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Greenhouse Gas Calculations

Elizabeth Drive Landfill Expansion Environmental Impact Statement

Prepared for:
SUEZ Recycling and Recovery Pty Ltd

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Contents

Glossary of Terms and Abbreviations

Term	Definition
CH_4	Methane
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
ECF	Energy content factor
EF	Emissions factor
EPL	Environmental Protection Licence
GHG	Greenhouse gas
GJ	Gigajoules
GSW	General Solid Waste
GWP	Global Warming Potential. An index used to convert relevant non-carbon dioxide greenhouse gases (e.g. methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons and perfluorocarbons) to a carbon dioxide equivalent (CO_2-e)
IPCC	Intergovernmental Panel on Climate Change
kg	Kilograms
kL	Kilolitres
kWh	Kilowatt hours
N/A	Not applicable
NGA	National Greenhouse Accounts
NGER	National Greenhouse and Energy Reporting
SAWT	SUEZ Advanced Waste Treatment facility
t	Tonnes
t CO_2-e	Tonnes of carbon dioxide equivalent

1.0 Introduction

Greenhouse gases (GHGs) are emitted into the Earth's atmosphere as a result of natural processes (e.g. forest fires) and human activities (e.g. burning of fossil fuels to generate electricity). GHGs absorb and re-radiate heat from the sun. Since the industrial revolution there has been an increase in the amount of anthropogenic (human induced) GHGs emitted into the atmosphere which has increased the concentration of GHG emissions in the atmosphere. The increased concentration of GHGs in the Earth's atmosphere has led to an increase in the Earth's average temperature (surface temperature), this is known as the Greenhouse Effect (or enhanced greenhouse effect). The Greenhouse Effect has caused the phenomenon of Climate Change to occur. Climate Change (also known as global warming) refers to the change in climate patterns due to an increase in the average temperature of the Earth.

1.1 Measurement of greenhouse gas emissions

GHGs are reported for accounting purposes as tonnes of carbon dioxide equivalent (t CO_2-e). There are numerous GHGs which contribute to the Greenhouse Effect. These gases have varying Global Warming Potential (GWP). The higher GWP, the higher the intensity of effect each tonne of that gas has on the Enhanced Greenhouse Effect. GHGs are standardised by expressing them as carbon dioxide equivalent emissions (CO_2-e) where carbon dioxide has a GWP of 1. For example, the GHG methane has a GWP of 25, thus one tonne of methane has a Greenhouse Effect equivalent to 25 tonnes of carbon dioxide. The GWP of the six GHGs used in carbon accounting, commonly known as the Kyoto GHGs, are shown in the following table.

Table 1.1 Global Warming Potential of Greenhouse Gases[1]

Greenhouse gas	Global warming potential
Carbon Dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous Oxide (N_2O)	298
Sulphur Hexafluoride (SF_6)	22,800
Hydrofluorocarbons (HFCs)	HFC_5 – 1,300-11,700 (depending on the HFC)
Perfluorocarbons* (PFCs)	CF_4 – 6,500. C2F6 – 9,200

Note: *Varies depending on compound. Source: DCC, 2009, *National Greenhouse Accounts (NGA) Factors*.

1.2 Scope of greenhouse gas emissions

GHG emissions are categorised into three different scopes (either Scope 1, 2 or 3) in accordance with the Intergovernmental Panel on Climate Change (IPCC) and Australian Government GHG accounting/classification systems. The GHG emission scopes are illustrated in Figure 1.

- Scope 1 – direct emissions: GHG emissions generated by sources owned or controlled by the Project, for example fugitive emissions of landfill gas or emissions generated by the use of diesel fuel in Project-owned plant, equipment or vehicles.
- Scope 2 – indirect emissions: GHG emissions from the consumption of purchased electricity in Project-owned or controlled equipment or operations. These GHG emissions are generated outside the Project's boundaries, for example the use of electricity purchased from the grid.
- Scope 3 – indirect upstream/downstream emissions: GHG emissions generated in the wider economy due to third party supply chains as a consequence of activity within the boundary of the Project, for example GHG emissions associated with the offsite extraction, production and transport of purchased fuels.

[1] http://www.cleanenergyregulator.gov.au/NGER/The-safeguard-mechanism/Baselines/Reported-baseline/global-warming-potentials

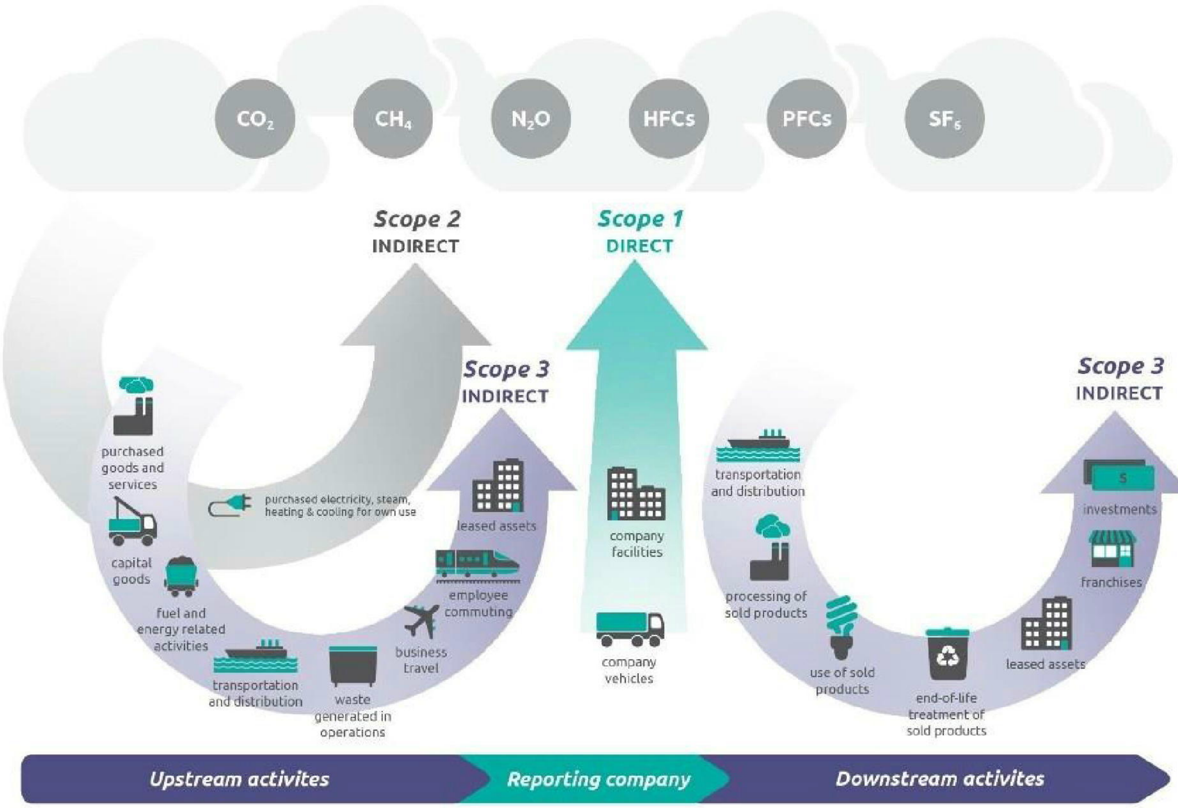

Figure 1.1 Greenhouse Gas Emission Scopes (WBCSD & WRI, 2005)

2.0 Methodology

2.1 Overview of approach

To estimate the GHG emissions associated with the Project the following steps were undertaken:

1. The GHG assessment boundary for the Project was defined (refer **Section 2.1.3**).
2. The scenarios for comparison between landfill gas generation for the existing landfill and the Project were defined (refer **Section 2.2.1**).
3. The assumptions and data to be used were determined (e.g. quantities of fuel, electricity and waste).
4. The quantity of GHG emissions were estimated, as follows:
    - GHG emissions from fuel use and electricity consumption (purchased from the grid) were calculated using the methodology, equations and emissions factors set out within the NGA Factors (July 2018 Update).
    - GHG emissions (methane) released from the landfill were calculated using the methodology, equations and factors contained within the *National Greenhouse and Energy Reporting Scheme Measurement Technical Guidelines* and using the Elizabeth Drive Landfill NGER Solid Waste Calculator 2017-18.
    - GHG emissions from the combustion of landfill biogas (methane) for electricity production and flaring were calculated using the methodology, equations and factors contained within the *National Greenhouse and Energy Reporting Scheme (Measurement) Determination* 2008, as amended (the Determination).

This appendix outlines the methodology used to estimate the GHG emissions from waste decomposition, fuel combustion, and electricity consumption.

2.1.1 Legislation and guidelines

The methodology for this GHG assessment is based on relevant GHG reporting legislation and national and international reporting guidelines, including:

- *Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* (World Council for Sustainable Business Development and World Resources Institute, 2005)
- *Greenhouse Gas Protocol for the quantification of greenhouse gas emissions from waste management activities* version 5.0 (World Council for Sustainable Business Development and World Resources Institute, 2013)
- *National Greenhouse and Energy Reporting (NGER) Act 2007* (Commonwealth)
- AS/ISO 14064.1:2006 *Greenhouse Gas Part 1: Specification with guidance at the organisational level for quantification and reporting of greenhouse gas emissions and removals*
- The current *Australian National Greenhouse Accounts: National Greenhouse Accounts Factors* (NGA Factors) (Australian Government Department of the Environment and Energy, 2018a)
- The *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (Australian Government Department of the Environment and Energy, 2018b)
- The *National Greenhouse and Energy Reporting Scheme Measurement, Technical Guidelines for the estimation of greenhouse gas emissions by facilities in Australia* (Australian Government Department of the Environment and Energy, 2017)
- The *NGER Solid Waste Calculator* 2017-18 (Australian Government Clean Energy Regulator, 2018).

2.1.2 Guiding principles

The assessment has been conducted according to the following greenhouse gas accounting and reporting principles:

- Relevance – select and use greenhouse gas sources, sinks, data and methodologies appropriate for the project / organisation and intended use of greenhouse gas inventory results
- Completeness – include all relevant greenhouse gas emissions and information which support methodology and criteria used
- Consistency – use consistent data, calculation / modelling methods, criteria and assumptions to enable valid comparisons
- Transparency – include clear, sufficient and appropriate information to enable others to understand the basis for results and make decisions regarding use of greenhouse gas inventory results with reasonable confidence
- Accuracy – reduce bias and uncertainties, as much as practical.

In addition to the accounting and reporting principles presented above, the issue of materiality has also been assessed in the greenhouse gas assessment. This is a core accounting and auditing principle which ensures that sources, assumptions, values and procedures included in the greenhouse gas assessment are material to the project. As materiality is valued within the context of the project being assessed, this can vary significantly between projects. Emissions excluded from this assessment are discussed in **Section 2.1.4** of this appendix.

2.1.3 Greenhouse gas assessment boundary

The GHG assessment boundary defines the scope of GHG emissions and the activities to be included in the assessment.

Table 2.1 summarises the emission sources and activities considered within the Project's GHG assessment boundary, according to scope.

Table 2.1 Emission sources by Scope

Scope 1 – direct emissions	Scope 2 – indirect emissions	Scope 3 – indirect upstream/downstream emissions
• The on-site consumption of fuel by plant/equipment • Landfill gas emissions (methane) • The combustion of landfill gas for electricity production and flaring	• The on-site use of electricity purchased from the grid	• The extraction, production and transport of purchased fuels • The consumption of fuel for the transport of waste to site • The consumption of fuel for the transport of staff to/from site (private vehicles) • Transmission and distribution losses within the electricity network for electricity purchased from the grid

Landfill gas

Landfill gas emissions are considered anthropogenic as human activities create the anaerobic conditions which cause the decomposition of organic waste, when waste is buried and contained in an unnaturally low-oxygen environment (e.g. a landfill). Methane generation from waste in landfill is therefore required to be assessed as part of a GHG assessment under the *National Greenhouse and Energy Reporting Act 2007* (Cth). Carbon dioxide (CO_2) emitted as landfill gas is not considered in the assessment of GHG as it is considered to be part of the natural carbon cycle, and would be emitted from the decomposition of organic materials regardless of human intervention.

The anaerobic decomposition of waste varies depending on the composition of waste within the landfill, namely the quantity of organic waste, and is influenced by local climate conditions. Landfill gas is not generated immediately at the time of disposal of the waste as it takes time for the chemical reactions and methane-producing bacteria to break down the waste (Warnken ISE, 2007). Around 23% of degradable waste is estimated to remain after 30 years and 11% after 50 years (NSW EPA, 2012). Legacy landfill gas emissions can therefore continue to be generated post-closure of the landfill, requiring the ongoing management of landfill gas.

Figure 2.1 depicts the typical chemical composition and generation rate for landfill gas.

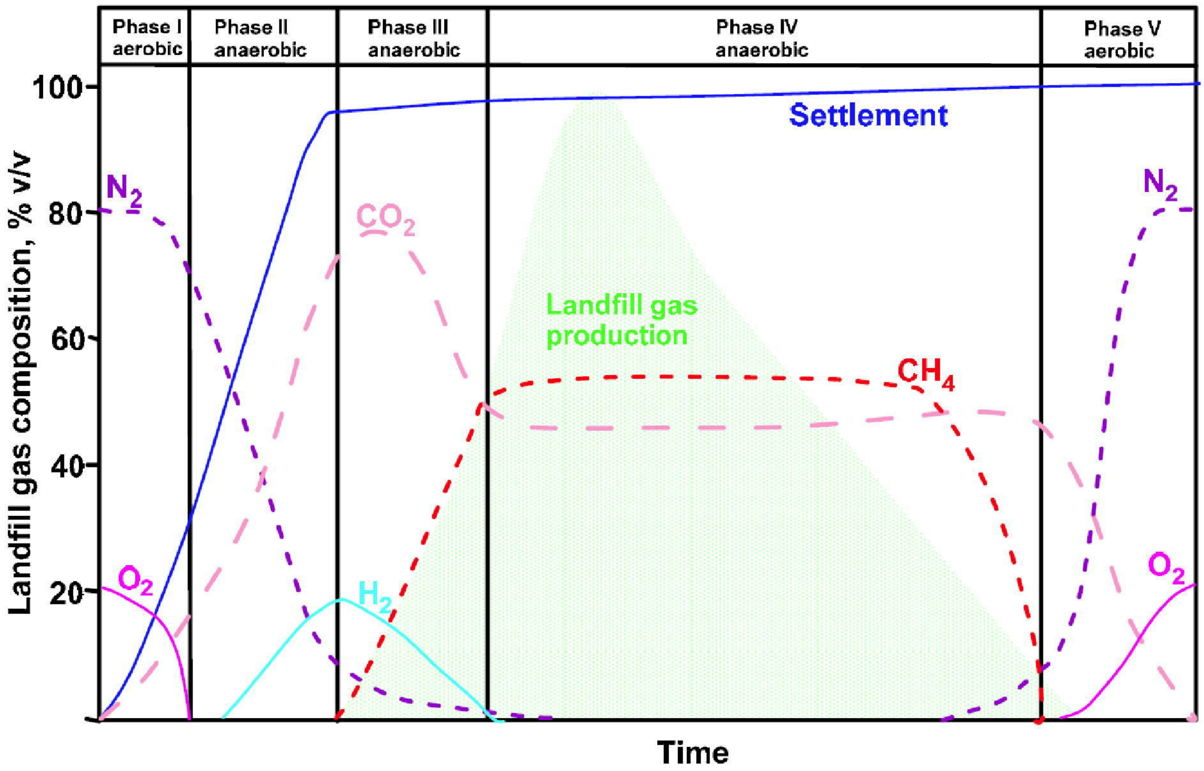

Figure 2.1 Stages of landfill gas generation (NSW EPA, 2012)

This assessment estimates the anticipated GHG emissions from activities associated with the expansion and continued operation of the Project. The assessment considers two scenarios:

- **Baseline scenario:** existing landfill operations continue for a further eight years (for the purposes of this assessment). Actual landfill data for the year to June 2018 has been used to inform the assessment of emissions, with continued operation of the landfill expected to be based on a disposal rate of 750,000 tonnes per annum between the years 2018 and 2026.
- **Project scenario:** expansion of the landfill by raising the final cap height by 15 metres within the Project Area, and continued operation of the landfill for approximately 5½ years beyond the current lifespan, to around 2031. Actual landfill data for the year to June 2018 has been used to inform the assessment of emissions, with continued operation of the landfill expected to be based on a disposal rate of 950,000 tonnes per annum. The landfill would continue to accept non-putrescible and restricted waste in accordance with the current operations.

Fugitive emissions from the landfill were considered for 50 years following closure of the landfill. Landfill gas is typically produced at a stable rate for a period of around 20-30 years, with gas continuing to be generated for 50 or more years following landfill closure (US EPA, 2017). A 50 year period also aligns with the findings of a previous study undertaken to model the landfill gas generation capacity at the Elizabeth Drive Landfill (Tonkin & Taylor, 2017), and from landfill gas modelling conducted as part of the concept design, which shows that the rate of landfill gas generation would decline and be near zero after a period of around 50 years following closure in 2025.

The existing landfill gas collection system would remain in operation and be extended as required throughout the extended life of the landfill, and beyond. Landfill gas would continue to be used by the on-site landfill gas-powered electricity generators to supply power to the SAWT facility and external power grid network. Any excess landfill gas would be flared and destroyed.

The SAWT currently operates under a separate consent and EPL to the main landfill site. This scenario would continue under the Project with operations continuing alongside the extended life of the landfill.

2.1.4 Exclusions

The following emissions were excluded from the assessment:

- The end of life (demolition, decommissioning, etc) of the project's infrastructure (site sheds, road, etc)
- The use of materials and construction equipment for maintenance purposes
- The mixed waste generated by construction and operational staff
- The operation, maintenance and sorting of waste at the waste transfer station
- Fugitive emissions of refrigerants from refrigeration and air conditioning systems
- Support services for the facility

As the Project involves raising the currently approved finished height of the landfill and this raising would occur fully within the existing landfill footprint (the Project Area), no changes to land use have been accounted for in this GHG assessment.

The GHG emissions associated with the operation of the SAWT have not been assessed as the SAWT facility operates under a separate consent and EPL to the landfill and is not considered part of the Project. The SAWT will continue to operate independently but alongside the landfill. It is noted that the combustion of landfill gas doesn't occur within the Project Area, but rather within the broader SUEZ Site; however as this is a direct product of the landfill operation it has been included in the assessment of Scope 1 emissions.

2.2 Greenhouse gas emissions calculation methodology

2.2.1 Landfill gas

Landfill gas emissions

GHG emissions (methane) released from the landfill were calculated using the methodology, equations and factors contained within the *National Greenhouse and Energy Reporting Scheme Measurement Technical Guidelines* and using the Elizabeth Drive Landfill NGER Solid Waste Calculator 2017-2018.

Combustion of landfill gas for electricity production

GHG emissions from the combustion of landfill gas (methane) for electricity production were calculated using the methodology, equations and factors contained within the *National Greenhouse and Energy Reporting Scheme (Measurement) Determination* 2008, as amended.

GHG emissions (t CO_2-e) = Q x ECF x EF / 1000

Where: Q is the quantity of methane in landfill gas combusted (in kL)

ECF is the relevant energy content factor (in GJ/kL)

EF is the relevant emission factor for each gas type (in kg CO_2-e/GJ)

Combustion of landfill gas during flaring

GHG emissions from the flaring of landfill gas (methane only) were calculated using the methodology, equations and factors for Method 1 as defined in the *National Greenhouse and Energy Reporting Scheme (Measurement) Determination* 2008, as amended.

GHG emissions (t CO_2-e) = Q_{flared} x ECF x EF / 1000

Where: Q_{flared} is the quantity of methane in landfill gas flared (in kL)

ECF is the relevant energy content factor (in GJ/kL)

EF is the relevant emission factor for each gas type (in kg CO_2-e/GJ)

2.2.2 Diesel fuel

To calculate the Scope 1 GHG emissions from the consumption of diesel the following formula was used:

GHG emissions (t CO_2-e) = Q x ECF x (EF_{CO2} + EF_{CH4} + EF_{N2O}) / 1000

Where: Q is the quantity of fuel (in kL)

ECF is the relevant energy content factor (in GJ/kL)

EF_{CO2} is the relevant CO_2 emission factor (in kg CO_2-e/GJ)

EF_{CH4} is the relevant CH_4 emission factor (in kg CO_2-e/GJ)

EF_{N2O} is the relevant N_2O emission factor (in kg CO_2-e/GJ)

To calculate the Scope 3 GHG emissions from the consumption of diesel the following formula was used:

GHG emissions (t CO_2-e) = Q x ECF x $EF_{scope\ 3}$ / 1000

Where: Q is the quantity of fuel (in kL)

ECF is the relevant energy content factor (in GJ/kL)

$EF_{scope\ 3}$ is the relevant emission factor (in kg CO_2-e/GJ)

The emissions factors used to calculate the GHG emissions associated with diesel use were sourced from the NGA Factors (July 2018 Update).

2.2.3 Electricity

To calculate the Scope 2 indirect GHG emissions from the consumption of purchased electricity from the grid the following formula was used:

GHG emissions (t CO_2-e) = Q x $EF_{scope\ 2}$ / 1000

Where: Q is the quantity of purchased electricity (in kWh)

$EF_{scope\ 2}$ is the Scope 2 emissions factor for NSW (in kg CO_2-e/kWh)

To calculate the Scope 3 GHG emissions from the consumption of purchased electricity from the grid the following formula was used:

GHG emissions (t CO_2-e) = Q x $EF_{scope\ 3}$ / 1000

Where: Q is the quantity of purchased electricity (in kWh)

$EF_{scope\ 3}$ is the Scope 3 emissions factor for NSW (in kg CO_2-e/kWh)

The emissions factors used to calculate the GHG emissions associated with electricity use were sourced from the NGA Factors (July 2018 Update).

3.0 Data sources and assumptions

To estimate the GHG emissions, the following data sources were used:

- SUEZ Elizabeth Drive Landfill NGER 2017-2018 Report
- SUEZ Elizabeth Drive Landfill NGER Solid Waste Calculator 2017-2018
- Contractor data on fuel consumption used to inform the Elizabeth Drive Landfill NGER 2017-2018 Report
- Assumptions developed as part of the Traffic and Transport Impact Assessment (refer Appendix B of the EIS)
- Emission factors from the NGA Factors 2018 and NGER (Measurement) Determination 2008 (as amended)

An independent audit of the data reported by SUEZ under NGERs was not conducted as part of this assessment. This assessment has assumed that the NGERs reports for the Elizabeth Drive Landfill submitted by SUEZ are accurate and complete.

Table 3.1 outlines the specific data sources and assumptions that were used to inform the GHG assessment for each emissions source, for both the Baseline and Project scenarios.

Table 3.1 Data and assumptions for the GHG assessment

Emissions source	Units	Data source	Assumptions	
			Baseline scenario	Project scenario
Fuel use				
Diesel oil for the transport of waste to site	kL	Elizabeth Drive Landfill NGER reporting for FY17/18, with data used to estimate proportions based on the approved and proposed throughput (tonnes of waste per year), using assumptions developed as part of the Traffic and Transport Impact Assessment(Appendix X)	• Transport energy purposes • Assumes an average 437 heavy vehicle trips per day for the transport of waste to site under the baseline (existing) scenario based on the estimates calculated in the Traffic and Transport Impact Assessment • Average fuel consumption for heavy vehicles of 0.546L/km (Greenfleet, 2011) • Average travel distance of 35km • Calculated for an average 252 working days per year as defined in the Traffic and Transport Impact Assessment	• Transport energy purposes • Assumes an average 547 heavy vehicle trips per day for the transport of waste to site under the Project scenario based on the estimates calculated in the Traffic and Transport Impact Assessment • Average fuel consumption for heavy vehicles of 0.546L/km (Greenfleet, 2011) • Average travel distance of 35km • Calculated for an average 252 working days per year as defined in the Traffic and Transport Impact Assessment
Diesel oil for landfill excavation	kL	Elizabeth Drive Landfill NGER reporting for FY17/18, with data used to estimate proportions based on the approved and proposed throughput (tonnes of waste per year), using assumptions developed as part of the Traffic and Transport Impact Assessment(Appendix X)	• Transport energy purposes • Data used to estimate proportions for the Baseline scenario at 750,000 tonnes of waste per year	• Transport energy purposes • Data used to estimate proportions for the Project scenario at 950,000 tonnes of waste per year
Diesel oil for waste placement onsite	kL	Elizabeth Drive Landfill NGER reporting for FY17/18, with data used to estimate proportions based on the approved and proposed	• Transport energy purposes • Data used to estimate proportions for the Baseline scenario at 750,000 tonnes of waste per year	• Transport energy purposes • Data used to estimate proportions for the Project scenario at 950,000 tonnes of waste per year

Emissions source	Units	Data source	Assumptions	
			Baseline scenario	Project scenario
		throughput (tonnes of waste per year), using assumptions developed as part of the Traffic and Transport Impact Assessment(Appendix X)		
Gasoline for the transport of staff to/from site	kL	Quantity estimated using assumptions developed as part of the Traffic and Transport Impact Assessment(Appendix X)	• Transport energy purposes • Assumes an average 40 light vehicle trips per day for the transport of staff to and from site • Average fuel consumption for light vehicles of 0.111L/km (Greenfleet, 2011) • Average travel distance of 10km • Calculated for an average 252 working days per year as defined in the Traffic and Transport Impact Assessment	• Transport energy purposes • No changes to staff numbers or movements are anticipated as part of the Project • Assumes an average 40 light vehicle trips per day for the transport of staff to and from site • Average fuel consumption for light vehicles of 0.111L/km (Greenfleet, 2011) • Average travel distance of 10km • Calculated for an average 252 working days per year as defined in the Traffic and Transport Impact Assessment
Petroleum based lubricants and greases	kL	Quantity estimated using the Elizabeth Drive Landfill NGER reporting for FY17/18	• Transport energy purposes • Data scaled for the Baseline scenario at 750,000 tonnes of waste per year	• Transport energy purposes • Data scaled for the Project scenario at 950,000 tonnes of waste per year
Electricity use				
Electricity purchased from the grid	kWh	Elizabeth Drive Landfill NGER reporting for FY17/18	• Data used to estimate proportions for the Baseline scenario at 750,000 tonnes of waste per year	• Data used to estimate proportions for the Project scenario at 950,000 tonnes of waste per year
Landfill gas				
Landfill gas emissions (methane)	t	Elizabeth Drive Landfill NGER reporting for FY17/18, with data used to estimate	• Quantities of waste entering the landfill for the future operating life of the landfill were based on the 2017/18 NGERs	• Quantities of waste entering the landfill for the proposed future operating life of the landfill were estimated by scaling

Emissions source	Units	Data source	Assumptions Baseline scenario	 Project scenario
		proportions for the Project scenario at 950,000 tonnes of waste per year and informed by the findings of the Tonkin and Taylor report *Elizabeth Drive Landfill – Landfill Gas Generation Modelling* (2017)	report • The percentage split of waste streams between Commercial and Industry (C&I) and Construction and Demolition (C&D) reported in the 2017/18 NGERs report was used for future projections • The default waste mix types (percentages) for C&I and C&D were used for future projections • The waste mix type (percentages) for licence restricted waste reported in the 2017/18 NGERs report were used for future projections • The quantity of methane in landfill gas transferred out of the landfill (for combustion) and the quantity flared by the landfill were estimated for the future operating life of the landfill years using the 2017/18 NGERs report • For the 50 year period post closure, the following landfill gas collection efficiencies were assumed based on information obtained from SUEZ: - 2019 – 2027: Steady increase from 50% to 80%. - Post closure (+50 years): 80% • The same split between landfill gas transferred for combustion and landfill gas flared as reported in the 2017/18 NGERs report (approx. 50:50) was applied for future projections • It was assumed that for the 30-50 year post closure period that all the landfill gas	up the waste volume reported in the 2017/18 NGERs report to 950,000 tonnes • The percentage split of waste streams between Commercial and Industry (C&I) and Construction and Demolition (C&D) reported in the 2017/18 NGERs report was used for future projections • The default waste mix types (percentages) for C&I and C&D were used for future projections • The waste mix type (percentages) for licence restricted waste reported in the 2017/18 NGERs report were used for future projections • The quantity of methane in landfill gas transferred out of the landfill (for combustion) and the quantity flared by the landfill were estimated for the future operating life of the landfill years using the 2017/18 NGERs report scaled up to reflect the increased waste quantities. • For the 50 year period post closure, the following landfill gas collection efficiencies were assumed based on information obtained from SUEZ: - 2019 – 2031: Steady increase from 50% to 80%. - Post closure (+50 years): 80% • The same split between landfill gas transferred for combustion and landfill gas flared as reported in the 2017/18 NGERs report (approx. 50:50) was

Emissions source	Units	Data source	Assumptions	
			Baseline scenario	Project scenario
			generated would be sent to the flare. • The landfill gas collection efficiency percentages were applied to the total volume of methane estimated using the NGERS solid waste calculator. • No cover material is expected to be imported as the landfill would continue to use locally won shale as cover.	applied for future projections • It was assumed that for the 30-50 year post closure period that all the landfill gas generated would be sent to the flare. • The landfill gas collection efficiency percentages were applied to the total volume of methane estimated using the NGERS solid waste calculator. • No cover material is expected to be imported as the landfill would continue to use locally won shale as cover.
Combustion of landfill gas (methane) for electricity production	t	Elizabeth Drive Landfill NGER reporting for FY17/18	• The Emissions Factor and Energy Content for methane and nitrous oxide were sourced from the Determination. • The quantity of methane in landfill gas transferred out of the landfill (for combustion) determined as outlined under the discussion of landfill gas emissions above was used as the quantity of fuel combusted for the purpose of calculating emissions of methane and nitrous oxide.	• The Emissions Factor and Energy Content for methane and nitrous oxide were sourced from the Determination. • The quantity of methane in landfill gas transferred out of the landfill (for combustion) determined as outlined under the discussion of landfill gas emissions above was used as the quantity of fuel combusted for the purpose of calculating emissions of methane and nitrous oxide.
Combustion of landfill gas (methane only) during flaring	t	Elizabeth Drive Landfill NGER reporting for FY17/18	• The Emissions Factor and Energy Content for methane and nitrous oxide were sourced from the Determination. • The quantity of methane in landfill gas flared, determined as outlined under the discussion of landfill gas emissions above, was used for the purpose of calculating emissions of methane and nitrous oxide from landfill gas flaring.	• The Emissions Factor and Energy Content for methane and nitrous oxide were sourced from the Determination. • The quantity of methane in landfill gas flared, determined as outlined under the discussion of landfill gas emissions above, was used for the purpose of calculating emissions of methane and nitrous oxide from landfill gas flaring.

4.0 GHG assessment results

The following sections present the results of the GHG emissions calculations, which have been estimated for two scenarios, the Baseline scenario and the Project scenario.

4.1 Baseline scenario

Table 4.1 Estimated total GHG emissions (Baseline scenario – 2018 to 2025 with 50 years post closure)

Emissions source	Quantity	Units	GHG emissions (tonnes CO_2-e)			Total GHG emissions (tonnes CO_2-e)	% of total
			Scope 1	Scope 2	Scope 3		
Solid waste disposal							
Landfill gas emissions (methane)	750,000 / year	t	3,141,593			3,141,593	84.0 %
Combustion of landfill gas							
Combustion of landfill gas to produce electricity	N/A*	m^3	45,531			45,531	1.2%
Landfill gas flared	N/A*	m^3	55,349			55,349	1.5%
Fuel use – transport energy purposes							
Diesel oil for landfill excavation	26,587	kL	72,362		3,695	76,057	2.0%
Diesel oil for waste placement on-site	18,172	kL	49,459		2,525	51,984	1.4%
Petroleum based lubricants and greases	686	kL	93		96	189	0.01%
Diesel oil for the transport of waste to site (Scope 3)	124,164	kL			355,188	355,188	9.5%
Gasoline for the transport of staff to/from site (Scope 3)	1,320	kL			3,216	3,216	0.09%
Electricity use							
Electricity purchased from the grid	10,408,662	kWh		8,535	1,041	9,576	0.26%
Total emissions			**3,364,387**	**8,535**	**365,761**	**3,738,683**	**100%**
			90 %	**0.2 %**	**9.8 %**	**100%**	

Note: numbers may not sum to totals due to rounding

*Quantity of methane combusted and flared differs based on the assumed landfill gas collection efficiency (refer Table 3)

Table 4.2 Average annual GHG emissions (Baseline scenario – 2018 to 2025 with 50 years post closure)

Average annual emissions	
Baseline scenario (eight years of continued operation and 50 years post closure)	64,460 tonnes CO_2-e

4.2 Proposed scenario

Table 4.3 Estimated total GHG emissions (Project scenario – 2018 to 2031 with 50 years post closure)

Emissions source	Quantity	Units	GHG emissions (t CO_2-e)			Total GHG emissions (tonnes CO_2-e)	% of total
			Scope 1	Scope 2	Scope 3		
Solid waste disposal							
Landfill gas emissions (methane)	950,000 / year	t	5,183,340			5,183,340	86.1%
Combustion of landfill gas							
Combustion of landfill gas to produce electricity	N/A*	m^3	71,033			71,033	1.2%
Landfill gas flared	N/A*	m^3	83,430			83,430	3.4%
Fuel use – transport energy purposes							
Diesel oil for landfill excavation	37,102	kL	100,980		5,156	106,135	1.8%
Diesel oil for waste placement on-site	25,359	kL	69,019		3,524	72,543	1.2%
Petroleum based lubricants and greases	957	kL	130		134	264	0.004%
Diesel oil for the transport of waste to site (Scope 3)	171,223	kL			489,808	489,808	8.13%
Gasoline for the transport of staff to/from site (Scope 3)	1,455	kL			3,543	3,543	0.06%
Electricity use							
Electricity purchased from the grid	14,525,082	kWh		11,911	1,453	13,363	0.22%
Total emissions			**5,509,932**	**11,911**	**503,617**	**6,025,459**	**100%**
			92 %	**0.2 %**	**8.4 %**	**100%**	

Note: numbers may not sum to totals due to rounding
*Quantity of methane combusted and flared differs based on the assumed landfill gas collection efficiency (refer Table 3)

Table 4.4 Average annual GHG emissions (Project scenario – 2018 to 2032 with 50 years post closure)

Average annual emissions (t CO_2-e per year)	
Project scenario (15 years of continued operation and 50 years post closure)	92,700 t CO_2-e