewage treatment system (cut and carry) and Cooks Beach sewage treatment system (forestry). The benefits of these systems include additional nutrient uptake for cut and carry systems, and improved hydraulic management and land stabilisation for forestry systems.

Given that the sites identified in Table 4 tend to incorporate predominantly hilly country with some terraced ridges, irrigated forestry is more likely to be an applicable landuse with some opportunities for cut and carry pasture based fodder crops on the flatter areas of terraced ridgelines and valleys.

Due to the topography in the Raglan area the most likely type of irrigation would be solid set.

3.1.4 Additional Considerations

It is noted that with non-deficit irrigation, leaching of treated wastewater does occur and therefore consideration needs to be given to down gradient water takes and receptors in order to avoid contaminating groundwater sources. It is noted that the Raglan water take is to the north-east of Cluster A and therefore particular attention would be required to investigate and monitor groundwater movement from a land treatment system in this area.



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LAND TREATMENT POTENTIAL PARCEL CLUSTERS

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A03532200	10	A

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3.2 Non-deficit Irrigation with Winter Marine Discharge

A non-deficit irrigation system with alterative marine discharge during the wetter winter months would require a land area in the order of 80 – 110 ha which would require 1 – 3 parcels to be used. Table 5 summarises theoretical clusters (E-I) that could be used for this scenario. Figure 11 details the theoretical cluster locations.

Table 5: 100% Non-Deficit Irrigation Potential Land Treatment Combined Parcels

Cluster	WAA Ranking Numbers	Combined Usable Area
E	2, 7, 9	118
F	1, 6	122
G	4, 12	154
H	19, 20	133
I	3, 11	108

The parcels ranked 4 and 19 under the WAA assessment could potentially be used as single parcels under this scenario, however, their usable areas are at the lower limit of the required area at 82 ha and 85 ha respectively.

3.2.1 Storage Options

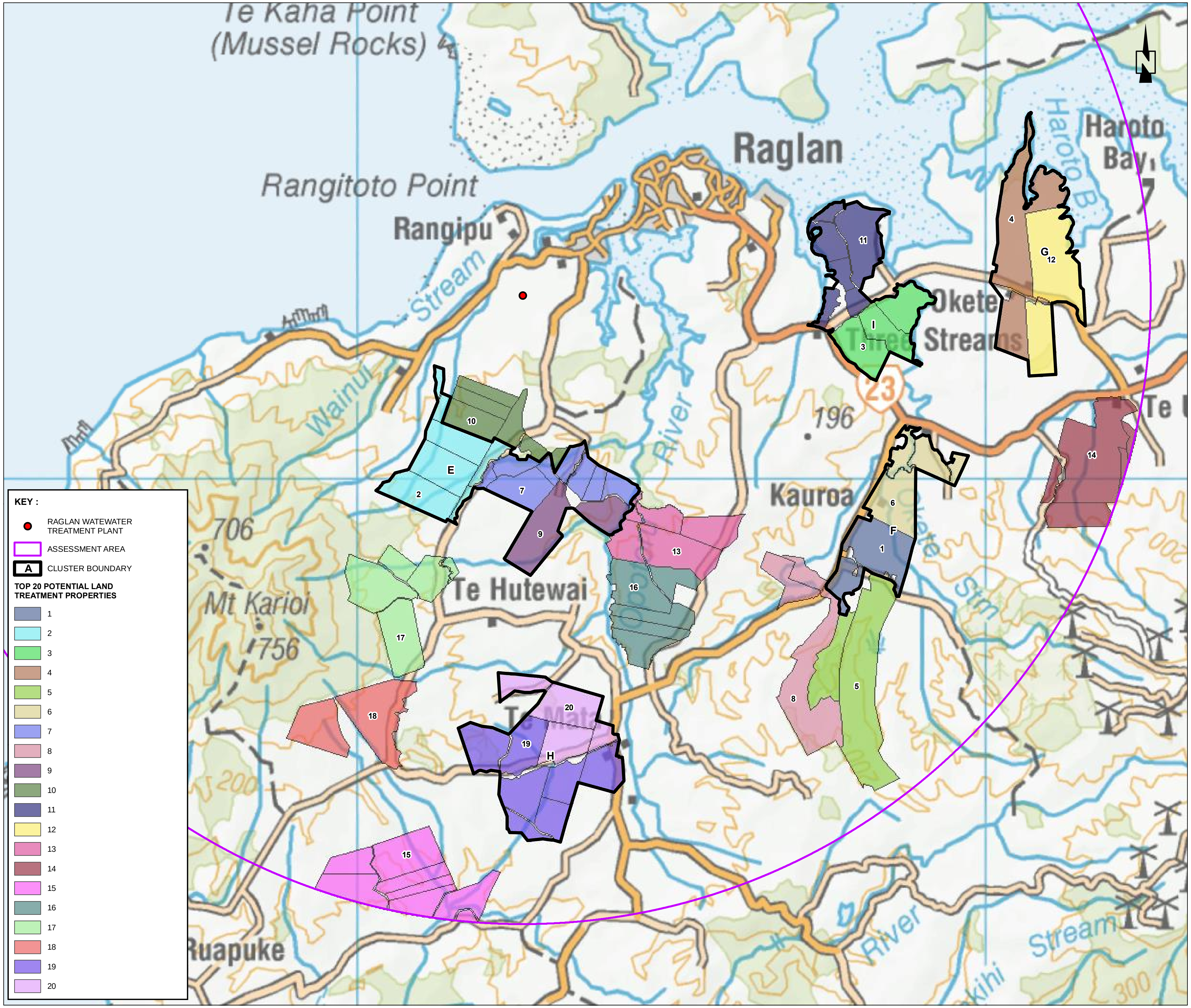
A much smaller storage volume, in the order of 20,000 m^3, would be required for this option, which would generally be used during periods of heavily rainfall in the drier months, and/or when treated wastewater volumes exceed the daily irrigation limits.

Due to the reduced size of the required storage facility, this could be a constructed storage lagoon at the irrigation site, within a suitable area of flat land.

3.2.2 Land Use and Irrigation Type

As with the non-deficit, 100% irrigation to land option, there are a variety of landuse options that could be implemented at the treatment site including pastoral grazing, non-consumptive crops, cut and carry, and forestry.

As the clusters generally incorporate predominantly hilly country with some terraced ridges, irrigated forestry is more likely to be an applicable landuse with some opportunities for cut and carry based cropping on the flatter areas of terraced ridgelines and valleys. For Clusters 2b, 4b and 5b, these sites are located on gentler sloping land and cut and carry maybe a more dominant operation for these sites.



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1. TOPOGRAPHICAL INFORMATION DERIVED FROM LINZ DATA.

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A03532200	11	A

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3.3 Forward Work

Identified key knowledge gaps and key inputs which need to be incorporated into progressing land treatment as a potential discharge option or part-option, are:

- Legislation and regional planning review to solidify position on any regulatory aspects that may influence any land treatment option.
- Iwi consultation and involvement, particularly to assist in identifying any culturally sensitive areas that should be excluded from further land treatment consideration.
- Initial stakeholder / landowner consultation re: potential interest in either working with WSL collaboratively or land sale/lease possibilities.
- Field investigation to assess general soil types and permeability confirmation at sites where there is landowner interest.
- Initial land treatment concept design with size and application method, including very rough order costing on concept option.

4.0 Short Listed Options Costing Assessment

A rough order costing assessment was undertaken for the following three short listed options:

- Non-deficit 100% irrigation to land.
- Non-deficit irrigation to land with an alternative discharge solution.
- Non-deficit irrigation to potentially available public land with an alternative discharge solution.

Irrigation of public land, with an alternative discharge option, has been included in the short-listed option cost assessment, should it be found that only public land is available. Public land irrigation costing assessments have been based on irrigating Wainui Reserve, the Raglan Golf Course and the council owned section of Raglan Airstrip.

Because no private land has been secured at the time of this assessment, costing assessments for irrigation of private land has been based off an arbitrary location based on Clusters A and E (refer to Section 3.0).

D R A F T

4.1 Non-Deficit Irrigation to Land 100% Irrigation

A rough order cost for the non-deficit 100% irrigation to land option has been based on irrigation to private land off Te Hutewai Road (Cluster A).

4.1.1 Land Area

A base irrigation area of 130 ha has been used in the costing based on a soil moisture model run with the 2055 average daily wastewater volume of 1,957 m^3 and hydraulic conductivities of K_{sat} = 10 mm/d and K_{-40} = 1 mm/d.

To account for the undulating nature of the Raglan area, which will require lower irrigation rates in steeper sections, the slope adjusted area within the parcels has determined the potential irrigation area. Based on slope adjusted areas for the area incorporating Cluster A (61% adjustment factor) approximately 213 ha of irrigable area is required.

A 30% buffer zone factor has also been applied to allow for offset distances from boundaries and streams. The entire parcel that encompasses the slope adjusted area has been included in the land purchase cost. For the costing assessment, it has been assumed that adjacent parcels (for complete farm operations) require purchase for this option, requiring a total land purchase area of 550 ha (based on the Cluster A location).

4.1.2 Dam

A rough order cost for a storage dam of 150,000 m^3 is based on the main elements for the structure such as dam embankment, penstock and stormwater diversion. It is assumed that the dam embankment is a compacted earthen embankment and that there is suitable material on site for the construction of the embankment, within land parcels selected for irrigation. A liner for the dam has not been included.

The dam site has been selected based on the proximity to Te Hutewai Road and minimal upstream catchment area. It is assumed that access to the site is possible from Te Hutewai Road. Any final dam site selection would require:

- Undertaking site selection process looking at geology and potential geohazard issues such as relic landslides;
- Assessing availability of purchase of land for the dam site and reservoir;
- Assessing any cultural issues;
- Location of disposal area;
- Pipeline routes available to dam site location; and
- Carrying out geotechnical site investigation to determine site suitability.

A 15% allowance for surveying of selected site, geotechnical investigations, detailed design costs, any required resource consenting and overall project management costs has been included in the cost.

4.1.3 Irrigation Type and Landuse

The irrigation equipment has been costed based on solid-set irrigation due to the undulating topography in the area. Irrigation costs also include pipeline infrastructure from the main pipeline termination point to the storage dam, pump station and three distribution rising mains to various points across the irrigation area.

The landuse for this costing has been assumed to be conversion to irrigated forestry on steeper land (15% to 30% slope) with cut and carry pasture (hay or silage) on the flatter areas of terraced ridgelines and valleys (<15% slope).

4.1.4 Rough Order Cost Estimate

Table 6 summarises the cost estimate for the non-deficit 100% irrigation to land option.

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Table 6: Non-deficit Irrigation to Land 100% Irrigation Cost

Item	Capital Cost	Cost
1.0	**Wastewater Treatment**	**To be costed separately**
2.0	**Conveyance**	**To be costed separately**
3.0	**Irrigation System**	**$9,000,000**
	Irrigation Equipment and Distribution[1]	$7,820,000
	Pump Stations	$480,000
	Landuse Establishment	$270,000
	Electrical and Control	$430,000
4.0	**Storage Dam**	**$5,980,000**
A	**Sub Total**	**$14,980,000**
B	Preliminary and General[2]	$1,200,000
C	Offsite Overheads[2]	$1,200,000
D	**Total Construction (A+B+C)**	**$17,380,000**
E	Professional Services[3]	$2,610,000
F	Irrigation site investigations and consenting	$690,000
G	Dam Site Investigation, Consenting Costs[4]	$900,000
H	Unscheduled Items[5]	$3,480,000
I	Contingency[6]	$5,210,000
J	Land Purchase[7]	$16,500,000
K	**Total CAPEX (D+E+F+G+H+I)**	**$46,800,000**
L	**Total Annual OPEX**	**$60,000**

Notes:

1. *Including internal distribution rising mains.*
2. *8% of capital cost.*
3. *15% of total construction.*
4. *Includes geotechnical investigations for detailed design for dam construction.*
5. *20% of total construction.*
6. *30% of total construction.*
7. *Land purchase price based on $30k per hectare.*

4.2 Non-Deficit Irrigation to Land with Alternative Discharge

A rough order cost for the non-deficit irrigation to land with alternative discharge option has been based on irrigation to private land off Te Hutewai Road (Cluster E).

4.2.1 Land Area

A base irrigation area of 90 ha has been used in the costing based on a soil moisture model run with the 2055 average daily irrigation volume of 1,957 m^3 and hydraulic conductivities of K_{sat} = 10 mm/d and K_{-40} = 1 mm/d.

To account for the undulating nature of the Raglan area which will require lower irrigation rates in steeper sections the slope adjusted area within the parcels has been used to determine the potential irrigation area. Based on slope adjusted areas for the area incorporating Cluster E (62% adjustment factor) approximately 145 ha of irrigable area is required.

A 30% buffer zone factor has been applied. The entire parcel that encompasses the slope adjusted area has been included in the land purchase cost. For the costing assessment, it has been assumed that adjacent parcels (for complete farm operations) require purchase for this option, requiring a total land purchase area of 320 ha (based on the Cluster E location).

4.2.2 Storage Pond

A storage pond of 20,000 m^3 capacity, located within the irrigation area has been included in the costing to help buffer flows and allow for short term periods where soils exceed saturation or run-off is a risk. This volume is in addition to the 25,000 m^3 of storage which is anticipated to be available at the WWTP.

4.2.3 Irrigation Type and Landuse

The irrigation equipment has been costed on solid set irrigation due to the undulating topography in the area. Irrigation costs also include pipeline infrastructure from the main pipeline termination point to the storage pond, pump station and two distribution rising mains to various points across the irrigation area.

The landuse for this costing has been assumed to be mainly irrigated forestry with cut and carry pasture based fodder crops on the flatter areas of terraced ridgelines and valleys.

4.2.4 Expected Alternative Discharge

This option allows for alternative discharge (marine) of the treated wastewater during the wetter winter months. The average monthly irrigation volumes and average monthly volumes to alternative discharge based on the average daily flow of 1,372 m^3 and 1,957 m^3 for 2025 and 2055 respectively, are summarised in Table 7.

Table 7: Average Wastewater Alternative Discharge and Irrigation Volumes

Month	2025		2055	
	Alternative Discharge Volume (m^3)	Irrigation Volume (m^3)	Alternative Discharge Volume (m^3)	Irrigation Volume (m^3)
January	0	51,356	0	67,202
February	0	48,220	0	61,557
March	0	50,286	0	62,456
April	0	45,121	1,470	48,089
May	327	26,549	31,140	26,549
June	17,669	21,961	37,849	21,961
July	20,256	19,372	38,263	19,372
August	16,808	25,453	34,165	25,453
September	4,912	37,915	19,912	37,915
October	516	54,667	8,280	56,072
November	0	45,682	535	60,087
December	0	52,457	0	66,056

Notes:

1. *Discharge volumes based on soil moisture model with hydraulic conductivities of Ksat = 10 mm/d and K_{-40} = 1 mm/d and an irrigation area of 90 ha.*

4.2.5 Rough Order Cost Estimate

The rough order cost estimate for the non-deficit irrigation to land with alternative discharge option is summarised in Table 8.

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Table 8: Non-deficit Irrigation to Land with Alternative Discharge Concept Cost

Item	Capital Cost	Cost
1.0	**Wastewater Treatment**	**To be costed separately**
2.0	**Conveyance**	**To be costed separately**
3.0	**Alternative Discharge**	**To be costed separately**
4.0	**Irrigation System**	**$5,820,000**
	Irrigation Equipment[1]	$5,030,000
	Pump Station	$330,000
	Landuse Establishment	$180,000
	Electrical and Control	$280,000
5.0	**Storage Lagoon**	**$900,000**
A	**Sub Total**	**$6,720,000**
B	Preliminary and General[2]	$540,000
C	Offsite Overheads[2]	$540,000
D	**Total Construction (A+B+C)**	**$7,260,000**
E	Professional Services[3]	$1,090,000
F	Irrigation Site Investigation, Consenting Costs	$440,000
G	Unscheduled Items[4]	$1,450,000
H	Contingency[5]	$2,180,000
I	Land Purchase	$9,630,000
J	**Total CAPEX (D+E+F+G+H+I)**	**$22,100,000**
K	**Total Annual OPEX**	**$80,200**

Notes:
1. *Including internal distribution rising mains.*
2. *8% of capital cost.*
3. *15% of total construction.*
4. *20% of total construction.*
5. *Land purchase price based on $30k per hectare.*

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4.3 Non-Deficit Irrigation to Public Land – with Alternative Discharge

A rough order cost for the non-deficit irrigation to public land option has been based on potential irrigation to three public land areas, Wainui Reserve, the Raglan Golf Course and the Raglan Airstrip. Costing for the alternative discharge has been excluded.

4.3.1 Land Area

Two possible irrigable areas, a maximum of 59 ha and a minimum of 38 ha, have been outlined for the public spaces and are summarised in Figure 12 and Figure 13. The maximum area reflects the theoretical area that could be irrigated across the three spaces based on the WAA usable area and excluding infrastructure such as carparks and the golf clubhouse. The minimum area is more conservative and incorporates a 50 m buffer inside the parcel boundaries and excludes specific land use on Wainui Reserve which may conflict with the irrigation scheme, such as the Amphitheatre, Sound Splash (annual music festival) and para-gliding. The rough order cost has been based on the maximum irrigable area. It should be noted that theoretical irrigation area of the Wainui Reserve has included a large area designated as Maori Area of Significance which would significantly decrease the irrigatable area if excluded.

Based on the soil types observed in these areas it has been assumed that irrigation to Wainui Reserve and the Raglan Airstrip can occur year round, while irrigation to the Raglan Golf Course will only occur during the summer months from December – March.

It is assumed that Wainui Reserve and the Golf Course would operate on a rotation period of four and three days respectively to allow time for the soils to rest. The maximum irrigation capacity is 8 mm/day.

4.3.2 Storage

A storage pond of 1,000 m^3 at Wainui Reserve has been allowed for to buffer irrigation volumes. It is assumed that irrigation to the Golf Course and the Airstrip can occur directly from the WWTP.

4.3.3 Irrigation Type

The irrigation equipment costing has been based on drip line irrigation. This minimises the risk of potential conflict with public land use, allowing for the existing land use to be maintained.

4.3.4 Expected Irrigation Volumes

The average monthly irrigation volumes to public land based on the maximum area at each location are summarised in Table 9. It is assumed that non-deficit irrigation will occur at Wainui Reserve and the Raglan Airstrip, and deficit irrigation will occur at the Raglan Golf Course. The WWTP storage pond volume of 25,000 m^3 was utilised in the SMM's.

Table 9: Public Land Monthly Irrigation Volumes

Month	Wainui Reserve	Golf Course	Airstrip
January	14,875	15,197	6,962
February	14,078	11,852	6,354
March	15,062	10,627	6,732
April	14,597	0	6,366
May	9,673	0	6,718
June	7,803	0	6,544
July	6,888	0	5,435
August	9,050	0	6,103
September	13,481	0	6,089
October	18,310	0	7,096
November	12,965	0	5,983
December	15,890	15,801	6,735

Notes:
1. *All units in m^3/month.*
2. *irrigation of Wainui Reserve and Airstrip based on non-deficit irrigation.*
3. *Irrigation of golf course based on deficit irrigation.*

4.3.5 Rough Order Cost Estimate

The cost for the irrigation to public land with alternative discharge is summarised in Table 10.

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Table 10: Irrigation to Public Land with Alternative Discharge Concept Cost

Item	Capital Cost	Cost
1.0	**Wastewater Treatment**	**To be costed separately**
2.0	**Conveyance**	**To be costed separately**
3.0	**Alternative Discharge**	**To be costed separately**
4.0	**Irrigation System**	**$2,750,000**
4.01	Irrigation Equipment[1]	$2,570,000
4.02	Pump	$50,000
4.03	Electrical and Control	$130,000
A	**Sub Total**	**$2,750,000**
B	Preliminary and General[2]	$220,000
C	Offsite Overheads[2]	$220,000
D	**Total Construction (A+B+C)**	**$3,190,000**
E	Professional Services[3]	$480,000
F	Irrigation site investigations and consenting	$210,000
G	Unscheduled Items[4]	$640,000
H	Contingency[5]	$960,000
I	**Total CAPEX (D+E+F+G)**	**$5,500,000**
K	**Total Annual OPEX**	**$98,000**

Notes:

1. *Including internal distribution rising mains and storage pond.*
2. *8% of capital cost.*
3. *15% of total construction.*
4. *20% of total construction.*
5. *30% of total construction.*

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KEY :

- RAGLAN WATEWATER TREATMENT PLANT
- ASSESSMENT AREA
- IRRIGATABLE AREA

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CLIENT :
Watercare
An Auckland Council Organisation

PROJECT :
RAGLAN WWTP
DISCHARGE OPTIONS

TITLE :
PUBLIC LAND POTENTIAL
LAND TREATMENT AREAS

pdp solutions for your environment
PATTLE DELAMORE PARTNERS LTD
Auckland Tauranga Wellington Christchurch

SCALE : 1:12,500 (A3)

0 100 200 400 600
METRES

PROJECT NO. :	FIGURE NO. :	REVISION :
A03532200	12	A

A03532200Z012_IrrigatableArea.mxd

KEY :

- RAGLAN WATEWATER TREATMENT PLANT
- ASSESSMENT AREA
- PUBLIC LAND POTENTIAL LAND TREATMENT AREAS BUFFERED

SOURCE:
1. AERIAL PHOTO FLOWN (2016-19)DERIVED FROM LINZ.

NO.	REVISION		DATE	APP.
A	ISSUE	FOR DISCUSSION 13/01/2021		

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SCALE : 1:12,500 (A3)
0 75 150 300 450
METRES

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A03532200	13	A

A03532200Z013_Public&PotentialLandTreatmentAreas .mxd

4.4 Sizing and Costing Assumptions

The following assumptions have been made for the rough order costings:

- Irrigation areas have been based on the anticipated average daily flows (ADF) for 2055, at 1,957 m^3/d (as provided by Beca Limited);
- Peak flows are balanced within the WWTP and storage facilities. Where flows exceed the ADF, it is assumed that additional flows are either discharged to the long term storage dam (100% irrigation to land option) or discharged via the alternative discharge method;
- Pumping hours are based on 24 hour pumping per day with storage at site to enable 12 hours of irrigation per day. Public land is based on 6 hours pumping per day;
- Irrigation onto private land is considered to be on well to moderately well drained soils, with a saturated permeability of 10 mm/d and a field capacity drainage rate of 1 mm/d;
- Irrigation to public land (with the exception of the air strip) is considered to be on imperfectly drained soils, with a saturated permeability of 10 mm/d and a field capacity drainage rate 1 mm/d. For the air strip the soil is considered to be well drained (sand) with a saturated permeability of 10 mm/d and a field capacity drainage rate 2 mm/d;
- Irrigation of private land is based on solid set irrigation at a rough order capital cost of $20k/ha and public land irrigation is based on drip line irrigation at $30k/ha. Rates per ha allowance is higher than industry standard to account for the steep topography and irregular shaped irrigation areas;
- Landuse set-up costs have been included for forestry only with the assumption that cut and carry operations on the flatter sections are pre-existing;
- Parcels of adjacent land can be purchased for the land treatment options, i.e. distribution piping to separated sections has not been accounted for in the costing;
- Land cost has been assumed to be $30k/ha;
- Foreign currency exchange fluctuations, $NZD inflation and GST have been excluded.

5.0 Conclusions and Recommendations

Land treatment (irrigation to land) has been investigated, at a high level, as an alternative option for disposal of treated wastewater from the Raglan wastewater treatment plant (WWTP).

5.1 Long List Assessments

Four potential irrigation options were investigated, including deficit and non-deficit irrigation, with and without alternative winter disposal options (dual discharge). Soil moisture models developed for each option indicate that the following irrigation areas and storage are required:

- Non-deficit, all year round: 90 ha – 190 ha, 150,000 m^3 of storage;
- Non-deficit, dual discharge: 80 ha – 110 ha, 20,000 m^3 of storage;
- Deficit, all year round: 260 ha-570 ha, 300,000 m^3 – 400,000 m^3 of storage;
- Deficit, dual discharge: 220 ha-240 ha, 20,000 m^3 of storage.

A weighted attribute, GIS based, assessment (WAA) was conducted to identify potential irrigation areas within a 10 km radius of the Raglan WWTP. The assessment took into account available area, topography, landuse, district plan zoning, land ownership type and distance from the WWTP. 40 preferred sites were selected on the south side of Raglan Harbour, with varying irrigable areas. To enable a non-deficit irrigation option, 2 to 4 parcels will be required, while 4 to 11 parcels will be required for a deficit option.

The two non-deficit schemes, irrigation to land all year round and part-year irrigation with alternative marine discharge, have been chosen to progress to short listed options due to the smaller land area and storage area requirements.

5.2 Short List Assessment

For the short listed, non-deficit wastewater irrigation options, potential cluster sites have been assessed to identify potential combined irrigation areas that could form part of a complete single location system.

For the non-deficit, 100% irrigation to land, 4 irrigation clusters were identified within the 10km radius assessment area, the optimum location is situated south of the treatment plant, near Te Hutewai Rd. There are a number of incised valleys in this location which could provide for large storage dams. Land-uses that could operate under the irrigation system, for the identified Cluster sites, would likely include a combination of forestry for steeper slopes and cut and carry pasture based fodder crops for lesser sloped areas such as ridges and valleys.

For the non-deficit irrigation option with an alternative discharge solution, the required land area is slightly less than the 100% irrigation option. For the reduced area, 5 potential irrigation clusters have been identified. Similar to the 100% irrigation option, the properties along Te Hutewai Rd are likely to be a preferred location.

The rough order cost for the three short listed land treatment options are:

- Option 1 – Non-deficit 100% to land: $47 M
- Option 2 – Non-deficit with alternative discharge: $22M
- Option 3 – Non-deficit to public land with alternative discharge: $5.5M

If these short-listed options are to progress further, identified key knowledge gaps and key inputs which need to be incorporated into progressing land treatment as a potential discharge option or part-option, are:

- Legislation and regional planning review to solidify position on any regulatory aspects that may influence any land treatment option.
- Iwi consultation and involvement, particularly to assist in identifying any culturally sensitive areas that should be excluded from further land treatment consideration.
- Initial stakeholder / landowner consultation re: potential interest in either working with WSL collaboratively or land sale/lease possibilities.
- Field investigation to assess general soil types and permeability confirmation at sites where there is landowner interest.
- Initial land treatment concept design with size and application method, including very rough order costing on concept option.

6.0 Glossary

DBI	Deep bore injection
Deficit Irrigation:	Irrigation to bring soil moisture up to field capacity only, to minimise drainage from the soil
Dual discharge:	Irrigation to land during drier periods with alternative discharge during wetter, winter months, generally from May to September
Field Capacity:	Soil moisture content where water stops draining from the soil
Non-Deficit Irrigation:	Irrigation at rates beyond the soil field capacity
PAW, Profile available water:	Net difference in porosity between field capacity and wilting point
WDC	Waikato District Council
WRC	Waikato Regional Council
WSL	Watercare Services Limited
WWTP	Wastewater treatment plant

Appendix A: WAA Methodology

The Raglan land treatment weighted attribute analysis (WAA) has been conducted utilising the following criteria and method.

Parcels of land with identical Certificates of Title that are adjacent to each other have been assessed as a single parcel.

Useable Land Area

The 'useable land area' for each parcel was assessed against the area required for irrigation assuming a daily average discharge of 1,957 m^3/day and an application rate of 0.5 m/yr.

Each parcel rated 1 – 5 based on Table A1 below. This distribution was used to determine the ranking for the useable land criteria. A higher rank was given to parcels with larger usable areas as the practicality of a land treatment system on one area is greater i.e. it is expected to be simpler to obtain one big parcel than several smaller ones as less land owners would require negotiation (if leased) or purchasing land required for the scheme.

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Table A1: Useable Land Area Ranking

Rank	1	2	3	4	5
Useable Area/Required Irrigation Area	0 – 20%	20 – 30%	30 – 40%	40 – 70%	70 – 100%

Land Suitability – Slope

Land slope is a key contributor to the suitability and efficiency of land for land treatment. GIS scripts were used to delineate the usable area into polygons of 0 – 5% slope, 5 – 10% slope, 10 – 15% slope, 15 – 20% slope, 20 – 25% slope and 25 – 30% slope. Slopes greater than 30% have been excluded from usable areas. These polygons were intersected with the parcel, and the cumulative areas of each polygon, within each parcel, was used to inform the score for this criterion. The effect of slope on land treatment performance was analysed using an 'effective area' approach. The effective area was generated by applying reduction ratios to the total useable area, using the reduction ratios described in Table A2 below.

The effective area was then divided by the usable area within the grid to determine the effective area as a percentage. Each parcel rated 1 – 5 based on Table A3 below.

Table A2: Effective Area Reductions for Slope

Slope	Ratio / Factor	Area Reduction Basis
0 – 5%	100%	Optimal slope – no reduction
5 -10%	90%	Area of 5 – 10% slope factored at 90%
10 – 15%	80%	Area of 10 – 15% slope factored at 80%
15 – 20%	70%	Area of 15 – 20% slope factored at 70%
20 – 25%	30%	Area of 20 – 25% slope factored at 30%
25 – 30%	20%	Area of 25 – 30% slope factored at 20%

Table A3: Slope and Soil Ranking

Rank	1	2	3	4	5
Effective Area	0 – 20%	20 – 40%	40 – 60%	60 – 80%	80 – 100%

Land Suitability – Soil Drainage

Polygons of different soil drainage types were intersected against the usable area and the parcels. For each parcel, areas were produced that corresponded to each soil drainage type.

The effect of soil drainage on land treatment performance was also analysed using an 'effective area' reduction. The effective area was generated by applying reduction ratios to poorer draining soil types, as described in Table A4, below. Moderately well drained soils were given a reduction rating of 60% after visual soil analysis during site visits (21 – 22 July 2020) indicated that these soils are likely to behave like imperfectly drained soils. The effective area was then divided by the usable area within the grid to determine the effective area as a percentage. Each parcel rated 1 – 5 based on Table A3.

Table A4: Effective Area Reductions for Soil Drainage

Soil Drainage	Ratio / Factor	Area Reduction Basis
Bare rock	0%	Unsuitable
Very poorly drained	20%	Area of very poorly drained soil worth 20% of well-drained soil
Poorly drained	40%	Area of poorly drained soil worth 40% of well-drained soil
Imperfectly drained	60%	Area of imperfectly drained soil worth 60% of well-drained soil
Moderately well drained	60%	Area of moderately well drained soil worth 60% of well-drained soil – site visits indicated soils more aligned with imperfectly drained soil
Well drained	100%	Optimal soil drainage type – no reduction

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Distance from WWTP

The distance between the centroid of each parcel and the Raglan WWTP treatment plant was evaluated using GIS scripts. The greater the distance between the WWTP and the potential land treatment scheme will likely correlate with greater transmission complexity i.e. greater pipeline length, increased pumping requirements and associated complexity in planning, design, construction and operation.

Each parcel rated 1 – 5 based on Table A5 below, which was based on the possible distance from the WWTP to the furthest extremity of the assessment area divided evenly into five divisions. This distribution was used to determine the ranking for the distance criterion.

Table A5: Distance Ranking

Rank	1	2	3	4	5
Distance	0 – 2,000 m	2,000 – 4,000 m	4,000 – 6,000 m	6,000 – 8,000 m	>8,000 m

District Zone

Polygons of different district zones were intersected against the parcels. For each parcel, areas were produced that corresponded to each district zone.

The effect of district zone on land treatment performance was also analysed using an 'effective area' reduction. The effective area was generated by applying reductions ratios as described in Table A6 below. The effective area was then divided by the usable area within the grid to determine the effective area as a percentage. Each parcel rated 1 – 5 based on Table A7.

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Table A6: Effective Area Reductions for District Zone

Zone	Ratio / Factor	Area Reduction Basis
Coastal	80%	Area may interfere with recreation
Recreational	50%	Area will likely require displacement of recreation
Rural	100%	Suitable area – no reduction

Table A7: District Zone Ranking

Rank	1	2	3	4	5
Effective Landuse Area	0 – 20%	20 – 40%	40 – 60%	60 – 80%	80 – 100%

Existing Landuse

It is deemed preferable that a potential land treatment scheme could be implemented onto land without the need to greatly alter or displace the existing land use activities. Land cover data obtained from Landcare Research categorises landuse within the assessment area into 19 types. PDP has categorised these landuse types into six categories and applied an 'area reduction' factor to less desirable existing land uses, as described in Table A8 below.

Table A8: Area Reductions Applied based on Landuses

Ratio / Factor	Grouping of Landcare Research Landuse Type	Explanation
0%	Built-up Area (settlement), Herbaceous Freshwater Vegetation, Herbaceous Saline Vegetation, Lake or Pond, River, Indigenous Forest	Unsuitable (and majority already excluded during the useable land area criterion)
20%	Gravel or Rock, Sand or Gravel	Major redevelopment of land required for to provide viability
50 %	Broadleaved Indigenous Hardwoods	Reduced ratio due to limitations with installing irrigation plant.
60%	Urban Parkland/Open Space	Redevelopment of existing land likely required and displacement of recreation likely.
80%	Manuka and/or Kanuka, Short-rotation Cropland	Crop – Landuse is largely compatible but may displacement food production. Land use largely compatible, but not deemed as desirable as faster growing exotic species.
100%	High Producing Exotic Grassland, Low Producing Grassland, Deciduous Hardwoods, Exotic Forest, Forest – Harvested, Gorse and/or Broom, Mixed Exotic Shrubland	Landuse is largely compatible and unlikely to displace other activities.

The effective area was then divided by the usable area within the grid to determine the effective area as a percentage. Each grid cell was rated 1 – 5 based on Table A9 below. This distribution was used to determine the ranking for the landuse criteria as the suitability of land for land treatment will increase linearly with effective landuse areas.

TableA9: Landuse Ranking

Rank	1	2	3	4	5
Effective Landuse Area	0 – 20%	20 – 40%	40 – 60%	60 – 80%	80 – 100%

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Land Ownership

Land ownership was assessed for each parcel and the effect on land treatment performance was analysed by applying reductions ratios as described in Table A10 below. Each parcel rated 1 – 5 based on Table A11.

Table A10: Reductions for Land Ownership

Land Ownership	Ratio / Factor	Area Reduction Basis
Public	100%	Suitable area – no land negotiations required
Maori	30%	Sensitive area – likely to have cultural sensitivities, land cannot be purchased only leased
Private	70%	Negotiations required to obtain land. WDC has preference for public land.

Table A11: Land Ownership Ranking

Rank	1	2	3	4	5
Effective Land Ownership Area	0 – 20%	20 – 40%	40 – 60%	60 – 80%	80 – 100%

Criterion Weightings & Final Suitability

The individual criterions used in this analysis are deemed to carry different levels of importance. To account for this, weightings were applied to criterion within the WAA, and this was used to calculate the overall score for each parcel. The criteria weightings and overall WAA score are summarised in Table A12 and Table A13. A greater weighting has been placed on the usable area within a property as this is a key requirement for limiting the number or parcels required for a land treatment option. A sensitivity analysis, with more even weightings, identified that sites with little usable area began to score more highly, which is counter to the objective of the assessment.

The overall WAA score was used to identify the top 20 parcels suitable for land treatment.

Table A12: WAA Criteria and Weightings

Criteria	Weighting
Useable Land	23%
Slope	18%
Drainage	14%
Distance to WWTP	9%
District Zone	14%
Existing Land Use	14%
Land Ownership	9%

Notes:

1. *At this stage of the assessment, capital and operational costs have not been incorporated. This is apart from the recognition that distance between the land treatment area and the treatment plant will relate to capital and operational costs.*

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Table A13: Land Treatment Overall Suitability Scoring System

Suitability Score	Overall WAA Score[1, 2]	Colour Code
Low Suitability	<2.50	Red
Low-Moderate Suitability	≥2.50 to <3.00	Orange
Moderate Suitability	≥3.00 to <3.50	Yellow
Moderate-High Suitability	≥3.50 to <4.00	Light Green
High Suitability	≥4.00	Dark Green

Notes:

1. *Score for each criterion is calculated by: 'Criterion Weighting' x 'Criterion Score'.*
2. *The 'overall WAA score' is the sum of each criterion score; with 5 being the maximum possible (highest marks for every criterion), and 1 being the lowest score possible (lowest marks for every criterion).*

Table A14: Land Treatment Weighted Attribute Analysis Scoring System

Criteria	Criteria Weighting	Explanation	Comparative Rating (Criterion Score)				
			1 (Worst)	2	3	4	5 (Best)
Useable Land	23%	Physical area assessed against approximate irrigation area required. Greater usable area scored better as less landowners would be negotiated with / displaced by the scheme, and purchasing land required for the scheme is expected to be simpler if dealing with less landowners.	< 20	20 - 30	30 - 40	40 - 70	> 70
Suitability of Land - Slope	18%	Area weighted assessment of slope. Increased land suitability scored higher as these areas will allow for increased irrigation loading with less runoff and as such, less land area for an equivalent volume scheme.	Low (Steep Slopes)	M-Low	Med	M-High	High (Flatter Slopes)
Suitability of Land - Soil	14%	Area weighted assessment of soil drainage. Increased land suitability scored higher as these areas will allow for increased irrigation loading and as such, less land area for an equivalent volume scheme.	Low (Poorly Drained)	M-Low	Med	M-High	High (Well Drained)
Distance [1]	9%	Distance between each grid unit and the wastewater treatment plant (km). Locations closer to the WWTP scored higher as these would require a shorter transmission pipeline and likely less road and river crossings, and less elevation changes.	> 8,000	6,000 – 8,000	4,000 – 6,000	2,000 – 4,000	< 2,000
District Zone	14%	A weighted assessment based on district plan zoning. Higher score for Rural area as minimal displacement likely.	< 20	20 - 40	40 - 60	60 – 80	> 80
Existing Land Use	14%	Suitability of existing land use for land treatment in terms of the need for redevelopment and the displacement of other activities. Higher suitability scored greater as less land redevelopment would be required as a part of the scheme development, and productive land is less likely to be displaced.	Low	M-Low	Med	M-High	High
Land Ownership	9%	Weighted assessment based on land ownership. Higher score for public land as easier to obtain.	< 20	20 - 40	40 - 60	60 – 80	> 80

Notes:

1. *At this stage of the assessment, capital and operational costs have not been incorporated. This is apart from the recognition that distance between the land treatment area and the treatment plant will relate to capital and operational costs.*

Appendix B: Landcare Research Soil Assessment Report

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Manaaki Whenua
Landcare Research

Review of selected soils near the Raglan Wastewater Treatment Plant

Prepared for: Pattle Delamore Partners

August 2020

Review of selected soils near the Raglan Wastewater Treatment Plant

Contract Report: LC3830

Malcolm McLeod

Manaaki Whenua – Landcare Research

Reviewed by:	*Approved for release by:*
Scott Fraser Soil Scientist Manaaki Whenua – Landcare Research	Chris Phillips Portfolio Leader – Managing Land & Water Manaaki Whenua – Landcare Research

Contents

Summary

Project and Client

- Pattle Delamore Partners staff sought advice from Manaaki Whenua – Landcare Research on assessment of usefulness of selected soils for treated wastewater irrigation.

Objective

- Assist Pattle Delamore Partners staff with identification of soil properties pertinent to irrigation of treated wastewater.

Methods

- At selected sites confirm soil properties pertinent to treated wastewater irrigation by way of hand-auguring and reference to existing soil maps of Bruce (1978) and Smap online.

Results

- Seven sites were inspected with soil properties pertinent to treated wastewater irrigation and discussed onsite. Most sites had clayey soils that would require high levels of irrigation management, but one site had loamy soils more suited to wastewater irrigation.

Conclusions

- From a soil perspective alone, soils at Site 2, Te Hutewai Road, have the most potential for land application of treated wastewater because of their useful permeability and ability to absorb phosphorus within the soil. Sandy soils at Site 4 have useful infiltration but limited ability to renovate treated wastewater because of their sandy nature. Clayey soils at other sites would need high levels of irrigation management to avoid inducing waterlogged conditions.

1 Introduction

A general overview of some soils near Raglan was undertaken with Pattle Delamore Partners (PDP) staff to determine their usefulness for irrigation of treated municipal wastewater. Soil restrictions which may influence the choice of the soil for irrigation with treated wastewater was noted. The site visit took place on 21 and 22 July 2020.

The sites for investigation were selected by PDP staff in conjunction with others.

2 Background

Soils in the area have been mapped by Bruce (1978) and this “legacy” soil information interpreted for entry into Smap online.

3 Objectives

The objective of this fieldwork and report is to assist PDP staff with identification of soil properties pertinent to irrigation of treated wastewater.

4 Methods

At seven sites, selected by PDP staff, a brief auger description was made to determine the main soil features pertinent to irrigation of treated wastewater. The relationship to soils mapped by Bruce (1978) and Smap was also established. Sites were located using a hand-held Global Positioning System device (Garmin GPSMAP 64s). Location is given in decimal degrees of latitude and longitude using WGS84 geodetic datum. The approximate location of the sites is shown in Figure 1.

Figure 1. Approximate location of the sites (1–7) visited.

5 Results

Site 1. Raglan golf course. Location -37.814771 174.861012

Bruce (1978) mapped these soils as Raglan soils developed in the upper bed of Hamilton Ash overlying beds of the same formation. Bruce (1978) notes that surface drainage is rapid but internal drainage is impeded by the very firm clay subsoil and the soil is only moderately well drained. Because of its heavy texture the soil is prone to compaction and structural deterioration under stocking in winter.

Smap records the map unit as 100% Opita_2a.1, a Typic Orthic Granular Soil (Hewitt 2010). Soil depth is >1 m with no slowly permeable layer (<4 mm/h) and permeability of the slowest layer within 1 m is between 4 and 72 mm/h. Bypass flow, whereby water and entrained nutrients/contaminants move to depth rapidly with restricted amelioration, is reported as high.

Site visit: Auger observations confirmed Orthic Granular Soils developed in Hamilton Ash beds and soils having a firm subsoil. It is likely the subsoil has slower permeability than the topsoil. Lateral flow within the soil, on sloping ground, should be considered. Fine manganese concretions and paler colours in the uppermost subsoil confirm wet soil conditions in the upper part of the soil during part of the year. The site sampled for hydraulic conductivity was moderately well drained but observations surrounding the sampling site showed imperfect drainage.

Figure 2a. Auger profile of the soil at Site 1, Raglan golf course, to 50-cm soil depth.

Figure 2b. landscape at Site 1.

Site 2. Te Hutewai Road. Location -37.852775 174.841553

Bruce (1978) mapped these soils as Kauroa soils developed in moderately weathered volcanic ash or Mairoa ash beds and classified as yellow-brown loams. Although not recorded, yellow-brown loams have high P-retention thus any applied phosphorus is tightly bound by the clay mineral allophane. The soils were described as friable. Furthermore, Bruce (1978) considered that the friable consistence and ready drainage enabled the soil to withstand trampling and also maintain moisture levels such that it does not dry out in summer or become compacted with soil structure deterioration in winter. Bruce (1978) suggested Kauroa soils to be one of the most productive soils in the Raglan district.

Smap records the map unit as 60% Kapu_3a.1 a Typic Orthic Brown Soil and 40% Otorohanga_12d.2 a Typic Orthic Allophanic Soil. The main difference in this vicinity between a Brown Soil and an Allophanic Soil is that the Allophanic Soil must have P-retention >85%. Brown Soils can grade into Allophanic Soils as P-retention increases. For both Brown and Allophanic Soils, soil depth is >1 m with no slowly permeable layer (<4 mm/h) and permeability of the slowest layer within 1 m is between 4 and 72 mm/h. Bypass flow is reported as medium for the Brown Soil and low for the Allophanic Soil. However, if the Kauroa soil has 30–50% amorphous minerals (on a whole soil basis) as reported by Bruce (1978), bypass flow is likely to be considered low.

Site visit: Auger observations confirmed the soils to be friable and classified as Typic Orthic Brown Soils (Hewitt 2010). The P-retention of the soil at Site 2, judged from a reactive-aluminium field test, indicated that while the soils have medium or high P-retention (Blakemore et al. 1987) it is not high enough for Allophanic Soils. Judging from soil colour, there are no rapid changes in permeability, meaning applied irrigation of wastewater would move uniformly to depth. The soils observed fit the concept of Kauroa soils and those in Smap. The soil is well drained at the sampling site and surrounds.

Figure 3a. Auger profile of the soil at Site 2, Te Hutewai Road, to 70-cm soil depth.

Figure 3b. Landscape at Site 2.

Site 3. Mangatawhiri Road. Location -37.844334 174.886673

In this area Bruce (1978) mapped the soils as Kauroa soils developed in moderately weathered volcanic ash or Mairoa ash beds and classified as yellow-brown loams. However, at this location the soils are clayey and firm. In the general local vicinity, the landscape is hilly rather than rolling and a hill soil association could be delineated using techniques not available to the original soil surveyors. In hilly land (slopes 16–25°) it is difficult to give a single profile description as the soil generally varies with landscape position and nowadays the soil variability would be further described.

Smap records the map unit as 60% Raglan_1a.1 a Typic Orthic Granular Soil (NOT) and 40% Okupata_3a.1 a Typic Oxidic Brown Soil (BXT). The clayey Granular Soils are reported to be moderately well drained and 70–90 cm deep over basalt.

Site visit: An auger observation on a 5° slope shows clayey textures more related to a Granular Soil shown in Smap than the loamy textures associated with a yellow-brown loam mapped by Bruce (1978). The soil had a firm subsoil indicating it is likely the subsoil has slower permeability than the topsoil. Lateral flow within the soil, on sloping ground, should be considered. Fine manganese concretions and paler colours in the uppermost subsoil confirm wet soil conditions during part of the year. The soil at the sampling site was moderately well drained.

At this site, to the south west, we observed an area of rolling land. Soil maps show the soils to be developed in moderately weathered volcanic ash (Mairoa ash beds). From a soil perspective, this land could be useful for irrigation of treated wastewater but would need further investigation to confirm.

Figure 4a. Auger profile of the soil at Site 3, Mangatawhiri Road, to 75-cm soil depth.

Figure 4b. Landscape at Site 3.

Site 4. Airfield. Location -37.852771 174.841505

Bruce (1978) did not map the soils on the airfield but the legend on the soil map suggests sandy soils.

Smap records the map unit as 100% Price_4b.2 with clay over loamy material. Clearly an error has occurred. Likely a soil boundary onto the Bruce (1978) unmapped area has not been included.

Site visit: While this soil is classified as a Typic Truncated Anthropic soil because of earthworks to form the airfield it is likely to have been a Recent Sandy Soil. Without modification the soil should show some colour gradation between topsoil and subsoil. This graduation was not observed in the field. Sandy soils have been used in other parts of New Zealand for land application of treated wastewater. Generally, sandy soils have useful permeability for land application of treated wastewater but because of their sandy nature have limited ability to absorb any chemical contaminants entrained in the treated wastewater. Sandy soils generally have low anion and cation exchange capacity so cannot absorb many applied anions or cations such as phosphorus or sodium. At the observation site the soil was well drained.

Figure 5a. Auger profile of the soil at Site 4, Airfield, to 80-cm soil depth.

Figure 5b. Landscape at Site 4.

Site 5. Te Ahiawa Road. Grid Reference -37.825281 174.843455

Bruce (1978) mapped these soils as Raglan soils plus Okupata hill soils. The Raglan soils are developed in the upper bed of Hamilton Ash overlying beds of the same formation. Bruce (1978) notes that surface drainage is rapid but internal drainage is impeded by the very firm clay subsoil and the soil is only moderately well drained. Because of its heavy texture the soil is prone to compaction and structural deterioration under stocking in winter. Okupata hill soils are developed on flow basalt and large boulders are common on the surface. Bruce (1978) notes that in many places the topsoil contains appreciable amounts of volcanic ash that imparts a silt loam or silty clay loam texture.

Smap records the map unit as 100% Okupata_3a.1 a Typic Oxidic Brown Soil (Hewitt 2010). Soil depth is reported as being well drained with 70–80 cm on rock with no slowly permeable layer (<4 mm/h) and permeability of the slowest layer is between 4 and 72 mm/h. Bypass flow, whereby water and entrained nutrients/contaminants move to depth rapidly with restricted amelioration, is reported as medium.

Site visit: Auger observations confirmed a clay loam topsoil with firm clayey subsoil. Consistent with landscape position, mottles were observed in the upper and middle subsoil indicating some drainage restriction. Lateral flow within the soil, on sloping ground, should be considered. Large surface boulders were observed nearby suggesting the soils are Okupata soils of Bruce (1978) and belonging to the Smap Okupata family but at the auger location site the soils are on rolling rather than hilly land. At this location soil depth exceeded 80 cm, possibly because of the landscape position. To be classified as Typic Oxidic Brown Soils the soils must have friable or very friable failure, meaning that at all moisture contents the soil aggregates crumble under slight stress. This was not the case with the soil being semi-deformable whereby the soil compressed under finger pressure leading to a classification of the soil at the site of Mottled Orthic Brown Soil. At the observation site the soil was imperfectly drained.

Figure 6a. Auger profile of the soil at Site 5, Te Ahiawa Road, to 50-cm soil depth.

Figure 6b. Landscape at Site 5. Note surface boulders in top right of image.

Site 6. Wainui reserve. Location -37.814099 174.834878

In the vicinity, Bruce (1978) mapped these soils as Raglan soils plus Horea soils subdominant in the map unit. Raglan soils are developed in the upper bed of Hamilton Ash overlying beds of the same formation. Bruce (1978) notes that surface drainage is rapid but internal drainage is impeded by the very firm clay subsoil and the soil is only moderately well drained. Because of its heavy texture the soil is prone to compaction and structural deterioration under stocking in winter. Horea soils are developed on weathered sand with some admixture of volcanic ash (Bruce 1978). Soils developed in Hamilton Ash beds are favoured over Horea soils as the soil inspected do not have sandy clay textures (Bruce 1978) in the subsoil.

Smap records the map unit as 60% Opita_2a.1, a Typic Orthic Granular Soil (Hewitt 2010). These soils are deep (>1 m), moderately well-drained soils with no slowly permeable layer (<4 mm/h) and permeability of the slowest layer within 1 m is between 4 and 72 mm/h. Bypass flow, whereby water and entrained nutrients/contaminants move to depth rapidly with restricted amelioration, is reported as high. Price_4b.2 is a Typic Orthic Brown Soil (Hewitt 2010) and covers 40% of the map unit. The Brown Soils cover the Horea soils of Bruce (1978).

Site visit: Site and auger observations suggest the soils are developed in Hamilton Ash bed materials and the soils having a firm subsoil. It is likely the subsoil has slower permeability than the topsoil. Lateral flow within the soil, on sloping ground, should be considered. The site was in a slightly concave landscape position and water could be seen moving through the lower topsoil/uppermost subsoil, consistent with the presence of manganese concretions in the soil. The presence of manganese concretions and paler colours in the uppermost subsoil confirms wet soil conditions during part of the year. Rust-coloured mottles throughout the soil suggest at the site a Mottled Orthic Granular Soil would be a better classification. The parent material for the soil is likely the upper Hamilton Ash beds as the soil inspected does not fit the description for the subdominant map unit of Bruce (1978) or that in Smap. The soil at the site is imperfectly drained.

Figure 7a. Auger profile of the soil at Site 6, Wainui reserve, to 55-cm soil depth.

Figure 7b. Landscape at Site 6.

Site 7. Wainui reserve. Location -37.812040 174.836445

In the vicinity Bruce (1978) mapped these soils as Raglan soils plus Horea soils. Raglan soils are developed in the upper bed of Hamilton Ash overlying beds of the same formation. Bruce (1978) notes that surface drainage is rapid but internal drainage is impeded by the very firm clay subsoil and the soil is only moderately well drained. Because of its heavy texture the soil is prone to compaction and structural deterioration under stocking in winter. Horea soils are developed on weathered sand with some admixture of volcanic ash (Bruce 1978). At this site, soils developed in Hamilton Ash beds are favoured over Horea soils as the soil inspected do not have sandy clay textures (Bruce 1978) in the subsoil.

Smap records the map unit as 60% Opita_2a.1, a Typic Orthic Granular Soil (Hewitt 2010). These soils are deep (>1 m) moderately well drained soils with no slowly permeable layer (<4 mm/h) and permeability of the slowest layer within 1 m is between 4 and 72 mm/h. Bypass flow, whereby water and entrained nutrients/contaminants move to depth rapidly with restricted amelioration, is reported as high. Price_4b.2 is a Typic Orthic Brown Soil (Hewitt 2010) and covers 40% of the map unit. The Brown Soils cover the Horea soils of Bruce (1978).

Site visit: Auger observations confirmed soils developed in Hamilton Ash beds and soils having a firm clayey subsoil. The uppermost subsoil was slightly paler than the lower subsoil, suggesting water movement through the soil is not uniform and permeability in the lower subsoil is slower than in the upper subsoil. Lateral flow within the soil, on sloping ground, should be considered. The soil at the site was moderately well drained.

Figure 8a. Auger profile of the soil at Site 7, Wainui reserve, to 55-cm soil depth.

Figure 8b. Landscape at Site 7.

6 Conclusions

From a soil perspective alone, soils at Site 2, Te Hutewai Road, have the most potential for land application of treated wastewater because of their useful permeability and ability to absorb phosphorus within the soil. Sandy soils at the airfield (Site 4) also have useful permeability to accept treated wastewater but limited ability to absorb chemicals entrained in the treated wastewater. Clayey soils at sites 1, 3, 5, 6, and 7 would need high levels of irrigation management to avoid waterlogged conditions as all the clayey soils were judged (based on their morphology) to have slower permeability in the subsoil compared with the topsoil and could lead to lateral flow within the soil, on sloping ground.

7 References

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