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GREENHOUSE GAS REPORT

APPENDIX HH

ENVIRONMENTAL IMPACT STATEMENT

BORAL CONSTRUCTION MATERIALS
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BORAL

Greenhouse Gas Assessment for the Gold Coast Quarry

Prepared for

Cardno HRP

April 2013

Final

Prepared by

Katestone Environmental Pty Ltd

ABN 92 097 270 276
Ground Floor, 16 Marie Street
PO Box 2217
Milton, Queensland, Australia 4064

www.katestone.com.au
environmental@katestone.com.au
Ph +61 7 3369 3699
Fax +61 7 3369 1966

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Glossary

Term	Definition
Units of measurement	
GJ	Gigajoule
PJ	Petajoule
TJ	Terajoule
kL	Kilolitre
MWh	Megawatt hour
Mt	Million tonnes
Mtpa	Million tonnes per annum
tCO_2-e	tonnes of CO_2 equivalent
h/day	Hours per day
d/year	Days per year

Air pollutants and chemical nomenclature

CH_4	Methane
CO_2	Carbon dioxide
HFCs	Hydrofluorocarbons
N_2O	Nitrous oxide
PFCs	Perfluorocarbons

Other abbreviations

ACCUs	Australian Carbon Credit Units
DCC	Department of Climate Change
DCCEE	Commonwealth Department of Climate Change and Energy Efficiency
EEO	Energy Efficiency Opportunities
GWP	Global warming potential
GHG	Greenhouse Gas
LULUCF	Land Use, Land Use Change and Forestry
NGA	National Greenhouse Accounts
NGER	National Greenhouse and Energy Reporting
ToR	Terms of Reference
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

Katestone Environmental Pty Ltd (Katestone) has been commissioned by Cardno HRP, on behalf of Boral Resources (Qld) Pty Limited (Boral), to conduct a greenhouse gas assessment of the proposed Gold Coast Quarry suitable for inclusion in an Environmental Impact Statement (EIS) and application for Environmental Approval.

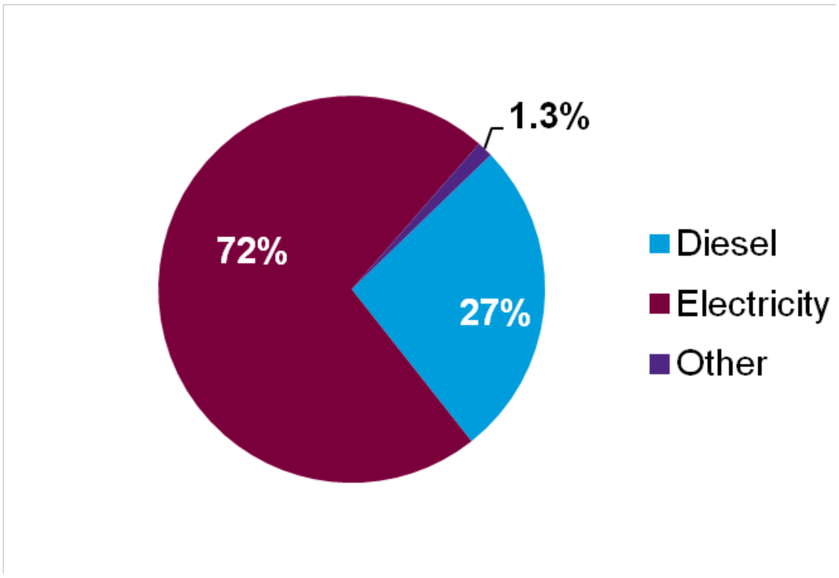
Boral is proposing to establish a new extractive industry operation on a greenfield site bordering Old Coach Rd and Tallebudgera Creek Road, at Reedy Creek on the Gold Coast.

This assessment responds to the Queensland Coordinator-General's Terms of Reference for assessment of greenhouse gas emissions as part of the Environmental Impact Statement for the Gold Coast Quarry (the Project). Calculations of greenhouse gas emissions are based on expected activity data supplied by the proponent together with National Greenhouse Account factors and other suitable emissions estimation methods.

Annual greenhouse gas emissions for the Project peak at 6,900 tonnes of equivalent carbon dioxide emissions (tCO_2-e) during the site establishment, development and plant construction stages and 10,300 tCO_2-e during the quarry operational stages. The table and figure below summarise the annual greenhouse gas emissions from the Project.

Summary of annual greenhouse gas emissions (t $CO_{2\text{-}e}$)

Year	Phase	Total emissions	% of total
1	Site establishment, development and plant construction	2,303	0.5%
2		4,934	1.1%
3		6,914	1.6%
4		2,621	0.6%
5		3,279	0.7%
6	Plant construction/Operation	6,599	1.5%
7 to 47	Operation	10,304	93.9%
	TOTAL	438,810	100.0%



Source contributions to total greenhouse gas emissions from the Project

Transportation of quarry products is relatively costly, greenhouse intensive activity. There are, therefore, a range of benefits achieved if a quarry is located close to its markets. The relative emissions of greenhouse gas emissions for the Gold Coast Quarry compared with possible alternative sources of quarry materials, supplying areas around Reedy Creek, Mudgeeraba and Palm Beach have been estimated. This has found that the Gold Coast Quarry could avoid between 2,067 and 12,918 tonnes per year of CO_2*-e, which amounts to between 82,000 tonnes and 517,000 tonnes* CO_2*-e over 40 years when compared with alternative sources of materials.*

The proposed quarry does not trigger the threshold for National Greenhouse and Energy Reporting (NGER) although emissions from the quarry will be captured through reporting obligation associated with Boral (the Boral group) as a corporation. Energy usage at the site may also be considered as part of Boral's participation in Energy Efficiency Opportunities (EEO's).

Overall the vast majority of the greenhouse gas emissions occur during the operation/production phase of the Project.

A range of mitigation measures are proposed.

1. Introduction

Katestone Environmental Pty Ltd (Katestone) has been commissioned by Cardno HRP, on behalf of Boral Resources (Qld) Pty Limited (Boral), to conduct a greenhouse gas assessment of the proposed Gold Coast Quarry suitable for inclusion in an Environmental Impact Statement (EIS) and application for Environmental Approval.

Boral is proposing to establish a new extractive industry operation on a greenfield site bordering Old Coach Rd and Tallebudgera Creek Road, at Reedy Creek on the Gold Coast. The proposed development will operate as a quarry for the extraction and processing of hard rock primarily for use in concrete, asphalt, drainage materials, road base, bricks/blocks, pavers, pipes and landscape supplies. The proposed Gold Coast Quarry has the potential to supply the Gold Coast region with high grade construction materials for at least of 40 years.

This report has been prepared to address the Queensland Coordinator-General's Terms of Reference (ToR) for the Gold Coast Quarry, specifically in relation to Section 4.6 Greenhouse Gas Emissions. The relevant components of the ToR are:

> *Provide an inventory of projected annual emissions for each relevant greenhouse gas, with total emissions expressed in CO_2-e terms for the following categories:*
>
> - *Scope 1 emissions - means direct emissions of greenhouse gases from sources within the boundary of the facility and as a result of the facility's activities*
> - *Scope 2 emissions - means emissions of greenhouse gases from the production of electricity, heat or steam that the facility will consume, but that are physically produced by another facility*
>
> *Discuss the potential for greenhouse gas abatement measures, including:*
>
> - *a description of the proposed measures (alternatives and preferred) to avoid and/or minimise direct greenhouse gas emissions*
> - *an assessment of how the preferred measures minimise emissions and achieve energy efficiency*
> - *a description of any opportunities for further offsetting greenhouse gas emissions through indirect means, including sequestration and carbon trading*
>
> *Discuss any potential benefits of the project in terms of its overall greenhouse gas footprint.*

2. Greenhouse gas assessment

2.1 Background

This greenhouse gas assessment considers the potential impact of the Project on the global climate system by changes that it may cause to net greenhouse gas emissions. Climate change is an environmental concern at a global level. Any source or sink of greenhouse gases has a nominally equivalent effect no matter where it occurs in the world. While few if any individual projects would make a noticeable change to the Earth's climate, the summation of human activities increasing the concentrations of greenhouse gases in the upper atmosphere does. Governments and the global scientific community have established conventions for accounting for greenhouse gas emissions to enable pollution control among all global jurisdictions. This assessment employs these established conventions so that the relative impact of the current project can be properly understood.

The term greenhouse gases comes from the 'greenhouse effect', which refers to the process whereby greenhouse gases in the atmosphere absorb the radiation released by the Earth's surface and then radiate some heat back towards the ground, increasing the surface temperature (Rapston, 2011). Human activity, especially burning fossil fuels, is increasing the concentration of greenhouse gases and hence increasing the absorption of outgoing heat energy. Even a small increase in long-term average surface temperatures has numerous direct and indirect consequences for climate.

The main greenhouse gases influenced directly by human activities and included in carbon accounting are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and synthetic gases, such as sulphur hexafluoride (SF_6) hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (Raupach and Fraser 2011; pp. 15-20). These gases vary in effect and longevity in the atmosphere, but scientists have developed a system called Global Warming Potential to allow them to be described in equivalent terms to CO_2 (the most prevalent greenhouse gas) called equivalent carbon dioxide emissions (CO_2-e). A unit of one tonne of CO_2-e is the basic unit used in carbon accounting. An emissions inventory, or 'carbon footprint', is calculated as the sum of the emission rate of each greenhouse gas multiplied by the global warming potential. For example:

$$\text{tonnes } CO_2\text{-e} = \text{tonnes } CO_2 \times 1.0 + \text{tonnes } CH_4 \times 21 + \text{tonnes } N_2O \times 310$$

CO_2 and CH_4 are part of the carbon cycle, which refers to the natural movement of carbon among the ocean, plants, soil and the atmosphere. Fossil fuels such as coal, oil and natural gas are the product of ancient deposits of organic matter. When combusted, their stored carbon is released again to the atmosphere at an extremely rapid rate in comparison to the rate at which it became stored.

Burning fossil fuels always causes greenhouse gas emissions and energy from fossil fuels underpins the global economy and the human development gained from it. Consequently, changing this pattern to reduce emissions and protect climate is extremely difficult. The need for a global solution to this problem has led to the United Nations Framework Convention on Climate Change (UNFCCC), the associated Kyoto Protocol and the world scientific body, the Intergovernmental Panel on Climate Change (IPCC). In 2010, governments agreed that emissions need to be reduced so that global temperature increases are limited to below two degrees Celsius (UNFCCC, 2012). Australia is an active participant in these global arrangements and this has a strong effect on domestic economic and environmental policy.

2.2 Australian policy and regulation

2.2.1 Australian international commitments

The following discussion of Australia's global commitments to respond to climate change is derived from information published by the Commonwealth Department of Climate Change and Energy Efficiency (DCCEE) on its website (DCCEE, 2012c).

The United Nations Framework Convention on Climate Change (UNFCCC) provides the basis for global action 'to protect the climate system for present and future generations'. Australia ratified the Convention in 1992. The Convention entered into force in 1994 after a requisite 50 countries had ratified it. There are now 193 Parties to the UNFCCC - almost all of the members of the United Nations.

Parties to the Convention have agreed to work towards stabilising 'greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'.

Under the convention, Australia is committed to:

- Submitting a national inventory of emissions and removals of greenhouse gases
- Implementing national programs to mitigate climate change and adapt to its impacts
- Conducting research related to the climate system and promoting relevant technologies
- Raising public awareness about climate change
- Submitting comprehensive National Communications (i.e. reports)

The Kyoto Protocol is an international agreement created under the UNFCCC in Kyoto, Japan in 1997. Australia's ratification of the protocol came into effect on 11 March 2008. The protocol aims to reduce the collective greenhouse gas emissions of developed country parties by at least five per cent below 1990 levels during 2008 to 2012 – referred to as the first commitment period. Australia has a target for emissions of 108 percent of estimated emissions for 1990 or 591.5 Mt CO_2-e.

At the United Nations climate change negotiations in Durban, South Africa in 2011, Parties to the Kyoto Protocol decided to establish a second commitment period from 1 January 2013. On 9 November 2012, the Australian Government announced its intention to join a second commitment period under the Kyoto Protocol, conditional on a number of factors to be negotiated at the Doha Conference of the Parties in late 2012. All countries that are party to the UNFCCC are negotiating a new global agreement that is intended to have legally binding commitments for all major emitters. This agreement is due for finalisation by 2015 and come into effect in 2020 (Combet, 2012).

The Australian Government has a constitutional power to ensure that Australia meets its international commitments, including those made under the UNFCCC. There are two related national policies, statutes and regulations that are important to Boral's development and operation of the Project, including:

- The *National Greenhouse and Energy Reporting (NGER) Act 2007* and regulations – Boral must participate in the national emissions reporting process
- The *Energy Efficiency Opportunities Act 2006* – Boral will have to identify, evaluate and report publicly on cost effective energy savings opportunities

This legislation is enforced by Australian Government agencies and penalties apply for non-compliance.

2.2.2 National Greenhouse and Energy Reporting

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) established a national framework for corporations to report greenhouse gas emissions and energy consumption. Registration and reporting is mandatory for corporations that have energy production, energy use or greenhouse gas emissions that exceed specified thresholds. The quarry does not exceed the thresholds for energy use and greenhouse gas emissions. The energy use is estimated at 43 TJ of electricity and 35 TJ of diesel per year, which is approximately 78 TJ (12,000 MWh electricity, 900kL diesel) in total compared to the facility threshold of 100 TJ, while the annual greenhouse gas emissions are 13 ktCO2-e compared to the facility threshold of 25 ktCO2-e. Although the facility thresholds are not exceeded it is likely that emissions from this facility will need to be reported as a component of Boral's corporate NGER reporting obligations.

The NGER Act is now administered by the Clean Energy Regulator and the scheme will also be the basis for the *Clean Energy Act 2011* and associated carbon pricing mechanism (i.e. emissions trading). Registered, corporations are required to report by 31 October following the reporting year, and must submit an NGER Report for every year that it remains registered (Clean Energy Regulator, 2012a).

2.2.3 Energy Efficiency Opportunities

The Energy Efficiency Opportunities (EEO) program encourages large energy-using businesses to improve their energy efficiency. It does this by requiring businesses to identify, evaluate and report publicly on cost effective energy savings opportunities (DRET, 2011). Participation in Energy Efficiency Opportunities is mandatory for corporations that use more than 0.5 petajoules (PJ) of energy per year.

The quarry has been estimated to require 0.08 PJ of energy per year. As a result the quarry would not be required to participate in EEO. The facility may be included in the Boral corporate reporting, meaning that reporting standards will need to be consistent with corporate requirements and potential inclusion of usage and opportunities in future EEO reports.

2.2.4 Clean Energy Act (Carbon Pricing Mechanism)

The *Clean Energy Act 2011* has established a carbon emissions trading system for Australia including a fixed price period, a 'ceiling' period and full emissions trading from 1 July 2015, where the market will determine prices (with some restrictions). Emissions covered under the Act are essentially those which the facility directly emits (Scope 1); however, covered emissions do not include emissions from the combustion of liquid petroleum fuel that has been subject to any duty under the *Customs Tariff Act 1995* or the *Excise Tariff Act 1921*. As the quarry scope 1 emissions are related to diesel use and therefore not covered, the quarry will not be a liable entity under the Act.

2.2.5 Reporting tools

The DCCEE monitors and compiles databases on anthropogenic activities that produce greenhouse gases in Australia. The DCCEE has published greenhouse gas emission factors for a range of anthropogenic activities. The DCCEE methodology for calculating greenhouse gas emissions is published in the National Greenhouse Accounts (NGA) Factors workbook (DCCEE, 2012b) and is based on Australian data. This workbook is updated regularly to reflect current compositions in fuel mixes and evolving information on emission sources.

The scope that emissions are reported under, and the emission factors used are determined by whether an activity is within an organisation's boundary or not. Direct emission factors are used to calculate Scope 1 emissions from activities within the organisation's boundary. Indirect emission factors are used to calculate Scope 2 emissions from the generation of electricity purchased and consumed by an organisation.

Scope 3 emissions occur as an indirect result of an activity. For an example, Scope 3 emissions are those that occur due to the production of fuel or the losses associated with the transmission of electricity. The determination of Scope 3 emissions relating to the quarry have been limited to those available in the NGA namely electricity generation and fuel production.

3. Sources of greenhouse gas emissions

3.1 Site Development and Construction Phase

The site development and construction phase of the Project is expected to last for five and a half years. The key activities carried out during this phase will be:

- Establishment of site access roads and the facilities area
- Construction of dam and sediment pond
- Vegetation clearing
- Topsoil and overburden removal
- Mobile crushing operations
- Construction of permanent fixed crushing plant
- Set up of stockpile areas

Vegetation acts as a carbon sink and sequesters carbon; hence, the removal of vegetation results in general in the eventual return to the atmosphere of the carbon sequestered in the vegetation.

Greenhouse gas emissions associated with this phase of the project can be predominantly attributed to:

- Land clearing
- Fuel usage
- Electricity consumption
- Blasting

Table 1 provides a summary or emission sources and usage rates for the construction phase of the Project.

Table 1 Emission sources and usage during development and construction phase

Year[1]	Diesel	Electricity	Petroleum based oil	Acetylene	Explosives
	L	MWh	L	m^3 @ STP	t
1	646,700	600	35,000	1,100	0
2	1,615,500	600	35,000	1,100	100
3	2,346,100	600	35,000	1,100	150
4	754,900	600	35,000	1,100	150
5	999,105	600	35,000	1,100	150
6	426,400	300	17,500	550	100

Table note:
[1] Construction forecast to be completed by mid way through Year 6

3.2 Operations Phase

Production and sale of hard rock quarry products will commence mid-way through the development phase utilising a mobile crushing plant. After approximately six years, upon completion of the fixed crushing and screening plant, up to 2 Mtpa of hard rock will be processed into products suitable for use in concrete, asphalt, drainage materials, road base, bricks, pavers, pipes and landscape supplies.
Table 2 provides a summary of proposed operations at the quarry once it is in full operational mode.

Table 2 Summary of Project Operations

Project component	Detail
Reserve volume estimate	79 Mt
Production rate	Up to 2 Mt per annum
Project life	over 40 years
Operating hours	6am – 6pm Monday – Saturday (actual hours of operation are likely to be less than 6am-6pm)
Number of employees	Up to 25 full time employees Up to 90 construction jobs
Site equipment and infrastructure	Mobile Fleet (comprising excavators, graders, front end loaders, bulldozers ,dump trucks, water trucks and haulage trucks) Fixed Plant (crushing and screening, product storage and outloading) Product stockpiles Site administration and workshop buildings Water storage facilities
Product Transport	Road haulage via road truck
Site Access	Old Coach Road

Table 3 provides a summary of the expected diesel fuel, electricity consumption and explosives for each year of operation.

Table 3 Emission sources and annual usage during production phase

Source	Units	Usage
Diesel	L/year	900,000
Electricity[1]	MWh/year	9,000
Maintenance oils	L/year	35,000
Acetylene	m^3@STP/year	1,100
Explosives	t/year	550

Table note:
[1] Assumes 8MW (connected motor power) x 0.75 (estimated duty/load factor) x 2000 h/year

4. Method used to estimate greenhouse gas emissions

4.1 Emission factors

DCCEE has published greenhouse gas emission factors for a range of anthropogenic activities. The DCCEE methodology for calculating greenhouse gas emissions is published in the National Greenhouse Accounts (NGA) Factors workbook (DCCEE, 2012d) and is based on Australian data. This workbook is updated regularly to reflect current compositions in fuel mixes and evolving information on emission sources.

The greenhouse gas intensity of each activity has been calculated using the simplified equation as follows:

$$\mathrm{GHG} = \mathrm{E} \times \mathrm{EF}$$

Where:

GHG: Annual greenhouse gas emissions in tonnes of carbon dioxide equivalent (tCO_2-e)

E: Annual energy use (GJ/yr or kWh/yr)

EF: Emission factors for CO_2, CH_4 and N_2O (kg CO_2-e/GJ or kg CO_2-e/kWh)

The total annual CO_2-e emissions are the sum of the individual CO_2-e emissions of CO_2, CH_4 and N_2O. The emission factors that have been used to calculate greenhouse gas emissions are presented in Table 4.

Table 4 Greenhouse gas emission factors for emission sources

Activity	Emission factor				Source
	unit	Scope 1	Scope 2	Scope 3	
Diesel consumption	kg CO_2-e/GJ	69.9	-	5.3	Table 4 & Table 39 (DCCEE, 2012d)
Purchased electricity	kg CO_2-e/kWh	-	0.86	0.12	Table 5 & Table 40 (DCCEE, 2012d)
Petroleum based oils[1]	kg CO_2-e/GJ			5.3	Table 39 (DCCEE, 2012d)
Acetylene	kg CO_2-e/kg C_2H_2	3.4			Stoichiometric calculation
Explosives	t CO_2-e/t	0.17			Table 4 (DCC, 2008Jan)

Table note:
[1] Used for vehicle maintenance, not combusted

4.2 Carbon storage

The Full Carbon Accounting Model (FullCAM) software published by the Australian Government Department of Climate Change and Energy Efficiency was used to estimate a worst-case quantity of carbon released to the atmosphere as a result of vegetation clearing during the site establishment and development and fixed plant construction phase of the Project.

A footprint for the Project was estimated from available information and the distribution of various vegetation types within this footprint was analysed, using vegetation data from a GIS database.

The FullCAM model was based on:

- Disturbance footprint: The disturbance footprint for the project was estimated to be 66ha based on the project design (Cardno HRP)
- Vegetation type: Cardno Chenoweth advised that the forest being cleared is most closely allied with Eucalypt Open Forests (MVG 3 – as defined by the Department of Environment and Water Resources (2007))
- Forest clearing scenario: A one off forest clearing event occurring at project commencement was determined as a worst case scenario with cleared vegetation remaining on-site and decomposing naturally
- Spatial characteristics: FullCAM uses the geographical location of site to characterise the relationship between rainfall and biomass taking into account factors such as forest type and soil nutrient availability of the region. Due to the relatively small area being cleared for the project on a regional scale it is sufficient to characterise the site using the mid-point of the plot

The carbon storage assessment has not accounted for the rehabilitation of benches within the quarry void or rehabilitation of buffer zones. These would be relatively small areas from a carbon storage perspective and are unlikely to cause a significant change. Notwithstanding this, rehabilitation of quarry benches and buffer zones will provide some additional carbon storage capacity.

5. Greenhouse gas inventory

5.1 Project greenhouse gas inventory

The greenhouse gas emissions estimated for each year of operation of the quarry commencing with the construction phase are summarised in Table 5. These figures cover scope 1, 2 and 3 components, and are based on the assumption of constant year to year operations once the operational phase is established.

Table 5 Estimated greenhouse gas emission by year of operation (t CO_2-e)

Year	Annual Emissions Summary			Total emissions	% of total
	Scope 1	Scope 2	Scope 3	Scopes 1 & 2 only	
1	1,787	516	211	2,303	0.5%
2	4,418	516	410	4,934	1.1%
3	6,398	516	559	6,914	1.6%
4	2,105	516	234	2,621	0.6%
5	2,763	516	284	3,279	0.8%
6*	2,471	4,128	762	6,599	1.5%
7-47	2,564	7,740	1,271	10,304	93.9%
TOTAL	122,500	316,310	53,310	438,810	100.0%

Table note:
* The change over from the development and construction phase to the operational production phase is estimated to occur mid-way through Year 6

Table 6 shows the percentage contribution of each emissions source to the total projected greenhouse gas emissions (Scope 1, 2 and 3 as described above) for the life of the project (see also Figure 1). It can be seen from Table 6 that the emissions from electricity consumption are expected to have the greatest contribution to the total greenhouse gas emissions from the project.

Table 6 Estimated greenhouse gas emissions by emission source (t CO_2-e)

Emission source	Emissions summary			Total emissions	% of total
	Scope 1	Scope 2	Scope 3	Scopes 1 & 2 only	
Diesel[1]	116,664	-	8,846	116,664	27%
Electricity	-	316,308	44,136	316,308	72%
Petroleum based oils	1,743	-	331	1,743	0%
Acetylene	199	-	-	199	0%
Explosives	3,897	-	-	3,897	1%
TOTAL	122,500	316,310	53,310	438,810	100%

Table note:
[1] Information currently available does not include a breakdown between mobile and stationary plant. Transport fuels are covered directly under the carbon pricing mechanism (Clean Energy Regulator, 2012b, c); therefore the Scope 1 emissions from diesel are not 'covered' emissions and the quarry will not exceed the Carbon Pricing Mechanism facility threshold of 25,000 tCO_2-e/y. An equivalent carbon price is applied through adjustments to fuel tax credits and excise

The predicted annual emission rate of scope 1 and 2 greenhouse gases from the quarry is 10 ktCO_2-e, which is not significant on a national or state scale. The Project's emissions represent:

- 0.002% of Australia's estimated greenhouse gas emissions for the year to March, 2012 (551 Mt CO_2-e) (DCCEE, 2012d).
- 0.008% of Queensland's annual emissions (scope 1 and 2). The total greenhouse gas emissions reported for Queensland were 134.3 Mt CO_2-e in the 2009/2010 reporting period (DCCEE, 2012f), excluding emissions and removals from Land Use, Land Use Change and Forestry (LULUCF). With the inclusion of emissions and removals from LULUCF, the total greenhouse gas emissions were 157.3 Mt CO_2-e.

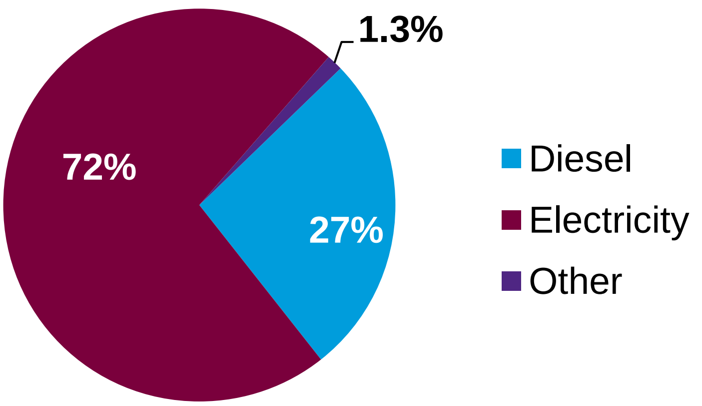


Figure 1 Source contributions to total greenhouse gas emissions from the Gold Coast Quarry

Location: N/A	**Data source:** Based on emissions calculations from activity data supplied by client	**Units:** Percentage
Type: Pie chart	**Prepared by:** Lisa Smith	**Date:** 4 March 2013

5.2 Carbon storage emissions

The greenhouse gas emissions resulting from clearing an area of forest of approximately 66ha have been estimated using the FullCAM model.

The FullCAM method of estimating carbon emissions has been developed for use on a regional scale, its use for comparatively small areas relating to infrastructure projects and similar are still being refined. As a result, this method for estimating Scope 1 emissions associated with vegetation clearing is not as accurate as available methods for determining emissions associated with diesel, electricity and explosives. To account for the greater level of uncertainty inherent in this estimation method, carbon emissions relating to forest clearing have been considered separately to the other emissions sources detailed in this report.

The annual carbon emissions resulting from forest clearing of the Gold Coast Quarry site are summarised in Figure 2. The highest annual emissions of 11 ktCO_2-e occur immediately following the clearing of the site. The total project greenhouse gas emissions associated with forest clearing are 67 ktCO_2e.

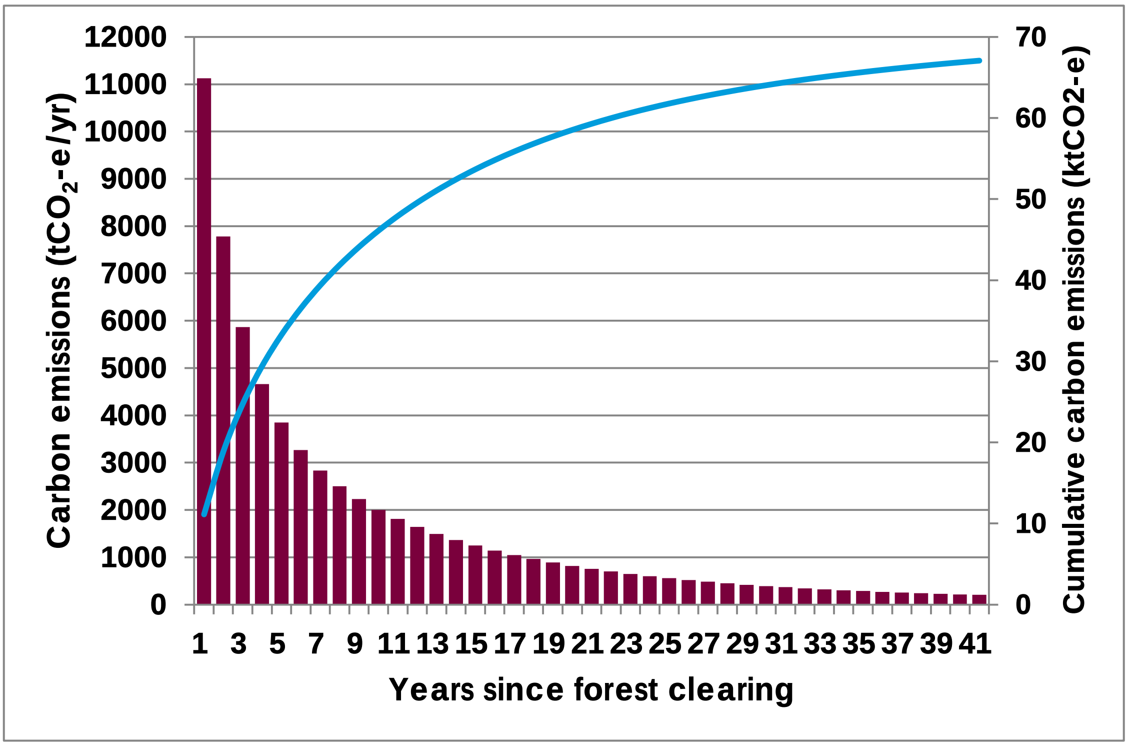


Figure 2 Carbon emissions from forest clearing of the Gold Coast Quarry site		
Location: N/A	**Data source:** FullCAM Model	**Units:** Years, tCO_2-e
Type: Bar Chart	**Prepared by:** Lisa Smith	**Date:** 4 February 2013

Figure 3 shows the overall contribution of land clearing to total project emission is approximately 13%

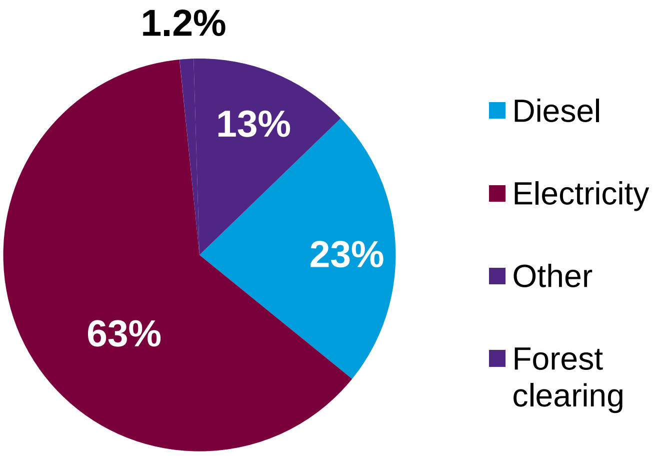


Figure 3	**Source contributions to total greenhouse gas emissions from the Gold Coast Quarry including forest clearing**	
Location: N/A	**Data source:** Based on emissions calculations from activity data supplied by client	**Units:** Percentage
Type: Pie chart	**Prepared by:** Lisa Smith	**Date:** 4 March 2013

5.3 Planned burns

Planned burns will be utilised on site as an integral component of the Gold Coast Quarry Bushfire Management Plan to reduce the risk and severity of bushfires. Obligations under the Kyoto Protocol currently incorporate prescribed burning of savannas, as part of the agriculture category, this does not presently extend to prescribed burning activities relating to forests, additionally there is still ongoing discussion and conjecture concerning the net effect of prescribed burning of forest areas and the impact of the activity on carbon emissions. It has been suggested that in areas with a high risk of bushfires that prescribed burning activities will lead to a lower net emission of greenhouse gases, taking into consideration the higher rate of regrowth and soil carbon accumulation that occurs following a prescribed burning activity compared to a bushfire (Narayan, 2007). These emissions have not been accounted for in this instance due to the uncertainty relating to the overall impact of planned burns on net carbon emissions.

6. Benefits of project

Transportation of quarry products is relatively costly, greenhouse intensive activity. There are, therefore, a range of benefits achieved if a quarry is located close to its markets. Locating a quarry close to the points of use of the quarry materials avoids greenhouse gas emissions from truck diesel that would occur if the materials had to travel further. Quarry products are dense and their transport requires more energy compared to lighter payloads; that is, they require sturdier vehicles and consume comparatively more diesel. Hence, proximity to market is more advantageous in minimising greenhouse gas emissions than for less dense payloads.

The amount of greenhouse gas emissions that would be avoided depends on the additional distance to be travelled, and the comparative process efficiency (regarding greenhouse gas emissions) of alternative sources of material and the fuel efficiency of the truck fleets. Greenhouse gas benefits would accompany multiple other benefits of minimising the distance between quarry and point of use, notably cost, safety and amenity.

This assessment has incorporated a quantitative comparison of alternative source quarries and possible points-of-use (markets) for quarry products to investigate the potential greenhouse gas emissions benefits of a proximal quarry site. Norling and Davies (2012) identified a series of alternative sources of quarry materials and also concluded that the proposed Gold Coast Quarry is the only strategic hard rock resource on the central and southern parts of the Gold Coast. These locations were taken as alternative source quarries. Mudgeeraba, Reedy Creek and Palm Beach were selected as possible points-of-use, based on Emerging Community areas identified in the Gold Coast City Council planning scheme, and an urban location (Palm Beach). The distances between these points by road was established using Google Maps, the results of which are presented as a matrix in Table 7.

Table 7 Matrix of distances between alternative quarry sites and possible points of use

Source quarry	Point-of-use:[1]	Mudgeeraba	Reedy Creek	Palm Beach
	Assumed address:	**Jarema Drive, Mudgeeraba**	**Abilene Place, Reedy Creek**	**Jefferson Lane, Palm Beach**
	Land use:	**Emerging community[2]**	**Emerging community[2]**	**Existing urban**
	Assumed address	**Distance (km)[3]**	**Distance (km)**	**Distance (km)**
Gold Coast Quarry	Old Coach Road, Reedy Creek	5	4	10
Nerang Hymix/Hanson	Hymix Road, Nerang	21	26	31
Oxenford (Nucon)	33 Maudsland Rd	28	33	37
Darlington Range	Hideaway Road, Willow Vale[4]	46	52	56
Tumbulgum Quarry	Pollards Road, Dulguigan, NSW	47	45	36
Stapylton	Stonemaster Drive, Stapylton	48	53	58
Blue Rock (Cedar Creek)	Rowe Lane, Cedar Creek[4]	63	68	72
Ballina	North Teven Road, Teven[4]	105	103	95

Table note:
[1] Indicative points-of-use only
[2] Based on Reedy Creek Structure Plan - Emerging Communities Map EC8, GCCC
[3] Distances taken from Google Maps Directions, selecting first option.
[4] Not actual quarry addresses

The source to market distance matrix in Table 7 was used to estimate potential greenhouse gas emissions benefits. The emissions calculations assumed 2 Mtpa of quarry product transported by trucks with a 28 tonne payload, burning 20 litres per hour and travelling 60 km in an hour. The analysis further assumed that there would be no differences in vehicle fleet, product characteristics or production efficiency among the alternatives.

Figure 4 presents the results of this analysis. The next nearest source quarry, Nerang Hymix/Hanson, would have between double and five times (an additional 2,067 to 2,842 t/y CO_2-e depending on point-of-use) the greenhouse gas emissions due to transport. Transporting quarry materials to these markets from Ballina would increase emissions by a multiple of 8 to as much as 25 times (between 10,979 to 12,918 t/y). On this analysis, the minimum annual savings would be 2,067 tonnes and the maximum savings would be 12,918 tonnes. Over 40 years, the total savings would range between 82,000 tonnes and 517,000, tonnes CO_2-e.

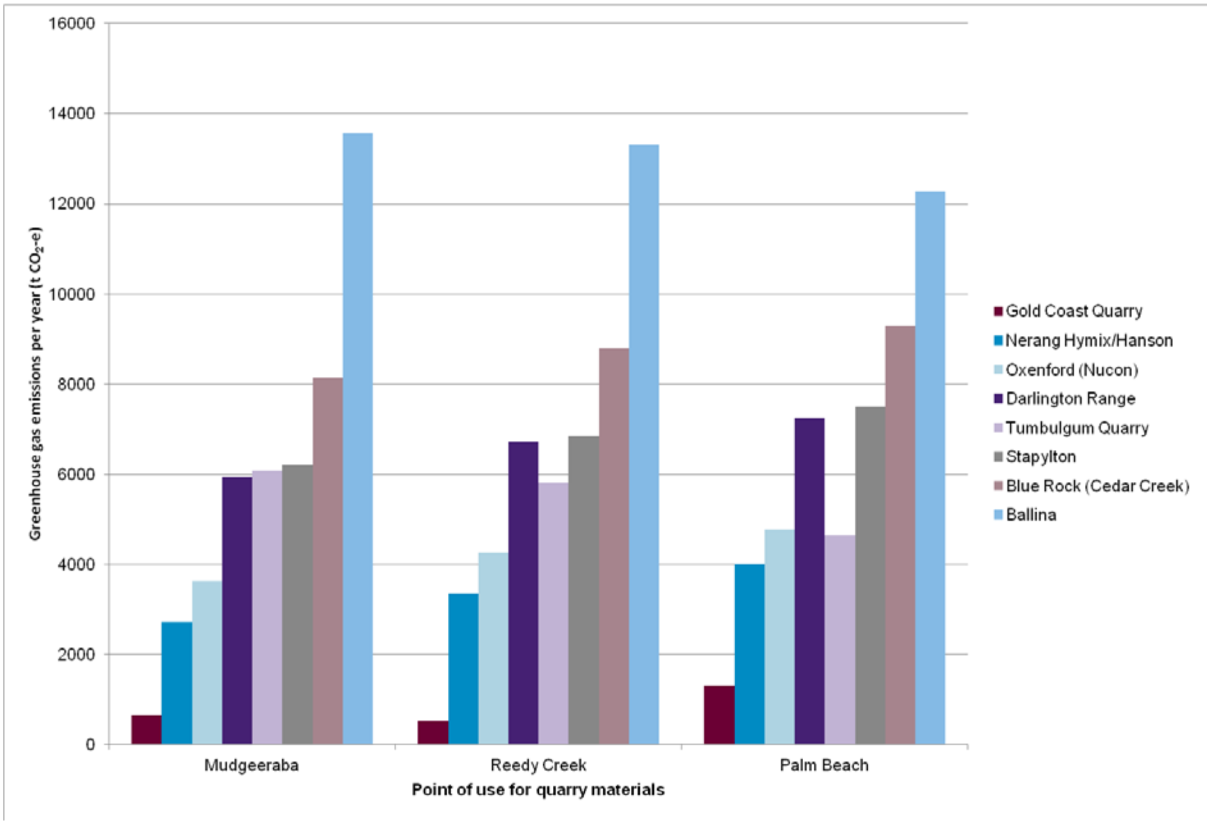


Figure 4	**Illustration of differing annual greenhouse gas emissions from truck movements to service points of use from alternative quarry locations**	
Location: N/A	**Data source:** Based on emissions calculations from activity data supplied by client	**Units:** t CO_2-e
Type: Clustered column chart	**Prepared by:** Scott Losee	**Date:** 1 March 2013

7. Mitigation of greenhouse gas emissions from the Project

There are many opportunities throughout the construction and operation of the Project to reduce greenhouse gas emissions. In many instances, these measures would also have the potential to save capital and/or operational expenditure and complement other environmental and business processes.

Although the quarry as a facility would not give rise to a liability under the Clean Energy Act (carbon tax), Boral as a corporation will likely be a liable entity under the Act. As a result there will be a cost associated with a portion of Scope 1 emissions. In addition, the pass-through effect of the carbon pricing mechanism is designed to create a price signal to discourage carbon emissions and therefore construction and operational costs would be indirectly affected at the quarry in the form of increasing diesel, electricity and other consumable prices. The Energy Efficiency Opportunities (EEO) Act would also apply at a corporate level as with carbon mitigation measures are frequently the same as those that would be identified under EEO.

The following is general advice about initiatives that may mitigate or avoid greenhouse gas emissions. Their individual viability would vary and most require further analysis prior to adoption.

7.1 Management approaches

- Review of existing environmental management system to ensure that it incorporates management strategies and targets for energy and reduction of greenhouse gas emissions
- Set a project policy (e.g. on environmental management or sustainability) that incorporates commitment to minimising greenhouse gas emissions wherever cost-effective
- Communicate, induct and train project staff and contractors on energy and greenhouse priorities alongside other matters (e.g. safety, environmental management)
- Ensure that energy management information including sub-metering and control systems are implemented with development of the infrastructure and buildings to track energy consumption to a level of detail that is useful. Assign responsibility for controlling energy use.

7.2 Design and operation

- Develop an energy consumption model for all steps in the process from extraction of rock from the quarry to delivery of the aggregate product to the customer – optimise the technologies, energy sources and operational schedules with a view to minimising energy costs and greenhouse gas emissions. The optimisation analysis should highlight trade-offs in design and operation, such as between diesel and electricity consuming equipment
- Hard rock processing can be an energy intensive activity. The degree of processing should be in line with delivery requirement to improve the efficiency of plant operations. This has the potential to reduce the electricity consumption related to the usage of secondary and tertiary crushing operations
- Optimise the movement of material onsite to reduce distances travelled and ensure optimal loading of mobile equipment. For heavy use haulage routes consider installing a conveyor system as part of an integrated transport management plan

- Incorporate energy efficiency goals into procurement criteria for plant items such as crushers and conveyors. Select equipment on a net present value basis that includes operation, maintenance and energy costs
- Design all site buildings to provide adequate worker comfort and heat protection for equipment with minimum electricity requirements. Techniques include (to the extent relevant):
  - Considering whole-of-life costs in air-conditioning plant selection
  - Providing thermally efficient design including building orientation and opportunities for natural ventilation and use of electric fans
  - Include shaded outdoor common areas for meals and breaks
  - Provide for natural light indoors that minimises addition to heat load (e.g. use window film)
  - Install energy efficient lighting, separation of lighting bank controls and automatic timers
- Consider on-site renewable energy generation to provide part of load requirements on land particularly for infrastructure buildings. Solar photovoltaic (PV) generation would seem the most likely option. Solar power is normally relatively expensive; however, there are sometimes site and load-specific circumstances that make it commercially advantageous, such as reducing peak demand and sharing the benefit of this with the electricity distributor
- Ensure that water pumping operations are matched with usage requirements to minimise energy use. Choose pumps of appropriate type and capacity for the application
- Identify activities that can be carried out during off-peak periods to reduce peak demand, this will reduce costs and better utilise electrical infrastructure, an added benefit to electricity suppliers
- Implement recommended operation, maintenance and replacement regimes for assets and equipment (e.g. conveyors) to ensure that equipment continues to operate to design expectations for energy demand

7.3 Voluntary good management practices

The following practices undertaken in a voluntary capacity by Boral and reviewed periodically may provide additional abatement opportunities:

- Match processing operations with demand for specific products to avoid over crushing of rock
- Consider staging equipment start-up to limit peak demand and associated electricity cost as an integral part of an electricity demand management program.
- Maximise the efficiency of distribution operations through the optimisation of delivery schedules matched to vehicle capacity; including the use of articulated haul trucks where practical
- Ensure lighting is only on when necessary and select energy efficient public lighting (considering whole-of-life costs including maintenance and energy consumption)
- Incorporate driver training and awareness as part of operational requirements. This has been found (Carbon Trust, 2011) to lead to reduced idle time, improved maintenance regimes (e.g. tyre pressure), and improved haulage routes all related to fuel efficiency

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