PATTLE DELAMORE PARTNERS LTD

Russell Landfill Options Assessment

Far North District Council

Russell Landfill Options Assessment

Prepared for

Far North District Council

June 2022

PATTLE DELAMORE PARTNERS LTD
Level 5, PDP House
235 Broadway, Newmarket, Auckland 1023
PO Box 9528, Auckland 1149, New Zealand

Office +64 9 **523 6900**
Website **http://www.pdp.co.nz**
Auckland Tauranga Hamilton Wellington
Christchurch Invercargill

solutions for your environment

Quality Control Sheet

TITLE	Russell Landfill Options Assessment
CLIENT	Far North District Council
VERSION	Final
ISSUE DATE	17 June 2022
JOB REFERENCE	A03889701
SOURCE FILE(S)	A03889701R001_Russell Landfill Options Assessment_FINAL.docx

DOCUMENT CONTRIBUTORS

Prepared by

SIGNATURE

Dave Stafford

Reviewed and Approved by

SIGNATURE

Alan Pattle

Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Far North District Council and others (not directly contracted by PDP for the work), including Northland Waste Ltd. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of Far North District Council for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Table of Contents

SECTION		PAGE
1.0	Introduction	1
1.1	Background	1
2.0	Aim of Assessment	1
2.1	Project Objectives	1
3.0	Current Landfill Status	2
3.1	Key Source of Information	2
3.2	Site Inspection	2
3.3	Key Findings	3
4.0	Options to be Assessed	5
4.1	Option 1 – Immediate closure	5
4.2	Option 2 – Landfill expansion & continued long-term landfill operation	5
4.3	Option 3 – Continued short-term landfill operation to maximise fill capacity, followed by planned closure	6
5.0	Option Scoping	6
5.1	Option 1 Scope – Immediate Closure	7
5.2	Option 2 Scope – Landfill expansion & continued long-term landfill operation	11
5.3	Option 3 Scope – Continued short-term landfill operation to maximise fill capacity followed by planned closure	16
6.0	Risk Assessment	21
7.0	Cost Estimate	24
7.1	CAPEX	24
7.2	OPEX	24
7.3	Cost Summary	25
8.0	Assessment Process	26
8.1	Multi Criteria Analysis (MCA) Framework	26
8.2	Criteria Definition	26
8.3	Weighting	30
8.4	Scoring	31
9.0	MCA Results	31
9.1	Non-Cost Assessment	31
9.2	Final Results	32
9.3	Sensitivity Analysis	33

10.0 Conclusion 34

11.0 References 34

Table of Tables

Table 1: Option 1 – Scope and Investment Cost Estimate 7

Table 2: Option 2 – Scope and Investment Cost Estimate 11

Table 3: Option 3 – Scope and Cost Estimate 16

Table 4: Option 1 Risk Register 21

Table 5: Option 2 Risk Register 22

Table 6: Option 3 Risk Register 24

Table 7: 'Whole of Life' Cost Summary 25

Table 8: Cost Criteria Definition 27

Table 9: Risk Criteria Definition 27

Table 10: Environment Criteria Definition 28

Table 11: Social Impact Criteria Definition 29

Table 12: Cultural Impact Criteria Definition 29

Table 13: Strategy & Logistics Criteria Definition 30

Table 14: Scoring System[1] 31

Table 15: Scoring Summary of MCA (non-cost) 32

Table 16: Final MCA Assessment Results[1] 32

Table 17: Sensitivity Analysis Summary 33

Appendices

Appendix A: Site Photographs

1.0 Introduction

Pattle Delamore Partners Ltd (PDP) have been engaged by Far North District Council (FNDC) to review the existing condition of the Russell Landfill and develop a structured decision-making framework to help FNDC decide the best future for the Russell Landfill following resource consent expiration (30 April 2023).

1.1 Background

The Russell Landfill is an unlined municipal facility situated adjacent to the Russell WWTP at the head of an unnamed Uruti Bay tributary.

The site currently consists of a transfer station (accessible from Florance Avenue to the north) and a sloped fill area, the toe of which extends to an unclassified 'wetland' to the south-east (referred to as the 'Raupo Swamp', associated with the Uruti Bay tributary).

The site has been operated for approximately 50 years, initially as an 'uncontrolled' activity. Given the age of the fill site the landfill is understood to be unlined.

Resource consent for solid waste disposal at the landfill expires 30 April 2023. Following which time, a decision must be made regarding the future use of the landfill.

The landfill is currently non-operational due to operator (Northland Waste Ltd) concerns regarding geotechnical stability of the placed fill. Northland Waste Ltd have subsequently recommended FNDC to immediately cease using the landfill and seek geotechnical specialist advise before any fill activity can recommence.

Since the Russell Landfill's closure, collected waste is currently being transported and disposed of at the Puwera Landfill, Whangarei.

2.0 Aim of Assessment

The overall aim of this assessment is to determine the most beneficial option for the future of the landfill site.

2.1 Project Objectives

In order to achieve the above aim, the following project objectives are defined to guide the scope of works.

- Determine the current state of the landfill with regards to geotechnical risk and environmental compliance.
- Determine the consenting risk and associated requirements to meet MfE (Ministry for the Environment) landfill guidelines for the following FNDC defined options.

1. Closure
2. Continued long-term landfill operation
3. Continued short-term use with planned closure.

Each of the above options are presented in detailed as part of this assessment.

- Develop a scope and high-level cost estimate for each option.
- Develop a Multi-Criteria-Analysis (MCA) to rank options as a framework to aid structured decision-making. The MCA will incorporate investment costs associated with geotechnical, environmental, engineering and consenting requirements, as well as qualitative assessment of social, cultural and strategic considerations for each option.
- Deliver a report to FNDC detailing the above assessment to inform stakeholder decision making, including concise table presentation of the MCA outcomes.

3.0 Current Landfill Status

3.1 Key Source of Information

The following reports / source of information have been reviewed as part of this assessment.

- Resource Consent (CON20060478901);
- Landfill Management Plan (VK Consulting, 2002);
- Previously undertaken Geotechnical Assessment (Bruce Judd, 2001);
- Northland Waste Landfill Operation Contract (Contract 07/21/601);
- Anecdotical discussion regarding historic landfill construction and operational practices with FNDC; and
- Site Inspection undertaken by PDP geotechnical engineer, landfill engineering and environmental specialists.

3.2 Site Inspection

PDP undertook a site inspection on 29 March 2022 to assess the existing landfill condition. The inspection was undertaken by qualified landfill engineering, geotechnical and environmental management specialists.

In the absence of any previous intrusive geotechnical or environmental sampling investigations, an initial site inspection by experienced technical specialists was required to determine the sites' existing condition with regards to the following key areas:

Geotechnical

- Visual evidence of instability (slips and slope subsidence);
- Fill placement ('Terrace' structure and compaction);
- Angle of battered slopes;
- Composition of fill material;
- Stormwater control / diversion.

Environmental

- Leachate collection system;
- Visible discharge of leachate (seep zones);
- Inspection of receiving environment (Wetland);
- Inspection of 'daily', 'intermediate' and 'final cover'.
- Odour.

3.3 Key Findings

The following section provides a summary of the landfill condition based on a review of available information, anecdotal discussion with FNDC and visual inspection of the landfill site.

Annotated site photos from the recent site inspection are presented in Appendix A.

Geotechnical Observations

- The Russell Landfill is a valley in-fill site. The landfill generally comprises of a sloped fill area from the elevated northern landfill boundary (head of valley accessible off Florence Avenue) to the down-gradient south-eastern landfill boundary, immediately adjacent to the Raupo Swamp. The topography of the landfill comprises an elevated level area to the north and two battered slopes separated by a central bench, accessed via ramp cut down the eastern site boundary.

- There are no visual signs of any scarps, cracking or excessive hammocking indicative of any significant movement of the placed fill;

- Evidence of a small slump was observed at the base of the main ramp to central bench;

- The top of the landfill (northern fill area), adjacent to the transfer station has been levelled and a gravel pad has been created to accommodate several containers associated with waste recycling. It is unknown if the fill has been suitably prepared and capped prior to gravel/container placement. No assessment of the potential effect of loading the upper landfill area on slope stability has been made. It is recommended that slope failure assessment is undertake to quantify this potential risk.

- The upper slope (approximately 4:1, above the central bench) is the active fill area. At the time of site inspection, intermediate cover was being placed by an excavator across this area.
- The lower fill slope (below the central bench) is a steep (approximately 3:1), un-terraced fill slope extending approximately 200 m from the central bench to the landfills south-eastern boundary immediately abutting the downgradient Raupo Swamp. This old fill area is densely vegetated. The surface is hummocky, although it was not possible to determine if this is a result of uneven waste placement or settlement.
- Although there are no clear visual signs of significant instability of the landfill, given the age of the fill material and steep unterraced lower slope it is recommended that a desktop slope stability assessment be undertaken. This modelling assessment approach will assess the potential risk of both shallow and deep slope failure across site.

Environmental

- It is understood that given the age and historically 'uncontrolled' nature of the landfill that the fill is unlined. Little is known about the underlying groundwater setting or the estimated volume of leachate generation and discharge to the receiving environment.
- Stormwater from the slopes above the landfill are intercepted by a contoured ring drain, diverted around the landfill and discharged down-gradient to the Raupo Swamp.
- Environmental monitoring is limited to surface water 'grab sampling' from the Uruti Bay tributary. A preliminary review of recent monitoring data indicates minor anoxic conditions but does not suggest any gross contamination of the Raupo Swamp. PDP has not assessed all historic data at this stage.
- There are no groundwater monitoring bores surrounding site to assess the impact to groundwater quality.
- A rudimentary leachate collection 'rock-drain' has been constructed behind the bund at the southern fill boundary (date of construction unknown). The efficacy of the leachate collection system to intercept migrating landfill leachate is unquantified.
- Intercepted leachate is gravity fed to a down-gradient leachate collection chamber to the south of site which is subsequently pumped to the neighbouring wastewater treatment plant (WWTP). The WWTP currently has a maximum leachate acceptance limit of 5 m^3/day (rolling average).
- Preliminary review of pumped leachate volumes from the leachate collection chamber suggests that leachate collection is highly impacted by rainfall run-off. This is either indicative of high rainfall infiltration

across the fill site or poor separation of the stormwater and leachate collection systems. As a result, pumped leachate volumes to WWTP are at times significantly above the maximum daily leachate acceptance limit stipulated by the WWTP consent conditions (AUT.008339.02.03).

4.0 Options to be Assessed

The following options for the future of the Russell Landfill were provided by FNDC. Each option is described in detail below, including key design, consenting and operational considerations.

4.1 Option 1 – Immediate closure

This option proposes to permanently close the Russell Landfill.

No new consent to operate the Russell Landfill will be sought when consent expires in April 2023. However, discharge consents for stormwater, leachate and landfill gas will be required for the closure and aftercare period.

The waste transfer station will be maintained and received waste will be transported and disposed of at Puwera Landfill, Whangarei.

Key Considerations

- Formal closure planning in accordance with WasteMINZ (MfE, 2001) landfill closure guidance will be required to ready the existing fill site for permanent closure. A detailed scope of works for Option 1 is provided in Section 5.
- The Russell Landfill is the only landfill site within the district. The strategic implications of closing the Russell landfill on long-term solid waste management should be considered.

4.2 Option 2 – Landfill expansion & continued long-term landfill operation

This option proposes to seek reconsent for continued long-term landfill operation.

This option aims to extend the life of the Russell Landfill to accept additional waste for a long-term (~30 year) resource consent.

Key Consideration

- There is likely to be consenting challenges associated with attempting to expand the fill volume due to the site's situation (close proximity to wetland and Uruti Bay tributary) and the unlined nature of the historic landfill.
- Given the physical constraints of site, any additional fill will need to be placed on top of the existing fill.

- Because the landfill in unlined, complete closure of the existing fill site will be required prior to any successive fill placement (new consented activity). This will involve capping the historic fill area and the installation of a new leachate collection system on top of the old fill to meet current MfE guidance.
- Detailed assessment of the site's existing impact of the environment will also be required to support any new resource consent application.

A detailed scope of works for Option 2 is provided in Section 5.2.

4.3 Option 3 – Continued short-term landfill operation to maximise fill capacity, followed by planned closure

This option proposes to continue operating the Russell Landfill for approximately 5-6 years until the originally consented fill volume is exhausted, following which the landfill will be closed.

Key Consideration

- It is understood that this option aims to efficiently maximise the remaining landfill area without the requirement for significant design and/or earthworks to facilitate a larger scale landfill expansion (as per Option 2).
- This option will require new resource consents to continue any waste disposal after April 2023.
- This option proposes to fill the remaining landfill capacity under the existing consent. The existing consent however expires in April 2023 and therefore a new consent will need to be sought to progress this option. A short-term consent will require a similar consenting process as per Option 2.

A detailed scope of works for Option 3 is provided in Section 5.3.

5.0 Option Scoping

PDP have developed a preliminary scope of works to advance each option. Each scope has been developed based on technical review of the available information and PDP industry experience on similar landfill projects in New Zealand.

The purpose of this preliminary scoping exercise is to estimate investment cost (CAPEX) and identify project risks associated with scope uncertainly. Where appropriate, a risk-based 'cost multiple' is applied to reflect the perceived level of uncertainty to generate a risk adjusted cost estimate for fair option comparison.

The presented scope of works and rough order costs (ROC) are intended to be conservative pre-concept design level estimates to aid decision making. Scope and costing will require refinement as part of a future stage of works once a preferred option is selected.

5.1 Option 1 Scope – Immediate Closure

Table 1: Option 1 – Scope and Investment Cost Estimate

Preliminary Scope				Rough Order Cost Estimate ($)	Risks / Assumptions	Proposed risk-based Cost Multiple *(Risk Adjusted Cost Estimate)*
1	**Survey & Design**	1.1	**Survey** *To calculate capping material volume and cut/fill for earthworks.*	$20,000	Assumption that there is enough potential capacity to enable a full 30-year consent term.	**Cost Multiplier 1.5x** *$30,000*
		1.2	**Concept Design** *Engineering concept design / drawings to inform landfill improvement works (physical works)*	$30,000	Full extent of earthworks required to close fill site to be confirmed following completion of geotechnical assessment.	**Cost Multiplier 1.5x** *$45,000*
2	**Physical Works**	2.1	**Earthworks** *Required to prepare the site for capping and closure (i.e. vegetation removal, contouring, terracing, construction of down-gradient buttress (if required), stormwater upgrades etc).*	$100,000		**Cost Multiplier 2x** *$200,000*
		1.2	**Engineered fill capping.** *Cost estimate based on indicative material pricing and estimated capping coverage.*	$200,000	Cost of capping / topsoil dependant on source availability, location etc. Final volumes of import to be determined.	**Cost Multiplier 2x** *$400,000*
		1.3	**Topsoil / Revegetation** *Cost estimate based on indicative material pricing and estimated capping coverage.*	$200,000		**Cost Multiplier 2x** *$400,000*
		1.4	**Site security** (fencing partition for waste transfer station etc)	$50,000	Final cost estimate to be confirmed following design of final layout.	**Cost Multiplier 2x** *$100,000*

Table 1: Option 1 – Scope and Investment Cost Estimate

Preliminary Scope				**Rough Order Cost Estimate ($)**	**Risks / Assumptions**	**Proposed risk-based Cost Multiple** *(Risk Adjusted Cost Estimate)*
3	**Assessment of Environmental Effects** *AEE in accordance with MFE best practice to support Resource Consent*	3.1	**Groundwater & Surface Water Assessment of Effects / Leachate Management Plan for Closure** *There is currently no information regarding volume and quality of leachate leakage to the receiving environment. Furthermore, there is limited information on existing leachate collection system and underling hydrogeological setting.* *Baseline monitoring will be required to support an assessment of effects for resource consent. This will involve the construction of groundwater monitoring piezometers and a comprehensive monitoring program (both groundwater and surface-water sampling of the downstream wetland).* *Estimated cost inclusive of drilling new groundwater monitoring bores, groundwater, and surface water sampling, completion of technical report and monitoring plan to support consent application.*	$150,000	Unknown environmental impact of existing fill. Further investigation and/or remediation works may be required following outcome of baseline assessment.	***Cost Multiplier* x1.5** *$225,000*
		3.2	**Geotechnical Risk Assessment** (Slope Stability and Settlement – Desktop Modelling Assessment) *Assess the stability of the current slopes based on the existing survey for both static and seismic conditions (modelling). Settlement will be determined based on engineering judgement and empirical experience on similar landfill projects.*	$25,000	Potential need for intrusive site investigation to support stability assessment.	**Cost Multiplier 2x** *$50,000*

Table 1: Option 1 – Scope and Investment Cost Estimate

Preliminary Scope				Rough Order Cost Estimate ($)	Risks / Assumptions	Proposed risk-based Cost Multiple *(Risk Adjusted Cost Estimate)*
		3.3	**Land Gas Risk Assessment** *In accordance with MFE, Landfill gas generation is considered a human health and safety risk. No previous assessment of landfill gas risk as be undertaken. Landfill gas monitoring will likely be required to define potential risk and support closure plan.*	$25,000	Potential need for additional physical works to mitigate identified gas risk (gas venting / harvesting). To be confirmed following baseline assessment.	**Cost Multiplier 2x** *$50,000*
		3.4	**Stormwater Management Plan** *Alterations and/or updates to the stormwater management plan for long-term site closure.*	$20,000	Potential requirement for further detailed design depending on the scale of earthworks undertaken (i.e. change to existing profile).	**Cost Multiplier x1.5** *$30,000*
		3.5	**Ecological Assessment** *Terrestrial ecological survey required to support AEE.*	$20,000	Potential requirement for freshwater ecological assessment following surface monitoring (see scope item 3.1)	**Cost Multiplier x1.5** *$30,000*
		3.6	**Traffic Management Plan**	$20,000		**Cost Multiplier x1.5** *$30,000*

Table 1: Option 1 – Scope and Investment Cost Estimate

Preliminary Scope				Rough Order Cost Estimate ($)	Risks / Assumptions	Proposed risk-based Cost Multiple *(Risk Adjusted Cost Estimate)*
3	**Resource Consent Application**	3.1	**Consent Application & Stakeholder Engagement** *Estimated costs to prepare and submit consent application including planning and legislative requirements (RMA, regional and district plans)*	$50,000	Potential risk associated with stakeholder opposition and requirement for extensive stakeholder engagement.	***Cost Multiplier* 1.5x** *$75,000*
Total Estimate Cost				$910,000		***$1,665,000 (Risk adjusted)***

5.2 Option 2 Scope – Landfill expansion & continued long-term landfill operation

<table>
<tr><th colspan="7">Table 2: Option 2 – Scope and Investment Cost Estimate</th></tr>
<tr><th colspan="4">Preliminary Scope</th><th>Rough Order Cost Estimate ($)</th><th>Risks / Assumptions</th><th>Proposed risk-based Cost Multiple

(Risk Adjusted Cost Estimate)</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Survey & Design</td><td>1.1</td><td>Survey

To determine achievable new fill volume. Also used to calculate capping material volume and cut/fill for earthworks.</td><td>$20,000</td><td>Assumption that there is enough potential capacity to enable a full 30-year consent term.</td><td>Cost Multiplier 1.5x

$30,000</td></tr>
<tr><td>1.2</td><td>Concept Design

Engineering concept design / drawings to inform landfill improvement works (physical works)</td><td>$50,000</td><td rowspan="3">There is risk associated with constructing a new fill cell on top of an historical landfill of unknown construction.

Major buttressing and/or construction of a large down- gradient toe bund represent significant risk to CAPEX increase. Furthermore, construction of toe-bund on down-gradient site boundary may require major earthworks through old fill material. This would be significantly more expensive (on a m^3 basis).</td><td>Cost Multiplier 1.5x

$75,000</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Physical works

Given the age of the existing fill site, the current landfill will need to be capped and a new leachate collection system installed before additional fill material is placed.</td><td>2.1</td><td>Earthworks for existing fill closure (i.e. vegetation removal, contouring, terracing, construction of down-gradient buttress (if required)).</td><td>$100,000</td><td>Cost Multiplier 3x

$300,000</td></tr>
<tr><td>2.2</td><td>Earthwork for site expansion (buttressing, new toe bund, site boundary upgrades, new stormwater diversion etc.)</td><td>$200,000</td><td>Cost Multiplier 3x

$600,000</td></tr>
</table>

Table 2: Option 2 – Scope and Investment Cost Estimate

Preliminary Scope				Rough Order Cost Estimate ($)	Risks / Assumptions	Proposed risk-based Cost Multiple *(Risk Adjusted Cost Estimate)*
		2.3	**Engineered Fill Capping.** *Placement of engineered capping layer over existing fill site.* *Cost estimate based on indicative material pricing and estimated capping coverage.*	$200,000	Cost of capping / topsoil dependant on source availability, location etc. Final volumes of import to be determined.	**Cost Multiplier 2x** *$400,000*
		2.4	**Leachate Collection System** *A new leachate collection system will need to be installed on top of the capped old fill.* *Cost estimate inclusive of detailed design.*	$200,000	Detailed design and contractor cost estimate	**Cost Multiplier 2x** *$400,000*
		2.5	**Leachate Reticulation** *Upgrades to the existing leachate collection, reticulation, and treatment. Treatment at the adjacent WWTP will need to be confirmed.* *Cost estimate inclusive of detailed design.*	$100,000	Assumption that leachate will continue to be sent to neighbouring WWTP.	***Cost Multiplier 2x*** *$200,000*

Table 2: Option 2 – Scope and Investment Cost Estimate

Preliminary Scope				Rough Order Cost Estimate ($)	Risks / Assumptions	Proposed risk-based Cost Multiple *(Risk Adjusted Cost Estimate)*
3	**Assessment of Environmental Effects** *AEE in accordance with MFE best practice to support Resource Consent*	3.1	**Groundwater & Surface Water Assessment of Effects / Leachate Management Plan for Closure** *There is currently no information regarding volume and quality of leachate leakage to the receiving environment. Furthermore, there is limited information on existing leachate collection system and underling hydrogeological setting.* *Baseline monitoring will be required to support an assessment of effects for resource consent. This will involve the construction of groundwater monitoring piezometers and a comprehensive monitoring program (both groundwater and surface-water sampling of the downstream wetland).* *Estimated cost inclusive of drilling new groundwater monitoring bores, groundwater, and surface water sampling, completion of technical report and monitoring plan to support consent application.*	$150,000	Unknown environmental impact of existing fill. Further investigation and/or remediation works may be required following outcome of baseline assessment.	***Cost Multiplier* x1.5** *$225,000*
		3.2	**Geotechnical Risk Assessment** (Slope Stability and Settlement – Desktop Modelling Assessment)	$25,000	Potential need for intrusive site investigation to support stability assessment.	**Cost Multiplier 2x** *$50,000*

Table 2: Option 2 – Scope and Investment Cost Estimate

Preliminary Scope				Rough Order Cost Estimate ($)	Risks / Assumptions	Proposed risk-based Cost Multiple *(Risk Adjusted Cost Estimate)*
			Assess the stability of the current slopes based on the existing survey for both static and seismic conditions. Settlement will be determined based on engineering judgement and empirical experience on similar landfills projects.			
		3.3	**Land Gas Risk Assessment** *In accordance will MfE landfill closure requirement, Landfill gas generation is considered to be a human health and safety risk consideration. No previous assessment of landfill gas risk as be undertaken. Landfill gas monitoring will likely be required to support closure plan.*	$25,000	Potential need for additional physical works to mitigate identified gas risk (gas venting / harvesting). To be confirmed following baseline assessment.	**Cost Multiplier 2x** *$50,000*
		3.4	**Stormwater Management Plan** *Alternations and/or updates to the stormwater management plan for long-term site closure.*	$20,000	Potential requirement for further detailed design depending on the scale of earthworks undertaken (i.e. change to existing profile).	**Cost Multiplier x1.5** *$30,000*
		3.5	**Ecological Assessment** *Terrestrial ecological survey required to support AEE.*	$20,000	Potential requirement for freshwater ecological assessment following surface monitoring (see scope item 3.1).	**Cost Multiplier x1.5** *$30,000*

Table 2: Option 2 – Scope and Investment Cost Estimate

Preliminary Scope				Rough Order Cost Estimate ($)	Risks / Assumptions	Proposed risk-based Cost Multiple *(Risk Adjusted Cost Estimate)*
		3.6	**Air Quality & Odour**	$20,000		**Cost Multiplier x1.5** *$30,000*
		3.7	**Traffic Management Plan**	$20,000		**Cost Multiplier x1.5** *$30,000*
4	**Resource Consent Application** (Land discharge consent)	4.1	**Stakeholder Engagement** *To include social and cultural engagement with iwi and local communities.*	$50,000	Potential risk associated with opposition and requirement for extensive stakeholder engagement.	**Cost Multiplier x3** *$150,000*
		4.2	**Consent Application** *Estimated costs to prepared and submit consent application based on the above detailed AEE as well as all planning and legislative requirements (RMA, regional and district plans)*	$50,000		***Cost Multiplier* 3x** *$150,000*
5	**Closure Planning** *Landfill closure at the end of the landfill life (allowing for 30 year aftercare).*		Scope and associated costs as per Option 1.	$910,000	See Option 1	$1,665,000
Total Estimated Cost				$2,160,000		*$4,425,000 (Risk adjusted)*

5.3 Option 3 Scope – Continued short-term landfill operation to maximise fill capacity followed by planned closure

Table 3: Option 3 – Scope and Cost Estimate

<table>
<tr><th colspan="4">Preliminary Scope</th><th>Rough Order Cost Estimate ($)</th><th>Risks / Assumptions</th><th>Proposed risk-based Cost Multiple
(Risk Adjusted Cost Estimate)</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Survey & Design</td><td>1.1</td><td>Survey
To determine achievable new fill volume. Also used to calculate capping material volume and cut/fill for earthworks.</td><td>$20,000</td><td>Assumption that there is capacity to enable continued fill activity.</td><td>Cost Multiplier 1.5x
$30,000</td></tr>
<tr><td>1.2</td><td>Concept Design
Engineering concept design / drawings to inform landfill improvement works (physical works)</td><td>$50,000</td><td rowspan="2">There is risk associated with constructing a new fill cell on top of an historical landfill of unknown construction.</td><td>Cost Multiplier 1.5x
$75,000</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Physical works
Given the age of the existing fill site, the current landfill will need to be capped and a new leachate collection system installed before additional fill material is placed.</td><td>2.1</td><td>Earthworks for existing fill closure (i.e. vegetation removal, contouring, terracing, construction of down-gradient buttress (if required)).</td><td>$100,000</td><td>Cost Multiplier 3x
$300,000</td></tr>
<tr><td>2.2</td><td>Engineered Fill Capping.
Placement of engineered capping layer over existing fill site.
Cost estimate based on indicative material pricing and estimated capping coverage.</td><td>$200,000</td><td>Cost of capping / topsoil dependant on source availability, location etc. Final volumes of import to be determined.</td><td>Cost Multiplier 2x
$400,000</td></tr>
</table>

Table 3: Option 3 – Scope and Cost Estimate

Preliminary Scope				Rough Order Cost Estimate ($)	Risks / Assumptions	Proposed risk-based Cost Multiple *(Risk Adjusted Cost Estimate)*
		2.3	**Leachate Collection System** *A new leachate collection system will need to be installed on top of the capped old fill.* *Cost estimate inclusive detailed design.*	$200,000	Detailed design and contractor cost estimate	**Cost Multiplier 2x** *$400,000*
		2.4	**Leachate Reticulation** *Upgrades to the existing leachate collection, reticulation, and treatment. Treatment at the adjacent WWTP will need to be confirmed.* *Cost estimate inclusive detailed design.*	$100,000	Assumption that leachate will continue to be send to neighbouring WWTP.	***Cost Multiplier* 2x.**
3	**Assessment of Environmental Effects** *AEE in accordance with MFE best practice to support Resource Consent*	3.1	**Groundwater & Surface Water Assessment of Effects / Leachate Management Plan for Closure** *There is currently no information regarding volume and quality of leachate leakage to the receiving environment. Furthermore, there is limited information on existing leachate collection system and underling hydrogeological setting.* *Baseline monitoring will be required to support an assessment of effects for resource consent. This will involve the construction of groundwater monitoring piezometers and a comprehensive monitoring program (both groundwater and*	$150,000	Unknown environmental impact of existing fill. Further investigation and/or remediation works may be required following outcome of baseline assessment.	***Cost Multiplier* x1.5** *$225,000*

Table 3: Option 3 – Scope and Cost Estimate

Preliminary Scope				Rough Order Cost Estimate ($)	Risks / Assumptions	Proposed risk-based Cost Multiple *(Risk Adjusted Cost Estimate)*
			surface-water sampling of the downstream wetland). *Estimated cost inclusive of drilling new groundwater monitoring bores, groundwater, and surface water sampling, completion of technical report and monitoring plan to support consent application.*			
		3.2	**Geotechnical Risk Assessment** (Slope Stability and Settlement – Desktop Modelling Assessment) *Assess the stability of the current slopes based on the existing survey for both static and seismic conditions. Settlement will be determined based on engineering judgement and empirical experience on similar landfills projects.*	$25,000	Potential need for intrusive site investigation to support stability assessment.	**Cost Multiplier 2x** *$50,000*
		3.3	**Land Gas Risk Assessment** *In accordance will MfE landfill closure requirement, Landfill gas generation is considered to be a human health and safety risk consideration. No previous assessment of landfill gas risk as be undertaken. Landfill gas monitoring will likely be required to support closure plan.*	$25,000	Potential need for additional physical works to mitigate identified gas risk (gas venting / harvesting). To be confirmed following baseline assessment.	**Cost Multiplier 2x** *$50,000*

Table 3: Option 3 – Scope and Cost Estimate

Preliminary Scope				Rough Order Cost Estimate ($)	Risks / Assumptions	Proposed risk-based Cost Multiple *(Risk Adjusted Cost Estimate)*
		3.4	**Stormwater Management Plan** *Alternations and/or updates to the stormwater management plan for long-term site closure.*	$20,000	Potential requirement for further detailed design depending on the scale of earthworks undertaken (i.e. change to existing profile).	**Cost Multiplier x1.5** *$30,000*
		3.5	**Ecological Assessment** *Terrestrial ecological survey required to support AEE.*	$20,000	Potential requirement for freshwater ecological assessment following surface monitoring (see scope item 3.1)	**Cost Multiplier x1.5** *$30,000*
		3.6	**Air Quality & Odour**	$20,000		**Cost Multiplier x1.5** *$30,000*
		3.7	**Traffic Management Plan**	$20,000		**Cost Multiplier x1.5** *$30,000*
4	**Resource Consent Application** (Land discharge consent)	4.1	**Stakeholder Engagement** *To include social and cultural engagement with iwi and local communities.*	$50,000	Potential risk associated with opposition and requirement for extensive stakeholder engagement.	**Cost Multiplier x2** *$100,000*
		4.2	**Consent Application** *Estimated costs to prepared and submit consent application based on the above detailed AEE as*	$50,000		***Cost Multiplier 2x*** *$100,000*

Table 3: Option 3 – Scope and Cost Estimate

Preliminary Scope				Rough Order Cost Estimate ($)	Risks / Assumptions	Proposed risk-based Cost Multiple *(Risk Adjusted Cost Estimate)*
			well as all planning and legislative requirements (RMA, regional and district plans)			
5	**Closure Planning** *Landfill closure at the end of the landfill life (allowing for 30-year aftercare).*		Scope and associated costs as per Option 1.	$910,000	See Option 1	*$1,665,000*
Total Estimated Cost				$1,960,000		*$3,715,000 (Risk adjusted)*

6.0 Risk Assessment

An initial risk assessment has been undertaken to highlight key risks for each option.

Risks associated with investment CAPEX is summarised in Section 5.0. Cost risks are presented in the below risk registers in addition to non-cost risks associated with resource consent, environmental, social, cultural and strategic considerations.

Option 1

Table 4: Option 1 Risk Register

Phase of Works	Risk Category	Risk
Physical Works	Cost	• Cost of imported capping (clay) and topsoil dependant on source availability and location. Final volumes of import material to be determined following survey.
Assessment of Environmental Effects	Environmental	• Unknown environmental impact of existing fill on receiving groundwater and surface water.
	Cost	• Potential requirement for extensive leachate monitoring and/or remediation. • Unknown landfill gas generation prior to detailed assessment. Potential need to gas venting / flaring infrastructure.
Resource Consent Application Process	Cost	• Risk of potential cost increase due to stakeholder engagement.
Operation (Transfer and disposal to Purewa Landfill)	Strategy	• By closing the Russell Landfill, FNDC are committed to long-term solid waste transfer out of district. This may reduce flexibility of waste management within the district and create dependency on third-party contractors to transfer and disposal of waste.

Table 4: Option 1 Risk Register		
Phase of Works	**Risk Category**	**Risk**
		• FNDC will have limited control over the end point of waste disposal. For example, what is the lifespan of the Puwera Landfill and will FNDC have long-term assurance to transfer waste? • Reduced contingency in the event that waste cannot to transferred out of district. For example, road closure, ferry limits to heavy vehicles etc.
	Logistics	• Additional truck movements may face opposition.
	Cost	• Limited long-term contractor cost control due to dependency.

Option 2

Table 5: Option 2 Risk Register		
Phase of Works	**Risk Category**	**Risk**
Physical Works	Cost	All as per Option 1 (see Table 4), plus the addition of the following: • Prior to completion of detail Geotechnical Assessment, the potential requirement for major buttressing and/or construction of a large down- gradient toe bund represent significant risk to CAPEX increase. • Construction of toe-bund on down-gradient site boundary may require major earthworks through old fill material. This would be significantly more expensive on a cost per cube (m^3) of earth moved. • Contractor cost estimate to construct leachate collection system.

Table 5: Option 2 Risk Register

Phase of Works	Risk Category	Risk
Assessment of Environmental Effects	Cost, Consenting	• Unknown volume of leachate generation prior to detailed design / Leachate Management Plan. Leachate collection volumes on new fill likely to exceed WWTP daily acceptance limit (5 m^3/day). • Potential requirement for costly WWTP upgrades to accept collected leachate volume.
Resource Consent Application Process	Consenting	• Key consenting risk associated with community and/or iwi opposition to landfill expansion. • Loss of existing community led recycling activity to accommodate new fill. May result in community opposition.
	Cost	• Potential for significant cost increase to undertake prolonged stakeholder engagement.
Operation (Expanded Russell Landfill)	Risk	• Operational Health and Safety concerns associated with public access to operational landfill and operator safety.
	Strategy	• Operation the landfill asset may be considered to be a FNDC liability.
	Logistics	• Engagement of a limited number of suitably qualified landfill operators in the district.
	Cost	• Costly long-term monitoring requirements.
	Environmental	• Continued landfill operation carries risk of future environmental impact (contaminated leachate migration, air quality, ecological degradation etc)

Option 3

Table 6: Option 3 Risk Register		
Phase of Works	**Risk Category**	**Risk**
Physical Works	Cost	All as per Option 2 (see Table 5)
Assessment of Environmental Effects	Cost	All as per Option 2 (see Table 5)
Resource Consent	Risk	All as per Option 2 (see Table 5)
Operation	Strategy, Logistics, Cost, Environment	All as per Option 2 (see Table 5)

7.0 Cost Estimate

7.1 CAPEX

Estimated CAPEX (investment cost) is outlined in in Section 5.0. CAPEX summary of each option is presented in Table 7 below.

7.2 OPEX

To accurately compare each option's 'whole of life' cost, estimated operational costs (OPEX) are considered.

The 'whole of life' timeframe for each option is assumed to be 30 years for fair comparison. This lifespan is based upon the typically sought consent period for a new landfill activity (as per Option 2).

OPEX cost for each option have been generated based on the recent Northland Waste Ltd contract cost comparison between Russell landfill operation and 'transfer and disposal' to Puwera Landfill (Contract 07/21/601). Northland Waste Ltd consent costs provided by FNDC (May 2022).

OPEX costs are inclusive of Northland Waste Ltd contract costs, Waste Levy and Carbon Credits. Future OPEX forecasting has be made based on known short-term cost increases to the waste levy and carbon credit system (FNDC Comms. May 2022). Long-term, a 5% annual inflation is assumed across all costs.

It is recognised that there is significant uncertainly associated with predicting future operational costs for both landfill operation and waste transfer. Nevertheless, the OPEX estimate presented is considered to provide fair cost comparison suitable for the proposes of decision making.

7.3 Cost Summary

Option 1 (landfill closure) is identified as the cheapest CAPEX and OPEX solution with a total 'whole of life' cost estimate of $12.5M over the next 30 years.

Options 2 is the most costly option with regards to both initial CAPEX and OPEX with a 'whole of life' cost estimate of $23.5M.

The ranking for cost has been assigned as a percentage of the total 'whole of life' cost estimate for each option. The lowest cost is given a score of 100%. Each option is subsequently ranked as a percentage of the lowest cost option.

The integration of cost rankings with non-cost criteria into the MCA is discussed in detail in the following Sections.

Table 7: 'Whole of Life' Cost Summary

Phase of Works	Cost Estimate ($) *(Risk Adjusted)*[1]		
	Option 1	Option 2	Option 3
CAPEX			
Survey & Design	$75,000	$105,000	$105,000
Physical Works	$1,100,000	$1,900,000	$1,300,000
Assessment of Environmental Effects	$415,000	$455,999	$445,000
Resource Consent Application	$75,000	$300,000	$200,000
Closure Plan	-	$1,665,000	$1,665,000
Total CAPEX	**$1.665M**	$4.425M	$3.715M
Total OPEX	**$10.8M**	$19.1M	$12.1M
Total 'Whole of Life' Cost	**$12.5M**	$23.5	$15.8M
Score	**100%**	53%	79%

Notes:
1. *Presented costs are 'risk adjusted' to reflect uncertainty associated with CAPEX and future cost inflation ('whole of life').*
2. *Highest ranked option shown in **bold.***

8.0 Assessment Process

A Multi-criteria Analysis (MCA) has been developed to provide a structured and transparent framework on which the three options can be compared.

The following sections outline the MCA framework including criteria section, definition, weighting and assessment scoring.

PDP has developed the following MCA framework based on industry standard guidelines specifically developed to aid long-term infrastructure decision-making (Australian Infrastructure, 2021 & UK Government Publication, 2009).

8.1 Multi Criteria Analysis (MCA) Framework

The aim of the Multi-Criteria-Analysis (MCA) is to combine cost and non-cost (consenting, social, cultural & strategy) elements of each option into a clearly defined, structured decision-making framework to enable FNDC and elected members to make an informed decision.

MCA process consists of the following stages:

1. Establish a decision context - define the purpose of the MCA and decision makers.
2. Identify options to be assessed
3. Define assessment criteria (agreed to by decision makers)
4. Define criteria scoring (agreed to by decision makers)
5. Define criteria weighting (agreed to by decision makers)
6. Combine the weights and scores for an overall option score
7. Undertake a sensitivity analysis
8. Provide recommendation on outcome.

8.2 Criteria Definition

The following criteria have been selected to assess each option against.

These industry standard criteria are considered to be appropriate given the nature and complexity of the Russell Landfill assessment.

Each criterion is discussed in detail below.

Sub-criteria under each project outcome have been developed to define each criteria's measurable outcomes more clearly. Selected criteria are presented below.

- Cost
- Risk

- Environment
- Social
- Cultural
- Strategic & Logistical Considerations

Cost

Table 8: Cost Criteria Definition

Outcome	Outcome	Definition	Measurement
Cost effective management and disposal of solid waste.	**C1** – CAPEX Upfront investment cost.	Whole of life cost including CAPEX & OPEX.	Rough order cost estimate (CAPEX) provided by PDP.
	C2 – OPEX Operational cost estimate over the duration of the consent term.		OPEX estimate by PDP based on existing Northland Waste Ltd contact rates (provided by FNDC).

Risk

Table 9: Risk Criteria Definition

Outcome	Criteria	Definition	Measurement
Overall project risk management to best practical extent	**R1 –**Consenting & Legal	Risk associated with achieving resource consent and avoidance of potential legal action.	Qualitative assessment of perceived risk. Feedback to be sought from decision makers.
	R2 – Timeframe	Not meeting timeframes set out by FNDC	
	R3 – Operational Risk	Risks associated with ongoing operation of the landfill, including; health and safety compliance, risk to property and people and/or potential environmental impact.	

Environment

Table 10: Environment Criteria Definition

Outcome	Criteria	Definition	Measurement
Long-term environmental impact of the landfill with regards to potentially adverse effects on area ecology, landscape and recreation are to be minimised.	**E1 –** Ecology (Terrestrial and Freshwater)	The impact on self-sustainability and inter-relationships among plants, animals and insects.	The degree of change compared to the existing environment
	E2 – Landscape	The impact on the character of sites and places and their aesthetic qualities.	A degree of change compared to the existing environment
Temporary effects from construction are to be managed as best as practicable.	**E3 –** Construction	Effect of construction activities of the option including the natural environment, traffic, noise, disruption to public and services, health and safety risk, damage to assets and/or access to private property.	The degree of adverse effects from construction activities.

Social

Table 11: Social Impact Criteria Definition

Outcome	Criteria	Definition	Measurement
Long-term environmental impact of the landfill with regards to potentially adverse effects to social cohesion and community are to be minimised.	**S1 –** Community Impact (Social & Recreation)	The option recognised the social value of the site, including existing value and future potential value (recreation etc.) to the local community.	Qualitative assessment of impact – recreation, community use, cohesion, health and wellbeing. Feedback to be sought from decision makers.

Cultural

Table 12: Cultural Impact Criteria Definition

Outcome	Criteria	Definition	Measurement
Long-term environmental impact of the landfill with regards to potentially adverse effects to culture and heritage are to be minimised.	**H1 –** Culture & Heritage	The impact on sites and activities of historical and/or cultural significance. The impact on local heritage protection groups and Iwi/Hapū views of the sites existing and potential resource and value.	Qualitative assessment of cultural impact. Alignment to FNDC Significance and Engagement Policy (2021) and Iwi/ Hapū Management Plan Policy (2016) FNDC to lead to assessment to ensure due consideration.

Strategy & Logistical Considerations

Table 13: Strategy & Logistics Criteria Definition

Outcome	Criteria	Definition	Measurement
Long term strategic / logistical consideration to regional waste management.	**L1 –**Strategy	Assess the strategic value of the landfill to FNDC to meet long-term waste management aims.	Qualitative assessment of strategic value and logistic considerations. Feedback from FNDC required.
	L2 – Logistics	Logistical consideration of options (contractor engagement etc).	

8.3 Weighting

In the simplest form, MCA weighting can be applied equally to all assessment criteria. This is typically appropriate where there is broad agreement concerning equal importance of each criterion. This approach is generally less contentious as it avoids perceived decision-maker bias. Alternatively, in more complex applications, MCA weightings can be used to place emphasis on key criterion either to align with key objectives or where there is minimal concern/objection to certain criterion.

It is recommended that decision-maker and stakeholder engagement be sought as part of the criteria weighting process.

For the purposes of this assessment criteria weighting is equal.

FNDC to provide feedback regarding the weighting.

8.4 Scoring

Each assessment criteria are assigned a numerical score between 1 and 5. A higher MCA score indicates a more favourable option. The scale and magnitude of each score in defined is Table 14 below.

Important Note

Scoring of non-cost criteria can be subjective depending on the point of view of the decision maker. It is therefore recommended that a 'workshop' discussion is undertaken to collectively decide on criterion scoring to encompass the collective priorities of all stakeholders.

Table 14: Scoring System[1]

Magnitude	Score	Description
Strong Positive	5	Strong positive impact for the criteria or measure
Moderate Positive	4	Moderate positive impact
No Significant Impact	3	Neutral. No significant positive or negative impact
Moderate Negative	2	Moderate negative impact
Strong Negative	1	Strong negative impact

Notes:
1. *Recommended criteria scoring system from Infrastructure Australia 2021.*

9.0 MCA Results

9.1 Non-Cost Assessment

Table 15 summaries the comparative scores for each option based on the MCA (non-cost) assessment criteria.

Important Note

MCA scoring of non-cost assessment criteria is subjective based on the perceived importance of criteria to stakeholder / decision-makers. The scores presented by PDP are to be considered a preliminary score only at this time, pending review by FNDC and other stakeholder groups considered critical to the decision-making process.

Table 15: Scoring Summary of MCA (non-cost)			
Criteria	**MCA Scoring**		
	Option 1	**Option 2**	**Option 3**
Risk	4	2	3
Environment	4	2	2
Social Impact	5	2	2
Cultural Impact	5	2	2
Strategy & Logistics Considerations	2	4	4
Total	**20**	12	13
Percentage[2]	**80%**	48%	52%

Notes:

1. *Highest ranked option in* ***bold.***
2. *Percentages are determined by MCA total non-cost assessment score divided by the maximum potential score of 25.*

9.2 Final Results

Combining both the non-cost (Table 15) and cost (Table 7) MCA assessment criteria gives a final score for each option.

Table 16 presents the overall weighted scores for each option as a percentage score. All non-cost and cost scores have been given an equal weighting.

Final weighting to be determined following FNDC review.

Table 16: Final MCA Assessment Results[1]			
Criteria	**MCA Scoring**		
	Option 1	**Option 2**	**Option 3**
Sum of non-cost assessment[2]	**80%**	48%	52%
Sum of cost assessment	**100%**	53%	79%
Total Score	**83%**[1]	49%	57%

Notes:

1. *MCA is equally weighted across all 6 assessment criteria each with a 1/6th weighting.*
2. *Percentages are determined by MCA total non-cost assessment score divided by the maximum potential score of 25. Non-cost assessment accounts for 5/6th weighting.*
3. *Percentages are determined as per 'whole of life' cost estimate with lowest score getting 100%.*

Option 1, 'Landfill Closure' scored the highest overall (83% total scoring). Option 1 scored highest for both cost and non-cost based assessment criteria.

9.3 Sensitivity Analysis

To assess the relative impact of criteria weighting on the overall MCA outcome, a sensitivity analysis has been undertaken. The weighting of each criterion has been systematically increased (relative to other criterion) to quantify the sensitivity of MCA to each criterion assessed.

Table 17 shows the impact of doubling the weighting of each criterion in turn on the MCA outcome.

Based on the preliminary scoring of the MCA, the sensitivity analysis shows no change to the overall outcome of the MCA. This suggests a general robustness of the MCA findings.

Table 17: Sensitivity Analysis Summary

Criteria	Final MCA Score[1]		
	Option 1	Option 2	Option 3
Equal Weighting	**83%**	49%	57%
2x Weighting to Cost	**86%**	49%	60%
2x Weighting to Risk	**83%**	48%	57%
2x Weighting to Environment	**83%**	48%	52%
2x Weighting to Social Impact	**86%**	48%	54%
2x Weight to Cultural Impact	**86%**	48%	54%
2x Weighting to Strategy / Logistics	**77%**	53%	60%

Notes:

1. *Final MCA score inclusive of both non-cost and cost criterion.*
2. *Percentages are determined by MCA total non-cost assessment score divided by the maximum potential score of 25. Non-cost assessment accounts for 5/6th weighting.*
3. *Percentages are determined as per 'whole of life' cost estimate with lowest score getting 100%.*
4. *Highest scoring option highlighted in **bold.***

10.0 Conclusion

Based on the MCA undertaken, closure of the Russell landfill (Option 1) is identified as the preferred option based on both cost and non-cost criteria.

Preliminary scope of works required to advance Option 1 is outlined in Table 1. Recommended next stage of works is as follows:

- Geotechnical Risk Assessment;
- Concept Design to inform required engineering works; and
- Groundwater / Surface Water Assessment of Effects to support resource consent.

11.0 References

Bruce Judd Consultancy (2001) Geotechnical Investigation of the Russell Landfill. Report prepared for Far North District Council (August, 2001)

Department for Communities and Local Government (2009) Multi-criteria analysis: a manual. UK Government Publication (January 2009).

Far North District Council (2016) Iwi/Hapu (Environmental) Management Plans Policy.

Infrastructure Australia (2021) Technical guide of the Assessment Framework: Guide to multi-criteria analysis (July, 2021)

Ministry for the Environment (2001) A Guide for the Management of Closing and Closed Landfill in New Zealand.

Northland Waste Ltd (2021) Russell Landfill Operation Waste and Recycling Contract 07/21/601 (Variation Agreement dated 16 August 2021).

VK Consulting Environmental Engineers Ltd (2002) Russell Landfill Management Plan. Report prepared for Far North District Council (July, 2002).

Appendix A: Site Photographs

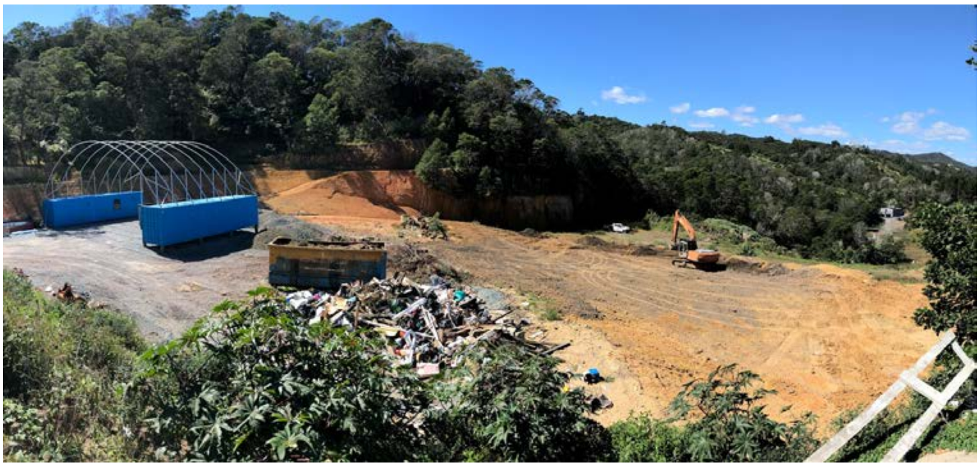

Photo 1: View looking east from waste transfer station.

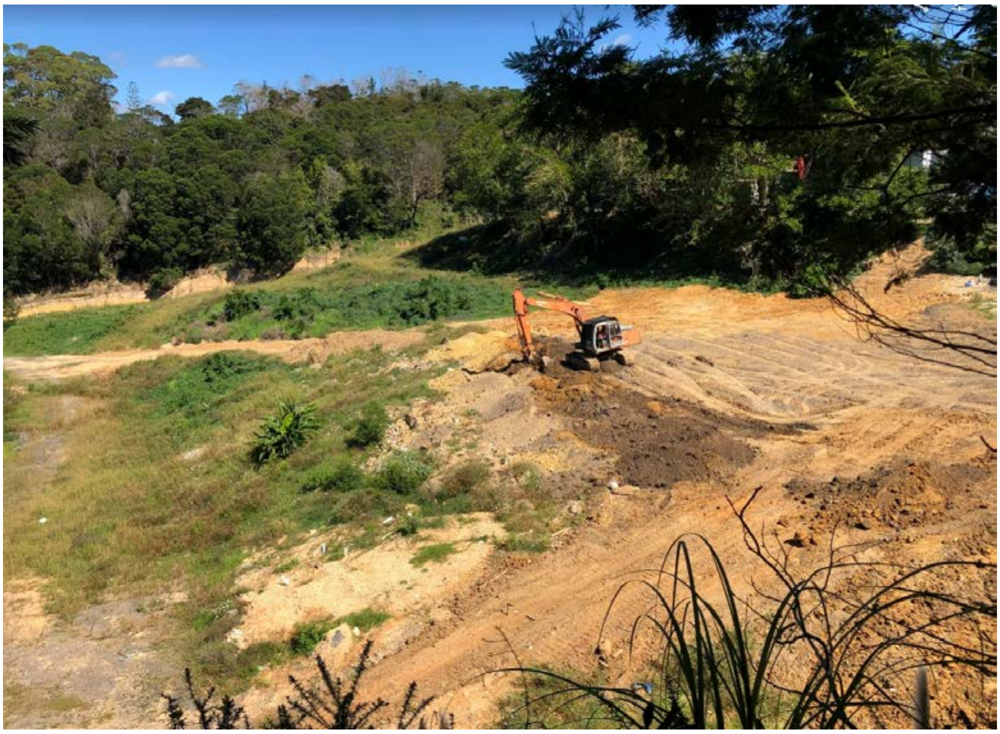

Photo 2: View looking west. Central bench (left of photo), working slope (right of photo) above bench.

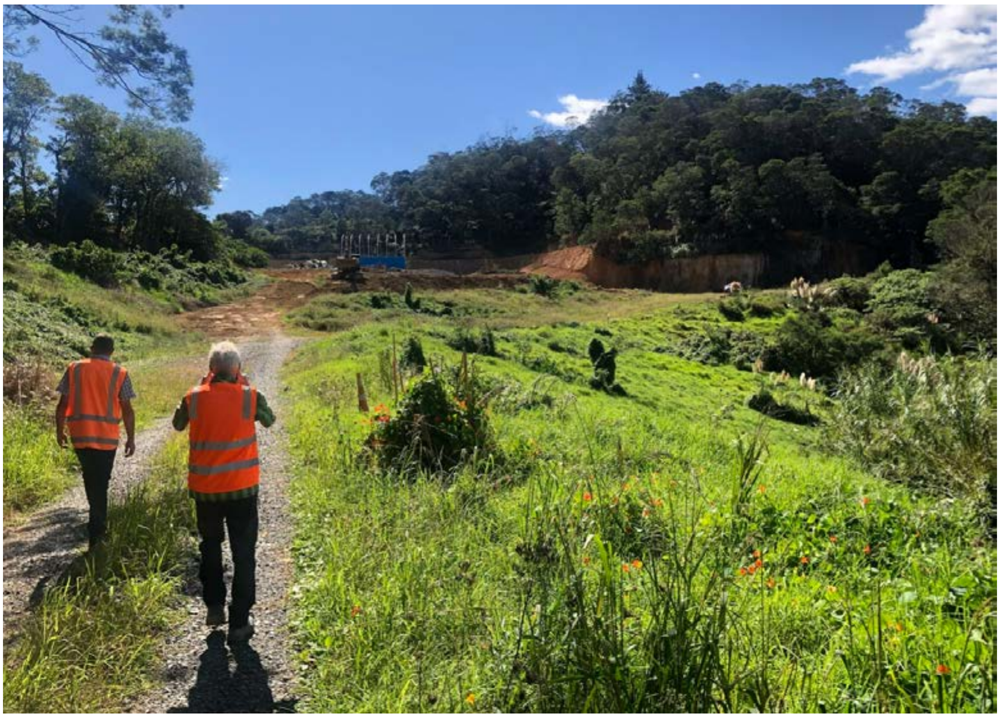

Photo 3: View looking north-east from central bench. Top of landfill in distance, old fill slope (right of photo).

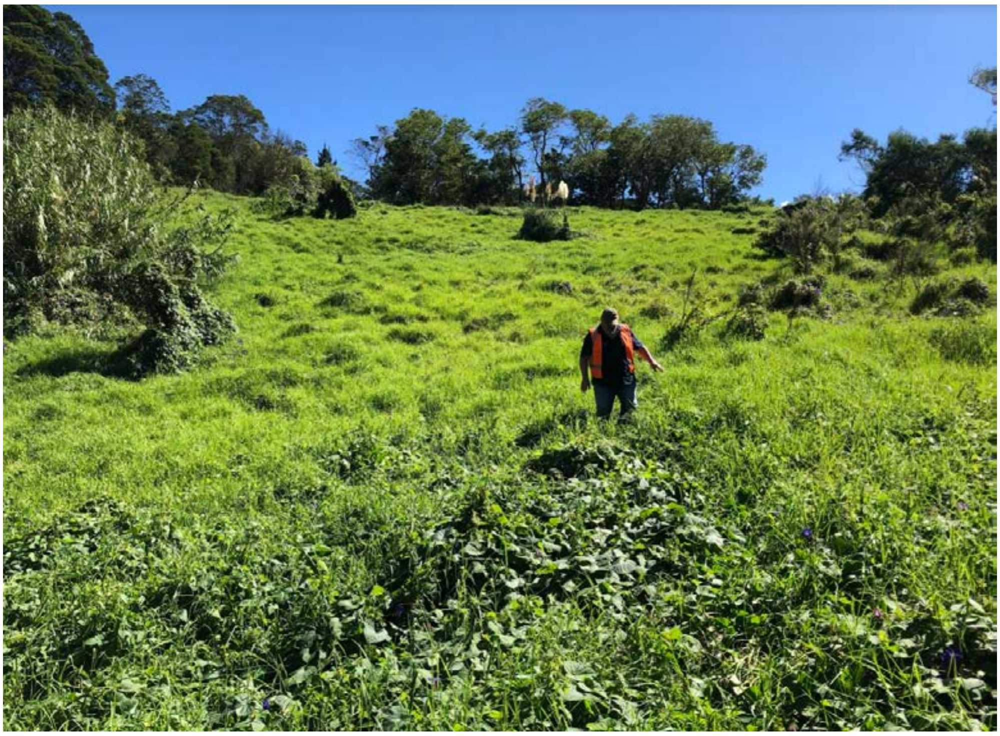

Photo 4: View looking north from based on lower slope. Densely vegetated and hummocky surface.

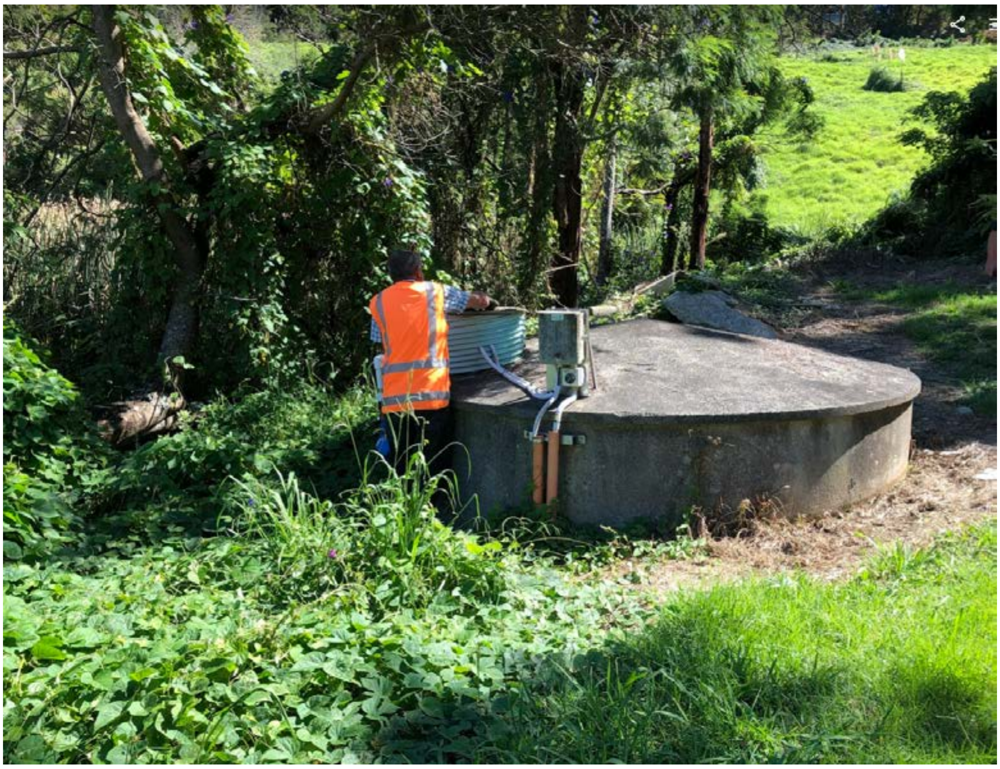

Photo 5: Leachate collection chamber to the south of landfill footprint / adjacent to Raupo Swamp.