Council

O'NEIL ROAD WASTE MANAGEMENT FACILITY – CLOSURE AND POST CLOSURE MANAGEMENT PLAN

Mount Barker Waste Management Facility – Closure and Post Closure Management Plan – May 2021 - GHD

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Shire of Plantagenet

Mount Barker Waste Management Facility
Closure and Post Closure Management Plan

May 2021

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1. Introduction

1.1 Background

The Mount Barker Waste Management Facility (WMF or the site) is the main waste management facility operated by the Shire of Plantagenet (Shire). The landfill has been in operation since the 1960s, with waste disposal activities occurring in the northern portion of the site, covering a footprint of approximately 16 ha of the total 76 ha of the site.

The Shire intends to expand the landfill to maximise available airspace and extend the remaining operational life of the site. The Shire has commissioned GHD Pty Ltd (GHD) to develop a Closure and Post Closure Management Plan (CPCMP or Plan) for the site to provide direction and guidance on the closure of the landfill and post closure requirements.

1.2 Purpose

This CPCMP for the Mount Baker WMF outlines the proposed final landfill footprint and landform, as well as management measures for key site infrastructure, as part of the site closure and post closure management. The proposed closure and post closure approach outlined in this Plan is founded on a risk-based approach after completing additional site investigation works at the site (GHD 2020a).

1.3 Limitations

This report has been prepared by GHD for Shire of Plantagenet and may only be used and relied on by Shire of Plantagenet for the purpose agreed between GHD and the Shire of Plantagenet as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Shire of Plantagenet arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Shire of Plantagenet and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Site details

GHD's understanding of the existing site conditions for the Mount Barker WMF is based on the background review of previous information provided by the Shire as well as other, publicly available and accessible information and data. Additional information was obtained during a site inspection on 14 May 2020 and a targeted site investigation by a Senior GHD Environmental Scientist on 3 and 4 November 2020, as summarised in this section.

2.1 Site description

The site is located at Lot 7546 on Plan 186612, on Crown Reserve 23969 O'Neil Road, Mount Baker, approximately 5 km south west of Mount Baker, as identified on Figure 1, Appendix A.

The site is licensed under L7026/1997/14 to accept up to 1,000 kL per annual period of liquid waste (Category 61) and up to 10,000 tonnes per annual period of class II or III putrescible landfill waste for burial (Category 64) (DWER 2014), following an approved increase in the licence limit on 11 May 2018. The site receives household, commercial and industrial waste collected by the Shire and its contractors, as well as putrescible, general household, green waste and recyclables from nearby rural residents. Over the last five years, the quantity of solid waste accepted and disposed to landfill has ranged between 3,900 tonnes and 6,800 tonnes.

2.2 Site operations

The following operations are being undertaken at the site, as identified in Figure 2, Appendix A. It is noted that there is no power on site and no ability to get power to the site in the future.

- Active landfilling of putrescible waste in the southern portion of the landfill footprint. All putrescible waste accepted by members of the public is disposed of in the contained transfer shed to the north of the site and is disposed of by site operators into the active landfill area once a week, utilising a landfill compactor and front-end loader.
- Active asbestos burial pits to the northwest of the landfill, with historical asbestos burial pits located to the east of the landfill footprint
- Animal burial pits to the northwest of the landfill footprint, with historical animal burial pits to the north of the active landfill area
- Transfer station, including community drop off and tip shop, directly north of the landfill footprint, which accepts recyclables, batteries, white goods, e-waste, tyres, oil etc.
- Liquid waste facility, consisting two lined discharge and evaporation ponds, located to the west of the transfer station
- Green waste and scrap metal stockpiles directly west of the transfer station and south of the liquid waste facility
- Inert waste is stockpiled throughout the landfill footprint, with historical ad-hoc inert waste stockpiles located to the south of the landfill footprint.

2.3 Surrounding land use

The surrounding land uses are summarised below:

North – O'Neill Road, with the adjacent plot of land densely vegetated with an unnamed waterway running through the centre.

East – Densely vegetated land with several tracks and sporadic cleared areas.

South – Densely vegetated bushland with some vehicle access tracks and a cleared rural property to the southeast. Sleeman Creek is located 50 m south of the landfill.

West – Agricultural property with a number of surface water bodies between 500 m and 1 km west of the site.

The nearest residential dwelling is located approximately 2.5 km northwest of the site.

2.4 Site characteristics

2.4.1 Topography

The topography of the site and surrounding area comprises gentle slopes from 187 mAHD in the northeast towards 175 mAHD in the south, as shown in Figure 2, Appendix A.

The landfill contours range from 188 mAHD in the central-western portion of the landfill to the lowest elevation of 176 mAHD at the toe of the south-southwestern landfill batters.

2.4.2 Geology

The surface geology at the site consists of a thin layer of quaternary coastal sandy deposits over Pallinup siltstone, and Weillup Formation clay, sandstone and limestone of the late Eocene Plantagenet group (Smith 1997). Archean granitoil bedrock of the Yilgarn Craton underlies this formation.

A targeted soil investigation was undertaken as part of GHD's site investigations at the site. Ten push tubes were advanced to the west and south of the existing landfill footprint to a maximum depth of 3 m below ground level (mbgl). The push tubes returned geology consisting of sand over a clay unit with variable amounts of sand fraction at each location (GHD 2020).

A previous soil investigation has also been undertaken in the western portion of the site, adjacent to the transfer station and landfill area, where the Shire intends constructing a new landfill cell (Lynch 2016). Eight test pits were excavated to depths ranging between 2.4 m and 2.8 mbgl. The test pits revealed a layer of coarse sandy material followed by sandy clay loams, clay loams and occasional light to medium clays with a significant portion of gritty angular sands. It was suggested that the sands are formed on either weathered metasediments or deposited from surrounding higher topography (Lynch 2016).

As part of the previous soil investigation, clay material from three of the test pits was sampled and analysed for various chemical and physical properties. The hydraulic conductivity results ranged from 4.7×10^{-9} m/s to 1.9×10^{-10} m/s. Results for Cation Exchange Capacity were generally low across all three clay samples and were dominated by sodium. Therefore, it is likely that the clays are dispersive (Lynch 2016).

2.4.3 Hydrogeology

Six groundwater monitoring wells are currently installed on site, as identified on Figure 2, Appendix A. MW1 is located hydraulically up-gradient of the landfill with MW2 hydraulically cross-gradient, and the remaining wells MW3 - MW6 hydraulically down-gradient.

As required for licence compliance, groundwater monitoring has historically been undertaken at groundwater monitoring wells MW1, MW2 and MW3. Historical standing water levels at these three monitoring wells indicate that local groundwater on the site flows in a southerly direction (Great South Bio Logic 2019). Groundwater elevations measured at these monitoring wells generally range between 177 mAHD ad 180 mAHD up-gradient from the landfill at MW1, and between 174 mAHD and 177 mAHD down-gradient of the landfill at MW3.

Results from annual groundwater monitoring report (Great Southern Bio Logic 2019) indicate that groundwater levels down gradient of the landfill at MW3 range between 0 mbgl and 1 mbgl, with groundwater rising to the surface in months with high rainfall.

Groundwater monitoring wells, MW4, MW5 and MW6, were installed down-gradient of the landfill footprint by GHD in 2020. During installation, the wells intercepted groundwater between 6 mbgl and 7.5 mbgl during drilling. It is understood that the aquifer intercepted is confined and under pressure as settled water levels post-well construction rose to between 0.3 mbgl and 2.4 mbgl (considered potentiometric water level).

Preliminary hydraulic conductivity tests were undertaken at two of the new groundwater wells, MW4 and MW6, and returned hydraulic conductivity values of 0.25 m/day and 0.4 m/day, respectively.

2.4.4 Hydrology

Upstream surface water enters the site from the north via an unnamed creek and drains through the site through the informal landfill drainage system, as identified on Figure 2, Appendix A. The drainage system includes a large diversion drain along the northern boundary of the landfill and carries surface water to the west of the landfill footprint where it further drains in a southerly direction via informal stormwater drains.

An informal drain is also located to the east of the landfill footprint, to divert both on and off-site surface water in a southerly direction.

There are two sediment ponds located on site, an informal sediment pond in the north western corner of the site that collects upstream surface water runoff and a formal sediment pond to the south of the landfill that is intended to collect surface water runoff from the landfill.

Surface water monitoring is undertaken at three on-site sampling locations: at the site entrance (SW1), within the downstream sediment pond (SW2) and within Sleeman Creek to the south of the landfill (SW3).

2.4.5 Meteorological conditions

The nearest Bureau of Meteorology (BOM) weather station with rainfall and temperature data is the Albany Station (Station No. 9500), located approximately 1 km to the south east of the Mount Barker WMF. The monthly average rainfall, maximum temperatures and evaporation are highlighted in Table 2-1 and Figure 2-1.

Table 2-1 Average monthly meteorological data

	January	February	March	April	May	June	July	August	September	October	November	December
Mean rainfall (mm)	23.7	22.5	38.4	68.4	114.8	130.9	142.6	126.7	101.4	77.9	44.8	30.1
Mean maximum temperature (°C)	22.8	22.9	22.2	20.9	18.7	16.7	15.8	16.4	17.3	18.5	20.4	21.8
Mean evaporation (mm)	225.8	179.1	150.6	98.5	66.9	55.1	54.7	69.9	95.8	135.2	162.8	204.1

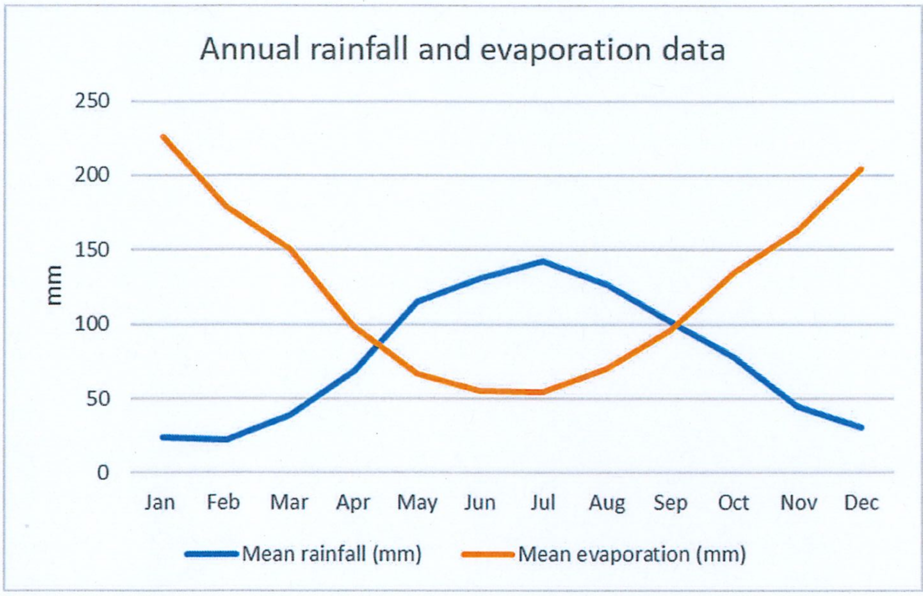

Figure 2-1 Average rainfall and evaporation data

2.4.6 Sensitive receptors

Several surface water bodies, identified as potential surface water receptors are located to the west and south west of the site and in the adjacent property, including Sleeman Creek that intercepts the western site boundary and runs through the southern portion of the site, approximately 50 m south of the landfill footprint.

During the wet season, it is noted that small tributary creeks form in the southern portion of the site, receiving run-off from the landfill area.

2.5 Existing site infrastructure and environmental controls

2.5.1 Landfill construction

It is understood that the existing landfill footprint was not lined prior to the commencement of landfilling, and waste was disposed directly onto the natural ground level, with no cell excavation occurring.

Based on the soil investigation undertaken in 2016 (Lynch 2016), detailed in Section 2.4.2, the soil beneath the landfill is likely to be sandy underlain by low permeability clays. Recent site investigations undertaken by GHD (GHD 2020) revealed this low permeability clay extends to a minimum of 6 mbgl before encountering a confined and under pressure aquifer.

At present, the entire landfill has been capped with an interim cap consisting clean fill.

2.5.2 Transfer station operations

The transfer station is located directly north of the landfill and includes a community drop off area and tip shop.

The transfer station accepts recyclables, batteries, white goods, e-waste, tyres and oil.

2.5.3 Liquid waste management

Liquid waste accepted at the on-site liquid waste facility is discharged into a system comprising a receival pond and an evaporation pond, which was constructed in February 2014, under works approval (W4729/2010/1). The works included three stages:

- Stage 1 – Construction of a new geomembrane-lined liquid waste receival pond
- Stage 2 – Decommissioning and de-hydration of the old receival pond, to enable the removal of sludge material from the redundant clay lined liquid waste pond
- Stage 3 – Construction of a new liquid waste evaporation pond, designed to receive liquid waste flow from the new receival pond.

As detailed in the Shire's licence amendment application to DWER in 2017, the receival and evaporation ponds are connected via a 225 mm diameter pipe, which allows overflow from the receival pond into the evaporation pond.

The receival and evaporation ponds are both lined with a high-density polyethylene (HDPE) liner and have respective design capacities of 1,000 m^3 (100,000 L) and 8,200 m^3 (821,000 L).

It is understood that the Shire maintains a freeboard of at least 500 mm in both ponds, and immediately cease receipt of all liquid waste deliveries if this freeboard is reached.

2.5.4 Stormwater management

An existing downstream sediment pond, SW2, is located to the south west of the landfill, which sporadically collects surface water runoff from the landfill. However, it is understood that there are currently no formal drains in place to direct the runoff towards this pond.

All surface water runoff from the upstream catchment and the site are directed in a southerly direction towards Sleeman Creek via several informal diversion drains.

2.5.5 Leachate management

The landfill is not lined and there is no leachate collection or management system present on site. It is anticipated that leachate generated from the waste gradually seeps out through the base of the landfill, out of the external batter or at ground level (IW Projects 2013).

Given the low permeability of the clay layer identified beneath the site, it is unlikely that significant leachate migration to groundwater occurs. If any, leachate migration is expected to occur slowly and within close proximity to the landfill (IW Projects 2013). As there is no formal leachate collection and management infrastructure at the site, it is likely that the leachate flows along the ground surface and enters the surface water system on site.

While no leachate management infrastructure is present on site, routine groundwater and surface water monitoring is undertaken to identify potential leachate impact on down gradient groundwater and downstream surface water.

2.5.6 Landfill gas management

There is currently no landfill gas management system in operation at the site and no landfill gas monitoring has been undertaken on at the site to date. Based on the age of the landfill (>50 years) and the high percentage of putrescible waste disposed to landfill each year, it is likely that landfill gas is generated and present within the landfill, however generation rates across the landfill will vary given the disposed waste is at various decomposition stages (GHD 2020b).

It is understood that the landfill has been covered with an interim cap consisting of clean fill, which is likely allowing landfill gas generated at the site to passively vent vertically from the landfill through the cap.

3. Qualitative risk assessment

3.1 General

A risk-based approach has been applied with regards to the key design considerations within this Plan. Using the existing site details, historical development, landfill waste characterisation, previous and recent on-site investigations, and surrounding land uses/sensitive receptors, GHD has identified the following key environmental risks at the site:

1. Leachate generated within the landfill has the potential to infiltrate through the underlying geology and contaminate down gradient groundwater
2. Leachate generated within the landfill has the potential to contaminate surface water runoff and impact ecological receptors downstream of the site
3. Landfill gas generated within the landfill has the potential to migrate to on-site buildings and the off-site adjacent agricultural property.

3.2 Leachate impacts on groundwater

It is noted that potential hydraulic connections and interaction between groundwater and surface water in the southern portion of the site were previously uncertain, given the shallow groundwater levels reported at the original down gradient monitoring well, MW3. As part of the recent site investigation undertaken by GHD (GHD 2020a), groundwater and surface water level surveyed heights were picked up, as well as groundwater and surface water quality samples to further investigate the potential interaction between groundwater and surface water. The findings from this investigation indicated that the surface water system to the south of the landfill footprint is a seasonal perched system that does not appear to be connected to the underlying groundwater system.

Groundwater monitoring wells, MW4, MW5 and MW6, were installed down gradient of the landfill footprint as part of the recent site investigations, which intercepted groundwater between 6 mbgl and 7.5 mbgl during drilling. It is understood that the aquifer intercepted is confined and under pressure as settled water levels post-well construction rose to 0.3 – 2.4 mbgl (considered to be the potentiometric water level).

A cross section was developed from the site investigation findings (refer to Figure 3, Appendix A), which suggests that due to the nature of the low-permeability clay substrate, the landfill mass is positioned on the unsaturated zone of the soil. Given the pressure of the underlying aquifer, there is potential for groundwater to penetrate this unsaturated zone of the soil and rise within close proximity of the ground surface and landfill base. This has been considered as part of future landfill progression and environmental management infrastructure, to maintain an appropriate buffer between site infrastructure and groundwater, where possible.

3.3 Leachate impacts on surface water

Surface water runoff and leachate discharge from the landfill mass (seepage) to Sleeman Creek is considered the most plausible emission-pathway-receptor scenario for the site.

Surface water is monitored on a bi-annual basis from the three surface water monitoring locations, SW1 to SW3. Surface water monitoring has been regularly undertaken at all three locations since 2009. Water quality at upstream location, SW1, and downstream location, SW3, have followed a similar fluctuating trend since monitoring began.

Elevated nutrient (ammonia (as N) and total nitrogen) and metal (chromium, nickel and lead) concentrations have been reported at on-site sediment pond SW2, which collects surface water runoff from the landfill. Given the lack of leachate management infrastructure at the site, there is potential for leachate to seep from the landfill footprint and enter this sediment pond.

Surface water within this sediment pond is contained and does not appear to be impacting surface water downstream at SW3, as the elevated nutrient and metal concentrations are not reflected at this location. However, there is potential for the pond to overflow and result in downstream surface water contamination.

3.4 Landfill gas impacts on buildings

No landfill gas monitoring or investigations have been undertaken at the site to date and it is therefore unknown to what extent landfill gas may be currently generated. Based on the existing interim clean fill cap, it is likely that any landfill gas generated at the site passively vents vertically from the landfill through the cap.

As part of the landfill closure, a final landfill cap consisting a low permeability layer will be constructed over the entire landfill footprint, which will prevent landfill gas from passively venting thoroughly the cap and potentially directing the gas to migrate laterally off site. With the intention of operating the site as a formal transfer station after landfill closure, landfill gas also has the potential to accumulate in and/or under on-site buildings associated with the transfer station.

4. Final landform

GHD previously prepared the *Landfill Closure Design Basis* (GHD 2020b) that presented three final landform options for the site, based on the final landform considerations detailed in Section 4.2. The Shire preferred the final landform that provided the maximum available airspace at the site, whilst also meeting the final landform considerations. The final landform was re-evaluated following the site investigations and modified slightly in the southern portion of the landfill to minimise the potential interaction between the landfill and groundwater.

4.1 Post closure land use

Upon closure of the landfill, the transfer station and liquid waste facility in the northern portion of the site will continue to operate.

4.2 Final landform considerations

The following aspects were considered as part of the future development of the final landform for the site:

- The transfer station and liquid waste facility in the northern portion of the site will continue to operate
- External landfill batters of 1V:4H to optimise airspace whilst continuing to provide easy access for site operators for mowing and cap maintenance, and allow for effective stormwater management.
- Sufficient level areas to allow for future site operations including weighbridge, site office, transfer station and hardstand/stockpile areas.

  These may also provide for possible post closure activities, as required, including open park/recreational space.
- 35 m buffer to the adjoining property to the west and 5 m buffer to the eastern site boundary, as outlined in the site licence.

4.3 Final landform

The final landform has been included in SK001, Appendix A and includes three new cells to the west of the existing landfill footprint.

The final landform includes the re-profiling of the external eastern and southern batters of the landfill footprint to 1V:4H to create additional airspace for future inert filling and reprofile the batters to allow for final cap construction. The final landform also extends to the west of the current landfill footprint and the current transfer station. The landform has been developed with the external batters of 1V:4H, with the landfill plateau extending to a maximum height of approximately 187-189 mAHD.

The proposed final landform provides approximately 203,140 m^3 of airspace based on the February 2020 site survey.

5. Landfill staging

Landfilling and closure will prioritise the creation of the final landform and capping on the site with the objective to minimise the disturbed area and allow for the appropriate management of site operations, stormwater and leachate.

To efficiently manage stormwater and leachate whilst minimising cross contamination, future filling at the site is to commence in the south and progress in a northerly direction. This allows for the progressive construction of leachate and stormwater infrastructure in each stage as required. To minimise the interaction between groundwater and leachate at the site, the proposed leachate sump has been relocated from the initial indicative location identified in the Design Basis Report (GHD 2020b) to within the existing sediment basin, SW2, which will be decommissioned as part of future landfilling.

Future filling with putrescible waste will be undertaken in the central and western portions of the site, where leachate collected can drain along the natural topography in a southerly direction towards the leachate sump. Given the existing topography of the landform and surrounding ground levels in the eastern portion of the site, leachate generated within this portion of the site would drain in a southerly direction. As this leachate would no longer naturally drain to the proposed leachate sump, a high-level options assessment determined that it was more practical and cost effective to fill the eastern landfill batters with inert material, than to construct a liner and leachate management infrastructure, including an additional leachate sump, on the eastern side of the landfill footprint. Therefore, future filling on the eastern and southern landfill batters will be undertaken using inert material accepted at the site.

Portions of the site that have reached final elevation and will receive no further filling are to be progressively capped with the final cap profile to minimise rainfall infiltration and associated leachate generation. This progressive capping is outlined in the staging plan sketches. Stormwater and leachate infrastructure is also to be progressively constructed as the landfill progresses to distribute capital costs and allow for their effective separation and management. Further detail on the stormwater and leachate infrastructure is detailed in Section 8.2 and 8.3, respectively.

The landfill staging plan is detailed in this section and illustrated in sketches SK002 to SK007, Appendix B.

Stage 1

- Landfilling to be undertaken within the existing landfill footprint, working towards creating a smooth plateau that grades towards the west.
- Inert material accepted at the site, where not reused or recycled, is to be disposed in the southern landfill batter to create a smooth 1V:4H batter in preparation for final cap construction.
- A new sediment pond, SW4, is to be excavated and constructed to the south of the landfill footprint, with further details of the pond provided in Section 8.2.
- Sediment pond, SW2, is to be decommissioned and Cell 1, leachate interception drain and leachate sump will be constructed, with further details on the leachate infrastructure provided in Section 0.

  Cell 1 liner is to include the construction of a liner on the existing landfill batters (piggy-back liner) to the north, east and southeast of Cell 1, with further details on cell and piggyback liner provided in 7.1.

- Stormwater diversion drain and haul roads are to be constructed along the western boundary of Cell 1 and southern landfill batter, to direct surface water runoff towards sediment pond SW4.

  Down gradient monitoring well, MW3, may require decommissioning to allow for the construction of this infrastructure.
- Cross gradient groundwater monitoring well, MW2, is to be decommissioned to allow for future landfill expansion in this area.

Stage 2

- Landfilling to be undertaken in Cell 1 to an interim elevation of 183 mAHD, with external batters of 1V:4H, to key into the existing footprint to the north, east and southeast.
- Inert material accepted at the site, where not reused or recycled, is to be disposed in the south-eastern landfill batter to create a smooth 1V:4H batter in preparation for final cap construction
- Construction of Cell 2 and leachate interception drain to retrofit with Cell 1 leachate infrastructure. Piggyback liner is also to be constructed on the existing landfill batter and plateau to the east in preparation for future filling

  The extent of the piggyback liner required on the central portion of the landfill will depend on the extent of future landfilling proposed by the Shire (whether the Shire intend of landfilling in line with Stage 6 proposed below)
- Stormwater diversion drain and haul roads are to be constructed along the western boundary of Cell 2 and south western landfill batter, to direct surface water runoff towards sediment pond SW4.

Stage 3

- Landfilling to be undertaken in Cell 2 to an interim elevation of 185 mAHD. Landfilling is to commence against the existing eastern landfill batter and progress in a westerly direction, beginning in the southern portion of the cell

  By filling from the south, a diversion bund will be constructed to the north of the landfilling activities to allow for the collection and discharge of undisturbed surface water run-off prior to run-off entering the leachate collection system
- Inert material accepted at the site, where not reused or recycled, is to be disposed in the central-eastern landfill batter to create a smooth 1V:4H batter in preparation for final cap construction
- Green waste and metal hardstands located to the west of the transfer station are to be relocated to allow for the construction of Cell 3
- Construction of Cell 3 and leachate interception drain to retrofit with Cell 1 and Cell 2 leachate infrastructure
- Stormwater diversion drain and haul roads are to be constructed along the northern and western boundary of Cell 3 and the central eastern landfill batter, to direct surface water runoff towards sediment pond SW4.

Stage 4

- Landfilling to be undertaken in Cell 3 to a final elevation of 189 mAHD. Landfilling is to commence against the existing eastern batter and progress in a westerly direction, beginning in the southern portion of the cell

- Inert material accepted at the site, where not reused or recycled, is to be disposed in the active landfilling area
- Final cap construction in the southern portion of the landfill, with further details on the final cap profile provided in Section 8.1.1.

Stage 5

- Landfilling to be undertaken in the central-western portion of the landfill footprint to a final elevation ranging between 187 mAHD and 189 mAHD, commencing in the south and progressing in a northerly direction.
- Inert material accepted at the site, where not reused or recycled, is to be disposed in the active landfilling area
- Final cap construction along the eastern portion of the landfill.

Stage 6

- Progressive construction of the final cap across the remainder of the site, to begin in the southern portion of the site and progress in a northerly direction.

6. Airspace consumption and timing

6.1 Airspace consumption

The site is licensed to accept up to 10,000 tonnes of waste for disposal per annum. However based on a review of the waste data provided by the Shire from March 2015 to February 2020, approximately 2,800 tonnes to 4,800 tonnes of solid waste is disposed to the landfill each year, excluding clean fill used as cover material and asbestos containing material, as detailed in Table 6-1 and Figure 6-1. From 2019, inert waste type 1 that was accepted on site has been stockpiled and not disposed to landfill, resulting in a decrease in the volume of waste disposed to landfill.

Table 6-1 O'Neill Road waste acceptance

Time period	Waste accepted[1] (tonnes)
03/2015 – 02/2016	4,790
03/2016 – 02/2017	2,800
03/2017 – 02/2018	3,590
03/2018 – 02/2019	2,980
03/2019 – 02/2020	2,870

Notes

1 Waste volume excludes clean fill and asbestos containing material

Figure 6-1 O'Neill Road waste acceptance

Population growth data, sourced from the Western Australia sub region population projections (Western Australian Planning Commission 2019), revealed a low projected annual growth rate for the Shire of Plantagenet, as detailed in Table 6-3.

Table 6-2 Shire of Plantagenet population growth rates

Year	Average annual growth rate from 2016 (%)
2021	0.1
2026	0.15
2031	0.13

Given the predicted low population growth rates for the Shire, a constant airspace consumption rate has been assumed. To determine the operational life of the landfill, a consistent annual waste acceptance of 3,500 tonnes has been identified. An annual waste acceptance of 3,5000 tonnes equates to 7,000 m^3/year of waste, with the inclusion of an additional 30% volume for daily cover soil and adopting a compaction rate of 0.65 tonne/m^3, based on discussions with site operators and typical compaction rates for landfill compactors. The annual airspace consumption rate for the site is summarised in Table 6-3.

Table 6-3 Annual airspace consumption rate

Annual waste landfilled	Annual airspace consumption (m^3)	Annual airspace consumption, including soil day cover (m^3)
3,500	5,400	7,000

6.2 Filling timeline

The final landform makes an allowance for approximately 203,140 m^3 of airspace based on the February 2020 site survey. Based on the annual airspace consumption rate discussed above in Section 6.1, the operational life of the landfill is approximately 29 years. A breakdown of the landfill staging is outlined in Table 6-4.

Table 6-4 O'Neill Road filling timeline

Stage	Available airspace (m^3)	Operational life (years)
Stage 1	5,170	0.7
Stage 2	14,280	2.0
Stage 3	67,140	9.6
Stage 4	58,330	8.3
Stage 5	58,220	8.3
Stage 6	-	-
Total	**203,140**	**28.9**

Future filling in the eastern and southern most landfill batters is to be undertaken with inert material only to avoid the need to leachate infrastructure in this portion of the site. The airspace available in these areas has been modelled, as detailed below in Table 6-5, to provide the Shire an indication of the volume of inert material required to create the preferred batter slopes.

Table 6-5 O'Neill Road additional inert filling

Stage	Inert filling airspace (m^3)
Stage 1	3,860
Stage 2	13,270
Stage 3	9,000
Stage 4	-
Stage 5	-
Stage 6	-

It is important to note that the airspace consumption rate does not include consideration of changes in waste management practices over time. Changes in consumer behaviour or the regulatory framework, with increases in recycling and resource recovery initiatives or markets, the introduction of a landfill levy, as well as changes in landfill operational practices, such as the use of alternative daily cover, may significantly impact this airspace consumption estimate.

Settlement of the existing waste material has also not been considered. Natural disasters or other unforeseeable events can also impact on the volume of available airspace. It is recommended that the airspace consumption be modelled on a regular basis to track progress against this estimate.

6.3 Airspace monitoring

The airspace consumption rate has been based on projected waste generation rates and population trends. As outlined in Section 6, there are several factors that could significantly affect this estimate. It is therefore important that the Shire continue to monitor airspace consumption on a regular basis; at a minimum annual basis. Airspace monitoring should include survey of the operational area, modelling of void space consumption and tracking this against the landfill staging.

7. Filling operations

7.1 Cell construction and lining

It is understood that the existing landfill footprint was not lined prior to the commencement of landfilling, and waste was disposed directly onto the natural ground level, with no cell excavation occurring.

As part of the construction of future landfill cells, as well as areas where future filling is proposed on existing unlined landfill, a landfill liner is to be constructed to effectively contain and manage leachate from waste material within the proposed filling areas. A different liner profile is required for construction on previous unlined landfill (known as a piggyback liner) as consideration must be made for future settlement of the underlying waste material, compared to the cell liner which will be constructed directly onto natural ground. The profile of the cell liner and piggyback liner will be confirmed during detailed design and will be determined based on a risk-based approach.

Given the high clay content and associated low permeability results reported for the on-site clay material, ranging from 4.7×10^{-9} m/s to 1.9×10^{-10} m/s (Lynch 2016), it is proposed that a layer of compacted low-permeability clay be incorporated into the cell liner profile, as well as the piggyback liner profile, if available quantities allow. It is noted that previous soil investigation also highlighted that the on-site clay material was dominated by sodium and is likely to be dispersive. Further soil testing may be required to determine if the clay material requires ameliorating prior to use as liner material.

Following the extension of the landfill, it is important that a layer of soil or alternative protective layer is immediately placed on top of the liner for protection. The first layer of soil, or alternative protective layer is immediately placed on top of the liner for protection.

7.1.1 Cell liner

The cell liner is to be constructed and keyed into the natural ground at the base of the existing landfill, to allow leachate from the existing landfill to drain seamlessly into the new landfill cell and towards the proposed leachate collection system, detailed in Section 0.

A cell liner profile that could be constructed as part of the construction of future landfill cells is detailed below in Figure 7-1. The type of material and thickness of each layer, as well as any additional leachate management, will be confirmed as part of detailed design.

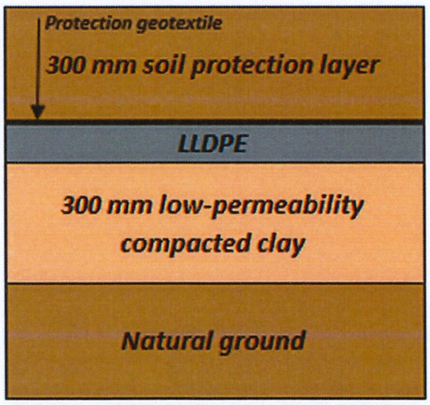

Figure 7-1 Cell liner profile

7.1.2 Piggyback liner

A piggyback liner comprises a similar profile to standard cell liners, however, it includes a landfill gas layer to effectively manage landfill gas generated from the underlying unlined landfill cell, and a settlement control layer to retain the integrity of the landfill liner as the underlying waste material settles over time.

A typical piggyback liner profile that could be constructed on the Cell 1 batters, prior to future landfilling, is detailed below in Figure 7-2. The type of material and thickness of each layer will be confirmed as part of detailed design.

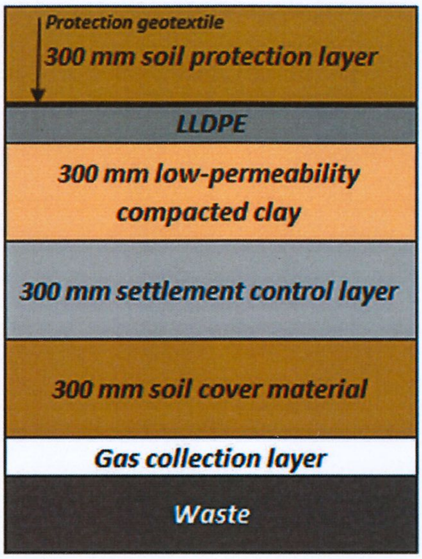

Figure 7-2 Typical piggyback liner profile

7.2 General waste placement and compaction

Only waste permitted under the site licence shall be landfilled at the site.

The surface area of waste exposed during operations shall be minimised. The area of the active tipping face should be no greater than 400 m^2.

No waste batters shall be steeper than 1 (vertical) in 3 (horizontal).

Waste placement shall be undertaken such that pre-capping contours are suitable for placement of the final capping layer.

Every lift of waste must be evenly compacted with mechanical plant to the greatest extent practicable. A typical model for effective waste placement and compaction, onion skin tipping, is illustrated in Figure 7-3 below. The level of compaction that can be achieved is, among others, dependent on the machine used. As discussed in Section 6, it is estimated that a compaction of 0.65 tonne/m^3 will be achieved on site. To maximise compaction and machinery efficiency, the following shall be considered:

- Where soil cover is used, temporary soil cover should be removed at the commencement of daily operations and pushed to the top and base of the tip face to create soil bunds which assist the diversion of stormwater around the tip face.
- Where feasible, a small bund should be constructed to delineate the working face ahead of filling. This bund can be constructed from reclaimed cover material placed on previous fill sections. This bund can be constructed from reclaimed cover material placed on previous fill sections. This bund will help ensure the width of the working face is not extended beyond suitable dimensions.

- Waste should be placed as close to the tip face as possible to reduce machinery movements.
- Where possible, waste should be placed at the top of the tip face and pushed vertically down the tip face in lifts no more than 300 mm in thickness.
- A minimum of four passes in two directions should be completed on each lift of waste.
- Isolate or separate bulky loads at the tip face that have limited potential for compaction.
- Instrumentation can also be installed within the compactor to track waste compaction density and assist with guiding the operator on where to focus.
- More frequent airspace survey and modelling can also help track compaction efficiency.

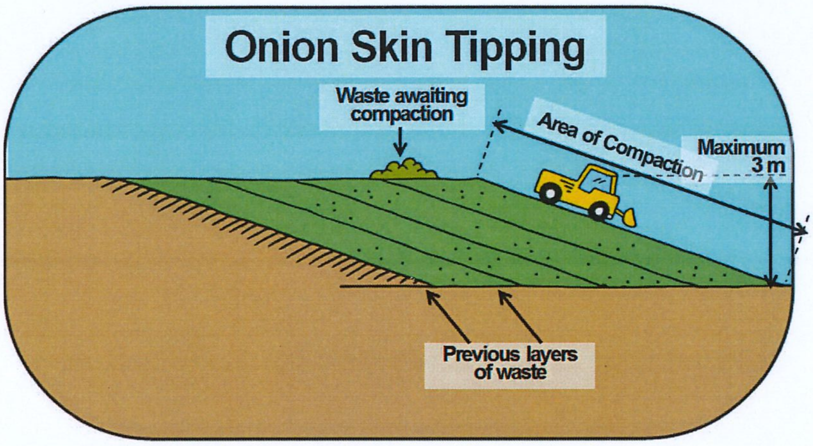

Figure 7-3 Waste placement and compaction

7.3 Daily cover

At the completion of each day the operational tip face should be covered with soil or an approved alternative daily cover material such as lids, tarps or spray seals.

The cover layer should be sufficient to prevent wind-blown litter and vermin accessing the waste.

At the commencement of each day as much soil or alternative daily cover as possible should be removed from the operational tip face.

A minimum of 2 weeks of daily cover material should be stockpiled on site at all times.

To maximise airspace consumption, investigations should be undertaken into the use of alternative daily covers. Temporary alternative daily covers, such as geomembrane covers, can provide the necessary waste cover each day without taking up any airspace as it can be reused numerous times. Alternative daily cover sprays can also be used, which consume less airspace than a typical soil cover, however these type of alternative covers cannot be removed the next day.

7.4 Cell filling progress

Each cell should be progressively filled in rows that commence adjacent to the existing waste mass and move forward in a linear manner. This will help reduce the area of stormwater that should be contained as leachate and allow interim surfaces to be graded away from the operational area.

7.5 Wet weather tip face

A wet weather tip face should be prepared in an area of site that can be easily and safely accessed during significant rainfall. This area will need to change with progressive filling. The wet weather tip face should include a gravel track, which leads to a tip face containing temporary cover material. The tip face should be covered at all times with temporary cover material and only opened during operation during an emergency event.

This tip face will replace the general waste tip face during emergency weather due to wet weather or limited site access. It is expected that when the emergency tip face is operational the general tip face will be covered so as to limit the operational tip face to one area at all times.

7.6 Access ramps

To allow for access of plant and trucks into the active waste cell, at least during the initial stages, an access ramp shall be constructed across the perimeter bund. The location of the ramp shall be selected such that it can provide cell access for the longest possible period.

The gradient of the ramp shall be suitable for truck access, considering the vehicle traction under full load. If the required space and construction materials are available, it is advisable to construct the ramp with a shallow gradient to avoid regular disturbance of the ramp surface.

Under consideration of the direction of approaching or departing trucks, a sufficiently large truck turning area shall be allowed for. Trucks approaching the ramp at an angle cause significantly greater disturbance to the ramp surface, which could lead to gradual reduction of the ramp depth over time.

The location of access ramps during each landfill stage is detailed on the filling plan sketches, SK002 to SK007, Appendix B.

7.7 Stockpile and hardstand locations

Type I inert waste is currently stockpiled within the existing landfill footprint, with green waste and metal hardstands located to the west of the transfer station. Inert waste not reused or recycled is to be used to reprofile the eastern and southern landfill batters, as detailed in the staging plan; refer to Section 5. As the landfill progresses, the green waste and metal hardstands will require relocation to allow for the construction of a future landfill cell.

It is important that measures are taken to manage stormwater runoff from stockpiles and hardstands to minimise the likelihood of sediment laden runoff. This could include diversion bunds around the stockpiles or hardstands as well as cover materials on the stockpiles.

8. Closure plan

8.1 Progressive capping

As discussed in Section 5, it is anticipated that the landfill closure will be staged to spread capital costs associated with landfill capping. The construction of the final cap is expected to follow the staged closure plan, with the final cap constructed following each finalised stage. Progressive capping will involve the placement of an appropriately designed low-permeability cap profile, to minimise surface water infiltration, leachate generation and landfill gas migration.

As stated in the License L7026/1997/14 Condition 1.2.8 (c), "*The Licensee shall manage the landfilling activities to ensure: rehabilitation of a cell or phase takes place within 6 months after disposal in that cell or phase has been complete;*".

The proposed staging of the progressive capping activity is detailed in Section 5 and identified on the filling plan sketches, included as Appendix B.

8.1.1 Final cap profile

It is understood that there is currently no landfill guideline or standard enacted in Western Australia, and that DWER do not specifically endorse or expect adherence to guidelines of other jurisdictions. While DWER's predecessors have historically endorsed BPEM (Victoria EPA 2015) as the primary guidance for assessment of landfill closure aspects, including proposed final cap design, it is understood that DWER will assess in line with their risk-based approach. Each facility and project will have to provide a minimum level of confidence that the proposed standards for design and construction are suitable for the particular site or project in its environmental setting.

Cognisant of the above, however, it is perceived that the general requirements for a landfill cap meeting BPEM criteria are applicable in this instance. BPEM states that the final cap should be:

- Designed to limit water infiltration into the landfill and gas migration through the cap
- Sufficiently graded to prevent water ponding on the cap and minimising infiltration through the cap
- Landfill plateaus are to be graded to at least 5% to adequately shed water
- External landfill batters steeper than 20% require specific stormwater infrastructure to control runoff and minimise cap erosion
- Designed to provide a landform suitable for its intended after use.

The final capping profile for the site should be based on the outcomes of site-specific risk assessment to ensure the cap is sufficient to manage risks to the environment and human health. The proposed final capping profile for the site is illustrated in Figure 8-1 and described below. The type of material and thickness of each layer will be confirmed as part of detailed design.

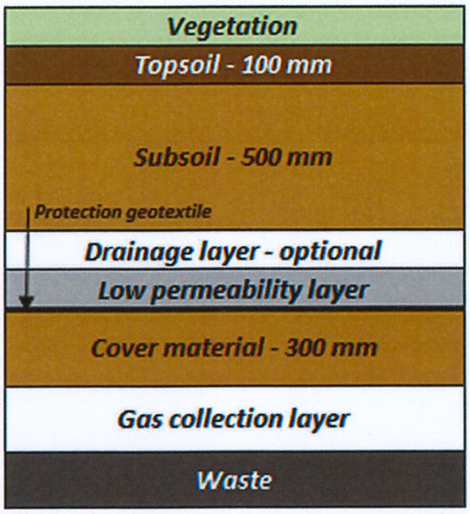

Figure 8-1 Proposed landfill cap design

Topsoil

The purpose of the topsoil layer is to establish and sustain grasses, which can assist with maintaining the integrity of the cap, primarily through prevention of erosion.

Soil subgrade

The soil subgrade layer should comprise selected fill material that provides additional support for the topsoil vegetation layer and protect the drainage/low permeability layer from root intrusion.

Drainage layer

The purpose of the drainage layer is to reduce pressure on the low permeability layer by promoting infiltrated water to run off the landform.

This drainage layer is optional and can be excluded from the final cap profile if the final landform is graded in such a way that surface water runoff is promoted.

Low permeability layer

The low permeability layer is to achieve a hydraulic conductivity no greater than 1×10^{-9} m/s to reduce the potential for rainfall infiltration. This low permeability layer can comprise a number of options including:

- Compacted clay layer
- Geosynthetic clay liner (GCL)
- Linear low-density polyethylene liner (LLDPE)

A protection layer has been proposed underneath the low permeability layer to provide extra protection against the cover material layer, as the cover material used may not be uniform and appropriately screened.

Gas collection layer

Dependent on the anticipated landfill gas generation of the site, a gas collection layer can be included in the final cap profile as part of an active landfill gas extraction system.

Further landfill gas investigations at the site are required to determine if this layer is necessary.

Cover material

The cover material is essentially a bearing layer above the waste, which is generally no less than 300 mm thick. This should ensure sufficient stability for placement of the final cap profile.

8.2 Stormwater management requirements

8.2.1 Stormwater drainage

As each landfill stage is progressively capped and stabilised, formal diversion, down batter and toe drains will be constructed into the final landform and around the perimeter of the landfill to effectively convey runoff from the landfill to the south where it is discharged off site, while minimising soil and cap erosion. Typical details for these drains have been detailed on Figure 4, Appendix A.

It is important to note that if cap erosion is observed during the post closure monitoring, additional stormwater drainage may require construction of the landfill to control surface water runoff.

8.2.2 Stormwater storage

The sediment pond to the south west of the landfill, SW2, is currently within the proposed final landfill footprint, and will therefore require relocation as the landfill progresses. With the preliminary landfill filling proposed to commence in this south western portion of the landfill, priority is to be given to the relocation of this sediment pond and all associated drainage infrastructure. It is proposed that this sediment pond be located further south of the landfill footprint as identified on the staging plan sketches, SK001 to SK007, Appendix B. The sediment pond will be lined with a 300 mm compacted clay layer, utilising in situ excavation material.

Preliminary pond sizing has been undertaken to size the sediment pond, with design parameters, assumptions and dimensions detailed below in Table 8-1. More accurate pond sizing will be undertaken as part of detailed design.

It is noted that the entire landfill footprint itself occupies approximately nine hectares, and it is expected that clean surface water runoff is progressively diverted from the sediment pond to minimise the volume of runoff requiring treatment, prior to off-site discharge.

Table 8-1 Sediment pond details

Parameter	Value
Catchment area	4.0 ha
Rainfall depth for a 24 hour storm event, ARI of 1 in 20 years	96.48 mm
Volumetric runoff coefficient	0.7
Upper settling volume	2,700 m^3
Sediment storage zone (half the size of settling volume)	1,350 m^3
Required sediment storage and settling volume	**4,050 m^3**
Estimated pond storage and settling zone dimensions (from base to spillway height)	
Pond dimensions, L x W	60 m x 50 m
Storage pond depth (from base to spillway height)	2.0 m
Internal slope	1V:3H
Available pond volume (including freeboard volume)	**4,776 m^3**

8.3 Leachate management requirements

To manage leachate from future landfill areas, a leachate interception drain is to be incorporated into the cell liner along the cell boundary to capture leachate and direct it to a centralised leachate sump, which is to be located in the vicinity of the existing sediment pond, SW2. Typical details of the proposed leachate interception drain and leachate sump are detailed on Figure 4, Appendix A.

With the introduction of the leachate interception drain, progressive capping will require enforcement on site to ensure that inactive landfill areas are appropriated capped with an interim material to minimise surface water infiltration into the landfill, and subsequent leachate generation.

Leachate collected within the leachate sump will be fitted with a solar telemetry system to feed real-time water level data to site operators. Rainfall and evaporation data for the site identifies the ability to manage leachate via evaporation during dry months, October through to April.

Therefore, a leachate evaporation pond has been proposed to the south west of the extended landfill footprint, as identified on SK001 to SK007, Appendix B. Similar to the liquid waste ponds at the front of the site, it is proposed that the leachate evaporation pond be lined with a HDPE liner underlain by a 300 mm compacted clay layer, utilising in situ excavation material.

Leachate from the leachate sump will require pumping to the evaporation pond, either pumping manually by site operators or installing an automated solar-operated or diesel generated pump. Alternative leachate management may be required during wet months, May to September, such as off-site disposal, recirculation or irrigation.

A leachate water balance and preliminary pond sizing has been undertaken to size the leachate evaporation pond, included as Appendix C, which details all relevant assumptions and results. Based on the findings of the leachate water balance, the proposed leachate pond is to have the following features:

- A freeboard of 0.5 m to guard against wave action causing leachate to overtop the banks, as well as to provide capacity for any unforeseen events
- Internal slopes of 1V:2H
- Total depth (including freeboard) of 3 m
- Pond dimensions of 86 m x 81 m
- Leachate storage capacity of approximately 15,000 m^3 and 18,500 m^3, respectively excluding and including freeboard.

8.4 Landfill gas management requirements

Landfill gas monitoring is not currently undertaken at the site and therefore it is unknown to what extent landfill gas (LFG) is currently being generated. The final landfill cap comprising a low permeability layer constructed over the entire landfill footprint will prevent landfill gas from passively venting through the cap and may potentially direct it to migrate laterally off site. There is potential for the landfill gas to accumulate in and/or under the on-site transfer station and site buildings.

In the absence of landfill gas monitoring results, the following landfill gas management measures are required:

1. A LFG monitoring program is to be developed and implemented during site operations and post closure, which is to include:
   - During site operations: surface emissions, and buildings and other on-site structures
   - Post closure: surface emissions, buildings and other on-site structures and landfill gas vents (as detailed below). Perimeter gas monitoring wells may be required should surface gas monitoring outside of the landfill footprint and/or gas accumulation monitoring within buildings and services indicate that migration is occurring.
2. Prior to the construction of a final cap, a landfill gas collection layer is to be constructed comprising a 50 m x 50 m gravel trench grid system that is connected to a number of landfill gas vents. An indicative landfill gas collection network is detailed on SK001, Appendix B. It is noted that this layout is indicative and is to be confirmed as part of detailed cap design.

9. Post closure plan

Following the closure of the landfill, it is important that a routine monitoring and maintenance program be established to ensure that the integrity of the site infrastructure is maintained. It can further demonstrate that the site is not presenting an unacceptable risk to the surrounding environment. The establishment and recording of a robust monitoring and maintenance program will assist the Shire in demonstrating that post closure management requirements have been met.

9.1 Control measures and management

9.1.1 Capping

In order to maintain the integrity of the cap, the following control measures need to be maintained:

- The vegetation layer should be maintained at all times to reduce erosion and sediment mobilisation, and ensure batter stability
- The cap thickness should be maintained to ensure the required barrier thickness between the waste and the environment is in place at all times
- Sufficient grade should be maintained on the landfill plateau and batters to facilitate stormwater flow off site and reduce the potential for ponding.

9.1.2 Stormwater

To manage stormwater at the site, the following control measures need to be maintained so that it operates efficiently and effectively:

- Correct alignment and grade of surface water drains
- Grass vegetation or other suitable lining material within surface water drains, where possible
- The sediment pond should be desilted on a regular basis to maintain the required capacity.

9.1.3 Leachate

The site licence does not provide any specific requirements for leachate management at the site.

To manage leachate at the site, the following control measures need to be maintained to minimise the risk of leachate impacting on downstream sensitive receptors:

- Landfill capping and stormwater control measures, outlined in Sections 9.1.1 and 9.1.2, respectively, need to be maintained to minimise leachate generation and divert stormwater around the landfill
- Always maintain a minimum freeboard of 300 mm within the leachate sump and leachate evaporation pond
- The leachate evaporation pond is to be emptied prior to a known rainfall events to avoid the risk of leachate overflow, via means such as off-site disposal, landfill recirculation or irrigation.

9.1.4 Landfill gas

The site licence does not outline any specific requirements for landfill gas management and monitoring.

To manage landfill gas at the site, routine landfill gas monitoring is to be undertaken, as well as the landfill capping control measures outlined in Section 9.1.1.

Based on the relatively low volume of waste disposed at the landfill each year, it is unlikely that there will be sufficient LFG generation to warrant the installation of an active landfill gas extraction system. The need for landfill gas management infrastructure will need to be confirmed by undertaking a landfill gas risk assessment, which will need to be revised approximately every five years with landfill progress.

9.2 Monitoring

9.2.1 Water quality

A groundwater and surface water monitoring network has already been established at the site with the details of this discussed within the site licence, which outlines the frequency and parameters to be monitored. Requirements for surface water monitoring have also been included within the site licence, outlining the frequency and parameters to be monitored.

With the installation of a leachate sump, and the relocation of the sediment pond, an additional leachate and surface water location will be added to the monitoring network, along with the three additional groundwater monitoring wells recently installed.

Monitoring locations

The proposed groundwater, surface water and leachate monitoring locations are outlined in SK001, Appendix B, and summarised below in Table 9-1.

Table 9-1 Monitoring locations

Monitoring location	Location	Purpose
Groundwater		
MW1	Located in the north east portion of the site, adjacent to the transfer station.	Up gradient
MW3	Located in the south western portion of the site, adjacent to the current sediment pond, to the west of the landfill footprint. *It is noted that this groundwater well may require decommissioning as part of the landfill expansion.*	Down gradient
MW4	Located in western portion of site, to the west of the Stage 2 cell and proposed leachate pond.	Cross gradient
MW5	Located in the southern portion of the site, to the west of the proposed sediment pond.	Down gradient
MW6	Located in the southern portion of the site, to the south of the proposed sediment pond.	Down gradient
Surface water		
SW1	Located in the formal diversion drain in the north east portion of the site, east of the facility driveway.	Upstream
SW3	Located in the southern portion of the site, south of the landfill footprint within the ephemeral drainage line.	Downstream
SW4	Proposed surface water monitoring location within the new sediment pond, located south of the landfill footprint.	On-site sediment pond
Leachate		

Monitoring location	Location	Purpose
L01	Leachate sump located within Cell 1.	Leachate

Frequency

Groundwater, surface water and leachate quality monitoring are to be undertaken every six months in line with the site licence.

Following post closure monitoring after a period of at least five years, the frequency of monitoring can be reviewed. If groundwater, surface water and leachate monitoring indicates leachate impacts, the frequency of monitoring may need to be increased and corrective actions outlined in Section 9.3 be adopted.

Assessment guidelines

Groundwater, surface water and leachate results should be reviewed for trend analysis and compared against relevant published regional, state and national guidelines that are consistent with the receiving water body water quality, where applicable, including:

- Australian and New Zealand Guidelines for Fresh Water Quality (ANZG, August 2018)
  - Freshwater values for 95% species protection
- Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (ANZECC/ARMCANZ) (2000). *National Water Quality Management Strategy, Australian and New Zealand Guidelines for Fresh and Marine Water Quality,* November 2000.
  - Southwest Australia Lowland River guidelines
- Department of Environment Regulation (now DWER) (2014) Assessment and management of contaminated sites, Contaminated Sites Guidelines, December 2014
  - Long Term Irrigation Guidelines
  - Non-Potable Use Guidelines
  - Fresh Water Guidelines

9.2.2 Landfill gas

Monitoring locations

Landfill gas monitoring, including ambient surface emissions, building and other on-site structures (perimeter sub-surface gas monitoring wells) should be completed on a regular basis to identify landfill gas migration and confirm that the accumulation does not present an unacceptable risk to site users.

Frequency

Landfill gas monitoring should be undertaken on a biannual basis, to gain an understanding of the potential for landfill gas migration and accumulation. Following completion of routine monitoring for a period of five years post closure, the monitoring program can be reviewed to determine the most suitable frequency.

If elevated landfill gas concentrations, above the trigger levels outlined in Table 9-2 are identified on a regular basis, the frequency of monitoring may need to be increased and corrective actions in Section 9.3 be adopted.

Assessment guidelines

Trigger levels for routine landfill gas monitoring are outlined in Table 9-2.

Table 9-2 Landfill gas monitoring trigger levels

Parameter	Monitoring type			Trigger level source guideline
	Perimeter soil gas wells and vents	Ambient surface emissions	On-site structures	
Methane	1.0%	100 ppm	1.0% (10,000 ppm)	EPA Victoria (Siting, Design, Operation and Rehabilitation of Landfills, Publication 788.3, 2015)
Carbon dioxide	1.5%	N/A	1.5%	
Hydrogen sulphide	10 ppm	10 ppm	10 ppm	Hazardous Substances Information System
Oxygen	N/A	18%	18%	UK Environmental Agency

Notes

All concentrations are expressed on a volume/volume (v/v) basis, unless specified otherwise.

N/A = Not Applicable

9.3 Corrective actions

9.3.1 Capping

Vegetation

Should areas of vegetation die back or bare earth be identified in the landfill cap, the following corrective actions are to be adopted:

- **Investigate** – Determine the reason for the absence of vegetation (lack of water, gas migration, leachate seepage) as this will guide the most appropriate mitigation and remediation measures.
- **Mitigate** – Based on the identified reason for the absence of vegetation, employ mitigation measures to prevent this reoccurring, including:
  - Increase frequency of irrigation
  - Undertake routine landfill gas monitoring of the area
  - Review the leachate management system.
- **Remediate** – The area of exposed soil should be re-vegetated as soon as practicable as follows:
  - Place additional topsoil in the area (if required)
  - Re-vegetate the area with grass seeds, hydromulch or turf depending on the most suitable solution
  - Implement a regular irrigation program for the area until vegetation has re-established.

Erosion

Should erosion be identified in the landfill cap, the following corrective actions are to be adopted:

- **Investigate** – Determine the reason for the erosion including inspection of upstream stormwater infrastructure or drainage
- **Mitigate** – Rectify any failures in the upstream stormwater infrastructure to prevent reoccurrence, which may include corrective actions outlined in Section 9.3.2

- **Remediate –** Reinstate the area with imported material or suitable material sourced from the site. The placement and compaction of the materials should be consistent with that undertaken as part of the capping construction (i.e. replacement of topsoil layer, protection layer and low permeability layer (where required)). The area should then be vegetated in accordance with corrective actions outlined for vegetation above.

Surface integrity

Should significant settlement of the landfill be identified that facilitates ponding of surface water on the landfill, the following correction actions are to be adopted:

- **Investigate –** Determine whether the change in grade has resulted in variation to the landfill cap that impedes surface water flow over the surface and/or within drainage channels
- **Mitigate –** Rectify any failures in stormwater drainage to prevent further ponding on site, which may include corrective actions outlined in Section 9.3.2
- **Remediate –** Reinstate the area with imported material or suitable material sourced from the site and raise the area to a level consistent with the surrounding landfill. The placement and compaction of the materials should be consistent with that undertaken as part of the capping construction (i.e. replacement of topsoil layer, protection layer and low permeability layer (where required)). The area should then be vegetated in accordance with corrective actions outlined for vegetation above.

9.3.2 Stormwater drainage

Stormwater infrastructure

Should an inspection identify a non-conformance of the stormwater infrastructure, the following corrective actions are to be adopted:

- **Investigate –** Determine the source of failure by inspecting drainage infrastructure at the failure, as well as upstream of the failure
- **Mitigate –** Address any upstream issues that may be contributing to the failure, where identified
- **Remediate –** The type of remediation required will be dependent on the nature of the failure:
  - If ponding has occurred, the drain may require regrading consistent with the corrective action outlined in Section 9.3.1 for surface integrity
  - If erosion has resulted in exposed soils, bare areas will need to be revegetated consistent with the corrective actions outlined in Section 9.3.1 for vegetation
  - If drains have become blocked, these will need to be cleared and regraded, where necessary.

Sediment pond

A routine desilting program will need to be established for the on-site sediment pond to ensure sufficient capacity is maintained. However, if failures of the sediment pond are identified, the following corrective actions should be adopted:

- **Investigate –** Determine the source of failure by inspecting infrastructure at the failure, as well as upstream of the failure
- **Mitigate –** Address any issues that may be contributing to the failure, where identified

- **Remediate –** The type of remediation required will be dependent on the nature of the failure:
  - If significant erosion or failure of the pond walls is identified, these must be reinstated as soon as possible and consideration given to different construction methods to reduce the likelihood of reoccurrence
  - If the overflow structure is blocked, remediation consistent with the corrective actions outlined above for stormwater infrastructure
  - If the water within the sediment pond contains sheens, odours, algae/weed or excessive vegetation, water quality analysis should be completed to determine the likely cause. The requirement of remediation and the most suitable remediation option can be considered based on the laboratory results.

9.3.3 Leachate

Leachate seeps

Should an inspection identify leachate seepage, the following corrective actions are to be adopted:

- **Investigate –** Determine the source of seepage by inspecting the landfill cap
- **Mitigate –** Leachate should be contained and analysed to confirm its characteristics, and disposed of appropriately based on the volume of seepage (recirculation or lined evaporation pond)
- **Remediate –** Landfill cap repair should occur to prevent further leachate seepage through the cap, as outlined in Section 9.3.1.

Leachate impacts identified

Should routine water quality monitoring indicate leachate impact from the landfill, the following corrective actions are to be adopted:

- **Investigate –** Additional water quality analysis may need to be undertaken, and / or the installation of additional groundwater monitoring wells and / or surface water sample locations may need to be identified to confirm and quantify the extent of impact. An inspection of the landfill should also be undertaken to identify visible failures that could be contributing to the impacts identified.
- **Mitigate –** Address any issues within the landfill that may be contributing to the impacts such as failures of the cap and / or stormwater management infrastructure
- **Remediate –** The type of remediation required will be dependent on the extent of the impacts and if the source of the impact can be readily identified. This may include installation of additional landfill management measures to control stormwater and leachate or groundwater remediation.

Evaporation pond

A routine monitoring program will need to be established for the on-site evaporation pond to ensure sufficient capacity is maintained. However, if failures of the evaporation pond are identified, the following corrective actions should be adopted:

- **Investigate –** Determine the source of failure by inspecting infrastructure at the failure, as well as upstream of the failure
- **Mitigate –** Address any issues that may be contributing to the failure, where identified

- **Remediate –** The type of remediation required will be dependent on the nature of the failure:
  - If significant erosion or failure of the pond walls is identified, these must be reinstated as soon as possible and consideration given to different construction methods to reduce the likelihood of reoccurrence
  - If the overflow structure is blocked, remediation consistent with the corrective actions outlined above for stormwater infrastructure

9.3.4 Landfill gas

Should routine landfill gas monitoring indicate elevated methane concentrations, the following corrective actions are to be adopted:

Elevated ambient surface emissions

Ambient gas monitoring over the surface of the site is to be conducted, as well as a visual cap inspection, to determine if damage has occurred to the landfill cap. If the landfill cap has been damaged, cap repairs should be undertaken immediately as outlined above in Section 9.3.1.

Elevated concentrations within buildings and other on-site structures

Gas monitoring in or under buildings and other on-site structures is to be conducted to determine if gas is accumulating in these areas, specifically in or through services ducts etc. If gas accumulation is identified in buildings or other on-site structures, immediate actions should be undertaken to implement air flow through these areas to disperse the gas. Additional building control measures (e.g. passive venting or relocation of buildings) may also need to be considered should the issues persist.

Elevated concentrations within perimeter gas wells

Gas monitoring within the perimeter gas wells is to be conducted to understand the trend in concentrations over time. If concentrations begin increasing, consideration is to be given to the construction of additional landfill gas management infrastructure on site, such as passive vents or an active gas collection system.

9.4 Monitoring and inspections

Inspections of the landfill cap and stormwater infrastructure should be completed on a regular basis so that failure of any control measures can be identified and rectified. Example inspection checklist templates are included as Appendix D.

Immediately following the completion of closure works, regular inspections should be undertaken approximately every three to six months. Over time, as the landfill stabilises and vegetation is well established, inspection frequency can be reduced to annual or event based, following a significant rain event.

9.5 Recording and reporting

Example inspection checklist templates are included as Appendix D. A detailed checklist should be prepared following closure of the landfill. The checklist template includes an area to outline the key elements to be inspected, a check box to identify whether or not these elements conform to the control measures and an area to identify any corrective actions that may be required. Where a non-conformance is identified, corrective actions will need to be implemented.

A record of all groundwater, surface water, leachate (where required) and landfill gas monitoring results should be recorded and a graphical representation of key parameters plotted so that an assessment of trends over time can be undertaken. This information should be prepared in an annual report in accordance with the site's licence condition 3.1.

10. Completion of post closure obligations

The licence (L7026/1997/14) does not define a specific time period by which post closure care must be undertaken at the site. It is therefore recommended that post closure monitoring and maintenance requirements set out in the Plan are undertaken for a period of 20 years or until it can be demonstrated that the site is geotechnically stable and will not release contaminants to the environment.

The Shire must provide sufficient information to DWER to adequately demonstrate that residual risks at the site have reduced to a level that is acceptable to surrender the site licence. The most effective way to do this is to ensure that the environmental monitoring and inspection program is closely adhered to and adequately documented.

When the Shire believes that the landfill has reached stability and regular monitoring and maintenance is no longer required, they can seek a written release of the licence from DWER Following confirmation from DWER that after care obligations have been met and the landfill is considered stable, monitoring, inspections and maintenance can cease.

11. References

- Australian and New Zealand Guidelines for Fresh Water Quality (ANZG, August 2018).
- Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (ANZECC/ARMCANZ) (2000). *National Water Quality Management Strategy, Australian and New Zealand Guidelines for Fresh and Marine Water Quality,* November 2000.
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- IW Projects Pty Ltd 2013. *O'Neill Road Waste Management Facility: Works approval application supporting documentation.* Prepared for the Shire of Plantagenet.
- Lynch, D 2016. *Site Investigations Proposed Western Extension O'Neill Road Waste Disposal Facility.*
- Smith, R.A. 1997. *Hydrogeology of the Mount Barker Albany 1:1250,000 sheet: Western Australia, Water and Rivers Commission,* Hydrogeological Map Explanatory Notes Series Report.

Appendices

Appendix A – Figures

Figure No.	Title
Figure 01	Site Locality Plan
Figure 02	Existing Site Conditions
Figure 03	Conceptual Cross Section
Figure 04	Typical Stormwater and Leachate Details

SHIRE OF PLANTAGENET
O'NEILL ROAD LANDFILL
12531104

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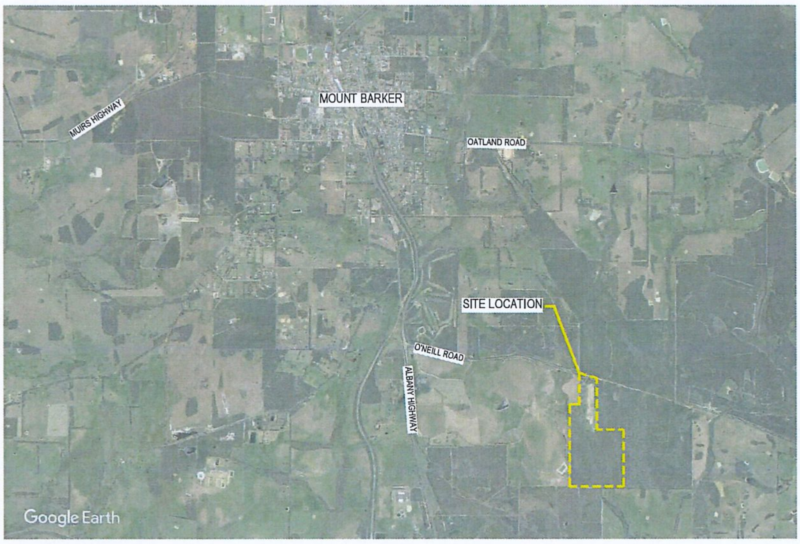

LOCALITY PLAN
NOT TO SCALE

DRAWING LIST

DRAWING No.	TITLE
12521104-FIG01	SITE LOCALITY MAP
12521104-FIG02	EXISTING SITE CONDITIONS
12521104-FIG03	CONCEPTUAL CROSS SECTION
12521104-FIG04	TYPICAL STORMWATER AND LEACHATE DEATILS

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SHIRE OF PLANTAGENET
O'NEILL ROAD LANDFILL

SITE LOCALITY PLAN

Job Number	12531104
Revision	A
Date	JULY 2020

Figure 01

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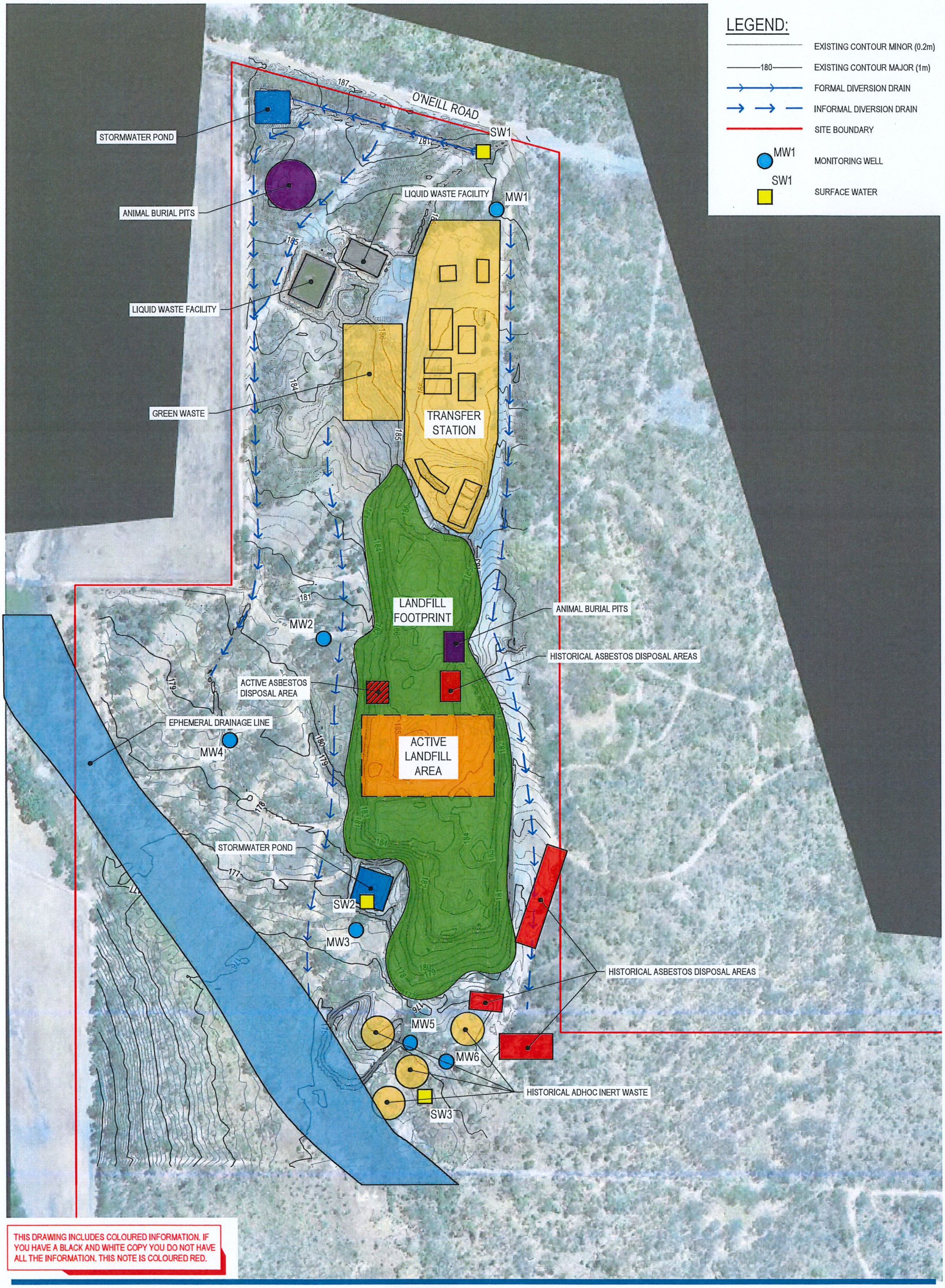
Plot Date 17 July, 2020 - 2:46 PM Plotted by James Edwards Cad File No C:\126\SW\data\P-00-12D-001161-12531104 - O'Neill Road Landfill_638\CADD\Drawings\12531104-FIG01.dwg



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SHIRE OF PLANTAGENET
O'NEILL ROAD LANDFILL

EXISTING SITE CONDITIONS

Job Number	12531104
Revision	A
Date	MAR 2021

Figure 02

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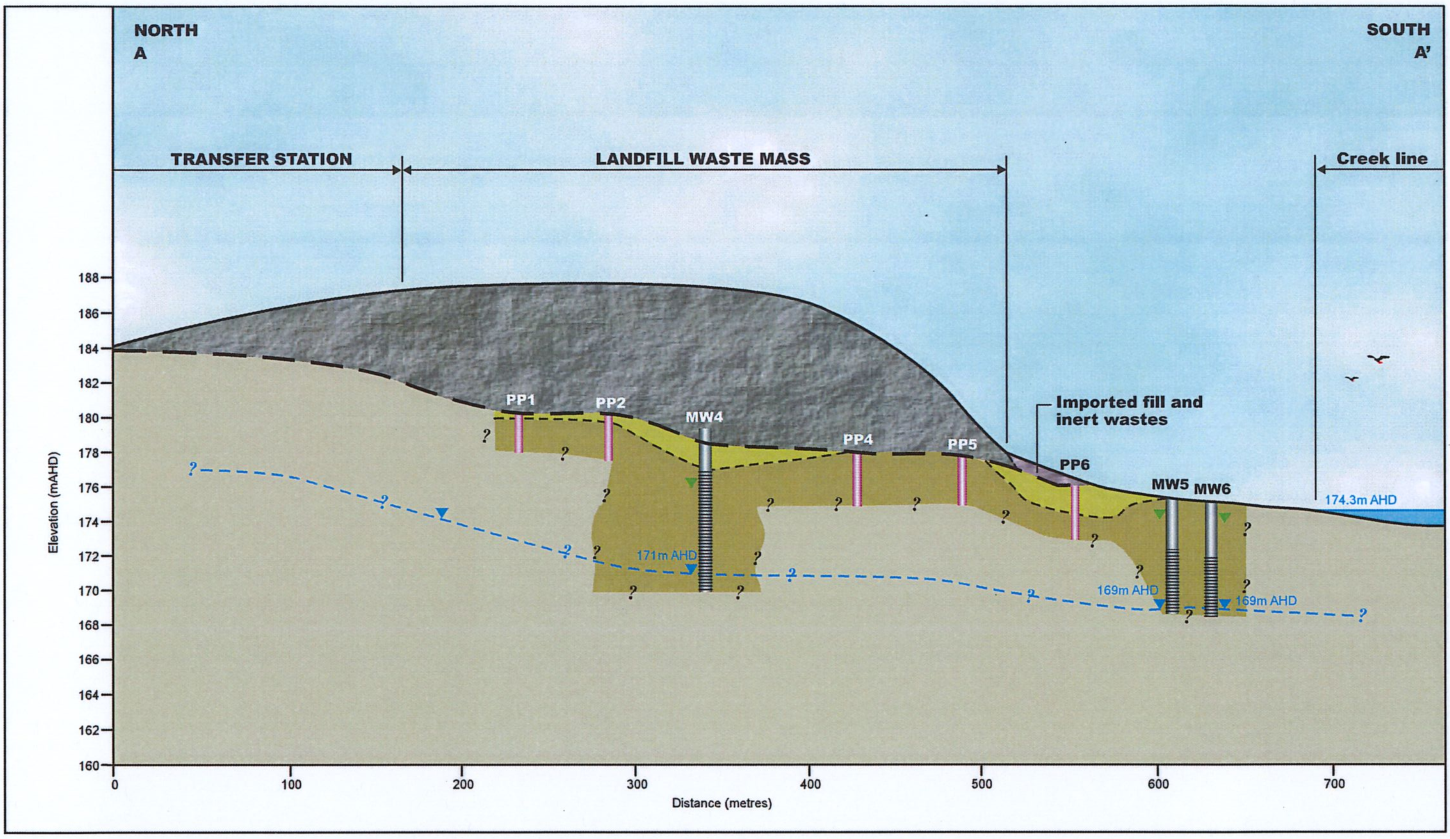

LEGEND

- Landfill waste
- Inferred ground level
- Geological boundary
- Sand
- Interchanging sand clay/clayey sand/ clay layers
- Water strike during drilling
- Potentiometric water level
- Inferred confined groundwater level

Shire of Plantagenet
O'Neil Road Landfill Site Investigations

Job Number 12-531104
Revision 0
Date 22 Dec 2020

Conceptual Cross Section

Figure 3

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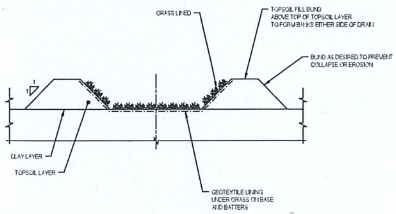

DOWN BATTER DRAIN
TYPICAL SECTION
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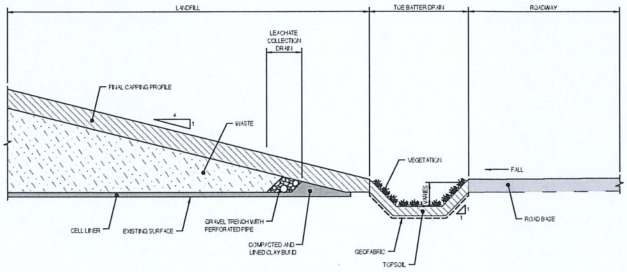
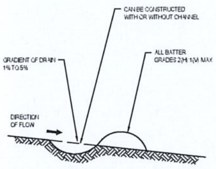


TYPICAL SECTION
HAUL ROAD WITH TOE BATTER DRAIN AND
LEACHATE COLLECTION DRAIN
SCALE 1:20



DIVERSION BUND - TYPE 1
(TYPICAL SECTION)
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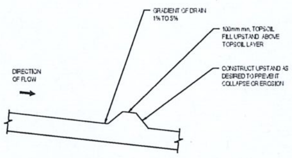

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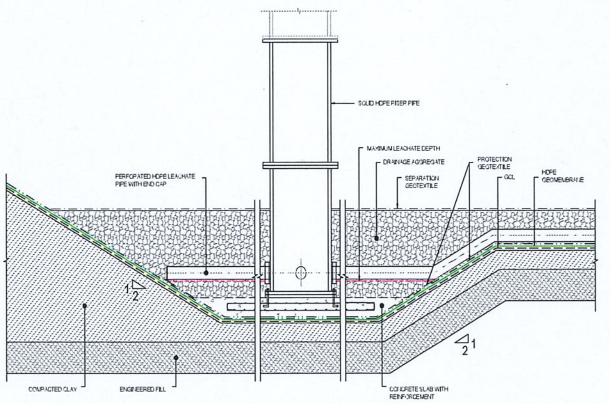

TYPICAL LEACHATE COLLECTION SUMP DETAIL
SCALE 1:50

NOTES:

1. STORMWATER MANAGEMENT CONTROLS SUCH AS DOWN BATTER DRAINS AND DIVERSION BUNDS TO BE PROGRESSIVELY CONSTRUCTED, MAINTAINED AND MODIFIED AS SITE DEVELOPMENT PROGRESSES.
2. THIS FIGURE SHOULD BE READ IN CONJUNCTION WITH THE FILLING PLAN SKETCH SET.
3. EROSION AND SEDIMENT CONTROL STRUCTURES SUCH AS SEDIMENT FENCES, ROCK DRAINS ETC. TO BE CONSIDERED AND PLACED AS REQUIRED.

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SHIRE OF PLANTAGENET
O'NEILL ROAD LANDFILL

TYPICAL STORMWATER AND
LEACHATE DETAILS

Job Number | 12531104
Revision | A
Date | MARCH 2021

Figure 04

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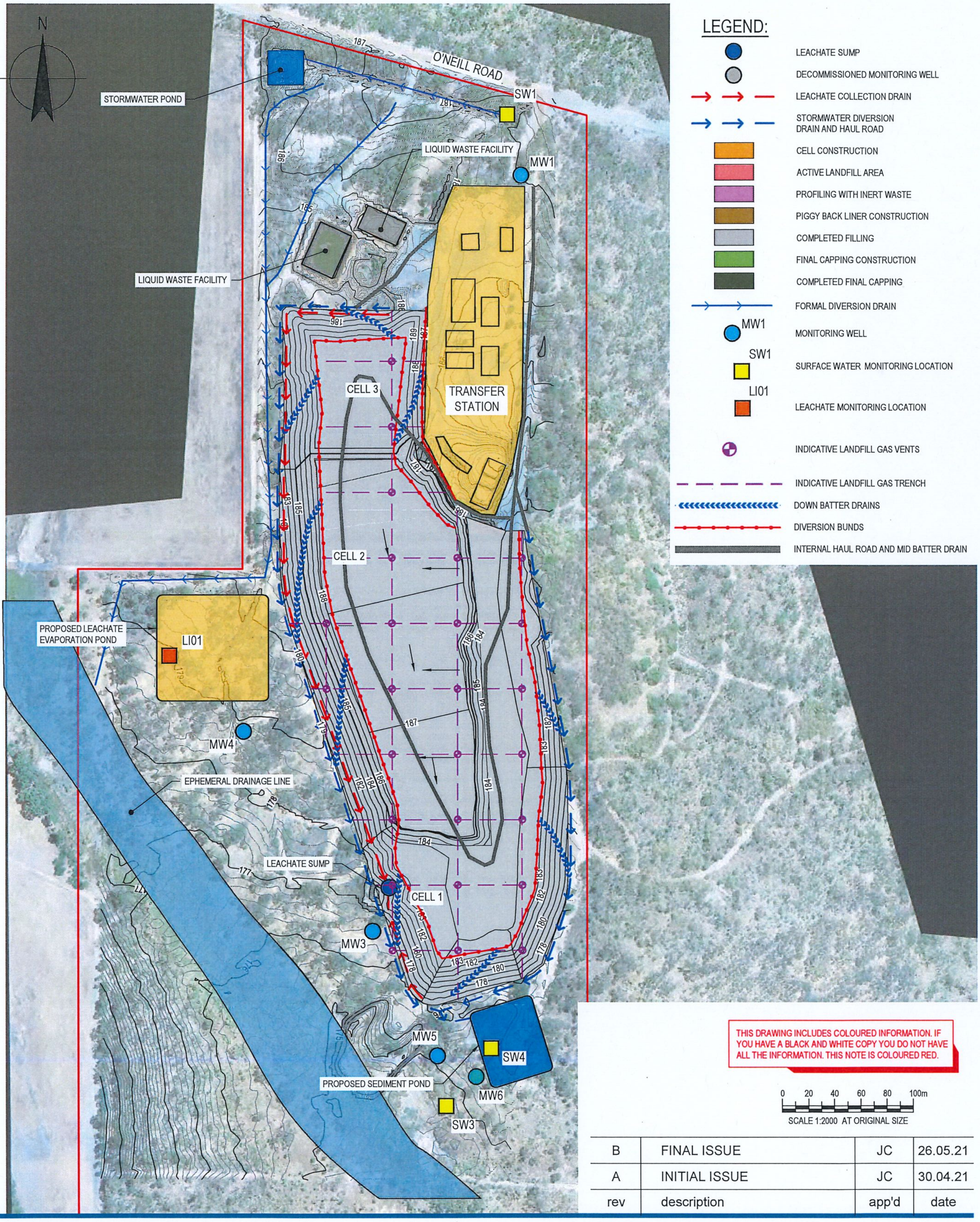
Appendix B – Filling plan sketches

Sketch No.	Title
SK001	Final Landform
SK002	Filling Stage 1
SK003	Filling Stage 2
SK004	Filling Stage 3
SK005	Filling Stage 4
SK006	Filling Stage 5
SK007	Filling Stage 6



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SHIRE OF PLANTAGENET
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FINAL LANDFORM

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date MAY 2021 rev no. B

approved (PD) J.CRAMER SK001

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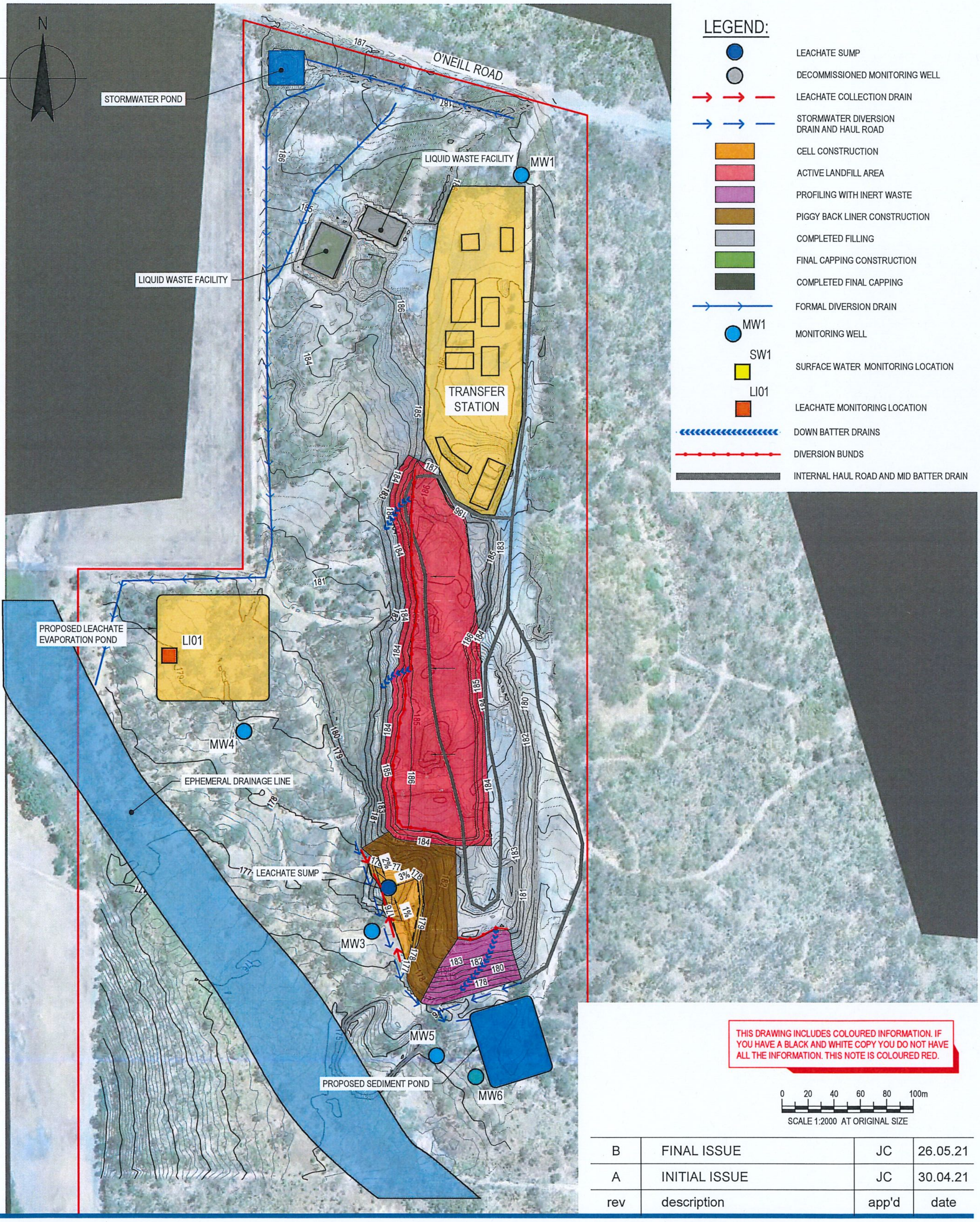

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SHIRE OF PLANTAGENET
O'NEILL ROAD LANDFILL

STAGE 1

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date MAY 2021 rev no. B

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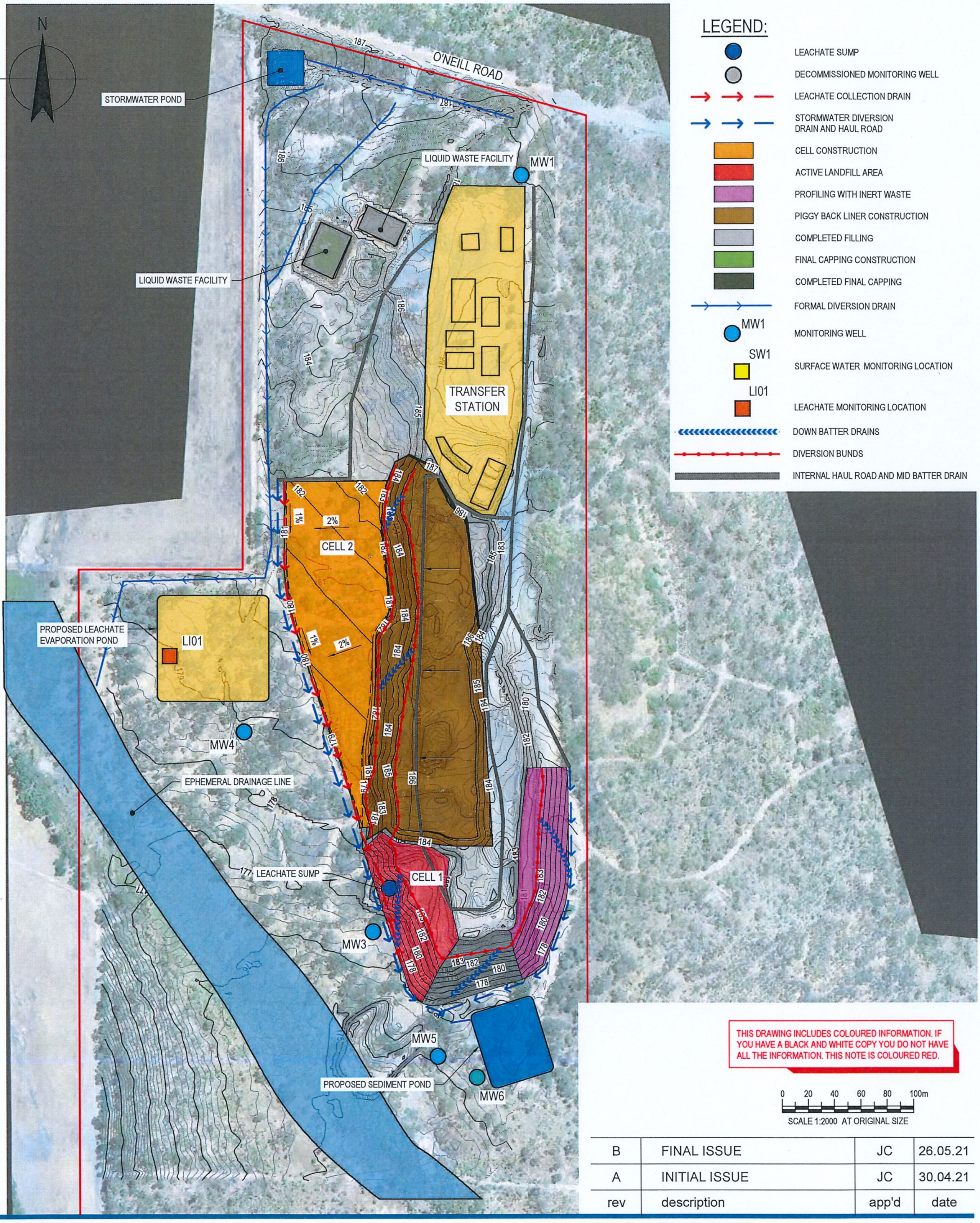

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STAGE 2

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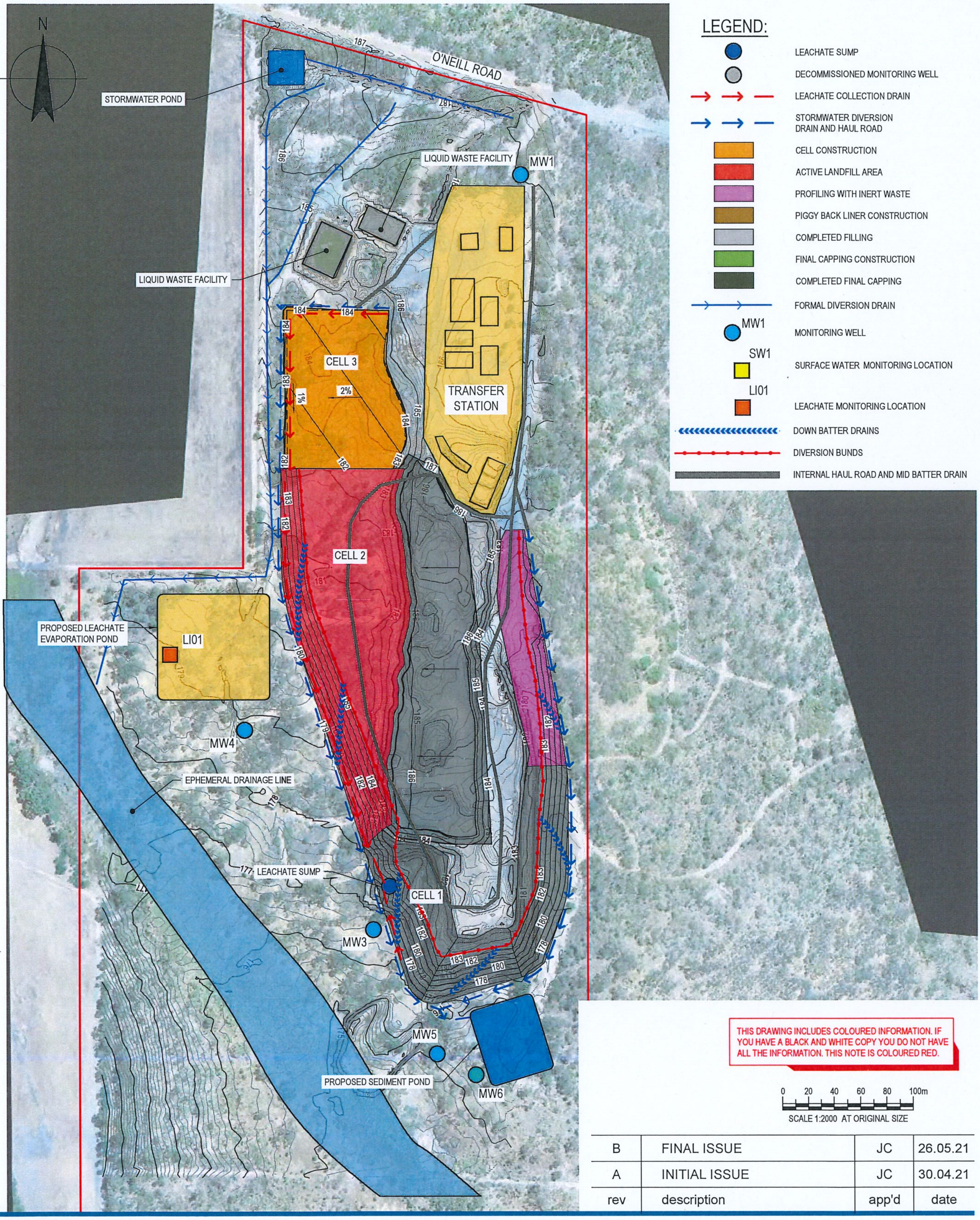

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SHIRE OF PLANTAGENET
O'NEILL ROAD LANDFILL

STAGE 3

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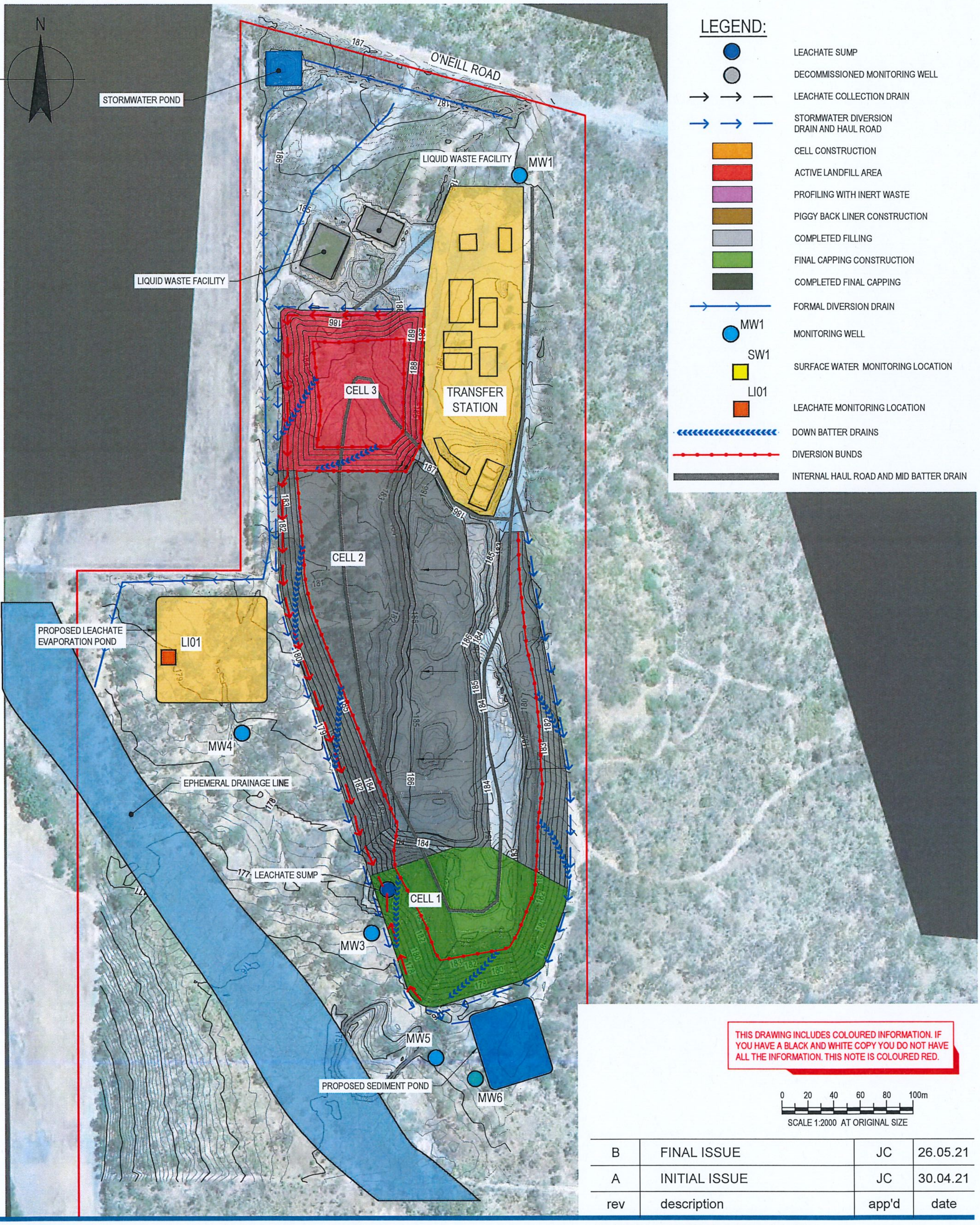

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SHIRE OF PLANTAGENET
O'NEILL ROAD LANDFILL

STAGE 4

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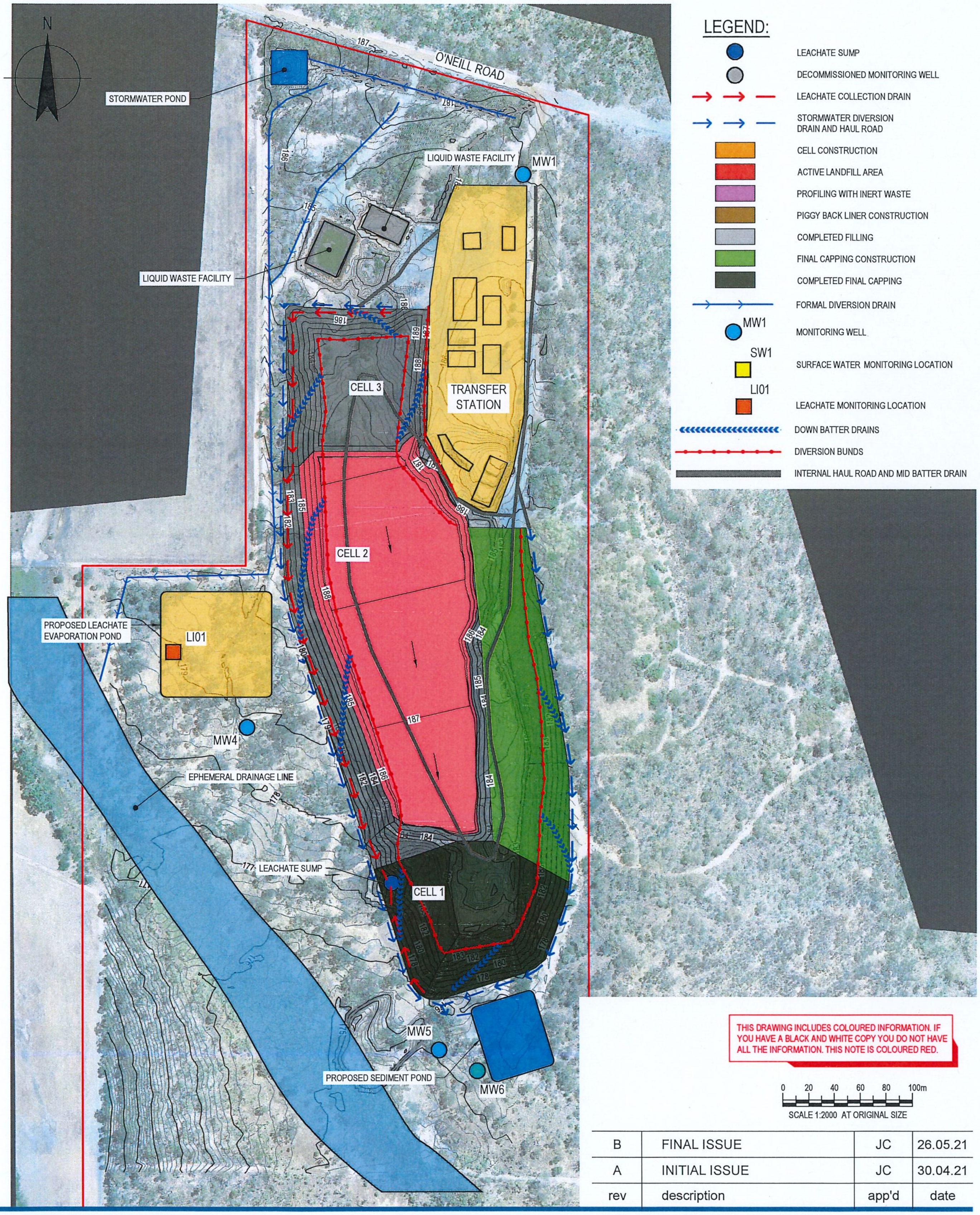

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STAGE 5

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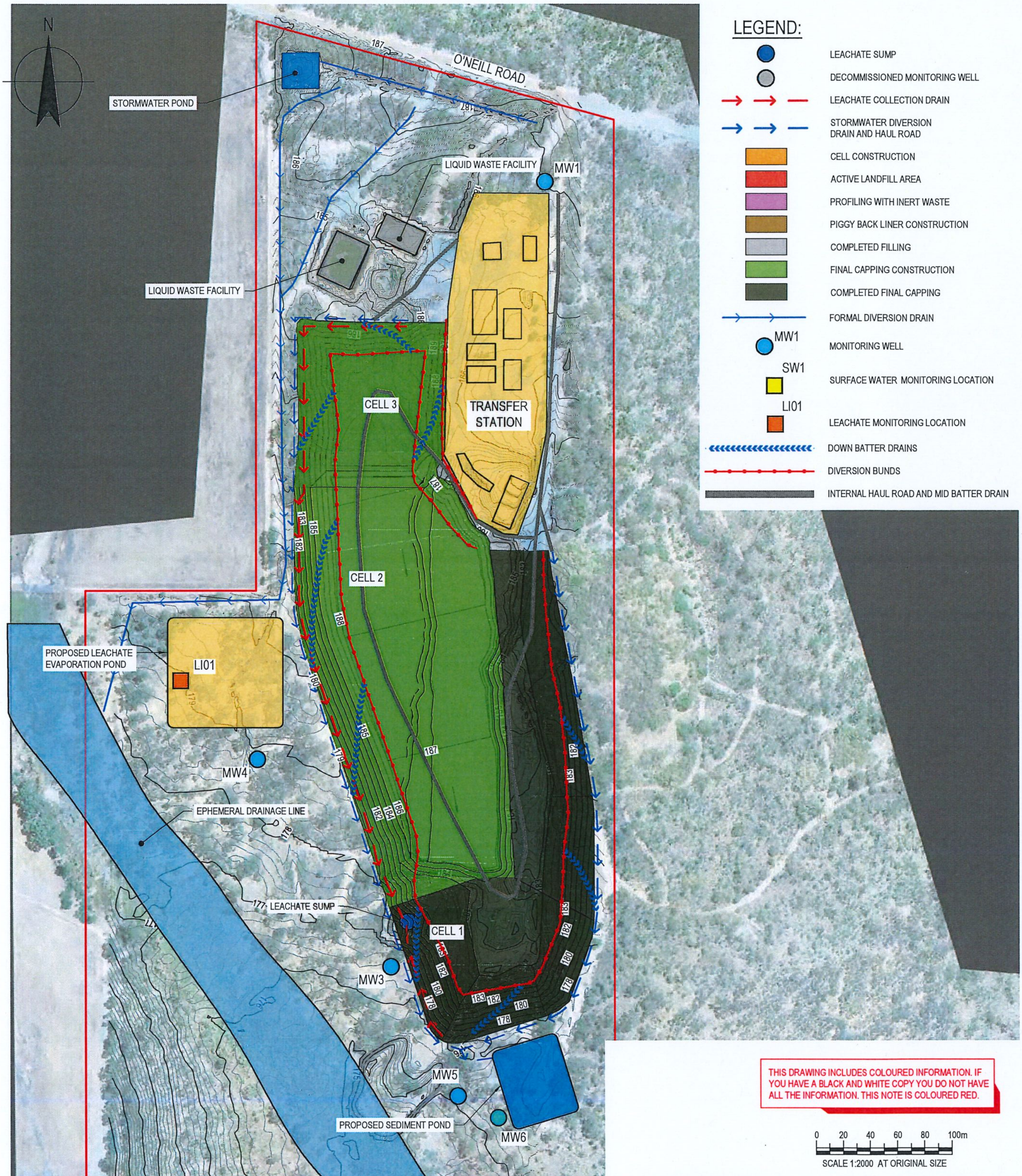

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SHIRE OF PLANTAGENET
O'NEILL ROAD LANDFILL

STAGE 6

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Appendix C – Leachate Pond Sizing

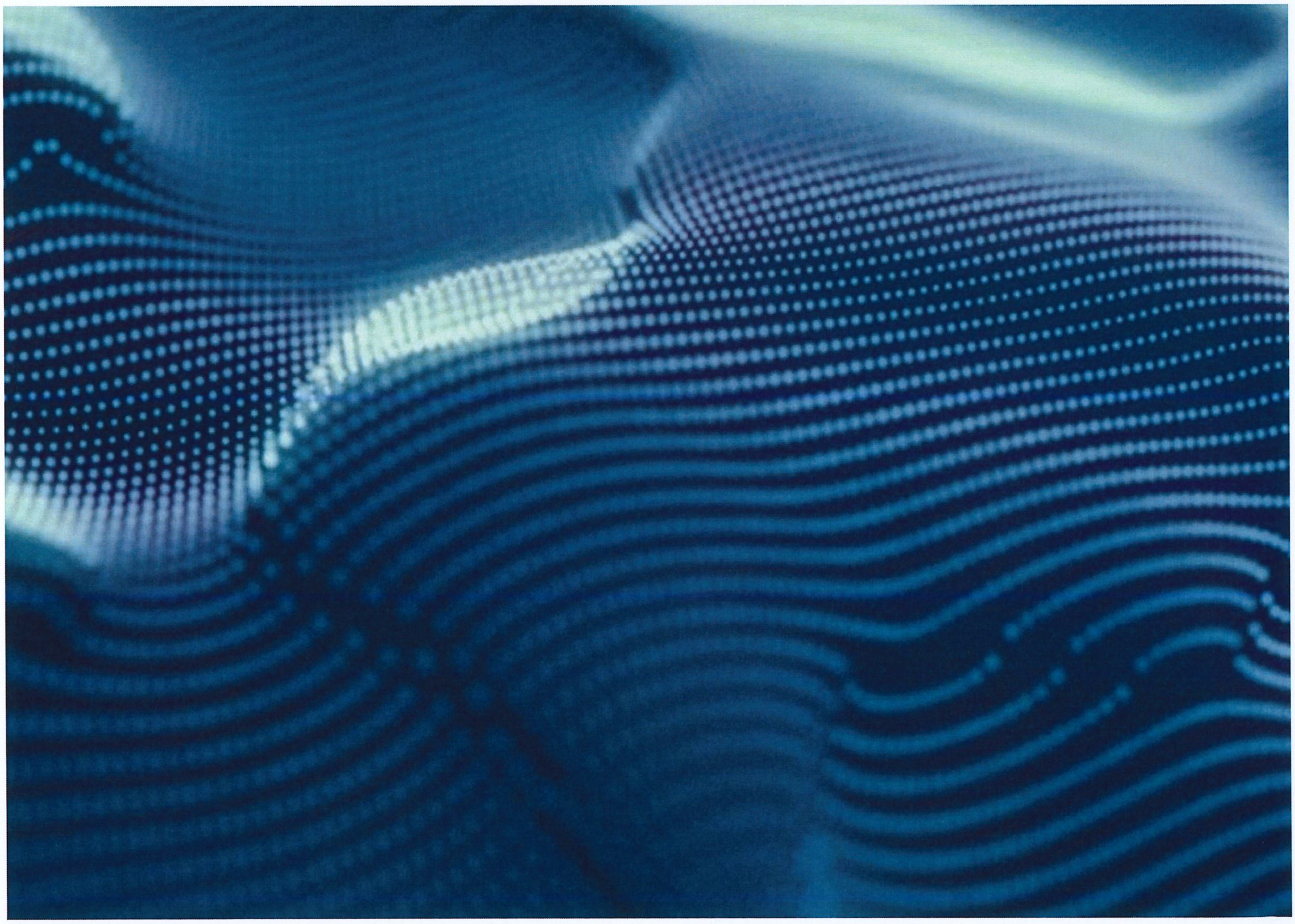
Leachate Pond Sizing

O'Neill Road Landfill Extension

Shire of Plantagenet

7 May 2021

→ **The Power of Commitment**



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Printed date	28/05/2021 12:24:00 PM
Last saved date	18 May 2021
File name	https://projectsportal.ghd.com/sites/pp18_01/oneilroadlandfillclo/ProjectDocs/12531104-REP_Water Balance and Leachate Pond Sizing .docx
Author	Jamie Wills
Project manager	Natasha Ambrey
Client name	Shire of Plantagenet
Project name	O'Neill Road Landfill Closure Plan and Works Approval- Shire of Plantagenet
Document title	Leachate Pond Sizing | O'Neill Road Landfill Extension
Revision version	Rev 0
Project number	12531104

Document status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	0	J Wills	L Yum	[signature]	J Cramer	[signature]	28/05/2021

Contents

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Figure index

Appendices

1. Introduction

The following report outlines the assumptions and results of a leachate containment and water balance study completed as part of the landfill extension works at O'Neill Road Waste Management Facility (the Site).

The infiltration assessment will focus on potential leachate generation rates in relation to the construction of lined cells associated with the proposed landfill extension at the Site. The indicative staging plan for the Site is detailed in Section 5 of the *Mount Barker Waste Management Facility – Closure and Post Closure Management Plan* (GHD 2021) and illustrated on SK001 to SK007, Appendix B of the previously mentioned report. The infiltration assessment focuses on stages two to six, which involve landfilling within lined cells.

1.1 Purpose of the study

The purpose of the infiltration assessment is to estimate rainfall infiltration into the waste mass during filling and post completion of final capping. Infiltration rates will be input to the leachate water balance study to assist in recommending the size of the leachate pond.

1.2 Landfill Closure and Post Closure Management Plan

This report is a subordinate document that is described in the Closure and Post Closure Management Plan. The leachate pond sizing report outlines the leachate water balance assessment for the landfill extension and key assumptions and requirements for the sizing of the leachate pond.

1.3 Reliance

GHD has relied upon the following information:

- SILO (2021), Patched Point data for station: Lat, Long: -34.65, 117.70
- EPA Victoria (2015), Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills, EPA Publication 788.3, dated August 2015.

1.4 Scope and limitations

This report has been prepared by GHD for Shire of Plantagenet and may only be used and relied on by Shire of Plantagenet for the purpose agreed between GHD and Shire of Plantagenet as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Shire of Plantagenet arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 4 to 6 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Shire of Plantagenet and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

2. Methodology

To inform the assessment, GHD has undertaken the following:

- Gather local climate data for the Site
- Undertake calculations to estimate infiltration of rainfall through the landfill waste mass to determine leachate generation
- Undertake calculations to estimate total leachate storage required via a leachate water balance.

3. Climate data

GHD has gathered a comprehensive set of daily climate data to represent the site. Observational data recorded by the Bureau of Meteorology was interpolated by SILO, an enhanced climate data bank hosted by The Science Delivery Division of the Queensland Department of Science, Information Technology, Innovation and the Arts (DSITIA). Patched point data uses real historical data, where available, and patches missing or suspect data with interpolated data.

Data from SILO grid point -34.65 (latitude), 117.70 (longitude) was extrapolated for the years 1970 to 2020. The grid point is located within 2 km of the Site.

The 90th percentile rainfall based on the SILO data was adopted for this assessment. These values were used to estimate leachate generation by infiltration through the waste. Figure 1 indicates that evaporation significantly exceeds rainfall each year, as such evaporation is a viable treatment strategy for leachate disposal at the Site.

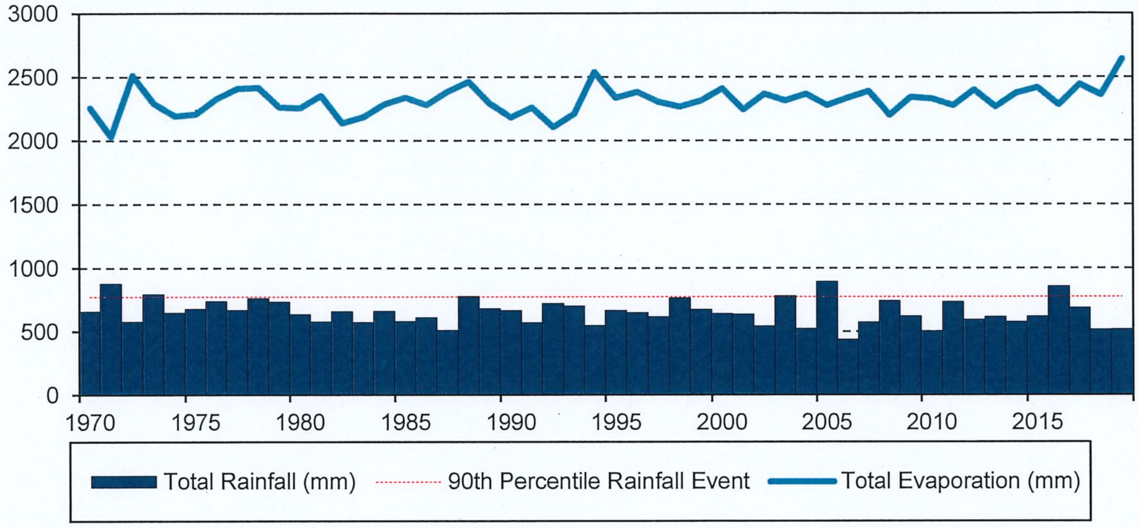

Figure 1 ***Annual climate data (SILO data)***

Table 1 below summarises the rainfall information for the 90th percentile rainfall used for this assessment. No on-site weather data is available for this Site. Two consecutive 90th percentile rainfall events are adopted for "worst case" leachate generation in general accordance with the Victorian EPA best practice environmental management (Landfill BPEM) for the siting, design, operation and rehabilitation of landfills (Publication 788.3, 2015).

Table 1 ***Summary of climate data (SILO data)***

	Total rainfall (mm)	Total evaporation (mm)
90th Percentile Rainfall Years (1988)	775.5	1477.4
Two consecutive 90th Percentile Rainfall Years	1551.0	2954.8

4. Infiltration

4.1 Cover and cap arrangements

Infiltration has been considered for the following cover/cap arrangements as outlined in Table 2. The infiltration ranges are based on conservative values from several landfill infiltration modelling assessments completed by GHD with similar climatic conditions.

It is noted that daily cover and intermediate cover material will be sourced from clean fill accepted on Site. Appropriate infiltration rates have been considered for cover materials with consideration that some evapotranspiration will occur within the material following placement.

Table 2 Cap and cover arrangements (top to bottom)

Area	Profile	Infiltration rate
Active tipping area (no runoff)	3 m waste material	100%
Daily cover area	0.15 m clean fill 3 m waste material (one lift of waste)	60%
Intermediate Cover Areas	0.5 m intermediate cover material 3 m waste material	15%
Cover Areas	0.7 m revegetation layer LLDPE Geomembrane 0.6 m Compacted Clay Liner 0.3 m seal bearing layer 10 m waste material	0.5%

4.2 Cover scenarios and leachate generation rates

For the purpose of this assessment the leachate generation for each stage was estimated for two consecutive 90th percentile rainfall as prescribed by the Landfill BPEM. The results indicate that the peak leachate generation over the two wet years was 15,740 m^3 and occurred during stage 5. As such, it is considered to be a *worst case* scenario.

The approximate areas for each cover arrangement and maximum leachate generation volume for each filling stage is summarised in Table 3. Areas are based on 2D staged boundaries, an extra 5% has been included to account interim waste slopes during filling works.

Given large "active" staged areas within the staging plan it is assumed that areas will be progressively covered with intermediate capping material such that the maximum daily cover / tipping face area does not exceed 5,000 m^2.

Table 3 Approximate areas for each filling stage

	Tipping Face	Daily Cover	Intermediate Cover	Final Cover	Leachate Generation
Stage 2	400 m^2	4,600 m^2	618 m^2	-	5,045 m^3
Stage 3	400 m^2	4,600 m^2	21,612 m^2	-	9,929 m^3
Stage 4	400 m^2	4,600 m^2	27,030 m^2	4,662 m^2	10,761 m^3
Stage 5	400 m^2	4,600 m^2	46,433 m^2	4,662 m^2	15,740 m^3
Stage 6		-	-	56,095 m^2	63 m^3

5. Leachate water balance

5.1 Methodology

The containment capacity of the site has been assessed against the expected volumes of leachate generated in a *worst case* climatic scenario of two 90th percentile rainfall years (i.e. year 1988 repeated twice).

The water balance considers:

- The leachate collected from the landfilled waste
- Rainfall into the leachate dam
- Incidental evaporation from the leachate dam.

5.2 Leachate pond

The leachate water balance assumes a pond:

- Internal slopes 1 in 2
- Depth of 2.5 m (excluding 0.5 m freeboard allowance).

In undertaking the water balance:

- It is assumed that the leachate pond is quarter full at the beginning of the period. The pond storage level at the end of the first year is the pond storage at the beginning of the second year.

5.3 Assumptions

Regarding leachate collection, the following is assumed:

- The adopted infiltration percentages assume good operational practices for leachate management and diversion of stormwater from the active filling areas
- There is no groundwater infiltration into the leachate collection and containment system
- No evapotranspiration occurs within the waste material, some evapotranspiration will occur within daily cover and intermediate cap material and has been considered in conjunction with infiltration rates
- Leachate is only collected within the proposed extension area (i.e. lined areas)

Regarding leachate storage, the following is assumed:

- No leakage from and no groundwater infiltration into the leachate storage structures
- No additional sources of contaminated water will be stored within the pond
- Evaporation occurs from the surface of open leachate ponds

5.4 Results of leachate water balance

The results of the leachate water balance for Stage 5 are summarised in Table 4 and the complete water balance contained in Appendix A. A summary of the peak containment capacities for each stage is also included in Table 5.

Table 4 *Leachate water balance results summary*

Year 1	Required Containment (m^3)	Storage Capacity (%)	Year 2	Required Containment (m^3)	Storage Capacity (%)
January	2,151	19%	January	5,823	52%
February	1,255	11%	February	4,927	44%
March	1,024	9%	March	4,696	42%
April	770	7%	April	4,442	39%
May	3,356	30%	May	7,028	62%
June	4,827	43%	June	8,499	75%
July	5,825	52%	July	9,497	84%
August	6,483	58%	August	10,155	90%
September	7,172	64%	September	**10,844**	**96%**
October	7,149	63%	October	10,821	96%
November	7,071	63%	November	10,743	95%
December	6,490	58%	December	10,162	90%

Table 5 *Peak containment capacity across all stages*

	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Containment (m^3)	4,932	9,109	9,889	**14,560**	2,912
Pond Stage Level (%)	33	61	66	**97**	19

Note: red text indicated peak leachate containment.

5.5 Required pond size

Based on the results of the water balance the required pond sizing is as follows:

- Leachate storage capacity (not including freeboard): 14,560 m^3
- Waterline dimensions: 85 m x 80 m (not including freeboard)

This design provides sufficient capacity for the lifecycle of the landfill extension works.

As the peak containment capacity is assumed to be later in the landfill lifecycle (i.e. stage 5) consideration for creating two ponds and decommissioning in accordance with the staging plan may also be an appropriate option.

5.6 Design and safety

The following design and safety considerations should be considered as part of the detailed design of the leachate evaporation pond:

- Geomembrane lined leachate ponds should consider prevention of whaling and potential uplift from groundwater
- A gas dissipation system should be included in the leachate design to release any pressure beneath the lining system
- Leachate ponds should have suitable fencing, signage and safety infrastructure (e.g. flotation devices, ladders) to allow access/exit during an emergency
- Leachate pond to have 0.5 m of freeboard to guard against wave action causing leachate to overtop the banks, as well as to provide capacity for any unforeseen events
- The leachate bund shall be raised 1 m above ground such that surface water runoff occurs.

6. Recommendations

It is noted that the leachate infiltration modelling and leachate water balance are based on several assumptions, as outlined in this report.

The model requires calibration with on-site data to assess its accuracy and should be regularly reviewed against any design amendments and change in operations.

Appendix A

Water balance

O'Neil Landfill (Stage 1)

LANDFILL GENERATION		
Active Tipping Face	0.0	m^2
Daily Cover	0.0	
Intermediate cover	0.0	m^2
Final cap	0.0	m^2
Unlined reduction factor		
Unlined reduction factor	100%	
CONTAINMENT		
Leachate pond capacity	15021	m3
Leachate pond surface area	6800	m2
Leachate pond basal area	5250	m2
Leachate pond catchment area	6966	m2
Initial Leachate Pond Volume	25%	vol/vol
INFILTRATION RATES		
Active Tipping Face	100%	
Daily Cover	60%	
Intermediate cover	15%	
Final cap	0.5%	

Parameter		January	February	March	April	May	June	July	August	September	October	November	December
		31	28	31	30	31	30	31	31	30	31	30	31
Precipitation (mm)													
1988	(mm)	16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Pan Evaporation													
Evaporation (from SILO)	(mm)	208.7	218.3	172.6	109.9	61.1	51.1	47.6	63.6	90.1	118.1	147.5	188.8
Leachate generated from cell (mm)													
Active Tipping Face		16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Daily Cover		9.8	0.8	23.2	9.7	134.2	79.5	56.5	43.6	50.3	22.3	25.4	9.9
Intermediate cover		2.4	0.2	5.8	2.4	33.5	19.9	14.1	10.9	12.6	5.6	6.4	2.5
Final cap		0.1	0.0	0.2	0.1	1.1	0.7	0.5	0.4	0.4	0.2	0.2	0.1
Total Leachate Collected	(m3/month)	0	0	0	0	0	0	0	0	0	0	0	0
Leachate containment pond													
Rainfall into Pond	(m3)	114	10	270	113	1,558	923	656	506	584	258	295	115
Evaporation From Pond	(m3)	1,177	1,231	973	620	344	288	268	359	508	666	832	1,064
Net Leachate Generation	(m3)	-1,063	-1,221	-703	-507	1,213	635	388	148	77	-407	-536	-949
Required containment	(m3)	2,692	1,471	768	261	1,474	2,109	2,497	2,645	2,721	2,314	1,778	828
Pond storage level	(m3)	2,692	1,471	768	261	1,474	2,109	2,497	2,645	2,721	2,314	1,778	828
Pond storage level	(%)	18%	10%	5%	2%	10%	14%	17%	18%	18%	15%	12%	6%
Excess leachate to be disposed	(m3)	0	0	0	0	0	0	0	0	0	0	0	0

Parameter		January	February	March	April	May	June	July	August	September	October	November	December	Total mm	Total m3	Percent
		31	28	31	30	31	30	31	31	30	31	30	31			
Precipitation (mm)																
1988	(mm)	16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5	1551		100%
Pan Evaporation																
Evaporation (from SILO)	(mm)	208.7	218.3	172.6	109.9	61.1	51.1	47.6	63.6	90.1	118.1	147.5	188.8	2955		191%
Leachate generated from cell (mm)																
Active Tipping Face		16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5	1551	0	100%
Daily Cover		9.8	0.8	23.2	9.7	134.2	79.5	56.5	43.6	50.3	22.3	25.4	9.9	931	0	
Intermediate cover		2.4	0.2	5.8	2.4	33.5	19.9	14.1	10.9	12.6	5.6	6.4	2.5	233	0	15%
Final cap		0.1	0.0	0.2	0.1	1.1	0.7	0.5	0.4	0.4	0.2	0.2	0.1	8	0	1%
Total Leachate Collected	(m3/month)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Leachate containment pond																
Rainfall into Pond	(m3)	114	10	270	113	1,558	923	656	506	584	258	295	115		10,804	
Evaporation From Pond	(m3)	1,177	1,231	973	620	344	288	268	359	508	666	832	1,064		16,658	
Net Leachate Generation	(m3)	-1,063	-1,221	-703	-507	1,213	635	388	148	77	-407	-536	-949		-5,853	
Required containment	(m3)	0	0	0	0	1,213	1,848	2,236	2,384	2,460	2,053	1,517	567			
Pond storage level	(m3)	0	0	0	0	1,213	1,848	2,236	2,384	2,460	2,053	1,517	567			
Pond storage level	(%)	0%	0%	0%	0%	8%	12%	15%	16%	16%	14%	10%	4%			
Excess leachate to be disposed	(m3)	0	0	0	0	0	0	0	0	0	0	0	0			

O'Neil Landfill (Stage 2)

LANDFILL GENERATION		
Active Tipping Face	400.0	m^2
Daily Cover	4600.0	
Intermediate cover	617.5	m^2
Final cap	0.0	m^2
Unlined reduction factor		
Unlined reduction factor	100%	
CONTAINMENT		
Leachate pond capacity	15021	m3
Leachate pond surface area	6800	m2
Leachate pond basal area	5250	m2
Leachate pond catchment area	6966	m2
Initial Leachate Pond Volume	25%	vol/vol
INFILTRATION RATES		
Active Tipping Face	100%	
Daily Cover	60%	
Intermediate cover	15%	
Final cap	0.5%	

Parameter		January	February	March	April	May	June	July	August	September	October	November	December
		31	28	31	30	31	30	31	31	30	31	30	31
Precipitation (mm)													
1988	(mm)	16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Pan Evaporation													
Evaporation (from SILO)	(mm)	208.7	218.3	172.6	109.9	61.1	51.1	47.6	63.6	90.1	118.1	147.5	188.8
Leachate generated from cell (mm)													
Active Tipping Face		16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Daily Cover		9.8	0.8	23.2	9.7	134.2	79.5	56.5	43.6	50.3	22.3	25.4	9.9
Intermediate cover		2.4	0.2	5.8	2.4	33.5	19.9	14.1	10.9	12.6	5.6	6.4	2.5
Final cap		0.1	0.0	0.2	0.1	1.1	0.7	0.5	0.4	0.4	0.2	0.2	0.1
Total Leachate Collected	(m3/month)	53	5	126	53	727	431	306	236	273	121	138	54
Leachate containment pond													
Rainfall into Pond	(m3)	114	10	270	113	1,558	923	656	506	584	258	295	115
Evaporation From Pond	(m3)	1,177	1,231	973	620	344	288	268	359	508	666	832	1,064
Net Leachate Generation	(m3)	-1,010	-1,216	-578	-454	1,940	1,066	694	384	349	-287	-398	-896
Required containment	(m3)	2,745	1,529	951	497	2,438	3,504	4,198	4,582	4,932	4,645	4,247	3,351
Pond storage level	(m3)	2,745	1,529	951	497	2,438	3,504	4,198	4,582	4,932	4,645	4,247	3,351
Pond storage level	(%)	18%	10%	6%	3%	16%	23%	28%	31%	33%	31%	28%	22%
Excess leachate to be disposed	(m3)	0	0	0	0	0	0	0	0	0	0	0	0

Parameter		January	February	March	April	May	June	July	August	September	October	November	December	Total		Percent
														mm	m3	
		31	28	31	30	31	30	31	31	30	31	30	31			
Precipitation (mm)																
1988	(mm)	16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5	1551		100%
Pan Evaporation																
Evaporation (from SILO)	(mm)	208.7	218.3	172.6	109.9	61.1	51.1	47.6	63.6	90.1	118.1	147.5	188.8	2955		191%
Leachate generated from cell (mm)																
Active Tipping Face		16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5	1551	620	100%
Daily Cover		9.8	0.8	23.2	9.7	134.2	79.5	56.5	43.6	50.3	22.3	25.4	9.9	931	4281	
Intermediate cover		2.4	0.2	5.8	2.4	33.5	19.9	14.1	10.9	12.6	5.6	6.4	2.5	233	144	15%
Final cap		0.1	0.0	0.2	0.1	1.1	0.7	0.5	0.4	0.4	0.2	0.2	0.1	8	0	1%
Total Leachate Collected	(m3/month)	53	5	126	53	727	431	306	236	273	121	138	54	5,045	5,045	
Leachate containment pond																
Rainfall into Pond	(m3)	114	10	270	113	1,558	923	656	506	584	258	295	115		10,804	
Evaporation From Pond	(m3)	1,177	1,231	973	620	344	288	268	359	508	666	832	1,064		16,658	
Net Leachate Generation	(m3)	-1,010	-1,216	-578	-454	1,940	1,066	694	384	349	-287	-398	-896		-809	
Required containment	(m3)	2,341	1,125	547	93	2,033	3,099	3,794	4,178	4,527	4,241	3,842	2,947			
Pond storage level	(m3)	2,341	1,125	547	93	2,033	3,099	3,794	4,178	4,527	4,241	3,842	2,947			
Pond storage level	(%)	16%	7%	4%	1%	14%	21%	25%	28%	30%	28%	26%	20%			
Excess leachate to be disposed	(m3)	0	0	0	0	0	0	0	0	0	0	0	0			

O'Neil Landfill (Stage 3)

LANDFILL GENERATION		
Active Tipping Face	400.0	m^2
Daily Cover	4600.0	
Intermediate cover	21612.3	m^2
Final cap	0.0	m^2
Unlined reduction factor		
Unlined reduction factor	100%	
CONTAINMENT		
Leachate pond capacity	15021	m3
Leachate pond surface area	6800	m2
Leachate pond basal area	5250	m2
Leachate pond catchment area	6966	m2
Initial Leachate Pond Volume	25%	vol/vol
INFILTRATION RATES		
Active Tipping Face	100%	
Daily Cover	60%	
Intermediate cover	15%	
Final cap	0.5%	

Parameter		January	February	March	April	May	June	July	August	September	October	November	December
		31	28	31	30	31	30	31	31	30	31	30	31
Precipitation (mm)													
1988	(mm)	16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Pan Evaporation													
Evaporation (from SILO)	(mm)	208.7	218.3	172.6	109.9	61.1	51.1	47.6	63.6	90.1	118.1	147.5	188.8
Leachate generated from cell (mm)													
Active Tipping Face		16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Daily Cover		9.8	0.8	23.2	9.7	134.2	79.5	56.5	43.6	50.3	22.3	25.4	9.9
Intermediate cover		2.4	0.2	5.8	2.4	33.5	19.9	14.1	10.9	12.6	5.6	6.4	2.5
Final cap		0.1	0.0	0.2	0.1	1.1	0.7	0.5	0.4	0.4	0.2	0.2	0.1
Total Leachate Collected	(m3/month)	104	9	248	104	1,431	848	603	465	537	238	271	106
Leachate containment pond													
Rainfall Into Pond	(m3)	114	10	270	113	1,558	923	656	506	584	258	295	115
Evaporation From Pond	(m3)	1,177	1,231	973	620	344	288	268	359	508	666	832	1,064
Net Leachate Generation	(m3)	-959	-1,212	-456	-403	2,645	1,483	991	613	614	-170	-265	-844
Required containment	(m3)	2,797	1,585	1,129	726	3,371	4,854	5,845	6,458	7,071	6,902	6,637	5,793
Pond storage level	(m3)	2,797	1,585	1,129	726	3,371	4,854	5,845	6,458	7,071	6,902	6,637	5,793
Pond storage level	(%)	19%	11%	8%	5%	22%	32%	39%	43%	47%	46%	44%	39%
Excess leachate to be disposed	(m3)	0	0	0	0	0	0	0	0	0	0	0	0

Parameter		January	February	March	April	May	June	July	August	September	October	November	December	Total		Percent
														mm	m3	
		31	28	31	30	31	30	31	31	30	31	30	31			
Precipitation (mm)																
1988	(mm)	16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5	1551		100%
Pan Evaporation																
Evaporation (from SILO)	(mm)	208.7	218.3	172.6	109.9	61.1	51.1	47.6	63.6	90.1	118.1	147.5	188.8	2955		191%
Leachate generated from cell (mm)																
Active Tipping Face		16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5	1551	620	100%
Daily Cover		9.8	0.8	23.2	9.7	134.2	79.5	56.5	43.6	50.3	22.3	25.4	9.9	931	4281	
Intermediate cover		2.4	0.2	5.8	2.4	33.5	19.9	14.1	10.9	12.6	5.6	6.4	2.5	233	5028	15%
Final cap		0.1	0.0	0.2	0.1	1.1	0.7	0.5	0.4	0.4	0.2	0.2	0.1	8	0	1%
Total Leachate Collected	(m3/month)	104	9	248	104	1,431	848	603	465	537	238	271	106	9,929	9,929	
Leachate containment pond																
Rainfall Into Pond	(m3)	114	10	270	113	1,558	923	656	506	584	258	295	115		10,804	
Evaporation From Pond	(m3)	1,177	1,231	973	620	344	288	268	359	508	666	832	1,064		16,658	
Net Leachate Generation	(m3)	-959	-1,212	-456	-403	2,645	1,483	991	613	614	-170	-265	-844		4,076	
Required containment	(m3)	4,834	3,623	3,167	2,764	5,408	6,892	7,882	8,496	9,109	8,940	8,675	7,831			
Pond storage level	(m3)	4,834	3,623	3,167	2,764	5,408	6,892	7,882	8,496	9,109	8,940	8,675	7,831			
Pond storage level	(%)	32%	24%	21%	18%	36%	46%	52%	57%	61%	60%	58%	52%			
Excess leachate to be disposed	(m3)	0	0	0	0	0	0	0	0	0	0	0	0			

O'Neil Landfill (Stage 4)

LANDFILL GENERATION		
Active Tipping Face	400.0	m^2
Daily Cover	4100.0	
Intermediate cover	27030.1	m^2
Final cap	4662.0	m^2
Unlined reduction factor		
Unlined reduction factor	100%	
CONTAINMENT		
Leachate pond capacity	15021	m3
Leachate pond surface area	6800	m2
Leachate pond basal area	5250	m2
Leachate pond catchment area	6966	m2
Initial Leachate Pond Volume	25%	vol/vol
INFILTRATION RATES		
Active Tipping Face	100%	
Daily Cover	60%	
Intermediate cover	15%	
Final cap	0.5%	

Parameter		January	February	March	April	May	June	July	August	September	October	November	December
		31	28	31	30	31	30	31	31	30	31	30	31
Precipitation (mm)													
1988	(mm)	16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Pan Evaporation													
Evaporation (from SILO)	(mm)	208.7	218.3	172.6	109.9	61.1	51.1	47.6	63.6	90.1	118.1	147.5	188.8
Leachate generated from cell (mm)													
Active Tipping Face		16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Daily Cover		9.8	0.8	23.2	9.7	134.2	79.5	56.5	43.6	50.3	22.3	25.4	9.9
Intermediate cover		2.4	0.2	5.8	2.4	33.5	19.9	14.1	10.9	12.6	5.6	6.4	2.5
Final cap		0.1	0.0	0.2	0.1	1.1	0.7	0.5	0.4	0.4	0.2	0.2	0.1
Total Leachate Collected	(m3/month)	113	10	268	112	1,551	919	654	504	582	257	294	114
Leachate containment pond													
Rainfall into Pond	(m3)	114	10	270	113	1,558	923	656	506	584	258	295	115
Evaporation From Pond	(m3)	1,177	1,231	973	620	344	288	268	359	508	666	832	1,064
Net Leachate Generation	(m3)	-950	-1,211	-435	-394	2,764	1,554	1,041	652	659	-150	-242	-835
Required containment	(m3)	2,805	1,594	1,159	765	3,529	5,083	6,125	6,777	7,436	7,286	7,044	6,209
Pond storage level	(m3)	2,805	1,594	1,159	765	3,529	5,083	6,125	6,777	7,436	7,286	7,044	6,209
Pond storage level	(%)	19%	11%	8%	5%	23%	34%	41%	45%	50%	49%	47%	41%
Excess leachate to be disposed	(m3)	0	0	0	0	0	0	0	0	0	0	0	0

Parameter		January	February	March	April	May	June	July	August	September	October	November	December
		31	28	31	30	31	30	31	31	30	31	30	31
Precipitation (mm)													
1988	(mm)	16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Pan Evaporation													
Evaporation (from SILO)	(mm)	208.7	218.3	172.6	109.9	61.1	51.1	47.6	63.6	90.1	118.1	147.5	188.8
Leachate generated from cell (mm)													
Active Tipping Face		16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Daily Cover		9.8	0.8	23.2	9.7	134.2	79.5	56.5	43.6	50.3	22.3	25.4	9.9
Intermediate cover		2.4	0.2	5.8	2.4	33.5	19.9	14.1	10.9	12.6	5.6	6.4	2.5
Final cap		0.1	0.0	0.2	0.1	1.1	0.7	0.5	0.4	0.4	0.2	0.2	0.1
Total Leachate Collected	(m3/month)	113	10	268	112	1,551	919	654	504	582	257	294	114
Leachate containment pond													
Rainfall into Pond	(m3)	114	10	270	113	1,558	923	656	506	584	258	295	115
Evaporation From Pond	(m3)	1,177	1,231	973	620	344	288	268	359	508	666	832	1,064
Net Leachate Generation	(m3)	-950	-1,211	-435	-394	2,764	1,554	1,041	652	659	-150	-242	-835
Required containment	(m3)	5,259	4,048	3,613	3,218	5,983	7,537	8,578	9,231	9,889	9,739	9,497	8,662
Pond storage level	(m3)	5,259	4,048	3,613	3,218	5,983	7,537	8,578	9,231	9,889	9,739	9,497	8,662
Pond storage level	(%)	35%	27%	24%	21%	40%	50%	57%	61%	66%	65%	63%	58%
Excess leachate to be disposed	(m3)	0	0	0	0	0	0	0	0	0	0	0	0

Parameter		Total mm	Total m3	Percent
Precipitation (mm)				
1988	(mm)	1551		100%
Pan Evaporation				
Evaporation (from SILO)	(mm)	2955		191%
Leachate generated from cell (mm)				
Active Tipping Face		1551	620	100%
Daily Cover		931	3815	
Intermediate cover		233	6289	15%
Final cap		8	36	1%
Total Leachate Collected	(m3/month)	10,761	10,761	
Leachate containment pond				
Rainfall into Pond	(m3)		10,804	
Evaporation From Pond	(m3)		16,658	
Net Leachate Generation	(m3)		4,907	
Required containment	(m3)			
Pond storage level	(m3)			
Pond storage level	(%)			
Excess leachate to be disposed	(m3)			

O'Neil Landfill (Stage 5)

LANDFILL GENERATION		
Active Tipping Face	400	m^2
Daily Cover	4600	
Intermediate cover	46433	m^2
Final cap	4662	m^2
Unlined reduction factor		
Unlined reduction factor	100%	
CONTAINMENT		
Leachate pond capacity	15021	m3
Leachate pond surface area	6800	m2
Leachate pond basal area	5250	m2
Leachate pond catchment area	6966	m2
Initial Leachate Pond Volume	25%	vol/vol
INFILTRATION RATES		
Active Tipping Face	100%	
Daily Cover	60%	
Intermediate cover	15%	
Final cap	0.5%	

Parameter		January	February	March	April	May	June	July	August	September	October	November	December
		31	28	31	30	31	30	31	31	30	31	30	31
Precipitation (mm)													
1988	(mm)	16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Pan Evaporation													
Evaporation (from SILO)	(mm)	208.7	218.3	172.6	109.9	61.1	51.1	47.6	63.6	90.1	118.1	147.5	188.8
Leachate generated from cell (mm)													
Active Tipping Face		16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Daily Cover		9.8	0.8	23.2	9.7	134.2	79.5	56.5	43.6	50.3	22.3	25.4	9.9
Intermediate cover		2.4	0.2	5.8	2.4	33.5	19.9	14.1	10.9	12.6	5.6	6.4	2.5
Final cap		0.1	0.0	0.2	0.1	1.1	0.7	0.5	0.4	0.4	0.2	0.2	0.1
Total Leachate Collected	(m3/month)	165	14	393	164	2,269	1,345	956	738	851	377	430	167
Leachate containment pond													
Rainfall into Pond	(m3)	114	10	270	113	1,558	923	656	506	584	258	295	115
Evaporation From Pond	(m3)	1,177	1,231	973	620	344	288	268	359	508	666	832	1,064
Net Leachate Generation	(m3)	-898	-1,207	-311	-342	3,482	1,980	1,344	886	928	-31	-106	-782
Required containment	(m3)	2,858	1,651	1,340	998	4,480	6,460	7,804	8,689	9,617	9,586	9,480	8,698
Pond storage level	(m3)	2,858	1,651	1,340	998	4,480	6,460	7,804	8,689	9,617	9,586	9,480	8,698
Pond storage level	(%)	19%	11%	9%	7%	30%	43%	52%	58%	64%	64%	63%	58%
Excess leachate to be disposed	(m3)	0	0	0	0	0	0	0	0	0	0	0	0

Parameter		January	February	March	April	May	June	July	August	September	October	November	December	Total		Percent
														mm	m3	
		31	28	31	30	31	30	31	31	30	31	30	31			
Precipitation (mm)																
1988	(mm)	16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5	1551		100%
Pan Evaporation																
Evaporation (from SILO)	(mm)	208.7	218.3	172.6	109.9	61.1	51.1	47.6	63.6	90.1	118.1	147.5	188.8	2955		191%
Leachate generated from cell (mm)																
Active Tipping Face		16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5	1551	620	100%
Daily Cover		9.8	0.8	23.2	9.7	134.2	79.5	56.5	43.6	50.3	22.3	25.4	9.9	931	4281	
Intermediate cover		2.4	0.2	5.8	2.4	33.5	19.9	14.1	10.9	12.6	5.6	6.4	2.5	233	10803	15%
Final cap		0.1	0.0	0.2	0.1	1.1	0.7	0.5	0.4	0.4	0.2	0.2	0.1	8	36	1%
Total Leachate Collected	(m3/month)	165	14	393	164	2,269	1,345	956	738	851	377	430	167	15,740	15,740	
Leachate containment pond																
Rainfall into Pond	(m3)	114	10	270	113	1,558	923	656	506	584	258	295	115		10,804	
Evaporation From Pond	(m3)	1,177	1,231	973	620	344	288	268	359	508	666	832	1,064		16,658	
Net Leachate Generation	(m3)	-898	-1,207	-311	-342	3,482	1,980	1,344	886	928	-31	-106	-782		9,887	
Required containment	(m3)	7,801	6,594	6,283	5,941	9,423	11,403	12,747	13,633	14,560	14,530	14,424	13,642			
Pond storage level	(m3)	7,801	6,594	6,283	5,941	9,423	11,403	12,747	13,633	14,560	14,530	14,424	13,642			
Pond storage level	(%)	52%	44%	42%	40%	63%	76%	85%	91%	97%	97%	96%	91%			
Excess leachate to be disposed	(m3)	0	0	0	0	0	0	0	0	0	0	0	0			

O'Neil Landfill (Stage 6)

LANDFILL GENERATION		
Active Tipping Face	0.0	m^2
Daily Cover	0.0	
Intermediate cover	0.0	m^2
Final cap	56095.2	m^2
Unlined reduction factor		
Unlined reduction factor	100%	
CONTAINMENT		
Leachate pond capacity	15021	m3
Leachate pond surface area	6800	m2
Leachate pond basal area	5250	m2
Leachate pond catchment area	6966	m2
Initial Leachate Pond Volume	25%	vol/vol
INFILTRATION RATES		
Active Tipping Face	100%	
Daily Cover	60%	
Intermediate cover	15%	
Final cap	1%	

Parameter		January	February	March	April	May	June	July	August	September	October	November	December
		31	28	31	30	31	30	31	31	30	31	30	31
Precipitation (mm)													
1988	(mm)	16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Pan Evaporation													
Evaporation (from SILO)	(mm)	208.7	218.3	172.6	109.9	61.1	51.1	47.6	63.6	90.1	118.1	147.5	188.8
Leachate generated from cell (mm)													
Active Tipping Face		16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5
Daily Cover		9.8	0.8	23.2	9.7	134.2	79.5	56.5	43.6	50.3	22.3	25.4	9.9
Intermediate cover		2.4	0.2	5.8	2.4	33.5	19.9	14.1	10.9	12.6	5.6	6.4	2.5
Final cap		0.1	0.0	0.2	0.1	1.1	0.7	0.5	0.4	0.4	0.2	0.2	0.1
Total Leachate Collected	(m3/month)	5	0	11	5	63	37	26	20	24	10	12	5
Leachate containment pond													
Rainfall into Pond	(m3)	114	10	270	113	1,558	923	656	506	584	258	295	115
Evaporation From Pond	(m3)	1,177	1,231	973	620	344	288	268	359	508	666	832	1,064
Net Leachate Generation	(m3)	-1,058	-1,221	-693	-502	1,276	672	414	168	100	-397	-524	-945
Required containment	(m3)	2,697	1,476	784	281	1,557	2,229	2,644	2,812	2,912	2,515	1,991	1,046
Pond storage level	(m3)	2,697	1,476	784	281	1,557	2,229	2,644	2,812	2,912	2,515	1,991	1,046
Pond storage level	(%)	18%	10%	5%	2%	10%	15%	18%	19%	19%	17%	13%	7%
Excess leachate to be disposed	(m3)	0	0	0	0	0	0	0	0	0	0	0	0

Parameter		January	February	March	April	May	June	July	August	September	October	November	December	Total mm	Total m3	Percent
		31	28	31	30	31	30	31	31	30	31	30	31			
Precipitation (mm)																
1988	(mm)	16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5	1551		100%
Pan Evaporation																
Evaporation (from SILO)	(mm)	208.7	218.3	172.6	109.9	61.1	51.1	47.6	63.6	90.1	118.1	147.5	188.8	2955		191%
Leachate generated from cell (mm)																
Active Tipping Face		16.3	1.4	38.7	16.2	223.6	132.5	94.2	72.7	83.9	37.1	42.4	16.5	1551	0	100%
Daily Cover		9.8	0.8	23.2	9.7	134.2	79.5	56.5	43.6	50.3	22.3	25.4	9.9	931	0	
Intermediate cover		2.4	0.2	5.8	2.4	33.5	19.9	14.1	10.9	12.6	5.6	6.4	2.5	233	0	15%
Final cap		0.1	0.0	0.2	0.1	1.1	0.7	0.5	0.4	0.4	0.2	0.2	0.1	8	435	1%
Total Leachate Collected	(m3/month)	5	0	11	5	63	37	26	20	24	10	12	5	435	435	
Leachate containment pond																
Rainfall into Pond	(m3)	114	10	270	113	1,558	923	656	506	584	258	295	115		10,804	
Evaporation From Pond	(m3)	1,177	1,231	973	620	344	288	268	359	508	666	832	1,064		16,658	
Net Leachate Generation	(m3)	-1,058	-1,221	-693	-502	1,276	672	414	168	100	-397	-524	-945		-5,418	
Required containment	(m3)	0	0	0	0	1,276	1,948	2,362	2,530	2,631	2,234	1,709	765			
Pond storage level	(m3)	0	0	0	0	1,276	1,948	2,362	2,530	2,631	2,234	1,709	765			
Pond storage level	(%)	0%	0%	0%	0%	8%	13%	16%	17%	18%	15%	11%	5%			
Excess leachate to be disposed	(m3)	0	0	0	0	0	0	0	0	0	0	0	0			

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→ The Power of Commitment

Appendix D – Inspection checklist templates

_______________ Inspection Checklist

Location: ....

Date: ....

Time: ....

Weather Conditions: ....

Days since last rainfall event: ....

Inspection conducted by: ....

Element	Yes	No	Comments	Actions (refer to Corrective Actions for each element)	Action Completed (tick box and sign)

(Note, a site plan and photographic evidence must accompany this checklist to identify the severity and locations of observed issues)

Erosion and Sediment Control (ESC) Daily Site Inspection

LOCATION **Mount Barker Waste Management Facility** . . . .

INSPECTION OFFICER . . . . **DATE** . . . .

SIGNATURE . . . .

Legend: OK / Not OK / N/A (not applicable)

Item	Consideration	Assessment
◗	Any current work areas are appropriately defined via signage and traffic cones.	. . . .
◗	The site is clear of litter and unconfined rubbish.	. . . .
◗	Dust problems are under control.	. . . .
◗	Up slope “clean” water is being appropriately diverted around/through the site.	. . . .
◗	Flow diversion banks have not been damaged by traffic.	. . . .
◗	There is no scour at flow concentration points or along the base of embankments.	. . . .
◗	There are no overtopping flows due to sediment deposition upslope of the bank.	. . . .
◗	No areas of exposed soil are in need of erosion control.	. . . .
◗	Earth batters are free of “rill” erosion.	. . . .
◗	Any rills have been filled out as appropriate.	. . . .
◗	Sediment-laden stormwater is not simply flowing “around” the sediment pond.	. . . .
◗	All sediment ponds are free of excessive sediment deposition.	. . . .
◗	Erosion control measures have not been damaged.	. . . .
◗	Runoff is not undermining the erosion control measures.	. . . .
◗	Any stabilised areas are protected from raindrop impact via turf/vegetation application of appropriate material.	. . . .
◗	Any damaged areas have been hydroseeded/turfed/vegetated with an appropriate material.	. . . .
◗	Established grasses are being watered appropriately.	. . . .
◗	The site is adequately prepared for imminent storms.	. . . .
◗	All pollutants washed or blown from the site are collected and secured as soon as practicable.	. . . .

Item	Consideration	Assessment
◗	All chemicals and hydrocarbons are being stored and bunded correctly.	....
◗	All reasonable and practicable measures are being taken to control sediment runoff from the site.	....
◗	All stormwater treatment and control measures are in proper working order.	....

Comments

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Erosion and Sediment Control (ESC) Weekly Site Inspection

LOCATION **Mount Barker Waste Management Facility**. . . . .

INSPECTION OFFICER . . . . **DATE** . . . .

SIGNATURE . . . .

Legend: OK / Not OK / N/A (not applicable)

Item	Consideration	Assessment
◗	Sediment pond access points are clear of excessive sediment deposition.	. . . .
◗	Sediment pond access points have adequate void spacing to trap sediment.	. . . .
◗	Any work areas are appropriately defined via signage and traffic cones.	. . . .
◗	The site is clear of litter and unconfined rubbish.	. . . .
◗	Adequate stockpiles of emergency stormwater treatment materials exist on site.	. . . .
◗	To control dust problems, area of soil disturbance is being limited at any given time.	. . . .
◗	Unsealed tracks have been gravelled or regularly undergo dust suppression measures.	. . . .
◗	Traffic movements on exposed surfaced have been managed and speed minimised.	. . . .
◗	Appropriate drainage and sediment controls have been installed.	. . . .
◗	Up slope “clean” water is being appropriately diverted around/through the site.	. . . .
◗	Drainage lines are free of soil scour and sediment deposition.	. . . .
◗	Flow diversion banks have not been damaged by traffic.	. . . .
◗	There is no scour at flow concentration points or along the base of the embankment.	. . . .
◗	There are no overtopping flows due to sediment deposition upslope of the bank.	. . . .
◗	No areas of exposed soil are in need of erosion control.	. . . .
◗	Earth batters are free of “rill” erosion.	. . . .
◗	Long-term soil stockpiles are protected from wind, rain and stormwater flow with appropriate cover, and drainage and erosion controls.	. . . .
◗	Sediment-laden stormwater is not simply flowing “around” the sediment ponds.	. . . .

Item	Consideration	Assessment
◗	All sediment ponds are free of excessive sediment deposition.	....
◗	Erosion control measures have not been damaged.	....
◗	Runoff is not undermining the erosion control measures.	....
◗	Stabilised areas are protected from raindrop impact via turf/vegetation application of appropriate material.	....
◗	Any damaged areas have been hydroseeded/turfed/vegetated with appropriate material.	....
◗	Established grasses are being watered appropriately.	....
◗	There is no erosion downslope of the sediment fence outlet structures.	....
◗	Revegetated areas are being maintained regularly.	....
◗	Revegetation is being monitored and checked to ensure that it is performing its purpose of erosion control and soil stabilisation.	....
◗	Any rills have been filled out and planted as appropriate.	....
◗	Areas which have been damaged or where vegetation has failed to establish, have been re-seeded and turfed/vegetated with appropriate material.	....
◗	Weed growth is kept in check.	....
◗	Stabilised surfaces have a minimum 70% soil coverage.	....
◗	The site is adequately prepared for imminent storms.	....
◗	Emergency and pollution control procedures adopted on the site are appropriate for the site conditions, local environmental values, and the type, cost, scope and complexity of the operational activities.	....
◗	All pollutants washed or blown from the site are collected and secured as soon as practicable.	....
◗	The paved roads at the site are being appropriately swept clean.	....
◗	All reasonable and practicable measures are being taken to control sediment runoff from the site.	....
◗	All stormwater treatment and control measures are in proper working order.	....

Comments

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Item	Consideration	Assessment

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12531104-90522-16/https://projectsportal.ghd.com/sites/pp18_01/oneilroadlandfillclo/ProjectDocs/12531104-REP-0_O'Neill Road Landfill Closure and Post Closure Plan.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
DRAFT	N Ambrey	R Wilkes		J Cramer		1/04/2021
0	N Ambrey	R Wilkes	R. Wilkes	J Cramer	[signature]	28/05/2021

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