Roads and Maritime Services/Sydney Airport Corporation Limited

Sydney Gateway Road Project

Environmental Impact Statement/ Preliminary Draft Major Development Plan

Technical Working Paper 16

Former Tempe Landfill Assessment

November 2019

Sydney Gateway Road Project – Former Tempe Landfill Assessment

Technical Working Paper 16

August 2019

Executive Summary

This report has been prepared as part of the preparation of the EIS for the Sydney Gateway Road Project. The purpose of this report is to assess the potential environmental impacts from constructing and operating the project on the Former Tempe Landfill and to address the relevant environmental assessment requirements of the Secretary of the Department of Planning, Industry and Environment (the SEARs), issued on 15 February 2019.

The Sydney Gateway Road Project includes the stripping of the existing capping layer in certain locations around the Former Tempe Landfill, followed by limited excavation and relocation of waste on Site. Infrastructure to support the Sydney Gateway will be put in place on Site, including bridge piers, piling, and roads.

The appropriate management of the excavation/ extraction, stockpiling/ storage, movement, and relocation of waste material is considered essential to mitigate the risks identified by this assessment. Reinstating the capping layer as well as the leachate and gas management systems in areas disturbed by the Project will be required to comply with the requirements of the VRA currently in place on Site.

Table of Contents

List of Tables

List of Figures

Glossary and Abbreviations

AHD	Australian height datum
CLM Act	*Contaminated Land Management Act 1997*
CoCs	Contaminants of concern
DECC	Former department of environment & climate change
EIS	Environmental impact statement
EMP	Environmental management plan
ENM	Excavated natural materials
EP&A Act	*Environmental Planning & Assessment Act 1979*
EPA	Environmental protection agency
EPL	Environment protection licence
ESG	Environmental services group
Groundwater	All water occurring below the land surface
HELP	Hydrologic evaluation of landfill performance
HEPA	Heads of EPAs Australia and New Zealand
IWC	Inner West council (formerly Marrickville, St Peter's, and Petersham councils)
Landfill gas	The gas created from the decomposition of the organic and putrescible material over time within the site.
Landfill integrity	The structural components of the 2004 remediation, including the surface capping layer, bentonite cut-off wall, and the leachate collection and treatment systems.
Leachate	The liquid that passes through, or is released by waste over time from biodegradation of material within the site. Groundwater passing through waste is considered to be leachate.
LTP	Leachate treatment plant
MDP	Major development plan
NEMP	National environmental management plan
Offensive odours	Odours having impacts on the health and wellbeing of humans, and adversely affecting local amenity or surrounding environment as a result of the intensity, character, frequency and duration of the odour.
PFASs	Per- and poly-fluoroalkyl substances, such as PFHxS, PFOA, and PFOS
PFHxS	Perfluorohexanesulfonate
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
POEO Act	*Protection of the Environment Operations Act 1997*

PRMP	Post remediation management plan
Roads and Maritime	Roads and Maritime services
SAR	Site audit report
SAS	Site audit statement
SEARS	Secretary's environmental assessment requirements
Site	The Former Tempe Landfill
SPL	Species protection limit
Surface water	Water located in the rivers, creek, lakes, etc. Surrounding a landfill and that could potentially be affected by discharges of contaminated water from the landfill.
SWL	Standing water level
TPH	Total petroleum hydrocarbons
% v/v	Percentage volume per volume
VENM	Virgin excavated natural materials
VRA	Voluntary remediation agreement
VRP	Voluntary remediation proposal

1 Introduction

1.1 Overview

1.1.1 Sydney Gateway and the project

Sydney Kingsford Smith Airport (Sydney Airport) and Port Botany are two of Australia's most important infrastructure assets, providing essential domestic and international connectivity for people and goods. Together they form a strategic centre, which is set to grow significantly over the next 20 years. To support this growth, employees, residents, visitors and businesses need reliable access to the airport and port, and efficient connections to Sydney's strategic hubs.

The NSW and Australian governments are making major investments in the transport network to achieve this vision. New road and freight rail options are being investigated to cater for the forecast growth in passengers and freight through Sydney Airport and Port Botany. Part of this solution is Sydney Gateway, which comprises the following road and rail components:

- Sydney Gateway Road Project.
- Botany Rail Duplication.

Sydney Gateway will expand and improve the road and freight rail networks to Sydney Airport and Port Botany to keep Sydney moving and growing. Sydney Gateway forms part of the NSW Government's long-term strategy to invest in an integrated transport network and make journeys easier, safer and faster. The Botany Rail Duplication forms part of the Australian Government's commitment to invest in transport infrastructure across Australia.

As part of Sydney Gateway, NSW Roads and Maritime Services (Roads and Maritime Services) and Sydney Airport Corporation Limited propose to build the Sydney Gateway Road Project (the project). The project comprises new direct high capacity road connections linking the Sydney motorway network at St Peters interchange with Sydney Airport's terminals and beyond (Figure 1-1).

1.1.2 Approval Requirements

The project is declared State significant infrastructure under Division 5.2 of the NSW *Environmental Planning & Assessment Act 1979* (EP&A Act) and needs approval from the NSW Minister for Planning. The project is also major airport development under the *Commonwealth Airports Act 1996* (Airports Act) (Cth) and needs approval from the Australian Minister for Infrastructure, Transport and Regional Development. A combined environmental impact statement (EIS) and draft major development plan (MDP) will be prepared to support the application for approval under the EP&A Act and the Airports Act, respectively.

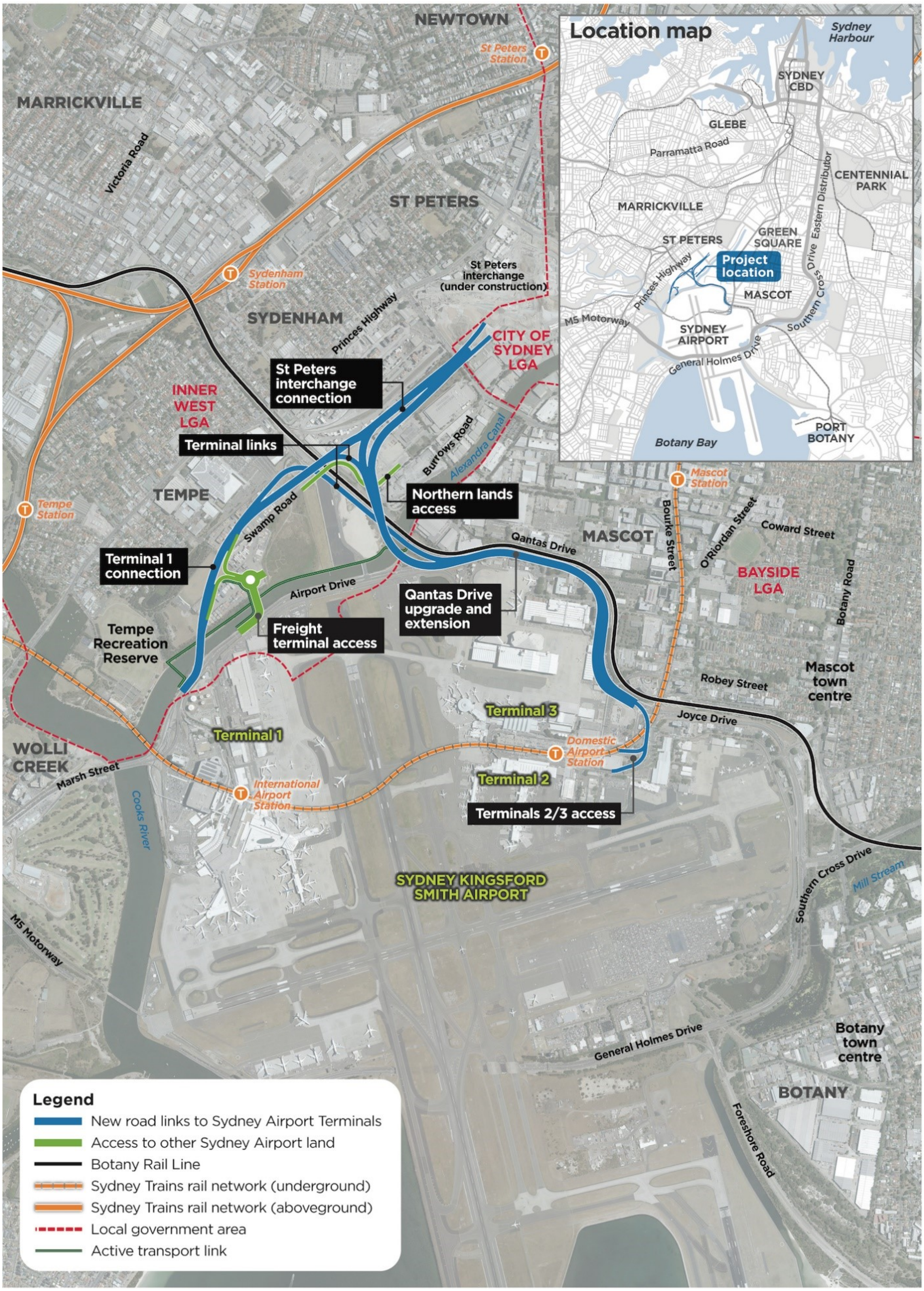


Figure 1-1: Sydney Gateway Road Project Location

Source: Roads and Maritime

This report has been prepared by the Environmental Services Group (ESG) as part of the project. It addresses the relevant environmental assessment requirements of the Secretary of the Department of Planning, Industry and Environment (the SEARs), issued on 15 February 2019 for preparation of the EIS.

1.2 The Project

1.2.1 Key features

The project involves constructing and operating new and upgraded sections of road connecting to the airport terminals, new bridges over Alexandra Canal, and other ancillary infrastructure and road connections. The key features of the project include:

- Terminal 1 connection – a new grade-separated section of road connecting Sydney Airport Terminal 1 (Terminal 1) and the Sydney motorway network via St Peters interchange, including a new bridge over Alexandra Canal.
- Qantas Drive upgrade and extension – widening and upgrading Qantas Drive and providing a new grade-separated section of road connecting the Sydney motorway network and Sydney Airport Terminals 2 and 3 (Terminals 2/3) via a new high-level bridge over Alexandra Canal.
- St Peters interchange connection – a new grade-separated section of road connecting Qantas Drive and the Terminal 1 connection with St Peters interchange.
- Terminal links – two new grade separated sections of road linking Terminal 1 and Terminals 2/3, including a new bridge over Alexandra Canal.
- Terminals 2/3 access – a new grade-separated road connection to Terminals 2/3 from the upgraded Qantas Drive.
- Active transport facilities – realigning the existing shared path and providing connections to other shared paths around Alexandra Canal, Tempe and Mascot.

The key features of the project are shown in Figure 1-1. Ancillary work would include new sections of road to provide access to Sydney Airport land, new drainage infrastructure, signage and lighting, and protecting/relocating utilities. The project would also require temporary facilities during construction, including compounds, work areas and site access.

Further information on the project is provided in the EIS/draft MDP.

1.2.2 Location

The project is located about eight kilometres south of Sydney's central business district and to the north of Sydney Airport on both sides of Alexandra Canal. The northern extent of the project is located at St Peters interchange, which is currently being constructed to the north of Canal Road in St Peters. The western extent of the project is located near the entrance to Terminal 1 on Airport Drive, to the north of the Giovanni Brunetti Bridge and south-west of Link Road. The eastern extent of the project is located near the intersection of Joyce Drive, Qantas Drive, O'Riordan Street and Sir Reginald Ansett Drive.

The project is located mainly on publicly owned land in the suburbs of Tempe, St Peters and Mascot, in the Inner West, City of Sydney and Bayside local government areas. The location of the project is shown in Figure 1-1.

1.3 Purpose and scope of this report

The purpose of this report is to assess the potential environmental impacts from constructing and operating the project on the Former Tempe Landfill (the Site, brown outline in Figure 1-2) by:

- Describing the existing environment with respect to the Former Tempe Landfill.
- Outlining the historical and current environmental challenges associated with the Former Tempe Landfill, as identified during the environmental report review.
- Identifying facets of the Site likely to be affected by the proposal during both construction and operation.
- Identifying the sensitivity of the Site.
- Identifying and characterising the associated impacts.
- Identifying and evaluating feasible mitigation measures for the identified impacts.

Environmental issues of potential relevance to the proposal that are discussed here include:

- Contamination management, including disturbed landfill materials and waste management
- Leachate management
- Groundwater and surface water management
- Air quality, including odour and landfill gas management.

This assessment addresses the relevant SEARs, the MDP requirements according to the Airports Act and the requirements of relevant agencies, as outlined in Table 1-1 below.

Figure 1-2: Tempe site location

Source: Interim Groundwater and Landfill Gas Investigation (AECOM, 2019)

Environmental issues of potential relevance to the proposal that are discussed here include:

- Contamination management, including disturbed landfill materials and waste management
- Leachate management
- Groundwater and surface water management
- Air quality, including odour and landfill gas management.

This assessment addresses the relevant SEARs, the MDP requirements according to the Airports Act and the requirements of relevant agencies, as outlined in Table 1-1 below.

Table 1-1: SEARs

Requirement	Addressed in this document
Water Quality	
1. The proponent must:	
a) Describe background conditions for surface and groundwater resources likely to be affected by the proposal, including leachate from Former Tempe Landfill;	The background environment is discussed in Section 5.2
b) State the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associated trigger values or criteria for the identified environmental values;	Addressed by *Technical Working Paper 8 – Water Quality*
c) Identify and estimate the quality and quantity of all pollutants that may be introduced into the water cycle by source and discharge point and describe the nature and degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants (including contaminated groundwater) that pose a risk of non-trivial harm to human health and the environment;	Addressed by *Technical Working Paper 8 – Water Quality*
d) Assess the impacts of leachate generation from project related activities on the Former Tempe Landfill and proposed measures for managing potential impacts during construction and operation;	An assessment of construction and operational impacts is included in Sections 6.2 and 7.2.
e) describe the proposed measures for treating and disposing of construction and operational wastewater flows; and	Mitigation measures are included in sections 8.1.2 and 8.2.1
f) identify the rainfall event that the water quality protection measures will be designed to cope with;	Addressed by *Technical Working Paper 8 – Water Quality*
2. The assessment should consider the results of any current water quality studies, as available, for the catchment areas traversed by the proposal.	Addressed by *Technical Working Paper 8 – Water Quality*

Requirement	Addressed in this document
Contamination	
1. The Proponent must assess the potential for contamination and any impacts associated with the management of contaminated soils and water resources including, but not limited to:	
a) a detailed assessment of the extent and nature of any contamination of the soil, groundwater and soil vapour including from activities on Former Tempe Landfill and PFAS;	An assessment is included in Section 0
b) an assessment of potential risks to human health and the environmental receptors in the vicinity of the site;	Addressed by *Technical Working Paper 15 – Human Health*
c) a description and appraisal of any mitigation and monitoring measures; and	Mitigation measures are included in Section 8
d) consideration of whether the site is suitable for the proposed development.	Addressed in *Technical Working Paper 5 – Contamination and Soils*
2. Any assessment of contamination must be in accordance with relevant guidelines produced or approved under the *Contaminated Land Management Act 1997*.	An assessment of contamination with respect to the landfill is addressed in *Technical Working Paper 5 – Contamination and Soils*
3. All reports prepared for the assessment of contamination must be prepared, or reviewed and approved, by a consultant certified under either the Environment Institute of Australia and New Zealand's Certified Environmental Practitioner (Site Contamination) scheme (CEnvP(SC)) or the Soil Science Australia Certified Professional Soil Scientist Contaminated Site Assessment and Management (CPSS CSAM) scheme.	An assessment of the likely contamination of the landfill and any required remediation is addressed in *Technical Working Paper 5 – Contamination and Soils*
4. The Proponent must assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and future land uses. Where assessment and/or remediation is required, the Proponent must document how the assessment and/or remediation would be undertaken in accordance with current guidelines.	An assessment of the likely contamination of the landfill and any required remediation is addressed in *Technical Working Paper 5 – Contamination and Soils*
Air Quality	
1. The Proponent must undertake an air quality impact assessment (AQIA) for construction and operation of the project in accordance with the current guidelines.	An assessment is included in Sections 6.2.1 and 7.3. This SEAR is further addressed in *Technical Working Paper 4 – Air Quality.*
2. The Proponent must ensure the AQIA also includes the following:	
a) demonstrated ability to comply with the relevant regulatory framework, specifically the *Protection of the Environment Operations Act 1997* and the Protection of the Environment Operations (Clean Air) Regulation (2010);	Addressed in *Technical Working Paper 4 – Air Quality*

Requirement	Addressed in this document
b) the identification of all potential sources and types of air pollution (including PM10, PM2.5, CO, NOX, volatile organic compounds and odour sources) during construction and operation including mechanically generated combustion and transport related emissions and potential for landfill gas generation from the Former Tempe Landfill;	An assessment of the potential for landfill gas generation is included in Sections 6.2.1 and 7.3. An assessment of all other potential source and types of air pollution is addressed in in *Technical Working Paper 4 – Air Quality*
c) any proposed air quality monitoring;	Proposed landfill gas monitoring is addressed in Section 8.
d) a cumulative local and regional air quality impact assessment including impacts generated by the operation of nearby key infrastructure proposals such as the New M5 and Botany Rail Duplication; and	Addressed in *Technical Working Paper 4 – Air Quality*
e) proposed construction and operational management measures.	Mitigation measures are included in Section 8

1.4 Structure of this report

The structure of the report is outlined below.

- Section 1 (above) provides an introduction to the Sydney Gateway Road Project.
- Section 2 outlines the legislative and policy context for the assessment, including relevant guidelines.
- Section 3 describes the methodology for the assessment.
- Section 4 describes the historical background for the Former Tempe Landfill, including a review of available documentation and reports for the Site.
- Section 5 describes the existing environment on the Site.
- Section 6 provides an assessment of potential construction impacts to the Former Tempe Landfill.
- Section 7 provides an assessment of potential operational impacts to the Former Tempe Landfill.
- Section 8 outlines the recommended mitigation measures.

1.5 Report limitations

The considerations listed above will be assessed in this paper only in regard to their relevance to the Former Tempe Landfill. The following technical papers have been prepared to specifically address environmental considerations across the rest of the Project area. These papers are *Technical Working Paper 4 – Air Quality, Technical Working Paper 5 – Contamination and Soils* (WSP & GHD, 2019), *Technical Working Paper 7 – Groundwater* (WSP & GHD, 2019), *Technical Working Paper 8 – Water Quality,* and *Technical Working Paper 15 – Human Health.* They may also provide further recommendations in addition to those outlined within this paper.

Other considerations which may be relevant to the Project and Site but are not assessed in this technical paper include (but are not limited to) acid sulfate soils, geotechnical impacts, visual amenity, and worker health & safety.

2 Legislative and Policy Context

2.1 Environmental Planning and Assessment Act 1979 (NSW)

The *Environmental Planning and Assessment Act 1979* (EP&A Act) is administered by the NSW Department of Planning, Industry and Environment and includes provisions for the assessment of developments, including for State Significant Infrastructure.

State Significant Infrastructure (SSI) projects are high priority infrastructure projects that are essential to the State for economic, social or environmental reasons. SSIs must receive ministerial approval under Division 5.2 of the Act.

2.1.1 Secretary's Environmental Assessment Requirements

Under the EP&A Act and regulations, the planning secretary is required to issue environmental assessment requirements (SEARs) when an application for approval of an SSI project is made. The Act also requires that an EIS be prepared by the proponent according to the SEARs.

The project meets the definition of SSI in accordance with Division 5.2 of the EP&A Act, and by operation of clause 14(1) and Schedule 3 of *State Environmental Planning Policy (State and Regional Development) 2011*, and clause 94 of *State Environment Planning Policy (Infrastructure) 2007*.

This assessment addresses the relevant SEARs, the MDP requirements according to the Airports Act and the requirements of relevant agencies, as outlined in Table 1-1.

2.2 Contaminated Land Management Act 1997 (NSW)

The *Contaminated Land Management Act 1997* (CLM Act) is part of the management framework for contaminated land in NSW. The Act enables the NSW Environment Protection Agency (EPA) to respond to and manage site contamination when it considers that contamination is significant enough to require regulation. Site contamination requires regulation under the Act when a site is declared "significantly contaminated land" or when land is subject to a management order issued by the EPA or an approved voluntary management proposal.

2.2.1 Relevance to the Former Tempe Landfill

The EPA declared the Former Tempe Landfill as a Remediation Site (now taken to be "significantly contaminated land") on 25 July 2000 under the CLM Act (Declaration No. 21005) due to the findings that leachate generated by the buried waste was migrating from the landfill towards Alexandra Canal (NSW EPA, 2000).

On 19 March 2003, Council entered into Voluntary Remediation Agreement (VRA) No. 26050 with the EPA to manage the environmental risks identified (NSW EPA, 2003).

2.3 Protection of the Environment Operations Act 1997 (NSW)

The *Protection of the Environment Operations Act 1997* (POEO Act) regulates air, noise, land and water pollution. Under the POEO Act, activities likely to generate pollution require Environment Protection Licences (EPLs) detailing authorised activities as well as controls in place to mitigate impacts. The EPA is typically responsible for implementing the POEO Act. Depending on the details of activities proposed on the Site and for the Sydney

Gateway Project in general, the proposed works may constitute a scheduled activity lister under Schedule 1 of the POEO Act. An EPL may therefore be required by the EPA to manage potential pollution impacts.

2.3.1 Environmental Guidelines - Solid Waste Landfills (2016)

The EPA’s 2016 Environmental Guidelines - Solid Waste Landfills (Solid Waste Landfill Guidelines) detail the minimum standards for the environmental management of NSW landfills and involve a mix of design and construction techniques, effective site operations, monitoring and reporting protocols, and post-closure management (NSW EPA, 2016).

The guidelines are used by the EPA to assess applications for new or varied landfill licences under the POEO Act and to assess issues that arise during the operational and post-closure periods of landfills. The broad goals of the guidelines have been followed for the landfill related activities and impacts of the Project.

2.3.2 Relevance to the Former Tempe Landfill

During its operation as a landfill between 2000 and 2004, the Site was regulated under EPL 6665 (NSW EPA, 2000), which labelled the Site as a Class 2 Landfill under the POEO Act. This licence allowed for the acceptance of inert material, being waste from building and demolition activities, including bricks, concrete, glass, plastics, metal, and timber.

At its closure in 2004, the surrender notice of historical EPL 6665 was varied three times between 2004 and 2010 to include gas monitoring requirements in addition to the original leachate monitoring requirements. The modified conditions include:

- Quarterly gas monitoring with provision of reports to the EPA.
- Notifying nearby property owners of the potential migration of gas on their premises.
- Assessing the feasibility of gas migration remedial measures.

3 Assessment Methodology

This technical working paper has been prepared based upon a desktop review of historical reports and assessments relating to the former Tempe landfill. The desktop review was supplemented by a four-week sampling program to characterise groundwater and leachate conditions, including leachate levels, as well as the development of a water balance model in accordance with the EPA's Solid Waste Landfill Guideline 2016.

3.1 Historical record review

A desktop review was conducted of available historical reports relating to past environmental investigations, remedial works, and onsite management activities taking place at the Site. The report list is presented in Appendix Table 10-1, with a summary of the findings included in Table 4-1.

Information obtained from the background review was used to establish the existing site conditions and identify likely risks associated with the project. The assessment also involved confirming whether the existing system complies with the legislative requirements of the VRA under the CLM Act, EPL surrender conditions under the POEO Act, and Sydney Water Trade Waste Agreement.

3.2 Late 2018 - early 2019 Site inspection and investigations

A site inspection was conducted in November 2018, followed by a four-week sampling program. The sampling program took place at the Site between 11 February 2019 and 4 March 2019 and was carried out to characterise the leachate collected within the sumps and pits. It is noted that this did not include a review of the performance of the existing Ion Exchange treatment system.

The sampling program involved the measurement of water levels, leachate volumes, and the collection and testing of samples from each of the six leachate sump pits. In addition, samples were also collected over the same four-week period from the existing groundwater monitoring bores along the boundary of the Site on each side of the bentonite cut-off wall.

3.3 Modelling

3.3.1 Water balance modelling

To assess potential changes to hydraulic conditions, the Solid Waste Landfill Guidelines recommend the use of a Hydrologic Evaluation of Landfill Performance (HELP) model that considers changes in rainfall infiltration through the various operational phases of a landfill (NSW EPA, 2016).

A water balance model equivalent to the HELP model was therefore developed to assess the potential impacts of the construction works on the Site, such as changes to the leachate volumes produced on Site and the associated environmental impacts. The developed model uses the principles detailed in the guidelines and includes modelling of impacts on the leachate management system. The model estimates leachate generation for landfills using known or predicted volumes of rainfall, infiltration, and other water pathways during the various stages of construction and operation.

Two infiltration scenarios were modelled to assess an average and a worst-case rainfall event, as follows:

Scenario 1: Average rainfall

The scenario used average rainfall values from the 1929-2018 period, and the monthly data for the year closest to the average rainfall in that period (1992). The scenario provides the most likely estimates based on a typical rain event.

Scenario 2: Ninetieth percentile rainfall

The scenario used the data for the year closest to 90th percentile wettest year rainfall values, which was recorded in 1974. This is used as a worst-case scenario to inform what increased disposal capacity may be required and whether additional storage should be considered.

3.3.2 Landfill gas modelling

The production of landfill gas is due to the decomposition of carbon based materials in anaerobic (no oxygen) conditions. When landfills are progressively filled and finally capped with a low permeable cover, anaerobic conditions occur. The main decomposition gases produced are methane and carbon dioxide. The production of landfill gas is the highest in the few years following closure and steadily declines with the readily degradable waste (putrescible/food waste) consumed within 30 years. Other carbon-based wastes such as paper or wood will continue to degrade when suitable (usually wet) conditions exist, albeit at a slower rate.

Due to the age of the Site, it is expected that the majority of putrescible waste has degraded, but that there will be ongoing low production of landfill gas from other carbon sources. There is also the possibility of landfill gas trapped in pockets where there is insufficient gas to create enough pressure to move through the waste.

Modelling of landfill gas production will use average information on the assumed waste composition (household, industrial, construction and demolition) and the tonnage of waste received each year. The Landfill Emissions Assistant (LEA) used in the National Pollutant Inventory (NPI) reporting uses the age, area, depth of the waste mass, and a number of default values to estimate the emission of Volatile Organic Carbon (VOCs) on a yearly basis. Methane is the primary component of VOCs and thus an estimate of the production of landfill gas. This model has been used to estimate the current production of landfill gas. Additional information on air quality impacts can be found in *Technical Working Paper 4 – Air Quality.*

4 Site Background

4.1 Site setting

Spear Brick, Pipe and Tile Works Ltd initially operated part of the Site as a shale quarry (a brick pit), specifically in the north-western section (Coffey Geosciences Pty Ltd, 2003). Following completion of quarrying activities, the now Inner West Council (formerly St Peters, Petersham, and Marrickville Councils) began using the Site as a landfill. Between 1910 and the mid-1970s, the Site received waste from a wide range of sources, accepting domestic refuse, industrial waste, liquids and hazardous waste, and general council waste (Smith Environmental, 1998). The original Tempe Landfill footprint is provided in Figure 1-2. Parts of the Site were used as a scrapyard once landfilling operations ceased (Coffey Geosciences Pty Ltd, 2003).

In 2000, Council was issued with an Environmental Protection Licence (EPL) for filling activities as a Class 2 Inert Landfill under the *Protection of the Environment Operations Act 1997* (POEO Act). Partial filling activities resumed with deposition of construction waste such as sandstone, concrete, bricks, and steel, and minor quantities of putrescible material.

Prior to 2004, much of the Site was being used as an empty shipping container storage facility. Following completion of the remediation works in 2006, the Site has been used for multiple concurrent purposes including:

- A golf driving range and dog park in the western portion within the Tempe Recreation Reserve
- a container storage facility in the middle portion
- a Sydney Airport carpark and navigation lights for incoming aircrafts at the eastern portion
- a commercial precinct in the northern portion.

The original surface topography within the Site area was significantly modified by clay/shale extraction and subsequent major filling operations, resulting in up to 17m depth of fill over the last 100 years. The Former Tempe Landfill was split into 11 areas in preparation for the 2004-2006 remediation works (Figure 4-1).

While 11 areas were identified during the remediation works, Areas 2 and 3 were not actually remediated or capped. This may have been because the areas were expected to be re-developed into a freeway at the time (see Figure 1, Coffey Geosciences Pty Ltd, 2005), and remediation was not deemed essential. As such, the reviewed remediation and audit reports do not mention them further, and no information exists on their remediation status. Areas 2 and 3 are currently being utilised by the IWC as a container storage area.

Figure 4-1: Former Tempe Landfill – Remediation Areas

This figure has been created using the general areas boundaries indicated in the *Site Environmental Management Plan – Areas 4*-11 (Tenix Projects, 2006). Subdivided areas (such as areas 1a/ 1b, areas 3a/ 3b) are grouped into one.

4.2 Historical review finding

Table 4-1 provides a summary of the key milestones that have either led to and/or managed the contamination associated with the Site.

Table 4-1: Key contamination milestones

Date	Activity	Details	Bibliography reference(s)
1910	Commencement of landfilling	Council operated a landfill facility which received waste from a wide range of sources including domestic refuse, industrial waste, liquids and hazardous waste, and general council waste.	(Smith Environmental, 1998)
From 1970s	Landfilling ceased	The landfilling at the Site ceased operation in stages between 1969 and 1974. By 1975 only solid waste disposal of roadworks material was accepted. This is based on the findings of environmental and geotechnical investigations, which indicate that towards the end of its life, the Site appears to have been filled with substantial quantities of construction waste including sandstone, concrete, bricks and steel, and some minor areas of garbage refuse.	(Coffey Geosciences Pty Ltd, 2003) (Smith Environmental, 1998)
1991 - 2019	Environmental investigations	Environmental assessments undertaken at the Site over the years have confirmed the presence of the historical filling activities and based on the findings identified three main stages: • Stage 1: Initially as a putrescible landfill, with filling of the former quarry extending from depth of about -4m AHD, ending at a level of about 12.5m AHD and varying across the Site (average thickness of 14 metres); • Stage 2: fill is generally comprised of solid waste (construction & building demolition wastes, potentially comprising asbestos) extending from about 7m AHD to 16m AHD and varying across the Site (average thickness of 3 metres); • Cap: a landfill cap was prepared as part of remediation work. The composition/ thickness of the cap is expected to be approximately 0.5m across the site.	(Coffey Geosciences Pty Ltd, 2003)

Date	Activity	Details	Bibliography reference(s)
25 July 2000	Regulation of the contamination under the CLM Act	The NSW EPA declared the land as a Remediation Site (now taken to be “significantly contaminated land”) under the CLM Act, due to identified offsite migration of leachate (primarily ammonia) into the Alexandra Canal.	(NSW EPA, 2000)
15 November 2000	Environmental Protection Licence under the POEO Act (Licence 6665)	Council was issued with an EPL which classified the Site as a Class 2 Landfill under the POEO Act. This licence allowed for the acceptance of inert material being waste from building and demolition activities includes bricks, concrete, glass, plastics, metal and timber.	(NSW EPA, 2000)
22 March 2001	Remediation Order - No. 23003 under CLM Act	Under the Remediation Order, Council was required to engage a site auditor and prepare a remedial action plan (RAP) to address the contaminants migrating towards the canal. This Order was complied with on 30 November 2001.	(NSW EPA, 2001)
26 November 2001	Site Audit Statement and Report GN 35	The audit was conducted to determine the suitability and appropriateness of the 1998 Remedial Action Plan (RAP) prepared by Waste Services NSW in accordance with the Remediation Order (No. 23003). **Conclusions of the Audit**: The 1998 RAP was considered to be suitable but lacking important detail. Further information was required regarding the thickness of usable capping material, a hydrogeological profile, a quantification and qualification of leachate to be treated. The auditor estimated that there was insufficient data to assess potential contamination migration impacts on biota and water quality, although migration was accepted.	(Environ, 2001)
19 March 2003	Voluntary Remediation Agreement - No 26050 (now taken to be “Voluntary Management Proposal”) under the CLM Act	The Voluntary Remediation Agreement detailed the required construction and operation of the leachate management system and the ongoing requirement to monitor the performance of the leachate collection and treatment system.	(NSW EPA, 2003)
4 September 2003	Remedial Action Plan	The new RAP was developed to outline the objectives and commitment for remediation, validation, and risk management actions to be met to render the site suitable for proposed development. This RAP was designed to comply with the VRA requirements.	(Coffey Geosciences Pty Ltd, 2003)

Date	Activity	Details	Bibliography reference(s)
30 August 2004	Site Audit Statement and Report GN 35B	The audit was conducted to address the appropriateness of the proposed leachate management system in accordance with the Voluntary Remediation Agreement (No. 26050). **Conclusions of the Audit**: The Audit concluded that sufficient investigation had been undertaken to appropriately design a leachate management system with performance specifications compatible with the VRA objectives. The winning tender design was not assessed by the auditor, although they were satisfied that the proposed processes and procedures for implementation were appropriate. The auditor recommended a post-construction validation strategy.	(Environ, 2004)
9 December 2004	Surrender of Licence 6665 under the POEO Act (No. 1041812)	The licence was surrendered on 9 December 2004 by Notice no. 1041812, subject to various surrender conditions.	(NSW EPA, 2004)
2004 - 2006	Remediation works	A leachate management system was installed which consisted of: • a bentonite cut-off wall down to the underlying impermeable rock; • sub soil drainage system; • pumping stations; • onsite leachate treatment system; and • an ongoing monitoring network installed within the drainage system and outside the bentonite wall.	(Menard Bachy, 2003)
27 September 2005	Site Audit Statement and Report GN 35C	The audit was conducted to determine whether the features of the proposal have been successfully conducted and that the objectives have been met in accordance with the Voluntary Remediation Agreement (No. 26050). **Conclusions of the Audit:** The Auditor concluded that the outstanding principal features of the VRP were conducted, and that the VRA objectives have been met. Specifically, the Auditor indicated that a leachate collection and treatment system had been installed, monitoring of its performance was carried out, the bentonite wall was installed generally in accordance with the quality control plan, and that the post-construction monitoring indicated substantial quantities of leachate were being prevented from entering Alexandra Canal.	(Environ, 2005)

Date	Activity	Details	Bibliography reference(s)
		The Auditor recommended the development and implementation of a detailed monitoring program for the leachate extraction rates, groundwater levels, leachate management system performance, as well as the evaluation and revision of the program after six-months.	
11 May 2006	Site Audit Statement and Report GN 35-1	The audit was prepared to assess the suitability of Areas 1A and 1B for future commercial/industrial uses, a review of its capping and containment of fill material, and the management of landfill gases. Remediation works were undertaken to prepare the Site for future uses and not to address the VRA. **Conclusions of the Audit:** The site was declared suitable for the proposed use, subject to compliance with the corresponding 2006 EMP.	(Environ, 2006)
12 July 2006	Site EMP Areas 1A and 1B	The EMP outlines the ongoing management and monitoring aspects of the site cap and gas monitoring provided for human health protection.	(Tenix Projects, 2006)
31 August 2006	Site Audit Statement and Report GN 35-1B	SAR (GN 35-1B) updated GN-35-1 to include a revised EMP and references to new lot and DP numbers.	(Environ, 2006)
10 October 2006	Variation of the Surrender Notice under POEO Act (No. 1048787)	On 11 October 2006, the EPA varied the conditions of the surrender notice via Variation of Surrender Condition Notice no. 1048787. As part of the variation Council was required to undertake a targeted remedial investigation to assess the feasibility of, and assist in designing of, landfill gas migration mitigation measures.	(NSW EPA, 2006)
November 2006	Site EMP Areas 4 to 11	The EMP outlines the monitoring program and ongoing maintenance requirements for the controls minimising access to contaminated material and environmental impacts; the monitoring program of the controls minimising offsite migration of landfill gas; and future controls for development and maintenance work.	(Tenix Projects, 2006)
4 July 2008	Site Audit Statement and Report GN 35-2	The audit was prepared to assess the suitability of the part of Tempe Lands known as Areas 4 to 11 for future commercial/industrial and open space uses. The Audit is limited to a review of the capping and containment of fill material over Areas 4 to 11 and the management of landfill gases. These works were undertaken to prepare the Site for future uses.	(Environ, 2008)

Date	Activity	Details	Bibliography reference(s)
		Conclusions of the Audit: The site was declared suitable for the proposed use, subject to compliance with the corresponding 2006 EMP.	
12 June 2010	Variation of the Surrender Notice under POEO Act (No. 1083919)	On 11 October 2006, the EPA varied the conditions of the surrender notice via Variation of Surrender Condition Notice no. 1048787. As part of the variation Council was required to undertake remediation works to mitigate the migration of landfill gas from the Site and provide evidence these works have been undertaken.	(NSW EPA, 2010)
9 July 2010	Site Audit Statement GN 420	The SAS was requested to determine the nature and extent of contamination on Areas 1A and 1B, as well as to determine the appropriateness of the remedial action plan for the areas, and whether the land was suitable for commercial retail uses in relation to the planned development of IKEA. **Conclusions of the SAS:** The auditor was of the opinion that the site could be made suitable for commercial/ industrial use, provided that the Remedial Action Plan prepared by WSP in 2010[1] for the area was adhered to. This included the installation of a landfill gas mitigation system, removal and remediation of underground storage tanks, remediation of hydrocarbon contamination, and capping.	(Environ, 2010)
12 November 2013	Site Audit Statement GN 420B	The SAS was requested to determine land use suitability for a Bulky goods retail store, in relation to the planned development of IKEA. **Conclusions of the SAS:** The auditor certified that the site was suitable for the proposed use, which was a bulky goods retail store as per Schedule 1 of Modification of Major Project Approval dated 7 August 2009, subject to compliance with the WSP 2013 EMP[1].	(Environ, 2013)

[1] The 2010 and 2013 EMPs were not provided for review by ESG.

4.3 Post Remediation Requirements

4.3.1 Environmental Management Plan

A condition of the site audit statement and report GN 35C prepared by Graeme Nyland (Environ, 2005) under the VRA (No. 26050) required the implementation of an approved Environmental Management Plan (EMP).

As a result of the site audit statement, two EMPs were prepared for the Site in 2006 by Tenix Project to split the management requirements according to the planned redevelopment of the land. The EMP for Areas 1A and 1B (i.e. the IKEA and warehouse area) required the implementation of a gas migration monitoring program (Tenix Projects, 2006). The EMP for Areas 4 to 11 (i.e. the remainder of the Site) outlined the monitoring requirements for the leachate, as presented in Table 4-2 (Tenix Projects, 2006). As mentioned earlier, Areas 2 and 3 are assumed to have not been remediated at the time.

Table 4-2: Monitoring requirements for the leachate containment and treatment system

Area Description	Inspection Frequency	Monitoring to be undertaken
Piezometers	Initially quarterly, then as agreed with EPA	• Monitoring of piezometer levels as indicator of cut-off wall and drainage system effectiveness. • Contamination sampling of water inside and outside the wall as indicator of cut-off wall performance.
Pump pits/ line	6 monthly and following pump fault alarm	• Visual inspection of pump pits for silt build up and damage. • Removal of silt and cleaning of drainage and pump lines to prevent ferric oxide built up.
Leachate treatment plant	Weekly and following alarm signal	• Visual inspection of plant for signs of leakage or malfunction. • Visual inspection of plant for levels of consumables and stored ammonia. • Checking levels of ammonia, pH, and conductivity in treated leachate by reading the PLC screen or by remotely dialling into it.
	Maintenance as defined in operating manuals	• Preventative maintenance and inspection at intervals defined in the operating manuals.
Area 7 compound	3 monthly	• Visual inspection of compound surface indicating damage to the cap.

4.3.2 EPL Surrender Conditions

EPL no.6665 was surrendered by IWC on 9 December 2004 (Notice no. 1041812), subject to the following surrender conditions (NSW EPA, 2004):

- Installation of additional gas monitoring wells by 2005[2].
- Undertaking quarterly monitoring on those wells (conditions 8, 9 and 10).

[2] Note: The 2003 RAP indicates that some historical monitoring of gas took place prior to the licence surrender across the site (Coffey Geosciences Pty Ltd, 2003), although reports on this monitoring were not provided for review. The RAP indicates further investigations into the gas were occurring at the time. It is assumed that the reports were provided to the EPA for review.

- Annual reporting of monitoring results to the EPA, with a 24-hour notification requirement should gas be detected above safety limits (conditions 10 and 11).
- Development of mitigation measures within 3 months of detection should offsite gas migration be detected (condition 12).
- Appropriate gas management measures required for any buildings or installations over the Site with penetrations more than 0.5m into the cap (condition 14).
- Leachate is to be contained and treated within the leachate collection system (conditions 16 and 17).
- Ongoing monitoring of the treatment plant and sub surface irrigation systems and development of alternate leachate disposal method should irrigation become unfeasible (conditions 19, 24 and 27).

A variation to the surrender conditions was lodged in 2006 with additional conditions relating to the findings of the first landfill gas investigation report (NSW EPA, 2006). This variation removed the above-mentioned conditions 8, 9, 10 and 12, and replaced them with the following conditions:

- Quarterly monitoring of the existing wells and increasing reporting requirements to within 10 days of the monitoring report (conditions 8.1 and 8.2).
- Quarterly gas accumulation monitoring in commercial buildings, certain residential buildings and utility trenches around the Site (condition 9.1).
- Owners of those properties and services would be notified of these requirements (condition 10.1).
- To conduct an investigation into the feasibility and design of gas migration mitigation measures (condition 12.1).

The EPA varied the notice further on 12 June 2010 (No. 1083919) based on the findings of the mitigation feasibility study (NSW EPA, 2010). This variation replaced conditions 12.1 and 12.2. The new conditions outlined the requirement for IWC to undertake the mitigation works outlined in the 2007 and 2010 feasibility studies by November 2010 and to notify EPA of the works completion. No modifications to the leachate conditions were made.

4.3.3 Sydney Water Trade Waste Agreement

A Trade Waste Agreement dated from 15 December 2017 (No. 35548) currently exists between the IWC and the Sydney Water Corporation until 31 December 2020 (Sydney Water Corporation, 2017).

Table 4-3: Excerpt 1 - Trade Waste Water Agreement No 35548

Substance	LTADM (kg/day)	MDM (kg/day)	Standard (mg/L)
Ammonia (as N)	11.0	20.0	100.0
Biochemical Oxygen Demand	28.0	75.0	-
Total Dissolved Solids	280.0	500.0	10,000.0
Grease	0.5	2.0	110.0

LTADM = Long-Term Average Daily Mass

MDM = Maximum Daily Mass

It provides consent to discharge industrial trade wastewater into the sewer according to the schedule outlined in Table 4-3 and to the specifications outlined in Table 4-4.

Table 4-4: Excerpt 2 - Trade Waste Water Agreement No 35548

Parameter	Condition
Temperature	Not to exceed 38 degrees Celsius
Colour	Determined on a system specific basis
pH	Within a range of 7.0 to 10.0
Fibrous material	None which could cause an obstruction to Sydney Water's sewerage system
Gross solids (other than faecal)	A maximum linear dimension of less than 20mm, a maximum cross section dimension of 6mm, and a quiescent settling velocity of less than 3 m/h
Flammability	Where flammable and/ or explosive substances may be present, the Customer must demonstrate to the satisfaction of Sydney Water that there is no possibility of explosions or fires occurring in the sewerage system. The flammability of the discharge must never exceed 5% of the Lower Explosive Limit (LEL) at 25 Celsius

The maximum allowed rate of discharge is 2L/sec, with a daily maximum of 250kL and an average daily discharge of 150kL. Monitoring requirements are also indicated in the agreement, such as the taking of composite and discrete samples over one full day, every 22 days. Under the requirements of the Trade Waste agreement, the analysis results are to be submitted to Sydney Water.

4.4 Findings of the Legislative requirements review

The review of historical information identified the following actions or activities with regards to the ongoing regulation and management of the Site. The following is a summary of the key findings:

- The current VRA as listed on the NSW EPA register, generally relates to the appropriate construction of the leachate management system and has a specified completion date of 30 June 2004;
- A requirement of the VRA was the preparation of a Site Audit Statement confirming the leachate system had been constructed in accordance with the VRA. The Site Audit Statement required the implementation of an EMP to manage the long-term issues associated with the leachate system. Based on the information provided, it is unclear whether the ongoing maintenance and monitoring requirements of the EMP are being carried out;
- Gas associated with the Site is currently managed under the POEO Act under a varied surrender notice for the former EPL; and
- Leachate concentrations and monitoring requirements are detailed in the Trade Waste Agreement with Sydney Water for sewer release from the leachate management system.

5 Existing Site Environment

5.1 Landfill integrity

In 2003, Coffey prepared a Remedial Action Plan (RAP) which outlined the initial management requirements for the operation of the leachate treatment system, the establishment of a containment system, and the associated ongoing monitoring of the success of the leachate treatment (Coffey Geosciences Pty Ltd, 2003). The Site areas defined in the RAP and discussed below are shown in Figure 4-1.

Remediation works undertaken in 2004 including the installation of a bentonite cut-off wall along the boundary with Alexandra Canal, as well as a capping layer, and leachate management systems.

5.1.1 Capping layer

Investigations carried out by Coffey (Coffey Geosciences Pty Ltd, 2003) identified that settlement over the life of the landfill could be an issue once additional capping material was added, and re-grading of certain sections occurred to provide better drainage.

Landfill cap validation reports were prepared for both Areas 1A/1B (Coffey, 2006), and Areas 4-11 (Coffey, 2007). These were reviewed as part of Site Audit Reports GN35-1 (Environ, 2006) and GN35-2 (Environ, 2008), with the Auditor noting that the cap was generally constructed as per specifications, using VENM capping to a minimum of 0.5m thickness and compacted to 100% standard compaction. Roads in Area 4 and small sections of Area 5 were capped to a thickness less than 0.5m due to the use of additional asphalt coverage. Areas 8-10 were to remain under Council control and were capped to approx. 0.2m thickness (Environ, 2008). Some materials used in the container area, in bulk filing or below roads in Areas 4-11 were also not consistent with VENM or inert waste classifications (Environ, 2008).

Drilling conducted in late 2018 (AECOM, 2019) confirmed the presence of a fill layer assumed to be the capping layer ranging between 0.5 and 1 metre in depth across the Golf Driving Range (Area 6, Figure 1-2 , SG-BH-102). Another borelog collected near the Alexandra Canal (Area 9, Figure 1-2, SG-BH-101) indicates that capping in this location consisted mostly of roadbase and gravel to approx. 1m depth, clay and unknown fill between 1m and 1.5m, alluvium clay to 9.5m depth, and sandstone lower down.

While no reports, audits, or management plans were sighted for Areas 2 and 3 (currently used by Tyne Containers), the 2018 drilling by AECOM indicated the presence of a fill layer approximately 3.0m deep across this section (Figure 1-2, bores SG-BH-103 and GW9). The layer consisted of 0.5m-1.0m of fine to coarse gravel, followed by 1-1.5m of clay and 1-2m of sand. It is unknown when this layer was installed.

5.1.2 Bentonite cut-off wall

Under the VRA (No. 26050), the principal requirement of the bentonite cut-off wall was to ensure the permeability was low enough to prevent leachate entering the canal and that the wall has no defects to allow significant leakage and extends to the full depth of potential leachate migration (Environ, 2005).

The validation report for the bentonite cut-off wall advised that the wall was installed down to an average depth of -10 mAHD (range: -4.0m to -12.0m AHD), although it was unknown whether this depth reached impenetrable rock along the entire wall (Coffey Geosciences Pty Ltd, 2005). The findings suggested that the wall was installed 1 to 3m below the surface of the residual clays, with shallower than planned portions around chainages CH1180, CH190, CH100, and CH40 (Coffey Geosciences Pty Ltd, 2005). It is understood to be 0.8 m wide, offset 3.5 m from the canal bank and with an overall permeability target of $1.6x10^{-9}$ m/s.

The 2005 site audit carried out to confirm the performance of the VRA (Environ, 2005) concluded:

- The field and laboratory testing conducted prior to construction indicated the soil bentonite cut-off wall should substantially prevent leachate flow to the canal.
- The monitoring results further supported the fact the wall was being successful in limiting flow to the canal.

A 2006 survey of the bentonite cut-off wall identified that the height of the wall was more varied across the Site than expected[3]. For example, the section between monitoring wells MPI15 and MPI6 was reported to be approx. 1.14m AHD, and sections around MPI16 to MPI17 were approx. 0.95m AHD (Uminex, February 2018). This was confirmed in 2007 with sections around monitoring wells MPI5, MPI6, MPI16 and MPI17 measured at 1.15m AHD, 1.28m AHD, 1.14m AHD, and 1.19m AHD respectively (Uminex, February 2018).

5.1.3 Leachate collection and treatment system

The remediation strategy as defined in the Coffey RAP was to prevent flows of contaminated leachate into the canal, not to alter the quality of the leachate flowing through the Site towards the canal (Coffey Geosciences Pty Ltd, 2003). The quality of the leachate, both within and outside the cut-off bentonite wall, was not to change in the medium term.

Under the VRA (No. 26050), the principal requirements of the collection and treatment system was to ensure leachate generated from the landfill was first collected to prevent over topping and collected and appropriately transported to the designated treatment system. Once at the leachate treatment system, the leachate would be treated to allow for reuse as irrigation. Based on the background review, treated leachate does not appear to have been used for irrigation but was instead discharged to sewer under an industrial trade wastewater agreement with Sydney Water.

The leachate management system consists of a 1.4km subsoil drainage system, six leachate pumping stations, a leachate transfer pipework/drain, and an on-site leachate treatment plant. Leachate generated from the landfill flows towards Alexandra Canal and is then intercepted by the drainage system leading to a series of leachate sumps. Leachate is then pumped to the leachate treatment plant, treated and then disposed to sewer in accordance with the Sydney Water Trade Waste Agreement.

5.2 Groundwater and Leachate

Groundwater levels were originally monitored along the bentonite wall using eighteen internal monitoring wells (MPI2 to MPI6, MPI8 to MPI20), and one on top of the landfill (TL9). Eleven external wells (MPE1 to MPE11) were also installed to monitor potential seepage through the wall (Coffey Geosciences Pty Ltd, 2005). Wells are generally located in pairs on either side of the bentonite wall, as can be seen in Figure 5-1. The 2003 RAP target for internal water levels was 1.0m AHD (Coffey Geosciences Pty Ltd, 2003).

[3] The Tenix 2006 report was not provided for review during the preparation of this document.

Figure 5-1: Monitoring wells and leachate pump pits located along the bentonite wall

Source: Figure 2 - *Cut Off Wall Validation Report (Coffey Geosciences Pty Ltd, 2005)*

5.2.1 Hydrogeology

The early geotechnical investigations indicated the wetland area was hydraulically up-gradient of the rest of the Tempe landfill, with a general groundwater flow towards Alexandra Canal in a North-east direction. The system is complex, with localised perching of groundwater on less permeable zones within the fill materials (Coffey Geosciences Pty Ltd, 2003). More recent investigations have modelled the local groundwater conditions and levels at the regional scale (WSP & GHD, 2019) and confirmed the Site flow direction (Figure 5-2). The report also indicated that groundwater levels on Site are 1-2m AHD, with an estimated velocity through the filled areas of 0.135 m/day (WSP & GHD, 2019).

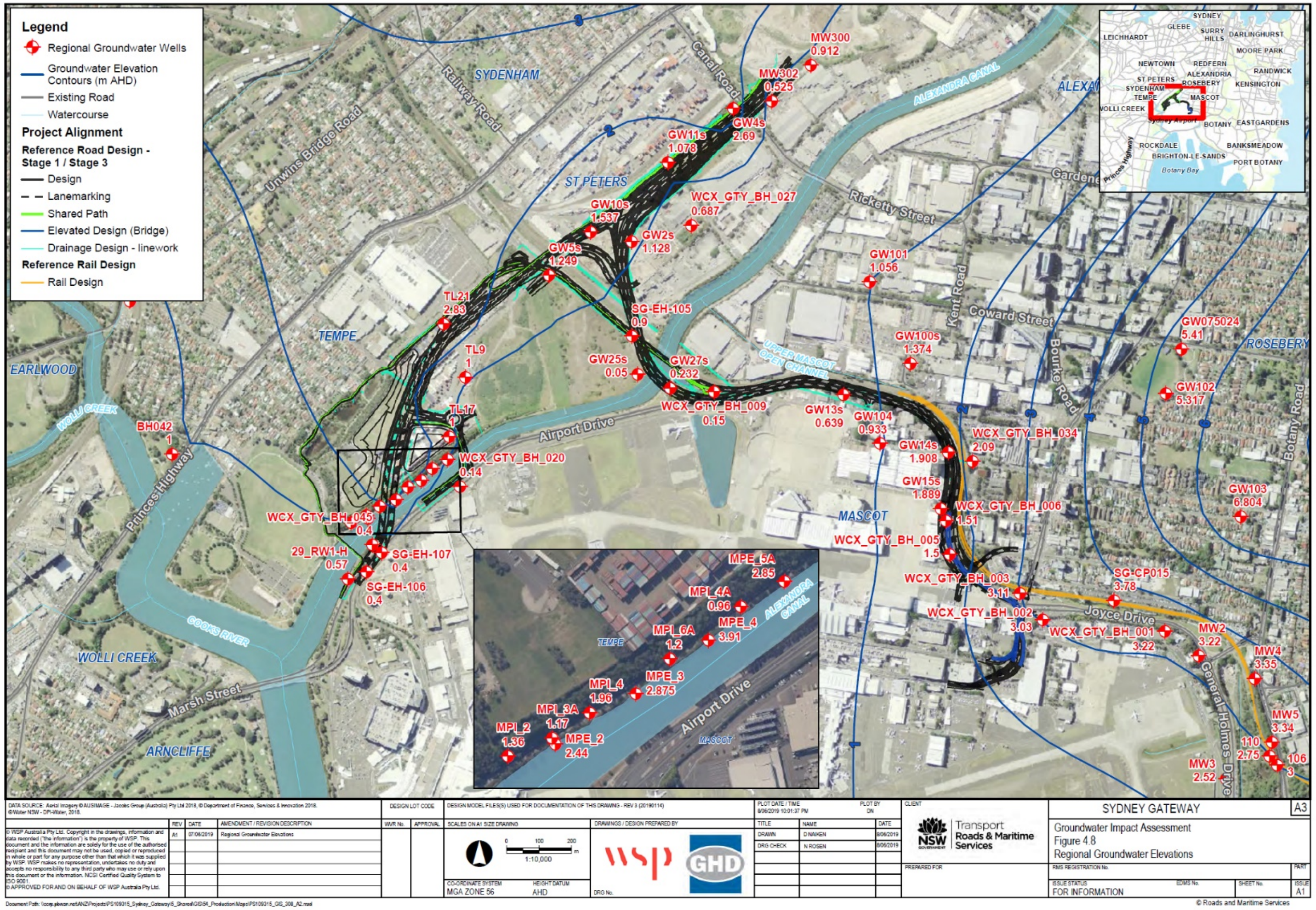


Figure 5-2: Groundwater contours

Source: Technical Working Paper 7 - Groundwater (WSP & GHD, 2019)

The groundwater at the Site is impacted by leachate generated from rainfall infiltration and waste decomposition. Previous assessments of groundwater at the Site under the VRA determined that the principal contaminants were metals and ammonia.

5.2.2 Leachate Characterisation

The initial leachate signature (concentration and contaminants composition) pre-remediation was characterised in 2003 (Coffey Geosciences Pty Ltd, 2003, Australian Wetlands, 2003). The reports found that Copper, Lead, Zinc, Total Petroleum Hydrocarbons (TPH) C_6-C_{36} and Ammonia were the main Contaminants of Concern (CoCs). The ANZECC marine thresholds for these contaminants (ANZECC, 2000) were provided for comparative purposes, although it is recognised that they are not legally relevant in this context (Table 5-1).

Table 5-1: 2003 reported leachate signature across 34 samples (Australian Wetlands, 2003)

CoC	Samples exceeding threshold	Concentration Threshold (µg/L)[1]	Sample Range (µg/L)	Sample Average Concentration (µg/L)
Copper	20	1.5	<1.0 - 6.0	3.0
Lead	6	4.4	<1.0 - 12.0	4.4
Zinc	24	15.0	6.0 - 96.0	24.0
TPH C_6-C_{36}	15	600.0	ND - 4,461.0	1,267.0
Ammonia	34	910.0	2,510.0 - 180,000.0	86,453.0

[1] Threshold values were taken from the ANZECC guidelines for the protection of 95% of species in marine and freshwater (ANZECC, 2000).

ND = Non-Detected

Coffey Environmental undertook post-remediation monitoring in 2006 (Coffey Environments, 2007), which found that the leachate treatment plant only functioned at about 60% of design capacity between July and December 2006, with discontinuous running the rest of the year (Coffey Environments, 2007). The report indicates that by 30 November 2006, the pumping rate was doubled to help manage groundwater levels. Half of the pumped leachate was treated, before being mixed with the remaining untreated leachate and discharged to sewer.

The investigation also identified several issues with the monitoring system in place, with a number of data logger failures occurring in early 2006 for MPI4, MPI9, MPI14 and MPI20; the data logger for MPI2 failed for a month in late May 2006 but recovered. Data loggers MPI2, MPI5, MPI11 and MPI12 failed in December 2006 (Coffey Environments, 2007). Leachate seepage was also identified in August 2006 near MPI2; this over-topping was attributed to faults with the leachate treatment plant management system (Coffey Environments, 2007).

2006 water quality monitoring results identified that the concentration of ammonia in external monitoring wells had reduced from a pre-remediation average of 89.46 mg/L (measured close to bentonite wall location) to a post remediation average of 53.68 mg/L (inside wall), and that concentrations on the outside of the wall had decreased to 8.59 mg/L (Coffey Environments, 2007). The report also indicated that CoCs were below detection limits and ammonia was generally below the guideline threshold in surface water samples collected from the canal (

Table 5-2) throughout the year (Coffey Environments, 2007). The peak in ammonia measured in the canal in August 2006 is attributed to overtopping of the wall at that period. The lower ammonia levels detected in the external wells compared to internal wells is generally supported by 2018 and 2019 monitoring, although the concentrations are higher than those reported in 2006 (Table 5-3). Current leachate conditions within the Alexandra Canal are reported in *Technical Working Paper 8 – Water Quality.*

Table 5-2: CoC post-remediation – Average well values for four sampling events in 2006

CoCs	Internal Wells (MPI3, MPI8, MPI12 and MPI16)				External Wells (MPE2, MPE4, MPE6 and MPE8)				Canal Surface Water #1 and #2 combined			
	21 Apr	30 May	31 Aug	30 Nov	21 Apr	30 May	31 Aug	30 Nov	21 Apr	30 May	31 Aug	30 Nov
Copper (µg/L)	<20	<20	<10	2.00	<20	<20	<10	3.00	<20	<20	<10	<20
Lead (µg/L)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Zinc (µg/L)	<50	<50	<50	34.50	55.00	62.00	47.00	60.00	<50	<50	<50	<50
Sum TPH C_6-C_{36} (µg/L)	300.00	390.00	462.00	720.00	ND	<220	<220	100.00	ND	ND	ND	ND
Ammonia (mg/L)	53.68	53.01	61.00	84.10	8.59	15.24	9.00	10.33	0.32	0.10	1.82	0.09

Note: ND means Not Detected. Non-specified numbers (e.g. <10) are reported as per the original Coffey report and are likely a representation of the wide range of values that have been averaged.

Table 5-3: CoC post-remediation for selected monitoring wells – December 2018/ February 2019

CoCs	MPI2	MPI18	Pair		Pair		Pair		Pair	
			MPI3/ MPI3A	MPE2	MPI8/ MPI8A	MPE4/ MPE5A	MPI12/ MPI12A	MPE6	MPI16	MPE8
December 2018										
Copper (µg/L)	<1	<1	<1	<1	N/A	84.00	<1	<1	<1	<1
Lead (µg/L)	<1	<1	<1	<1	N/A	2.00	<1	<1	<1	<1
Zinc (µg/L)	5.00	6.00	4.00	5.00	N/A	530.00	5.00	5.00	4.00	7.00
Ammonia (mg/L)	82.00	75.00	35.00	8.50	N/A	2.40	42.00	36.00	40.00	22.00
PFOS (µg/L)	0.28	0.06	0.06	<0.01	N/A	0.07	0.02	0.02	0.01	0.03
PFOA (µg/L)	0.50	0.21	0.11	0.01	N/A	0.03	0.03	0.03	0.04	0.04
PFHxS + PFOS (µg/L)	0.66	0.16	0.14	0.01	N/A	0.11	0.04	0.04	0.03	0.05
February 2019										
Copper (µg/L)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead (µg/L)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zinc (µg/L)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ammonia (mg/L)	94.00	90.00	39.00	12.00	90.00	13.00/ 0.30	48.00	25.00	100.00	25.00
PFOS (µg/L)	0.30	0.06	0.11	0.01	N/A	0.18	0.02	0.02	N/A	N/A
PFOA (µg/L)	0.53	0.20	0.14	0.02	N/A	0.09	0.03	0.03	N/A	N/A
PFHxS + PFOS (µg/L)	0.62	0.18	0.24	0.03	N/A	0.29	0.05	0.04	N/A	N/A

Note: N/A means not measured

Monitoring of the leachate present in the pump pits (Figure 5-1) was also undertaken in 2018/2019 to investigate the levels of CoCs and the potential presence of per- and poly-fluoroalkyl substances (PFAS) in groundwater (Table 5-3) and leachate (Table 5-5). PFAS were detected in the samples, albeit at low concentrations compared to health-based and ecological guideline values in the PFAS National Environmental Management Plan (HEPA, 2018). PFOA levels complied with the Drinking water criteria and 99% Species Protection Limit (SPL) (Table 5-4). PFOS generally complied with the 95% SPL and always complied the 90% SPL (Table 5-4). PFHxS + PFOS complied with the Recreational water criterion and often the drinking water criterion as well (Table 5-4). As a result, PFAS are not considered to be of concern on site.

Table 5-4: PFAS threshold criteria (HEPA, 2018)

CoC	Drinking Water (µg/L)	Recreational Water (µg/L)	99% SPL (µg/L)	95% SPL (µg/L)	90% SPL (µg/L)
PFOS	N/A	N/A	0.23×10^{-3}	0.13	2.00
PFOA	0.56	5.60	19.00	220.00	632.00
PFHxS + PFOS	0.07	0.70	N/A	N/A	N/A

The NEMP thresholds for PFAS are provided for comparative purposes only as it is recognised that they are not legally relevant in this context since the leachate is not used for drinking or recreational purposes. Currently, the Trade Waste Agreement (managed by Sydney Water) for the Site does not have a sampling requirement or criteria for PFAS discharge to sewer.

Table 5-5: CoC monitoring results within the leachate pump pits across four monitoring events in 2019

Date	Pit 1				Pit 2				Pit 3			
	11 Feb	18 Feb	25 Feb	4 Mar	11 Feb	18 Feb	25 Feb	4 Mar	11 Feb	18 Feb	25 Feb	4 Mar
Depth to water (m)	DRY	DRY	DRY	2.49	1.10	1.50	1.10	1.30	1.10	1.00	0.90	0.99
Ammonia (mg/L)	DRY	DRY	DRY	0.98	130.00	100.00	110.00	110.00	110.00	100.00	100.00	87.00
PFOA (µg/L)	DRY	DRY	DRY	0.03	0.09	0.11	N/A	0.08	0.06	0.09	N/A	0.06
PFOS (µg/L)	DRY	DRY	DRY	0.03	0.10	0.06	N/A	0.04	0.06	0.06	N/A	0.03
PFHxS + PFOS (µg/L)	DRY	DRY	DRY	0.04	0.15	0.12	N/A	0.08	0.10	0.11	N/A	0.07
TRH C10-C36 (mg/L)[1]	DRY	DRY	DRY	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Date	Pit 4				Pit 5				Pit 6			
	11 Feb	18 Feb	25 Feb	4 Mar	11 Feb	18 Feb	25 Feb	4 Mar	11 Feb	18 Feb	25 Feb	4 Mar
Depth to water (m)	0.98	0.96	0.94	0.89	1.00	1.10	0.97	0.94	1.20	1.20	1.54	1.54
Ammonia (mg/L)	110.00	88.00	96.00	81.00	110.00	96.00	82.00	88.00	120.00	89.00	95.00	88.00
PFOA (µg/L)	0.07	0.08	N/A	0.07	0.07	0.11	N/A	0.11	0.07	0.10	N/A	0.09
PFOS (µg/L)	0.07	0.05	N/A	0.04	0.07	0.07	N/A	0.08	0.07	0.07	N/A	0.07
PFHxS + PFOS (µg/L)	0.11	0.11	N/A	0.09	0.12	0.14	N/A	0.15	0.12	0.14	N/A	0.14
TRH C10-C36 (mg/L)[1]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

[1] 1999 NEPM fractions
Note: N/A means not measured; DRY indicates there was no liquid in the pit. Pits are 2.5m deep.

5.2.3 Standing water levels

The cut-off wall validation report indicates the piezometers (also referred to as "monitoring wells") were installed approximately 5m inside the wall (Coffey Geosciences Pty Ltd, 2005). It is evident from the reports sighted that the monitoring well system has changed over time, either through naming conventions, or due to replacement of faulty wells. Standing water level (SWL) measurements in the monitoring wells were collected in 2004 before and after installation of the cut-off wall as well as in 2005 after installation of the leachate management system (Coffey Geosciences Pty Ltd, 2005), in 2006 (Coffey Environments, 2007), in January 2018 (Uminex, February 2018), and in late 2018/early 2019 (AECOM, 2019). These are presented in Table 5-6.

Initial 2004 measurements prior to the installation of the wall for the internal wells were broadly in line with the external measurements after installation. Internal measurements increased significantly after installation and were generally higher than external measurements, indicating that was acting as a significant impediment to the flow of leachate towards the canal. It is worth noting that the levels reported in 2004 were prior to the installation of the leachate management system, which could explain why some of the 2004 values are higher than the reported top of the wall (1.4m AHD average). Tidal influence in the internal wells was also reported as lower (0.1m high) compared to that prior to installation (0.01m to 0.6m high internally, 0.8m high externally) (Coffey Geosciences Pty Ltd, 2005). Subsequent 2005 measurements of the water levels in the internal wells after the leachate management system was put in place were inconclusive due to issues with the pump system (Coffey Geosciences Pty Ltd, 2005). However, it is noted that the levels were comparatively lower than 2004 measurements (Table 5-6).

The January 2018 measurements by Uminex were also noted to be higher than the reported top of the wall (Uminex, February 2018). Uminex attributed these discrepancies to the use of old (2005) survey data for the internal well measures, the later installation of external wells with potentially different survey data, and the general replacement of wells over time. Considering the matching external well values are much lower than expected if over-topping was occurring, this explanation appears reasonable.

Table 5-6: SWL in monitoring wells along the bentonite wall over multiple years – in meters (AHD)

ID	MPI3/ MPI3A	MPE2	MPI5	MPE3	MPI8/ MPI8A	MPE4/ MPE5A	MPI10/ MPI10A	MPE5	MPI12/ MPI12A	MPE6	MPI14/ MPI4A	MPE7	MPI16	MPE8
May 2004	0.40	N/A	0.45	N/A	N/A	N/A	0.50	N/A	N/A	N/A	0.22	N/A	0.63	N/A
Nov/ Dec 2004	**1.62**	0.25	**1.90**	0.00	1.26	0.20	1.02	0.00	**1.70**	0.20	**1.57**	0.83	**1.46**	0.25
Jun/Aug 2005	**1.40**	N/A	**1.50**	N/A	0.85	N/A	0.70	N/A	1.25	N/A	**1.50**	N/A	1.25	N/A
Dec 2006	1.05	N/A	1.19	N/A	0.70	N/A	0.57	N/A	1.30	N/A	**1.41**	N/A	1.25	N/A
Jan 2018	**1.91**	0.17	N/A	0.21	**1.67**	0.02	**1.81**	-0.23	**1.99**	-0.05	**2.22**	-0.10	1.17	0.27
Dec 2018	0.61	0.01	**1.53**	0.31	N/A	0.44	1.23	0.58	0.84	0.31	0.02	-1.41	-1.25	-0.67
Feb 2019	0.76	0.37	DRY	0.23	N/A	0.18	1.27	-0.11	0.90	-0.10	1.25	-1.21	-1.20	-0.50
Mar 2019	0.90	0.45	DRY	0.32	N/A	-0.41	1.30	0.31	0.93	0.45	1.22	-1.53	-1.19	-0.53

ID	MPI18	MPE9	MPI19	MPE10	MPI20	MPE11	MPI2	MPI4	MPI4A	MPI6/ MPI6A	MPI9	MPI11/ MPI11A	MPI13/ MPI13A	MPI15	MPI17
May 2004	0.90	N/A	1.28	N/A	1.40	N/A	0.25	0.55	N/A	0.45	0.93	1.10	0.30	0.65	0.25
Nov/ Dec 2004	1.20	0.20	**1.80**	1.40	**2.08**	1.70	**1.40**	**1.90**	N/A	**1.66**	**1.50**	**1.40**	**1.65**	**1.45**	**1.40**
Jun/ Aug 2005	1.35	N/A	**1.60**	N/A	**1.80**	N/A	1.25	**1.45**	N/A	N/A	1.10	1.10	**1.40**	**1.45**	1.25
Dec 2006	1.30	N/A	**1.61**	N/A	**1.80**	N/A	1.25	1.22	N/A	1.20	1.10	1.02	**1.40**	**1.40**	1.25
Jan 2018	N/A	N/A	**1.71**	1.63	N/A	N/A	N/A	N/A	**1.46**	**1.45**	-0.20	**1.98**	**2.08**	1.34	N/A
Dec 2018	1.34	0.52	N/A	N/A	**1.64**	0.29	0.95	0.26	1.31	N/A	N/A	N/A	1.30	1.04	N/A
Feb 2019	1.05	0.29	N/A	N/A	**1.59**	0.25	0.90	-0.01	1.30	0.87	N/A	N/A	1.29	0.50	1.06
Mar 2019	0.99	0.20	N/A	N/A	**1.58**	0.36	0.94	0.32	1.32	0.94	N/A	N/A	1.28	0.24	1.00

Notes: MPI = Monitoring Point Internal, MPE = Monitoring Point External; paired wells are indicated by the large bold lines.
The double line indicates the point at which the bentonite cut-off wall was installed. N/A indicates a lack of result, either because a measurement was not taken or because of an unspecified technical issue. DRY indicates a recorded lack of water in the well at the time of measurement. Underlined values in bold are noted as higher than the top of the bentonite wall (1.4m average)

5.2.3.1 Delayed leachate discharge

The water balance model has assumed monthly rainfall will produce equivalent leachate volumes in the same month, which would be used to indicate potential storage volume requirements. To test this assumption, the sewer discharge rates provided by IWC and monthly rainfall from the Sydney airport weather station, the estimated monthly infiltration, and the known discharge volumes for 2018 were graphed (Figure 5-3).

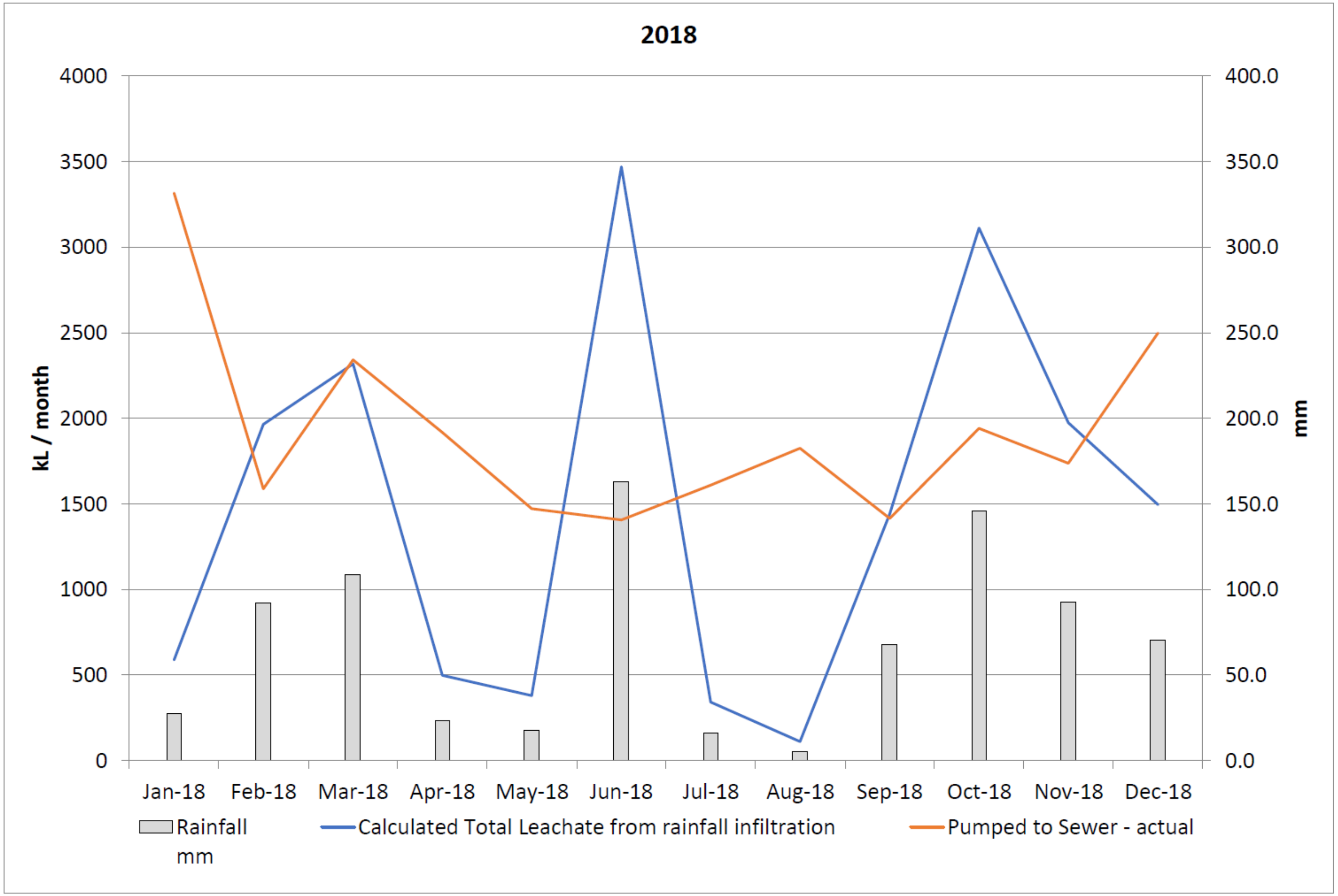


Figure 5-3: Water Balance Graphs

The results suggest the leachate generated in a high rainfall month will take approximately 90-120 days to produce a corresponding (and dampened) peak in the leachate discharge. Low rainfall months have less obvious drops in leachate generation in the following 90-120 days. The less obvious drop in leachate generation can be interpreted as an input of 10-20kL/day of groundwater, which is a rate also influenced by the rainfall in the 1650 ha catchment. It is possible that the rainfall infiltration takes a few months to reach the collections system, creating a time lag that spreads the "volume" over a few weeks and providing a buffer against a sudden influx of liquid.

5.2.4 Inspection of the existing leachate management system

Representatives from ESG, Roads and Maritime, and Inner West Council (IWC) inspected the existing leachate management system on 1 December 2018. During the inspection, the following observations were made:

- The leachate collection system appeared to be functional. However, it was evident leachate pumping capacity had reduced.
- The leachate treatment system appeared to be at the end of its effective life.
- The leachate levels were quite high in comparison to the bentonite cut-off wall, most likely due to the reduction in pumping capacity and overall leachate management system performance.

A recommendation of the inspection was a four-week monitoring program, which was carried out between 11 February 2019 to 4 March 2019. The sampling program found the total volume of leachate transferred from the six leachate pits to sewer (combination of treated and untreated leachate) was 1478 kilolitres (kL) over the 4-week period (average 52kL/day). Average volumes pumped to sewer varied from 40-108 kL/day (calculated weekly).

The leachate was mainly composed of mature and stable leachate with low ammonia, low organics (biological and chemical oxygen demand {BOD and COD}) and low total suspended solids. Ammonia concentrations within the leachate sump pits (indicated as "Pump Stations" in Figure 5-1) ranged between 81 mg/L to 130 mg/L, with evidence of a slight drop over the 4-week sampling period. Out of the six pits, Pit 2 had the highest ammonia concentration with an average of 112 mg/L. Pits 3-6 generally averaged 96 mg/L over the 4-week period. Pit 6 had an average of 88 mg/L during the monitoring periods, noting the pumps operate in series from Pits 1 to 6. Samples of the discharge to sewer were also collected on 25 February 2019 and 4 March 2019, with ammonia results of 77 mg/L and 78 mg/L respectively.

Leachate levels within the internal and external monitoring wells were all below the bentonite cut-off wall (approximately 0.8m to 3.2m). During the monitoring period, leachate levels were generally consistent and there was no evidence of overtopping. It was difficult to establish the zone of influence around the leachate sump pits based on the groundwater levels. It is noted that leachate levels in the sump pits ranged between 1m and 1.5m below the ground level (Figure 5-4).

Figure 5-4: Leachate sump and groundwater bore levels 2019

The Leachate Treatment Plant was commissioned in late 2004 and designed to have the capacity to treat an average flow of 80 kL/day and a peak flow of 180 kL/day. Sampling program results indicate that the current LTP daily leachate extraction rates vary in the order of 60-100 kL/day and are sufficient to manage the leachate levels near the bentonite cut-off wall. This rate is also significantly less than the daily maximum of 250 kL and average daily discharge of 150 kL authorised by the Trade Waste Agreement (Sydney Water Corporation, 2017).

5.3 Landfill gas

Landfill gas was first identified as an issue in the 2003 remediation action plan (RAP) (Coffey Geosciences Pty Ltd, 2003). Further investigation was recommended to inform whether management measures were required. The landfill gas monitoring program carried out in 2005 identified offsite landfill gas migration was occurring.

The 2005 landfill gas investigation indicated that the risk of significant impacts to residents and workers health was low (Coffey, 2006). The report also concluded that gas generation was expected to be within Phase 4 of a landfill cycle, with stable concentrations of methane, carbon dioxide, and nitrogen, and with ongoing reductions in methane production. Finally, the report indicated that landfill gas generation is likely to continue reducing from current levels as most of the organic and putrescible fill material was deposited over 30 years ago.

On 11 October 2006, the NSW EPA varied the conditions of the surrender notice (Surrender Condition Notice 1048787). As part of the variation IWC was required to undertake a targeted remedial investigation to assess the feasibility of, and assist in designing of, landfill gas mitigation measures (NSW EPA, 2006). A number of monitoring wells were installed between 2005 and 2006 (Figure 5-5, wells GW9-14 and GW16-21) to monitor the site along the affected areas, both on IWC-owned land and within surrounding properties.

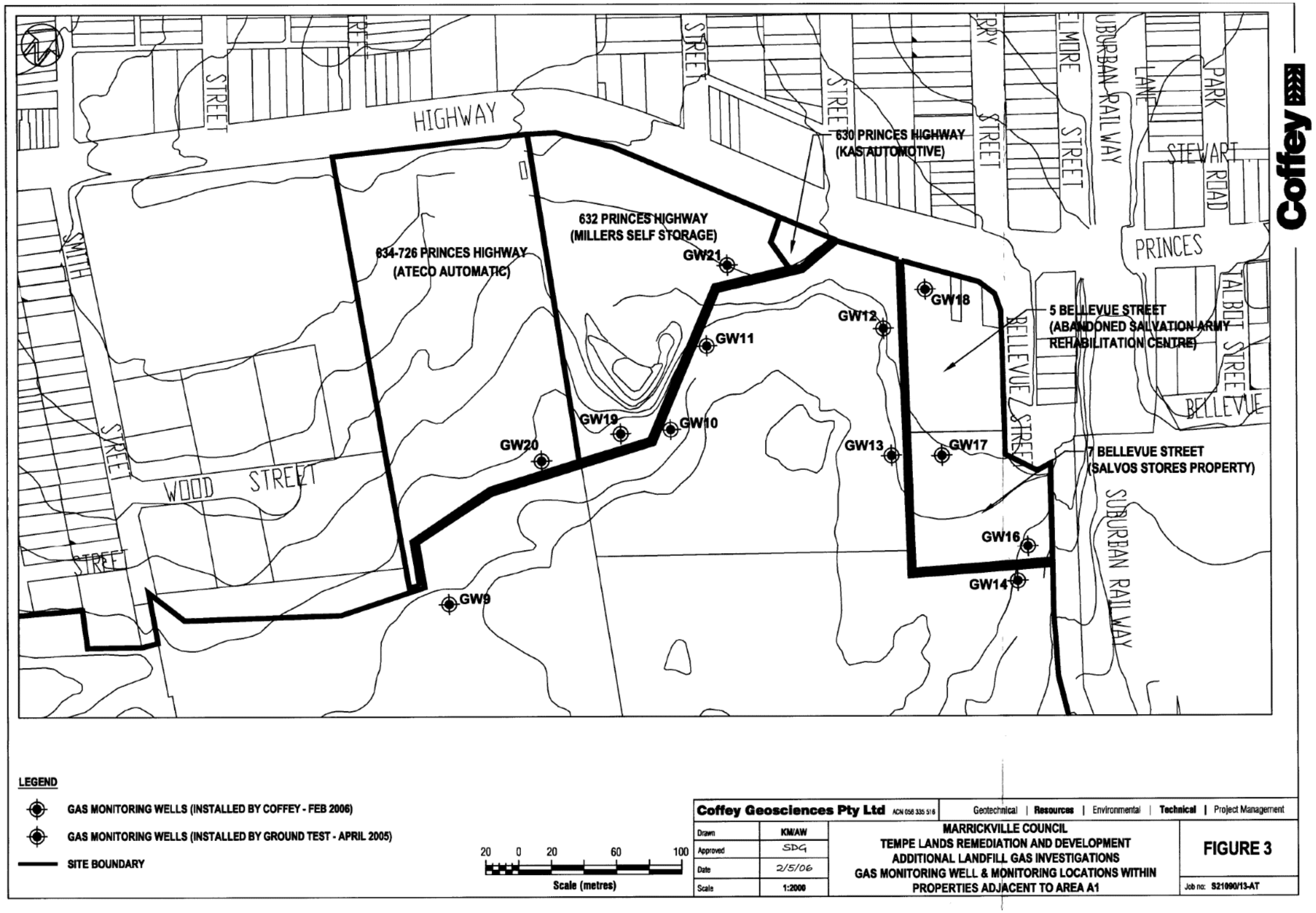


Figure 5-5: Historical Gas Monitoring Wells

Source: DRAFT Additional Landfill Gas Investigations (Coffey, 2006)

Between 2005 and 2009 landfill gas monitoring was carried out in accordance with conditions required under the EPL Surrender Notice. The monitoring results indicated that off-site landfill gas migration was occurring through the north-western property boundary. In accordance with the landfill gas migration requirement, a passive interception and venting trench was installed along the impacted boundary (Coffey Environments, 2010). The trench included a series of 6m tall venting stacks fitted with wind-driven ventilators (also known as rotating cowls) that extend to a sub-surface gravel filled trench and wells (Figure 5-5, thickest black line along the monitoring wells). The trench and passive venting system extend into the current IKEA property footprint (Environ, 2013).

5.3.1 Gas Monitoring along IKEA border

Ongoing gas monitoring has been carried out between 2016 and 2018 by UMINEX on behalf of IWC (Uminex, January 2018). The Uminex report noted that a number of the initial wells had been lost or damaged over time due to the development of the commercial properties along Areas 1A and 1B (Uminex, January 2018), such as during the construction of IKEA and Decathlon retail facilities. As a result, replacement wells were installed as close as possible to the original locations. The report also indicated that the mitigation measures implemented (in the form of venting stack) appeared to still be functioning in a satisfactory capacity (Uminex, January 2018).

At the time of the last sampling event in 2018, only six gas monitoring wells were available for monitoring: gas monitoring wells GW9A, GW10A and GW14 located on the landfill side and GW11A, GW16 and GW19A located outside of the interception and venting trench (Figure 5-5, the addition of an “A” is assumed to indicate the original well was replaced after the redevelopment of the site). During the sampling, these locations were described as being in generally poor condition with damaged well caps and well covers (Uminex, January 2018).

The Solid Waste Landfill Guidelines require a methane management plan where methane concentrations exceed 1.0% methane by volume which is equivalent to 20% of the lower explosive limit (LEL). The results from the January 2018 monitoring event indicated that methane levels on the inside of the passive interception and venting trench are greater than the 1.0% guideline concentration. In addition, there was evidence of elevated concentrations of carbon dioxide and depleted concentrations of oxygen. Outside of the passive interception and venting trench methane concentrations are below the 1.0% guideline, while levels of carbon dioxide were low and oxygen levels were near ambient concentrations. A summary of the most recent landfill gas monitoring data between 2016 and 2018 is provided in Table 5-7 (Uminex, January 2018).

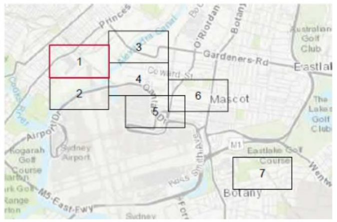
Table 5-7: Landfill gas monitoring carried out in accordance with licence requirements

Date	Gas	Inside Passive Interception and Venting Trench					Outside Passive Interception and Venting Trench			
		GW9A	GW10A	GW12A	GW13A	GW14	GW11A	GW16	GW19A	GW21A
29/2/16	CH_4 (%)	21.1	0.0	0.0	0.9	0.0	1.9	0.0	0.0	0.0
	CO_2 (%)	5.9	0.0	0.0	3.0	0.0	8.5	15.5	0.0	0.7
	O_2 (%)	1.8	20.7	20.9	15.8	20.9	7.2	2.7	20.7	20.6
	Flow Rate (l/hour)	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6/9/16	CH_4 (%)	26.6	Not Sampled	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	CO_2 (%)	7.0		0.0	0.1	0.1	14.8	4.8	5.2	8.4
	O_2 (%)	0.0		20.4	20.3	20.3	0.6	14.1	13.0	14.0
	Flow Rate (l/hour)	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
17/2/17	CH_4 (%)	34.5	Not sampled	9.9	30.2	7.0	5.6	0.0	0.0	0.0
	CO_2 (%)	8.0		7.6	12.0	16.0	16.1	19.8	7.0	4.6
	O_2 (%)	0.0		10.1	11.1	0.4	0.0	1.6	11.5	17.0
	Flow Rate (l/hour)	5.8		1.3	1.3	2.1	0.0	1.8	0.1	0.1
6/2/18	CH_4 (%)	21.4	54.7	Destroyed	Destroyed	5.0	NS	0.6	1.0	NS
	CO_2 (%)	8.7	22.0			14.0		0.1	0.1	
	O_2 (%)	0.0	0.0			0.4		21.0	20.0	
	Flow Rate (l/hour)	0.0	0.0			0.0		0.0	0.0	

5.3.2 Additional Gas Monitoring across the Site

Recent investigations carried out on behalf of Roads and Maritime in early 2019 have identified the presence of methane at 30-50% volume/volume (v/v) in the golf driving range and container storage depot (AECOM, 2019). Landfill gas was also identified at 5% v/v in one of the external wells along the Alexandra Canal (MPE7, Figures 5-6 Sheet 2), east of the container storage depot. The area west of the depot, including the dog park, had concentrations varying between 0.0 and 0.2% v/v methane.

GROUNDWATER LOCATIONS - SHEET 1



Legend

- Existing groundwater well
- New groundwater well
- Railway

Figures 5-6: AECOM Gas monitoring locations

Source: Interim Groundwater and Landfill Gas Data (AECOM, 2019)

5.3.3 Gas modelling

The current interception trench/venting system along the IKEA border as well as monitoring to date around the site support the assumptions that landfill gas is present in the waste mass but not produced in sufficient volumes to record gas flows or gas under pressure.

The standard methods currently used to estimate gas production from landfills require data on the tonnage and composition of waste received each year the landfill is operational to be known. This detailed information is not available for the Former Tempe Landfill, requiring the use of an alternative landfill gas estimation model such as the LEA estimation model. This model uses the volume of the waste mass (calculated using the known values for area and height of the landfill) and default values for waste composition, rainfall and percentage methane in the landfill gas. The model then estimates the volatile components of landfill gas with methane as a known proportional volume.

The methane production calculated using this model is estimated to be less than 30 m^3/hour. This is similar to other landfills in the Sydney region that have been closed for more than 30 years. As a result, while some of the detected methane concentrations are high (AECOM, 2019), the low production rate means that concentrations would be expected to rapidly decrease should venting occur.

5.4 Overall Environmental Condition of the Site

The recent investigations confirm the presence of the cap layer around the Alexandra Canal and Golf driving range (AECOM, 2019). The cap, the overall leachate management system, and the bentonite cut-off wall are preventing leachate entering the canal.

Based on the information available, volumes of leachate generated from the landfill appear to be within manageable limits of the existing leachate management system. The recent inspection of the overall leachate management system indicated that the treatment part is in poor condition and appears to be at the end of its effective life. The 2004 Site Audit Report (Environ, 2004) identified a need to replace the MesoLite media used in the leachate treatment plant every 750 days should the plant operate at the predicted 60kL/day all year long. No information on whether this was done has been sighted during this review. The leachate collection components of the system appeared to be functioning adequately to meet the requirements.

The standing water level data collected since 2006 suggests water levels are either in close proximity or potentially over topping the existing bentonite cut-off wall. Over topping of the existing bentonite cut-off wall has the potential to occur during rainfall or through increased infiltration into the landfill. Groundwater monitoring data also did not identify an increase in the concentrations of ammonia in the monitoring wells located outside the bentonite cut-off wall. It should be noted however that there is a significant gap in sighted reports between 2008 and 2018 data.

Landfill gas monitoring/ management on the Site currently only takes place along the IKEA boundary. Monitoring has been carried out at this location for approximately 12 years. Based on the data available, it is evident that conditions are relatively stable (i.e. concentrations have remained relatively low outside the passive interception and venting trench while relatively high within the landfill area), indicating that the system is performing acceptably.

6 Construction Impacts

During the construction phase, around 30 per cent of the construction footprint within the former Tempe Landfill would be removed, generating more than 90,000m^3 of excavated landfill material. Based on the concept design, the depth of excavation extends to around four metres in certain areas. Excavation would therefore extend through the capping layer and the construction fill layer, but is unlikely to extend to the putrescible waste layers, which is at an average depth of around four metres (Coffey Geosciences Pty Ltd, 2003). The consequential impacts of excavating into the closed landfill have been grouped into the following key areas, which are described in more detail below:

- Landfill integrity
- Groundwater and leachate
- Landfill gas
- Landfill odour.

An assessment of landfill odour has been documented in the Tempe Landfill Odour Assessment -Technical Memo.

6.1 Landfill Integrity

Landfill integrity refers to the capping layer, bentonite cut-off wall, and the leachate collection and treatment system. The following potential impacts to the landfill integrity during construction have been identified:

- Ground disturbances due to equipment and machinery moving across the site and excavating through the capping layer have the potential to result in stability issues such as the movement or collapse of landfill material, should parts of the waste not be adequately compacted.
- Ground disturbance to the capping layer or landfill waste has the potential to result in increased surface water infiltration.
- Removal of the capping layer during construction also has the potential for increased infiltration into the landfill, resulting in increases in leachate generation (discussed in section 6.2).
- The above-mentioned potential increases in infiltration and waste movement have the potential to result in further disturbance or settlement of the capping layer.
- Based on the current concept design, piling to support piers for the Terminal 1 Connection bridge and the freight terminal bridge would be installed within the landfill footprint in proximity to the existing bentonite cut-off wall. As the wall forms part of the leachate containment system, any potential impact to its integrity could result in leachate entering Alexandria Canal. Accordingly, detailed design will seek to avoid interactions with the bentonite cut-off wall.
- Potential damage to the leachate collection system (e.g. sumps and pipes) during site excavation works. This has the potential to disrupt the collection and transfer of leachate to the treatment plant, thus causing leachate to build up and potentially overtop the bentonite wall.

- Disturbance/mobilisation of landfill material, including contaminants, due to the unknown nature of the waste contained on site. This includes excavating landfill material that is unsuitable for emplacement in the waste mounds, and reaching the putrescible waste layer.
- Disturbance/mobilisation of landfill material, including contaminants, through inappropriate handling and stockpiling.

6.1.1 Excavation and Relocation of Landfill Waste

The project would require excavation into the landfill material as well as the sorting and stockpiling of materials for containment on-site. The excavated landfill material would be progressively emplaced into new waste mounds (mound options are further discussed in section 7.1). While the final mound design is not yet decided (Figure 6-1 and Figure 6-2), the impacts of the new mounds would globally remain the same irrespective of the selected location.

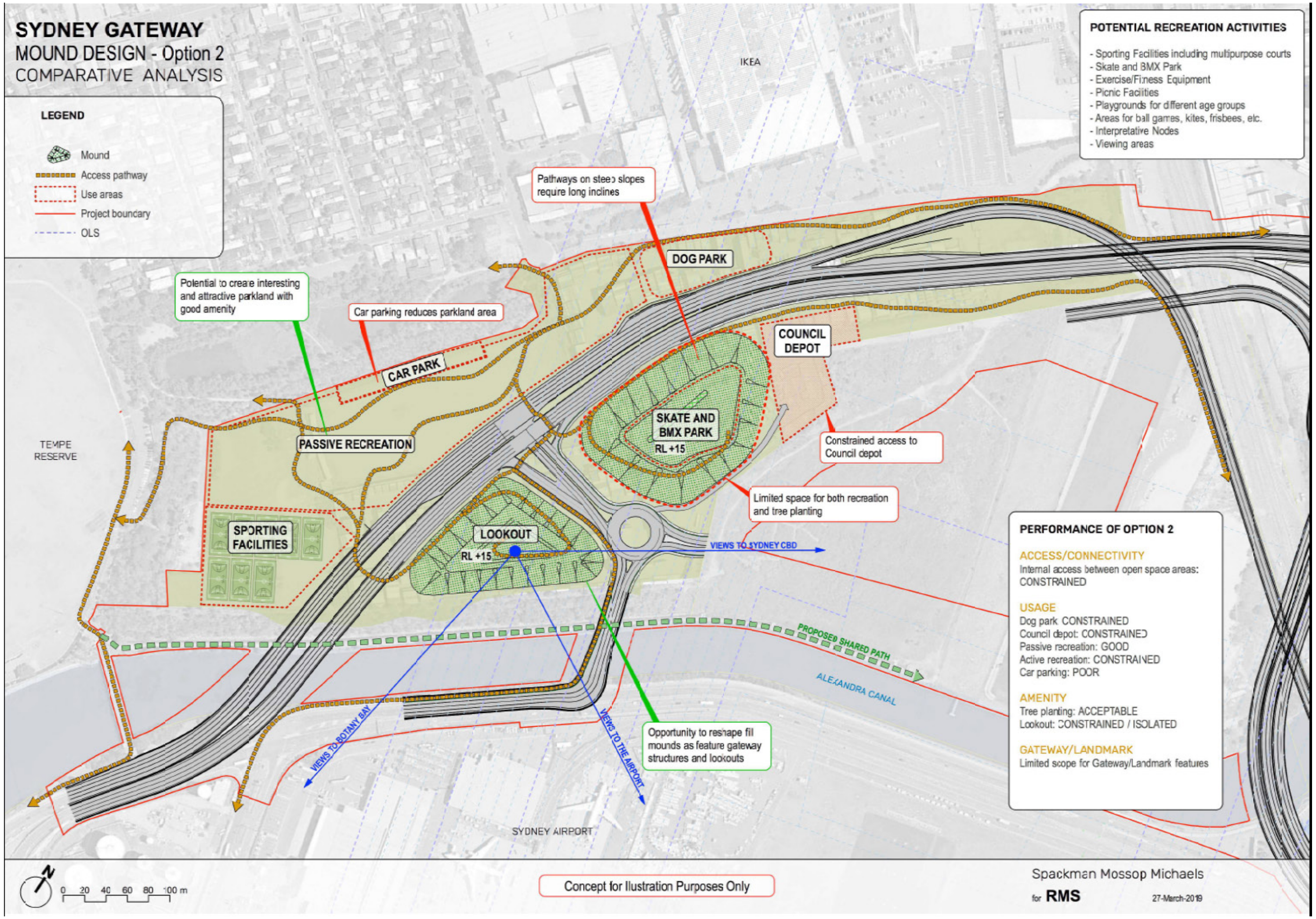


Figure 6-1: Option 2

Source: Roads and Maritime

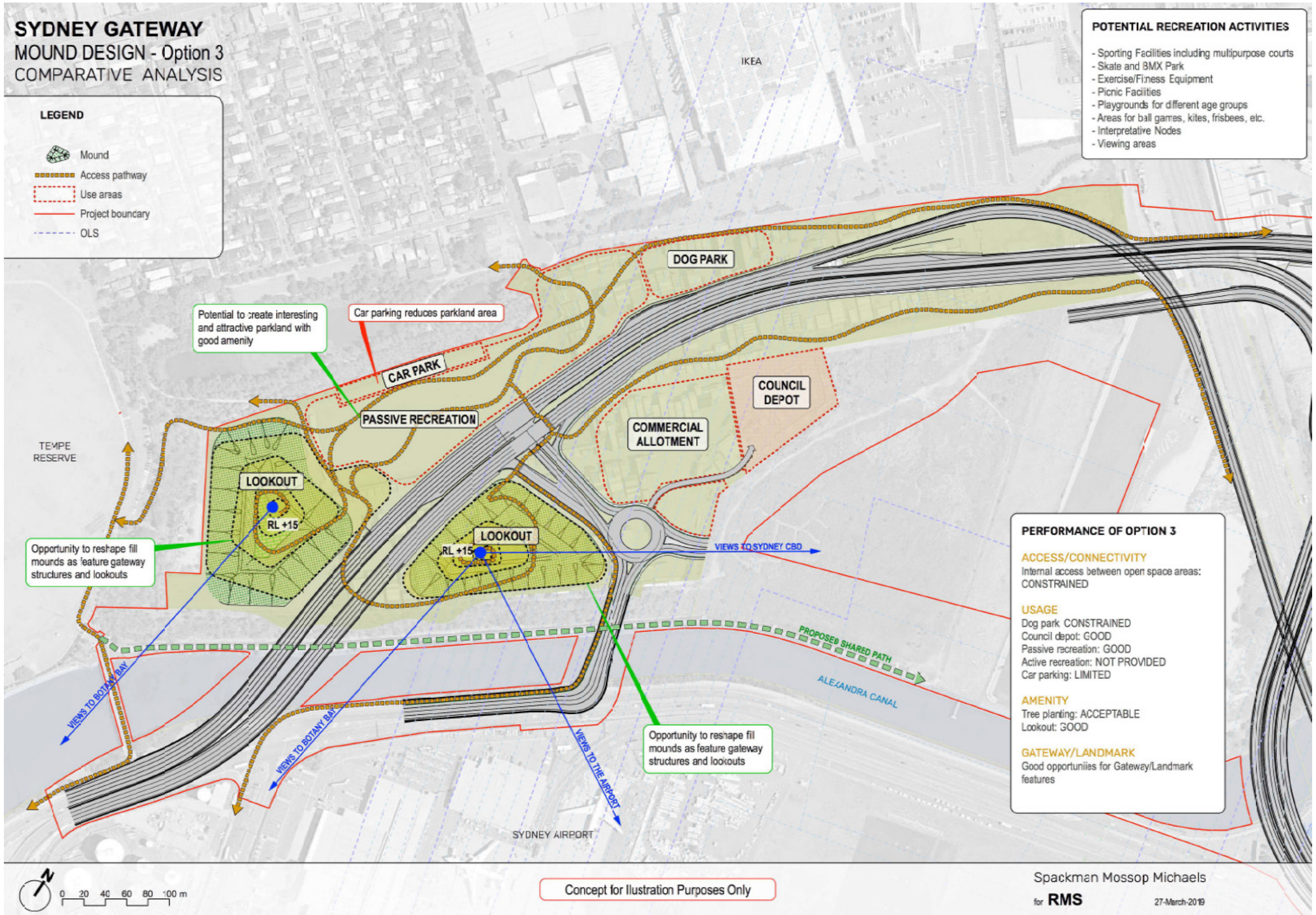


Figure 6-2: Option 3.

Source: Roads and Maritime

The weight of excavated waste material, in addition to the weight of construction related materials, has the potential to increase pressure to the landfill, thus creating settlement issues and affecting ground stability. As landfills are typically non-homogeneous and contain void spaces from leachate and landfill gas removal time, it is difficult to estimate the potential location and extent of settlement.

In addition to the above-mentioned settlement issues, there is the potential for some of the excavated landfill material to be unsuitable for stockpiling or emplacement within the new mounds. Unsuitable materials may include hazardous wastes, explosives, hazardous liquid drums, etc that are now managed differently under current EPA guidelines.

6.2 Leachate

Additional water infiltration during construction activities is likely to occur due to the removal of the existing cap, thus exposing a sub-layer with unknown permeability. Surface water infiltration can increase the generation and movement of leachate through the existing system, which may impact the leachate levels near the canal and bentonite cut-off wall. Subject to the volume of surface water infiltration and the capacity of the leachate management system, increases in leachate generation would potentially increase leachate levels near the wall. Any overtopping of the bentonite cut off wall would affect the water quality of Alexandra Canal.

Additionally, the emplacement of excavated material into new mounds has the potential to disturb or create settlement issues with the capping layer due to shifts in waste mass. This could have a squeeze-effect on leachate, shifting the current flow to new pathways.

Finally, there is the potential during excavation to block or change established leachate flow paths. This could result in leachate ponding within landfill or previously “untouched” waste encountering leachate and releasing additional contaminants.

6.2.1.1 Leachate and Model assumptions

As outlined in section 3.3, a water balance model was developed to assess potential changes to the leachate volumes produced during construction and operation. This section outlines the key inputs and model assumptions.

The model assumes the collected leachate is proportional to the monthly rainfall and is likely to be a mixture of infiltration through the landfill cap and groundwater from offsite catchments. The model also assumes this mixing continues for the construction period and that there are no significant changes to the offsite catchment input.

The model was generated assuming varying infiltration rates into revegetated, hardstand and road pavement areas (Table 6-1), and using average monthly rainfall statistics collected over 90-years from the nearby Sydney Airport (AMO 066037). The modelling also applied typical infiltration rates for active landfilling (as in Table 6-1) and assumed that standard mitigation measures will be put in place as described later.

Table 6-1: Assumed infiltration percentages

Landfill Parameters	Expected infiltration rate (%)[1]
Absorption into waste	3
Infiltration capped/ revegetated (existing)	10
Infiltration hardstand	1
Infiltration capped / revegetated (post road construction)	5
Infiltration sealed	1
Infiltration depots	5
Infiltration stripped	20[2]
Infiltration open cell	20[2]

[1]This rate is based on ESG's experience with leachate generation at other Sydney landfills.
[2]This is based on the capping advice report from Woodward-Clyde (Woodward-Clyde, 1999)

Additional assumptions were as follow:

- Assumed infiltration rates were compared to operational data from the known pumping rates (between 60 and 100 kL/day) and used to establish baseline conditions.
- Rainfall data from 1929 to 2018 has been sourced from the Bureau of Meteorology for the Sydney Airport AMO No. 066037.
- The mean annual rainfall data across this 90-year period was 1081.1mm for the Site.
- The year with the closest main rainfall data was 1992 (1082mm). Monthly values for that year were therefore used in the model to account for seasonal variations in rainfall.
- Infiltration rates on waste cells remains unchanged until the cells are capped.
- The majority of the existing waste mass is well compacted/ consolidated and largely degraded.
- All efforts will be made to divert stormwater away from the proposed excavation areas to minimise additional leachate generation.
- Daily cover of the stripped sections and relocated waste is used, with intermediate cover in place when not an operational area.
- The final capping will be at Solid Waste Landfill Guidelines performance criteria with lower infiltration rates than at present.
- Construction follows the proposed schedule:
  - Site is stripped over 3 months from January 2021
  - Excavation of waste occurs from February 2021 to August 2022
  - Stockpile of material stripped over the first 3 months is assumed to have similar infiltration rates hardstand/ compacted earth from March 2021
  - Waste mound 2 is filled between March 2021 to August 2021 (assumed even filling and capped following month)
  - Waste mound 1 is filled between September 2021 to December 2022 (assumed filled evenly and capped following month)
  - Waste mound 1 volume estimate – 35,000 m^3, waste mound 2 estimate – 55,000 m^3
  - Road construction at rate of 0.5 ha/month from July 2021.

The water balance used the timing proposed by Roads and Maritime for the stripping of capping material, excavation of waste, placement and capping of new waste mounds, construction of the roadway, and revegetation of those remaining parts of the landfill that were impacted by construction works. Table 6-2 summarises the relative proportions of vegetated versus hardstand areas across the Site that were used in the model. The areas were calculated using Figure 6-3.

Table 6-2: Assumed surface areas across the site

Tempe Landfill Areas	Area (ha)
Revegetated Areas	
- Sydney Airport land	7.04
- Golf Driving Range	3.53
- Dog Area	1.29
- Corridors	3.09
- Wetlands	4.05
Hardstand areas	16.52
Swamp Road	1.17
Council depot	0.38
Other Depot	0.77
TOTAL	37.51

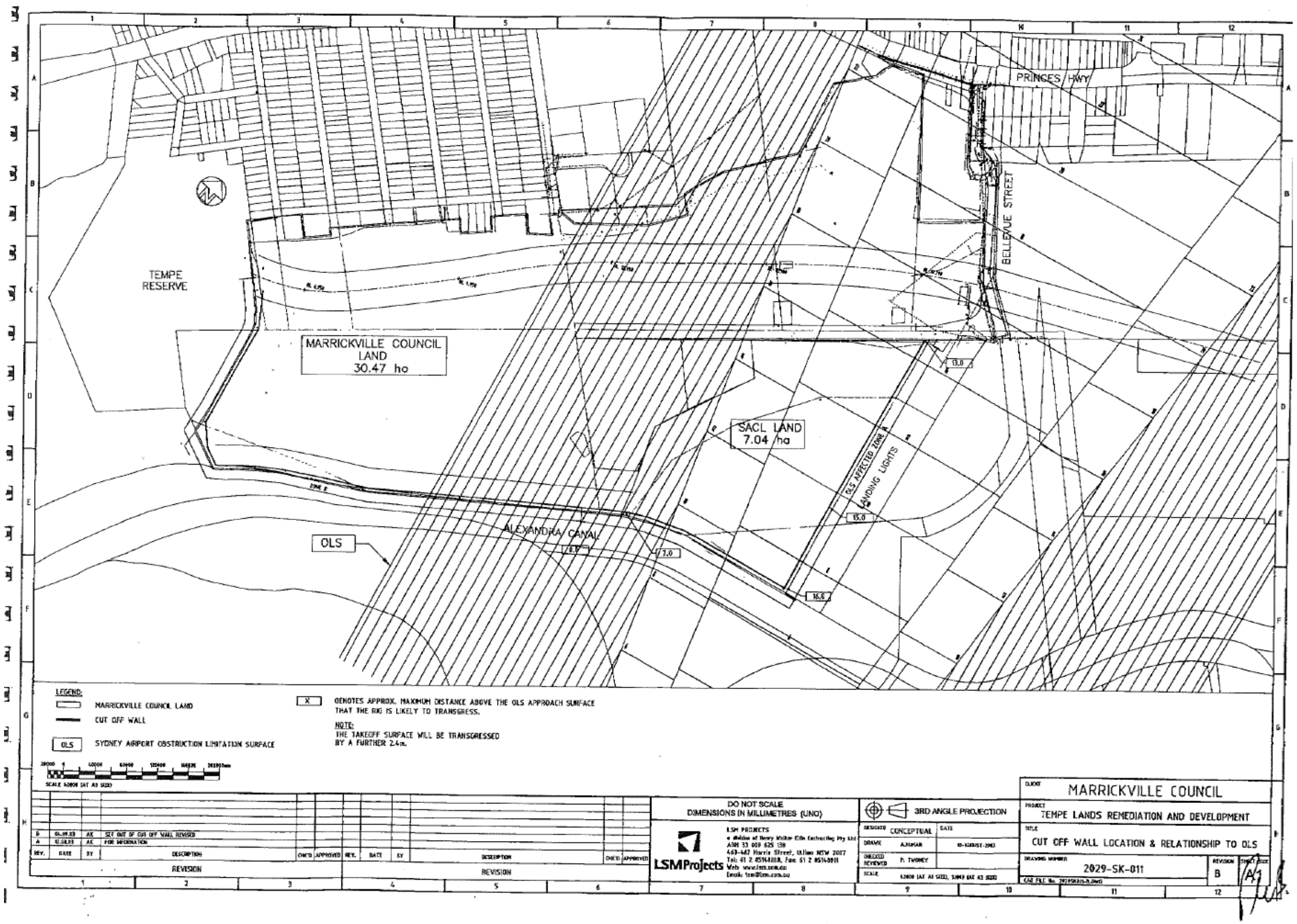


Figure 6-3: Tempe Landfill Construction Areas

Source: Roads and Maritime

6.2.1.2 Results of the modelling

The water balance indicates the following predicted volumes ***during construction*** from January 2021 to March 2023:

Scenario 1: Average rainfall

- Leachate generation is estimated at ***200 kL/day*** once the cap is stripped and excavation commences.

Scenario 2: Ninetieth percentile rainfall

- If the wettest year occurs in the first year of construction a leachate disposal rate of up to ***450 kL/day*** may be required to manage the predicted leachate volume.
- If the wettest year occurs in the second year of construction a leachate disposal rate of up to ***300 kL/day*** may be required to manage the predicted leachate volumes.
- If the wettest year occurs in the third year of construction a disposal rate of up to ***200 kL/day*** may be required to manage the predicted leachate production.

The findings from the leachate characterisation sampling program show the current raw leachate ammonia concentration levels are between 35-94mg/L in the groundwater wells (Table 5-3) and 81-130 mg/L in the sumps (Table 5-5). An increase in leachate generation may impact the ammonia levels adversely, although ammonia concentration in the leachate is likely to decrease during excavation works through dilution associated with additional rainfall infiltration into open waste areas (expected average ammonia levels <100 mg/L).

6.2.1 Changes in Leachate Flow Paths

As stated earlier, removal of the capping layer is expected to cause an increase in rainfall infiltration rate and lead to additional leachate generation during construction. The leachate is likely to continue to flow preferentially towards the leachate sumps and the bentonite cut-off wall as it follows the existing leachate drainage system. There is however the possibility that pre-loading on the Site, exposed landfill areas, and additional stockpiling or waste mounds would have a squeeze effect on existing leachate flows. This may cause a lateral shift of the flows towards the bentonite wall, as the wetlands and commercial buildings are generally hydraulically up gradient with restricted lateral movements potential.

Changes in leachate flow paths may affect the existing leachate management system by shifting the main leachate volume to parts of the site not currently experiencing flow, or by causing an increase in volumes to be collected and treated.

The current leachate level within the landfill is around 9-10 m below the landfill surface. At this depth, there is a minimal risk of leachate interaction during the shallow road excavation works. However, works associated with pier drilling and retaining walls are likely to intercept leachate flow and could result in leachate ponding and some localised odour. Alteration of existing leachate flow paths could result in an increase in leachate collection both in the short-term if perched leachate is reached and released, and in the long-term if there is the creation of a new preferential pathway through current blockages.

6.3 Landfill Gas

The breakdown of putrescible waste and organic matter in a landfill generates methane, carbon dioxide and other trace gases that may pose hazards to site safety, human health and surrounding environment. The combination of these is generically referred to as "Landfill gas". Generation of landfill gas can continue for many years after placement of the waste and needs to be managed.

While methane and carbon dioxide are odourless, other components of landfill gas (such as hydrogen sulfide and ammonia) can be odorous and impact on local amenity. Methane is also explosive when it is present at between 5% (lower explosive limit) and 15% (upper explosive limit) by volume (% v/v) in air. If present in excessive concentrations, methane or carbon dioxide can also be an asphyxiate. Landfill gas therefore poses a potential explosion or asphyxiation hazard when it migrates from the waste, either through the landfill surface or sub-surface.

As the proposed excavation and road construction works would involve removal of the existing landfill cap, there is potential for an increase in landfill gas emission, resulting in increased odour as well as explosion or asphyxiation risks. Similar impacts would result from the discovery of new/ unknown gas pockets in sections of the Site not currently monitored for landfill gas. Excavation works around the landfill may also potentially physically damage the existing gas collection systems along the IKEA boundary. This is however considered unlikely as the project is located well away from the system.

7 Operational Impacts

7.1 Landfill Integrity

Landfill settlement is expected to occur after the new waste mounds are constructed and the project roadworks are completed, with the resulting settlement having the potential to adversely affect the integrity of the leachate and gas management systems. Landfill settlement at the Site may arise from two main sources:

- Differences in the composition and thickness of landfill waste present beneath the landform surface at various levels, which could potentially cause integrity and performance issues in surface water drainage, subsurface water drainage pipes, leachate drainage pipes, and/or gas drainage pipes.
- Differences in foundation support for adjacent components, such as the landfill capping system at connection points with road infrastructure that is connected to underlying bedrock (for example retaining walls at bridge abutment and bridge piers). This may cause landform surface distortions and connection stresses.

Additional weight load from built infrastructure, such as roads, buildings, and vehicle weight, as well as the new waste mounds could result in a possible settlement of up to 0.5 to 1m over 30 years (expected life of Site) based on the type of waste reported to be within the landfill. In either case, settlement could result in fissures or breaches in the capping layer, which would potentially result in increased infiltration. Fissures also act as a preferential pathway for landfill gas emissions. Appropriate measures would be required to ensure the integrity of the landfill is safeguarded.

As discussed in section 5.1.1, the original capping layer was designed to be 0.5m thick across the site. Geotechnical investigations have however identified that the capping layer is actually around 0.2m under roads and container storage areas, and around 1m under the golf driving range. Following construction and emplacement of new waste mounds, a new landfill capping layer would be installed on disturbed areas to minimise the long-term leachate generation and gas generation. Any landfill gas flows beneath the cap would be collected in the gas drainage layer and directed to the passive gas collection system (Refer to Figure 8.4 showing typical landfill cap profile).

The new capping layer would be designed in accordance with the Solid Waste Landfill Guidelines to limit surface water infiltration into the underlying waste mass. The new cap would be no less than 1m in thickness across all disturbed areas, which would be an overall increase in capping thickness resulting in an overall decrease in potential landfill infiltration. Given that leachate production is estimated from infiltration across the total land area, the model predicted a small decrease in leachate production.

Due to the proposed shape and the size of the mounds, there is the potential for surface water runoff to cause scouring and erosion of the capping layer. Without mitigation, prolonged scouring has the potential to breach the capping layer, thereby causing increases in surface water infiltration, leachate seepage, and migration of landfill gasses. Surface water runoff also has the potential to cause scouring at the base of the mounds, potentially impacting the integrity of the capping layer. The design of the capping layer would need to be integrated with the design of surface water drainage to mitigate potential impacts to the integrity of the landfill - drainage design is expected to incorporate stormwater control device to minimise high velocity flows.

The design of the project through the Former Tempe landfill has been developed to reduce the long-term effect on the integrity of the Site. During operation, the pavement and road sub layers would form a barrier to the waste, limiting surface water infiltration. Similarly, stormwater drainage would be separated from the underlying waste and from overland flows across the surface of the landfill. As the road design would connect to the adjacent capping layer, the integrity of the landfill is potentially weakened along the interface. As for the new mounds, the design of the capping layer would need to be integrated with the road design to mitigate potential impacts to the integrity of the landfill.

Finally, the integration of a passive gas collection system and drainage layer into the cap and mound design (discussed further in section 7.38.1.3) would prevent the build-up of gas over time.

7.2 Leachate

The main expected operational impact on leachate is the potential changes in infiltration rates due to design modifications. This could result in long-term variations in leachate generation, as well as changes in leachate flows. Settlement of landfill material also has the potential to change the leachate flow paths and volumes generated in different sections of the landfill.

However, as stated above, the modified design includes improved capping and stormwater diversion through road drainage works, which would reduce water infiltration once the works are completed. This is due to the addition of a largely impervious road pavement layers, separation of stormwater runoff, and improved capping. Modelling has indicated that the project should decrease infiltration rates by between five and ten percent across 20% of the construction footprint.

During operation, these identified impacts are considered negligible and consequentially potentially reduce the leachate volumes.

7.3 Landfill Gas

Once the final capping layer which includes gas collection/passive venting is installed, the operational impacts associated with gas generation across the general landfill area would be minimal. However, the addition of piling through the cap and waste may cause the formation of new preferential pathways for the landfill gas to escape. There is also potential for landfill gas to flow via other preferential pathways resulting from the new infrastructure. This includes services and drainage trenches, as well as bridge piers and supports.

The low production rates of landfill gas (0.0-0.2 L/hour) reported by AECOM (AECOM, 2019) indicate that an interception mechanism similar to that currently in place around the IKEA footprint would be sufficient to limit gas concentrations to less than 1% methane by volume or 1.5% carbon dioxide by volume (NSW EPA, 2016), and to prevent adverse impacts from on and offsite migration.

The dual-purpose gas management system should be designed and operated to maximise the release of landfill gas while minimising the ingress of atmospheric gases to the landfill. A dual-purpose drainage system underlying the low-permeability capping layer with atmospheric vents would provide a preferential flow path for landfill gas near the surface. Installation of the passive venting system reduces the risk of shallow lateral migration of landfill gas and accumulation of gas beneath the capping system.

Roads and Maritime would install appropriate gas collection and venting for the road infrastructure and waste mounds as per the Solid Waste Guidelines, to allow landfill gas to be collected and passively vented to minimise the potential build-up. A passive gas collection system includes bentonite seals around perforations in the cap on bridge or support structures. This is expected to minimise the presence of preferential pathways along services and drainage trenches, etc.

In addition, the new capping layer is expected to reduce the potential for landfill gas emissions, and the increased topsoil/vegetation layer across the project area would promote oxidation of landfill gas before emission into the atmosphere.

Figure 7-1 shows the proposed gas collection and venting system for a typical road cross section in the fomer Tempe landfill from the concept design.

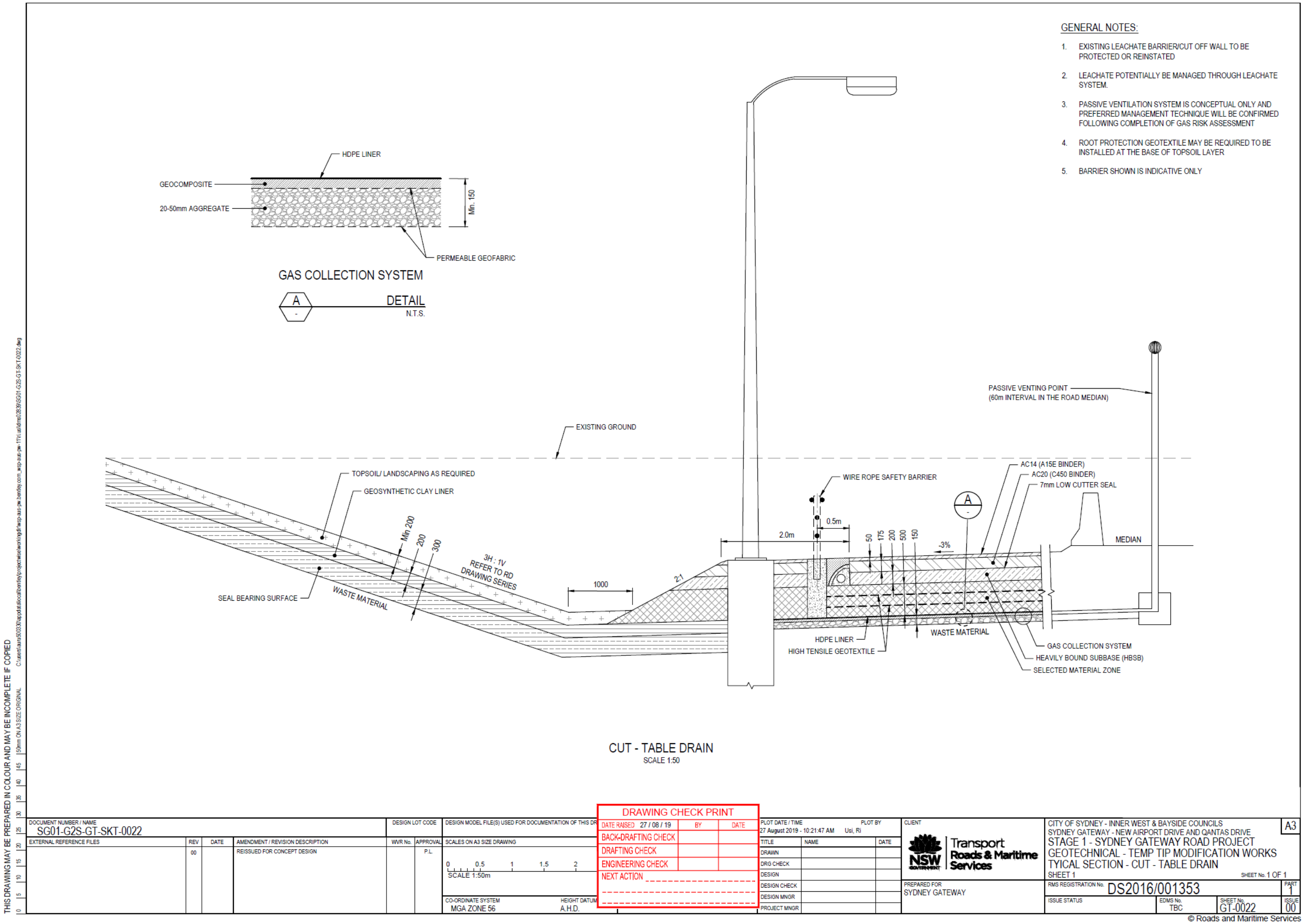


Figure 7-1: Gas collection system and drainage layer around roads

Source: Roads and Maritime

8 Recommended Mitigation Measures

The Project includes the removal of the existing capping layer in certain locations around the site, followed by limited excavation of waste and the emplacement of excavated material into new mounds. The Project also includes the installation of landfill gas management systems and landfill capping.

The design, implementation and ongoing management of the waste mounds, landfill capping, and landfill gas management system would be detailed in an Environmental Management Plan. The Plan would be prepared in accordance with the CLM Act and would be approved by an Independent Site Auditor accredited under the CLM Act. Construction and operation of the waste mounds, landfill capping and landfill gas management system would be carried out in accordance with the EMP. For further details on the EMP refer to *Technical Paper 5 - Contamination and Soils*.

The design, implementation and ongoing monitoring of leachate management would be detailed in a landfill management plan, prepared in consultation with relevant stakeholders. Construction and operation would be carried out in accordance with the plan.

8.1 Construction

8.1.1 Capping and contaminant management systems

Once excavated waste has been permanently relocated, the installation of a new capping layer using clean engineering fill/VENM is recommended, in accordance with the Solid Waste Landfill Guidelines. The EMP will detail the performance criteria of the landfill cap, as per the Solid Waste Landfill guidelines. It will also include standards regarding the diversion of rainwater and minimising infiltration (NSW EPA, 2016). Typical landfill cap layers can be seen in Figure 8-1.

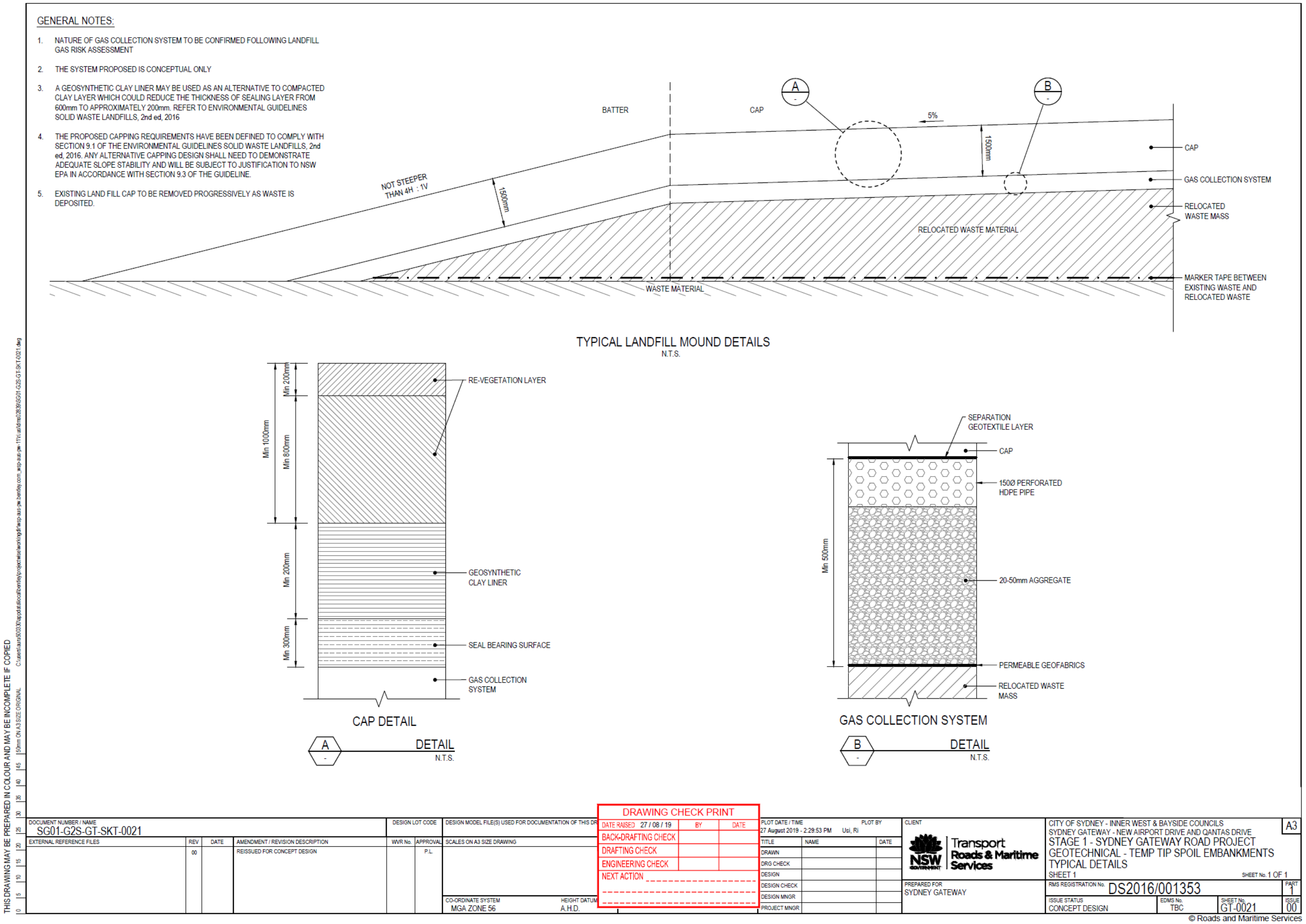


Figure 8-1: Typical Landfill cap details

Source: Roads and Maritime

8.1.1.1 Waste Mounds

While the designs for the landfill mounds have not been finalised, the following outcomes can be expected:

- Any leachate will filter through to the waste mass below
- The cap will meet the performance criteria of the landfill guidelines, with infiltration rates below 5%
- Surface water will be shed through drainage systems such that there is no scouring of the cap
- Landfill gas emissions are directed to venting systems through gas drainage layer. The revegetation layer of cap is expected to oxidise/consume any landfill gas not collected by the venting system.

Recommended mitigation measures to manage the integrity of new waste mounds are as follows:

- Settlement and slope stability analysis will need to be undertaken to ensure that the proposed waste mounds are designed to suitable engineering standards.
- Daily cover of the excavated areas and waste mounds in accordance with the Solid Waste Landfill Guidelines.

8.1.1.2 Bentonite Cut-off Wall

Recommended mitigation measures to ensure the continued integrity of the bentonite wall during construction are as follows:

- Establishing the physical location, vertically and horizontally, of the bentonite cut-off wall near the proposed bridge support structures, prior to finalising the design, including establishment of a suitable buffer zone.
- Any site works in close proximity to the bentonite cut-off wall would need to consider the existing leachate collection system (such as sumps and pumping equipment) and the status of the canal bank.
- Developing a framework for monitoring the bentonite wall and associated systems during construction.

8.1.1.3 Unexpected finds

Spotters should be used during any excavation work to prevent potentially hazardous material from being damaged. Any material identified as unsuitable for re-burial on Site should be treated as per current EPA guidelines and disposed of at an appropriate location.

8.1.2 Leachate

As identified in section 6.2, the result of the modelling indicates that during construction the volumes of leachate generation would be around 200 kL/day under annual average rainfall, and up to around 450kL/day under a worst-case scenario. Based on the predicted increases of leachate generation volumes and current operating capacity of the leachate management system, additional capacity and/or storage is required during construction to manage the increased volumes to be treated prior to discharge.

A leachate management plan should be prepared in consultation with relevant stakeholders, such as IWC and Sydney Water, prior to approval and implementation. The plan would set out:

- Specific methodologies and measures for leachate management including sufficient storage for the treatment and disposal of leachate up to around 450kL/day.
- A framework for monitoring leachate levels and quality including frequency, notification and reporting requirements.
- Regular monitoring of leachate levels and quality in the sumps and monitoring wells along the bentonite wall is recommended before construction commences to add to the current understanding of leachate characteristics
- Monitoring should continue throughout construction to ensure any changes in levels is acted on as soon as detected to prevent an over-topping of bentonite wall.
- Leachate levels in the landfill gas wells and other monitoring wells across the Site should also be monitored to assess and mitigate any impacts from road construction. Levels should remain below the top of the bentonite wall to avoid over-topping and migrating into Alexandra Canal. Should the levels rise noticeably, pumping from leachate sumps should be adjusted accordingly.
- A review of the Trade Waste Agreement following the completion of the works and any changes to the leachate management system is also recommended. It should be undertaken in consultation with IWC and include a review of the MDM and average daily leachate volumes to be discharged.

8.1.3 Landfill Gas and Air Quality

Mitigation measures to manage landfill gas and odour emissions during construction include:

- Explosion limit monitoring and personal monitors during construction works should be included to minimise the risk of fire or explosion.
- Monitoring of landfill gas emissions in wells located at the boundary of the landfill facility and within buildings located on or off site should also be undertaken.
- Minimising the area of the landfill at any one time for which there is no cap.
- Minimising the size and area of exposed waste stockpiles.
- Ensuring waste that has been disturbed, uncapped, or temporarily stockpiled is suitably covered at the end of each day, particularly from March to July when temperature inversion can occur overnight and increase offsite odours. The temporary cover should be removed once construction works in that area resume the following day.
- Installing a new capping layer on permanently relocated waste using clean engineering fill/VENM to meet the performance criteria of the guidelines, including standards regarding the diversion of rainwater and minimising infiltration (NSW EPA, 2016).
- Modifying activities when the wind direction is toward sensitive receptors.
- Installing odour spray/neutraliser systems on-site near proposed work areas (excavation area, waste stockpile etc.) and around the construction site. This may include a portable odour spray system and/or permanent odour system on boundary fence to deal with odours generated from exposed landfill and waste stockpile. The odour spray systems typically use a combination of high and low water pressure

through hydraulic hoses connected to nozzles, thus providing optimum atomisation and odour neutralisation. Odour control systems can also include the use of odour sensors, dust sensors, and wind direction sensors, producing the most effective applications required.

Measures to mitigate potential air quality impacts, other than gas and odour, during construction are documented in *Technical Working Paper 4 – Air Quality*. While these measures do not consider odour, they are relevant to the management of potential dust impacts with the Site. With the implementation of these measures the potential air quality impacts from works within the former Tempe landfill would be minimal.

8.1.4 General construction considerations

The following measures should be undertaken during construction:

- Landfill material should be appropriately handled, stockpiled, and transported across the Site, to ensure minimal impact to the surrounding community, onsite workers, and the environment.
- Surface water within the Former Tempe Landfill would be managed in accordance with Volumes 1 (Landcom, 2004) and 2B (DECC NSW, 2008) of the *Managing Urban Stormwater* Guidelines:
- Divert runoff from upslope areas around the Site and the associated disturbed surfaces within wherever practicable to avoid erosion, sediment mobilisation and contamination of surface water.
- Ensure that locations where material excavated from the former landfill is stored are adequately isolated from surface water runoff to prevent potential contaminant mobilisation.
- Ensure that any stockpiled material excavated from the former landfill is appropriately covered in the event of rain to minimise the potential for contamination of runoff.
- Ensure that runoff from stockpiled material excavated from the former landfill is captured and diverted to appropriate disposal options with appropriate testing as relevant.
- Minimise the area of exposed waste to prevent rainfall entering the waste.
- Ensure existing landfill cap is fully removed to ensure waste to waste contact to avoid impervious layers.
- Excavate through any impervious layers to allow any ponded leachate to filter to waste mass below.
- Install temporary leachate collection sumps (if necessary) and pump leachate to Leachate Holding Tanks using portable diesel pumps or tanker.
- Use of portable odour sprays for any ponded leachate to deal with any potential leachate odours.
- Capture all potentially contaminated surface water runoff from Site and prevent environmental discharge unless it is determined that the water is of suitable quality.
- Divert any potentially contaminated surface water runoff into open excavations within the Site (i.e. into the in-situ landfill materials) to avoid the need for environmental discharge or offsite disposal
- Consider the potential for water collected in sediment basins (if present) to be contaminated due to contact with excavated landfill materials and other potential contaminants and test accordingly prior to appropriate discharge or offsite disposal.

8.2 Operation

8.2.1 Leachate

As noted in section 7.2, the infiltration rates into the landfill would be reduced following construction of the road and implementation of an improved capping layer.

Based on the reduced infiltration rates, the modelling indicates that the total leachate generation is predicted to reduce compared to the existing situation. Considering the predicted reduction in leachate generation, the existing leachate management system, or any modified version adopted during construction should have sufficient capacity to prevent build-up of leachate in the drain and potential over topping of the bentonite wall.

8.2.2 Landfill Gas and Air Quality

Long-term management principles for landfill gas include minimising emissions of untreated landfill gas through surface or subsurface pathways, and minimising greenhouse gas emissions.

8.2.2.1 Odour management

Key odour management measures required during operational phase include:

- Ensuring the gas collection system is operating effectively
- Monitoring landfill gas migration and fugitive emissions
- Performing a site-specific landfill-gas risk assessment to identify appropriate monitoring and management measures.

Develop Work Health & Safety (WHS) procedures to manage potential fire and explosion risks, as well as asphyxiation due to accumulation in enclosed spaces

8.2.2.2 Landfill Gas emissions

Recommended mitigation measures to limit potential landfill gas emissions during operation are as follows:

- Design and install a landfill gas management system in accordance with the Solid Waste Guidelines including landfill gas collection infrastructure and passive vents. The system would provide a preferential flow path for landfill gas below the road infrastructure and waste mounds.
- Long term landfill gas monitoring in accordance with regulatory requirements. This may include regular monitoring of subsurface gas bores and surface emission monitoring requirements in accordance with Solid Waste Landfill Guidelines.

Ongoing maintenance of the new gas management system would be sufficient to mitigate any impacts going forward. However, if vent monitoring during the construction phase indicated that additional management controls for methane or odour control are required, then specific vents may need to be treated using a microbiological gas treatment system (i.e. bio filter or bio cover containing a material that can biologically oxidise the methane in the gas to carbon dioxide).

9 Bibliography

AECOM. (2019). *Sydney Gateway Project – Interim Groundwater and Landfill Gas Data.*

ANZECC. (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

Australian Wetlands. (2003). *Concept Design Report - Tempe Lands, Tempe.*

Coffey. (2006). *Remediation and Development of Tempe Lands - Additional Landfill Gas Investigation.* Draft.

Coffey. (2006). *Tempe Lands Remediation - Cap Validation Report, Areas 1A and 1B.*

Coffey. (2007). *Tempe Lands Remediation, Report on Validation of the Cap, Areas 4 to 11.* Draft.

Coffey Environments. (2007). *Groundwater Level Monitoring and Advice in Relation to Possible Overtopping of Perimeter of the Cut-Off Wall, Tempe Lands Remediation. Ref S21090.14-AS.* Annual Report.

Coffey Environments. (2007). *Groundwater Quality Monitoring, Tempe Lands, Tempe. Ref S21090.14.* Anual Report.

Coffey Environments. (2010). *Draft Addendum 1 - Revised Feasibility Study of Landfill Gas Migration Mitigation Measures.*

Coffey Geosciences Pty Ltd. (2003). *Remediation and Development of Tempe Lands - Geotechnical Investigation Report. Ref S21090/4-AT.*

Coffey Geosciences Pty Ltd. (2003). *Remediation and Development of Tempe Lands - Remedial Action Plan. Ref S21090/6-AG.*

Coffey Geosciences Pty Ltd. (2003). *Remediation and Development of Tempe Lands - Report on Groundwater/ Leachate and Fill Quality. Ref S21090/4-AR.*

Coffey Geosciences Pty Ltd. (2005). *Tempe Lands Remediation - Cut Off Wall Validation Report. Ref S21090/7-EC.*

DECC NSW. (2008). *Managing Urban Stormwater - Soils and Construction* (Vol. 2B Waste Landfills).

Environ. (2001). *GN35 - Summary - Remedial Action Plan for Tempe Lands, Tempe.* Site Audit Report.

Environ. (2004). *GN35B - Tempe Lands Remediation Project - Appropriateness of Detailed Design.* Site Audit Report.

Environ. (2005). *GN35C - Tempe Land Remediation Project - Site Validation.* Site Audit Report.

Environ. (2006). *GN35-1 - Validation of Remediation for Areas 1A and 1B of Tempe Lands.* Site Audit Report.

Environ. (2006). *GN35-1B - Validation of Remediation for Areas 1A and 1B of Tempe Lands.* Site Audit Report.

Environ. (2008). *GN35-2 - Validation of Remediation for Areas 4 to 11 of Tempe Lands.* Site Audit Report.

Environ. (2010). *GN420 - Remediation Action Plan, 630-726 Princes Highway and Areas 1A and 1B, Tempe Lands.* Site Audit Statement.

Environ. (2013). *GN420B - Ikea, 630-726 Princes Highway, Tempe.* Site Audit Statement.

HEPA. (2018). *PFAS National Environmental Management Plan.*

Landcom. (2004). *Managing Urban Stormwater - Soils and Construction* (4th ed., Vol. 1).

Menard Bachy. (2003). Tempe Land Remediation - Leachate Cut-Off Wall.

NSW EPA. (2000, July 25). Declaration of Remediation Site 21005.

NSW EPA. (2000). Environment Protection Licence 6665.

NSW EPA. (2001, March 22). Remediation Order 23003.

NSW EPA. (2003, March 19). Voluntary Remediation Agreement 26050.

NSW EPA. (2004, December 09). Approval of the Surrender of a Licence - Notice Number 1041812.

NSW EPA. (2006, October 11). Variation of Surrender Condition - Notice Number 1048787.

NSW EPA. (2010, June 24). Variation of Surrender Condition - Notice Number 1083919.

NSW EPA. (2016). Environmental Guidelines: Solid Waste Landfills. *Second Edition*.

Smith Environmental. (1998). *Future User & Occupational Risks Relevant to Remediation of the Former Tempe Tip Site.*

Sydney Water Corporation. (2017, December 15). Consent to discharge industrial trade wastewater - 35548.

Tenix Projects. (2006). Tempe Lands Site Environmental Management Plan for Areas 1A and 1B.

Tenix Projects. (2006). Tempe Lands Site Environmental Management Plan for Areas 4 to 11.

Uminex. (February 2018). *Leachate Collection Review.*

Uminex. (January 2018). *Landfill Gas Monitoring at the Former Tempe Lands.*

Woodward-Clyde. (1999). *Tempe Tip Remediations - Advice on Capping Design Revision 1.*

WSP & GHD. (2019). *Sydney Gateway Motorway - Technical Working Paper 5: Contamination and Soils.*

WSP & GHD. (2019). *Sydney Gateway Motorway - Technical Working Paper 7: Groundwater .*

10 Appendices

Table 10-1: Former Tempe Landfill historical reports used to inform the impact assessment

Year	Month	Author	Report name	Reviewed
1991	N/A	Earth and Environmental Sciences	*Environmental Audit of Properties Adjacent to Alexandra Canal Volumes 1 & 2*	No
	August	Coffey Partners	*Tip Geotechnical/Environmental Assessment*	No
1995	November	Coffey Geoscience	*Borehole Logging at Tempe Tip*	No
1997	December	Sinclair Knight Merz	*1. 614 Princes Highway, Tempe – Stage 1 Contamination Investigation* *2. South Street, Tempe – Phase 1 Contamination Investigation*	No No
1998	November	Douglas Partners	*Report on Geotechnical and Contamination Investigation, Tempe Landfill Swamp Road, Tempe*	No
		Waste Services NSW	Draft *Remediation Action Plan, Tempe Tip*	No
		Smith Environmental	*Future User & Occupational Risks Relevant to Remediation of the Former Tempe Tip Site*	Yes
	December	Douglas Partners	*1. Report on Preliminary Contamination Assessment, Tempe Landfill Swamp Road, Tempe* *2. Report on Geotechnical and Contamination Investigation - Addendum, Tempe Landfill Swamp Road, Tempe*	No No
		Perram & Partners	Draft *Tempe Tip Remediation and Temporary Use Statement of Environmental Effects*	No
1999	February	Woodward-Clyde	*Tempe Tip Remediations - Advice on Capping Design* Revision 1	Yes
2001	March	Coffey	*Contaminated Land Report*	No
	November	ENVIRON	Site Audit Report GN35 *Remedial Action Plan, Tempe Lands, TEMPE*	Yes
2003	May	Coffey Geosciences	*1. Geotechnical Investigation Report* *2. Remediation and Development of Tempe Land - Report on Groundwater/ Leachate and Fill Quality.* 3. *Tempe Lands Remediation and Development – Groundwater Report*	Yes Yes Yes
		Australian Wetlands	*Concept Design Report – Tempe Lands, Tempe*	Yes
	August	Coffey Geosciences	*1. Pump Test Report* 2. Discussion of Leachate Generation and Pumping	No
	September	Coffey	*1. Updated Groundwater Quality Statistics* *2. Remediation Action Plan* (RAP) *3. Statement of Environmental Effects* (SEE)	No Yes No
	December	Menard Bachy	*Tempe Land Remediation – Leachate Cut-off Wall* Design	Yes
2004	January	LSM Projects	*Leachate Control System, WC201 Contract*	Yes

	August	JET	*Results of Coal Tar testing – Samples from Tempe Stockpile*	No
		ENVIRON	Site Audit Report GN35B *Tempe Lands Remediation Project – Appropriateness of Detailed Design*	Yes
	December	Coffey	*Contamination Assessment - Recycled Asphalt Profilings Tempe Lands*	No
2005	January	Coffey	*Remediation and Development of Tempe Lands – Landfill Gas Monitoring Plan Tempe NSW*	No
	February	Coffey	*Additional Contamination Assessment – Recycled Asphalt Profilings Tempe Landfill*	No
	August	Coffey Geosciences	*Tempe Lands Remediation – Cut-Off Wall Validation Report* Revised	Yes
	September	ENVIRON	Site Audit Report GN35C *Tempe Lands Remediation Projects – Site Validation*	Yes
	October	Coffey	*Remediation and Development of Tempe Lands – Landfill Gas Investigation*	No
2006	February	Tenix Projects	*Site Environmental Management Plan (Areas 1A and 1B)*	Yes
	April	Coffey	Draft *Additional Landfill Gas Investigations*	Yes
	May	Coffey	*Tempe Lands Remediation – Cap Validation Report, Areas 1A and 1B*	No
		ENVIRON	Site Audit Report GN35-1 *Validation of Remediation for Areas 1A and 1B of Tempe Lands*	Yes
	August	ENVIRON	Site Audit Report GN35-1B *Validation of Remediation for Areas 1A and 1B of Tempe Lands*	Yes
	November	Tenix Projects	*Tempe Lands Site Environmental Management Plan (Areas 4 to 11)*	Yes
2007	January	Coffey Environments	1. *Annual Groundwater Quality Monitoring Report, January 2007, Tempe Lands, Tempe* 2. *Annual Groundwater Level Monitoring Report, January 2007 and Advice in Relation to Possible Overtopping of Perimeter of the Cut-Off Wall, Tempe Lands, Tempe* 3. *Annual Landfill Gas Monitoring Report (January 2007) Tempe Lands, Tempe*	Yes Yes Yes
	March	Coffey	Draft *Tempe Lands Remediation – Report on Validation of the Cap, areas 4 to 11*	No
2008	July	ENVIRON Australia	Site Audit Report GN35-2 *Validation of Remediation for Areas 4 to 11 of Tempe Lands*	Yes
	November	Coffey Environments	*Addendum 1: Tempe Lands Remediation – Revised Feasibility Study of Landfill Gas Migration Mitigation Measures, Chain Linkage -25.00 to 254.54*	Yes
2009	May	Tenix Projects & Coffey Environmental	Draft *Post-remediation management plan* (PRMP)	Yes
2010	March	Coffey Environments	*Addendum 1: Tempe Lands Remediation Revised Feasibility Study of Landfill Gas Migration Mitigation Measures*	Yes
	June	ENVIRON	Site Audit Statement GN420	Yes

2013	November	ENVIRON	Site Audit Statement GN420B	Yes
	December	Land and Environment Court NSW	Bundle of Documents – Remediation of Tempe Lands	Yes
2016	June	SMEC	Technical Note: Tempe Tip Earthworks Treatments	Yes
	July	SMEC	Technical Note: *Sydney Gateway Tempe Tip Workstream*	Yes
2017	February	SMEC	Technical Note: *Sydney Gateway Tempe Tip Photogrammetry Assessment*	Yes
2018	February	Uminex	*1. Landfill Gas Monitoring at the Former Tempe Lands – January 2018* *2. Leachate Management Review at the Former Tempe Lands* 3. Draft *Groundwater Monitoring at the Former Tempe Lands – January 2018*	Yes Yes Yes
	March	Uminex	*Tempe Landfill Leachate Management Scheme Improvements – Collection, Treatment and Disposal System Technical Review*	Yes
	November	Roads and Maritime	*Sydney Gateway road project - State Significant Infrastructure Scoping Report*	Yes

RMS.19.1443
ISBN 978-1-922338-10-5