Job No: 1011583
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Horowhenua District Council
C/- Catalyst Group
Level 3, 31 George Street
Palmerston North 4440

Attention: Greg Carlyon

Dear Greg

Levin Landfill
Closure Review - Technical Considerations

1 Introduction

Horowhenua District Council (HDC) has engaged Tonkin & Taylor Ltd (T+T) to undertake a review of issues related to early closure of Levin Landfill. This report provides a summary of our review of technical and engineering challenges associated with closure of Levin Landfill. We also comment on whether the scale and extent of the technical challenges depend on the date of landfill closure.

This letter report is complemented by a separate report that provides comment on the financial and commercial implications with closure of the landfill[1]. We have also completed analysis of best practicable options (BPO) for the closed landfill on the same site.

This review has been completed in accordance with our Letter of Engagement dated 25 July 2019 and consistent with the Agreement in Relation to the Levin Landfill (Landfill Agreement) dated 13 March 2019[2].

2 Background

2.1 General

Levin Landfill is an existing municipal solid waste landfill located on Hokio Beach Road, to the west of Levin. The landfill is owned by HDC and operated by EnviroWaste Services Ltd (EnviroWaste), under subcontract to Midwest Disposals Ltd.

The landfill consists of an "Original Landfill" and a "Current Landfill." The Original Landfill was established in the 1950s and includes two areas, Area 1 and Area 2. The Original Landfill is unlined and has been closed and capped.

[1] Tonkin & Taylor Ltd, 2019, "Levin Landfill Closure Review – Financial Considerations" 5 December.
[2] Environment Court, 2019, "Agreement in Relation to the Levin Landfill" Horowhenua District Council, Hokio Environmental Kaitaiki Alliance Incorporated, Horowhenua District Ratepayers and Residents Association Incorporated, s274 Parties" 13 March.

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The Current Landfill is located to the south of the Original Landfill. Operations at the Current Landfill commenced in 2004 and has since been developed progressively in stages referred to as Stages 1A, 2, 3A, 3B, and 3C. The focus of this letter report is an engineering review of the closure of the Current Landfill.

2.2 Current landfill

Development of the Current Landfill is subject to resource consent conditions issued in 1997 and subsequently amended in 2002 and 2010[3]. These consents require that the current landfill have a composite base liner system consisting of a flexible geomembrane underlain by a geosynthetic clay liner, or approved alternative.

From our review of background documents, we understand[4] that each stage of the Current Landfill has been designed and constructed with the following base liner system (from top to bottom):

- Gravel leachate collection layer;
- Liner protection layer consisting of a 100mm thick sand layer on the landfill base and a protection geotextile on the side slopes;
- 2mm thick HDPE geomembrane, to serve as a primary leachate barrier;
- 6mm thick geosynthetic clay liner (GCL), to serve as a secondary leachate barrier; and
- Prepared subgrade consisting of compacted sand.

Leachate from the Current Landfill is collected and pumped via a rising main to a leachate pond, where it is temporarily stored before being pumped to the Levin Wastewater Treatment Plant.

2.3 Information sources

The following documents were reviewed as part of our evaluation of the technical aspects of closure:

- Resource Consents 6009, 6010, 6011, 7289, and 102259 – Levin Landfill. Revised consent conditions dated 31 May 2010 (the *Resource Consents*);
- Ministry for the Environment, May 2001, "A Guide for the Management of Closing and Closed Landfills in New Zealand", (the *Closed Landfill Guidelines*);
- Waste Management Institute New Zealand (WasteMINZ), 2018, "Technical Guidelines for Disposal to Land", August;
- Stantec, 2017 and 2018 Annual Compliance Reports for 2016-2017 and 2017-2018 (the *Annual Reports*);
- Statements of Evidence prepared for the Section 127/128 review of resource consent conditions, submitted in September 2016 on behalf of Horowhenua District Council. Submitters included Phil Landmark, Doug Boddy, Gallo Saidy, Olivier Ausseil, and Stephen Douglass;
- Draft top of intermediate cover grades for Stages 1A, 2, and 3, prepared by Stantec in 2018; and
- Aerial survey dated May 2019 (*Existing Topography*).

[3] Resource Consents 6009, 6010, 6011, 7289, and 102259 – Levin Landfill.
[4] Landmark, P.S., 2016, "Statement of Evidence of Phillip Sverre Landmark (Design/Operations) on Behalf of the Consent Holder", Consent Holder: Horowhenua District Council, 2 September.

2.4 Closure date

We have considered two closure scenarios, as described below. Both closure scenarios would involve final capping of the Current Landfill and implementation of an Aftercare Plan which would apply to the full site, including both the Current Landfill and the Original Landfill.

Scenario 1 - Close Levin Landfill in 2021

This scenario involves Levin Landfill ceasing operation from mid-2021 when the current operations contract expires.

Scenario 2 - Levin Landfill continuing operation

This scenario involves Levin Landfill continuing operation after mid-2021, after the current operations contract expires. We note that the existing consents for the Levin Landfill expire in 2037, but intermediate closure dates such as 2025 have also been discussed.

3 Remaining capacity

3.1 Compaction

The site resource consent conditions require waste to be compacted to a minimum of 0.6 to 0.8 t/m^3. The compaction achieved has been assessed on an annual basis since 2007/2008 and reported in the Annual Reports. Compaction achieved has been assessed by dividing the annual waste tonnes accepted at the site (from weighbridge receipts) by the amount of airspace utilised during that period (from review of annual survey data). These compaction assessments indicate that compaction at the site has gradually increased from approximately 0.61 t/m^3 in 2007/2008, to between 0.93 and 1.01 t/m^3 from 2015 to 2018[5].

We anticipate that achieving the minimum required compaction will be technically feasible until landfill closure, provided the contractor continues with current operational practices.

The stated purpose of the compaction consent condition is "to ensure post closure settlement is minimised as far as possible." We note that significant settlement can be expected with any closed landfill, although the amount of total settlement can be reduced by achieving good compaction during operations. Sanitary landfills of mixed composition typically settle from 10 to 30% due to compression under self weight and decomposition of organic waste, with approximately 50% of this settlement expected prior to closure. The final landfill cap will need to be designed to accommodate the anticipated post-closure settlement, as is typical for closure design.

3.2 Capacity

3.2.1 General

The landfill currently accepts between 30,000 and 40,000 tonnes of waste per year. We understand that, based on recent survey data, EnviroWaste has been able to place and compact waste at a density of approximately 1 t/m^3. Therefore, we anticipate that between 30,000 and 40,000 m^3 of available airspace capacity will be utilised each year until closure.

We have reviewed the existing topography and proposed filling plans to assess if the landfill has sufficient capacity to accommodate the current waste intake rate until a mid-2021 closure. In particular, we reviewed the available airspace within the existing landfill footprint, to evaluate if a mid-2021 closure is practical without further expansion of the landfill.

[5] Stantec, 2018, "Levin Landfill Annual Compliance Report, July 2017-2018", Prepared for Horowhenua District Council, September.

3.2.2 Remaining capacity of Stages 2 and 3

Waste is currently being accepted and placed in Stages 2 and 3. Stage 1A has been capped with intermediate cover and is not currently accepting waste.

We have reviewed the recent aerial survey (from May 2019) and compared this survey with the draft capping plan for Stages 2 and 3, as presented in the 2017-2018 Annual Report. This review suggests that there is insufficient capacity remaining if waste placement is restricted to only the footprint of Stages 2 and 3.

In order to accommodate waste intakes rates until a mid-2021 closure, waste placed in the active landfilling area will need to layback against Stage 1A. We understand[6] that placement of waste fill above Stage 1A will involve stripping of the existing intermediate clayey cover soil in this area. Soil will be removed to the level of a sandy subbase layer, followed by placement of waste fill above.

Closure of the Current Landfill will therefore involve installation of a landfill cap over Stages 1A, 2, and 3. Stantec is currently developing draft design final cap contours for Stages 1A, 2, and 3.

3.2.3 Remaining capacity of Current Landfill

We have reviewed the remaining capacity of the Current Landfill, assuming that new waste will be placed over existing waste slopes in Area 1A.

Stantec has developed conceptual filling plans in this area, assuming maximum waste fill slopes of both 1V:4H and 1V:3H. The proposed waste fill plans for the next two years will be entirely within the existing lined areas. From our review of these filling plans, we anticipate that the proposed waste fill slopes are likely to be technically feasible[7] and consistent with typical landfill operations. However, cover soil over the completed Stage 1A landfill will need to be removed to achieve these filling plans, as discussed above.

Stantec has estimated the remaining capacity of the Current Landfill as of May 2017, as summarised in Table 3.1 below. We have extrapolated these capacity evaluations to estimate the remaining capacity as of December 2019, with no further expansion of the lined footprint.

As shown in Table 3.1, for a 1V:4H final cap profile, the remaining capacity of the Current Landfill is estimated to be fully utilised by early to mid-2021. For a steeper final cap profile of 1V:3H, the remaining capacity of the landfill would allow for continued operations in the Current Landfill until approximately 2023 to 2024, depending on the future waste acceptance rates and level of compaction.

Based on the above, we anticipate that to achieve a mid-2021 closure date, there would either need to be (1) a reduction in annual airspace utilisation rate to no more than 30,000 m^3/year, or (2) construction of final cap slope batters of up to 1V:3H.

[6] Email communication with Phil Landmark (Stantec), dated 31 October 2019.
[7] Proposed landfill slopes and cap design should be subject to waste slope and cover soil stability assessments, as discussed in Section 3.7.

Table 3.1 Estimated remaining capacity of Levin Landfill

Maximum Cap Slope	Capacity as of May 2017 (m^3)	Estimated remaining capacity as of December 2019 (m^3)[1]	Remaining life (yrs)[2]
1V:4H	141,000	46,000	1.1 to 1.5
1V:3H	225,000	130,000	3.2 to 4.3

Notes:

1. According to the Levin Landfill Annual Report for 2017-2018 (Stantec, 2018), approximately 40,000 m^3 of airspace was utilised between May 2017 and June 2018. We assume a similar airspace utilisation rate between June 2018 and December 2019, for a total of approximately 95,000 m^3 airspace utilised in the 31 months since the May 2017 survey.
2. The shorter time estimate assumes 40,000 m^3 of capacity utilised per year while the longer time estimate assumes 30,000 m^3 of capacity utilised per year.

3.2.4 Capacity for post-2021 closure

Expansion of the Current Landfill will be required for closure dates beyond the approximate timeframes outlined in Table 3.1.

Development plans for the landfill include the proposed construction of Stage 4 to the west of the active landfill, and Stage 5 to the north west of the active landfill. These stages would be lined in accordance with the consents and represent an expansion of the footprint of the Current Landfill.

These future stages would be required to provide sufficient capacity for continued operation of the landfill. The size and extent of Stage 4 and 5 expansion would depend on the desired closure date.

We anticipate that these future stages would not need to be constructed for a mid-2021 closure.

4 Feasibility evaluation - closure consent requirements

We have reviewed the landfill closure conditions in the Resource Consents and evaluated whether early closure of the landfill is likely to affect whether these conditions can be met. A summary of our evaluation is provided in Table 4.1. The focus of this evaluation is the technical aspects of landfill closure, however, many of these closure measures will also need to be assessed for financial feasibility, including the construction costs of landfill closure (e.g., capping and landfill gas control measures), and ongoing inspection and maintenance costs during the post-closure period.

Condition 14 of Resource Consent 6010[8] requires that the Current Landfill be closed and remediated through:

- Consent 6010, Condition 14(a): *Compacting refuse to such an extent and consistent with CAE guidelines of 600-800 kg/m^3, to ensure post closure settlement is minimised as far as possible;*
- Consent 6010, Condition 14(b): *Grading to a final slope of less or equal to 1V:3H (1 in 3) on any face*;
- Consent 6010, Condition 14(c): *Ensuring the landfill cap incorporates a layer at least 700mm thick with a permeability of no greater than 1 x 10^{-7} m/s, or has a material and layer structure that reduces rainwater infiltration to the waste to an equivalent extent*; and
- Consent 6010, Condition 14(d): *Establishing and maintaining a grass or tussock vegetation cover on the capped landfill, unless it can be demonstrated to the Regional Council's satisfaction that a different vegetation cover can produce clear benefits through reducing*

[8] Horizons Regional Council, 2010, "Section 128 Review of Consent Conditions, Consent Nos. – 6009/1, 6010/1, 6011/1, 7289/1 and 102259/1" Decision date 31 May 2010, Horizons file reference 1/4/HDC.

infiltration to the covered waste. Any vegetation cover should be consistent with an ongoing capacity to monitor and maintain the ongoing integrity of the landfill cap.

Resource Consents 6009 and 6010 apply additional conditions to closure of the Original Landfill. These conditions do not apply to closure of the Current Landfill, however, they are provided below for reference, as we believe these conditions represent good practice for landfill closure and should be considered for closure of the Current Landfill:

- Consent 6009, Condition 15(n): *Grading to a final slope on the landfill faces and caps of between 1V:3H (1 in 3) and 1V:40H (1 in 40);*
- Condition 6009, Condition 15(o): *Ensuring the final landfill surface is sloped to promote run-off toward the outside of the landfill footprint and prevent surface water ponding on the landfill cap*;
- Condition 6009, Condition 15(q): *Establishing and maintaining a grass or tussock vegetation cover on the capped landfill consistent with an ongoing ability to monitor and maintain the integrity of the landfill cap. The vegetation is to be managed to exclude tree species that can potentially develop root systems capable of disrupting the landfill cap and thereby enhancing rainwater infiltration*; and
- Condition 6009, Condition 15(r): *Monitoring the landfill cover on an annual basis to identify areas of differential settlement, slope stability issues, erosion and changing vegetation patters, including a topographic survey*.

Table 4.1: Technical review of consent requirements for mid-2021 closure

Consent Condition	Consent Description	Report Section	Comment
6010, 14(a)	Compacting refuse to 600 to 800 kg/m^3, to ensure post closure settlement is minimised	3.1	From recent survey data, waste compaction exceed the recommended range of 0.6 to 0.8 t/m^3, and in recent years are estimated to be closer to 1.0 t/m^3. This consent condition is interpreted to be a minimum compaction requirement. Compaction above these recommended levels is expected to reduce post-closure settlement.
6010, 14(b)	Grading to a final slope of less or equal to 1V:3H (1 in 3) on any face	5.1.2	Preliminary closure design include waste fill scenarios of 1V:3H or flatter. These fill grades are expected to be technically feasible (subject to appropriate design calculations).
6010, 14(c)	The landfill cap will need to incorporate a layer at least 700mm thick with a permeability of no greater than 1 x 10^{-7} m/s, or approved equal	5.1.1	We understand there is an existing clay stockpile located above the Original Landfill. However, additional soil may need to be imported from off-site to achieve capping over the full extent of the Current Landfill. Importing and compacting material to meet this requirement is expected to be technically feasible but may have a large financial implication. Continued operation of the landfill beyond 2021 may allow for gradual accumulation of additional clayey material and a reduction in the eventual cost of closure.
6010, 14(e)	Establishing and maintaining a grass or tussock vegetation cover on the capped landfill	5.6	We understand that appropriate vegetation cover has been successfully established on the Original Landfill. Maintenance requirements for vegetation on the final cap of the Current Landfill will need to be specified in the Aftercare Plan.
6009, 15(n)	Grading the final slope to no flatter than 1V:40H (1 in 40)	5.2.1	The preliminary final cap grades for the Current Landfill meet this requirement.
6009, 15(o)	Ensuring the final landfill surface is sloped to promote run-off toward the outside of the landfill footprint and prevent surface water ponding on the landfill cap	5.2.1	No areas of ponding identified within the Current Landfill area, based on review of recent survey. The draft final cap grades for the Current Landfill have been graded to continue to promote run-off towards the outside of the landfill footprint.
6009, 15(q)	Cap vegetation is to be managed to exclude tree species	5.6	Standard requirement for landfill caps. Type of vegetation, inspection, and maintenance requirements will need to be specified in the Aftercare Plan.
6009, 15(r)	Monitoring the landfill cover on an annual basis to identify areas of differential settlement, slope stability issues, erosion and changing vegetation patters, including a topographic survey	5.6	Requirements to be included in Aftercare Plan

5 Technical aspects of early closure

5.1 Final cap

5.1.1 Cover system design

Condition 14(d) of Resource Consent 6010 requires that the final cap of the Current Landfill incorporates a layer at least 700mm thick with a permeability of no greater than 1×10^{-7} m/s. This requirement exceeds the *Technical Guidelines for Disposal to Land*[9], which recommends a minimum 600mm thick compacted barrier layer with the same permeability. The barrier layer is expected to consist of fine-grained soil such as clay or high-plasticity silt.

Although it is not specified in the Resource Consents, we expect that, as recommended in the *Technical Guidelines for Disposal to Land*, the final cap design would include a minimum 500mm thick subsoil layer beneath the barrier layer. The subsoil layer is recommended as part of the final cover design to provide a uniform foundation for construction of the barrier layer and reduce the risk of cracking or differential movement. Existing intermediate cover soil may be suitable for use as the subsoil layer. Alternatively, on-site sources of sand may be suitable for use as the subsoil foundation layer, provided this layer is not left exposed for a prolonged period of time, as clean sandy soil is not expected to be an effective odour barrier for use as intermediate cover.

The *Technical Guidelines for Disposal to Land* also recommends a 150mm thick topsoil layer above the barrier layer. The purpose of this topsoil layer is to provide soil for vegetation growth, which will limit erosion on the cap and reduce infiltration.

From our review of existing site conditions, we consider that it is feasible to construct a final cover system consistent with the Resource Consent conditions and the *Technical Guidelines for Disposal to Land*[10].

To the extent practical, we recommend segregation of material which may be suitable for reuse in the final cover as intermediate cover, barrier soil, or topsoil. Gradual intake of suitable cleanfill material which can be reused for the final cap will reduce the overall cost of construction. For example, we understand that the site currently has a clay stockpile which could be utilised for construction of the final cap barrier layer. However, more material may need to be imported to the site to install a final cover over the full extent of the Current Landfill. We anticipate that for early closure, there will be less time available to supplement existing stockpiles, therefore, additional material may need to be imported to the site, which will increase the cost of closure.

5.1.2 Slope stability

The final cap profile will need to be designed to provide resistance against slope instability. Two types of slope failures should be considered: (1) global stability of the waste mass, and (2) translational sliding of the final cover soil.

The site Resource Consents requires grading to a final slope of less than or equal to 1V:3H on any face. This maximum allowable gradient is consistent with the recommendations in the *Technical Guidelines for Disposal to Land*. At the Levin Landfill, certain closure scenarios may require slope batters of up to 1V:3H, which is consistent with the Resource Consent. We note that landfill caps of up to 1V:3H have been implemented successfully at similar sites in New Zealand.

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[9] Waste Management Institute New Zealand (WasteMINZ), 2018, "Technical Guidelines for Disposal to Land", August.

[10] The cap configuration described above (consisting of intermediate cover, barrier soil, and topsoil) refers to the minimum final cover design recommended in the *Technical Guidelines for Disposal to Land*. Other final cover designs may also be suitable at the site, if it can be demonstrated that the alternative design can achieve equal or better performance.

The stability of the final cap profile would need to be assessed during detailed design of landfill closure. We would expect that these stability assessments would include a consideration of weak shear planes in the cap profile, such as along a compacted clay or geomembrane interface. If necessary to increase the factor of safety, a lateral drainage layer and/or geogrid reinforcement may be required.

We consider that, subject to the stability assessments described above, a cap profile of 1V:3H may be appropriate for the site. Depending on stormwater design for the closed landfill, additional erosion protection measures may be required on steeper portions of the cap. These measures may include installation of erosion control matting and/or construction of contour drains to limit the maximum flow path and velocity of water along a steep slope.

The batter of the landfill cap is expected to decrease with time as the waste settles.

5.2 Stormwater

5.2.1 Stormwater flow

Stormwater at the Current Landfill is managed so that leachate is separated from clean stormwater. We understand[11] that any rainfall on the operational area of the landfill is managed as leachate. Runoff from the active face is contained within the lined landfill area and forced to soak back into the waste, where it will infiltrate through the waste to the base liner system and be managed via the leachate collection system.

As the landfill is capped and stabilised, runoff from the cap is directed off from the landfill, to prevent ponding on the cap and reduce infiltration. Water is shed off the landfill cap by designing the landfill cap grades to provide positive flow of clean water away from the waste mass, and by avoiding the formation of low points of the cap which may cause ponding. From our review of the existing survey and proposed final cap grades, we did not identify low points of the Current Landfill that may be subject to ponding. Both the existing grades and proposed final cap grades provide for radial flow towards the perimeter. From this review, we anticipate that early closure of the Current Landfill is not likely to affect the ability to provide appropriate stormwater diversion measures.

Condition 15(n) of Resource Consent 6009 specified a minimum final cap gradient (for the Original Landfill) of 1V:40H. However, we note that the *Technical Guidelines for Disposal to Land* recommend a steeper minimum gradient of 1V:20H, to promote drainage of the top of the landfill. The proposed final cover grades for the Current Landfill meets this more stringent requirement.

5.2.2 Stormwater treatment

Clean stormwater shed from the lined area is currently directed to two inter-dune depressions referred to as SW2 and SW3. SW2 is located to the west of the Current Landfill and SW3 is located to the south east. Stormwater directed to these inter-dune depressions will soak into the underlying sand and infiltrate to groundwater. All surface water shed from the Current Landfill appears to be directed towards these soakage pits and does not flow off site. We note that management of stormwater via soakage pits is permitted via the site Discharge Permit 102259.

Two additional soakage pits are proposed for the Current Landfill. SW4 is located to the north and SW5 is located to the north west of the Current Landfill. As with SW2 and SW3, the proposed soakage pits are located at existing inter-dune depressions within the site boundary. Use of these inter-dune depressions as soakage pits is not contingent on the closure date of the Current Landfill.

[11] Landmark, P.S., 2016, "Statement of Evidence of Phillip Sverre Landmark (Design/Operations) on Behalf of the Consent Holder", Consent Holder: Horowhenua District Council, 2 September.

Regardless of the closure date, runoff from the capped northern face of Stage 2 and 3 will still need to be managed and treated.

The proposed post-closure stormwater management plan appears to be consistent with the Discharge Permit. The Discharge Permit also requires regular inspection and maintenance, including de-sludging or remediating the ponds as required, and monitoring the groundwater quality in bores upgradient and downgradient of the soakage area(s). We anticipate that these conditions would continue to apply in the post-closure period.

During and immediately following construction of the cap, and until vegetation has been established, the exposed cap has the potential to generate sediment-laden water. We anticipate that construction of the final cap will be need to be managed in accordance with applicable erosion and sediment control guidelines[12]. This construction stormwater management plan may involve installation of temporary erosion control features which would be decommissioned after the surface of the final cover has been stabilised.

5.3 Leachate management

The Current Landfill includes a leachate collection system which has been designed to remove leachate from the landfill and limit the head of leachate over the base liner system. This leachate collection system consists of perforated leachate collection pipes surrounded by 300mm thick gravel drainage aggregate. These leachate collection pipes have been designed so that leachate from each stage flows by gravity to a single leachate collection manhole. From the collection manhole, leachate is pumped to a lined leachate pond, then to the Levin Wastewater Treatment Plant, for offsite treatment and disposal.

We anticipate that closure of the Current Landfill will reduce but not eliminate leachate generation. Leachate will continue to be collected due to gradual draining of the existing moisture in the waste mass and generated from waste decomposition processes. Leachate will also be generated from infiltration of rainwater through the cap, although construction of a low permeability clay liner or GCL capping layer will substantially reduce the amount of infiltration.

Since leachate will still be generated, the leachate collection system will need to continue operating during the post-closure period. We expect that leachate will still need to be pumped from the leachate collection manhole to the pond, and then pumped to the wastewater treatment plant for treatment and disposal. The leachate collection pipes may also need be to occasionally jetted via clean-out drains to remove potential blockages. We also recommend periodic inspection of the landfill cap for evidence of leachate seeps, followed by repair of identified seeps. The inspection and maintenance requirements for the leachate collection system would need to be specified in the Aftercare plan.

5.4 Odour control

5.4.1 Sources

During the 2016 review of the landfill consent conditions, three air quality experts reviewed the sources of odour at the landfill[13]. These experts agreed that the main source of offsite odour is likely to be landfill gas. In particular, the principal sources of odour were identified as (i) passive discharge of landfill gas from portions of the landfill that had been capped with intermediate cover but have

[12] Horizons Regional Council has adopted: Greater Wellington Regional Council (GWRC), September 2002, Reprinted June 2006, "Erosion and Sediment Control Guidelines for the Wellington Region"

[13] Mr. Doug Boddy, Ms. Louise Wickham, and Ms. Debroah Ryan. Summary of landfill gas sources described in: Boddy, D., 2016, "Statement of Evidence of John William Douglas Boddy (Air Quality) on behalf of Horowhenua District Council" dated 2 September 2016.

not yet received final cover, and (ii) landfill gas emissions from the leachate collection manhole. The experts agreed that odour from the active landfill tipping area and leachate pond were likely to be minor contributors to odour detected beyond the landfill boundary.

Odour is likely to reduce with installation of a final cap, as clayey soil used to form the cover will act as a barrier to landfill gas migration.

Following closure, odours can be managed through appropriate control of landfill gas, as discussed in Section 5.5 below.

5.4.2 Odour control during construction

Closure design should avoid the need to excavate into existing waste to the extent possible, as this may release significant odours. From our review of existing topography, early closure and capping appears to be feasible without significant re-forming or excavation into existing waste. However, portions of the existing Stage 1A cap will need to be stripped to accommodate waste placement until a mid-2021 closure. Stripping the existing cover material has the potential to release odours.

We understand that stripping of the Stage 1A cover soil is currently ongoing, and that stripped areas are observed to have a noticeable increase in odour near the exposed waste. Odour generation is partially mitigated by stripping the clayey cover soil, but leaving the underlying sandy intermediate cover soil in place to provide a partial barrier to odours. The material that remains in place over the existing waste should be sufficiently porous to allow for vertical migration of leachate once additional waste is placed above. We anticipate that clean dune sand would be sufficiently permeable, but that sandy soil with a significant clay or silt fraction may act as a leachate barrier and increase the risk of a perched leachate table and leachate breakouts along the perimeter of the landfill.

During stripping, odour can also be managed by keeping the stripped area as small as possible and by appropriate timing of the stripping operations based on weather conditions.

5.5 Landfill gas

5.5.1 Landfill gas requirements

There is no condition in the landfill consents that require collection and treatment of landfill gas (LFG). However, the following conditions apply:

- Condition 3 of Discharge Permit 6011: *There shall be no discharge of odour or dust from the landfill that in the opinion of a Regional Council Enforcement Office is noxious, dangerous, offensive, or objectionable beyond the property boundary.*
- Condition 5 of Discharge Permit 6011: *The Permit Holder shall take all practicable steps to avoid, remedy or mitigate significant adverse effects of the discharge of landfill gases to air.*

Based on the above, and noting that landfill gas emission is the primary source of odour at the landfill, we anticipate that a landfill gas collection and treatment system will need to operate in the post-closure period to meet these consent requirements.

5.5.2 Landfill gas management

The National Environmental Standards (NES) for Air Quality[14] require capture and treatment of landfill gas if the landfill has a total capacity of greater than 1 million tonnes. We understand that the Current Landfill has a consented capacity of less than 1 million tonnes, including development of

[14] New Zealand Legislation, 2004, "Resource Management (National Environmental Standards for Air Quality) Regulations 2004" SR2004/309, Reprint as at 1 June 2011

future Stages 4 and 5[15]. Therefore, the NES requirement to capture LFG does not apply[16]. Collection of LFG and flaring may still be required to meet Conditions 3 and 5 of Discharge Permit 6011, as these measures may be needed to control odour and mitigate adverse effects of the discharge of LFG.

A LFG flare has been used from 2012, but the flare was not appropriately sized for the landfill and was highly deteriorated, therefore the use of the flare was discontinued in 2015. We understand that HDC has since added a new flare to this site. Continued operation of a flare in the post-closure period may be required to avoid adverse effects from discharge of LFG, unless HDC can demonstrate that current and predicted discharge of LFG is not likely to result in significant adverse effects or odours beyond the site boundary.

LFG discharge from the existing leachate manhole was also identified as a likely odour source. We understand that LFG is currently being extracted from the leachate manhole and treated via a biofilter. We expect that this biofilter would need to remain in place during the post-closure period to manage landfill gas and odours, unless other landfill gas treatment methods such as a flare have been established to treat this source of LFG discharge.

To manage LFG and reduce fugitive odour releases in the post-closure period, we also recommend periodic surface emissions monitoring of methane and/or hydrogen sulphide. The landfill gas monitoring requirements should be documented in the site Aftercare plan, and may include surface emissions survey of the landfill cap, a site walkover to inspect for damage to the cap or other LFG emission pathways, and walkovers along the perimeter to monitor odours. Damaged areas of the cap, or areas that are observed to have higher LFG surface emissions would then need to be repaired.

5.6 Aftercare

An aftercare plan will need to be prepared to describe the inspections, operations, and maintenance of the landfill in the post-closure period. This aftercare plan would need to consider the proposed end use of the landfill. For example, if the capped landfill is to be used for grazing by sheep or cattle, then the aftercare plan would need to contain measures to monitor and maintain the cap and repair any damage.

We anticipate that, as required by the Resource Consents, the only vegetation allowed on the cap will be grasses. The aftercare plan should contain a provision to regularly inspect the cap to identify and remove any inappropriate vegetation.

[15] MWH, 2015, "Modelling of District Waste Disposal Options and Solid Waste Activity Cashflows," Prepared for Horowhenua District Council, 10 March 2015.

[16] NES standards may need to be applied if future expansion result in an increase in the total estimated capacity to greater than 1 million tonnes. These standards may also apply if interpreted as the combined capacity of the Original Landfill and Current Landfill; however, we consider that this interpretation of the NES is not likely given that separate consents were granted for the Current Landfill.

6 Applicability

This report has been prepared for the exclusive use of our client Horowhenua District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Pty Ltd

Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Pty Ltd by:
	
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