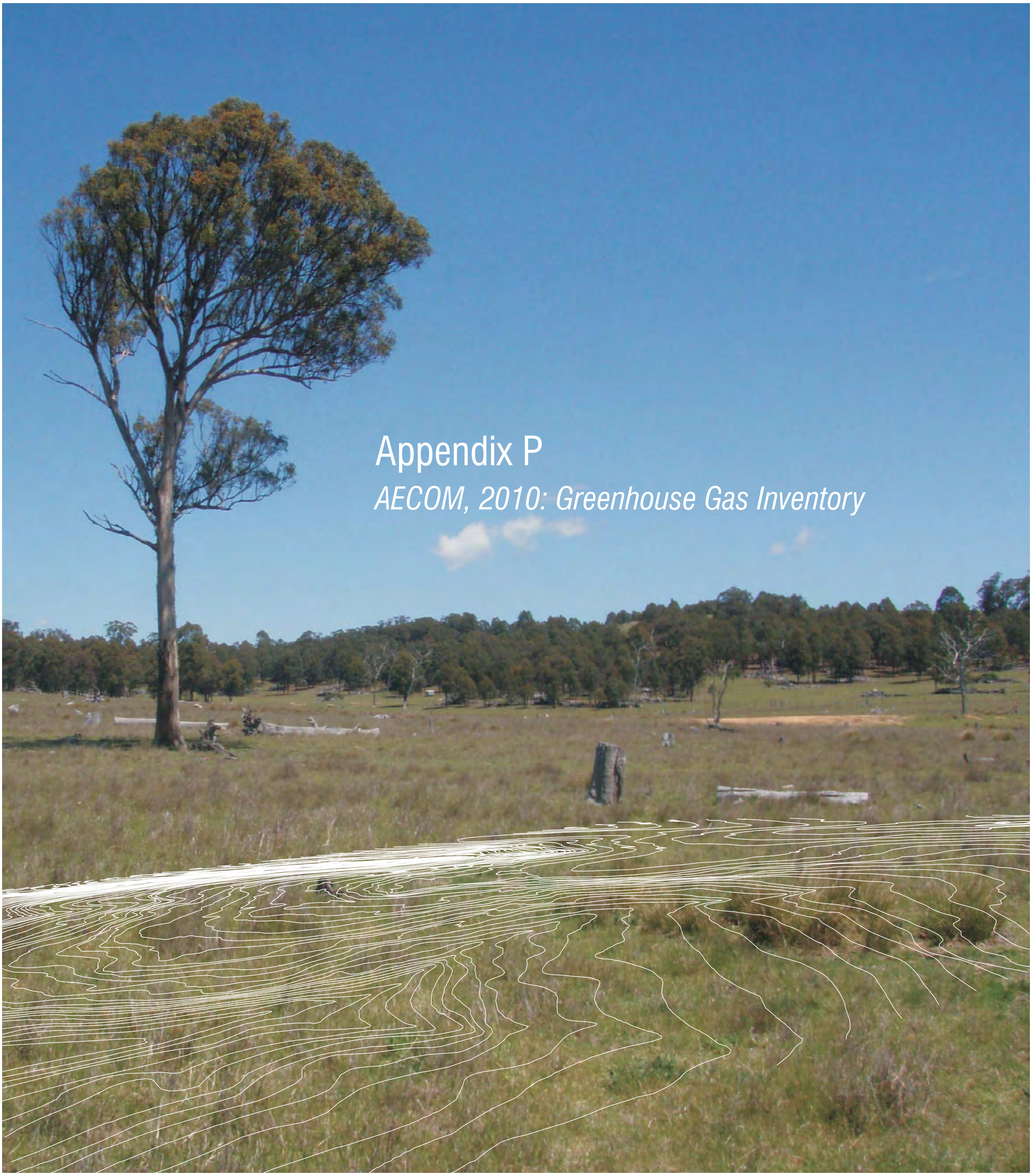
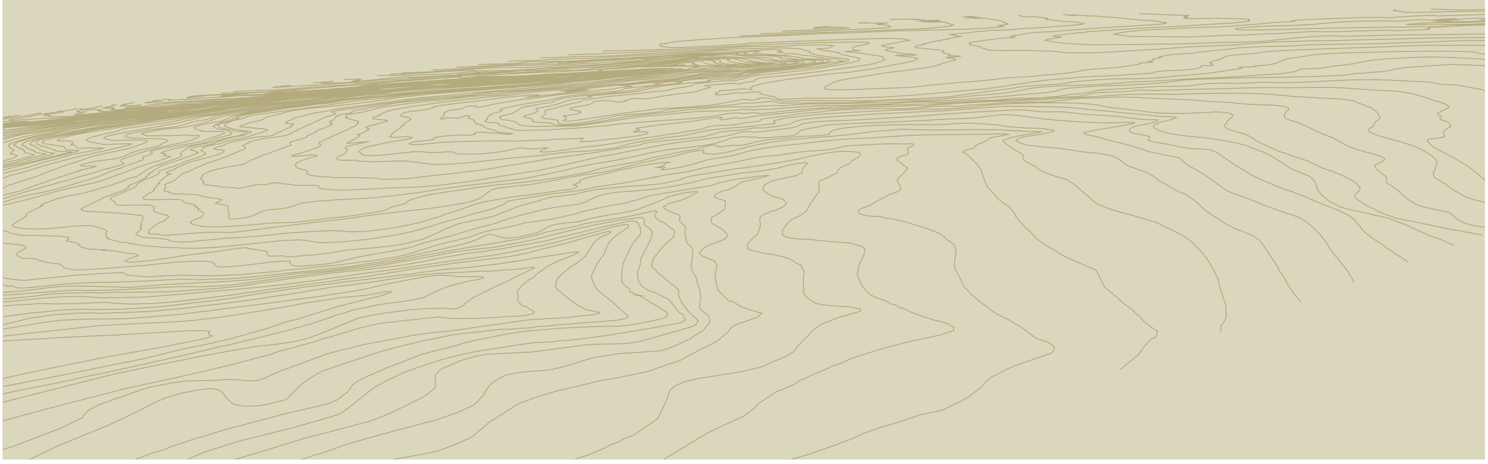


Appendix P

AECOM, 2010: Greenhouse Gas Inventory

ARMIDALE REGIONAL LANDFILL

Environmental Assessment



Armidale Regional Landfill

Armidale Dumaresq Council

12 February 2010

Greenhouse Gas Inventory

Greenhouse Gas Inventory

Prepared for

Armidale Dumaresq Council

Prepared by

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Reviewed by	Darryl Patching

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
B	12-Feb-2010	Final	Danielle Phillips Project Manager	

Table of Contents

1.0 Introduction

1.1 Project Background

Armidale Dumaresq Council (ADC) is planning to establish a landfill facility to service the Armidale, Guyra, Uralla Shire and Walcha Local Government Areas (LGAs).

The proposed Armidale Regional Landfill (the project) site is located 12km east of Armidale. It will be classed as a General Solid Waste (putrescibles) landfill and accept approximately 15,000 tonnes of waste per annum and over 750,000 tonnes over the life of the landfill. Based on this capacity and the estimated annual waste acceptance quantities, the landfill will have an expected life of approximately 50 years.

In order to allow the initial commencement of landfilling operations it is Council's intention to seek an operating licence to landfill General Solid Waste (putrescible) material, including putrescible material and other general waste recognised by the Department of Environment, Climate Change and Water (DECCW) under this "putrescible" definition for general solid wastes. It is Council's longer term objective, however, to begin operating the landfill, as soon as possible in the future (and then until final closure) only as a General Solid Waste (non-putrescible) facility, when appropriate additional off-site sorting and/or treatment technologies are able to be procured and successfully employed.

The majority of waste will be received and processed at the existing waste transfer station at Long Swamp Road (the site of the former Armidale Landfill), prior to being transported to the new facility. There will be no direct public access to the landfill. Special waste loads with no recoverable content may also be directed to unload directly at the landfill.

1.2 Purpose and Objectives

This Greenhouse Gas (GHG) Inventory as been prepared to provide a quantitative estimate the potential scope 1, 2 and 3 GHG emissions associated with the construction and operation of the proposed project.

The purpose of this inventory is to:

- Identify the sources of GHG emissions associated with the project
- Quantify the GHG emissions associated with each GHG source
- Present the Scope 1, 2 and 3 GHG emissions associated with the project
- Identify opportunities which may be implemented to reduce the GHG emissions associated with the project.
- Provide a detailed description of the measures which will be implemented to ensure that the project is energy efficient.

1.3 Greenhouse Gas Emissions

GHG emissions will be generated during the construction and operation of the proposed project.

Greenhouse gases (GHG's) 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). GHG's absorb and re-radiate heat from the sun. Since the industrial revolution there has been an increase in the amount of anthropogenic (human induced) GHG's emitted into the atmosphere which has increased the concentration of GHG emissions in the atmosphere. The increased concentration of GHG's 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.

1.3.1 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 21, thus one tonne of methane has a Greenhouse Effect equivalent to 21 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 Global Warming Potential of Greenhouse Gases

Greenhouse Gas	Global Warming Potential (GWP)
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous Oxide (N_2O)	310
Sulphur Hexafluoride (SF_6)	23,900
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*.

1.3.2 Scope of Greenhouse Gas Emissions

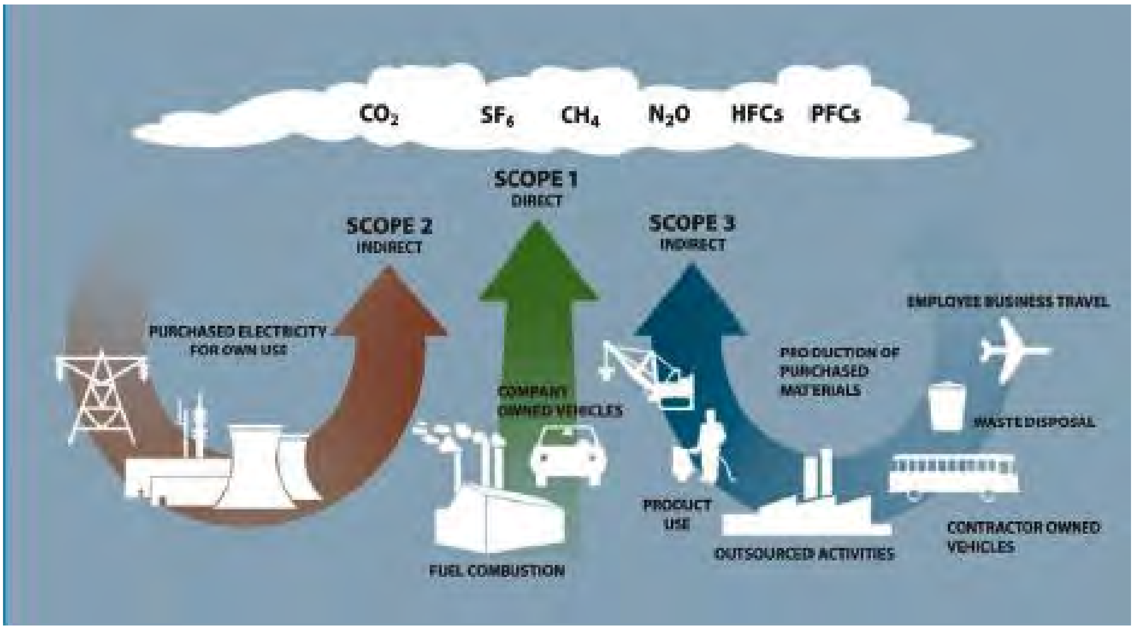
GHG emissions are categorised into three different scopes (either scope 1, 2 or 3) in accordance with the Intergovernmental Panel on Climate Change (IPCC) and Australian Government GHG accounting/classification systems. The GHG emission scopes are illustrated in Figure 1.

Scope 1 emissions, also called “direct emissions” are emissions which are generated directly by the project, e.g. emissions generated by the use of diesel fuel by construction plant/equipment.

Scope 2 emissions, also referred to as “indirect emissions” are emissions which are generated outside of the project’s boundaries to provide energy to the project, e.g. the use of purchased electricity from the grid.

Scope 3 emissions, also referred to as “upstream, indirect emissions”, are upstream emissions due to third party supply chains that are in direct relation to the project, e.g. extraction, production and transport of purchased materials and waste disposal offsite.

Figure 1 Greenhouse Gas Emission Scopes



Source: WBCSD & WRI, 2004

2.0 Scope

This GHG Inventory has been undertaken for the anthropogenic Scope 1, 2 and 3 emissions associated with the construction and operation of the project.

The GHG's which have been included in this inventory (also known as the Kyoto GHG's) are:

- Carbon Dioxide (CO_2)
- Sulphur Hexafluoride (SF_6)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)

GHG emission sources which have been included in this inventory are listed under each scope in the following Table.

Table 2 Emission Scopes

Scope 1 – Direct Emissions	Scope 2 – Indirect Emissions	Scope 3 – Upstream Indirect Emissions
• The onsite use of fuel by construction plant/equipment • The vegetation permanently cleared • Landfill gas (methane) emissions	• The onsite use of electricity purchased from the grid	• The onsite use of fuel by construction plant/equipment • The use of fuel for the transportation of construction materials and staff to/from the site • The onsite use of electricity purchased from the grid • The use of construction materials

3.0 Methodology

This GHG inventory was undertaken in accordance with a methodology based on the general principles outlined in:

- National Greenhouse Accounts (NGA) Factors, Australian Government Department of Climate Change (DCC), June 2009
- The National Greenhouse and Energy Reporting System Measurement, Technical Guidelines for the estimation of greenhouse gas emissions by facilities in Australia, DCC, June 2009
- Life Cycle Assessment Australian and New Zealand Standards (ISO 14040 series)
- Australian Standard (AS ISO 14064.1 – 2006) Greenhouse Gases Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.
- The Greenhouse Gas Protocol, World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI), 2004

To calculate the GHG emissions associated with the construction of the project, the following steps were undertaken:

1) The assumptions and data to be used in the assessment were determined (e.g. the source of construction materials and density of materials).
2) The total quantity of the vegetation cleared, materials, electricity and fuel consumed was estimated.
3) The quantity of GHG emissions were estimated:
    - Scope 3 construction material GHG emissions were calculated using the SimaPro Life Cycle Analysis software (version SimaPro 7.1)
    - GHG emissions for fuel and electricity were calculated using the NGA Factors methods (DCC, June 2009)
    - GHG emissions (methane) released from the landfill were calculated using the methodology, equations and factors contained within the National Greenhouse and Energy Reporting System Measurement Technical Guidelines (Part 5.2, DCC, 2009)
    - GHG emissions for permanently cleared vegetation were calculated using recently published scientific data on the average amount of carbon stored in vegetation (Green Carbon: The role of natural forests in carbon storage, Part 1. A green carbon account of Australia's south-eastern Eucalypt forests, and policy implications, Mackey, B.G., Keith, H., Berry, S.L. and Lindenmayer, D.B., The Fenner School of Environment & Society, The Australian National University, 2008)
    -

The assumptions used to complete this inventory and exclusions are described in Appendix A.

3.1 Data Sources

A fixed quantity of 15,000 t of waste will be landfilled each year. The construction material, fuel consumption, electricity use and vegetation clearing quantities were estimated based on the concept design information. Refer to Appendix B for a summary of the quantity data used in this inventory.

3.2 GHG Emissions Calculation Methodology

3.2.1 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 = quantity of fuel (in kL)

ECF = relevant energy content factor (in GJ/kL)

EF_{CO2} = 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 = quantity of fuel (in kL)

ECF = relevant energy content factor (in GJ/kL)

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

3.2.2 Landfill Gases

Methane will be generated as organic waste within the landfill decomposes. The volumetric composition of the gas produced by the mostly anaerobic decomposition that occurs in landfills is approximately 50% methane, 38% carbon dioxide, and 12% other gases[1]. The anaerobic conditions are created by human activity because the waste is buried and thus contained in an unnaturally low oxygen environment. The natural aerobic decomposition that occurs when waste is not buried does not produce methane, therefore methane produced in landfill decomposition is considered to be anthropogenic.

The amount of landfill gas which will be generated will be dependent upon the fraction of putrescible materials within the waste stream. The landfill will be classed as a General Solid Waste (putrescibles) landfill. It is Council's longer term objective, however, to begin operating the landfill, as soon as possible in the future (and then until final closure) only as a General Solid Waste (non-putrescible) facility, when appropriate additional off-site sorting and/or treatment technologies are able to be procured and successfully employed. To account for this, the following waste stream scenarios have been modelled:

- Scenario 1: General Solid Waste (putrescibles) landfill operating for 50 years
- Scenario 2: General Solid Waste (putrescibles) landfill operating from years 1-10, General Solid Waste (non-putrescible) landfill operating from years 11-50

Scenario 2 assumes that from year 11 onwards the waste landfilled will be pre-treated at an alternative waste treatment facility and that this facility will successfully remove 85% of the following materials from the waste stream:

- Food
- Paper and paper board
- Garden and park
- Wood and wood waste
- Nappies

To calculate the Scope 1 GHG emissions released from the decomposition of the organic material fraction of the waste disposed of in the landfill, the following formula was used:

GHG emissions emitted each year (t CO_2-e/yr) = [CH_4* – γ (Q_{cap} + Q_{flared} + Q_{tr})] x (1-OF)

Where: CH_4* is the estimated quantity of methane in landfill gas generated by the landfill during the year as determined under the conditions below (measured in t CO_2-e)

γ is the factor $6.784 \times 10^{-4} \times 21$ converting cubic meters of methane at standard conditions to CO_2-e tonnes

[1] 'Potential for Greenhouse Gas Abatement from Waste Management and Resource Recovery in Australia' (Draft), Warnken ISE March 2007.

Q_{cap} is the quantity of methane in landfill gas captured for combustion from the landfill during the year in cubic metres

Q_{flared} is the quantity of methane in landfill gas flared from the landfill during the year and measured in cubic metres

Q_{tr} is the quantity of methane in landfill gas transferred out of the landfill during the year and measured in cubic metres

OF is the oxidation factor for near surface methane in the landfill; default value 0.1

If: (Qcap / CH4 gen) ≤ 0.75, then $CH_4^* = CH_{4gen}$

Where: CH_{4gen} is the quantity of methane in landfill gas generation released from the landfill during the year estimated

If: (Q_{cap} / $CH_{4\ gen}$) > 0.75, then $CH_4^* = Q_{cap} \times (1/0.75)$

It is assumed that no landfill gas collection or flaring is carried out at the proposed landfill.

3.2.3 Land Use Change

Approximately 12.7ha of Stringybark Woodland will be permanently cleared for the construction of the project. This area will no longer have the potential to store carbon in vegetation biomass. The amount of carbon stored in the 12.7ha of Stringybark Woodland has been estimated and added to the scope 1 GHG emissions estimate of the project.

The quantity of Scope 1 GHG emissions associated with the permanent clearing of vegetation was calculated based on the following simplified formula:

GHG emissions (t CO_2-e) = A * S

Where: A = Area of vegetation permanently cleared (in ha)

S = Mass of carbon stored in vegetation (in t CO_2-e/ha)

The existing carbon store (S) has been estimated as approximately 360 t CO_2-e/ha (Green Carbon: The role of natural forests in carbon storage, Part 1. A green carbon account of Australia's south-eastern Eucalypt forests, and policy implications, Mackey, B.G., Keith, H., Berry, S.L. and Lindenmayer, D.B., The Fenner School of Environment & Society, The Australian National University, 2008). This estimate is based on vegetation biomass only (soil carbon excluded) and Eucalypt forests of South-Eastern Australia tree species group.

3.2.4 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 = quantity of purchased electricity (in kWh)

$EF_{scope\ 2}$ = 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 = quantity of purchased electricity (in kWh)

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

The emissions factors used to calculate the GHG emissions associated with diesel and electricity use were sourced from the NGA Factors (June 2009) workbook.

3.2.5 Construction Materials

The quantity of Scope 3 GHG emissions associated with the use of materials (embodied emissions) was calculated based on the following simplified formula:

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

Where: Q = quantity of material (in tonnes, kL, or m^3)

EF = relevant Emission Factor (in t CO_2-e/t of material)

The emission factors for the materials were sourced from the EcoInvent database (contained within the SimaPro 7.1 software). SimaPro is a Life Cycle Analysis software that draws on a large in-built database of materials and processes.

Scope 3 material embodied energy emissions sources that were not expected to contribute 'significantly' to total GHG emissions were excluded from the inventory to simplify the estimation process. The exclusion of insignificant emissions sources is consistent with ISO 14064 and the principles of relevance and consistency. Emissions sources that were estimated to cumulatively change the total estimate by less than 0.5% were defined as being insignificant and excluded from the assessment.

4.0 Results

4.1 Total GHG Emissions

The construction and 50 year operation of the project will generate approximately 693,871 tCO_2-e for Scenario 1 (i.e. if the putrescible materials and recyclables are not removed from the general waste prior to landfilling). The construction and 50 year operation of the project will generate approximately 279,381 tCO_2-e for Scenario 2 (i.e. if the putrescible materials and recyclables are removed from the general waste prior to landfilling from years 11 onwards). The breakdown of GHG emissions from the project are shown in the following Table.

Table 3 Estimated Total Greenhouse Gas Emissions (50 year period)

Emissions Source	Quantity	Units	GHG Emissions (t CO_2-e)			Total GHG Emissions (t CO_2-e)
			Scope 1	Scope 2	Scope 3	
Diesel Fuel Use						
Transport of Construction Materials	1,999	kL	5,394		409	5,804
Construction Equipment Onsite	11,856	kL	31,989		2,426	34,415
Transport of Waste to Landfill	1,452	kL	3,917		297	4,214
Landfill Gases						
Landfill Gas Emissions – Scenario 1*	750,000	t of waste	641, 622			641, 622
Landfill Gas Emissions – Scenario 2*	750,000	t of waste	227,132			227,132
Land Use Change						
Cleared vegetation	12.7	ha	4,572			4,572
Electricity Use						
Purchased Electricity	680,940	kWh		606	123	729
Use of Construction Materials						
Clay	338,831	t			678	678
Gravel	128,472	t			899	899
HDPE (liner)	167	t			363	363
Soil	308,459	t			463	463
Cover Material	75,960	t			114	114
Total – Scenario 1	**na**		**687,494**	**606**	**5,771**	**693,871**
Total – Scenario 2	**na**		**273,004**	**606**	**5,771**	**279,381**

Note:* refer to the scenario descriptions in section 3.2.2 of this report.

The total estimated quantities of fuel, waste disposed, vegetation removed, electricity and construction materials used during the 50 year operation of the project are shown in column 2 of the Table above.

The results show that the majority of GHG emissions are associated with Scope 1direct emissions, specifically the methane generated as the waste decomposes in the landfill.

The breakdown of the annual Scope 1 and Scope 2 GHG emissions associated with the project are provided in the following section.

4.2 Annual Scope 1 and Scope 2 Emissions

For Scenario 1 the project will generate approximately 13,658 t of Scope 1 CO_2-e per annum. For Scenario 2 the project will generate approximately 5,369 t of Scope 1 CO_2-e per annum.

For Scenarios 1 and 2, the project will generate approximately 12 t of Scope 2 CO_2-e per annum. The breakdown of annual Scope 1 and 2 GHG emissions from the project are shown in the following Table.

Table 4 Annual Scope 1 and Scope 2 GHG Emissions

Emissions Source	**Quantity**	**Units**	**GHG Emissions (t CO_2–e per annum)**		**Total GHG Emissions (t CO_2–e per annum)**
			Scope 1	**Scope 2**	
Fuel Use					
Construction Equipment Onsite	40	kL	108	0	108
Transport of Construction Materials	237	kL	640	0	640
Transport of Waste to Landfill	29	kL	78	0	78
Landfill Gases					
Landfill Gas Emissions – Scenario 1	15,000	t of waste	12,832	0	12,832
Landfill Gas Emissions – Scenario 2*	15,000	t of waste	4,543		4,543
Electricity Use					
Purchased Electricity	13,619	kWh	0	12	12
Total – Scenario 1	**na**	**na**	**13,658**	**12**	**13,671**
Total – Scenario 2	**na**	**na**	**5,369**	**12**	**5,381**

Note:* refer to the scenario descriptions in section 3.2.2 of this report.

The detailed GHG emissions calculations for each of the material types, electricity and fuel use sources, and land use change are presented in the detailed results tables in Appendix B. The detailed landfill gas emission calculations for each of the two landfilling scenarios (Scenario 1 and Scenario 2) are presented in Appendix C.

5.0 Discussion

5.1 Regulatory Requirements

The proposed landfill is to be assessed in accordance with the requirements of the *Environmental Planning and Assessment Act 1979* (the EP&A Act) and the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation).

The EP&A Act contains a general requirement to address environmentally sustainable principles. Recent precedents in environmental approvals suggest that a plan to address the negative external costs of GHG emissions is required to address sustainable development principles.

GHG emissions are specifically addressed in the EPA's 'Landfill Guidelines Benchmark Technique Number 11 – Extraction and Disposal of Landfill Gas', which states the following:

- *'A gas extraction system should be used to extract and, where possible, combust landfill gases. This system should reduce the risk of explosion and fire, reduce the contribution to greenhouse gases (methane is 20 to 30 times more potent than carbon dioxide), and lower the level of toxic organic compounds emitted from landfills. In conformance with the EPA's commitment to using landfill as a resource, applicants should evaluate generation of electricity as an option when designing the extraction system.'*

And:

- *Energy should be recovered from the landfill gas where possible, either by directly using the gas or by generating electricity for export.*

This report addresses these regulatory requirements by:

- Providing an assessment of potential GHG emissions from the project using a standard method that is internationally and locally recognised; and
- Identifying abatement measures.

The landfill may trigger National Greenhouse and Energy Reporting (NGERs) and Carbon Pollution Reduction Scheme (CPRS) obligations, depending on its proximity to other large landfills.CPRS obligations will be triggered by individual facilities if their emissions equal or exceed 25 kilo tonnes (kt) of CO_2-e per year. In addition, CPRS obligations apply to some landfill facilities that are near a large landfill that accepts similar waste, where the facility's emissions are at least 10kt CO_2-e a year.

The distance between landfills that triggers the lower threshold will be set in regulations. Businesses will be able to work out whether the lower threshold applies to them from a list of large landfills and their locations that will be published by the Australian Climate Change Regulatory Authority.

The nearest landfill to the proposed landfill is the Armidale Long Swamp Road Waste depot which is approximately 10km from the proposed landfill site which will be completely filled and capped potentially in the next few years.

Only Scope 1 (i.e. direct) emissions as determined by the NGERS Act are used to calculate the threshold. This includes direct emissions from processes such as methane as well as emissions from fuel combusted on site (e.g. vehicles used on site).

5.2 Comparison with NSW's Emissions

NSW's annual GHG emissions are approximately 162.7 million tCO_2-e, of which 5.3 million tCO_2-e of emissions in NSW are associated with the waste sector. (DCC, May 2009, Australia's National Greenhouse Accounts: State and Territory Greenhouse Gas Inventories 2007). Thus, the estimated annual scope 1 and 2 emissions from the project would contribute to approximately 0.25% and 0.10% of the state's annual waste sector emissions for Scenarios 1 and 2 respectively.

6.0 Proposed GHG Reduction Measures

The following hierarchy was used to develop proposed measures to reduce GHG emissions from the Landfill:

- Avoid
- Reduce
- Abate
- Offset

The above hierarchy is derived from generally accepted principles for sustainable resource management.

The following opportunities will be undertaken to reduce/offset GHG emissions associated with the project:

Fuel:

- Assess the fuel efficiency of the construction plant/equipment prior to selection and, where practical, use equipment with the highest fuel efficiency or equipment which uses lower GHG intensive fuel such as biofuels (e.g. biodiesel, ethanol)
- Consider the distance of construction material suppliers prior to procurement to reduce transport-related emissions

Equipment:

- Ensure construction equipment and transport vehicles are maintained to reduce energy efficiency losses associated with damaged/unmaintained equipment
- Ensure electrically efficient equipment is purchased

Materials:

- Plan construction works to avoid double handling of materials

Vegetation Sequestration:

The trees planted and maintained within the proposed Biodiversity Offset Area have the potential to sequester and store carbon. The trees within the Biodiversity Offset area have the potential to sequester and store (in the vegetation biomass only) an average of 360 t CO_2-e/ha.

Reduce areas of land clearing. Reductions in land clearing are 24-50 times more effective than replanting vegetation (NSW Energy and Greenhouse Guidelines for Environmental Impact Assessment, 2002)

Additional GHG reduction opportunities which will be considered during the design stage of the project include:

- Purchasing Green Power
- Purchasing emissions credits through a program such as ‘Greenfleet’.
- Maximising the energy efficiency of the buildings
- Reducing landfill methane emissions.

Maximising energy efficiency

During the detailed design stage additional and more specific energy efficiency and energy reduction measures to be implemented at the landfill facility will be determined, which may include:

- Using purchasing policies that favour electrically efficient equipment
- Enhancing the energy efficiency of the buildings by using:
  - Energy efficient lighting systems with low energy lights, wide-panel skylights, task lighting, timers, and motion sensors
  - Natural ventilation

  - Energy efficient heating and air conditioning systems, for example systems that incorporate ceiling fans with central air conditioning and heating plant or evaporative air conditioning
  - A well insulated building envelope
- Using a renewable form of energy. For example, combusting the available landfill gas and generating energy for use on site, or installing a solar photovoltaic array to produce electricity from the sun.

Reducing landfill methane emissions

The amount of landfill gas which will be generated will be dependent upon the fraction of putrescible materials within the waste stream. Reducing the amount of putrescible waste landfilled at the proposed facility will have the greatest impact on reducing the landfill's GHG emissions. It is Council's longer term objective, to begin operating the landfill, as soon as possible in the future (and then until final closure) only as a General Solid Waste (non-putrescible) facility, when appropriate additional off-site sorting and/or treatment technologies are able to be procured and successfully employed.

Additional methods which can be implemented to reduce the generation of landfill gas GHG emissions are discussed in the following. The measures to be implemented will be determined once the landfill has commenced operating and the quantity of emissions generated is determined. During the initial operational phase of the proposed development, the landfill's performance with respect to landfill gas production and other associated matters would be assessed and the results discussed with both the DECCW and DoP. Once the filling of Cell 1 is complete, landfill gas monitoring (perimeter well testing) would be conducted to determine if the amount of gas produced requires the installation of a gas extraction/control system.

Three suitable options to manage landfill gas at the landfill include:

- The application of a methane oxidation cap
- Passive venting and using a filter (e.g. activated carbon or the like) to reduce emissions
- Actively collecting the landfill gasses with a landfill gas collection system and flaring the methane (combustion conversion to CO_2)

The methane oxidation cap is a "biological' cap (sometimes called a phyto-remediation cap) that is used in preference to the standard compacted clay type of cap. It relies on a biomass that oxidises CH_4 as the landfill gas permeates through the soil media that constitutes the cap. Extensive research into this type of capping demonstrates a reduction in methane emissions from landfills of up to 10 times over a standard compacted clay cap. Currently research is being undertaken in Australia as part of the Australian Alternative Capping Assessment Program that is trying to loosen up the capping requirements nationally so that smaller landfills have an alternative to the prescriptive expensive caps that are typically required.

Landfill methane can be combusted by open flaring, burning to generate heat, or burning in an internal combustion engine to generate electricity. When anthropogenic methane is burned in air to produce carbon dioxide and water, the carbon dioxide produced is equal to the amount that would have been produced by natural decomposition, and is not considered anthropogenic GHG emissions.

Flaring is generally most effective and economically viable where smaller or unreliable quantities of methane are generated. Generation of heat or electricity has an additional benefit of offsetting electricity consumption, which further offsets total GHG emissions. However, these methods are only economically feasible where sufficient quantities of methane can be reliably collected over a long time.

In general, most commercially viable landfill gas to energy operations rely on consistent (i.e. 80% operational time) generation of 1MW for a period of 5-7 years. In order to achieve this, a landfill gas (LFG) flow of about $600m^3$/hr is required with a 50% CH_4, composition. To achieve this flow, a landfill will need to have approximately 1million tonnes of waste in place after about 10 years. Armidale Regional Landfill will have approximately 150,000 tonnes of waste after approximately 10 years of operation, hence generation of electricity from landfill methane is not likely to be commercially viable.

The amount of methane generated after the Landfill is operating will be monitored and assessed to determine whether the amount of methane produced is sufficient for either small scale self generation or commercial scale electricity generation and export.

7.0 Emissions Monitoring and Reporting

7.1 Proposed Monitoring Program

It is recommended that the Armidale Regional Landfill quantitatively measures, records and reports annual GHG emissions. Strategies to monitor and report emissions are as follows:

1. Transfer Station weighbridge. The Transfer Station weighbridge can be used to service commercial and reporting needs. Records of the waste types and weights are then maintained in order to improve the estimates of the waste being disposed of.
2. Gas measurements. If a landfill gas collection system is installed at the landfill the quantity of gas flared or captured can be measured by the inclusion of a gas meter in the collection circuit.

Emissions reported may be subject to a non-compulsory audit by the Australian Climate Change Regulatory Authority[2] (ACCRA) . Depending on the landfill's proximity to other landfills, it may trigger CPRS obligations i.e.>10,000 t CO_2-e for facilities within a prescribed distance of designated large landfill facility and >25,000 t CO_2-e for other facilities. As the distance that specifies the applicable threshold for CPRS obligations hasn't yet been specified and considering that the nearest landfill which is 10km from the proposed landfill will be closed in a few years (but will still emit GHG after closure), and the next closest large landfill will be in Tamworth or Coffs Harbour, approximately at a distance of 115km. It is therefore assumed that the 10,000 t CO_2-e threshold applies to the proposed landfill.

Registering for NGERS (if required) provides access to the Online System for Challenge Activity Reporting, or 'OSCAR', which can be used to record emissions data, and estimate emissions.

OSCAR enables participants to input and update their energy, waste and materials consumption data online by creating a database structure that represents the entity relationships within their organisation, and adding information to the emissions information to the database over time.

OSCAR stores all the necessary conversion factors to automatically convert energy, fuel, waste and materials consumption data into GHG emissions in quantities of CO_2-e.

Greenhouse performance can be tracked over time against specific business measures, and GHG abatement activities can be reported.

[2] Note: If passed, the Carbon Pollution Reduction Scheme Bill 2009 and Australian Climate Change Regulatory Authority Bill 2009 will establish the independent ACCRA

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