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AUCKLAND REGIONAL LANDFILL

LANDFILL MANAGEMENT PLAN

Lining System Management Plan

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SECTION 3.26 – LINING SYSTEM MANAGEMENT PLAN

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1. INTRODUCTION

1.1. Scope of this section

This section of the Landfill Management Plan (LMP) describes:

- lining system design
- lining system construction
- requirements for independent lining system quality assurance testing and reporting

Revision of this section will follow the general procedure for any revision of the LMP.

1.2. Consent requirements

Consent Condition	***Consent Requirements***	***LMP Section***
199	*The lining system for the landfill on both the base and side slopes shall, as a minimum, comprise one of the following two lining systems:* *a. Type 1 Lining system (from top to bottom):* *i. 300 mm layer of leachate drainage material;* *ii. Protection geotextile;* *iii. 1.5 mm HDPE geomembrane; and* *iv. 600 mm compacted soil (clay) with a coefficient of permeability k < 1 x 10^{-9} m/s.* *b. Or Type 2 lining system:* *i. 300 mm layer of leachate drainage material;* *ii. Protection geotextile;* *iii. 1.5 mm HDPE geomembrane;* *iv. Geosynthetic clay liner (GCL); and* *v. 600 mm compacted soil with a coefficient of permeability k < 1 x 10^{-8} m/s.*	*2.1, 2.2, 2.3*
200	*The Consent Holder may use alternative lining and leachate drainage systems demonstrated to provide equivalent or better performance compared with the specified systems. Use of an alternative lining system shall be subject to prior written approval of the Peer Review Panel and Council.*	*2.1, 2.2, 2.3, 2.4*
201	*Where the bottom of the lining system is less than 2 m vertically above fractured bedrock, the subgrade will be sub excavated and replaced with compacted inorganic soil with a coefficient of*	*2.2, 3.1*

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	permeability k < 1 x 10^{-8} m/s to provide an additional attenuation layer of a minimum 2 m thickness.	
202	*The specification for the selection, placement, compaction and testing of the lining soil/clay shall be presented to Council, prior to the first lining clay being placed, for review and approval as part of the Landfill Management Plan (Condition 356). All lining soil/clay shall meet the requirements of the approved specification.*	*2.4, 3.1, 4.1, 4.2, 5.1.1*
202A	*The selection and placement of the first layer of waste within any new landfill cell shall compromise softer waste to avoid damage to the lining system.*	*Landfill Management Plan (LMP)*
203	*A Type 2 lining system shall be used on the base of the landfill and on sidewalls up to the first bench.*	*2.1, 2.2, 2.3, 2.4*
204	*The selected GCL and geomembrane shall meet the requirements of the GRI Standards GCL3 and GM13.*	*2.1, 2.2, 2.3, 2.4*
205	*Except in the sumps, the leachate drainage system shall be designed to achieve a leachate head not in excess of 300 mm at any point above the geomembrane*	*2.1, 2.2, 2.3, 2.4*
206	*The depth of leachate above the liner at the lowest point of the landfill shall be measured either continuously or daily. Where a sump is present at the low point, the level shall be measured above the liner within 5 m of the top of the sump. Should the level exceed 300 mm for more than 7 consecutive days the Consent Holder shall notify Council and take immediate steps to reduce the leachate level. The Consent Holder shall report to Council daily, advising the leachate level and the action being taken until the level has returned to less than 300 mm above the liner.*	*Landfill Management Plan (LMP)*
207	*An additional HDPE geomembrane shall be provided beneath the GCL of the Type 2 lining system within the leachate sumps.*	*2.1, 2.2, 2.3, 2.4*
208	*Following an earthquake event that is likely to have resulted in peak ground acceleration of equal to or greater than 0.19g in the vicinity of the Site, a review of the lining system shall be prepared by a suitably qualified landfill engineer to confirm the performance of the geomembrane is not compromised and will be submitted to Council.*	*2.3, 2.4, 5.1.2, 6.2*
208A	*Following an event which results in slips or slumps that have the potential to impact on the lining system, a review of the lining system shall be prepared by a suitably qualified landfill engineer to confirm the performance of the geomembrane and stormwater systems is not compromised and will be submitted to Council. This shall be completed within a timeframe agreed with the Council, but shall be no longer than [4] weeks for the initial report.*	*2.3, 2.4, 5.1.2, 6.2*
209	*The Consent Holder shall retain an independent testing organisation approved by the PRP to monitor the construction of the lining system including the subgrade and to undertake quality assurance (QA) of all components of the lining system and their installation. QA shall include oversight of the testing undertaken by the contractor, regular observation of lining system placement and testing, and a review of all quality control documentation produced by the supplier and contractor.*	*4.1.1, 4.1.2, 4.1.3, 5.1.1, 5.2.1*
210	*On completion of each stage of lining system installation, a report shall be prepared by the independent testing organisation and shall*	*4.1.4, 5.3*

	include all of the test results, a description of the observations undertaken and certification that the lining system had been installed in accordance with the specification. This report shall be submitted to the Peer Review Panel (see Condition 212) who will make recommendations to Council on whether the lining system has been installed in accordance with the specifications. The Consent Holder shall obtain approval from Council of each stage of lining system construction prior to any waste being placed in the area.	
211	*Leachate storage and management facilities shall be designed for a capacity 50% greater than the calculated (as calibrated against the previous year's results) maximum leachate volume produced over a three day period for any stage of operation of the landfill. To demonstrate compliance with this condition, the calculated maximum leachate volume and the leachate storage and management facilities shall be described in the LMP, which is updated from time to time.*	*Landfill Management Plan (LMP)*

2. LINING SYSTEM DESIGN

2.1. Overview

The purpose of a landfill lining system is:

- to contain the solid waste and any liquid leachate within the landfill and to prevent it from entering the underlying soils or groundwater.

The most basic requirements of the landfill lining system are:

- to prevent leachate entry into the ground;
- to not be damaged by any landfill construction or operations in the landfill's lifetime;
- to be sufficiently robust so that time-related deterioration if any won't occur until long after the waste has broken down, stabilised and become innocuous;
- to include a system of pipes for the prompt removal of any free liquid leachate.

For a Class 1 landfill, the WasteMINZ Technical Guidelines for Disposal to Land August 2018 describe two equivalent lining systems both of which will be used at Auckland Regional Landfill (ARL) depending on ground slope and availability of the construction materials at the time (Appendix 3).

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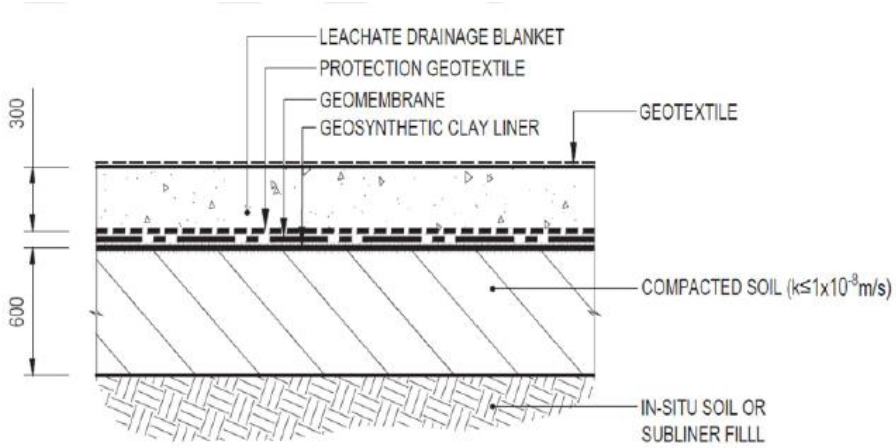

Figure 1: Type 2 Lining system

2.2. Performance requirements

The lining system design will be in general accordance with the drawings submitted and approved in the consent process. Final detailed design will be prepared for each area of the lining system in advance, phase-by-phase, with the following performance requirements.

Table: Performance requirements

Design feature	**Matters to consider in detailed design**
Lining system Type 1 or Type 2	Either lining system type may be used except Type 2 must be used on the floor and on sidewalls up to the first bench. Exact areas for each Type must be shown in the phase drawings. If another lining system is proposed, it requires prior approval of the PRP and Council.
Subgrade rock	An attenuation layer of soil-like ground is required beneath the lining system. If fractured rock is reasonably expected to be present within 2m beneath the lining system then it must be replaced in that zone with compacted soil.
Subgrade soundness	Excavation down to a sufficiently solid base, so that subsequent compaction of subliner and low permeability liner will meet specifications. Removal of compressible subgrade soil or rock, so that continuous fall will be maintained on the liner after compression of the ground under the future weight of refuse - Compression includes normal consolidation and reversal of heave.
Land stability	Land stability in terms of factor of safety (FoS):

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Design feature	**Matters to consider in detailed design**
	• Short term cut slopes FoS = 1.2 • Short term earth fill slopes FoS = 1.3 • Long term slopes FoS = 1.5
Liner soil/clay selection	The specification for the selection, placement, compaction and testing of the lining soil/clay must be approved by Council prior to the first liner clay/soil being placed. The source of soil/clay for the current phase must be identified and tested to confirm its ability to achieve specification. Uniformity of the soil material and absence of deleterious content.
Liner soil/clay placement	Low permeability ($<1 \times 10^{-9}$ m/s). Continuity of the layer. Avoidance of contamination during construction.
Phase layout	Phases may be divided into sub-phases, depending on constructability, stormwater control, future access for disposal, and available construction materials.
Flexible Membrane Liner	Resistance to chemical attack. Tolerance of tensile strain. Ability to be constructed without crinkles during construction. High Density Poly Ethylene (HDPE) or equivalent. Compliance with GRI Standards GCL3 and GM13.
Care of compacted low permeability soil liner	Protection during construction to avoid desiccation and erosion. Isolation to prevent surface water run-on that would add to leachate.
Gradient	Continuous fall for gravity flow to the leachate sump. Sufficient gradient to minimise leachate collection pipe siltation (e.g. 2%).
Leachate drainage blanket	Permeability consistent with clean medium gravel on floor areas. Permeability >5 times that of refuse on sidewall areas.

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Design feature	Matters to consider in detailed design
	Separation geotextile filter cloth at appropriate locations on top of the leachate drainage blanket gravel (prior to waste placement) to prevent silt clogging of the gravel - supplementary to Type 1 and Type 2 lining systems. Maximum 0.3 m depth of liquid, considering gravel permeability, primary and secondary collector drain spacing, impermeable base, pipe gradient, and areal input 15% of average rainfall. Allowance for >0.3 m depth of liquid in leachate sumps provided that sumps are double lined i.e. with another HDEP geomembrane.
Leachate collection pipes	Self-cleaning flow velocities in average conditions. Capacity for peak flow rate. Structural soundness under the weight of refuse. Durability to the end of the aftercare period. Accessibility for flushing of primary collector drains.

2.3. Risks

Table: Lining system risks

Risks	Mitigations
Leakage of leachate through lining system into underlying ground.	Detailed QA review of supplier info. Lining system design with multiple levels of backup (HDPE, GCL, soil liner, attenuation layer). HDPE virtually impermeable layer. GCL in floor area. Permanent mineral clay liner everywhere. Lining system materials with lifetime well beyond the time that it will take waste to degrade, stabilise and become harmless. Independent testing of liners. Independent QA review and oversight of construction.

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Risks	Mitigations
	Multiple reviews in series (design, testing, QA review, PRP, Council) prior to approval for waste placement. Leachate drainage to avoid liquid pressure on liner. Leachate collection, pumping and treatment so that the amount of free liquid leachate present in the waste is always minimal. Downstream groundwater monitoring.
Inadvertent placement of waste in areas yet to be lined	Sub-phase outlines kept to simple regular shapes. Approved lining outlines marked on site at the time of handover to operations staff.

2.4. Sign-off

Detailed design will be undertaken prior to construction in any area phase. Design will be in general accordance with the approved consent drawings, but more detail will be required.

Detailed design will cover

- the landfill generally
- the lining system specifically

The designer's deliverables will include:

- drawings
- specification
- design statement, or report to explain notable features and matters requiring Council approval

3. LINING SYSTEM CONSTRUCTION

3.1. Construction sequence

The typical lining system construction sequence is:

- Excavate to an intermediate excavation profile marginally above design subgrade level.
- Set out and establish coordinates of the outline of the inspection area for the current phase.
- Carry out an initial inspection (designer).
- Prepare subgrade as advised by the designer. Works may include subexcavation of rock, soft ground, tomos and springs. Additional requirements may relate to timing, extent, erosion protection, drainage and backfill.

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- Install subsoil drains and any specified under-liner drainage.
- Carry out a final subgrade inspection (designer) within 2 rain-free days prior to earth fill placement.
- Survey the subgrade, geological features, springs, and as-built drainage. The subgrade levels will be used to define subliner and liner thickness.
- Place and compact the subliner and liner fills to an over-filled level to allow for trimming back. Conduct testing and survey regularly during this work.
- Host inspections by the designer, QA reviewer and PRP.
- Trim overfill when ready to place GCL and/or HDPE immediately afterwards.
- Survey the trimmed fill, liner joints and test locations. Confirm soil liner thickness.
- Get through to placement of the leachate drainage blanket as soon as practical to prevent damage to lining system elements.

3.2. Photos

Figure 3a: Soil/clay liner

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Figure 3b: GCL liner

Figure 3c: HDPE liner

Figure 3d: Geotexile cushion and leachate drainage gravel

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Figure 3e: Leachate pipe in leachate drainage blanket

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4. LINING SYSTEM QUALITY ASSURANCE

4.1. Quality Assurance

4.1.1. Testing

WMNZ will commission an independent testing organisation or laboratory for quality assurance (QA) testing of materials including all lining system elements.

Employees of WMNZ may not undertake the testing and must facilitate the independent testing on site.

Some testing may also be undertaken instead by the contractor. Either way they will be independent of WMNZ.

The testing organisation's report will:

- identify the specification document
- list the specified test methods
- identify the required result standards
- describe and differentiate between the materials that have been tested
- list the dates and locations of sampling and testing
- submit evidence of test equipment calibration
- provide a traceable trail to retest of any repair after a non-complying result

4.1.2. Survey

WMNZ will commission a surveyor for setting out, picking up test locations, and providing as-built drawing information.

Employees of WMNZ may be used for survey work bearing in mind that their work will be scrutinised by the independent QA reviewer.

The surveyor's report will:

- provide drawings showing test locations and notable features picked up during construction (e.g. geology)
- provide tabular or electronic survey data as evidence (e.g. liner thickness)
- provide as-built drawings and/or survey information

The surveyor will save information electronically which will be available on request.

4.1.3. QA review

WMNZ will commission an independent engineer with relevant experience for QA review of the independent testing, survey, and quality control documentation produced by suppliers and contractors.

Employees of WMNZ may not do the independent QA review and must facilitate the independent work of the QA reviewer.

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WMNZ may assist in the collation of information.

The QA reviewer's report will:

- identify the consents and consent conditions that define their role and reason for their report
- identify the approved construction drawings
- name the personnel doing the QA review
- describe the QA reviewer's activities and observations during construction and testing
- describe any unusual matter that is addressed
- include the testing organisation's report
- include the surveyor's report
- provide "certification that the lining system had been installed in accordance with the specification" and refer to the evidence to support that conclusion.

4.1.4. Peer Review

WMNZ will send the QA reviewer's report to the PRP who will then do their own review before sending it on to Council.

The PRP's report will:

- identify the QA reviewer's report
- describe any further inquiry that they have made and the outcome
- make "recommendations to Auckland Council on whether the lining system has been installed in accordance with the specifications"

4.2. Sign-off

The lining system completion approval process including Council sign-off is described in Appendix 5.

5. MONITORING

5.1. Monitoring parameters

5.1.1. Construction

The monitoring parameters for constructed elements of the lining system will be defined by the lining system designer in the specification. Parameters will typically include but not be limited to:

- subgrade: strength and geology
- earth fill: strength, moisture content and density
- geomembranes: strength, stress-strain behaviour and joint integrity
- drainage gravel: soundness and particle size distribution

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5.1.2. Environment

The lining system effectiveness will be indicated by results of monitoring of the sub-liner sub-soil drains. Parameters are listed in the consent conditions and Groundwater Monitoring and Contingency Plan.

Table: Monitoring

Location / Event / Topic	Parameter	Frequency	TL1	TL2
Lining system seasonal construction	Subgrade parameters as per designer's specification.	Annually	As per Specification.	As per Specification.
Lining system seasonal construction	Earth fill parameters as per designer's specification.	Annually	As per Specification.	As per Specification.
Lining system seasonal construction	Geomembrane parameters as per designer's specification.	Annually	As per Specification.	As per Specification.
Lining system seasonal construction	Leachate drainage gravel parameters as per designer's specification.	Annually	As per Specification.	As per Specification.
Subsoil drains beneath landfill lining system	Groundwater chemistry samples	Quarterly	tba	tba
Subsoil drains beneath landfill lining system	Conductivity	Continuously	tba	tba
Subsoil drains beneath landfill footprint	Flow rate	Monthly	No limit. Monitored for information.	No limit. Monitored for information.

5.2. Monitoring procedures

5.2.1. Construction

The independent quality assurance testing organisation will be responsible for establishing and following their own testing procedures, customised if appropriate, to comply with the specification written by the designer.

5.2.2. Environment

Separate detailed step-by-step procedures will be used for monitoring events (variously known as work instructions, standard operating procedures, and safe work method statements). Procedures will be provided in a separate volume. Key features of those procedures are identified in the table below.

Table: Procedures

Procedure	**Key steps**
Continuous monitoring of conductivity from sub-liner sub-soil drains	• Electronic measurements data logged • Radio telemetry - web recording • Automated notifications of trigger level exceedances • Primary and/or secondary calibration schedule • Weekly inspection • Corrective action tracking • Maintenance records • Uploading of data to Waste Management Digital Dashboard

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5.3. Reporting

Table: Reporting

Location / Event / Topic	Report to	Method	Frequency
Lining system - all relevant materials and construction testing results.	QA reviewer	Email or file transfer	As required
Lining system completion (each phase) approval given by QA reviewer.	Peer Review Panel	Email or file transfer	As required
Lining system completion (each phase) approval given by PRP.	Auckland Council	Email or file transfer	As required
Lining system monitoring results (from sub-liner sub-soil drains and leachate collection system).	Community Liaison		

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6. CONTINGENCY

6.1. Trigger Levels - general

Response limits (or trigger levels) are values for the monitoring parameters which, if exceeded, require a course of action to be taken. Upon completion of a monitoring event, the results will be checked against the pre-specified response limits. If no response limit is exceeded, the monitoring event will be routinely reported in due course, including upload to the Waste Management Digital Dashboard. If any response limit is exceeded, action will be taken immediately as described in this contingency plan.

Response guidelines are summarised in the next section below.

The limits are set at two levels i.e. TL1 (warning) and TL2 (alarm) which are described in more detail in the surface water, groundwater and leachate monitoring and contingency plans, including when to notify Auckland Council.

The potential issues relating to the lining system (this section of the LMP) are addressed in the surface water, groundwater and leachate monitoring and contingency plans so are not repeated here.

6.2. Response guidelines

Table: Response guidelines - lining system

Contingency triggering event	**Response guidelines**
Groundwater contamination found in monitoring wells	Refer to Groundwater Monitoring and Contingency Plan.
Leachate head level rising in the landfill.	Refer to the Leachate Monitoring and Contingency Plan.
Earthquake	Immediate remedial, mitigative and precautionary action: • Ensure safety first. • Refer to the Site Emergency Management Plan. • Refer to the Groundwater Monitoring and Contingency Plan. With reference specifically to the lining system: • Look for signs of heating or fire near the lining system. • Look for signs of ground movement, landslip or consolidation in the waste and nearby. • Look for signs of liner rupture, leachate breakouts, and misdirected stormwater within the landfill footprint. • Take photographs. • Obtain geotechnical advice. • When waste placement recommences, open a working face only in an area where disturbance of the lining system is unlikely to have occurred.

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Contingency triggering event	Response guidelines
	Consider possible corrective and/or preventative action options: • Install a ring of pumped groundwater wells that would attract the contaminated groundwater towards the wells rather than allowing flow towards down-gradient aquifers and receptors. • Install a row of close-spaced wells to the relevant depth which are grouted and would form a subsurface curtain-like cut-off to contain the contaminated groundwater where it can be pumped away for treatment if required. • Selectively trace leachate inside the landfill using new technologies and possibly selectively exhume waste to find the source of contamination which would provide for targeted remediation. • Provide in-ground treatment which may involve use of biological or other agents that will neutralise contaminants.
Groundwater contamination found in sub-liner sub-soil monitoring drains.	Verification of readings (TL1 and TL2) • Inspect the monitoring site to check that the instrument is functioning correctly and/or the sampling point is not affected by interference (from other flows, stagnant water, wildlife, or anything else). • Inspect the monitoring site to check that there is flow (if the flow is zero then the response may be adjusted accordingly) • Compare telemetric monitoring outputs across the site for consistency or anomaly affecting readings. • Use portable meters to repeat or take parallel readings. • If not already done, take a grab sample from the sub-soil drain flow and analyse as specified in the consent conditions. Add metals and other parameters considered likely to help identify whether or not the source is leachate. Urgent remedial and precautionary action (TL2 only) • Close the outlet decant valve of the pond receiving the sub-soil flow to cease discharging from the pond while the results are assessed and other emergency treatment is activated. • Divert the sub-soil drain flow directly to a leachate holding and pumping point, and start pumping, either back into the landfill or to the regular on-site leachate holding and disposal system. • Follow emergency procedures as for a spill.

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Contingency triggering event	Response guidelines
	• Use site resources to immediately take field measurements at the monitoring site and in surface water and groundwater upstream and downstream to help find and assess the source and extent of the TL2. • If the situation is extreme with high flow of raw leachate, then close the subsoil drain outlet valve(s). • Commence investigation including review of old readings and taking of new readings relating to groundwater and leachate. • In all cases, record findings for the regular annual report. Corrective and preventative action (TL1 and TL2) • Provide permanent capture and diversion configuration for the subsoil drain outflow. • Increase the monitoring frequency. • Instigate amendments to the design and/or construction procedures for any further lining system work according to the findings of investigations.

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7. TASKS LISTS

7.1. Tasks and scheduled maintenance

Table: Tasks

Role	Task	Frequency
Monitoring Technician	Calibrate fixed meters for sub-liner sub-soil drain monitoring.	Annually
Monitoring Technician	Review readings from fixed meters in inflows to the Pond system (from sub- liner sub-soil groundwater drains).	Daily
Landfill Engineer	Engage an independent QA testing organisation. Obtain PRP approval.	Annually
Landfill Engineer	Arrange for professional geotechnical engineering subgrade inspections.	As Required
Landfill Engineer	Check lining system design consistency with consent conditions.	Annually
Landfill Engineer	Check lining system integrity after an earthquake.	As Required

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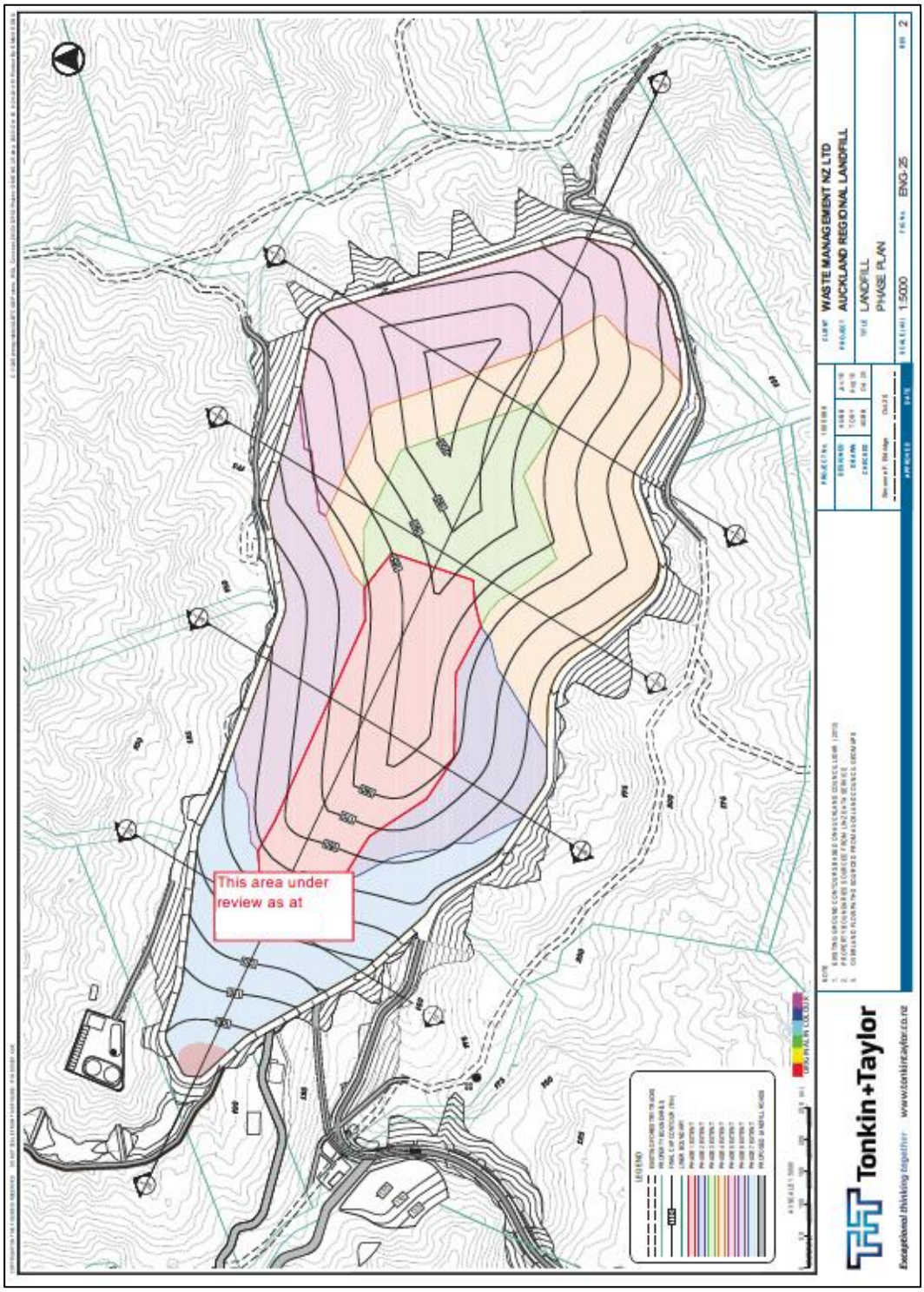
8. APPENDICES

8.1. Phase plan

Extract from: Statement of evidence of Anthony Gerard Bryce on behalf of Waste Management NZ Ltd, Landfill Design, 8 October 2020 (EVD0355), Appendix A, Engineering Drawing Package (EVD 0411).



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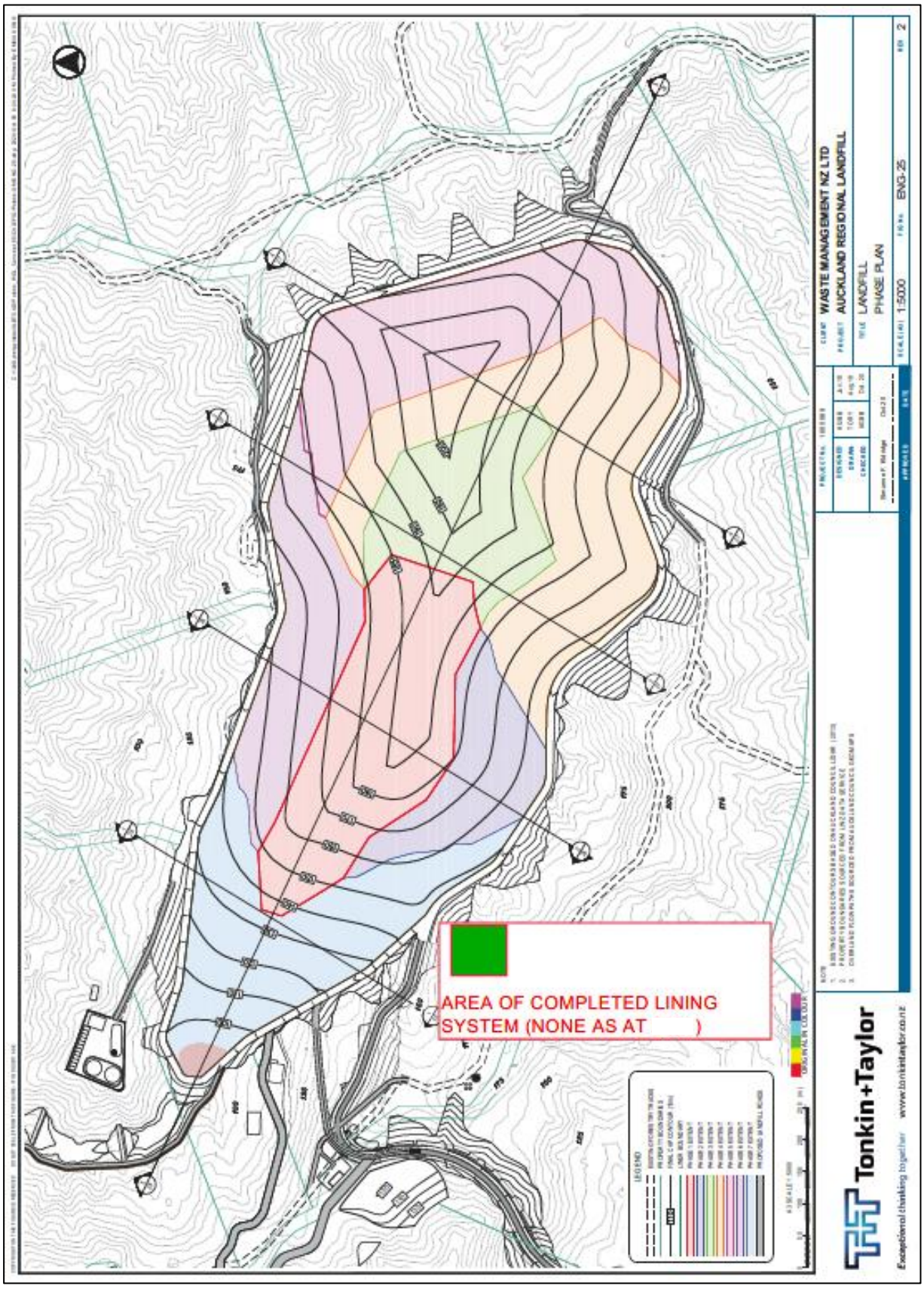
8.2. Phase plan showing completed lining



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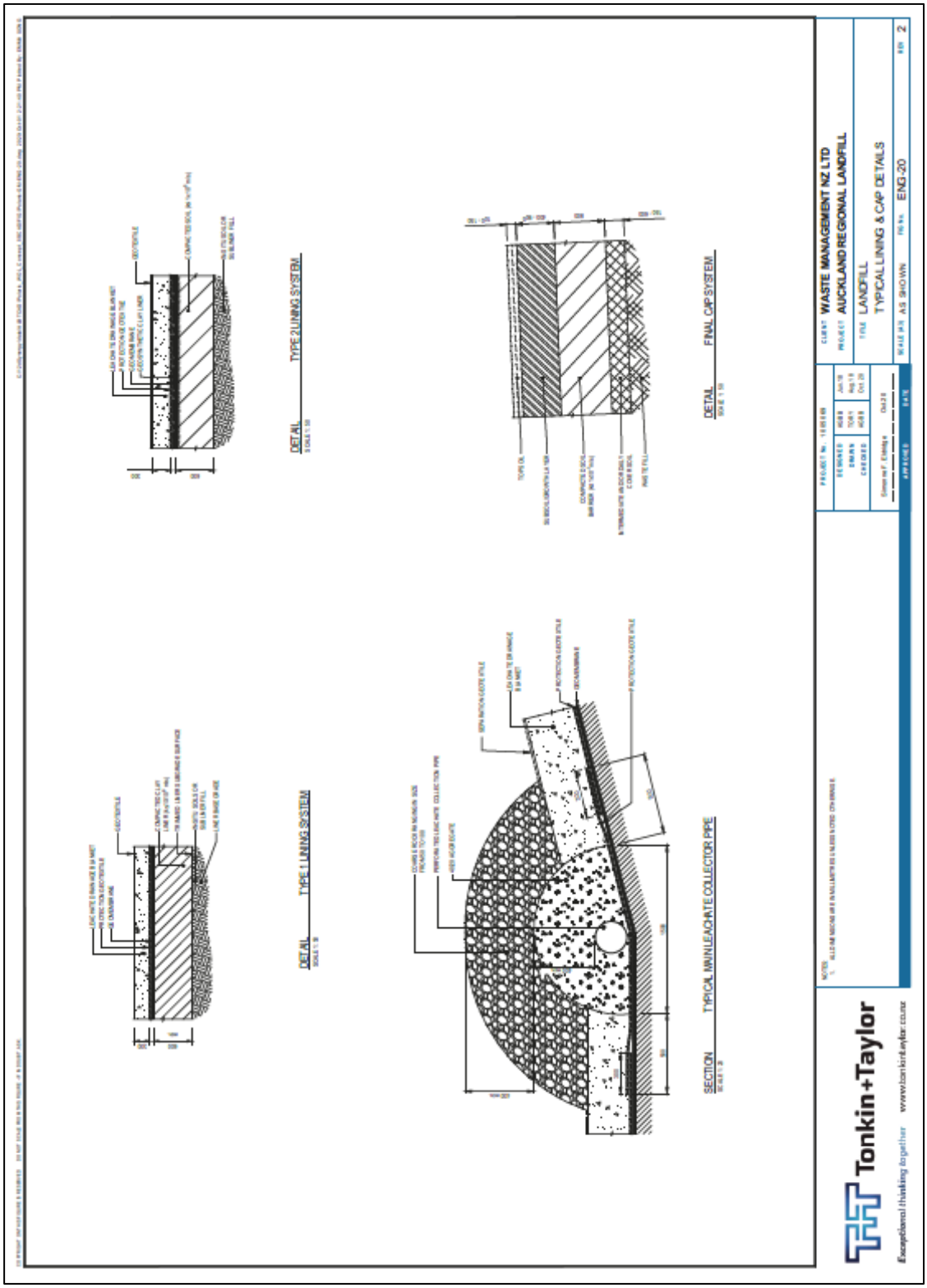
8.3. Lining system design drawing

Extract from: Statement of evidence of Anthony Gerard Bryce on behalf of Waste Management NZ Ltd, Landfill Design, 8 October 2020 (EVD0355), Appendix A, Engineering Drawing Package (EVD 0411).



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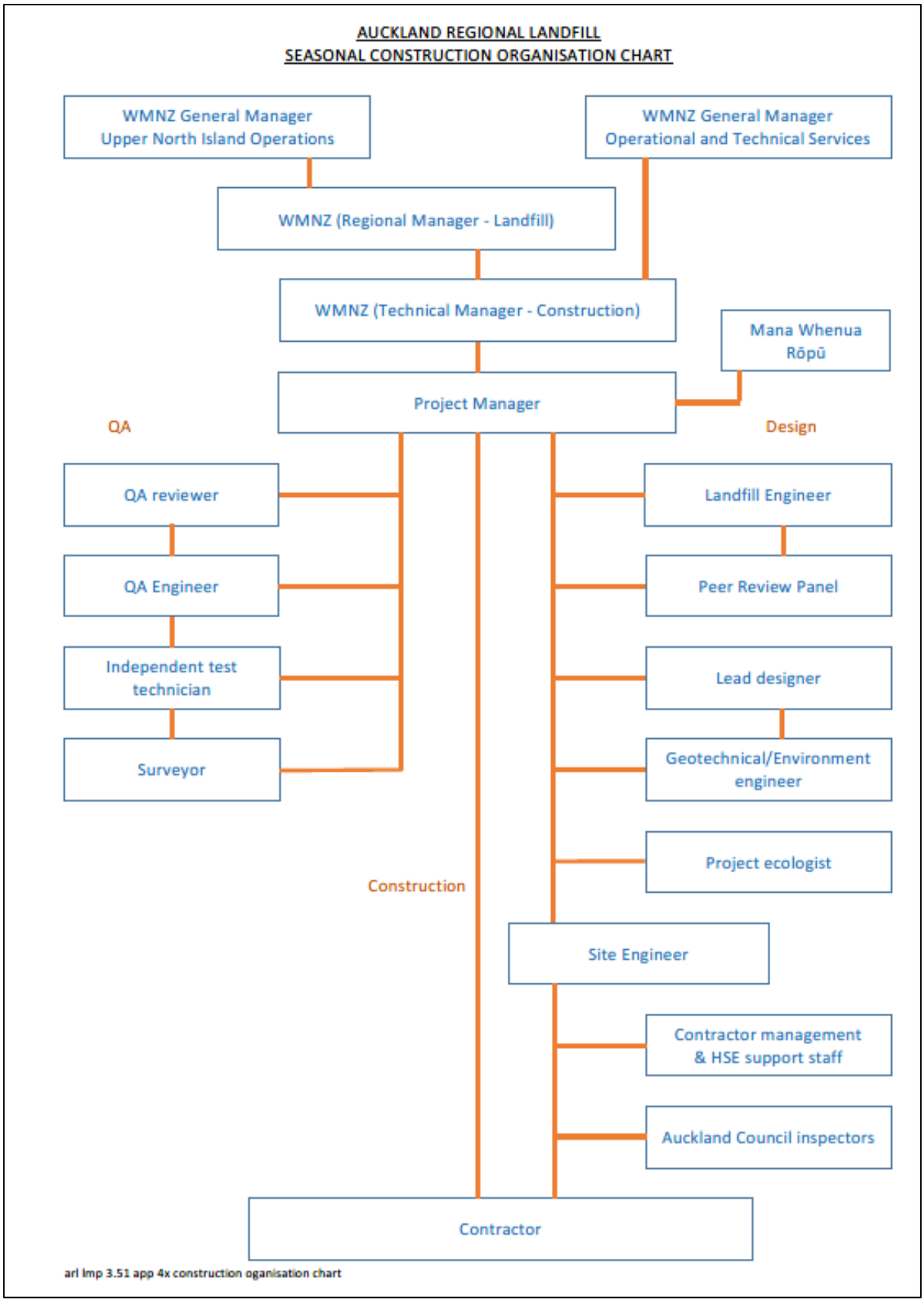
8.4. Construction organisation chart



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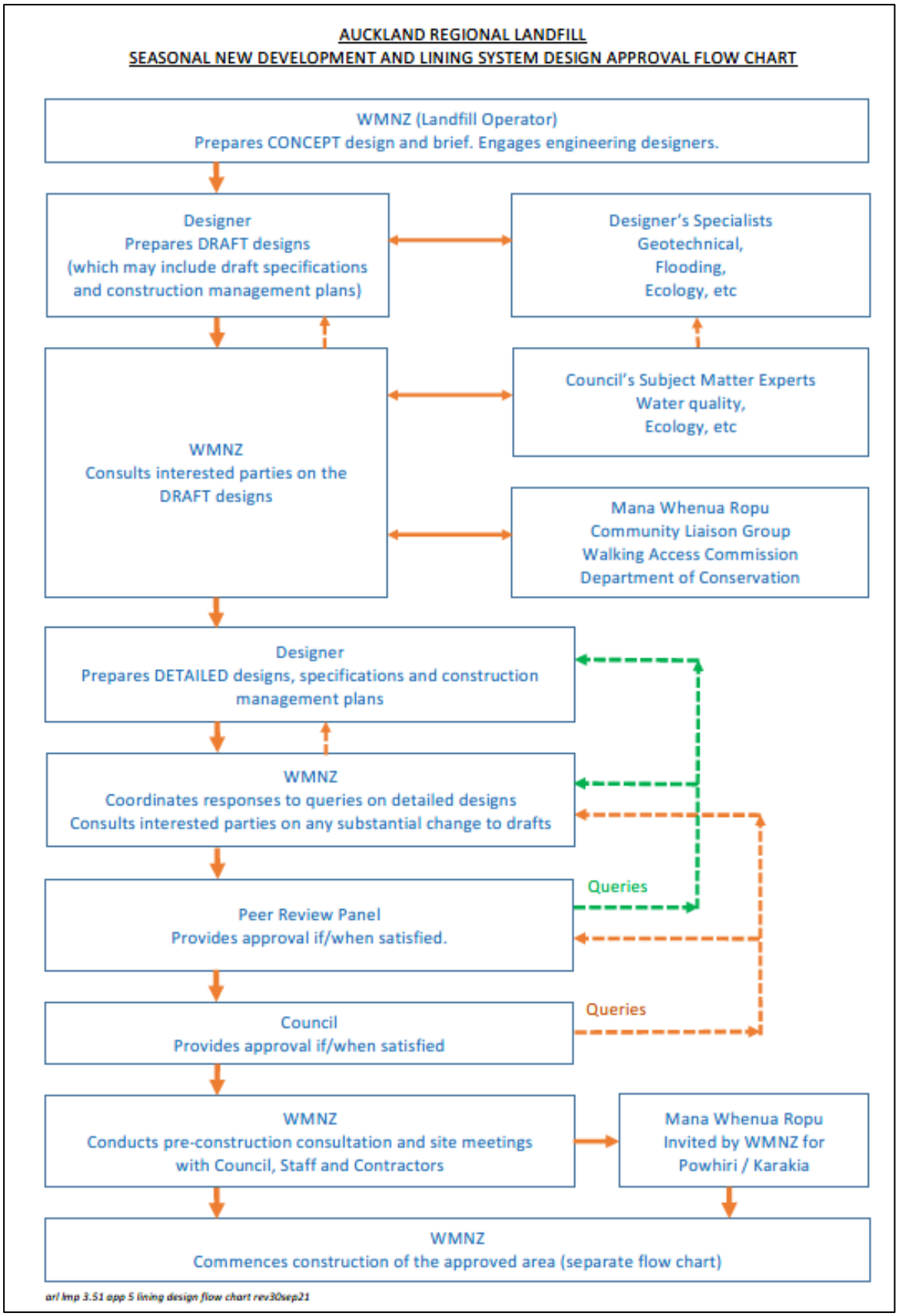
8.5. Lining system design approval flow chart



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8.6. Lining system construction completion approval flow chart