# Millar Road Landfill Leachate Generation Modelling Assessment

**19 SEPTEMBER 2025**

**IWP Projects**

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# 1. Introduction

BEC WA Pty Ltd, trading as BEC-IWP (BEC-IWP) has been engaged by IW Projects, on behalf of the City of Rockingham to prepare detailed leachate generation modeling over two landfills at the Millar Road Landfill. The Site is located at 204 Millar Road West, Baldivis WA 6171.

This report presents the results of the HELP modelling analysis, providing an assessment of the monthly leachate generation expected from the landfill.

## 1.1. Purpose

Model a range of scenarios at the site to understand leachate generation and storage requirements under varying environmental and operational conditions.

## 1.2. Limitations

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## 1.3. Reliance

The following data sources have been relied upon in the leachate generation model and water balance:

- HELP 3.95 Users Guide
- Department of Primary Industries and Regional Development, 2021, *Lawn Care,* updated 09/06/2021, Lawn care | Agriculture and Food

# 2. Site Setting

The Millar Road Landfill site, managed by the City of Rockingham since 1993, encompasses approximately 30 hectares and two filling areas referred to herein as the Western Landfill and the Eastern Landfill, respectively.

The Western Landfill comprises Cells 1 to 11, all of which have been constructed with a 1-meter-thick low-permeability clay basal liner. Filling in the Western Landfill ceased in approximately 2013, with the landfill being progressively capped as landfill cells reached maximum capacity. The landfill capping has been constructed of various capping systems (refer Section 6.3) with minimal grade in most areas. The Western Landfill area is approximately 214,000 $m^2$ in total.

The Eastern Landfill comprises existing Cells 12 to 17 and future Cells 18 to 28 (based on the Conceptual Final Landform Profile Layout Plan (IW Project, 2024). Cells 12 & 13, and part of Cell 14 & 15 have been rehabilitated and Cells 16 and 17 are currently active. Cells 12 & 13 within the Eastern Landfill have been constructed with a 1-meter-thick low-permeability clay basal liner, and Cells 14 to 16 have been lined with a composite lining system consisting of GCL and HDPE. The area encompassing existing cells is approximately 175,000 $m^2$ and the total Eastern Landfill area is approximately 434,000 $m^2$. It is anticipated that the future cells will also be constructed using a composite GCL/HDPE lining system.

## 2.1. Current Leachate Management

Four leachate ponds provide on-site leachate storage capacity at the Site. The leachate ponds are situated within the footprint of the Western Landfill. Leachate is pumped from both Eastern and Western landfill areas into the leachate ponds and volume reductions are managed through evaporation (natural and surface sprays) and recirculation onto the landfill surface via water cart.

Currently, the four existing leachate ponds are nearing capacity and further development of the Eastern Landfill suggests additional storage is required to adequately manage leachate levels within cells. However, the reshaping of the landfill surface and the establishment of an improved, suitably engineered landfill cap over the Western Landfill, if undertaken, is expected to offset significant leachate generation, hence the consideration to undertake leachate generation modelling under various scenarios.

## 3. Methodology

The volume of generated leachate was determined using the Hydraulic Evaluation of Landfill Performance (HELP 3.95D) software package. This quasi-two-dimensional hydrologic model assesses water movement across, into, though, and out of landfills. HELP modelling facilitates rapid estimation of the amount of runoff, evapotranspiration, drainage, leachate collection and liner leakage that may be expected to result from the operation of various landfill designs using site-specific data and assumptions (refer Section 6).

To understand leachate management requirements, leachate data outputs from HELP modelling have been input into a water balance model which considers evaporation balanced against inflows from leachate and rainfall within existing and/or potential future leachate ponds.

The *Siting, Design, Operation and Rehabilitation of Landfills – Victorian EPA, Section 6.5.2 – Leachate Management* requires that a water balance be modelled over at least two consecutive 90$^{th}$ percentile wet years to ensure that the leachate system has sufficient capacity to deal with all the leachate generated over the operational life of the landfill. This is an extremely conservative position, which due to the extreme weather years, results in substantial leachate generation, well above the typical leachate generation usually experienced on site.

The HELP modelling and subsequent water balance includes the two consecutive 90$^{th}$ percentile wet years but also includes consideration of the leachate generation during an average rainfall year.

## 4. Data Inputs and Assumptions

Model data was sourced from the Bureau of Meteorology and the Queensland Government (SILO, point data) from locations closest to the Site. Refer to Table 1 for a summary of the data sources incorporated into the model.

**Table 1 Summary of data sources**

| Item | Source | Date |
|---|---|---|
| Precipitation | Queensland Government, Long Paddock, Silo Data (-32.10,115.88) | 19 Dec 2024 |
| Radiation | Queensland Government, Long Paddock, Silo Data (-32.10,115.88) | 19 Dec 2024 |
| Temperature | Queensland Government, Long Paddock, Silo Data (-32.10,115.88) | 19 Dec 2024 |
| Pan Evaporation | Queensland Government, Long Paddock, Silo Data (-32.10,115.88) | 19 Dec 2024 |
| Humidity | Queensland Government, Long Paddock, Silo Data (-32.10,115.88) | 19 Dec 2024 |
| Windspeed | Bureau of Meteorology (JANDAKOT AERO- Station ID: 009172) | 19 Dec 2024 |

[1] Dataset utilized daily data from 1957 to 2024

### 4.1. Climate Data

Perth's climate is characterized by an extended summer season, lasting approximately eight months. This means the region experiences predominantly warm to hot weather for most of the year, with only a brief period of cooler conditions. Climate data for the analysis was obtained from the Jandakot Aero weather station (Station 9172) using the SILO database, as the nearest Bureau of Meteorology (BOM) Station 9253 lacked sufficient data for the study. The selected data provided comprehensive inputs for the HELP model, including daily records of rainfall, temperature, and solar exposure. Wind speed and humidity data specific to the site were also incorporated to ensure accurate and reliable modeling.

Using SILO data between 1957 and 2024, 1967 and 1981 were identified as wet (90$^{th}$ percentile rainfall) years. Using the same data, 1961 was identified as an average rainfall year.

In more recent years, rainfall at the site has declined. In 1961 (the average rainfall year between 1957 and 2024), the annual rainfall total was 816.4 mm. Using data from the year 2000 to 2024, the average annual rainfall total was 758.5mm (2002). Both 1961 and 2002 rainfall years have been modelled and are discussed in this report. Where referenced, the "average rainfall year" refers to 1961 and "short-term average rainfall year" refers to 2002.

#### 4.1.1. Temperature

Perth's climate is primarily defined by two main seasons: a long, hot summer and a mild winter. While spring and autumn are brief, they still contribute to the overall climate. The monthly average temperatures used in the model are outlined in Table 2.

Table 2 Average Monthly Temperature in years modelled (°C)

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23.75 | 25.67 | 21.68 | 19.89 | 16.40 | 15.60 | 12.68 | 12.83 | 15.12 | 18.11 | 19.46 | 21.87 | 1967 |
| 23.93 | 23.09 | 21.33 | 18.22 | 15.95 | 14.39 | 11.37 | 13.35 | 13.96 | 16.61 | 19.44 | 21.88 | 1981 |
| 25.76 | 24.91 | 22.98 | 17.08 | 16.23 | 14.10 | 12.37 | 13.17 | 15.61 | 16.78 | 19.52 | 22.12 | 1961 (avg. year) |
| 23.30 | 23.21 | 21.55 | 18.70 | 16.00 | 13.32 | 13.20 | 11.71 | 13.54 | 15.77 | 19.16 | 23.19 | 2002 (short-term avg. year) |

### 4.1.2. Rainfall

The monthly total rainfall utilised in the model is included in Table 3.

Table 3 Rainfall Depth in years modelled (mm)

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.7 | 9.7 | 7.7 | 54.6 | 215.4 | 300.8 | 206.1 | 111.3 | 19.2 | 36.2 | 16.3 | 29.2 | 1967 |
| 0.0 | 18.4 | 9.6 | 44.4 | 193.8 | 172.8 | 199.4 | 176.0 | 104.2 | 22.8 | 60.6 | 8.8 | 1981 |
| 8.4 | 9.7 | 47.7 | 88.8 | 50.1 | 173.1 | 197.8 | 135.7 | 56.8 | 21.7 | 4.2 | 22.3 | 1961 (avg. year) |
| 2.4 | 0.2 | 9.0 | 82.8 | 59.8 | 213.2 | 166.0 | 81.4 | 73.6 | 44.4 | 23.6 | 1.6 | 2002 (short-term avg. year) |

### 4.1.3. Pan Evaporation

Pan evaporation is a theoretical value of evaporation from an extremely small surface area of fresh water; however, large surface area evaporation is lower due to the presence of increased humidity immediately above the liquid surface. The degree of reduced evaporation is a function of the evaporation surface size, the larger the surface area, the larger the decrease in evaporation in comparison to the pan evaporation value. In addition, due to the salinity of leachate in comparison to fresh water, evaporation within the leachate ponds is further reduced. Hence, during modelling of evaporation ponds, a conversion factor of 0.8 (80%) is used to convert pan evaporation to theoretical leachate evaporation. This approach is consistent with the guidance provided in the *Siting, Design, Operation and Rehabilitation of Landfills – Victorian EPA*.

The monthly total pan evaporation used in the model is included in Table 4. It is noted that pan evaporation data sets for 1967 (wet year) and 1961 (average year) retrieved from Jandakot Aero weather station (station 9172) using the SILO database are identical. On review of raw data, it appears pan evaporation data from station 9172 is repeated until 1970. This may be due to limitations of the weather station prior to 1970. An average evaporation year (1979) was adopted instead. 2002 was used for the short-term average year.

Table 4 Pan Evaporation in years modelled (mm)

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 287.9 | 238.8 | 206.3 | 127.8 | 81.7 | 59.9 | 61.1 | 75.1 | 100.7 | 152.9 | 203.1 | 260.1 | 1967 |
| 237.5 | 282.4 | 270.3 | 210.3 | 120.2 | 106.6 | 66.8 | 69.0 | 86.4 | 99.5 | 139.7 | 183.0 | 1981 |
| 267.1 | 252.0 | 260.2 | 199.9 | 122.5 | 91.2 | 53.0 | 66.2 | 69.7 | 100.5 | 150.6 | 184.5 | 1979 (avg. year) |
| 254.9 | 247.8 | 285.9 | 197.9 | 123.5 | 75.9 | 62.5 | 62.0 | 74.7 | 108.2 | 141.3 | 227.6 | 2002 (short-term avg. year) |

### 4.1.4. Other Climate Data

Other climate data used in the model includes solar radiation, grass growing season, relative humidity, and wind speed.

**Solar Radiation**

Solar radiation is the measure of radiant energy emitting from the sun and falling on a horizontal surface. Solar radiation average from SILO data across both wet years, adopted for the model is 18.3 MJ/$m^2$.

**Relative Humidity**

Relative humidity is a direct indicator of rainfall and is used to determine the rate of evapotranspiration. Quarterly humidity utilised in the model to represent seasonality is presented in Table 5.

Table 5 Relative Humidity

| | Quarter 1 | Quarter 2 | Quarter 3 | Quarter 4 |
|---|---|---|---|---|
| Average quarterly humidity based on BOM (%) | 52.0 | 71.0 | 74.7 | 53.3 |
| Average quarterly humidity based on SILO (%) | 52.4 | 69.9 | 73.2 | 63.3 |
| Average (%) | 52.2 | 70.5 | 73.9 | 58.3 |

**Windspeed**

Windspeed is used to determine the rate of evapotranspiration. The annual average windspeed measured at 3pm used in the model 21.4 km/hr.

**Grass Growing Season**

HELP 3.95 considers seasonality of grass growth, noting that, typically, growing season for grasses begins when the normal mean daily temperature rises above 10-12.8°C (HELP 3.95 User Guide). Typically, mean daily temperature remains above 12°C throughout winter months in Perth, suggesting that grass will grow most, if not all of the year (if there is moisture available). This is supported by lawn care advice provided by the Department of Primary Industries and Regional Development, which recommends mowing weekly in Summer and monthly (or less) in Winter.

Anecdotally, die-off during the dry summer periods occurs in Perth due to insufficient rainfall, and consequently, the natural (i.e. without watering) grass growing period would be from May to October. However, for modelling purposes, year-round growing has been assumed.

**Evaporative Zone Depth and Maximum Leaf Area Index**

Nearmap aerial imagery from throughout the year indicates grass cover varies. During winter, the site appears to have a good to excellent stand of grass, whereas summer appears to be fair to good. It is noted shrubbery exists, predominantly in the northern and western sides of the landfill cap. On this basis, a maximum leaf area index of 4 has been adopted in line with typical values provided in Figure 1.

30cm evaporative zone depth has been assumed.

| Kind of vegetation | Maximum LAI |
|---|---|
| Bare ground | 0 |
| Poor stand of grass | 1.0 |
| Fair stand of grass | 2.0 |
| Good stand of grass | 3.5 |
| Excellent stand of grass | 5.0 |
| Shrubbery | 4 – 12 |
| Deciduous forest | 7 – 15 |
| Coniferous forest | 10 – 20 |

**Figure 1 Typical Values of the Maximum Leaf Area Index (source: HELP 3.95 Users Guide)**

### 4.2. Overview of Modelled Landfill Development Scenarios

Three scenarios were modelled using back-to-back 90$^{th}$ percentile rainfall years (1967 & 1981), the average rainfall year (1961), and the short-term average rainfall year (2002) respectively.

1. Western Landfill base case

Under this scenario, the Western landfill footprint has been modelled with the existing capping profiles (described further below), assuming a 0.1% grade and initial water content of waste is at steady state (default HELP input).

2. Western Landfill with landfill cap improvements (Final capping solution)

Under this scenario, a suitably designed landfill cap with seepage rates <7.5L/ha/day and minimum grade of 5% has been modelled.

3. Eastern Landfill cell operation

The Eastern Landfill capped, and active areas have been modelled for consideration alongside Scenario 1 and Scenario 2. The Eastern Landfill cell operational scenario includes an active cell, an area with interim capping (both sloped and relatively flat), and final capping. The Eastern Landfill has been modelled with an initial water content of waste of 15% based on BEC experience at other municipal solid waste landfills in Australia where moisture content testing of waste has been conducted.

### 4.3. Scenario 1 - Western Landfill Base Case

Broadly, the Western Landfill existing cap comprises two profiles. There are also four leachate ponds situated within the footprint of the Western Landfill cap, with the surface areas of the ponds having been excluded from the leachate generation component of the model on the assumption that infiltration from the footprint of the leachate ponds is negligible. Figure 2 is a plan view of the Western Landfill showing each capping area and the leachate ponds.


Figure 2 Western Landfill Cap Layout (Source: Nearmap, 06 December 2024)

The modelled areas for Scenario 1 are provided in Table 6 and corresponding design profiles provided in Table 7. Note that leachate pond area has been deducted from the Area 1 and Area 3 totals shown in Figure 2.

Table 6 Modelled Areas - Scenario 1

| Area no. | Relevant Cells | Capping status | Grade adopted for model | Percentage Utilized | Total Area ($m^2$) |
|---|---|---|---|---|---|
| 1 | Cell 1 to Cell 11 | GCL cap | Flat | 64% | 143,119 |
| 2 | Cell 8, 10 & 11. | Coated GCL cap | 1V:3.5H | 21% | 47,422 |
| 3 | Cell 1 & 3 | 1.0 m cover soil | Flat | 8% | 17,172 |
| 4 | Cell 1 & 3 | 1.0 m cover soil | 1V:3.5H | 1% | 1,581 |
| NA | Leachate Pond | | NA | 6% | 14,215 |

### Table 7 Soil and Design Data – Scenario 1

| Layer | Type | Thickness | Soil Texture Number | Total Porosity | Field Capacity | Wilting Point | Sat. Hydraulic Conductivity |
|---|---|---|---|---|---|---|---|
| | | cm | No. | vol/vol | vol/vol | vol/vol | cm/s |
| **Cell 1 to Cell 11 (including part of Cell 10 and excluding Cell 8)** | | | | | | | |
| Sand | VPL | 70 | 2 | 0.437 | 0.062 | 0.024 | 5.80E-3 |
| GCL | BSL | 0.6 | 17 | 0.750 | 0.418 | 0.400 | 3.0E-9 |
| Waste | VPL | 1500 | 18 | 0.671 | 0.292 | 0.077 | 1.0E-3 |
| Compacted Clay Liner | BSL | 100 | 29 | 0.451 | 0.419 | 0.332 | 1.0E-7 |
| **Cell 8 and part of Cell 10** | | | | | | | |
| Sandy Clay | VPL | 70 | 10 | 0.398 | 0.244 | 0.136 | 1.2E-4 |
| Sand Drainage Layer | LDL | 30 | 2 | 0.437 | 0.062 | 0.024 | 5.80E-3 |
| GCL | BSL | 0.6 | 17 | 0.750 | 0.418 | 0.400 | 3.0E-9 |
| Waste | VPL | 1,500 | 18 | 0.671 | 0.292 | 0.077 | 1.0E-3 |
| Compacted Clay Liner | BSL | 100 | 29 | 0.451 | 0.419 | 0.332 | 1.0E-7 |
| **Cell 1 and Cell 3 (flat)** | | | | | | | |
| Sandy Clay | VPL | 70 | 10 | 0.398 | 0.244 | 0.136 | 1.2E-4 |
| Waste | VPL | 1,500 | 18 | 0.671 | 0.292 | 0.077 | 1.0E-3 |
| Compacted Clay Liner | BSL | 100 | 29 | 0.451 | 0.419 | 0.332 | 1.0E-7 |
| **Cell 1 and Cell 3 (1V:3.5H)** | | | | | | | |
| Sandy Clay | VPL | 70 | 10 | 0.398 | 0.244 | 0.136 | 1.2E-4 |
| Waste | VPL | 1,500 | 18 | 0.671 | 0.292 | 0.077 | 1.0E-3 |
| Compacted Clay Liner | BSL | 100 | 29 | 0.451 | 0.419 | 0.332 | 1.0E-7 |

Note 1: Default HELP model settings for initial waste content used for Scenario 1

## 4.4. Scenario 2 - Western Landfill with Landfill Cap Improvements

Scenario 2 considers decommissioning of the existing leachate ponds and further waste placement within the Western Landfill area. Waste would be placed to form a low pyramid shape with 1V:20H grades, therefore additional waste depth has been modelled (based on the average waste height increase). A composite-lined (geomembrane/GCL) final cap covering a 2D area of 223,509 m² has been modelled.

Scenario 2 assumes the decommissioning of existing leachate ponds on the Western Landfill and the water balance (refer Section 6) assumes that the City of Rockingham will develop an equivalent area and volume of leachate ponds elsewhere on Site.

### Table 8 Modelled Area - Scenario 2

| Arrangement | Percentage Utilized | Total Area (m²) |
|---|---|---|
| Western Landfill (all cells) | 100% | 223,509 |

### Table 9 Soil and Design Data – Scenario 2

| Layer | Type | Thickness | Soil Texture Number | Total Porosity | Field Capacity | Wilting Point | Sat. Hydraulic Conductivity |
|---|---|---|---|---|---|---|---|
| | | cm | No. | vol/vol | vol/vol | vol/vol | cm/s |
| **Western landfill (all cells)** | | | | | | | |
| Sandy Clay | VPL | 70 | 27 | 0.400 | 0.366 | 0.288 | 7.8E-7 |
| Sand Drainage Layer | LDL | 30 | 2 | 0.437 | 0.062 | 0.024 | 5.8E-3 |
| LLDPE | GML | 0.15 | 36 | N/A | N/A | N/A | 4.0E-13 |
| Bentonite mat | BSL | 0.6 | 17 | 0.750 | 0.747 | 0.400 | 3.0E-9 |
| Waste | VPL | 19,500 | 18 | 0.671 | 0.292 | 0.077 | 1.0E-3 |
| Compacted Clay Liner | GML | 100 | 35 | N/A | N/A | N/A | 2.0E-13 |

Note: Default HELP model settings for initial waste content used for Scenario 1

## 4.5. Scenario 3 - Eastern Landfill cell operation

This scenario considers the active operation of the Eastern Landfill, where new cells are being filled while others are in interim or final capping stages. The HELP model accounts for ongoing waste disposal, tipping face runoff, and interim cap performance. This scenario helps determine the leachate management requirements for both the active and rehabilitated areas, ensuring sufficient storage capacity in the existing leachate ponds.

### Table 10 Modelled Areas - Scenario 3

| Area no. | Operational status | Capping status | Grade adopted for model | Total Area ($m^2$) |
|---|---|---|---|---|
| 1 | Active Cell (one cell) | 2.0 m waste placed across cell surface (no exposed liner area) | 1V:100H | 40,000 |
| 2 | Interim capping (1V3.5H) | 0.5 m interim cap | 1V:3.5H | 40,000 |
| 3 | Interim capping (1V:10H) | 0.5 m interim cap | 1V:10H | 40,000 |
| 4 | Final capping (two cells) | GCL/Geomembrane composite liner | 1V:5H | 80,000 |


Figure 3 Eastern Landfill Model Layout (Source: Nearmap, 06 December 2024)

Table 11 Soil and Design Data – Scenario 3

| Layer | Type | Thickness | Soil Texture Number | Total Porosity | Field Capacity | Wilting Point | Sat. Hydraulic Conductivity |
|---|---|---|---|---|---|---|---|
| | | cm | No. | vol/vol | vol/vol | vol/vol | cm/s |
| **Active Cell (one cell)** | | | | | | | |
| Sandy soil | VPL | 15 | 6 | 0.453 | 0.190 | 0.085 | 7.2E-4 |
| Waste | VPL | 200 | 18 | 0.671 | 0.292(1) | 0.077 | 1.0E-3 |
| Leachate Drainage Aggregate | LDL | 30 | 21 | 0.397 | 0.032 | 0.013 | 3.0E-1 |
| Geomembrane | GML | 0.2 | 35 | | | | 2.0.0E-13 |
| GCL | BSL | 0.6 | 17 | 0.750 | 0.747 | 0.400 | 3.0E-9 |
| **Interim capping (steep areas)** | | | | | | | |
| Sandy soil | VPL | 50 | 6 | 0.453 | 0.190 | 0.288 | 7.2E-4 |
| Waste | VPL | 1500 | 18 | 0.671 | 0.292 | 0.077 | 1.0E-3 |
| Leachate Drainage Aggregate | LDL | 30 | 21 | 0.397 | 0.032 | 0.013 | 3.0E-1 |
| Geomembrane | GML | 0.2 | 35 | | | | 2.0.0E-13 |
| GCL | BSL | 0.6 | 17 | 0.750 | 0.747 | 0.400 | 3.0E-9 |
| **Interim capping (flat areas)** | | | | | | | |
| Sandy soil | VPL | 50 | 6 | 0.453 | 0.19 | 0.085 | 7.2E-4 |
| Waste | VPL | 3000 | 18 | 0.671 | 0.292 | 0.077 | 1.0E-7 |
| Leachate Drainage Aggregate | LDL | 100 | 21 | 0.397 | 0.032 | 0.013 | 3.0E-1 |
| Geomembrane | GML | 0.2 | 35 | | | | 2.0.0E-13 |
| GCL | BSL | 0.6 | 17 | 0.750 | 0.747 | 0.400 | 3.0E-9 |
| **Final capping (two cells)** | | | | | | | |
| Sandy soil | VPL | 70 | 6 | 0.453 | 0.19 | 0.085 | 7.2E-4 |

| Layer | Type | Thickness | Soil Texture Number | Total Porosity | Field Capacity | Wilting Point | Sat. Hydraulic Conductivity |
|---|---|---|---|---|---|---|---|
| | | cm | No. | vol/vol | vol/vol | vol/vol | cm/s |
| Sand | LDL | 30 | 2 | 0.437 | 0.062 | 0.024 | 5.8E-3 |
| Geomembrane | GML | 0.15 | 36 | N/A | N/A | N/A | 4.0E-13 |
| Bentonite mat | BSL | 0.6 | 17 | 0.75 | 0.747 | 0.4 | 3.0E-9 |
| Waste | VPL | 2000 | 18 | 0.671 | 0.292 | 0.077 | 1.0E-3 |
| Leachate Drainage Aggregate | LDL | 100 | 21 | 0.397 | 0.032 | 0.013 | 3.0E-1 |
| Geomembrane | GML | 0.2 | 35 | | | | 2.0.0E-13 |
| GCL | BSL | 0.6 | 17 | 0.750 | 0.747 | 0.400 | 3.0E-9 |

Note:

1. 1% grade assumed to be maintained during operation in active cell.
2. Scenario 3 waste and cover soil modelled with initial moisture content of 15% v/v.
3. GCL/HDPE geomembrane base liner (it is noted that Cells 12 & 13 have 1 m compacted clay; however, will have minimal impact on the modelling outcome) and LDPE geomembrane cap modelled with eight defects per hectare with good installation quality.

# 5. Results

## 5.1. Scenario 1

A summary of leachate generation modelling results for Scenario 1 is provided in Table 12.

Table 12 Summary of leachate generation modelling results – Scenario 1

| Area no. | Relevant Cells | Capping status | 90th percentile rainfall: Year 1 leachate generation ($m^3$) | 90th percentile rainfall: Year 2 leachate generation ($m^3$) | Average year leachate generation ($m^3$) | Short term Average year leachate generation ($m^3$) |
|---|---|---|---|---|---|---|
| 1 | Cell 1 to Cell 11 | GCL cap | 21,409 | 37,985 | 17,239 | 19,134 |
| 2 | Cell 8, 10 & 11 | Coated GCL cap | 8,286 | 14,021 | 1,623 | 5,133 |
| 3 | Cell 1 & 3 (flat) | 1.0 m cover soil | 16,336 | 19,082 | 2,943 | 2,539 |
| 4 | Cell 1 & 3 (1V:3.5H) | 1.0 m cover soil | 1,504 | 1,757 | 271 | 234 |
| Total | | | 47,535 | 72,845 | 22,075 | 27,039 |

## 5.2. Scenario 2

A summary of leachate generation modelling results for Scenario 2 is provided in Table 13.

Table 13 Summary of leachate generation modelling results – Scenario 2

| Area no. | Relevant Cells | Capping status | 90th percentile rainfall: Year 1 leachate generation ($m^3$) | 90th percentile rainfall: Year 2 leachate generation ($m^3$) | Average year leachate generation ($m^3$) | Short term Average year leachate generation ($m^3$) |
|---|---|---|---|---|---|---|
| 1 | Western Landfill (all cells) | GCL/Geomembrane composite liner | 0 | 0 | 0 | 0 |

## 5.3. Scenario 3

A summary of leachate generation modelling results for Scenario 3 is provided in Table 14.

Table 14 Summary of leachate generation modelling results – Scenario 3

| Area no. | Relevant Cells | Operational/capping status | 90th percentile rainfall: Year 1 leachate generation ($m^3$) | 90th percentile rainfall: Year 2 leachate generation ($m^3$) | Average year leachate generation ($m^3$) | Short term Average year leachate generation ($m^3$) |
|---|---|---|---|---|---|---|
| 1 | Active Cell (one cell) | 2.0 m waste placed across cell surface | 8,124 | 17,336 | 0 | 0 |
| 2 | Interim capping (1V:3.5H) | 0.5 m interim cap | 0 | 0 | 0 | 0 |

| Area no. | Relevant Cells | Operational/capping status | 90th percentile rainfall: Year 1 leachate generation ($m^3$) | 90th percentile rainfall: Year 2 leachate generation ($m^3$) | Average year leachate generation ($m^3$) | Short term Average year leachate generation ($m^3$) |
|---|---|---|---|---|---|---|
| 3 | Interim capping (1V:10H) | 0.5 m interim cap | 0 | 0 | 0 | 0 |
| 4 | Final capping (two cells) | GCL/Geomembrane composite liner | 0 | 0 | 0 | 0 |
| Total | | | 8,124 | 17,336 | 0 | 0 |

## 5.4. Results Discussion

The modelling indicates the Western Landfill in current condition is the most significant contributor to leachate generation at the Site.

Modelling of the "worst case" scenario (back-to-back 90th percentile wet years) indicates:

- Leachate generation from the Western Landfill in current condition would total 120,380 $m^3$ by the end of the second year (47,535 $m^3$ for year 1 and 72,845 $m^3$ for year 2);
- Leachate generation from the Western Landfill with an improved cap would be negligible; and,
- Leachate generation from the Eastern Landfill would total 25,460 $m^3$ by the end of the second year (8,124 $m^3$ for year 1 and 17,336 $m^3$ for year 2).

Modelling of average and short-term average years indicates:

- Leachate generation from the Western Landfill in current condition would total 22,075 $m^3$ and 27,039 $m^3$, respectively. Interestingly, the short-term average year (2002) produced a higher volume of leachate despite having lower total rainfall for the year than the average rainfall year (1961). The reason for this is unclear however, it is noted that the average temperature was higher in the average year than the short-term average (18.36°C compared to 17.69°C). Rainfall at the Site appears to be decreasing and it's reasonable to assume a corresponding decrease in leachate generation in the long run. This unexpected result indicates it is not a direct correlation and some variability from year to year can be expected;
- Leachate generation from the Western Landfill with an improved cap would again be negligible; and,
- Leachate generation from the Eastern Landfill would be negligible.

Modelling of the Western Landfill with an improved cap demonstrated leachate generation within the Western Landfill could be reduced to negligible volumes, assuming moisture content of waste is at or below field capacity. In any event, if the moisture content of the waste was above the field moisture content at the time of capping, over time (anticipated to be a few years), the excess moisture would drain out of the waste, generating gradually diminishing leachate volumes, and eventually, the waste field moisture content would be achieved, and leachate generation would cease.

As discussed in Section 4.5, the initial moisture content of the waste in the Eastern Landfill was assumed to be 15%. Modelling indicates leachate generation from the Eastern Landfill will be limited to the active cell and negligible across other areas. This is likely to reflect the moisture storage capacity of the waste mass and suggests that, provided interim and final capping are placed in a timely manner upon completion of filling, leachate storage requirements for the Eastern Landfill will be governed by active cell only.

# 6. Water Balance

## 6.1. Overview of Water Balance

A water balance assessment was undertaken to assess the capacity of existing leachate ponds at the Site.

The leachate pond catchment/ evaporation area at the Site is approximately 14,000 m$^2$, with a total operating volume (allowing for 0.5 m freeboard) estimated to be 21,000 m$^3$ and an overflow volume of 28,000 m$^3$. These total pond volumes are based on the two smaller ponds having a maximum operating depth of approximately 1 m (estimate, as there is no as-constructed information available), with a total depth to overflow of approximately 1.5 m, and the two larger, newer ponds having an average operating depth of 1.875 m and an overflow depth of 2.375 m. That is a typical average operating depth of 1.5 m and overflow depth of 2 m, that would result in a maximum operating capacity of 21,000 m$^3$ and an overflow capacity of 28,000 m$^3$.

The four leachate ponds are situated within the footprint of the Western Landfill and would need to be decommissioned to implement the proposed cap improvements per Scenario 2. However, if this Scenario were to eventuate, leachate ponds of equivalent size would be constructed over the final capped areas of the Eastern Landfill. Therefore, leachate pond catchment/ evaporation area used in the water balance model is constant for all scenarios.

Enhanced evaporation systems (e.g. water mist evaporator) and water cart utilisation have been considered in the water balance model, noting their use at the Site may be adjusted seasonally, based on actual leachate generation.

As such, the water balance model inflows and outflows can be summarised as follows:

| Inflow | Outflow |
|---|---|
| Modelled leachate generation | Evaporation from leachate ponds |
| Rainwater falling within leachate ponds | Enhanced evaporation utilisation |
| | Water cart utilisation |

To determine the annual theoretical water balance with a particular scenario, the water balance calculation assumes that there is no legacy leachate (accumulation from previous years) within the leachate management system and hence, the leachate sumps and leachate ponds are empty at the commencement of the “wet season” (commencement of month where there is a net gain in the water balance). If the modelling indicates that there is an accumulation of leachate over the year, then this is an indication that there is a need to improve the leachate management system to either reduce generation or increase leachate evaporation or a combination of both.

The detailed water balance assessment is shown in Appendix A.

## 6.2. Back-to-Back Wet Years

This scenario simulates two consecutive 90th percentile wet years (1967 and 1981), in line with the EPA Victoria Landfill BPEM (2015) guidance for assessing landfill performance under extreme climatic stress. It is intended to evaluate the robustness of the leachate management system and assess potential risks associated with elevated rainfall and reduced evaporation over an extended wet period. The results of the modelling are summarised in Table 15.

**Table 15 Summary of Water Balance – 90th Percentile Wet Rainfall Years (1967 & 1981) With No Enhanced Evaporation or Water Cart Usage**

| Month | | Volume ($m^3$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Total Monthly Landfill leachate inflow | Precipitation in leachate pond/s | Enhanced Evaporation | Water Cart Utilisation | Evaporation within pond | Total monthly storage requirement (end of month) |
| YEAR 1 | January | 2,972.6 | 65.8 | 0.0 | 0.0 | 2,777.6 | 260.8 |
| | February | 2,898.4 | 135.8 | 0.0 | 0.0 | 2,763.0 | 532.0 |
| | March | 2,822.2 | 107.8 | 0.0 | 0.0 | 2,812.3 | 649.7 |
| | April | 2,740.7 | 764.4 | 0.0 | 0.0 | 2,104.5 | 2,050.3 |
| | May | 2,556.5 | 3,015.6 | 0.0 | 0.0 | 1,381.0 | 6,241.5 |
| | June | 2,671.5 | 4,211.2 | 0.0 | 0.0 | 840.0 | 12,284.2 |
| | July | 6,681.5 | 2,885.4 | 0.0 | 0.0 | 668.6 | 21,182.5 |
| | August | 9,311.4 | 1,558.2 | 0.0 | 0.0 | 677.6 | 31,374.5 |
| | September | 6,209.7 | 268.8 | 0.0 | 0.0 | 808.6 | 37,044.3 |
| | October | 5,685.8 | 506.8 | 0.0 | 0.0 | 1,139.0 | 42,097.9 |
| | November | 5,605.3 | 228.2 | 0.0 | 0.0 | 1,605.0 | 46,326.5 |
| | December | 5,503.7 | 408.8 | 0.0 | 0.0 | 2,246.7 | 49,992.2 |
| YEAR 2 | January | 5,395.0 | 0.0 | 0.0 | 0.0 | 2,777.6 | 52,609.6 |
| | February | 5,288.1 | 257.6 | 0.0 | 0.0 | 2,852.6 | 55,302.6 |
| | March | 5,177.2 | 134.4 | 0.0 | 0.0 | 2,802.2 | 57,812.0 |
| | April | 5,065.6 | 621.6 | 0.0 | 0.0 | 1,529.9 | 61,969.2 |
| | May | 5,050.8 | 2,713.2 | 0.0 | 0.0 | 1,241.0 | 68,492.3 |
| | June | 11,235.1 | 2,419.2 | 0.0 | 0.0 | 647.4 | 81,499.3 |
| | July | 8,066.9 | 2,791.6 | 0.0 | 0.0 | 665.3 | 91,692.5 |
| | August | 13,109.1 | 2,464.0 | 0.0 | 0.0 | 1,103.2 | 106,162.4 |
| | September | 9,041.2 | 1,458.8 | 0.0 | 0.0 | 1,467.2 | 115,195.2 |
| | October | 7,691.4 | 319.2 | 0.0 | 0.0 | 1,992.5 | 121,213.3 |
| | November | 7,590.7 | 848.4 | 0.0 | 0.0 | 2,386.7 | 127,265.7 |
| | December | 7,470.2 | 123.2 | 0.0 | 0.0 | 3,110.2 | 131,748.9 |

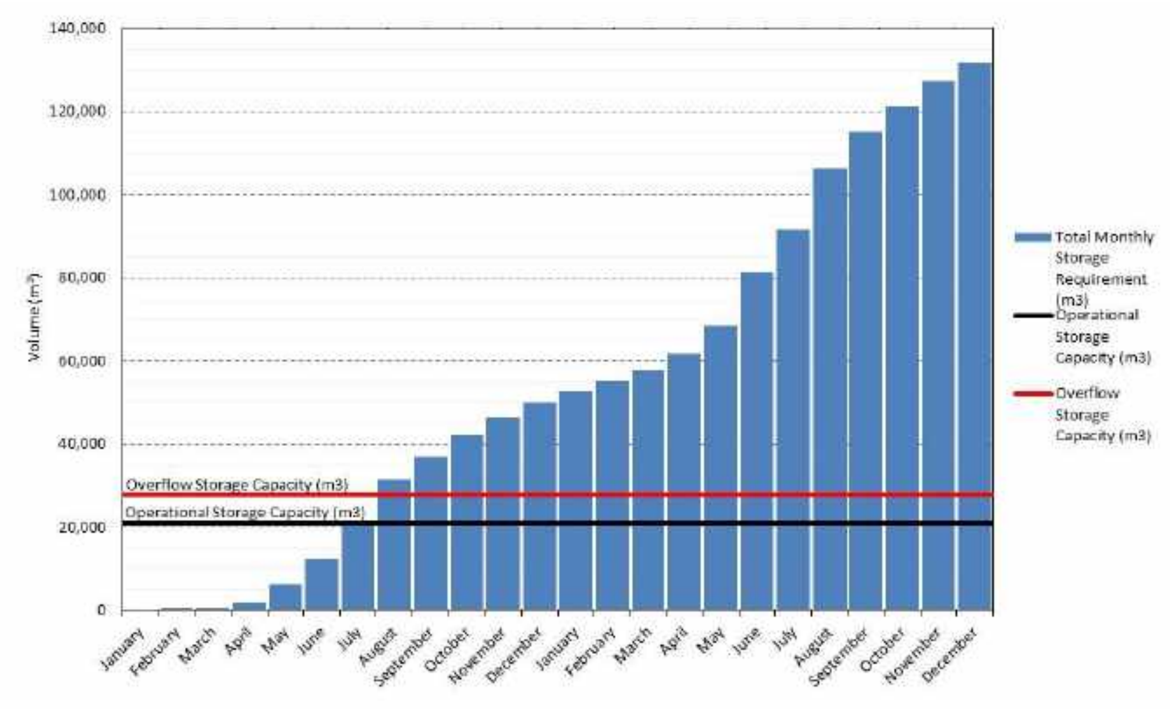


**Figure 4 Water Balance Volumes – 90th Percentile Wet Rainfall Years (1967 & 1981) With No Enhanced Evaporation or Water Cart Usage**

As can be seen from Figure 4, the modelling of this extreme two-year weather pattern results in significant leachate generation volume of 131,748 $m^3$, which based on the current 21,000 $m^3$ of available leachate pond operational storage, requires over 6 times the current available leachate pond operational capacity or 4.7 times the current capacity if the pond overflow volume is used (28,000 $m^3$). With this being an unrealistic expectation, no further modelling has been undertaken to assess the impact of pond surface sprays or water cart utilisation.

This water balance modelling exercise has been carried out simply as a result of the *Siting, Design, Operation and Rehabilitation of Landfills – Victorian EPA* requirements.

Due to the extreme nature of the leachate management system required to cater for this unrealistic event, this scenario has been ignored.

## 6.3. Average Year

### 6.3.1. Average Year without enhanced evaporation or water cart usage

This scenario is based on the historical climate data for the year 1961, which represents the long-term average rainfall and evaporation conditions within the available dataset. This approach aligns with the EPA Victoria Landfill BPEM (2015) methodology for assessing leachate generation and water balance behaviour under typical climatic conditions expected during the operational or post-closure life of the landfill. The results of the average year modelling are summarised in Table 16.

### Table 16 Summary of Water Balance - Average Year (1961) Without Enhanced Evaporation or Water Cart Usage

| Month | | Volumes ($m^3$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Total Monthly Landfill leachate inflow | Precipitation in leachate pond/s | Enhanced Evaporation | Water Cart Utilisation | Evaporation within pond | Total monthly storage requirement (end of month) |
| YEAR 1 | January | 1,410.7 | 117.6 | 0.0 | 0.0 | 2,777.6 | 15,749.6 |
| | February | 1,361.4 | 135.8 | 0.0 | 0.0 | 2,763.0 | 14,483.8 |
| | March | 1,339.9 | 667.8 | 0.0 | 0.0 | 2,812.3 | ****13,679.2** |
| | *April | 1,299.7 | 1,243.2 | 0.0 | 0.0 | 2,104.5 | 438.4 |
| | May | 1,277.3 | 701.4 | 0.0 | 0.0 | 1,381.0 | 1,036.1 |
| | June | 1,336.5 | 2,423.4 | 0.0 | 0.0 | 840.0 | 3,956.0 |
| | July | 1,569.2 | 2,769.2 | 0.0 | 0.0 | 668.6 | 7,625.8 |
| | August | 1,858.8 | 1,899.8 | 0.0 | 0.0 | 677.6 | 10,706.8 |
| | September | 2,262.4 | 795.2 | 0.0 | 0.0 | 808.6 | 12,955.7 |
| | October | 2,723.9 | 303.8 | 0.0 | 0.0 | 1,139.0 | 14,844.4 |
| | November | 2,834.7 | 58.8 | 0.0 | 0.0 | 1,605.0 | 16,133.0 |
| | December | 2,800.5 | 312.2 | 0.0 | 0.0 | 2,246.7 | 16,998.9 |

* April is the first month of net water balance gain, and the model assumes that the leachate system is empty as of 1 April.

** Represents the excess leachate within the system at the end of the annual cycle.

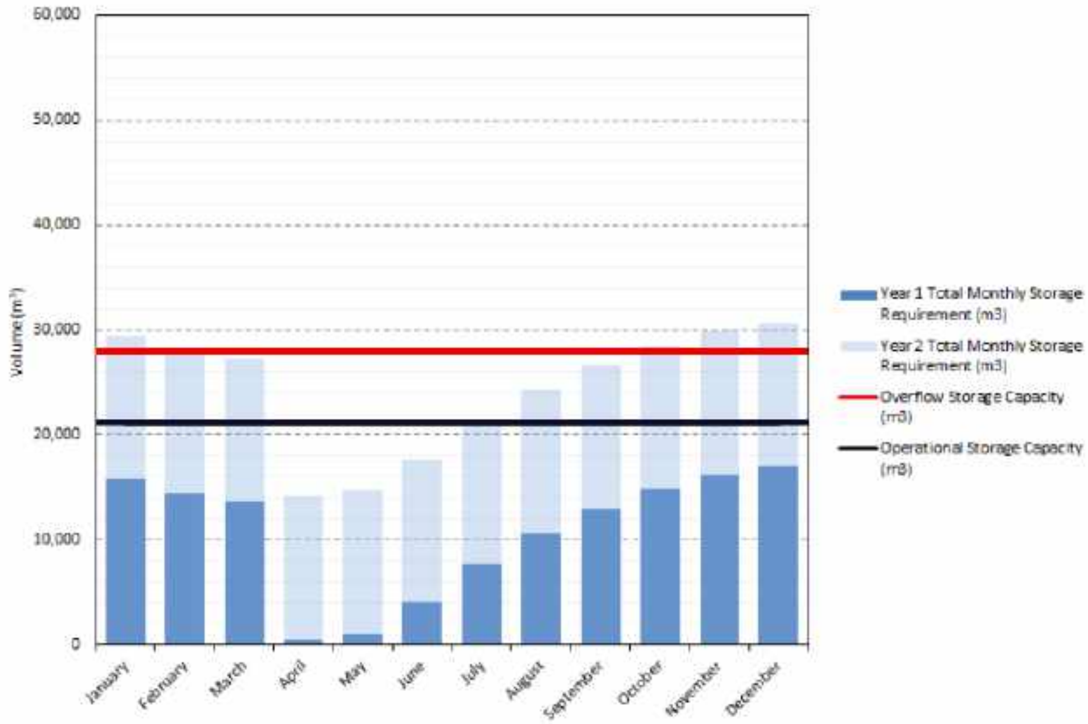


**Figure 5 Water Balance Volumes – Average Year (1961) Without Enhanced Evaporation or Water Cart Usage**

As can be seen from Figure 5, the modelling has assumed that the leachate ponds are all empty at the beginning of April; however, the water balance indicates that at the end of March, there is still 13,679 m³ of leachate stored in the leachate ponds. Consequently, there is a need for significantly increased leachate removal from the system in order for the water balance to result in the leachate ponds being empty at the beginning of April each year.

Without any enhanced evaporation or water cart utilisation, the current leachate ponds are insufficient to manage all leachate generation over an annual cycle.

With there being 13,679 m³ of excess leachate at the end of the annual cycle (March), there is still approximately 7,320 m³ or 35% of available operational storage within the ponds; hence, there is no environmental risk of pond overflow. However, there will then be insufficient available operational pond storage for the following annual cycle; hence, an urgent need to implement additional leachate reduction solutions.

### 6.3.1. Average Year with enhanced evaporation and water cart usage

Enhanced evaporation refers to the additional water loss that occurs when sprinklers or misters disperse water into the air, increasing its exposure to heat, and airflow. Spraying produces fine droplets with a high surface-area-to-volume ratio, which evaporate more rapidly as they travel through the air. This process increases the effective evaporative surface and results in greater overall evaporation. In modelling, this effect is represented as a percentage of monthly evaporation to account for the elevated losses associated with spray application.

The spray/sprinkler evaporation loss was estimated empirically using the Frost and Schwalen nomograph, as reproduced and interpreted by Zazueta (2018), based on the Site average conditions for relative humidity, air temperature, and wind speed. While actual losses will vary throughout the year depending on these factors, as well as system-specific parameters such as nozzle size and spray pressure, typical values are in the range of 4 - 5%. For the purposes of this assessment, enhanced evaporation has been calculated as 4% of the monthly evaporation to represent the increased evaporation associated with using spray systems.

Water cart utilisation is based on the use of a water cart to spray leachate over the active landfill area during the dry season, which has been assessed as being from October to March. This is a conservative assessment, as there will be periods where there is no rain between April and September, where the water cart can be utilised to spray leachate over the landfill surface. The number of water cart movements (30m$^3$/load) is determined by the volume of leachate that is needed to be removed from the system annually, in order to achieve a net zero annual water balance.

**Table 17 Summary of Water Balance - Average Year (1961) With Enhanced Evaporation and Water Cart Usage**

| Month | | Volumes (m$^3$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Total Monthly Landfill leachate inflow | Precipitation in leachate pond/s | Enhanced Evaporation | Water Cart Utilisation | Evaporation within pond | Total monthly storage requirement (end of month) |
| YEAR 1 | January | 1,410.7 | 117.6 | 111.1 | 2,147.7 | 2,777.6 | 6,588.9 |
| | February | 1,361.4 | 135.8 | 110.5 | 2,147.7 | 2,763.0 | 3,064.8 |
| | March | 1,339.9 | 667.8 | 112.5 | 2,147.7 | 2,812.3 | ****0.0** |
| | *April | 1,299.7 | 1,243.2 | 84.2 | 0.0 | 2,104.5 | 354.2 |
| | May | 1,277.3 | 701.4 | 55.2 | 0.0 | 1,381.0 | 896.7 |
| | June | 1,336.5 | 2,423.4 | 33.6 | 0.0 | 840.0 | 3,783.0 |
| | July | 1,569.2 | 2,769.2 | 26.7 | 0.0 | 668.6 | 7,426.0 |
| | August | 1,858.8 | 1,899.8 | 27.1 | 0.0 | 677.6 | 10,479.9 |
| | September | 2,262.4 | 795.2 | 32.3 | 0.0 | 808.6 | 12,696.5 |
| | October | 2,723.9 | 303.8 | 45.6 | 2,147.7 | 1,139.0 | 12,391.9 |
| | November | 2,834.7 | 58.8 | 64.2 | 2,147.7 | 1,605.0 | 11,468.6 |
| | December | 2,800.5 | 312.2 | 89.9 | 2,147.7 | 2,246.7 | 10,097.0 |

* April is the first month of net water balance gain, and the model assumes that the leachate system is empty as of 1 April.

** Represents the zero water balance accumulation at the end of an annual period (leachate management system empty).

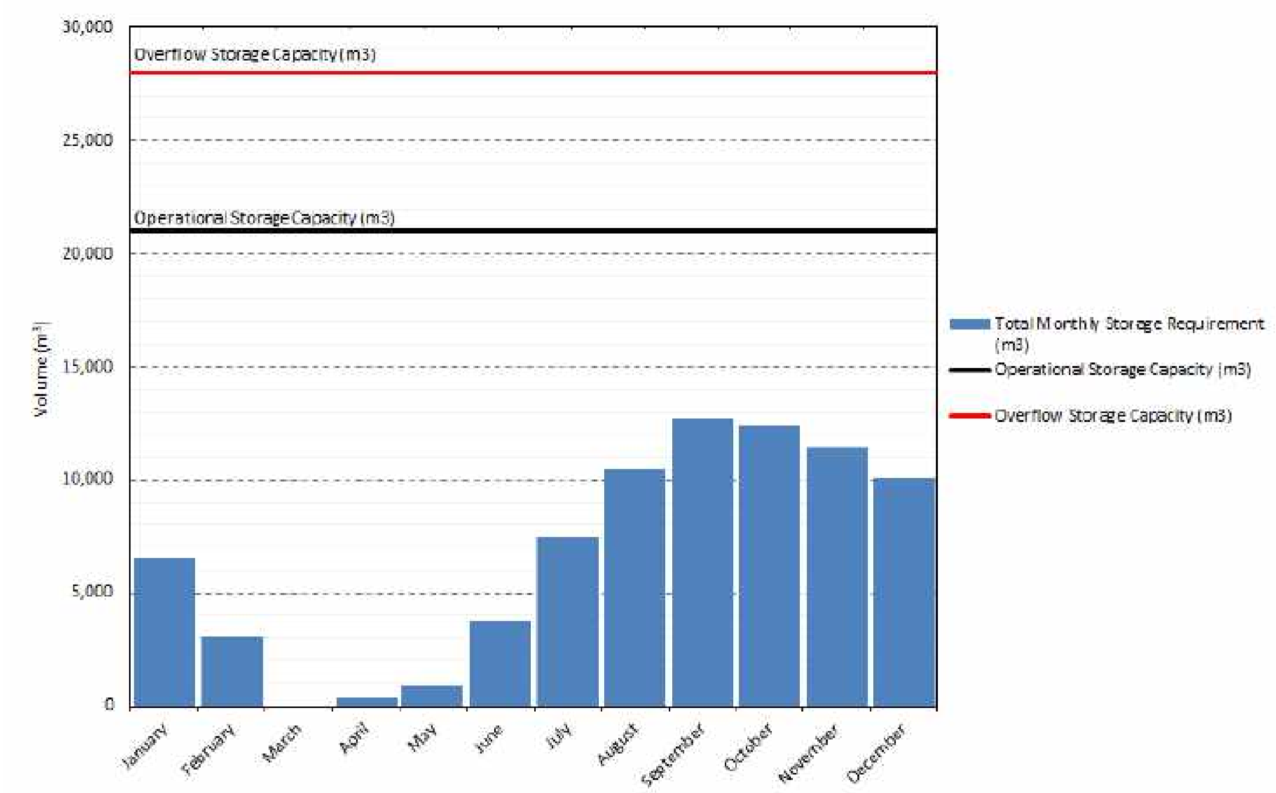


**Figure 6 Water Balance Volumes – Average Year (1961) With Enhanced Evaporation and Water Cart Usage**

As can be seen from Figure 6, the addition of sprays on the leachate pond surfaces and the utilisation of the water cart results in a net zero water balance, with the ponds being empty at the beginning of April each year; hence, with enhanced evaporation and water cart utilisation, the annual cycle of leachate generation can be adequately managed.

To achieve this net zero water balance, the 30kL water cart needs to spray an average of 3.3 loads per weekday of leachate over the active landfill surface during the summer period from October to March.

At the end of the annual leachate generation cycle, the leachate ponds will all be empty; hence, this scenario is a long-term sustainable solution to average year leachate generation.

In the event that there is excess leachate generation (above average year generation), the solution is to increase the water cart utilisation to balance the additional leachate generation to ultimately get to the scenario where the ponds are all empty at the end of the dry season. There is obviously an upper limit to the extent of water cart utilisation, which will be a function of available active landfill surface area and prevailing weather conditions; hence, there is an upper limit to the sustainability of this scenario. The available additional pond storage (September approximately 8,303 $m^3$) will provide a buffer for an excessively wet year; however, there will be a need for an average rainfall year the following year and also additional water cart utilisation to get the system back to being empty at the end of the dry season.

## 6.4. Additional Leachate Ponds

The City of Rockingham is in the process of designing and obtaining environmental approval for an additional three leachate ponds. The intention is to develop one or two of these ponds over the next few years to add additional capacity to the current leachate management system and once the Western Landfill is reshaped and comprehensively capped, the existing four leachate ponds will need to be replaced (as they are located on the top of the Western Landfill). These two new ponds will then be the replacement ponds. The third new leachate pond is a contingency pond that can be constructed if there is a need for additional leachate management capacity.

A summary of the three new leachate pond areas and storage volumes are summarised in Table 18 and Table 19.

Table 18: Summary of new leachate pond areas

| Pond | Operational Area ($m^2$) | Maximum Overflow Area ($m^2$) |
|---|---|---|
| Pond A | 7,281 | 7,628 |
| Pond B | 6,458 | 6,783 |
| Pond C | 5,308 | 5,604 |

Table 19: Summary of new leachate ponds storage volumes

| Pond | Operational Storage Volume ($m^3$) | Maximum Overflow Storage Volume ($m^3$) |
|---|---|---|
| Pond A | 12,155 | 15,882 |
| Pond B | 10,904 | 14,214 |
| Pond C | 9,156 | 11,884 |

The existing four leachate ponds have a total area of 14,000 $m^2$ and a total volume of 21,000 $m^3$. The first two new ponds will provide a total operational surface area of 13,739 $m^2$ and an operational volume of 23,059 $m^3$, which is similar in area but larger in volume than the current four leachate pond arrangement. Based on this, the two new ponds will provide more leachate management capacity than is currently available on site and hence, in future, will be able to replace the four leachate ponds that will be removed when the Western Landfill is redeveloped. The third new pond will be available as contingency and can be constructed in a relatively short time if required.

Ultimately, once the Western Landfill is redeveloped, there will be significantly less leachate being generated from this location; hence, in time, there may not be a need for both of the new leachate ponds.

Should the City construct the first new leachate pond, while the existing ponds are still available, this added leachate management capacity will result in an additional 6,933 $m^3$ of leachate being removed from the system annually, this will reduce the need to run the water cart from 3.3 loads per weekday down to 2.2 loads per weekday. Should the second new leachate pond be developed, this will decrease to 1.1 loads per weekday.

# 7. Recommendation

1) Ignore the two consecutive 90th percentile leachate generation scenario, as this is seen as an extremely unrealistic weather event, and the solutions involved in catering for this extreme event are multiple times greater than the current leachate management solutions.
2) Based on the current available leachate pond capacities, surface sprays and water cart utilisation is to be implemented to adequately manage the average weather year leachate generation.
3) To ensure that the leachate ponds are empty at the end of the annual cycle (end of dry season), the liquid depth of each leachate pond needs to be monitored, at least monthly, to confirm that the pond depths are dropping adequately each month during the dry season (e.g. halfway through the dry season, the ponds should be half empty in comparison to pond levels at the end of the wet season).
4) In the event of unseasonal wet conditions, the available excess storage in the leachate ponds can be used as a buffer to store accumulated leachate, with extra effort put in during the subsequent drier periods to reduce the accumulated leachate volumes to zero as soon as possible.
5) Leachate sumps should be maintained at the lowest level as possible, with the leachate ponds being used to store all accumulated leachate. Only in extreme events, when the leachate ponds are unable to receive any more leachate, should leachate be accumulated in the landfill sumps.
6) If the Western Landfill is to be refilled and capped, all existing leachate ponds will be progressively removed; hence, as a minimum, the City needs to construct two of the proposed new leachate ponds prior to removal of the existing leachate ponds. The sooner the new ponds are constructed, the greater the ability to manage leachate on site and potentially get ahead of the leachate generation, resulting in a completely empty leachate system at the end of the dry season, with minimal, if any water cart utilisation and an ability to easily manage unseasonal wet weather patterns.
7) The Construction of the third new leachate pond should be delayed and only constructed if actual leachate generation is greater than the leachate management system can cater for.
8) The leachate modelling and water balances are hypothetical assessments based on industry and site based best available information. The actual site leachate generation and leachate management will determine the net effect of the annual leachate accumulation, which will be variable, based on annual weather patterns, the stage of landfilling and the way that the City operates the leachate management system. To gauge the success/capacity of the leachate management system, it is essential that the City monitor the leachate generation in all of the landfill sumps, the performance of the leachate ponds and water cart utilisation. This actual site monitoring data can then be occasionally compared to the hypothetical modelling and water balance data to develop a more accurate forecast for future site leachate generation and hence future leachate management infrastructure requirements (if any).

## 8. References

Frost, K. R., & Schwalen, H. C. (1960). Evapotranspiration during sprinkler irrigation. Transactions of the ASAE, 3(1), 18–20. https://doi.org/10.13031/2013.41072

ASABE Technical Information Library

Zazueta, F. S. (2018). Evaporation loss during sprinkler irrigation (BUL 290). University of Florida, Institute of Food and Agricultural Sciences Extension. https://edis.ifas.ufl.edu/publication/AE048

edis.ifas.ufl.edu

# Appendices

# Appendix A

Water Balance Assessment

# Millar Road Average Rainfall (Year 1) 1967

**Back-to-back Wet Years**

| Water Balance Model Inputs | % Coverage | Area | |
|---|---|---|---|
| | | | |
| Initial leachate volume in leachate pond (rollover from end of April) | 0% | - | $m^2$ |
| Leachate Pond Catchment | N/A | 14,000 | $m^2$ |
| Leachate Pond Evaporation Area | N/A | 14,000 | $m^2$ |
| Enhanced evaporation (misters & sprinklers) | N/A | | percent |
| Water cart vol | N/A | 30 | $m^3$ |
| Daily water cart utilisation | N/A | - | no |

| OUTPUTS | | |
|---|---|---|
| Max Leachate Generation | 9,311 | KL/month |
| Average Leachate Generation Rate | 4,638 | KL/month |
| Total Yearly Leachate Generation | 55,659 | KL/year |

| POND CAPACITY | 28,000 | $m^3$ |
|---|---|---|

| Parameter | Unit | January | February | March | April | May | June | July | August | September | October | November | December | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Precipitation (mm)** | | | | | | | | | | | | | | |
| Rainfall | mm | 4.7 | 9.7 | 7.7 | 54.6 | 215.4 | 300.8 | 206.1 | 111.3 | 19.2 | 36.2 | 16.3 | 29.2 | 1,011.2 |
| Pan Evaporation (from SILO) | mm | 248.0 | 246.7 | 251.1 | 187.9 | 123.3 | 75.0 | 59.7 | 60.5 | 72.2 | 101.7 | 143.3 | 200.6 | 1,770.0 |
| 80% Pan Evaporation (from SILO) | mm | 198.4 | 197.4 | 200.9 | 150.3 | 98.6 | 60.0 | 47.8 | 48.4 | 57.8 | 81.4 | 114.6 | 160.5 | 1,416.0 |
| **Leachate Generation** | | | | | | | | | | | | | | |
| Western Landfill | $m^3$ | 2,972.6 | 2,898.4 | 2,822.2 | 2,740.7 | 2,556.5 | 2,671.5 | 3,402.7 | 4,998.6 | 5,676.9 | 5,685.8 | 5,605.3 | 5,503.7 | 47,535.0 |
| Eastern Landfill | $m^3$ | - | - | - | - | - | - | 3,278.8 | 4,312.8 | 532.8 | - | - | - | 8,124.4 |
| **Total Leachate Contribution** | $m^3$/month | **2,972.6** | **2,898.4** | **2,822.2** | **2,740.7** | **2,556.5** | **2,671.5** | **6,681.5** | **9,311.4** | **6,209.7** | **5,685.8** | **5,605.3** | **5,503.7** | **55,659.4** |
| **Leachate Storage** | | | | | | | | | | | | | | |
| **Leachate inflow from landfill** | (m3) | 2,972.6 | 2,898.4 | 2,822.2 | 2,740.7 | 2,556.5 | 2,671.5 | 6,681.5 | 9,311.4 | 6,209.7 | 5,685.8 | 5,605.3 | 5,503.7 | |
| **Precipitation in leachate pond/s** | (m3) | 65.8 | 135.8 | 107.8 | 764.4 | 3,015.6 | 4,211.2 | 2,885.4 | 1,558.2 | 268.8 | 506.8 | 228.2 | 408.8 | |
| **Enhanced evaporation** | (m3) | | | | | | | | | | | | | |
| **Water cart utilisation** | (m3) | - | - | - | - | - | - | - | - | - | - | - | - | |
| **Evaporation within pond** | (m3) | 2,777.6 | 2,763.0 | 2,812.3 | 2,104.5 | 1,381.0 | 840.0 | 668.6 | 677.6 | 808.6 | 1,139.0 | 1,605.0 | 2,246.7 | |
| **Net inflow (negative = outflow)** | (m3) | 260.8 | 271.2 | 117.7 | 1,400.6 | 4,191.2 | 6,042.7 | 8,898.3 | 10,192.0 | 5,669.9 | 5,053.6 | 4,228.6 | 3,665.8 | |
| **CUMULATIVE REQUIRED STORAGE** | (m3) | **260.8** | **532.0** | **649.7** | **2,050.3** | **6,241.5** | **12,284.2** | **21,182.5** | **31,374.5** | **37,044.3** | **42,097.9** | **46,326.5** | **49,992.2** | |
| **SUFFICIENT CAPACITY WITHIN POND?** | | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **NO** | **NO** | **NO** | **NO** | **NO** | |

# Millar Road Average Rainfall (Year 2) 1981

**Back-to-back Wet Years**

| Water Balance Model Inputs | % Coverage | Area | |
|---|---|---|---|
| | | | |
| Initial leachate volume in leachate pond (rollover from end of April) | 0% | - | $m^2$ |
| Leachate Pond Catchment | N/A | 14,000 | $m^2$ |
| Leachate Pond Evaporation Area | N/A | 14,000 | $m^2$ |
| Enhanced evaporation (misters & sprinklers) | N/A | | percent |
| Water cart vol | N/A | 30 | $m^3$ |
| Daily water cart utilisation | N/A | - | no |

| OUTPUTS | | |
|---|---|---|
| Max Leachate Generation | 13,109 | KL/month |
| Average Leachate Generation Rate | 7,515 | KL/month |
| Total Yearly Leachate Generation | 90,181 | KL/year |

| POND CAPACITY | 28,000 | $m^3$ |
|---|---|---|

| Parameter | Unit | January | February | March | April | May | June | July | August | September | October | November | December | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Precipitation (mm)** | | | | | | | | | | | | | | |
| Rainfall | mm | - | 18.4 | 9.6 | 44.4 | 193.8 | 172.8 | 199.4 | 176.0 | 104.2 | 22.8 | 60.6 | 8.8 | 1,010.8 |
| Pan Evaporation (from SILO) | mm | 248.0 | 254.7 | 250.2 | 136.6 | 110.8 | 57.8 | 59.4 | 98.5 | 131.0 | 177.9 | 213.1 | 277.7 | 2,015.7 |
| 80% Pan Evaporation (from SILO) | mm | 198.4 | 203.8 | 200.2 | 109.3 | 88.6 | 46.2 | 47.5 | 78.8 | 104.8 | 142.3 | 170.5 | 222.2 | 1,612.6 |
| **Leachate Generation** | | | | | | | | | | | | | | |
| Western Landfill | $m^3$ | 5,395.0 | 5,288.1 | 5,177.2 | 5,065.6 | 4,888.4 | 4,863.9 | 5,835.3 | 5,881.1 | 7,698.0 | 7,691.4 | 7,590.7 | 7,470.2 | 72,844.9 |
| Eastern Landfill | $m^3$ | - | - | - | - | 162.4 | 6,371.2 | 2,231.6 | 7,228.0 | 1,343.2 | - | - | - | 17,336.4 |
| **Total Leachate Contribution** | $m^3$/month | **5,395.0** | **5,288.1** | **5,177.2** | **5,065.6** | **5,050.8** | **11,235.1** | **8,066.9** | **13,109.1** | **9,041.2** | **7,691.4** | **7,590.7** | **7,470.2** | **90,181.3** |
| **Leachate Storage** | | | | | | | | | | | | | | |
| **Leachate inflow from landfill** | ($m^3$) | 5,395.0 | 5,288.1 | 5,177.2 | 5,065.6 | 5,050.8 | 11,235.1 | 8,066.9 | 13,109.1 | 9,041.2 | 7,691.4 | 7,590.7 | 7,470.2 | |
| **Precipitation in leachate pond/s** | ($m^3$) | - | 257.6 | 134.4 | 621.6 | 2,713.2 | 2,419.2 | 2,791.6 | 2,464.0 | 1,458.8 | 319.2 | 848.4 | 123.2 | |
| **Enhanced evaporation** | ($m^3$) | | | | | | | | | | | | | |
| **Water cart utilisation** | ($m^3$) | - | - | - | - | - | - | - | - | - | - | - | - | |
| **Evaporation within pond** | ($m^3$) | 2,777.6 | 2,852.6 | 2,802.2 | 1,529.9 | 1,241.0 | 647.4 | 665.3 | 1,103.2 | 1,467.2 | 1,992.5 | 2,386.7 | 3,110.2 | |
| **Net inflow (negative = outflow)** | ($m^3$) | 2,617.4 | 2,693.0 | 2,509.4 | 4,157.2 | 6,523.1 | 13,006.9 | 10,193.2 | 14,469.9 | 9,032.8 | 6,018.1 | 6,052.4 | 4,483.2 | |
| **CUMULATIVE REQUIRED STORAGE** | ($m^3$) | **52,609.6** | **55,302.6** | **57,812.0** | **61,969.2** | **68,492.3** | **81,499.3** | **91,692.5** | **106,162.4** | **115,195.2** | **121,213.3** | **127,265.7** | **131,748.9** | |
| **SUFFICIENT CAPACITY WITHIN POND?** | | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | |

# Millar Road Average Rainfall (Year 1) 1961

**Average Year without enhanced evaporation or water cart usage**

| Water Balance Model Inputs | % Coverage | Area | |
|---|---|---|---|
| | | | |
| Initial leachate volume in leachate pond (rollover from end of April) | 0% | - | $m^2$ |
| Leachate Pond Catchment | N/A | 14,000 | $m^2$ |
| Leachate Pond Evaporation Area | N/A | 14,000 | $m^2$ |
| Enhanced evaporation (misters & sprinklers) | N/A | | percent |
| Water cart vol | N/A | 30 | $m^3$ |
| Daily water cart utilisation | N/A | - | no |

| OUTPUTS | | |
|---|---|---|
| Max Leachate Generation | 2,835 | KL/month |
| Average Leachate Generation Rate | 1,840 | KL/month |
| Total Yearly Leachate Generation | 22,075 | KL/year |

| POND CAPACITY | | |
|---|---|---|
| | 28,000 | $m^3$ |

| Parameter | Unit | January | February | March | April | May | June | July | August | September | October | November | December | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Precipitation (mm)** | | | | | | | | | | | | | | |
| Rainfall | mm | 8.4 | 9.7 | 47.7 | 88.8 | 50.1 | 173.1 | 197.8 | 135.7 | 56.8 | 21.7 | 4.2 | 22.3 | 816.3 |
| Pan Evaporation (from SILO) | mm | 248.0 | 246.7 | 251.1 | 187.9 | 123.3 | 75.0 | 59.7 | 60.5 | 72.2 | 101.7 | 143.3 | 200.6 | 1,770.0 |
| 80% Pan Evaporation (from SILO) | mm | 198.4 | 197.4 | 200.9 | 150.3 | 98.6 | 60.0 | 47.8 | 48.4 | 57.8 | 81.4 | 114.6 | 160.5 | 1,416.0 |
| **Leachate Generation** | | | | | | | | | | | | | | |
| Western Landfill | $m^3$ | 1,410.7 | 1,361.4 | 1,339.9 | 1,299.7 | 1,277.3 | 1,336.5 | 1,569.2 | 1,858.8 | 2,262.4 | 2,723.9 | 2,834.7 | 2,800.5 | 22,075.0 |
| Eastern Landfill | m3 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total Leachate Contribution** | $m^3$/month | **1,410.7** | **1,361.4** | **1,339.9** | **1,299.7** | **1,277.3** | **1,336.5** | **1,569.2** | **1,858.8** | **2,262.4** | **2,723.9** | **2,834.7** | **2,800.5** | **22,075.0** |
| **Leachate Storage** | | | | | | | | | | | | | | |
| **Leachate inflow from landfill** | (m3) | 1,410.7 | 1,361.4 | 1,339.9 | 1,299.7 | 1,277.3 | 1,336.5 | 1,569.2 | 1,858.8 | 2,262.4 | 2,723.9 | 2,834.7 | 2,800.5 | |
| **Precipitation in leachate pond/s** | (m3) | 117.6 | 135.8 | 667.8 | 1,243.2 | 701.4 | 2,423.4 | 2,769.2 | 1,899.8 | 795.2 | 303.8 | 58.8 | 312.2 | |
| **Enhanced evaporation** | (m3) | - | - | - | - | - | - | - | - | - | - | - | - | |
| **Water cart utilisation** | (m3) | - | - | - | - | - | - | - | - | - | - | - | - | |
| **Evaporation within pond** | (m3) | 2,777.6 | 2,763.0 | 2,812.3 | 2,104.5 | 1,381.0 | 840.0 | 668.6 | 677.6 | 808.6 | 1,139.0 | 1,605.0 | 2,246.7 | |
| **Net inflow (negative = outflow)** | (m3) | - 1,249.3 | - 1,265.8 | - 804.6 | 438.4 | 597.7 | 2,919.9 | 3,669.7 | 3,081.0 | 2,249.0 | 1,888.7 | 1,288.6 | 865.9 | |
| **CUMULATIVE REQUIRED STORAGE** | (m3) | **15,749.6** | **14,483.8** | **13,679.2** | **438.4** | **1,036.1** | **3,956.0** | **7,625.8** | **10,706.8** | **12,955.7** | **14,844.4** | **16,133.0** | **16,998.9** | |
| **SUFFICIENT CAPACITY WITHIN POND?** | | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | |

# Millar Road Average Rainfall (Year 1) 1961

**Average Year with enhanced evaporation and water cart usage**

| Water Balance Model Inputs | % Coverage | Area | |
|---|---|---|---|
| | | | |
| Initial leachate volume in leachate pond (rollover from end of April) | 0% | - | $m^2$ |
| Leachate Pond Catchment | N/A | 14,000 | $m^2$ |
| Leachate Pond Evaporation Area | N/A | 14,000 | $m^2$ |
| Enhanced evaporation (misters & sprinklers) | N/A | 4% | percent |
| Water cart vol | N/A | 30 | $m^3$ |
| Daily water cart utilisation | N/A | 3.3 | no |

| OUTPUTS | | |
|---|---|---|
| Max Leachate Generation | 2,835 | KL/month |
| Average Leachate Generation Rate | 1,840 | KL/month |
| Total Yearly Leachate Generation | 22,075 | KL/year |

| POND CAPACITY | 28,000 | $m^3$ |
|---|---|---|

| Parameter | Unit | January | February | March | April | May | June | July | August | September | October | November | December | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Precipitation (mm)** | | | | | | | | | | | | | | |
| Rainfall | mm | 8.4 | 9.7 | 47.7 | 88.8 | 50.1 | 173.1 | 197.8 | 135.7 | 56.8 | 21.7 | 4.2 | 22.3 | 816.3 |
| Pan Evaporation (from SILO) | mm | 248.0 | 246.7 | 251.1 | 187.9 | 123.3 | 75.0 | 59.7 | 60.5 | 72.2 | 101.7 | 143.3 | 200.6 | 1,770.0 |
| 80% Pan Evaporation (from SILO) | mm | 198.4 | 197.4 | 200.9 | 150.3 | 98.6 | 60.0 | 47.8 | 48.4 | 57.8 | 81.4 | 114.6 | 160.5 | 1,416.0 |
| **Leachate Generation** | | | | | | | | | | | | | | |
| Western Landfill | $m^3$ | 1,410.7 | 1,361.4 | 1,339.9 | 1,299.7 | 1,277.3 | 1,336.5 | 1,569.2 | 1,858.8 | 2,262.4 | 2,723.9 | 2,834.7 | 2,800.5 | 22,075.0 |
| Eastern Landfill | m3 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total Leachate Contribution** | $m^3$/month | **1,410.7** | **1,361.4** | **1,339.9** | **1,299.7** | **1,277.3** | **1,336.5** | **1,569.2** | **1,858.8** | **2,262.4** | **2,723.9** | **2,834.7** | **2,800.5** | **22,075.0** |
| **Leachate Storage** | | | | | | | | | | | | | | |
| **Leachate inflow from landfill** | (m3) | 1,410.7 | 1,361.4 | 1,339.9 | 1,299.7 | 1,277.3 | 1,336.5 | 1,569.2 | 1,858.8 | 2,262.4 | 2,723.9 | 2,834.7 | 2,800.5 | |
| **Precipitation in leachate pond/s** | (m3) | 117.6 | 135.8 | 667.8 | 1,243.2 | 701.4 | 2,423.4 | 2,769.2 | 1,899.8 | 795.2 | 303.8 | 58.8 | 312.2 | |
| **Enhanced evaporation** | (m3) | 111.1 | 110.5 | 112.5 | 84.2 | 55.2 | 33.6 | 26.7 | 27.1 | 32.3 | 45.6 | 64.2 | 89.9 | |
| **Water cart utilisation** | (m3) | 2,147.7 | 2,147.7 | 2,147.7 | - | - | - | - | - | - | 2,147.7 | 2,147.7 | 2,147.7 | |
| **Evaporation within pond** | (m3) | 2,777.6 | 2,763.0 | 2,812.3 | 2,104.5 | 1,381.0 | 840.0 | 668.6 | 677.6 | 808.6 | 1,139.0 | 1,605.0 | 2,246.7 | |
| **Net inflow (negative = outflow)** | (m3) | - 3,508.1 | - 3,524.0 | - 3,064.8 | 354.2 | 542.5 | 2,886.3 | 3,643.0 | 3,053.9 | 2,216.6 | - 304.6 | - 923.3 | - 1,371.6 | |
| **CUMULATIVE REQUIRED STORAGE** | (m3) | **6,588.9** | **3,064.8** | **0.0** | **354.2** | **896.7** | **3,783.0** | **7,426.0** | **10,479.9** | **12,696.5** | **12,391.9** | **11,468.6** | **10,097.0** | |
| **SUFFICIENT CAPACITY WITHIN POND?** | | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | |

# Millar Road Average Rainfall (Year 1) 1961

**Average Year with enhanced evaporation and water cart usage + Pond 1**

| Water Balance Model Inputs | % Coverage | Area | |
|---|---|---|---|
| | | | |
| Initial leachate volume in leachate pond (rollover from end of April) | 0% | - | $m^2$ |
| Leachate Pond Catchment | N/A | 21,628 | $m^2$ |
| Leachate Pond Evaporation Area | N/A | 21,281 | $m^2$ |
| Enhanced evaporation (misters & sprinklers) | N/A | 4% | percent |
| Water cart vol | N/A | 30 | $m^3$ |
| Daily water cart utilisation | N/A | 2.2 | no |

| OUTPUTS | | |
|---|---|---|
| Max Leachate Generation | 2,835 | KL/month |
| Average Leachate Generation Rate | 1,840 | KL/month |
| Total Yearly Leachate Generation | 22,075 | KL/year |

| POND CAPACITY | 40,155 | $m^3$ |
|---|---|---|

| Parameter | Unit | January | February | March | April | May | June | July | August | September | October | November | December | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Precipitation (mm)** | | | | | | | | | | | | | | |
| Rainfall | mm | 8.4 | 9.7 | 47.7 | 88.8 | 50.1 | 173.1 | 197.8 | 135.7 | 56.8 | 21.7 | 4.2 | 22.3 | 816.3 |
| Pan Evaporation (from SILO) | mm | 248.0 | 246.7 | 251.1 | 187.9 | 123.3 | 75.0 | 59.7 | 60.5 | 72.2 | 101.7 | 143.3 | 200.6 | 1,770.0 |
| 80% Pan Evaporation (from SILO) | mm | 198.4 | 197.4 | 200.9 | 150.3 | 98.6 | 60.0 | 47.8 | 48.4 | 57.8 | 81.4 | 114.6 | 160.5 | 1,416.0 |
| **Leachate Generation** | | | | | | | | | | | | | | |
| Western Landfill | $m^3$ | 1,410.7 | 1,361.4 | 1,339.9 | 1,299.7 | 1,277.3 | 1,336.5 | 1,569.2 | 1,858.8 | 2,262.4 | 2,723.9 | 2,834.7 | 2,800.5 | 22,075.0 |
| Eastern Landfill | m3 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total Leachate Contribution** | $m^3$/month | **1,410.7** | **1,361.4** | **1,339.9** | **1,299.7** | **1,277.3** | **1,336.5** | **1,569.2** | **1,858.8** | **2,262.4** | **2,723.9** | **2,834.7** | **2,800.5** | **22,075.0** |
| **Leachate Storage** | | | | | | | | | | | | | | |
| **Leachate inflow from landfill** | (m3) | 1,410.7 | 1,361.4 | 1,339.9 | 1,299.7 | 1,277.3 | 1,336.5 | 1,569.2 | 1,858.8 | 2,262.4 | 2,723.9 | 2,834.7 | 2,800.5 | |
| **Precipitation in leachate pond/s** | (m3) | 181.7 | 209.8 | 1,031.7 | 1,920.6 | 1,083.6 | 3,743.8 | 4,278.0 | 2,934.9 | 1,228.5 | 469.3 | 90.8 | 482.3 | |
| **Enhanced evaporation** | (m3) | 168.9 | 168.0 | 171.0 | 128.0 | 84.0 | 51.1 | 40.7 | 41.2 | 49.2 | 69.3 | 97.6 | 136.6 | |
| **Water cart utilisation** | (m3) | 1,398.4 | 1,398.4 | 1,398.4 | - | - | - | - | - | - | 1,398.4 | 1,398.4 | 1,398.4 | |
| **Evaporation within pond** | (m3) | 4,222.2 | 4,200.0 | 4,274.9 | 3,199.0 | 2,099.2 | 1,276.9 | 1,016.4 | 1,030.0 | 1,229.2 | 1,731.4 | 2,439.7 | 3,415.2 | |
| **Net inflow (negative = outflow)** | (m3) | - 4,197.1 | - 4,195.2 | - 3,472.8 | - 106.6 | 177.7 | 3,752.4 | 4,790.2 | 3,722.5 | 2,212.5 | - 5.9 | - 1,010.1 | - 1,667.5 | |
| **CUMULATIVE REQUIRED STORAGE** | (m3) | **7,774.7** | **3,579.5** | **106.6** | **-** | **177.7** | **3,930.1** | **8,720.2** | **12,442.7** | **14,655.3** | **14,649.4** | **13,639.3** | **11,971.8** | |
| **SUFFICIENT CAPACITY WITHIN POND?** | | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | |

# Millar Road Average Rainfall (Year 1) 1961

**Average Year with enhanced evaporation and water cart usage + Pond 1&2**

| Water Balance Model Inputs | % Coverage | Area | |
|---|---|---|---|
| | | | |
| Initial leachate volume in leachate pond (rollover from end of April) | 0% | - | $m^2$ |
| Leachate Pond Catchment | N/A | 28,411 | $m^2$ |
| Leachate Pond Evaporation Area | N/A | 27,739 | $m^2$ |
| Enhanced evaporation (misters & sprinklers) | N/A | 4% | percent |
| Water cart vol | N/A | 30 | $m^3$ |
| Daily water cart utilisation | N/A | 1.1 | no |

| OUTPUTS | | |
|---|---|---|
| Max Leachate Generation | 2,835 | KL/month |
| Average Leachate Generation Rate | 1,840 | KL/month |
| Total Yearly Leachate Generation | 22,075 | KL/year |

| POND CAPACITY | 51,059 | $m^3$ |
|---|---|---|

| Parameter | Unit | January | February | March | April | May | June | July | August | September | October | November | December | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Precipitation (mm)** | | | | | | | | | | | | | | |
| Rainfall | mm | 8.4 | 9.7 | 47.7 | 88.8 | 50.1 | 173.1 | 197.8 | 135.7 | 56.8 | 21.7 | 4.2 | 22.3 | 816.3 |
| Pan Evaporation (from SILO) | mm | 248.0 | 246.7 | 251.1 | 187.9 | 123.3 | 75.0 | 59.7 | 60.5 | 72.2 | 101.7 | 143.3 | 200.6 | 1,770.0 |
| 80% Pan Evaporation (from SILO) | mm | 198.4 | 197.4 | 200.9 | 150.3 | 98.6 | 60.0 | 47.8 | 48.4 | 57.8 | 81.4 | 114.6 | 160.5 | 1,416.0 |
| **Leachate Generation** | | | | | | | | | | | | | | |
| Western Landfill | $m^3$ | 1,410.7 | 1,361.4 | 1,339.9 | 1,299.7 | 1,277.3 | 1,336.5 | 1,569.2 | 1,858.8 | 2,262.4 | 2,723.9 | 2,834.7 | 2,800.5 | 22,075.0 |
| Eastern Landfill | m3 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total Leachate Contribution** | $m^3$/month | **1,410.7** | **1,361.4** | **1,339.9** | **1,299.7** | **1,277.3** | **1,336.5** | **1,569.2** | **1,858.8** | **2,262.4** | **2,723.9** | **2,834.7** | **2,800.5** | **22,075.0** |
| **Leachate Storage** | | | | | | | | | | | | | | |
| **Leachate inflow from landfill** | (m3) | 1,410.7 | 1,361.4 | 1,339.9 | 1,299.7 | 1,277.3 | 1,336.5 | 1,569.2 | 1,858.8 | 2,262.4 | 2,723.9 | 2,834.7 | 2,800.5 | |
| **Precipitation in leachate pond/s** | (m3) | 238.7 | 275.6 | 1,355.2 | 2,522.9 | 1,423.4 | 4,917.9 | 5,619.7 | 3,855.4 | 1,613.7 | 616.5 | 119.3 | 633.6 | |
| **Enhanced evaporation** | (m3) | 220.1 | 219.0 | 222.9 | 166.8 | 109.4 | 66.6 | 53.0 | 53.7 | 64.1 | 90.3 | 127.2 | 178.1 | |
| **Water cart utilisation** | (m3) | 736.2 | 736.2 | 736.2 | - | - | - | - | - | - | 736.2 | 736.2 | 736.2 | |
| **Evaporation within pond** | (m3) | 5,503.4 | 5,474.6 | 5,572.2 | 4,169.7 | 2,736.2 | 1,664.3 | 1,324.8 | 1,342.6 | 1,602.2 | 2,256.8 | 3,180.0 | 4,451.6 | |
| **Net inflow (negative = outflow)** | (m3) | - 4,810.4 | - 4,792.8 | - 3,836.2 | - 513.9 | - 145.0 | 4,523.5 | 5,811.1 | 4,317.9 | 2,209.9 | 257.1 | - 1,089.4 | - 1,931.8 | |
| **CUMULATIVE REQUIRED STORAGE** | (m3) | **9,142.9** | **4,350.1** | **513.9** | **-** | **- 145.0** | **4,378.6** | **10,189.6** | **14,507.5** | **16,717.4** | **16,974.5** | **15,885.1** | **13,953.3** | |
| **SUFFICIENT CAPACITY WITHIN POND?** | | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | **YES** | |