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Documentation Review and Advice
Groundwater Status at Closed Daylesford Landfill
16 Ajax Road, Daylesford, VIC 3460

Australian Environmental Auditors Pty Ltd (AEA) was engaged by Hepburn Shire Council (HSC) on 19 November 2024 to undertake a documentation review to provide advice on the current groundwater conditions at the closed Daylesford Landfill (site) and assess how these conditions may impact the surrounding groundwater quality and advice relating to any other risks the site may pose to the nearby Daylesford area. The conclusions regarding the data review are provided as well as the recommendations, addressing key aspects of HSC's General Environmental Duty (GED) under the Act, with a particular focus on the potential effects on receiving properties.

The following documents were provided to AEA for review:

- *Thiess Pty Ltd, Daylesford Landfill Sampling, Hepburn Shire Council, November 2013.*
- *Thiess Pty Ltd, Daylesford Landfill Sampling, Hepburn Shire Council, February 2014.*
- *Thiess Pty Ltd, Daylesford Landfill Sampling, Hepburn Shire Council, May 2014.*
- *Thiess Pty Ltd, Daylesford Landfill Sampling, Hepburn Shire Council, August 2014.*
- *Ventia Utility Services Pty LTD, Daylesford Landfill Sampling, Hepburn Shire Council, July 2018.*
- *Nation Partners Pty Ltd, Hepburn Shire Council Separation Distances Assessment – Daylesford Former Landfill and Current Waste Transfer Station, 23 December 2022.*
- *Ventia Utility Services Pty LTD, August 2024 Monitoring Event report – Daylesford Landfill, Hepburn Shire Council, 02 September 2024.*

Based on the information reviewed, groundwater data highlights temporal and spatial variations in geochemical conditions, reflecting potential environmental risks. However, limitations such as inconsistent groundwater analysis, an incomplete monitoring network, and insufficient historical data constrain trend analysis. Additionally, uncertainties related to groundwater flow direction, the unlined nature of the landfill, and the absence of upgradient, and downgradient monitoring wells emphasize the need for further investigation and improved monitoring to better characterise site conditions and understanding of associated risks.

Introduction and Background

The site is located at 16 Ajax Road, Daylesford VIC 3460, with an approximate area of 5.6 hectares (ha), zoned as Public Use Zone (PUZ6) and surrounded by Sailors Creek approximately 100 m to the west, the Tipperary Springs Picnic Area approximately 770 m to the southwest, a residential property approximately 70 m to the east, the Boomerang Holiday Ranch directly to the west, and an Area of Aboriginal Cultural Heritage Sensitivity approximately 180 m to the west.

The site was used for a landfilling until its closure in 2004, during which time it was licensed to accept a variety of waste types, including municipal solid waste, and was classified as a Type 2 landfill for putrescible waste. The surface of the site has since been repurposed as a transfer station.

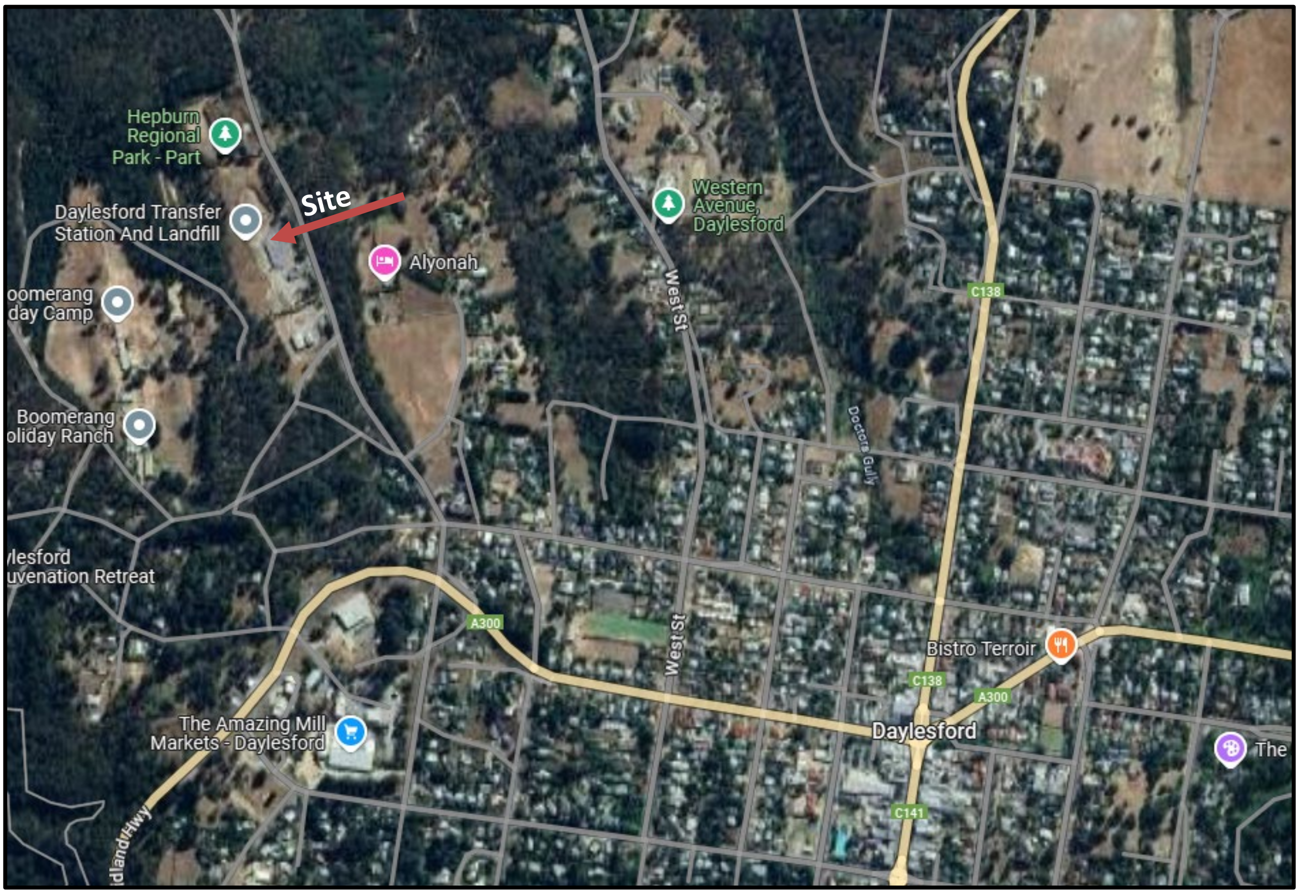

Figure 1: Site Location
(Source: Google)

A comprehensive review of the documentation provided by the HSC was undertaken to assess the groundwater conditions at the site. The review focused on evaluating whether groundwater in wells at the site poses any potential impacts on the surrounding environment. The documentation was also reviewed to pinpoint any data gaps and assess the potential risks linked to the site. This process aimed to understand the possible migration of groundwater contamination from the site to offsite areas and its implications for nearby sensitive receptors. The findings of this review are intended to inform recommendations for the future management of the site, ensuring compliance with the council's GED under the new Act, which mandates the prevention and management of contamination.

Legislation, Regulations and Guidelines

When conducting this documentation review, the following key pieces of legislation apply:

- Environment Protection Act 2017 (as amended by the Environment Protection Amendment Act 2018) (Victorian Government Printer) referred to as the Act.

- Environment Protection Regulations 2021, SR No. 47/2021. Victorian Government Printer.
- Environment Reference Standard (2021), Victorian Government Gazette, S245, 26 May 2021.
- Water Act 1989 (Vic.) Notice ID: 80 of 1989. Authorised Version Notice ID: 133 incorporating amendments as of 1 July 2021. (Victorian Government Printer).
- Waste Management Policy (siting, design and management of landfills). Victoria Government Gazette S264, 14 December 2004. (Victorian Government Printer).
- EPA Publication 668.1. Hydrogeological assessments (water quality) guidelines. October 2022.
- EPA Publication 669.1. Groundwater sampling guidelines. February 2022.
- EPA Publication 788.3 – Best Practise Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills. August 2015.
- EPA Publication 1323.3 – Landfilling Licensing Guidelines. September 2016.
- EPA Publication 1490.1 – Closed Landfill Guidelines. January 2018.
- EPA Publication 1671. Local Council Self-Assessment Tool for Closed Landfill Environmental Risk. February 2018.
- EPA Publication 1684 – Landfill Gas Fugitive Emissions Monitoring Guidelines. January 2018.
- EPA Publication - Landfill Buffer Guideline. August 2024

Documentation Review

The recent data indicates that the depth to groundwater beneath the closed landfill site ranges from 4.0 to 26 m below top of casing (mbTOC), with groundwater classified as Segment A2, based on Total Dissolved Solids (TDS) concentrations ranging from 601 to 1,200 mg/L (ERS, 2021). The landfill historically accepted putrescible municipal waste, and anecdotal evidence suggests the burial of car bodies on-site. The depth of landfilling is estimated to be up to 12m. The landfill was classified as a Type 2 facility for putrescible waste and was not lined; however, the leachate pond is reported to be lined. Groundwater and leachate monitoring of a leachate pond is understood to be conducted on a quarterly basis, noting that not all results were available for review; however, an aftercare management plan in accordance with the closed landfill guidelines is not currently in place for the site.

AEA understands that four groundwater monitoring wells (BH1 to BH4) have been installed across the site. Three of these wells are located along the western boundary, while the fourth well is positioned at the centre of the northeastern boundary, near the transfer station. Additionally, one lined leachate pond (LB1) has been installed on the site. The groundwater monitoring well locations and leachate pond are shown in Figure 2 below.

Figure 2: Groundwater Monitoring Well Locations

Groundwater Sampling

Groundwater data has been provided for the site, including sampling events conducted in November 2013, February, May and August 2014, July 2018, and August 2024. These samples were collected to assess the groundwater conditions at the site and to identify any discernible trends that may be relevant for discussion.

However, it is important to note that while all wells were sampled during each event, certain analytes were not included in some groundwater monitoring events. This inconsistency hinders a comprehensive understanding of the site's groundwater conditions. Additionally, certain metals, including manganese and iron, which are among typical landfill leachate markers were only analysed in the final sampling round (August 2024), with no prior data available for comparison.

The selection of analytes in the final sampling round is unclear, and the rationale behind the exclusion of specific analytes in this round is not evident. As a result, for some analytes, we can only rely on data available prior to 2024 for evaluation. Given these inconsistencies, the available groundwater results have been reviewed, and the following observations have been noted.

Groundwater samples were analysed for field parameters including pH, EC, temperature, DO, redox potential and turbidity. Groundwater parameters over time exhibit fluctuations in each well, which reflects the changing geochemical conditions within the aquifer. Among these parameters, redox potential trends highlight significant temporal and spatial variability, which are discussed as follows:

- **BH1, BH2 and BH3:**
  Between 2004 and 2011, redox potential in these wells was consistently negative, indicating a reducing environment. This suggests the potential for bacterial activity beneath the aquifer, which may facilitate the breakdown of contaminants. From 2011 to 2024, redox potential fluctuated between negative and positive values across various sampling events. In 2024, positive redox potentials were recorded at 52.7 mV, 43.8 mV, and 40.3 mV at BH01, BH02, and BH03, respectively, indicating a shift toward oxidising conditions. This transition corresponds with increased dissolved oxygen concentrations, as low dissolved oxygen was observed during periods of negative redox, implying oxygen consumption within the aquifer.
- **BH4:** BH4 displayed a distinct pattern in redox potential over time. Redox potential was positive between 2005 and 2007, negative between 2008 and 2011, and predominantly positive from 2011 to 2018. However, in the 2018 and 2024 sampling events, the redox potential became negative again, with recorded values of -125 mV in July 2018 and -5.5 mV in August 2024. These fluctuations suggest significant variability in the geochemical environment of BH4. The positive redox values from 2005 to 2007 and 2011 to 2018 indicate an oxidising environment, which is typically associated with the presence of dissolved oxygen and aerobic processes. In contrast, the negative redox values observed between 2008 and 2011, as well as in 2018 and 2024, point to a reducing environment. This shift may suggest anaerobic processes where microbial activity facilitates the reduction of contaminants. Notably, the low -125 mV reading in 2018 suggests a strongly reducing environment, potentially linked to the breakdown of contamination. The relatively slight negative redox value in 2024 (-5.5 mV) may reflect a transitional phase between reducing and oxidising conditions, indicating changes in contamination levels or groundwater dynamics at the site.

In 2024, groundwater and leachate samples were analysed for a range of leachate indicators, including total dissolved solids (TDS), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), chloride (Cl), sulphate (SO_4), bicarbonate, total organic carbon (TOC), chemical oxygen demand (COD), ammonia (NH_3), nitrate (NO_3), total Kjeldahl nitrogen (TKN), volatile fatty acids (VFA), dissolved metals (arsenic, cadmium, copper, lead, mercury, nickel, zinc), pH, and electrical conductivity (EC). In prior years, groundwater samples were analysed for the same suite, with additional analytes such as total recoverable hydrocarbons (TRHs) and phenols. However, the inconsistent selection of analytes over time has resulted in gaps in the dataset, limiting the ability to discern trends for key parameters from 2013 to 2018.

Leachate to Natural (L/N) Ratios

Using leachate from the pond and groundwater sampling results, a leachate to natural (L/N) ratio calculation ($(K + NH_4 + NO_3) / (Mg + Ca + Na) \times 100$) was performed to assess if leachate had potentially impacted groundwater at the site by comparing the ratio between naturally occurring ions in groundwater and ions indicative of leachate. L/N ratios in all monitoring wells were found to be one to two orders of magnitude lower than in leachate. Based on the L/N ratios alone groundwater at the site does appear to be impacted by leachate, however the L/N ratio is only one indicator and assessment of multiple lines of evidence is required to understand groundwater impacts, or lack of. It should be noted that these results provide an indication of leachate characteristics but are likely not fully represent the actual leachate due to the aerobic conditions present in the leachate ponds and dilution effects from rainfall. The aerobic pond environment will alter the composition and properties of the leachate, leading to discrepancies between the pond samples and the true leachate composition.

Groundwater Quality and Exceedances

Groundwater samples indicate TDS concentrations ranging from 1,200 to 2,800 mg/L, classifying the groundwater as Segment A2. Several exceedances above water-dependent ecosystem (WDES) criteria for metals (arsenic, copper, nickel, and zinc) were recorded historically, though these metals were not analysed during the August 2024 Groundwater Monitoring Event (GME).

During the August 2024 GME, manganese concentrations exceeded irrigation and drinking water criteria in BH2, exceeded irrigation, drinking water, and WDES criteria in BH3, and exceeded all relevant criteria in BH1 and BH4. Iron concentrations also exceeded all relevant criteria across all monitoring wells during this event. However, neither manganese nor iron had been analysed during previous GMEs, limiting the ability to evaluate their historical trends or determine potential sources.

Ammonia concentrations were elevated during the 2024 GME, exceeding the drinking water criterion in BH4. Similarly, during the 2018 GME, ammonia concentrations in BH2 exceeded the drinking water criterion. Ammonia data has been collected only during the 2018 and 2024 GMEs, limiting the ability to analyse trends or understand its variability over time.

Chloride, sodium, pH, and TDS concentrations were reported above the adopted site criteria. However, these exceedances are likely attributable to natural aquifer conditions and are not considered evidence of pollution.

Groundwater Flow Direction and Monitoring Network Limitations

No survey data has been provided to confirm groundwater flow direction. Based on topography, the inferred groundwater flow direction is westward toward Blacksmith Gully Creek, with BH4 potentially up-hydraulic gradient and BH3 and BH2 down gradient of BH4. BH1 is likely cross-gradient. However, the lack of a confirmed flow direction introduces significant uncertainty.

The leachate pond is located in the western portion of the site; however, no monitoring wells have been installed downgradient to evaluate potential leachate impacts on groundwater in those areas. Additionally, the lack of a confirmed landfill boundary introduces uncertainty regarding the classification of BH4 as a background well. The absence of an upgradient monitoring well to the east of the landfill further complicates efforts to differentiate between naturally occurring metals and potential contamination resulting from landfill activities. BH4 consistently exhibits higher metal concentrations compared to other wells. If BH4 could be reliably classified as a background well, the elevated analyte concentrations might be attributed to naturally occurring background levels. Consequently, elevated metal concentrations in downgradient wells relative to BH4 could also be interpreted as representative of natural conditions. However, due to the limited information available and the undefined extent of landfilling activities, this interpretation cannot be substantiated. Therefore, the elevated concentrations in BH4 and the downgradient wells could equally indicate contamination associated with landfill activities.

Given these limitations, the current monitoring network (comprising only four wells) is insufficient to comprehensively characterise groundwater conditions across the site. The installation of additional upgradient and downgradient wells is essential to delineate background conditions and evaluate potential landfill impacts in downgradient areas.

Landfill Construction and Potential Pollution Pathways

The closed Daylesford landfill is believed to be unlined, increasing the likelihood of contaminant migration through groundwater and as landfill gas. Given the unlined nature of the landfill, it is plausible that landfill gas may be migrating to surrounding areas. A landfill gas risk assessment is recommended to evaluate this potential pathway. However, the absence of landfill gas monitoring wells precludes any meaningful assessment of potential gas migration.

Conclusions

The analysis of groundwater monitoring data has identified temporal and spatial variations in key parameters, reflecting changing geochemical conditions and potential environmental risks. However, limitations such as inconsistent testing over time, incomplete monitoring well network, and insufficient historical data constrain the ability to fully evaluate trends or identify contaminant sources. Furthermore, uncertainties remain due to the lack of confirmed groundwater flow direction, the unlined nature of the closed landfill, and the absence of upgradient and downgradient monitoring wells. These findings underscore the need for improved monitoring, additional well installations, and further investigation to address data gaps and provide a clearer understanding of the site's groundwater conditions and potential risks.

Recommendations

Based on the current data gaps, site conditions, and regulatory requirements, the following recommendations are made to address key uncertainties and ensure effective management of potential environmental risks associated with the closed Daylesford landfill site and aiding HSC in meeting the GED:

1. Establish baseline groundwater conditions and determine the natural background situation, to do this the installation of new upgradient monitoring wells is recommended.
2. Determine the groundwater flow direction at the site, through conducting a survey of the existing monitoring wells and confirm the flow direction and establish hydraulic gradients.
3. Due to the lack of groundwater wells in downgradient areas, there is insufficient information to determine potential leachate impacts on the surrounding lands. It is recommended that downgradient monitoring wells be installed to evaluate any leachate impacts in these areas.
4. Given the current lack of a dedicated leachate well in the waste area, it is recommended that a leachate monitoring well be installed. This will enable accurate monitoring and identification of leachate levels and provide a more reliable means of assessing the leachate’s composition.
5. Identify the historical extent of landfilling activities and understand the locations where waste was historically placed. Additionally, an evaluation should be conducted to determine whether the existing monitoring network has adequate well coverage to effectively assess the overall groundwater situation on-site.
6. Closed landfills generally continue to generate landfill gas many years after closure, and no landfill gas assessment has been completed. As there are currently no landfill gas bores installed at the site. It is recommended that these be installed to assess potential landfill gas migration and risk from the site.
7. An assessment of the landfill cap's suitability is required due to the absence of available information. This evaluation should include a detailed review of the cap's structural integrity, permeability, and its ability to prevent the infiltration of water and the release of landfill gas emissions.
8. The closed Daylesford landfill has not undergone a formal audit, or the closed landfill process outlined in the closed landfill guidelines to evaluate its aftercare management and risks. It is recommended that ideally an aftercare management audit be completed to ensure the closed landfill is being managed in accordance with current regulations. And as a minimum an aftercare management plan be prepared in accordance with the closed landfill guidelines to manage the aftercare of the site and ensure suitable data is collected to assess and direct future management practises of any risks it may pose. This includes ensuring that HSC (as the duty holder) is fulfilling its GED and its duty to manage risks under the Act. This would address responsibilities related to the management of both groundwater and landfill gas risks at the site.