Appendix O – Greenhouse gas assessment

SITA Australia

Lucas Heights Resource Recovery Park Project

Greenhouse Gas Assessment

October 2015

Executive summary

SITA Australia (SITA) is proposing a number of activities at the Lucas Heights Resource Recovery Park (LHRRP) in Lucas Heights. This report has been prepared by GHD Pty Ltd to provide an assessment of greenhouse gas emissions associated with the proposal as an input to the environmental impact statement.

This report has been prepared to estimate the greenhouse gas emissions associated with operation of the LHRRP.

Two scenarios were included in the greenhouse gas assessment:

- Baseline scenario: do nothing scenario with the existing landfilling operating for a further 12 years.
- Proposal scenario: re-profiling of existing landfill areas, relocation and expansion of the existing garden organics (GO) facility and construction and operation of a fully enclosed advanced resource recovery technology (ARRT) facility.

The assessment results are outlined below.

Parameter	Units	Baseline scenario	Proposal scenario
Greenhouse gas emissions (total operations and 50 years post closure)	Mt CO_2-e	5.3	14.0
Greenhouse gas emissions intensity	t CO_2-e / t waste received	1.24	0.77
Average annual greenhouse gas emissions (total operations and 50 years post closure)	t CO_2-e per annum	88,950	191,548
Percentage of NSW greenhouse gas emissions per annum	%	0.06%	0.12%
Percentage of Australia's greenhouse gas emissions per annum	%	0.02	0.035%

The quantity of waste proposed to be sent to the LHRRP would be sent to an alternative landfill facility in the absence of the proposal. The emissions from the disposal of waste in an alternative landfill have not been considered as part of this assessment. However, since the collection efficiency for greenhouse gas for the proposal is higher than the average for landfills in NSW, it provides a better environmental outcome than sending the same amount of waste to an "average" landfill.

This greenhouse gas assessment did not consider the consequential impacts on greenhouse gas emissions due to the recovery of materials at the ARRT facility. Since it is likely that the recovery and reuse or recycling of such materials would be less emissions intensive than the production of equivalent material, the greenhouse gas impacts of the proposal would be additionally beneficial for the environment.

Fugitive emissions from the landfill are the greatest source of emissions for the proposal, contributing 93.7% of the emissions generated over the life of the proposal.

Opportunities to increase the methane capture rate would be investigated on an ongoing basis to allow an ongoing and continuous improvement to the landfill gas management system. As the landfill gas system would be progressively modified to accommodate the new final landfill profile during the entire operational life of the proposal, improvements could therefore be made as new knowledge/techniques/technology becomes available. It is likely that the gas capture rate would be improved in the future due to such opportunities and due to improved final capping.

Since the EIS studies were commenced, SITA has installed twenty nine additional landfill gas collection wells at the LHRRP. In addition, as part of the site specific odour monitoring, a number of localised emission points were identified. Subsequent surface gas monitoring has confirmed that they have since been rectified.

Furthermore, SITA would continue to work with its landfill gas management contractor to refine the landfill gas extraction and oxidation system in identified major emissions contributing areas – which are currently the existing northern batter and two areas of intermediate cover.

SITA would also continue to undertake regular testing and monitoring to identify any other major emissions contributing areas to ensure the ongoing landfill gas management system is effective. This would include subsurface gas and accumulation monitoring in accordance with environment protection licence frequency requirements (currently bi-monthly). Should gas monitoring identify any other major emission contributing areas, rectification measures would be implemented to improve gas extraction and oxidation in these areas.

Other greenhouse gas mitigation strategies that could possibly be implemented at the LHRRP are listed below:

- implement energy efficient practices and equipment to minimise electricity consumption
- install solar panels on large roof areas e.g. ARRT facility buildings
- utilise biofuels used in collection and facility vehicles.

These additional strategies would be investigated at the detailed design stage.

This report addresses the Secretary's Environmental Assessment requirements and concludes that the proposal would meet the following objectives:

- No significant impact on the community or environment
- Minimising landfill gas emissions to the atmosphere
- Recovery of energy from gas
- Efficient landfill gas extraction.

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Glossary

Term	Definition
ANSTO	Australian Nuclear Science and Technology Organisation
ARRT facility	Advanced Resource Recovery Technology facility
EIS	Environmental Impact Statement
EPA	New South Wales Environment Protection Authority and any successor body.
EP&A Act	*Environmental Planning and Assessment Act 1979*
Currently approved landform	The currently approved landform heights and contours outlined in the 1999 EIS
GIS	Geographic Information Systems
GO facility	The Garden Organics facility at LHRRP, that undertakes composting of waste including green and garden waste, but excluding waste types such as food waste and biosolids
GLALC	Gandangara Local Aboriginal Land Council
Landform reprofiling	Proposed changes to currently approved landform at the LHRRP.
LHRRP	Lucas Heights Resource Recovery Park
Mitigation	The application of techniques to reduce environmental impacts arising from the proposal
OEMP	Operational Environment Management Plan and all relevant future documents, these will be provided for the landfill, GO and ARRT and will detail how these projects can be managed to meet the environmental outcomes for the site
PCYC Mini-Bike Club	The mini-bike club operated by the Police and Community Youth Clubs NSW Limited (PCYC).
SSC	Sutherland Shire Council
SEAR	Secretary's Environmental Assessment Requirements (formerly known as Director-General's Requirements or DGRs)
SICTA	Sydney International Clay Target Association and any successor body
SITA	SembSITA Australia Pty Ltd (SembSITA) is the holding company for the SITA Australia (SITA) group of companies in Australia. SembSITA is the parent company of both SITA and WSN Environmental Solutions Pty Ltd (WSN). WSN owns part of the land on which the LHRRP is situated, and leases the remainder from ANSTO. SITA holds the environmental protection licence (EPL), and so is the operator of the facilities at LHRRP. For simplicity, the term 'SITA' is used to refer to all of these organisations in this report.

1. Introduction

1.1 Purpose of this report

SITA Australia (SITA)[1] is proposing a number of activities at the Lucas Heights Resource Recovery Park (LHRRP) in Lucas Heights (referred to in this report as 'the proposal'). This report has been prepared by GHD Pty Ltd on behalf of SITA to provide an assessment of greenhouse gas emissions associated with the proposal as an input to the environmental impact statement. Due to the existing operational arrangements at LHRRP, Sutherland Shire Council (SCC) is a joint applicant for the proposal. The environmental impact statement is being prepared by GHD in accordance with the requirements of Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (the EP&A Act).

The report addresses the requirements of the Secretary of the NSW Department of Planning and Environment (the Secretary's Environmental Assessment Requirements (SEARs No SSD-6835) dated 3 February 2015 (as outlined in Section 1.6).

In addition to addressing the SEARs requirements, this report provides an assessment of how well the proposal meets SITA's objectives of having no significant impacts on the community or environment. Environmental management and mitigation measures related to greenhouse gas are proposed (where necessary) to mitigate potential impacts and ensure that they are managed in accordance with statutory requirements, regulations and community expectations.

1.2 Objectives

The following objectives have been identified:

- No significant impacts on the community or environment
- Minimising landfill gas emissions to the atmosphere
- Recovery of energy from gas
- Efficient landfill gas extraction

1.3 Proposal overview

The LHRRP consists of approximately 205 hectares (ha) in two ownerships. 89 ha is owned by SITA and 116 ha owned by Australian Nuclear Science and Technology Organisation (ANSTO) and leased to SITA for waste management or other agreed purposes. The following activities are proposed at the LHRRP and are collectively referred to as 'the proposal'. The proposal would not have a significant impact on the community. In addition to the proposal detailed below, SITA are committed to better environmental outcomes by the application of best practice prevention, mitigation and rectification measures:

- **Reprofiling of existing landfill areas to provide up to 8.3 million cubic metres of additional landfill airspace capacity.** This is equivalent to approximately 8.3 million tonnes of waste, assuming 1 tonne of waste utilises 1 cubic metre of waste disposal airspace. As the process of reprofiling would include removal and replacement of capping material over previously landfilled waste and augmentation of gas and leachate collection systems, the environmental performance of the site would be ultimately improved by

[1] SembSITA Australia Pty Ltd (SembSITA) is the holding company for the SITA Australia (SITA) group of companies in Australia. SembSITA is the parent company of both SITA and WSN Environmental Solutions Pty Ltd (WSN). WSN owns part of the land on which the LHRRP is situated, and leases the remainder from ANSTO. SITA holds the environmental protection licence (EPL), and so is the operator of the facilities at LHRRP. For simplicity, the term 'SITA' is used to refer to all of these organisations in this report.

reducing the infiltration of stormwater into the landfill (resulting in reduced landfill leachate in the longer term) and increase the overall amount of landfill gas recovered from the site.

As part of the proposal, SITA is seeking permission to increase the approved quantity of waste landfilled at the site from 575,000 to 850,000 tonnes per year. This would enable the reprofiling of the site to be completed in 2037.

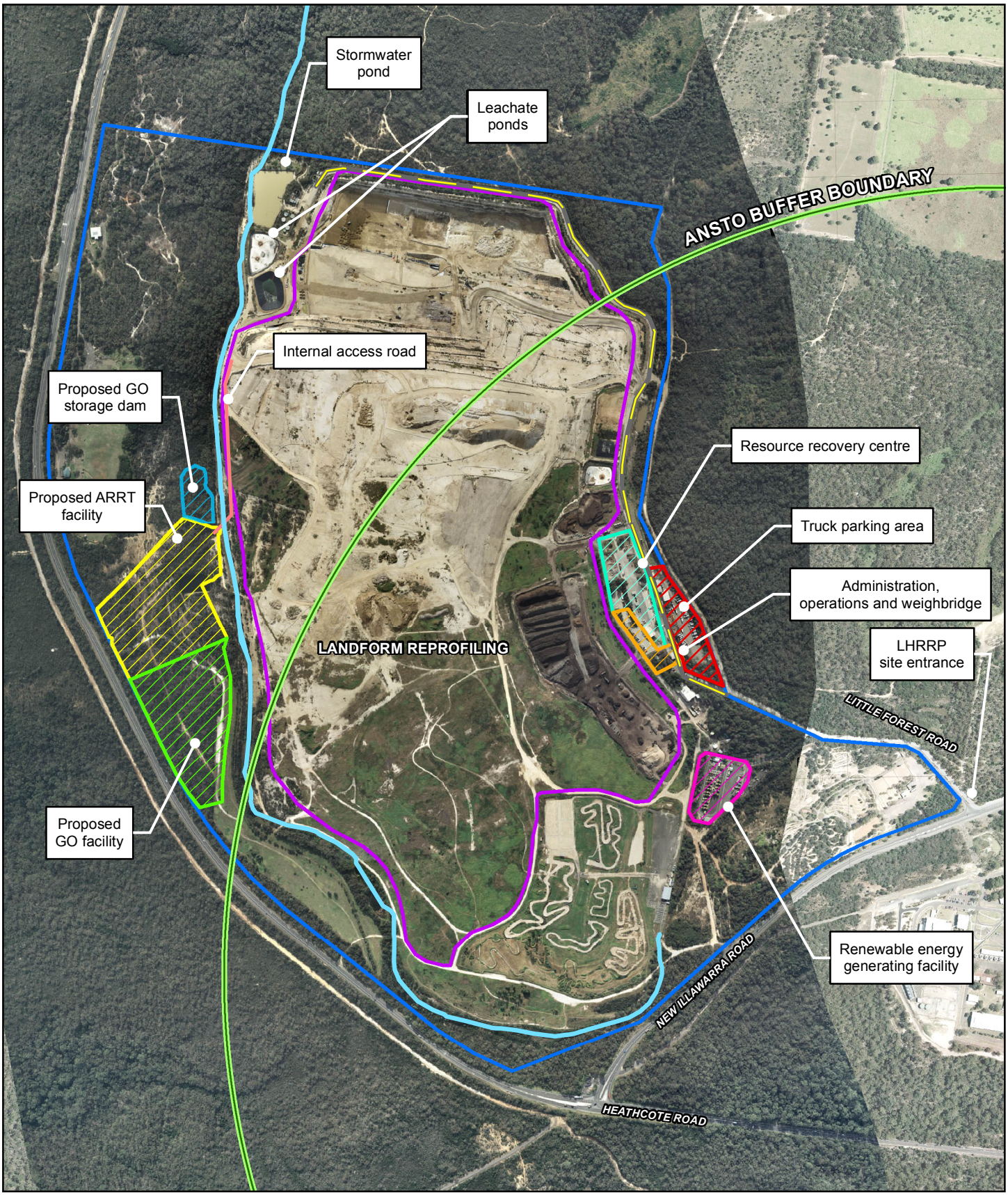
- **Relocation and expansion of the existing garden organics (GO) facility**. The existing garden organics facility would be relocated to the western side of the site adjacent to Heathcote Road. Approval is being sought to increase the approved capacity from 55,000 to 80,000 tonnes of green waste and garden waste received per year at the facility. The new facility would include the partial enclosure, active aeration and covering of the first four weeks of the active composting process, which coincides with the period of highest potential for odour generation, to enable more effective control of odour . Relocation of the facility would result in increased separation distances from the current nearest occupied land at ANSTO, existing residential areas and the proposed new residential area at West Menai.
- **Construction and operation of a fully enclosed advanced resource recovery technology (ARRT) facility**. The ARRT would be located on the western side of the site adjacent to the GO facility and would process and recover valuable resources from up to 200,000 tonnes of general solid waste per year, reducing the amount of waste disposed to landfill to approximately 60,000 tonnes per year. This would divert up to 140,000 tonnes of waste per year from landfill. SSC and other councils would have the opportunity to have their municipal waste processed by the ARRT facility.
- **Community parkland**. The landfill reprofiling would increase the area available for future passive recreation following site closure from 124 ha (existing approved parkland) to a total of 149 ha, an increase of approximately 25 ha. Landfilling would cease in 2037 after which time the site would be rehabilitated and converted to a community parkland, with capping and landscaping to be completed and the site made available for community use in 2039.

As part of the proposal SITA has committed to entering into an agreement with SCC in the form of a Voluntary Planning Agreement which includes ‘environmental undertakings’. In addition operational environmental management plans have been prepared for the landfill, GO facility, ARRT facility and post closure measures to manage potential environmental impacts, reflect regulatory requirements and provide guidance for site operators to undertake activities in an environmentally sound manner.

A Planning Proposal is being submitted in parallel with this State Significant Development Application. The Planning Proposal seeks to include new local provisions on the LHRRP site within the Sutherland Local Environmental Plan 2015 (SLEP), which would allow the proposal (a waste or resource management facility) to be undertaken on the proposal site.

The expansion of the LHRRP which is outlined in this EIS would not prevent the proposed future use of the land for recreational purposes, which is currently approved and would occur when the existing facility ceases operation in 2025. The proposal would however extend the timeframe for which the land would be unavailable for recreational purposes until 2037, due to the extension of operations at the proposed LHRRP.

These key components of the proposal are shown on Figure 1.1. The proposed final landform and preliminary masterplan for the parkland is shown in Figure 1.2.



LEGEND

- ANSTO buffer boundary
- Mill Creek
- Internal access road
- Existing access road
- Proposed GO facility
- Proposed ARRT facility
- Resource Recovery Centre
- Administration, operations and weighbridge
- Renewable energy generating facility
- Lucas Heights Resource Recovery Park boundary
- Landform reprofiling boundary
- Truck parking area

Paper Size A4

0 100 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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GHD

SITA Australia
Lucas Heights Resource Recovery Park

Job Number 21-23482
Revision A
Date 28 May 2015

Key existing infrastructure and proposed facility layout

Figure 1.1

N:\AU\Sydney\Projects\21\23482\GIS\Maps\MXD\21-23482-Z046_KeyProposedInfrastructure.mxd 15/133 Castlereagh Street Sydney NSW 2000 Australia **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com **W** www.ghd.com

Aerial Imagery: ESRI, 2014. Works: GHD/SITA, 2014. Roads: NSW LPMA, 2012. Created by:jrichardson

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Lucas Heights Resource Recovery Park

Job Number 21-23482
Revision A
Date 24 June 2015

Proposed parkland master plan **Figure 1.2**

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

N:\AU\Sydney\Projects\21\23482\GIS\Maps\MXD\21-23482-Z058_Parkland_Master.mxd

Data source: Taylor Brammer Landscape Architects Pty Ltd. Created by:jrichardson

1.4 Definitions

The following terms are used within this report when referring to the proposal site and surrounding areas:

The 'LHRRP' refers to the entire Lucas Heights Resource Recovery Park. The boundary of the LHRRP is shown as the blue line on Figure 1.3.

The 'proposal site' refers to the areas where the activities described in Section 1.3 would be located. The boundary of the proposal site is shown as the red line on Figure 1.3.

1.5 Location of the proposal

1.5.1 Existing

The proposal would be located within the boundary of the existing LHRRP. The LHRRP is located within the Sutherland local government area, approximately 30 kilometres (km) south west of the Sydney city centre. The site is bound to the west by Heathcote Road and New Illawarra Road to the south.

Specifically, the proposal would be located on:

- Lot 101 DP 1009354
- Lot 3 DP 1032102
- Lot 2 DP 605077

It is noted that the proposal directly affects only a portion of each of these lots. There is minimal encroachment into the SICTA leased land (part of Lot 3 DP 1032102).

The proposal site, within the boundary of the LHRRP, is shown on Figure 1.4.

The site is currently accessed from Little Forest Road, off New Illawarra Road.

Current facilities at the LHRRP include:

- Landfill
- Resource recovery centre and waste collection point
- GO facility for processing garden organics
- Renewable energy production (operated by Energy Developments Ltd)
- Truck parking area
- Community use areas (mini bike area at the southern extent of the site run by the Sutherland Police Citizens Youth Club and the Sydney International Clay Target Association (SICTA) leased land on the north western side of the site)

There are also several ancillary buildings and structures (e.g. weighbridge, machinery workshop, administration offices, stormwater and leachate dams).

The following land uses are located in the immediate vicinity of the LHRRP:

- Bushland areas that form part of ANSTO's exclusion zone (to the east and south)
- ANSTO's facilities (to the east on the opposite side of New Illawarra Road)

Land uses in the surrounding area include:

- Holsworthy Military Reserve (to the west, northwest and southwest)

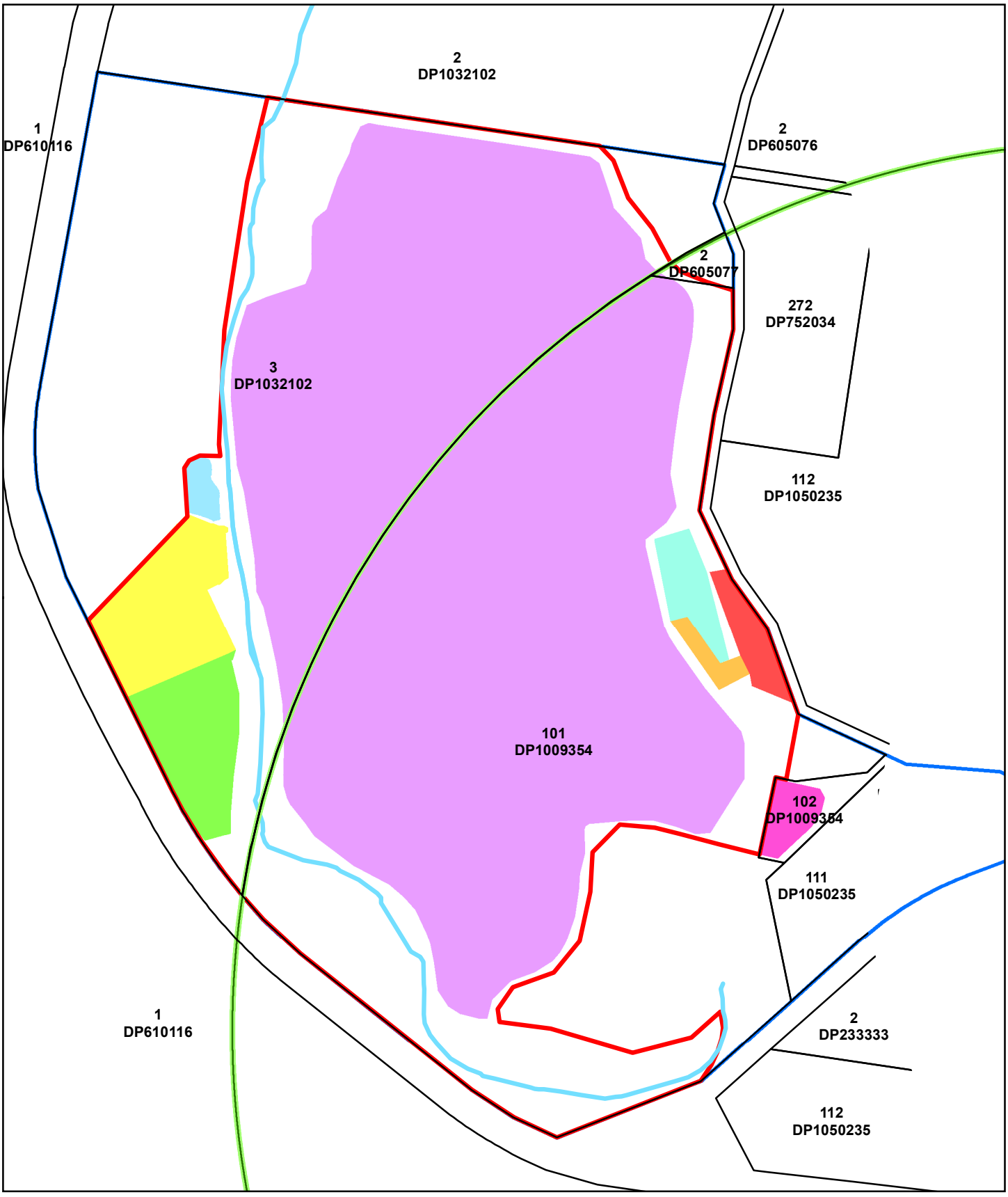
- The Ridge Sports Complex, a major regional sporting facility being developed on the site of the former Lucas Heights Waste and Recycling Centre (approximately 2.5 km to the north east)
- Lucas Heights Conservation Area (immediately to the north of the LHRRP)
- The suburbs of North Engadine (approximately 2 km to the east) and Barden Ridge (approximately 3 km to the north east)

Figure 1.4 shows these key areas.

1.5.2 Potential future surrounding land uses

The Gandangara Local Aboriginal Land Council (GALC) is proposing a development in the West Menai area. The West Menai State Significant Site contains 849 ha of mostly undeveloped land, covering parts of Menai, Barden Ridge and Lucas Heights.

The western boundary of the proposed development is Heathcote Road and the site extends east across Mill Creek to the edge of the existing Menai residential area close to New Illawarra Road. The location of the proposed West Menai State Significant Site is shown on Figure 1.4.



LEGEND

- ANSTO buffer boundary
- Mill Creek
- Cadastre
- Proposal site boundary
- Lucas Heights Resource Recovery Park boundary
- Truck parking area
- Proposed GO facility
- Proposed ARRT facility
- Resource Recovery Centre
- Administration, operations and weighbridge
- Renewable energy generating facility
- Landform reprofiling boundary

Paper Size A4

0 45 90 180 270 360

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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GHD

SITA Australia
Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	A
Date	25 Jun 2015

The proposal site

Figure 1.3

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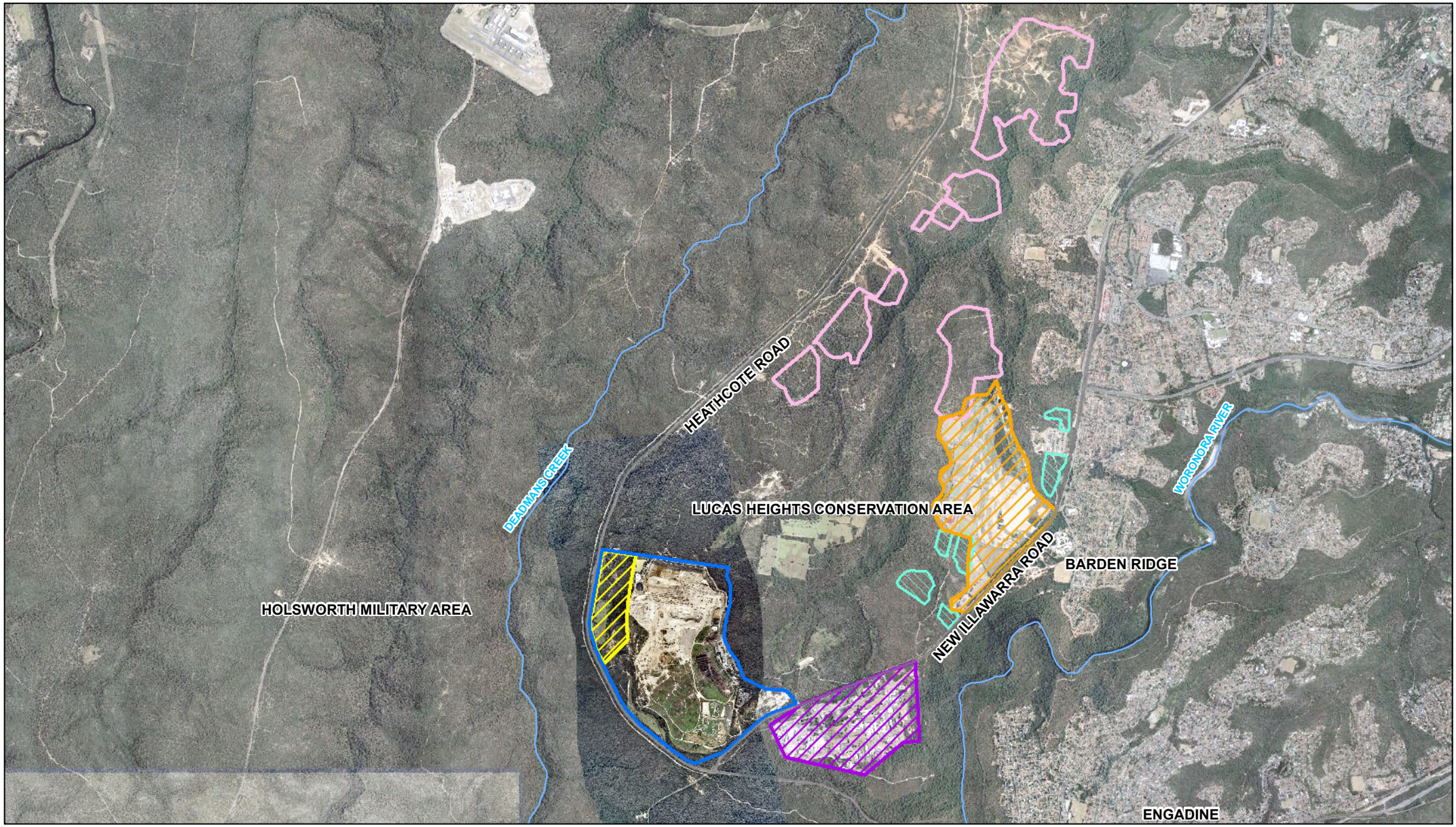
15/133 Castlereagh Street Sydney NSW 2000 Australia T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com W www.ghd.com

Aerial Imagery: ESRI, 2014. Works: GHD/SITA, 2014. Roads: NSW LPMA, 2012. Created by:afoddy



Paper Size A4

0 250 500 1,000 1,500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Legend

- LHRRP boundary
- SICTA boundary
- ANSTO
- Barden Ridge Sports Complex
- Potential future receptors
- Future receptors – Residential

SITA Australia
Lucas Heights Resource Recovery Park

Job Number 21-23482
Revision B
Date 14 Aug 2015

Surrounding landuses

Figure 1.4

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15/133 Castlereagh Street Sydney NSW 2000 Australia T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com W www.ghd.com

Aerial Imagery: SITA, 2014. Works: GHD/SITA, 2014. Roads: NSW LPMA, 2012. Created by:apmiller

1.6 Secretary's Environmental Assessment Requirements and agency requirements

The specific SEARs and agency requirements addressed in this report are summarised in Table 1.1.

Table 1.1 Secretary's Environmental Assessment Requirements

Assessment requirements	Where addressed in report
A quantitative assessment of the potential scope 1 and 2 greenhouse gas emissions of the development, and a qualitative assessment of the potential impacts of these emissions on the environment	Chapter 4 – Potential impacts Chapter 5 – Impact assessment
A detailed description of the measure that would be implemented on site to ensure that the development is energy efficient	Chapter 6 – Mitigation measures
Agency requirements	
Nil	n/a

1.7 Scope and structure of the report

1.7.1 Scope of report

This greenhouse gas assessment was undertaken with consideration given to the activities associated with the operation of the proposal.

This assessment has taken into account separate categories of direct and indirect emissions of works associated with the proposal. These categories include Scope 1 (direct emissions), Scope 2 (indirect emissions associated with the production of electricity, steam or heat); and Scope 3 (all other upstream and downstream emissions) as outlined in the GHG Protocol.

Two scenarios were assessed:

- Baseline scenario: do nothing scenario with the existing landfilling operating for a further 10 years from 2015.
- Proposal scenario: re-profiling of existing landfill areas, relocation and expansion of the existing GO facility and construction and operation of a fully enclosed ARRT facility. Operations would continue for 23 years from, 2015

For both scenarios, fugitive emissions from the landfill were considered for fifty years following closure of the landfill.

Details regarding the landfill gas capture system are not addressed in this report and discussed in other sections of the Environmental Impact Statement.

1.7.2 Structure of report

- **Chapter 1 – Introduction -** This chapter introduces the proposal, the proponent and describes the proposal area.
- **Chapter 2 – Existing environment -** This chapter describes the existing environmental values of the study area relevant to greenhouse emissions and the relevant Commonwealth and State legislation relating to the assessment.
- **Chapter 3 – Methodology -** This chapter defines the study area assessed in this report and describes the steps undertaken in the assessment.
- **Chapter 4 – Potential impacts -** This chapter examines the potential environmental impacts associated with the operation of the proposal.

- **Chapter 5 – Impact assessment -** This chapter compares the emissions associated with the proposal to the baseline emissions and to state and national greenhouse gas emissions.
- **Chapter 6 – Mitigation measures -** This chapter outlines the proposed mitigation strategies to be implemented during the life of the proposal to manage the potential environmental impacts.

2. Existing environment

2.1 Australia's and New South Wales' greenhouse gas emissions

The Commonwealth Department of the Environment estimates annual greenhouse gas emissions for Australia in order to fulfil reporting requirements of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The latest breakdown of Australia's GHG emissions by state and territory was published by the Department of the Environment for 2011/12 (DoE 2014).

Australian and NSW total greenhouse gas emissions for 2011/12 were estimated as 554.6 million tonnes of carbon dioxide equivalent (Mt CO_2-e) and 154.7 Mt CO_2-e respectively. A breakdown of greenhouse gas emissions by sector is provided in Table 2.1.

Table 2.1 Australia and NSW greenhouse gas emissions in 2011-12

Sector	Australia emissions (Mt CO_2-e)	Percentage of Australia emissions	NSW emissions (Mt CO_2-e)	Percentage of NSW emissions
Energy	413.4	74.5%	116.8	75.5%
Industrial processes	31.2	5.6%	11.1	7.2%
Agriculture	87.4	15.8%	17.2	11.1%
Waste	11.7	2.1%	3.8	2.5%
Land use, land use change and forestry	10.9	2.0%	5.8	3.7%
Total	**554.6**	**-**	**154.7**	**-**

2.2 National Greenhouse and Energy Reporting Scheme

The National Greenhouse and Energy Reporting Scheme (NGERS) is a national framework for corporations to report on greenhouse gas emissions, energy consumption and energy production. Reporting is based on financial years and the first reporting period was the 2008/09 financial year. The scheme is administered by the Clean Energy Regulator.

Corporations that exceed an NGERS threshold must report each financial year. There are two types of thresholds:

- Facility thresholds
  - Emissions of 25,000 t or more of greenhouse gas emissions (measured in carbon dioxide equivalence (CO_2-e)
  - Production of 100 TJ or more of energy
  - Consumption of 100 TJ or more of energy
- Corporate group thresholds
  - Emissions of 50,000 t CO_2-e or more of greenhouse gas emissions
  - Production of 200 TJ or more of energy
  - Consumption of 200 TJ or more of energy.

The following legislation applies to NGERS:

- *National Greenhouse and Energy Reporting Act 2007*
- *National Greenhouse and Energy Reporting Regulations 2008*
- *National Greenhouse and Energy Reporting (Measurement) Determination 2008*

- *National Greenhouse and Energy Reporting (Audit) Determination 2009*
- *National Greenhouse and Energy Reporting (Auditor Registration) Instrument 2012.*

SITA reports its greenhouse gas emissions, energy consumption and energy production from its existing facilities. The facilities developed as part of this proposal will be required to be included in SITA's annual reports to the Clean Energy Regulator.

2.3 Direct Action Plan

The Australian Government's Direct Action Plan contains several initiatives aimed at reducing Australia's greenhouse gas emissions by five percent below 2000 levels by 2020. The centrepiece of the Direct Action Plan is the Emissions Reduction Fund (ERF). The ERF expands the Carbon Farming Initiative (CFI), which was developed to give farmers, forest growers and landholders the ability to generate accredited domestic offsets for access to domestic voluntary and international carbon markets. The CFI was administered through the *Carbon Credits (Carbon Farming Initiative) Act 2011.* On 24 November 2014, the Australian Parliament passed the *Carbon Farming Initiative Amendment Bill 2014*. The Bill amended the *Carbon Credits (Carbon Farming Initiative) Act 2011* and other associated legislation and established the Emission Reduction Fund.

A key component of the ERF applicable to this proposal is the safeguard mechanism. The safeguard mechanism will apply to facilities that report emissions greater than 100,000 t CO_2-e per year through NGERS. An emissions intensity benchmark will be applied to all facilities that exceed the safeguard mechanism threshold of 100,000 t CO_2-e. Penalties will apply to facilities that exceed the emissions intensity benchmark.

For existing facilities, previous reporting data will be used to establish the emissions intensity benchmarks. For new projects, it has not been specified how the emissions intensity benchmarks will be determined. The facilities that form part of this proposal are likely to exceed the threshold for the safeguard mechanism and emissions intensity baselines may apply.

2.4 Landfill gas generation and emissions

Landfill gas is the primary source of greenhouse gas emissions at the LHRRP. Other more minor sources include emissions from combustion of collected gas, composting operations, fuel use and electricity consumption and so forth.

Landfill gas is a complex mixture of different gases produced by the degradation of biodegradable waste materials deposited within landfill sites. Landfill gas typically consists of 45-60% methane, 40-60% carbon dioxide and traces of other organic compounds (less than 1%). The composition varies according to the dominant phase of microbial degradation within the landfilled waste, as shown in Figure 2.1.

The generation rate and chemical composition of landfill gas varies depending on many factors including waste type, time, moisture content, temperature etc. During the anaerobic phase, when decomposition of biodegradable waste materials occurs in the absence of oxygen, methane and carbon dioxide are the major constituents of the landfill gas generated (although numerous other gases may also be present at low concentrations).

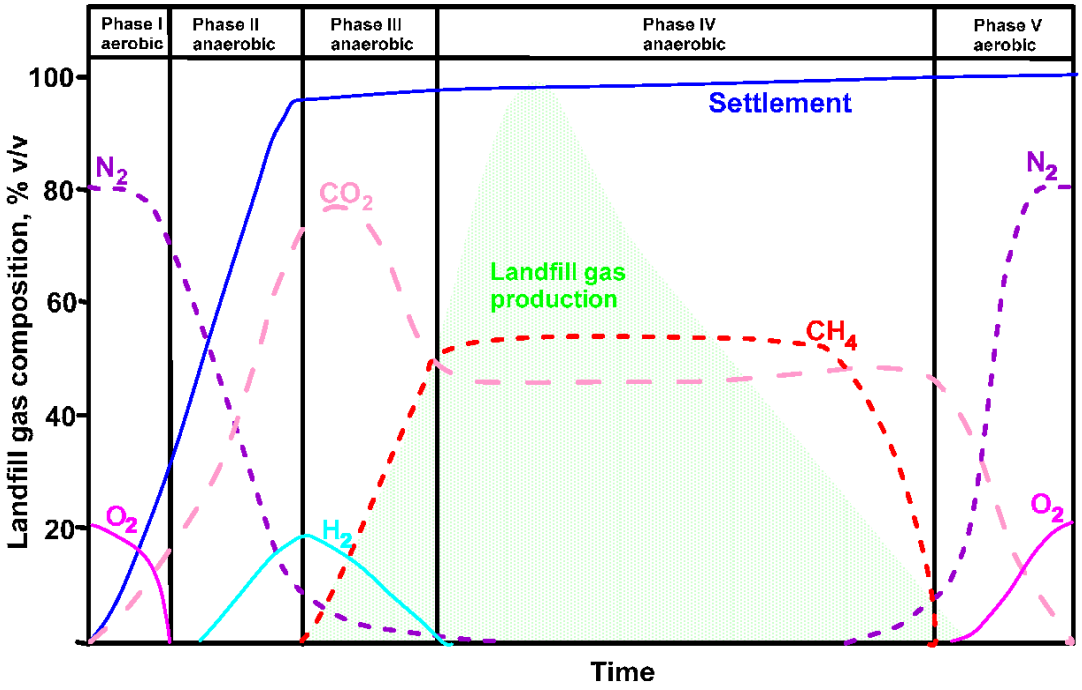

Figure 2.1 Idealised representation of landfill gas generation

Source: NSW EPA (2012) *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases*, p.8

The timescale for the evolution of significant quantities of landfill gas typically varies from 3 to 12 months following waste deposition, and can continue for well over 30 years.

If not controlled, the organic compounds can cause odour nuisance, and escaping landfill gas can reduce the oxygen content in soil to limit plant growth. Other potential impacts from landfill gas include contributing towards the greenhouse effect and the risk of explosions in confined spaces.

If not appropriately managed, landfill gas can be emitted from a landfill site by a number of pathways including:

- The landfill site's surface, including penetrations
- Subsurface geology
- Subsurface services (man-made)
- The landfill gas management system
- Leachate migration.

At the LHRRP there are currently four main management strategies for the control and extraction of landfill gas for the site. They are:

- Landfill gas extraction wells are progressively installed into the waste to control gas migration, some overlap of the radius of influence is allowed for extraction wells located at the border perimeter of the landfill, to assist effective control
- Inter-well spacing is equal to or less than twice the estimated radius of influence
- Landfill gas condensate is collected and recirculated into the landfill
- Ongoing utilisation of the gas to electricity power station located at the entrance to the LHRRP and a second station located at Lucas Heights 1 (closed landfill).

In addition, the OEMP for the LHRRP (SITA 2014) outlines the monitoring and performance indicators/targets for landfill gas management.

Energy Development Limited (EDL) currently has a contract with SITA for gas management at LHRRP, which includes the operation of the gas field and the two electricity generation plants.

3. Methodology

3.1 Overview

The greenhouse gas assessment was prepared in accordance with the general principles of:

- *The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard, Revised Edition,* developed by the World Resource Institute and the World Business Council for Sustainable Development (GHG Protocol).
- The Commonwealth *National Greenhouse and Energy Reporting (Measurement) Determination 2008.*
- The Commonwealth Department of the Environment *National Greenhouse Accounts (NGA) Factors*, July 2014 (DoE 2014).

These are considered to represent current good practice in Australian greenhouse gas accounting.

3.2 Greenhouse gases considered

The greenhouse gases and associated global warming potential (GWP) considered in this assessment are listed in Table 3.1. The global warming potentials were sourced from the National Greenhouse Accounts Factors - July 2014.

Table 3.1 Greenhouse gases and 100 year global warming potentials

Greenhouse gas	Global warming potential
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
Hydrofluorocarbons (HFCs)	140 – 11,700
Perfluorocarbons (PFCs)	6,500 – 9,200
Sulphur hexafluoride (SF_6)	23,900

3.3 Emission scopes

Emissions have been separated into Scopes 1, 2 and 3 in accordance with the GHG Protocol. These scopes are defined as follows:

1. Scope 1 emissions are greenhouse gas emissions created directly by a person or business from sources that are owned or controlled by that person or business.
2. Scope 2 emissions are greenhouse gas emissions created as a result of the generation of electricity, heating, cooling or steam that is purchased and consumed by a person or business. These are indirect emissions as they arise from sources that are not owned or controlled by the person or business who consumes the electricity.
3. Scope 3 emissions are greenhouse gas emissions that are generated in the wider economy as a consequence of a person's or business's activities. These are indirect emissions as they arise from sources that are not owned or controlled by that person or business but they exclude Scope 2.

Scope 1 emissions are produced by the combustion of fuels such as diesel at the development site and include fugitive emissions from the landfill. Scope 1 emissions are also produced by vehicles and equipment which the proponent owns and has operational control over. Note that only the direct combustion of the fuels is considered as Scope 1 emissions.

Scope 2 emissions arise from the consumption of electricity from the grid at the development site, in plant and equipment that is owned and operated by the proponent.

Emissions arising from the extraction, processing, transportation and distribution of fuels and electricity are classified as Scope 3, since these activities are not within the operational control of the end user.

All other emissions associated with the proposal are defined as Scope 3, since they are produced outside the development site and the proponent does not have operational control of the facilities from which they originate.

3.4 Boundary of assessment

The assessment included emissions from the following activities:

- fuel combustion during waste collection
- fuel combustion by vehicles at the facility
- fugitive emissions from the landfill
- combustion of landfill gas in gas engines
- composting of municipal solid waste and garden organics
- electricity sourced from the grid.

The boundary of the assessment did not consider the consequential impacts on greenhouse gas emissions due to the recovery of materials at the ARRT facility. It is likely that the recovery and reuse or recycling of such materials would be less emissions intensive than the production of equivalent material.

Exclusions are discussed in Section 3.5.

3.5 Exclusions from the assessment

Exclusions from the assessment were based on GHD's experience in conducting similar assessments. All greenhouse gas emissions excluded from this assessment, in GHD's opinion, satisfy the *de minimis* principle typically applied to greenhouse gas assessments, that is, any exclusion would be less than 1% of the total greenhouse gas emissions from the proposal and the sum of all exclusions would be less than 5% of the total greenhouse gas emissions from the proposal. This is consistent with the principles of ISO 14064-1 *Greenhouse gases -- Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals* and international greenhouse accounting programs such as the Certified Emissions Measurement And Reduction Scheme (CEMARS).

Emissions excluded from the assessment included:

- Emissions associated with the construction phase of the proposal. Such emissions were considered to be negligible compared with the emissions over the life of the proposal.
- Fugitive emissions of hydrofluorocarbons from air conditioning units and refrigeration. Such emissions were considered to be negligible compared with the emissions over the life of the proposal.
- Fugitive emissions of sulphur hexafluoride from electrical equipment. Such emissions were considered to be negligible compared with the emissions over the life of the proposal.

- Combustion of oils and greases in construction and operational vehicles and equipment. Such emissions were considered to be negligible compared with the emissions over the life of the proposal.
- Emissions associated with the manufacture of minor consumables such as office supplies, cleaning products and personal protective equipment and the transportation of such consumables to site. Such emissions were considered negligible compared to the overall emissions.
- Emissions associated with employee commuting for the proposal. Such emissions were considered to be negligible compared with the emissions over the life of the proposal.

3.6 Data sources and calculation procedures

The calculation of greenhouse gas emissions for the proposal was based on the methodology detailed in the GHG Protocol and relevant emission factors. The main sources of emission factors included:

- The Commonwealth *National Greenhouse and Energy Reporting (Measurement) Determination 2008.*
- The Commonwealth Department of the Environment *National Greenhouse Accounts (NGA) Factors*, July 2014.

Data was provided by SITA and included data submitted to the Clean Energy Regulator as part of its annual submission under the *National Greenhouse and Energy Reporting Act 2007*. This data was the basis for estimates of fuel consumption by collection vehicles and vehicles at the facility. Methane generation and collection volumes for the baseline and proposal scenarios were provided by EDL.

A spreadsheet model was specifically developed to estimate the greenhouse gas emissions for the proposal.

When data was unavailable, assumptions and approximations were made to obtain a reasonable estimate of activity levels or emission factors. All assumptions are detailed in Section 3.7.

All energy consumption and emissions data was converted into quantities of carbon dioxide equivalent ($CO_{2\text{-}e}$). The emission values have been summed to reach an estimate of the total greenhouse gas emissions for the proposal.

3.7 Assumptions

Assumptions used in estimating the activity levels and greenhouse gas emissions are listed in Table 3.2 for the baseline scenario and Table 3.3 for the proposal scenario.

The assessment was based on emission factors available at the time of the assessment.

Table 3.2 Assumptions for the baseline scenario emission sources

Parameter measured	Assumptions
Diesel consumption by waste collection vehicles	Quantity of diesel estimated as 7,968 kL over the baseline period. Emission factor (EF) sourced from *National Greenhouse Accounts Factors July 2014*, Tables 4 and 40.
Biodiesel consumption by waste collection vehicles	Quantity of biodiesel estimated as 2,015 kL over the baseline period. EF sourced from *National Greenhouse Accounts Factors July 2014*, Tables 4 and 40.
Petrol consumption by waste collection vehicles	Quantity of petrol estimated as 67 kL over the baseline period. EF sourced from *National Greenhouse Accounts Factors July*

Parameter measured	Assumptions
	2014, Tables 4 and 40.
Ethanol consumption by waste collection vehicles	Quantity of ethanol estimated as 6 kL over the baseline period. EF sourced from *National Greenhouse Accounts Factors July 2014*, Tables 4 and 40.
Diesel consumption by vehicles at the facility	Quantity of diesel estimated as 21,642 kL over the baseline period. EF sourced from *National Greenhouse Accounts Factors July 2014*, Tables 3 and 40.
Petrol consumption by vehicles at the facility	Quantity of petrol estimated as 49 kL over the baseline period. EF sourced from *National Greenhouse Accounts Factors July 2014*, Tables 3 and 40.
Ethanol consumption by vehicles at the facility	Quantity of ethanol estimated as 21 kL over the baseline period. EF sourced from *National Greenhouse Accounts Factors July 2014*, Tables 3 and 40.
Fugitive emissions from landfill	Quantity of fugitive emissions of methane from the landfill estimated as 356,286,600 m^3 CH_4 over a 60 year period (baseline period plus fifty years from the closure of the landfill). EF based on the conversion of the methane quantity from a volumetric basis to mass basis using the factor provided in *National Greenhouse and Energy Reporting (Measurement) Determination 2008*, Section 5.4 and a global warming potential for methane of 21.
Combustion of landfill gas	Quantity of methane from the landfill collected and combusted estimated as 803,563,000 m^3 CH_4 over a 60 year period (baseline period plus fifty years from the closure of the landfill). EF sourced from *National Greenhouse Accounts Factors July 2014*, Table 2.
Composting	Quantity of material composted estimated as 550,000 t over the baseline period. EF sourced from *National Greenhouse and Energy Reporting (Measurement) Determination 2008*, Section 5.22.
Electricity sourced from the grid	Quantity of electricity sourced from the grid estimated as 3,145,510 kWh over the baseline period. EF sourced from *National Greenhouse Accounts Factors July 2014*, Table 41.

Table 3.3 Assumptions for the proposal scenario emission sources

Parameter measured	Assumptions
Diesel consumption by waste collection vehicles	Quantity of diesel estimated as 17,955 kL over the proposal scenario period. Emission factor (EF) sourced from *National Greenhouse Accounts Factors July 2014*, Tables 4 and 40.
Biodiesel consumption by waste collection vehicles	Quantity of biodiesel estimated as 4,541 kL over the proposal scenario period. EF sourced from *National Greenhouse Accounts Factors July 2014*, Tables 4 and 40.
Petrol consumption by waste collection vehicles	Quantity of petrol estimated as 151 kL over the proposal scenario period. EF sourced from *National Greenhouse Accounts Factors July 2014*, Tables 4 and 40.
Ethanol consumption by waste collection vehicles	Quantity of ethanol estimated as 14 kL over the proposal scenario period. EF sourced from *National Greenhouse Accounts Factors July 2014*, Tables 4 and 40.
Diesel consumption by vehicles at the facility	Quantity of diesel estimated as 51,572 kL over the proposal scenario period. EF sourced from *National Greenhouse Accounts Factors July 2014*, Tables 3 and 40.
Petrol consumption by vehicles at the	Quantity of petrol estimated as 73 kL over the proposal scenario

Parameter measured	Assumptions
facility	period. EF sourced from *National Greenhouse Accounts Factors July 2014*, Tables 3 and 40.
Fugitive emissions from landfill	Quantity of fugitive emissions of methane from the landfill estimated as 919,700,100 m^3 CH_4 over a 73 year period (proposal scenario period plus fifty years from the closure of the landfill). EF based on the conversion of the methane quantity from a volumetric basis to mass basis using the factor provided in *National Greenhouse and Energy Reporting (Measurement) Determination 2008*, Section 5.4 and a global warming potential for methane of 21.
Combustion of landfill gas	Quantity of methane from the landfill collected and combusted estimated as 1,021,889,000 m^3 CH_4 over a 73 year period (proposal scenario period plus fifty years from the closure of the landfill). EF sourced from *National Greenhouse Accounts Factors July 2014*, Table 2.
Composting	Quantity of material composted estimated as 5,990,000 t over the proposal scenario period. EF sourced from *National Greenhouse and Energy Reporting (Measurement) Determination 2008*, Section 5.22.
Electricity sourced from the grid	Quantity of electricity sourced from the grid estimated as 218,309,873 kWh over the proposal scenario period. EF sourced from *National Greenhouse Accounts Factors July 2014*, Table 41.

4. Potential impacts

The greenhouse gas emissions for the operations phase of the proposal were calculated based on fuel consumed by collection vehicles, fuel and electricity consumed at the facility, fugitive emissions from the landfill and composting, and emission from the combustion of landfill gas.

Scope 1, 2 and 3 emissions for the baseline and proposal scenarios are summarised in Table 4.1. Total emissions were estimated at approximately 5,337,021 t CO_2-e for the baseline and 13,983,039 t CO_2-e for the proposal. The greater estimated emissions for the proposal compared to the baseline scenario is due to the increased life of the landfill (10 years to 23 years) and the increase in waste received over the life of the landfill (3,746,094 t for the baseline scenario compared with 12,099,650 t for the proposal scenario).

Table 4.1 Summary of greenhouse gas emissions for the proposal

Phase	Scope 1 (t CO_2-e)	Scope 2 (t CO_2-e)	Scope 3 (t CO_2-e)	Total (t CO_2-e)
Baseline	5,327,456	2,705	6,860	5,337,021
Proposal	13,751,813	187,746	43,479	13,983,039

Average annual emissions for the baseline scenario (based on 10 years of operation and 50 years post operations) were estimated as 88,950 t CO_2-e.

Average annual emissions for the proposal scenario (based on 23 years of operation and 50 years post operations) were estimated as 191,548 t CO_2-e.

The emissions intensities were estimated at approximately 1.24 t CO_2-e per tonne of waste received for the baseline scenario and 0.77 t CO_2-e per tonne of waste received for the proposal scenario. Therefore the emissions intensity of the proposal is lower than the baseline scenario.

The same quantity of waste proposed to be sent to the LHRRP would be sent to an alternative facility in the absence of the proposal. The emissions from the disposal of waste in an alternative landfill have not been considered as part of this assessment.

The entire greenhouse gas inventory is included in Appendix A.

The emission sources contributing the most to the overall inventory are listed in Table 4.2 for the baseline scenario and Table 4.3 for the proposal scenario.

Fugitive emissions from the landfill, the combustion of landfill gas and diesel consumed in vehicles at the facility were predicted as the greatest emission sources for the baseline scenario. These emission sources were predicted to contribute 99% of the total greenhouse gas emissions for the baseline scenario.

Fugitive emissions from the landfill, composting and electricity sourced from the grid were predicted as the greatest emission sources for the proposal scenario. These emission sources were predicted to contribute 97.2% of the total greenhouse gas emissions for the proposal scenario.

Table 4.2 Summary of major greenhouse gas emissions sources (baseline scenario)

Emission source	GHG emissions (t CO_2-e)	Percentage of proposal emissions
Fugitive emissions from landfill	5,075,801	95.1%
Combustion of landfill gas	146,322	2.7%
Diesel consumption by vehicles at the facility	62,485	1.2%
Total	**5,075,801**	**99.0%**

Table 4.3 Summary of major greenhouse gas emissions sources (proposal scenario)

Emission source	GHG emissions (t CO_2-e)	Percentage of proposal emissions
Fugitive emissions from landfill	13,102,416	93.7%
Composting	275,540	2.0%
Electricity sourced from the grid	216,127	1.5%
Total	**13,594,082**	**97.2%**

5. Impact assessment

The greenhouse gas emissions over the life of the proposal were estimated at approximately 13,983,039 t CO_2-e. The proposal scenario included 23 years of operations and 50 years of methane emissions post closure of the landfill. The average annual emissions over this time period were estimated to be approximately 191,548 t CO_2-e per annum. The 2011/12 greenhouse gas emissions for NSW (which is the latest available National Inventory Report) were approximately 154.7 Mt CO_2-e per annum.

Therefore the average annual emissions for the proposal are estimated to be approximately 0.12 percent of total annual emissions in NSW. Australia's 2011/12 greenhouse gas emissions were approximately 554.6 Mt CO_2-e per annum. Therefore, the average annual emissions for the proposal were estimated to be approximately 0.035 percent of Australia's annual emissions.

In the absence of the proposal, the same quantity of waste proposed to be sent to the LHRRP would be sent to an alternative landfill facility. The emissions from the disposal of waste in an alternative landfill have not been considered as part of this assessment.

Currently, the average methane capture rate for landfills in New South Wales is approximately 37%, whilst it has been estimated that 67% of methane generated by the landfill would be captured for combustion and energy generation purposes. Thus the proposal has a positive impact compared to disposal of the same amount of waste at an "average" landfill.

This greenhouse gas assessment did not consider the consequential impacts on greenhouse gas emissions due to the recovery of materials at the ARRT facility. Since it is likely that the recovery and reuse or recycling of such materials would be less emissions intensive than the production of equivalent material, the greenhouse gas impacts of the proposal would be additionally beneficial for the environment.

6. Mitigation measures

Fugitive emissions from the landfill are the greatest source of emissions for the proposal, contributing 93.7% of the emissions generated over the life of the proposal.

For the purpose of the greenhouse gas assessment it was assumed that 67% of methane generated by the landfill would be captured for combustion and energy generation purposes. This figure was provided by the current landfill gas management contractor, based on existing capture rate. This would be achieved by progressively expanding the gas collection network, including gas pipelines and gas wells, as the landfill reprofiling is undertaken. Care would be taken to ensure flows of gas from both the 'new' and 'old' waste are managed effectively.

Increasing the rate of capture and combustion of methane from the landfill from its predicted level of 67% to an even higher efficiency would be the most significant greenhouse gas mitigation option available for the proposal.

Opportunities to increase the methane capture rate would be investigated on an ongoing basis, as the landfill gas system is progressively modified to accommodate the new final landfill profile during the entire operational life of the proposal. Improvements could therefore be made to the gas extraction as new knowledge/techniques/technology becomes available. It is likely that the gas capture rate would be improved in the future due to such opportunities and due to improved final capping.

Since the EIS studies were commenced, SITA has installed twenty nine additional landfill gas collection wells at the LHRRP. In addition, as part of the site specific odour monitoring, a number of localised emission points were identified. Subsequent surface gas monitoring has confirmed that they have since been rectified. Furthermore, SITA would continue to work with its landfill gas management contractor to refine the landfill gas extraction and oxidation system in identified major emissions contributing areas – which are currently the existing northern batter and two areas of intermediate cover.

SITA would also continue to undertake regular testing and monitoring to identify any other major emissions contributing areas to ensure the ongoing landfill gas management system is effective. This would include subsurface gas and accumulation monitoring in accordance with EPL frequency requirements (currently bi-monthly). Should gas monitoring identify any other major emission contributing areas, rectification measures would be implemented to improve gas extraction and oxidation in these areas.

Other greenhouse gas mitigation strategies that could possibly be implemented at the LHRRP are listed below:

- implement energy efficient practices and equipment to minimise electricity consumption
- install solar panels on large roof areas e.g. ARRT facility buildings
- utilise biofuels used in collection and facility vehicles.

These additional strategies would be investigated at the detailed design stage.

The existing landfill gas wells cover the majority of the former landfilled areas where reprofiling of the surface with new waste is proposed. The existing landfill gas wells and connecting pipes would be protected, maintained and extended to allow gas extraction from the old waste to continue and the newly landfilled waste to be serviced by the existing wells (and additional wells where needed).

Additional gas controls would be installed prior to landfilling above previously landfilled areas, including a dual gas/leachate trench near the perimeter of the newly deposited waste. The trench would contain a perforated pipe and be backfilled with a high permeability material such

as gravel. This would provide a means for depressurising any areas where gas has accumulated at the interface of the existing and newly landfilled waste.

Furthermore, a comprehensive list of prevention, mitigation and rectification measures for landfill gas management have been identified and are detailed in the LHRRP OEMP (SITA Australia 2014a). The identified mitigation and rectification measures would be implemented as required and their exact details would be based on a case by case situation depending on the issue and technical solutions available at the time.

Examples of key measures that are included in the LHRRP OEMP include:

- Installation of landfill gas extraction wells in the completed areas to control gas migration
- Progressive installation of landfill gas wells in operational areas as the landfill develops
- Preparation and regular review of the emergency plan and emergency procedures
- Implementation of a program for scheduled monitoring of landfill gas (surface and subsurface).

7. Conclusions

The average annual emissions for 23 years of operations (2015 to 2037) and 50 years of methane emissions post closure of the landfill was estimated at approximately 191,548 t CO_2-e per annum. This is approximately 0.12 percent of total annual emissions in NSW and approximately 0.035 percent of Australia's annual emissions.

In the absence of the proposal, the quantity of waste proposed to be sent to the LHRRP would have to be sent to an alternative landfill facility or another location. The emissions from the disposal of waste in such an alternative landfill have not been considered as part of this assessment. However, since the collection efficiency for greenhouse gas for the proposal is expected to be higher than the average for landfills in NSW, the proposal provides a better environmental outcome than sending the same amount of waste to an alternative landfill of average standard.

Furthermore, the greenhouse gas assessment did not consider the possible reductions in greenhouse gas emissions due to the recovery of materials at the ARRT facility. It is anticipated that the recovery and reuse or recycling of such materials would be less emissions intensive than the production of equivalent material. This indicates that the greenhouse gas benefits of the proposal could be greater than the current modelling indicates.

This report addresses the SEARs requirements (section 1.6) and concludes that the proposal would meet the following objectives as identified in section 1.2:

- No significant impact on the community or environment
- Minimising landfill gas emissions to the atmosphere
- Recovery of energy from gas
- Efficient landfill gas extraction.

8. References

Commonwealth of Australia, *Carbon Credits (Carbon Farming Initiative) Act 2011*.

Commonwealth of Australia, *Carbon Farming Initiative Amendment Bill 201*4.

Commonwealth of Australia, *National Greenhouse and Energy Reporting Act 2007*.

Commonwealth of Australia, *National Greenhouse and Energy Reporting (Measurement) Determination 2008*.

Commonwealth of Australia, Department of the Environment 2014, *National Greenhouse Accounts (NGA) Factors*, July 2014

Commonwealth of Australia, Department of the Environment 2014, Australian National Greenhouse Accounts: State and Territory Greenhouse Gas Inventories 2011-12.

NSW EPA 2012, Guidelines for the assessment and management of sites affected by hazardous ground gases

International Organization for Standardization,ISO 16064-1 Greenhouse gases -- Part 1: Specification with guidance at the organization level for quantification

SITA Australia 2014, *LHRRP Operational Environmental Management Plan*, No. LH-EMP-005, Draft 9

World Resource Institute and the World Business Council for Sustainable Development 2004, *The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard, Revised Edition,* http://www.ghgprotocol.org/.

9. Limitations

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

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

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

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

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

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Appendices

Appendix A – Greenhouse gas inventory

Table A1 Greenhouse gas inventory for the baseline scenario

Emission source	Value		Scope 1 Emission Factor	Scope 2 Emission Factor	Scope 3 Emission Factor	Total Emission Factor		Method	Scope 1 Emissions	Scope 2 Emissions	Scope 3 Emissions	Total Emissions	Proportion of operations and construction	Rank
	(Q)	Units	t CO_2-e / units	t CO_2-e / units	t CO_2-e / units	t CO_2-e / units	Units		(t CO_2-e)	(t CO_2-e)	(t CO_2-e)	(t CO_2-e)	%	
Operations														
Diesel consumption by waste collection vehicles	7,968	kL	2.69	0	0.20	2.90	kL	Q x EF	21,472	0	1,630	23,102	0.4%	5
Biodiesel consumption by waste collection vehicles	2,015	kL	0.12	0	0.18	0.30	kL	Q x EF	237	0	370	607	0.0%	7
Petrol consumption by waste collection vehicles	67	kL	2.29	0	0.18	2.47	kL	Q x EF	153	0	12	165	0.0%	8
Ethanol consumption by waste collection vehicles	6	kL	0.01	0	0.12	0.13	kL	Q x EF	0	0	1	1	0.0%	11
Diesel consumption by vehicles at the facility	21,642	kL	2.68	0	0.20	2.89	kL	Q x EF	58,058	0	4,427	62,485	1.2%	3
Petrol consumption by vehicles at the facility	49	kL	2.29	0	0.18	2.47	kL	Q x EF	113	0	9	122	0.0%	9
Ethanol consumption by vehicles at the facility	21	kL	0.01	0	0.12	0.13	kL	Q x EF	0	0	3	3	0.0%	10
Fugitive emissions from landfill	356,286,600	m3 CH	0.014	0	0.00	0.014	m3	Q x EF	5,075,801	0	0	5,075,801	95.1%	1
Combustion of landfill gas	803,563,000	m3 CH	0.00018	0	0.00	0.00018	m3	Q x EF	146,322	0	0	146,322	2.7%	2
Composting	550,000	t	0.05	0	0.00	0.05	t	Q x EF	25,300	0	0	25,300	0.5%	4
Electricity sourced from the grid	3,145,510	kWh	0	0.00086	0.00013	0.00099	kWh	Q x EF	0	2,705	409	3,114	0.1%	6
Total operations emissions									**5,327,456**	**2,705**	**6,860**	**5,337,021**		

Table A2 Greenhouse gas inventory for the proposal scenario

Emission source	Value		Scope 1 Emission Factor	Scope 2 Emission Factor	Scope 3 Emission Factor	Total Emission Factor		Method	Scope 1 Emissions	Scope 2 Emissions	Scope 3 Emissions	Total Emissions	Proportion of operations and construction	Rank
	(Q)	Units	t CO_2-e / units	t CO_2-e / units	t CO_2-e / units	t CO_2-e / units	Units		(t CO_2-e)	(t CO_2-e)	(t CO_2-e)	(t CO_2-e)	%	
Operations														
Diesel consumption by waste collection vehicles	17,955	kL	2.69	0	0.20	2.90	kL	Q x EF	48,383	0	3,673	52,057	0.4%	6
Biodiesel consumption by waste collection vehicles	4,541	kL	0.12	0	0.18	0.30	kL	Q x EF	534	0	833	1,367	0.0%	7
Petrol consumption by waste collection vehicles	151	kL	2.29	0	0.18	2.47	kL	Q x EF	345	0	27	372	0.0%	8
Ethanol consumption by waste collection vehicles	14	kL	0.01	0	0.12	0.13	kL	Q x EF	0	0	2	2	0.0%	10
Diesel consumption by vehicles at the facility	51,572	kL	2.68	0	0.20	2.89	kL	Q x EF	138,353	0	10,551	148,904	1.1%	5
Petrol consumption by vehicles at the facility	73	kL	2.29	0	0.18	2.47	kL	Q x EF	166	0	13	179	0.0%	9
Fugitive emissions from landfill	919,700,100	m3 CH	0.014	0	0.00	0.014	m3	Q x EF	13,102,416	0	0	13,102,416	93.7%	1
Combustion of landfill gas	1,021,889,000	m3 CH	0.00018	0	0.00	0.00018	m3	Q x EF	186,077	0	0	186,077	1.3%	4
Composting	5,990,000	t	0.05	0	0.00	0.05	t	Q x EF	275,540	0	0	275,540	2.0%	2
Electricity sourced from the grid	218,309,873	kWh	0	0.00086	0.00013	0.00099	kWh	Q x EF	0	187,746	28,380	216,127	1.5%	3
Total operations emissions									**13,751,813**	**187,746**	**43,479**	**13,983,039**		

GHD

133 Castlereagh St Sydney NSW 2000

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T: +61 2 9239 7100 F: +61 2 9239 7199 E: sydmail@ghd.com.au

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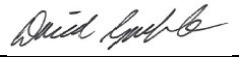
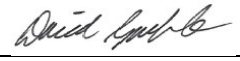
Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
11	A Montgomery	D Gamble		D Gamble		16/09/15

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