Appendix H

Pipeline Greenhouse Gas Assessment

PACIFIC **ALUMINIUM**

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Katherine to Gove Gas Pipeline

Pipeline Greenhouse Gas Assessment

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KATHERINE TO GOVE GAS PIPELINE
PIPELINE GREENHOUSE GAS ASSESSMENT

Rev	Description	Originator	Reviewer	WorleyParsons Approval	Date	Client Approval	Date
0	Issued for Client Use	R Hynes	A Hanly	A Wood	27-Mar-13		
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EXECUTIVE SUMMARY

A greenhouse gas (GHG) assessment has been performed on the Katherine Gove to Gas pipeline project. The assessment was performed based on the principles outlined in the Greenhouse Gas Protocol and the methodologies provided by the Australian Government's National Greenhouse and Energy Reporting (Measurement) Determination 2008.

The assessment covers GHG emissions from a wide range of pipeline construction-related activities and from the operation of an in-line compressor gas turbine. Embedded-energy related emissions in steel pipeline sections and vegetation clearances were also included.

Direct Scope 1 GHG emissions (from the direct combustion of fuels) and indirect Scope 3 GHG emissions (from the extraction, processing and transport of imported fuels) were assessed.

During the construction period, total Scope 1 and 3 GHG emissions from fuel consumption for construction machinery and transport, and gas vented from commissioning activities are 50,820 tonnes CO_2-e, excluding embedded energy emissions and land clearances.

Embedded energy related GHG emissions in the 603 km of steel pipeline, when annualised over an assumed 50-year lifetime, are relatively insignificant.

The most significant source of GHGs arises from the clearance of 2050 hectares of vegetation. This releases approximately 248,000 tonnes CO_2-e. Over the lifetime of the project, it is expected that at least 60% of the pipeline ROW will be allowed to naturally re-vegetate and therefore approximately 60% of the carbon sequestration potential of the vegetation can be recovered. Actions such as seeding with local grasses, re-spreading stockpiled soils to help encourage re-growth and replanting in the high risk areas will help achieve this.

GHG emissions from decommissioning activities are approximately 720 tonnes CO_2-e.

In terms of operational GHG emissions, these will mainly arise from a single in-line gas compressor turbine, from fugitive gas emissions and from venting activities. These are tabulated below:

A number of GHG mitigation actions in relation to construction activities have been discussed that focus on minimising fuel consumed by construction machinery and transport vehicles, minimising land clearances and progressive revegetation of cleared land.

Operational GHG emissions can be reduced by regular maintenance and repair programs, minimised venting and regular maintenance of the gas turbine and the compressor seals.

The key results are summarised in the following tables.

Activity related to construction of the pipeline	Energy used	GHG emissions totals over the construction period (tonnes CO_2-e)	
Grading, trenching, pipe-laying, backfilling	9126 kL diesel	Scope 1:	24,620
		Scope 3:	1,870
Transportation of pipeline sections	421 kL diesel	Scope 1 :	1,140
		Scope 3:	90
Operate construction camps	3,890 kL diesel	Scope 1:	10,430
		Scope 3:	795
Fuel haulage	100 kL diesel	Scope 1:	270
		Scope 3:	20
Transport of camp infrastructure and plant	145 kL diesel	Scope 1:	290
		Scope 3:	30
Transport of workers	2340 kL diesel	Scope 1:	6,310
		Scope 3:	480
Water haulage	120 kL diesel	Scope 1:	320
		Scope 3:	25
Vegetation clearances	-	Scope 1:	247,907 based on 2054 hectares cleared
Airline travel	-	Scope 3:	4,080
Embedded energy related emissions for steel pipes	-	Scope 3:	1,750 Per annum emissions, amortised over 50 year pipeline lifetime.
Pipeline commissioning	-	Scope 1	14
Pipeline decommissioning	-	Scope 1	718

Activity related to operating the pipeline	Scope 1 GHG emissions (tonnes CO_2-e per annum)
Pipeline fugitive emissions	5,260
Compressor Station blowdown	1,990
Pipeline blowdown	5,760
Inline compressor gas consumption	28,900
Leaks around compressor seals	130
Total	**42,040**

CONTENTS

1 INTRODUCTION

Pacific Aluminium (a business unit of Rio Tinto) owns and operates a bauxite mine and alumina refinery at Gove, 650 kilometres (km) east of Darwin in north east Arnhem Land, Northern Territory. The Gove mine and refinery produce high grade alumina which is then shipped to other locations for smelting and further processing.

Power and steam for the Gove Refinery and mining operations are currently generated from imported fuel oil. In order to reduce fuel oil consumption and improve operating costs at the Refinery, it is proposed to provide the facility with natural gas as an alternative fuel source. The lower cost natural gas will help underpin the long term operating viability of the Refinery.

The Katherine to Gove Gas Pipeline (KGGP) is proposed to deliver natural gas from the existing NT Amadeus Gas Pipeline at a point approximately 20 km south of Katherine, to the Gove Refinery. The KGGP would be a high pressure, steel pipeline approximately 603 km long with a nominal diameter of 300mm and a design operating life of 50 years. It will also include above ground facilities at specific locations along the route such as metering facilities, scraper stations, mainline valves and a compressor station. The supplied gas from the Amadeus Pipeline is sales quality so no additional processing of gas would be required. The pipeline would be constructed within a 30 m wide construction corridor and would include supporting infrastructure such as temporary work camps and equipment access tracks to facilitate construction activities.

1.1 Scope of Assessment

This technical report presents the GHG inventory for activities related to the construction and operation of the Katherine Gove to Gas Pipeline (KGGP).

The specific scope of this report covers the following sources:

- Pipeline construction (stationary and mobile diesel consumption);
- Vegetation clearances;
- Transport of materials, fuels and machinery (mobile diesel consumption);
- Transport between camps and work sites (includes workers flights which are indicatively assumed to be from Brisbane for the purpose of this assessment. Actual requirements will be determined during final construction planning);
- Operation of construction camps (stationary diesel consumption);
- Commissioning the pipeline– purging with natural gas;
- Operation of the pipeline (assumes one compressor station) – includes fugitive emissions, compressor and pipeline blowdown events, and combustion of natural gas for compression; and
- Decommissioning the pipeline – venting gas to the atmosphere.

The assessment considers Scope 1 GHG emissions, which arise from the direct combustion of fuels required for construction machinery; various transport vehicles, power generators and the compressor station. It is assumed no grid electricity will be used at the camps.

Scope 3 emissions also arise from the extraction, production and transport of all fossil fuels and sources such as airline travel for workers.

These GHG emissions Scopes are defined in Section 2.

1.2 Legislative Framework

GHG emissions are covered by a number of legislative and policy requirements at both the State and the Federal level, as well as international protocols to which Australia is signatory. These include:

- United Nations Framework Convention on Climate Change
- Kyoto Protocol, to which Australia is a signatory
- *National Greenhouse and Energy Reporting Act 2007*

1.2.1 International policy

The Kyoto Protocol to the United Nations Framework Convention on Climate Change was signed in 1997 and ratified by Australia in December 2007. One of the aims of the Kyoto Protocol is to achieve the stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The Kyoto Protocol sets reduction targets on GHG emissions produced by Annex 1 countries, including Australia. Under the Kyoto Protocol, Australia has committed to reducing its GHG emissions to a level equivalent to 108% of 1990 levels by 2008–2012. A key outcome from the United Nations climate talks in Qatar is that there has been an agreement to extend the Kyoto Protocol until 2020.

The greenhouse gases reportable under the Kyoto Protocol are:

- Carbon dioxide, CO2;
- Methane, CH4;
- Nitrous oxide, N2O;
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons; and
- Sulphur hexafluoride, SF6.

1.2.2 Australian Government Policy

The Australian Government has set the following medium-term 2020 GHG emission reduction targets:

- An unconditional target of a 5% reduction below 2000 levels by 2020;

- A conditional target of 25% below 2000 levels by 2020 if the world agrees to an ambitious global deal capable of stabilizing atmospheric GHG levels at 450 ppm or lower; and
- In the absence of a global deal, the Government has set a conditional target of between 5 and 15% reduction below 2000 levels by 2020.

The Government has also committed to a long-term GHG emissions reduction target of 80 per cent below 2000 levels by 2050.

In July 2011, the Government announced the Clean Energy Bill, which was designed to put a price on carbon pollution (the Carbon Pricing Scheme), promote investment in renewable and clean energy technologies and support action to reduce carbon pollution.

In late November 2011, the *Clean Energy Act 2011 (Cth)*, and associated legislation that establishes a national carbon pricing scheme, was passed into law. The Carbon Pricing Scheme is currently in the three year fixed price period and will transition to a flexible price, cap-and-trade, emissions trading scheme (ETS) on 1 July 2015.

The Carbon Pricing Scheme will have a general compliance triggering threshold of 25,000 tonnes CO_2-e (including all Scope 1 emissions not expressly excluded from the Scheme). Liable entities will be those with operational control of facilities that trigger the thresholds, in line with the *National Energy and Greenhouse Reporting* (NGER) definitions.

Liable entities will be obliged to surrender permits (or certain carbon offset credits) equivalent to their emissions (in the fixed price period) and their pollution cap (in the flexible price period). During the fixed price period the carbon price started at $23 per tonne CO_2-e on 1 July 2012 and will increase by 2.5% each year to $24.15 in 2013-14 and to $25.40 in 2014-15.

1.2.3 National Greenhouse and Energy Reporting Act 2007

The National Greenhouse and Energy Reporting Act (2007) is a national framework for Australian corporations to report GHG emissions, and energy consumed and produced from 1 July 2008. The Act and supporting systems have been designed to provide a robust, quantitative database for the proposed Carbon Pricing Scheme.

Since 1 July 2008, corporations have been required to report Scope 1 and Scope 2 GHG emissions. In 2011-12, corporations were required to report if:

- They controlled facilities emitting more than 25,000 tonnes CO2-e, or produced or consumed more than 100 terajoules (TJ) of energy; or
- Their corporate group emitted more than 50,000 tonnes CO2-e, or produced or consumed more than 200 TJ of energy.

The six GHGs covered under the Kyoto Protocol are all reportable under the NGER Act.

1.2.4 Energy Efficiency Opportunities Act (2006)

The Energy Efficiency Opportunities Act 2006 (EEO Act) was introduced by the Department of Resources, Energy and Tourism (DRET). It requires significant energy users, consuming over 0.5 PJ per annum of energy, to take part in a transparent process of energy efficiency assessment and reporting.

The program's requirements are set out in the legislation, which came into effect on 1 July 2006. Participants in the program are required to assess their energy use and report publicly on cost effective opportunities to improve energy efficiency. In particular, corporations must report publicly on opportunities with a financial payback period of less than four years.

Proposed extension of the Energy Efficiency Opportunities Act

It has been announced in the Australian Government's Clean Energy Future package that EEO assessments will be expanded to include the design and commissioning phase for major new development projects (i.e. greenfield projects) and expansions, which was set to come into effect on 1 July 2012. An Options Paper has been released detailing the impacts of the extended EEO legislation, and submissions from key stakeholders have been received by Government and considered in the drafting of the regulations. In 2013, the Department has commenced trialling the application of the modified EEO assessment and reporting framework on several new development and expansion projects. The results of these trials will inform the Regulatory Impact Statement (RIS) and identify what type of assessment and reporting framework, if introduced, would be most suitable for new developments. The RIS will be made public for comment in early May 2013.

The new regulations will require corporations to conduct an assessment at the design and commissioning phase. The amount of increased energy use that would trigger consideration of a site under the new EEO Greenfields Framework range between 0.1 PJ and 0.5 PJ – the exact trigger level is yet to be determined.

If the extension to the EEO Act is implemented, then an Assessment Plan for the pipeline facility may need to be developed detailing how the assessment at the design and commissioning stages will be undertaken.

2 GREENHOUSE GAS ACCOUNTING METHODOLOGY

The GHG inventory assessment was performed based on the principles outlined in the Greenhouse Gas Protocol and the methodologies provided by the Australian Government's National Greenhouse and Energy Reporting (Measurement) Determination 2008.

The guiding principles for compiling a GHG inventory are:

- Relevance;
- Completeness;
- Consistency;
- Transparency; and
- Accuracy.

Specifically, the GHG Protocol advocates defining a reporting boundary for an inventory, and subsequently segmenting the GHG producing sources within that boundary according to their scope.

The scopes of these GHG emissions are defined as:

- Scope 1 GHG emissions, which are produced directly from combustion of purchased liquid, solid or gaseous fuels, or fugitive emissions of GHGs, within the Project's boundary;
- Scope 2 GHG emissions arise from imported electricity, heat and steam. These emissions are generated outside of the Project boundary; and
- Scope 3 GHG emissions are related to the activities of the Project but arise from sources beyond the Project's reporting boundary (i.e. up and down the corporations supply chain or the raw materials and products of a process). Scope 3 GHG emissions associated with the extraction, processing and transport of purchased fuels are considered relevant for the present assessment.

These sources are subsequently quantified in terms of quantities of fuels and electricity consumed. These quantities are multiplied by the appropriate emission factors to generate GHG emission quantities.

Note that of the six Kyoto Protocol greenhouse gases described in section 1.2.1, only CO_2, CH_4 and N_2O are considered relevant to this project, and CO_2 is the most relevant gas. All results are reported in units of tonnes CO_2-equivalent.

Ozone depleting chemicals such as chlorofluorocarbons are generally used as air conditioning gases, refrigerants and fire extinguishers. Strict regulations have been imposed on the use of ozone depleting chemicals under the Montreal Protocol. It is assumed that PacAl has very small or zero volumes of these compounds and hence their emissions should be negligible.

The impacts of native vegetation clearances associated with the development include the associated loss of carbon sequestered from the atmosphere by vegetation. The sequestration potential from

native vegetation growth can be quantified by application of the FullCAM model from the National Carbon Accounting Toolbox (NCAT).

The software provides valuation of native vegetation in terms of its carbon sequestering function. In this project a set of emissions factors have been established based on the National Vegetation Inventory System (NVIS), broad floristic types to level II.

The vegetation types for the area proposed to be cleared are assessed for tonnes of carbon dioxide per hectare (t C/ha). These factors can then be applied to determine the loss of carbon sequestration potential on a per hectare basis.

3 SOURCES OF GREENHOUSE GAS EMISSIONS

The Project boundary for the construction and operation of the pipeline facility is as indicated in Figure 3.1.

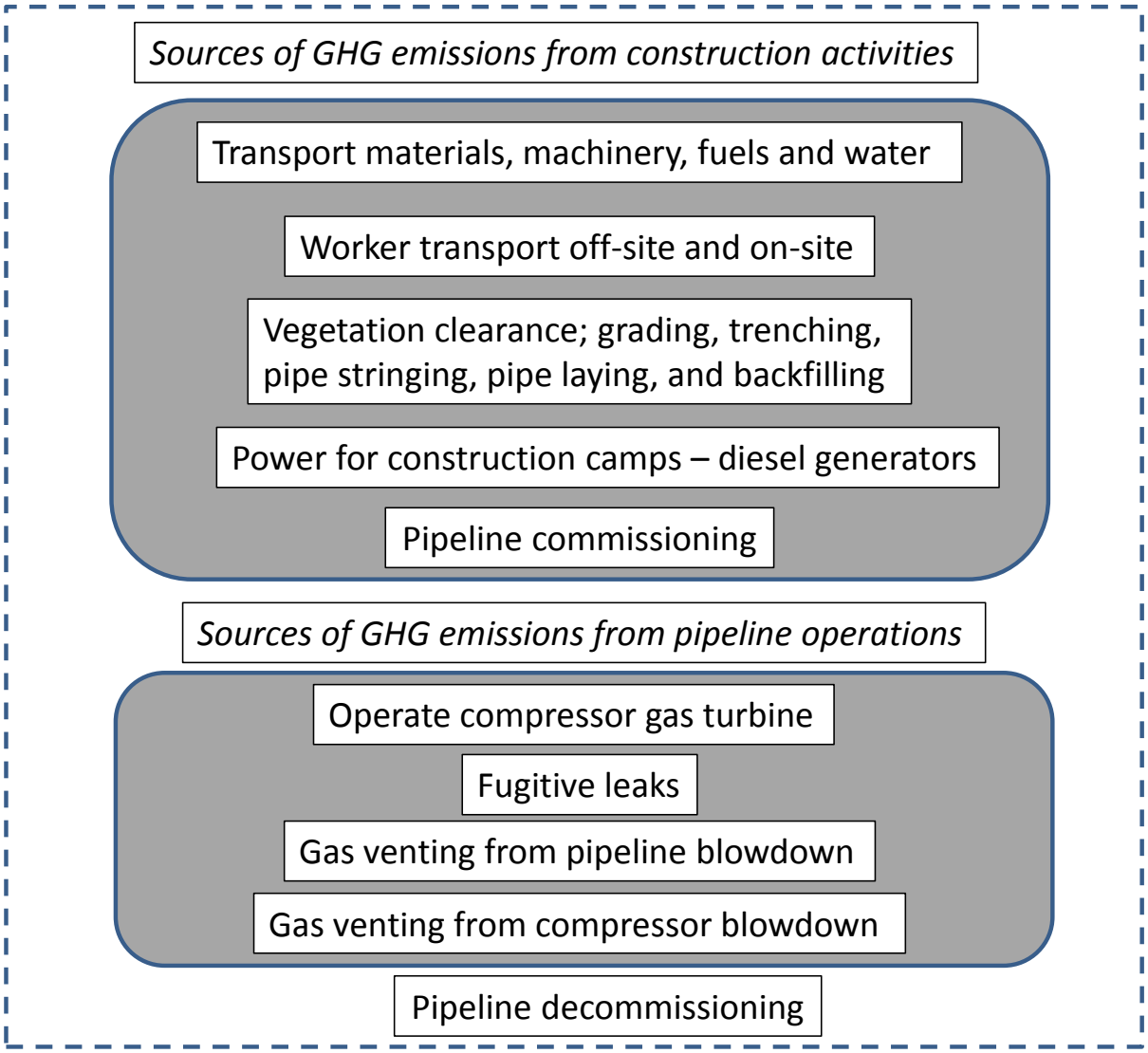

Figure 3.1 GHG emissions during pipeline construction and operation phases

3.1 Fuel Consumption in Constructing the Pipeline

The key sources of GHG emissions arise from:

- Stationary and mobile combustion of diesel for grading, trenching, pipe laying and road building machinery;

- Combustion of diesel for transport of pipe sections to both Gove and Katherine from various ports; and
- Combustion of diesel for transport of pipe sections from both Gove and Katherine to various laydown points near camps.

The following items of machinery are likely to be used for the construction of the pipeline with approximate fuel efficiencies. The numbers of each type of machinery were sourced from estimates of machinery numbers and crew sizes.

Machinery	Fuel Economy (L/hr)	Number (both construction spreads)
Graders	40	18
Backhoes	15	44
Bulldozers	65	7
Excavators	31	2
Trenching machines	78	12
Side boom cranes	50	29
Padding machines	37	8
Horizontal drilling rigs	30	1

The construction period is assumed to last for 180 days with each item of machinery operated for approximately 11 hours per day. The volume of diesel consumed is 9130 kL over the construction period.

The Scope 1 GHG emission factor for diesel fuel consumption (mobile combustion) is 2.70 tonnes CO_2-e/kL.

The Scope 3 GHG emission factor for extraction, production and transport of purchased fuels (i.e. a supply chain emission) is 0.205 tonnes CO_2-e/kL.

GHG emissions from blasting are excluded.

3.2 Transport of Pipe Sections

The assessment has been undertaken on the basis of the following truck movements:

- Approximately 860 return truck trips are required to transport the pipe sections from the Port of Darwin to Katherine;
- 572 return truck trips are required to transport pipe sections from the Port of Gove to the Gove stockpile; and

- To transport pipe sections to the various laydown points from both Katherine and Gove will require 860 trips with an assumed average return trip distance of 200 km.

Fuel consumption for all truck trips is based on a truck fuel efficiency of 0.55 L/km. The total distance for all pipe section haulage was estimated to be 780,200 km leading to a total of 420 kL diesel consumed.

The Scope 1 GHG emission factors for mobile diesel consumption is 2.70 tonnes CO_2-e/kL. The Scope 3 emission factor for purchased fuels is as above.

The above numbers will be subject to final construction logistics. However, given the small contribution to the overall project emissions, revised figures for pipeline transport are expected to have a minor impact on the overall assessment.

3.3 Operation of Construction Camps

There are five construction camps proposed, with each camp having the capacity to house approximately 300 people. The estimated maximum number of site personnel across both construction spreads may reach 780. To estimate the GHG emissions from construction camp operations, it is assumed that all 5 camps will operate simultaneously for 180 days each.

Each camp will require 2 x 600 kW diesel generator sets to provide on-site power. These generators are assumed to operate for 24 hours a day at 75% capacity. Total diesel consumption is 3900 kL over the construction period.

The Scope 1 GHG emission factors for stationary diesel consumption is 2.68 tonnes CO_2-e/kL. The Scope 3 emission factor for purchased fuels is as above.

The assessment neglects the staggered mobilization and demobilization of the camps and assumes each camp operates simultaneously for 180 days. This is therefore a conservative estimate of the GHG emissions.

3.4 Transport of Fuel, Water, Camp Infrastructure and Plant, and Workers

The volume of fuel required per day is of the order of 75 kL for all camps and construction machinery. It is assumed that the fuel will be trucked in, with trucks travelling an average return distance of 400 km. Each fuel truck is assumed to carry 20 kL of fuel, making a total of 460 trips over the construction period. The average heavy vehicle fuel (diesel) fuel efficiency is 0.55 L/km. The fuel delivery trucks will consume approximately 100 kL of diesel.

Water is required for a number of purposes such as dust suppression (150 kL/day), camp potable water supplies (180 kL/day) and water for horizontal directional drilling (6 kL/day for each construction spreads). It is assumed that water will be carted to various points along the length of the pipeline corridor, with a water truck making an assumed 100 km return trip. A large water cart truck can carry

15 kL water, making approximately 4100 trips. Based on a fuel economy of 0.29 L/km, water carting trucks will consume approximately 120 kL of diesel.

Transport of camp infrastructure for both mobilization and demobilization will require 120 trips and transport of plant mobilization will require 250 trips. The average return trip is assumed to be 400 km, and using the same heavy vehicle fuel efficiency as above results in a total fuel consumption of 80 kL.

Worker transport to and from camps and work sites for both construction spreads will require the use of approximately 200 diesel 4WDs, 60 trucks, and 8 minibuses. The average distance travelled per day for each vehicle is assumed to be 160 km per day over the 180 day construction period. This may be a conservative estimate and will require data from the Traffic and Transport estimates to improve the accuracy. The overall fuel consumption by all vehicles (for simplicity all vehicles are diesel-fuelled) is 2340 kL.

Airline travel is also included in the assessment as an indirect or Scope 3 GHG emission as a result of fly-in fly-out working arrangements. The basis for the calculation is 300 workers to be flown in and out over 2 days every month for a 6 month period. Workers will fly in and out from Darwin airport using bus transport. Buses will make a 400 km round trip. The overall number of passenger movements over the construction period is 3600 with 1800 leaving and 1800 returning. For the basis of the current assessment it is assumed that ann “average” workers flight will be between Darwin and Brisbane. with a return trip of 5667 km, a medium haul passenger aircraft with a GHG emission factor of 0.2 kg CO_2-e/km.passenger, resulting in 4,100 tonnes CO_2-e emissions from aircraft transport.

3.5 Vegetation Clearance

The pipeline right of way (ROW) covers a diverse range of vegetation types. The NVIS vegetation types used for the assessment, and associated clearance areas are shown below:

Vegetation types	Clearances (hectares)	Emission factor tonnes CO_2/ha
Eucalyptus low open woodland	70.0	61.9
Eucalyptus low woodland	186.3	69.8
Eucalyptus open forest	721.5	142.4
Eucalyptus woodland	1076.0	118.8
Total	**2054**	

The National Greenhouse Accounts Factors report defines deforestation (or clearances) as the deliberate removal of forest cover of trees with a potential height of at least two metres and crown cover of at least 20 per cent in patches greater than 0.2 hectare in area. Therefore vegetation such as Melaleuca open forest and mixed low tussock grassland were not included in the assessment. GHG emissions are calculated by multiplying the vegetation-specific emission factor by the area of vegetation cleared.

3.6 Embedded Energy-related Emissions in Steel Pipe

The mass of steel in the 603 km of gas pipeline has been estimated at 32,400 tonnes. The embedded energy related greenhouse gas emission factor (that is, the emissions associated in producing one tonne of steel pipe) is 2.70 t CO2-e/tonne pipe. This is a Scope 3 indirect emission for the KGGP project. The pipeline has an assumed lifespan of 50 years and the embedded energy related GHG emissions are amortised over the lifespan.

3.7 Commissioning and Decommissioning the Pipeline

It is expected that the only commissioning activity will require that the pipeline (after being dried to target dew point) be purged of air prior to the start of operations with a charge of natural gas – in some circumstances a slug of inert gas may be introduced ahead of the gas to reduce the gas-air interface.

Decommissioning the gas pipeline will require venting the natural gas and replacing it with a hydrocarbon-free atmosphere, typically air but in some cases the line may be filled with a non-flammable stabilising slurry (typically bentonite / cement mixture). It is expected that the pipeline will remain in situ rather than being excavated and removed to prevent any further disturbance of the pipeline ROW. The aboveground compressor and meter stations would be completely removed, but GHG emissions associated with this task are expected to be immaterial.

It was assumed that the entire volume of natural gas in the transmission would be purged and replaced with dry air or nitrogen. The volume of the pipeline is approximately 49,720 m^3, which is calculated to contain 40 tonnes of natural gas.

3.8 Operation of the Gas Pipeline

The GHG emissions from the gas pipeline are generally minimal and come from 3 main sources:

- Fugitive emissions from the pipeline e.g. from valves, flanges, pneumatic devices and pig insertion and removal (it is assumed that new welded pipes should not leak);
- Operation of an inline compressor and gas turbine;
- Compressor blowdown events, which are generally rare occurrences; and
- Pipeline blowdown events, also a rare occurrence.

The calculation of the fugitive emissions from the transmission pipeline uses the National Greenhouse and Energy Reporting Measurement Determination default method. This is based on generic methane and carbon dioxide emission factors per kilometer of pipeline. The total emission factor is 8.72 tonnes CO_2-e/km of pipeline.

For compressor and pipeline blowdown events and leaks around compressor seals, very little information is available in Australia. Emission factors were therefore sourced from the American Petroleum Institute's *Compendium of Greenhouse Gas Emission Methodologies for the Oil and Natural Gas Industry*, 2009.

It is assumed that one compressor station will be installed along the length of the pipeline requiring a single Solar Taurus 70 (5.5 MWe) gas turbine. Gas engine generators at the compressor station are not included as the load is yet to be sized. The gas turbine consumes 65.8 GJ/hr of fuel gas and runs for 8760 hours per annum (no downtime has been included for maintenance). The quantity of fuel gas combusted required per annum 576,320 GJ. The emission factor for stationary combustion of natural gas, assuming that the gas is sourced entirely from the Blacktip field, is 0.050 tonnes CO_2-e/GJ.

The composition of the gas is given below (Source: Draft EIS for the Trans Territory Pipeline prepared by Alcan Engineering (2004).)

N_2	CO_2	Methane	C_2	C_3	NC_4	IC_4	NC_5	IC_5	C_6	total (%)
8.10	0.90	87.00	2.50	0.80	0.20	0.10	0.10	0.10	0.20	100.0

where C_2, C_3, C_4 represent higher hydrocarbons with one, two, three and four carbon atoms.

GHG emissions from gas-fired heaters have not been included. If heaters are required they will be located in the Gove Facility and a waste heat stream from the refinery process will be used to provide the heat, if practical. Otherwise a gas-fired heater will be used. GHG emissions from this source may be considered in the GHG assessment of the refinery.

For compressor blowdown events, the emission factor is 101.7 tonnes methane/station.yr. This assumes only one compressor station. The global warming potential of methane is 21. For pipeline blowdown events, the emission factor is 0.4881 tonnes methane/km.yr.

Leakage of natural gas around compressor seals is also included. This assumes the compressor is a centrigual compressor with one seal. The emission factor is 7.1×10^{-4} tonnes methane/component-hr.

4 GHG INVENTORY AND EMISSIONS FORECASTS

The results of the GHG inventory during construction are shown in Table 4.1 below. All of the construction emissions are once-off emissions except for the embedded energy related GHG emissions in the steel pipeline, which are amortised over the 50-year lifespan for the pipeline.

Table 4.1 Summary of GHG emissions sources during construction

Activity related to construction of the pipeline	Energy used	GHG emissions totals over the construction period (tonnes CO_2-e)	
Grading, trenching, pipe-laying, backfilling	9126 kL diesel	Scope 1:	24,620
		Scope 3:	1,870
Transportation of pipeline sections	421 kL diesel	Scope 1 :	1,140
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Airline travel	-	Scope 3:	4,080
Embedded energy related emissions for steel pipes	-	Scope 3:	1,750 Per annum emissions, amortised over 50 year pipeline lifetime.
Pipeline commissioning	-	Scope 1	14
Pipeline decommissioning	-	Scope 1	718

Scope 1 GHG emissions, exclusive of vegetation clearances but including commissioning and decommissioning activities, are approximately 44,160 tonnes CO_2-e, and total Scope 3 GHGs associated with fuel consumption are 3,300 tonnes CO_2-e. Including airline travel, Scope 3 GHG emissions are 7,390 tonnes CO_2-e, representing 17% of total GHG emissions for construction. Total emissions from all Scopes are approximately 51,540 tonnes CO_2-e.

The GHG emissions from vegetation clearances add a further 247,907 tonnes CO_2-e of GHG emissions. This represents 87% of all construction-related GHG emissions.

Scope 3 GHGs from embedded energy emissions in the steel pipeline are 87,500 tonnes CO_2-e. Assuming the gas pipeline has a 50-year lifetime, then the annualised emissions are 1,750 tonnes CO_2-e/yr, which is relatively insignificant.

Figure 4.1 shows the breakdown of Scope 1 and Scope 3 construction-related GHG emissions.

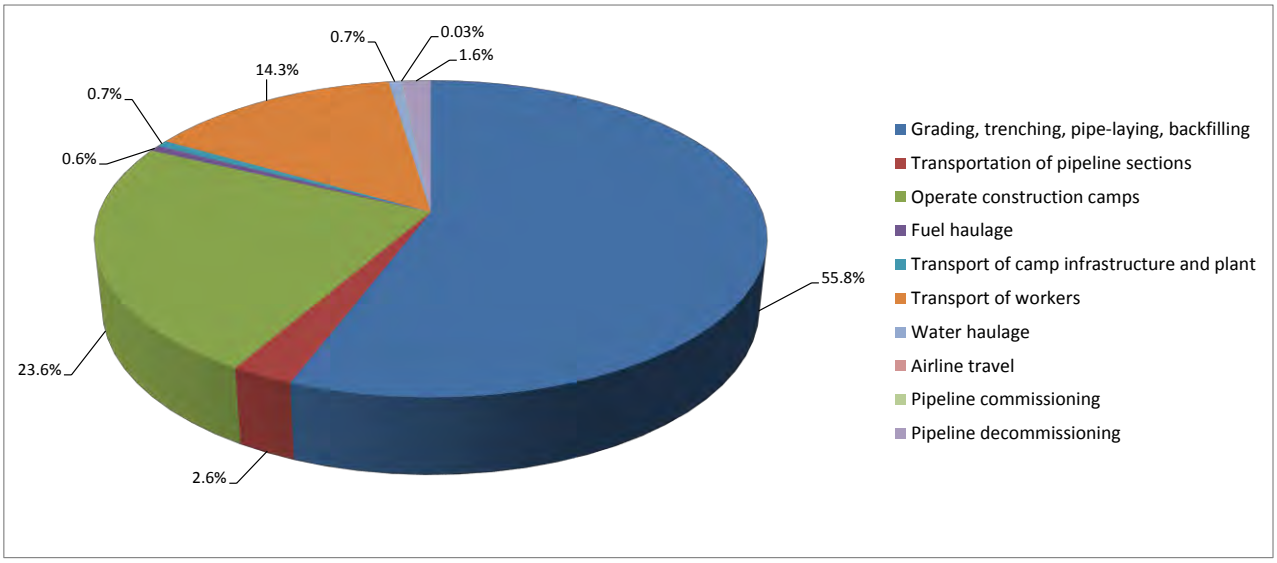

Figure 4.1 Breakdown of construction-related Scope 1 + Scope 3 GHG emissions (exclusive of vegetation clearances and embedded energy emissions)

A summary of annual GHG emissions during operations is shown in Table 4.2. Note that there are no published Scope 3 emission factors for the extraction of natural gas for the Northern Territory; hence these are not included below. Total Scope 1 GHG emissions are approximately 40,600 tonnes CO_2-e per annum. Including the annualised embedded energy related emissions from the steel pipe sections (1,750 tonnes CO_2-e per annum) gives a total of approximately 42,300 tonnes CO_2-e per annum.

Table 4.2 Summary of annual GHG emissions during operations

Activity related to operating the pipeline	Scope 1 GHG emissions Tonnes CO_2-e per annum
Pipeline fugitive emissions	5,260
Compressor Station blowdown	1,990
Pipeline blowdown	5,760
Inline compressor gas consumption	28,900
Leaks around compressor seals	130
Total	**42,030**

Figure 4.2 below shows the annual GHG emissions from all assessed construction and operations activities (decommissioning GHG emissions are not shown in the final year of operations due to their small contribution). This covers all GHG emission sources including annualized embedded energy emissions. All GHG emissions from land clearances are assumed to be released during the construction period only.

It is clear that the construction-related GHG emissions are significant on an annual basis. Taking into account the vegetation clearances, the GHG emissions from construction are approximately 7 times that of the operational GHG emissions.

GHG emissions during operations are dominated by fuel gas consumption for the inline compressor turbine with small quantities of fugitive gas emissions and vented gas.

From this assessment, it is possible that the construction works will trigger the NGERs facility reporting threshold of 25,000 tonnes CO_2-e per annum of Scope 1 emissions, excluding GHG emissions from vegetation clearances. During operations, the gas pipeline will certainly exceed the facility trigger and will therefore be required to report under the NGERs legislation.

Additionally, during operations the inline compressor gas turbines could consume more than 0.5 PJ per annum, requiring the KGGP pipeline operators to participate in the Energy Efficiency Opportunities program. Being a greenfield development, an energy efficiency assessment may be required during the design phase of the project, depending on the timing of the detailed design schedule. This assessment is likely to require the consideration, documentation and reporting of a rigorous energy efficiency improvement process at each stage of the design and commissioning phases of the project.

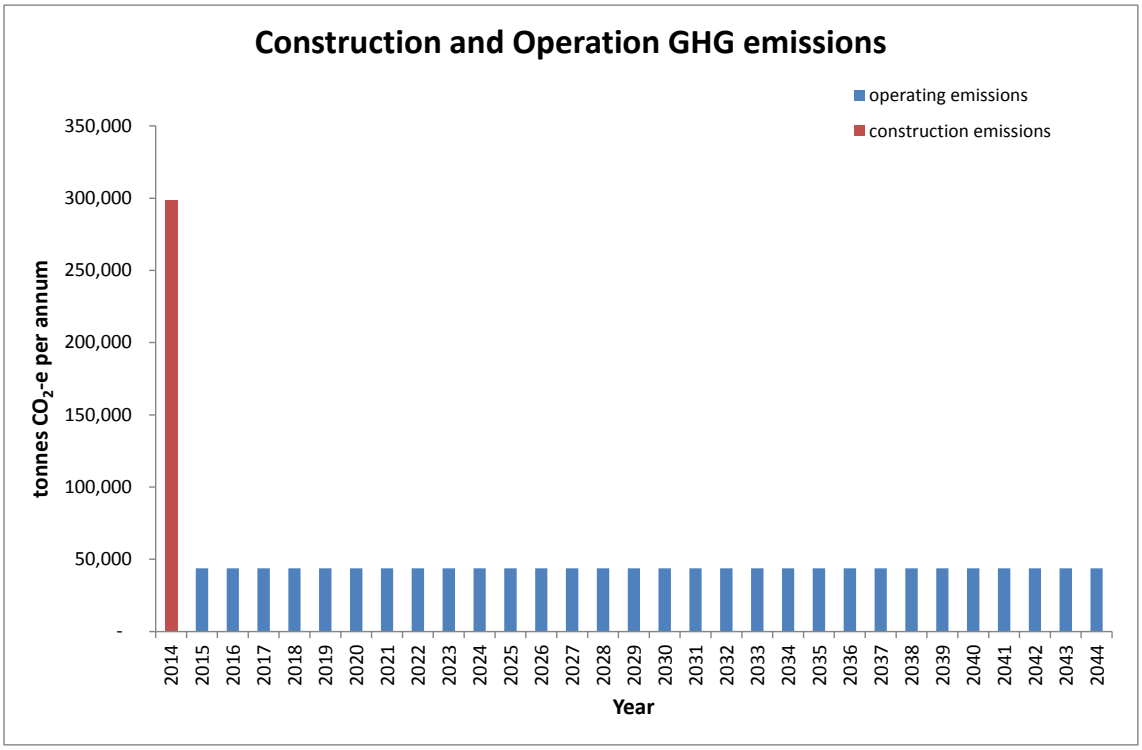

Figure 4.2 Annual construction and operations-related GHG emissions

5 GHG MITIGATION MEASURES

The following measures, based on leading practice, can lead to improvements in energy efficiency and reductions in GHG emissions in relation to construction and operation of the pipeline.

Construction

The GHG emissions will primarily arise from the clearance of vegetation for the pipeline right of way, from the use of construction machinery and site vehicles, and the use of vehicles in transporting people and construction materials. Operational controls that should be considered for adoption include:

- Encouraging regrowth and revegetation of the pipeline ROW. At least 60% of the ROW will be allowed to regrow. Actions to encourage this include:
  - seeding with local grass species in order to more immediately stabilise disturbed areas and to help stop weeds taking hold;
  - stockpiled topsoil and cleared vegetation would be respread to encourage regrowth from natural seedbank; and
  - Some re-planting only in high risk areas where stability needs to be rapidly achieved.
- Using fuel efficient vehicles and machinery where practicable and optimise transport logistics (of people and equipment) to reduce fuel consumption;
- Back-loading of trucks, and sourcing materials and services from local suppliers where possible;
- Operating the vehicles and machinery in a fuel efficient manner e.g. on-site vehicles to be operated at an optimal speed, and no idling for extended periods;
- Assessing construction techniques to determine the most fuel efficient and least GHG intensive methods, i.e. on-site versus modular construction;
- Clearing the minimum amount of vegetation including grass cover for project works;
- Progressively rehabilitating land cleared for construction, especially exposed soils;
- Maximising the amount of land re-vegetated;
- Minimise the volume of natural gas released during decommissioning of the pipeline;
- Considering good quality biodiversity offsets for land cleared;
- Assessing the use of alternative fuels e.g. CNG, LNG, LPG and biodiesel versus diesel and petrol; and
- Sourcing low embedded emissions construction materials where appropriate.

Operation

Control Measures ***s*** that should be considered for adoption during the operations phase include:

- Carrying out regular corrosion and leak detection monitoring, intelligent pigging and regular patrols to check for leaks and undertake prompt repairs. This is important around pressure relief valves, compressor seals around rod packing, connectors and pneumatic controllers;
- Conducting regular energy audits for the compressor station to ensure compressor turbine operates at peak efficiency;
- When carrying out pipeline blow-down activities for pipeline maintenance, consider using pipeline pump-down techniques. These involve using in-line compressors either alone or in sequence with portable compressors. This removes the natural gas from sections of the pipeline before maintenance or repair. This will reduce GHGs associated with natural gas venting; and
- Reducing leakage in reciprocating compressor rod packing - replacing packing when expected reduction in leaks will pay back costs.

6 CONCLUSION

A high level GHG assessment has been performed for the proposed Katherine to Gove gas pipeline. This covered construction-related and operations-related GHG emissions, including vegetation clearances, pipeline commissioning and decommissioning. GHG emissions for direct Scope 1 and Scope 3 activities were assessed.

During the construction period, total Scope 1 and 3 GHG emissions from fuel consumption for construction machinery and transport, and gas vented from commissioning activities are 50,820 tonnes CO_2-e, excluding embedded energy emissions and land clearances. GHG emissions from decommissioning activities are approximately 720 tonnes CO_2-e.

GHG emissions from the clearance of 2054 hectares of land amounted to 248,000 tonnes CO_2-e, which is the largest source of GHG emissions in the project, assuming all emissions are released during the construction period. Over the lifetime of the project, it is expected that at least 60% of the pipeline ROW will be allowed to naturally re-vegetate and therefore approximately 60% of the carbon sequestration potential of the vegetation can be recovered. Actions such as seeding with local grasses, re-spreading stockpiled soils to help encourage re-growth and replanting in the high risk areas will help achieve this.

Embedded energy related emissions from steel pipeline sections amounted to 1,750 tonnes CO_2-e/annum and are not significant when annualized over an assumed 50-year lifetime.

Total Scope 1 and Scope 3 GHG emissions from all sources related to construction of the pipeline amounts to 301,195 tonnes CO_2-e. This contributes 2.04% and 0.054% to Northern Territory and Australian GHG emissions, respectively

On an annual basis, construction-related GHG emissions are more significant compared to operations-related GHG emissions. GHG emissions during operations are dominated by gas consumption by the 5.5 MWe gas compressor turbine. At maximum capacity, the pipeline is estimated to produce approximately 42,000 tonnes CO_2-e per annum in direct Scope 1 GHG emissions.

Operational GHG emissions for the pipeline will have to be annually reported under the National Greenhouse and Energy Reporting (NGER) Act by the party which has operational control over the pipeline. It is expected that the pipeline operators will also need to participate in the Carbon Pricing Scheme. They will also be required to participate in the Energy Efficiency Opportunities (EEO) Program, and may be required to assess energy efficiency measures during the design and commissioning stages as proposed in the expansion to the EEO program to cover major new developments and major expansion projects.

To offset Scope 1 GHG emissions, consideration of GHG emissions offsets through third party projects may also be required. An example of this would be where a third party participates in tree planting projects that are compliant with Carbon Farming Initiative regulations and generates Australian carbon credit units (ACCUs). The pipeline operator may then purchase these credits to offset the appropriate quantity of GHG emissions.