watersecurity
MAJOR PROJECTS

Appendix P

Greenhouse gas assessment

Environmental impact statement

February 2009

ACTEW
CORPORATION

watersecurity
MAJOR PROJECTS

Greenhouse Gas Assessment
ECD, CP, CPS, M2G & M2C

October 2008

ACTEW CORPORATION

Certificate of approval for issue of documents

Document number	23/12629/143337
DM5 number	
Title	[Title]
Revision	v
Document status	None
Date of issue	

	Position	Name	Signature	Date
Prepared by	Senior Engineer	Andrew Maddocks		15/10/08
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Approved by				

Document revision control

Version	Author	Date	Description	Approval
0	A Maddocks	4/9/08	Draft	S Trahair
1	A Maddocks	2/10/08	Draft	S Trahair
2	A Maddocks	15/10/08	Final	

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Executive Summary

Greenhouse gas assessments were undertaken for the construction and operational phases of the Enlarged Cotter Dam (ECD), Cotter Precinct (CP), Cotter Pump Station (CPS), Murrumbidgee to Googong pipeline (M2G) and the Murrumbidgee to Cotter pipeline (M2C). The assessments considered the emissions associated with the production of raw materials, transportation of materials to site, fuel and electricity consumption during construction, the disposal of waste generated during construction, bio-emissions associated with the inundation of the reservoir for the ECD and the removal of forested areas for the ECD/CP and M2G and the electricity consumption during operations.

The assessments were based on concept design estimates provided by Bulk Water Alliance (BWA) design and construction personnel. As such the emissions estimates require updating as the designs and construction planning progress (refer Table 1 for key project dates). The greenhouse assessments therefore provide an indication of the order of magnitude of the anticipated emissions.

Table 1 Key project dates for Enlarged Cotter Dam, Cotter Pump Station, Murrumbidgee to Googong pipeline and Murrumbidgee to Cotter Pipeline

Project	Date		
	Design Freeze	Target Outturn Cost Freeze	Environmental Impact Statement
ECD	April 2009	June 2009	September 2008
CPS	December 2008	December 2008	June 2009
M2G	January 2009	April 2009	June 2009
M2C	September 2008	September 2008	January 2008

The estimate emissions associated with construction were (refer Table 2):

- ECD/CP – 106,000 t CO_2-e;
- CPS – 29,250 t CO_2-e;
- M2G – 4,100 t CO_2-e; and
- M2C – 22,000 t CO_2-e.

For the purposes of comparing operational emissions, the ECD and CPS projects were combined, as the two projects are intrinsically linked. The estimated emissions for operations were (refer Table 3):

- ECD/CP/CPS – 8,000 t CO_2-e/year;
- M2G – 8,500 t CO_2-e/year; and
- M2C – 500 t CO_2-e/year.

For the first 30 years of operation, the construction emissions contributed 10%, 5% and 1% to the total emissions for ECD/CPS, M2G and M2C respectively (Figure 1).

Table 2 Summary of emissions associated with construction of Enlarged Cotter Dam, Cotter Precinct, Cotter Pump Station, Murrumbidgee to Googong Pipeline and Murrumbidgee to Cotter Pipeline

Project	Emissions [t CO_2]			
	Scope 1	Scope 2	Scope 3	Total
ECD & CP	22,000	6,000	78,000	106,000
CPS	350	500	3,250	4,100
M2G	16,000	250	13,000	29,250
M2C	500	500	1000	2,000

Table 3 Summary of emissions associated with operation of Enlarged Cotter Dam, Cotter Precinct, Cotter Pump Station, Murrumbidgee to Googong Pipeline and Murrumbidgee to Cotter Pipeline

Project	Emissions [t CO_2/year]			Total emissions for 30 years [t CO_2]
	Scope 1	Scope 2	Scope 3	
ECD/CP/CPS	1,000[1]	7,000	1,000	241,000
M2G	0	7,000	1,500	255,000
M2C	0	400	100	15,000

1. Emissions associated with the inundation of vegetation during flooding of the reservoir. These emissions are total one-off

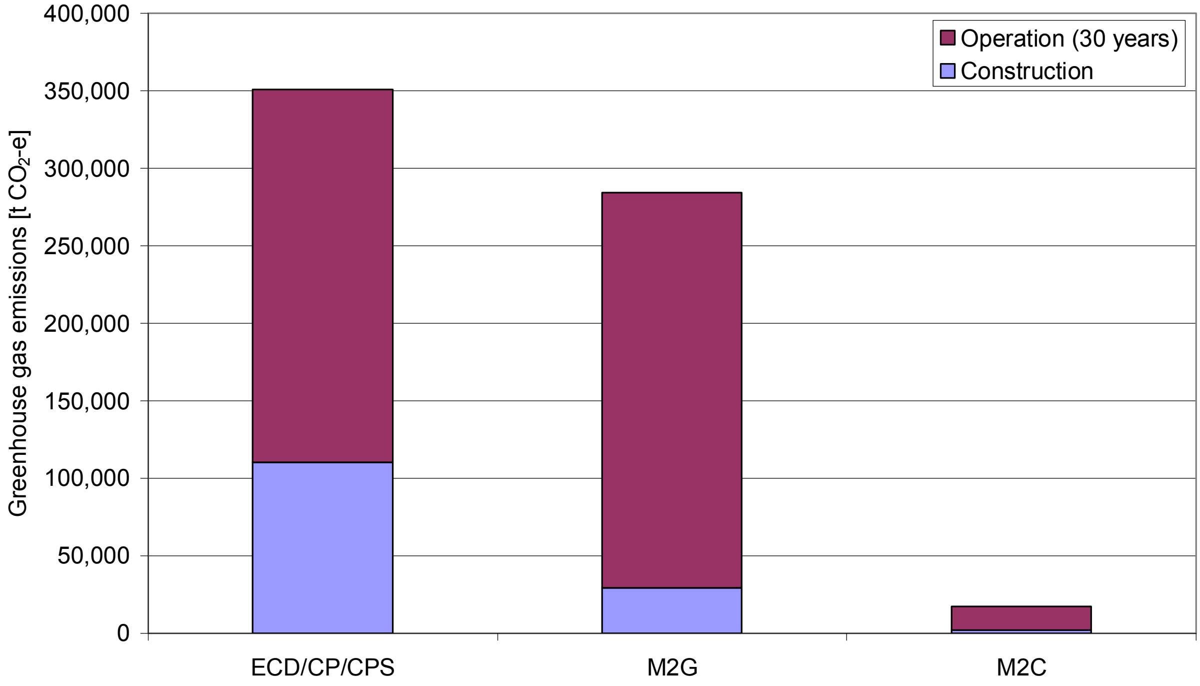

Figure 1 **Emissions associated with construction and 30 years of operation of the Enlarged Cotter Dam, Cotter Precinct, Cotter Pump Station, Murrumbidgee to Googong Pipeline and Murrumbidgee to Cotter Pipeline.**

Workshops were held to present and discuss the greenhouse gas assessments to key BWA design and construction personnel. The following major data gaps were identified:

- Determination of the existing pumping regime through the existing Cotter Pump station to determine a baseline for emissions associated with ECD/CPS. This baseline is irrelevant if all operation emissions are offset, however, this analysis would provide details on the likely changes to pumping associated emissions due to the ECD; and
- Details of the electricity infrastructure required for the projects.

Emission reduction opportunities were also identified during the workshops, the highest priority opportunities are listed below:

- A cut and cover approach for burial of the M2G pipeline where trenching occurs in easily excavated earth and construction of a surface trench in difficult to excavate areas;
- The use of bio-fuels for construction activities; and
- Multi-variable optimisation of the M2G considering tunnelling, mini-hydro, pipe size and configuration of inflows and outflows.

Abbreviations

a	Annum
AGO	Australian Greenhouse Office
BWA	Bulk Water Alliance
CH_4	Methane
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent emissions (emissions of other greenhouse gases are multiplied by their GWP so that their effects can be compared to emissions of carbon dioxide)
CP	Cotter Precinct
CPS	Cotter Pump Station
DCC	Commonwealth Department of Climate Change
ECD	Enlarged Cotter Dam
EF	Emission Factor
EIS	Environmental Impact Statement
EPA	Environment Protection Authority
FullCAM	The Australian Government Full Carbon Accounting Model
G	Giga (billion or $x10^9$)
GHG	Greenhouse Gas
i.d.	Inside diameter
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standards Organisation
kg	kilogram
kL	kilolitre
km	kilometre
KVA	Kilovolt ampere
kWh	kilowatt hour
LCA	Life Cycle Assessment
M	Mega (million or $x10^6$)
M2C	Murrumbidgee to Cotter Pipeline
M2G	Murrumbidgee to Googong Pipeline
NGA	National Greenhouse Accounts
RCC	Roller compacted concrete

t	Tonnes
TOC	Target outturn cost

1 Introduction

1.1 Background

The Bulk Water Alliance (BWA) is responsible for delivering five projects under the ACT government's Water Security Program, namely:

- Enlarged Cotter Dam (ECD);
- Cotter Precinct (CP);
- Murrumbidgee to Googong Pipeline (M2G);
- Murrumbidgee to Cotter Pipeline (M2C); and,
- Cotter Pump Station (CPS).

ACTEW, as the owner and operator of the projects, is required to measure and report the greenhouse gas emissions associated with the construction and operation of the five water security projects. ACTEW is committed to offsetting all emissions associated with the five projects during operations. In addition ACTEW is also considering offsetting emissions associated with construction. To compliment this commitment ACTEW is interested in reducing emissions as much as practicable for construction and operations. To assess what can be reduced and what may need to be offset, the BWA were requested by ACTEW to undertake a greenhouse gas assessment to determine the emissions footprint of each of the five projects. These emissions footprints are to satisfy ACTEW's greenhouse gas reporting policy. It is anticipated that the emission footprints will also be used in the decision making processes to facilitate environmental optimisation and the results for the ECD, CP, M2G and CPS will be used to assess any significant reduction opportunities.

This report details the greenhouse gas assessments undertaken for the ECD, CP, M2G, M2C and CPS. The assessments were based primarily on concept design construction estimates, and as such the emissions footprints should be regarded as estimates only. It is envisaged that the assessments will be refined as the projects' designs progress, reducing the uncertainty in the emissions footprints.

1.2 Greenhouse Gas Assessment Scope

The purpose of the greenhouse assessment is to calculate the predicted emissions of greenhouse gases associated with the projects, and to identify strategies for reducing emissions. In order to obtain a comprehensive estimate, both direct and indirect emissions sources associated with the activities listed below, were considered:

- Emissions and energy use associated with the extraction and processing of construction raw materials, such as concrete, gravel, sand, fly-ash and aggregates;
- Emissions from the transportation of construction materials from their extraction and processing locations to the project site;
- Fuel use by bulldozers, excavators, conveyers and other equipment during the construction phase;
- Usage of grid electricity during construction;
- Transportation and landfill disposal of construction waste;
- Emissions of biogas from the initial flooding of the dam;

- Usage of electricity during the operation of the dam following the expansion;
- Usage of fuels for stationary energy (for generators, etc) such as natural gas, coal and diesel (if any).

The emissions from these life cycle stages were then aggregated into a single greenhouse gas emissions inventory for each project.

1.3 Methodology

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

- The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard developed by the World Business Council for Sustainable Development (GHG Protocol). This is a recognised international standard;
- Life Cycle Assessment principles (ISO 14040 series); and
- The Commonwealth Department of Climate Change (DCC) National Greenhouse Accounts (NGA) Factors, 2008 (which replaces the Australian Greenhouse Office (AGO) Factors and Methods Workbook).

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

1.3.1 Emission Scope

Emissions have been separated into scopes 1, 2 and 3, in accordance with the Greenhouse Gas Protocol for the projects. These scopes are defined as follows:

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

1.3.2 System Boundaries of Assessments

The system boundary is the inputs and outputs of each of the identified life cycle stages, including transportation. This includes the extraction and processing of raw materials, the use of energy and utilities, changes to land use and the treatment of solid, liquid and gaseous wastes generated.

The system boundaries for the ECD, CP, CPS, M2G and M2C greenhouse gas assessments are shown in Appendix A and includes emissions from raw materials, the use of energy and utilities, changes to land use and the treatment of solid, liquid and gaseous wastes generated. Details of the exclusions are provided in the relevant project sections. Some of these exclusions are likely to be included within the system boundary as design progresses and details are provided.

1.3.3 Data Collection and Calculation Procedures

General

Emission factors that are used in the greenhouse footprint calculations are outlined in Appendix B. Where possible, factors have been sourced from the *National Greenhouse Accounts (NGA) Factors,*

2008. If factors have been sourced elsewhere then source references have been provided in Sections 2 - 5.

Wherever possible, estimates with high accuracy were used to calculate greenhouse gas emissions. For example, electricity consumption estimates can be multiplied by the NGA emission factors to calculate greenhouse gas emissions with a high degree of accuracy. When data is unavailable, assumptions and approximations were made in order to obtain a reasonable estimate. For example, emissions factors for some of the materials used in equipment manufacture were not readily available, and these were estimated based on the best available information. Recognised standards, such as the World Business Council Greenhouse Gas Protocol, were used to assist in these estimations whenever appropriate.

All energy consumption and emissions data has been converted into quantities of carbon dioxide equivalent for each life cycle stage of the project, as shown in Appendix B. The emission values for each life cycle stage have been summed to reach an estimate of the total greenhouse gas emissions over the entire life cycle.

Bio-emissions from flooding a reservoir

Permanently flooding land through the construction of reservoirs creates the potential for greenhouse gas emissions due to the decay of the biomass within the inundation zone. Microbial decay of this biomass can, over time, result in the generation of carbon dioxide (CO_2) and methane (CH_4) in the aqueous environment provided by the reservoir. Evidence suggests that greenhouse gas emissions for approximately the first ten years after flooding are the results of decay of organic matter on the land prior to flooding. This is the result of the easily degradable (labile) carbon and nutrients being made available to microbes upon flooding and metabolised.

The methodological approach presented here provides two modelling approaches to estimate the range of possible emissions from flooded land. The magnitude of emissions calculated using these models may inform further decision regarding an ongoing greenhouse gas emissions measurement program of emissions due to land flooding.

The emission accounting approach employed is an iterative process that provides initially coarse estimates that will be refined over time. Importantly, these initial estimates will reveal the likely range of total emissions and those project components that will materially contribute to overall project emissions.

The two approaches to be used are:

- Intergovernmental Panel on Climate Change (IPCC) tier 1 algorithms for both carbon dioxide (CO_2) and methane (CH_4) emissions; and
- The Australian Government Full Carbon Accounting Model (FullCAM) will be used to establish current carbon stocks within the inundation zone of the Enlarged Cotter Dam.

IPCC methodologies

The 2006 IPCC Guidelines for national Greenhouse Gas Inventories provide separate algorithms for CO_2 and CH_4 emissions from land converted to permanently flooded land. As the algorithm for CO_2 is designed explicitly to cover the ten years following flooding, the algorithms have been modified here, based on the conservative assumption that CH_4 is emitted across this period. Both algorithms have been designed such that they are applicable to regions where reservoir surfaces freeze during winter, hence in this instance 365 is included to indicate no days of frozen reservoir surface:

CO_2 emissions (t CO_2/10 years) $= 365 \times E(CO_2)_{diff} \times A_{flood,total\_surface} \times f_A \times 10^{-6}$

CH_4 emissions (t CH_4/10 years) $= 365 \times E(CH_4)_{diff} \times A_{flood,total\_surface} \times f_A \times 10^{-6}$

Where:

$E(CO_2)_{diff}$ is measured diffusive CO_2 emissions (warm temperate dry climate, median = 5.2 kg CO_2/ha/day)

$E(CH_4)_{diff}$ is measured diffusive CH_4 emissions (warm temperate dry climate, median = 0.044 kg CH_4/ha/day)

$A_{flood,total\_surface}$ is total reservoir surface area (ha)

f_A is the fraction of the total reservoir area flooded after 10 years (conservative assumption is 90%)

FullCAM methodology

FullCAM was parameterised to determine current biomass in the area to be flooded (at maximum, and at 10 years) based on age class and current land status:

- Mature forest (very limited areas);
- Regrowth forest following 2003 fires (limited area); and
- Deforested areas.

All carbon pools were included within this modelling framework:

- Trees (above and below ground);
- Debris;
- Herbaceous species; and
- Soil.

Importantly, FullCAM can be used to determine the mass of labile carbon within these carbon pools. For example, the biologically available components of trees are likely to be:

- Leaves;
- Fine roots;
- Bark; and
- Other labile carbon in the debris, soil; and herbaceous pools.

1.3.4 Greenhouse gases considered

The greenhouse gases considered in this assessment are:

- Carbon dioxide;
- Nitrous oxides; and
- Methane.

The projects are unlikely to use, store or generate any hydrofluorocarbons, perfluorocarbons or sulphur hexafluoride. These gases have therefore been excluded.

2 Enlarged Cotter Dam and Cotter Precinct

2.1 Project Description

The assessment was undertaken on the following understanding of the ECD project:

- A roller compacted concrete dam wall will be constructed approximately 125 m downstream of the existing dam wall.
- Two earth and rock fill saddle dams will be constructed adjacent to the right abutment of the new dam wall.
- The saddle dams will be comprised of material entirely from within the precinct boundary.
- Onsite quarries will provide aggregate to the onsite concrete batch plants as well as materials for the saddle dams.
- The capacity of the enlarged reservoir is 78 GL.

The emissions associated with the CP project have been included in assessment for ECD. These emissions are associated with the removal of vegetation in the Cotter Precinct for ECD construction activities.

Table 4 summarises the key dates for then ECD. As no major construction occurs for CP, only key dates for ECD have been listed.

Table 4 Key dates for Enlarged Cotter Dam Design

Item	Date
Design Freeze	April 2009
TOC Freeze	June 2009
Time to EIS	September 2008

2.2 Exclusions and Assumptions

2.2.1 Exclusions

The materiality of the omitted emission sources is difficult to accurately establish. The discrepancies in the total emissions inventory due to the exclusions and limitations of the assessment are anticipated to be minor.

Exclusions from the greenhouse gas assessment that are unlikely to be included in future assessments are:

- Emissions associated with the manufacturing of construction vehicles and equipment and their transportation to site. The construction period was considered minimal when compared to the life of the capital equipment required for construction activities such as excavators, dozers, trucks, cranes, batch plants and crushing plants. Therefore, construction equipment is not manufactured primarily for this project and hence the emissions associated with manufacturing are not included. The emissions from use of the construction equipment were included.

- Emissions associated with the production of fly-ash. Fly-ash is considered to be a waste product of electricity generation and emissions associated with fly-ash production are wholly attributed to electricity and therefore the production was excluded from the system boundary. The emissions associated with the transportation of fly-ash from the power station to the construction site were included.
- Emissions associated with travel of construction personnel to site as part of their normal work. These emissions are likely to occur regardless of whether the personnel are working on the ECD construction or working in another location as part of their everyday employment.
- Emissions associated with on-site refuelling infrastructure. It is understood that the re-fuelling infrastructure comprises a mobile plant. The emissions associated with the transportation and construction of the refuelling infrastructure and the fugitive emissions from fuel storage and refuelling activities were excluded.

The following exclusions could be included in future assessments. The magnitude of these exclusions is difficult to quantify, however the exclusions have been listed in the expected deceasing contribution to the inventory:

- Emissions associated with infrastructure for electricity distribution onsite (lines, substations etc).
- Emissions associated with minor construction items and materials such as cabling and associated electrical equipment, rubber rings or flanges (if used) for pipe connections, and minor pipe work. These details were not available at the time of the assessment.
- Emissions associated with the consumption, treatment and disposal of water and wastewater during construction.
- Emissions associated with the maintenance of construction vehicles and the use of oils, grease, lubricants and replacement parts. Details of these items were not provided during the assessment and were therefore excluded. These items are likely to be included as the construction planning progresses.
- Emissions associated with establishing and maintaining vegetation planted after construction. Details of vegetation maintenance such as seedling growth, transportation to site, fertilisation and water use, weather protection measures and mulching were not available during the assessment.
- Emissions associated with operation and maintenance of the dam. The level of maintenance for the dam is considered to be low and therefore items required for minor maintenance/repair, and waste disposal were excluded. Emissions associated with pumping water from the dam were included within the system boundary for CPS. Only minor maintenance related emissions are anticipated and have therefore been excluded at this stage of the design.
- Emissions associated with decommissioning. Details of decommissioning procedures were not available at the time of the assessment. It was assumed that the infrastructure would be made safe and remain in place should operations cease in 100 years. The emissions associated with the decommissioning of minor items, such as pumps and pipe work are unlikely to be significant when annualised over the operating life of the dam and were therefore excluded.
- Emissions associated with the construction of viewing platforms and other public infrastructure surrounding the Enlarged Cotter Dam.

2.2.2 Assumptions

Assumptions used in estimating the activity levels and associated greenhouse gas emissions for the ECD are listed in Table 5.

Table 5 Greenhouse gas assessment assumptions for Enlarged Cotter Dam and Cotter Precinct

Parameter measured	Assumptions
Raw materials	
Cement	Quantity estimated by BWA engineering calculations as 75 kg/m^3 for RCC concrete, 350 kg/m^3 for conventional concrete and 1450 t for grouting. Emission Factor (EF) sourced from SimaPro based on Australian data for Portland Cement.
Flyash	Quantity estimated by BWA engineering calculations as 125 kg/m^3 for RCC concrete. EF assumed to be zero as fly-ash is a waste product of electricity generation for coal fired power stations.
Sand	Quantity estimated by BWA engineering calculations as 125 kg/m^3 for RCC concrete as 160,000 t for RCC concrete, 14,000 t for conventional concrete and 11,000 t for filters. EF sourced from SimaPro based on Australian data for sand from river.
Gravel - imported	Quantity estimated by BWA engineering calculations as 28,000 t of quarry products not sourced from the on-site quarry. EF sourced from SimaPro based on Australian data.
Reinforcing steel	Quantity estimated by BWA engineering calculations as 3,200 t. EF sourced from SimaPro based on Australian data for steel with 10% recycled content.
Trash screens, shutters, valves, miscellaneous steel	Quantity estimated by BWA engineering calculations as 5 t for trash screens, 5 t for shutters and 5 t for valves and miscellaneous steel items, EF sourced from SimaPro based on Australian data for steel with 10% recycled content.
Pipework (steel)	Quantity estimated by BWA engineering calculations as 30,000 t. EF sourced from SimaPro based on Australian data for steel with 10% recycled content.
Bitumen	Quantity estimated by BWA engineering calculations as 77 m^3 (48,000 m^2 spray and chip roads). EF sourced from SimaPro based on Australian data for bitumen.
Explosives	Quantity estimated by BWA engineering calculations as 650 t. EF from Table 4 of the DCC NGA Factors (January 2008) for heavy ANFO.
Transport to Site	
Cement	It is assumed that cement will be sourced from suppliers in Sydney and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au.

Parameter measured	Assumptions
	Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Flyash	It is assumed that fly-ash will be sourced from Eraring power station and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Sand	It is assumed that sand will be sourced from Bungendore, NSW and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Gravel -imported	It is assumed that gravel will be sourced from local suppliers within 40 km of the site and transported by rigid truck. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Reinforcing Steel	It is assumed that reinforcing will be sourced from suppliers in Sydney and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Trash screens, shutters, valves, miscellaneous steel	It is assumed that equipment will be sourced from suppliers in Sydney and transported by rigid truck. No allowance has been made for transportation of the equipment from the manufacturer to Sydney. However, this may be included at a later stage once the manufacturers are known. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Pipes	It is assumed that pipes will be sourced from suppliers in Somerton, VIC and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Explosives	It is assumed that ammonium nitrate will be sourced from suppliers in Newcastle and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Diesel	It is assumed that diesel will be source from Kurnell, NSW and transported by tanker. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks and assumed to be same as a fuel tanker.
Bitumen	It is assumed that bitumen will be sourced from Kurnell, NSW and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Construction	
Electricity for crushing	Quantity estimated by BWA based on 4 plants operating for 9 hours per day, 21 days

Parameter measured	Assumptions
plant	per month for 18 months and a power rating 213 kW for 85 t/h plant, sourced from http://www.crusher.net.au. Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3).
Electricity for batch plants	Quantity estimated by BWA based on 9 hours per day, 21 days per month for 18 months and a power rating of 460 kW for 400 m^3/h plant and a power rating 230 kW for 200 m^3/h plant sourced from http://www.compactor_truemax.com/concrete_batch_plant_output.html, model H2S200. Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3).
Other electricity consumption (site sheds etc)	Quantity estimated by BWA based on 9 hours per day, 21 days per month for 18 months for offices containing lighting, heating, computers, microwave, hot water, refrigerator and miscellaneous electrical equipment. Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3.
Compressors	Quantity estimated by BWA based on 2 compressors operating for 9 hours per day, 21 days per month for 18 months and power rating 186 kW sourced from http://www.sccompressors.com.au. Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3.
Tower Crane	Quantity estimated by BWA based on 1 tower crane (10 t capacity) operating for 9 hours per day, 21 days per month for 18 months and power rating 69 kW, sourced from http://www.hi-unique.com. Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3.
Diesel consumption - construction vehicles	The quantity of diesel consumed by construction equipment was estimated using Brake Specific Fuel Consumption data reported in US EPA's report *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition, Report No. NR-009c (2004)*. The hours of use for each construction vehicle/equipment was estimated by BWA based on 9 h per day, 21 days per month, an utilisation factor of 1 (i.e. vehicles/equipment used 100% of time, except for light passenger vehicles where a utilisation factor of 0.7. was assumed). The number of months for each vehicle/equipment was estimated by BWA and varied between 6 to 18 months. The horsepower for each vehicle/equipment was obtained from manufacturer vehicle specifications, where the model to be used was known, or estimated based on similar vehicles (using Caterpillar Performance Handbook Ed 38). The fuel consumption predicted by the US EPA model was crosschecked with consumption rates for Caterpillar vehicles listed in the Caterpillar Performance Handbook. The crosscheck accounted for approximately 50% of total fuel consumption. The fuel consumption predicted by the US EPA model was 2% higher than the fuel consumption predicted by the Caterpillar Performance Handbook based on a high load factor and the maximum fuel consumption rate. EF from Table 3 of the DCC NGA Factors (January 2008) for diesel (Scopes 1 and 3).
Diesel consumption - generators	The quantity of diesel consumed by generators was estimated using Brake Specific Fuel Consumption data reported in US EPA's report *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition, Report No. NR-009c (2004)*. The hours of use were estimated by BWA based operation for 9 hours per day, 21 days per month for 18 months and power rating 400 kVA.

Parameter measured	Assumptions
	EF from Table 1 of the DCC NGA Factors (January 2008) for diesel (Scopes 1 and 3)
Construction waste to landfill	Quantity estimated by BWA engineering calculations as 150 t. A breakdown of the waste was not available and therefore recycling opportunities were not considered. EF from Table 21 of the DCC NGA Factors (January 2008) for construction and demolition waste.
Transportation of construction waste to landfill	A landfill site within 40 km of the site was assumed and waste transported by rigid ruck. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Vegetation clearance	The quantity of vegetation cleared during construction was estimated by BWA as 13 ha. EF sourced from FullCAM and based on native forest.

2.3 Greenhouse Assessment Results Analysis

Emissions were calculated based on Scope 1, 2 and Scope 3 emissions. These emissions were categorised as either occurring during the construction period or as an operational emission (annual basis). Note that operational emissions for ECD were excluded from the assessment. Bio-emissions from flooding of the reservoir are included in Section 2.3.3

2.3.1 Greenhouse Inventory for Construction

The greenhouse assessment indicates total construction emissions of approximately 106,000 tonnes of CO_2-e over a construction period of 18 months. Scope 1, 2 and 3 emissions are summarised in Table 6.

Table 6 Summary of Scope 1, 2 and 3 emissions for Enlarged Cotter Dam and Cotter Precinct

Scope	Quantity (t CO_2-e)
Construction	
1	22,000
2	6,000
3	78,000
Total for construction emissions	106,000
NSW & ACT total emissions 2006[1]	161,100,000

1. Total emissions for NSW and ACT based on DCC ‘State and Territory Greenhouse Gas Inventories 2006’.

The emissions were also categorised as raw materials (i.e. emissions associated with the extraction and processing of raw materials), transportation of raw materials to site, and construction activities. Construction activities are estimated to contribute 51% of all emissions associated with the ECD, raw materials 39% and transportation 11%. The major sources of emissions are summarised in Section 2.3.2 and the total emissions inventory is given in Appendix B.

2.3.2 Major Emission Sources for Construction

The emissions contributing to 90% of the total emissions for construction are listed in Table 7.

Table 7 Emissions contributing 90% of total emissions for Enlarged Cotter Dam and Cotter Precinct

Ranking	Source	Emissions (t CO_2-e)	Fraction of emissions
1	Diesel consumption in construction vehicles	32,000	30%
2	Cement	30,000	28%
3	Reinforcing steel	7,000	6%
4	Electricity for crushing plant	6,000	5%
5	Removal of vegetation for construction	5,000	5%
6	Electricity for batch plants	5,000	4%
7	Transportation of fly-ash	4,000	4%
8	Diesel consumption in generators	3,000	3%
9	Sand	3,000	3%
10	Transportation of cement	3,000	3%
Total		**98,000**	**91%**

Note: Values have been rounded. Only orders of magnitude should be compared.

2.3.3 Bio-emissions from Flooding of Reservoir

The emissions due to flooding of the reservoir are listed in Table 8.

Table 8 Emissions from the flooding of the reservoir

Method	Emissions (t CO_2-e)
IPCC (total emissions over ten year period)	60
FullCAM (carbon stock metabolised to CO_2)	1,060

3 Cotter Pump Station

3.1 Project Description

The assessment was undertaken on the following understanding of the CPS project:

- Construction of a new pump station with capacity of 150 ML/year to transfer water from the Enlarged Cotter Dam to the Mt Stromlo water treatment plant;
- New pipe sections to be laid above ground.

Table 9 summarises the key dates for then CPS.

Table 9 Key dates for Cotter Pump Station Design

Item	Date
Design Freeze	December 2008
TOC Freeze	December 2008
Time to EIS	June 2009

3.2 Exclusions and Assumptions

3.2.1 Exclusions

The materiality of the omitted emission sources is difficult to accurately establish. The discrepancies in the total emissions inventory due to the exclusions and limitations of the assessment are anticipated to be minor.

Exclusions from the greenhouse gas assessment that are unlikely to be included in future assessments are:

- Emissions associated with the manufacturing of construction vehicles and equipment and their transportation to site. The construction period was considered minimal when compared to the life of the capital equipment required for construction activities such as excavators, dozers, trucks and cranes. Therefore, construction equipment is not manufactured primarily for this project and hence the emissions associated with manufacturing are not included. The emissions from use of the construction equipment were included.
- Emissions associated with travel of construction personnel to site as part of their normal work. These emissions are likely to occur regardless of whether the personnel are working on the CPS construction or working in another location as part of their everyday employment.
- Emissions associated with on-site refuelling infrastructure. It is understood that the re-fuelling infrastructure comprises a mobile plant. The emissions associated with the transportation and construction of the refuelling infrastructure and the fugitive emissions from fuel storage and refuelling activities were excluded.

The following exclusions could be included in future assessments. The magnitude of these exclusions is difficult to quantify, however the exclusions have been listed in the expected deceasing contribution to the inventory:

- Emissions associated with infrastructure for electricity distribution onsite (lines, substations etc).

- Emissions associated with minor construction items and materials such as cabling and associated electrical equipment within the pump station structures, rubber rings or flanges (if used) for pipe connections, and minor pipe work within pump station structures. These details were not available at the time of the assessment.
- Emissions associated with the consumption, treatment and disposal of water and wastewater during construction.
- Emissions associated with the maintenance of construction vehicles and the use of oils, grease, lubricants and replacement parts. Details of these items were not provided during the assessment and were therefore excluded. These items are likely to be included as the construction planning progresses.
- Emissions associated with the removal, establishment and maintenance of vegetation planted after construction. Details of vegetation removal and revegetation were not available at the time of the assessment.
- Emissions associated with the general maintenance of the pump station during operation. The emissions associated with general maintenance were considered low compared with anticipated electricity consumption and were therefore excluded.
- Emissions associated with decommissioning. Details of decommissioning procedures were not available at the time of the assessment. It was assumed that the infrastructure would be made safe and remain in place should operations cease in 100 years. The emissions associated with the decommissioning of minor items, such as pumps and valves are unlikely to be significant when annualised over the operating life of the pump station and were therefore excluded.

3.2.2 Assumptions

Assumptions used in estimating the activity levels and associated greenhouse gas emissions for the CPS are listed in Table 10.

Table 10 Greenhouse gas assessment assumptions for Cotter Pump Station

Parameter measured	Assumptions
Raw materials	
Pipes	Quantity estimated by BWA engineering calculations as 500 m of Mild Steel Cement Lined pipe, steel i.d. 1404 mm, steel wall thickness 8 mm, 10 mm layer cement and 800 m of Mild Steel Cement Lined pipe, steel i.d. 1575 mm, steel wall thickness 10 mm, 10 mm layer of cement. The density of cement was assumed to be 3150 kg/m^3. This is based on Portland cement and considered a conservative estimate. The EFs for the pipe raw materials were used as an approximation for the manufactured pipe. Steel EF sourced from SimaPro based on Australian data for steel with a 10% recycled content. Cement EF sourced from SimaPro based on Australian data for Portland Cement.
Pumps	Quantity estimated by BWA engineering calculations as 14.48 t. It was assumed that the pumps were 80% iron and 20% steel. The EFs for the pump raw materials were used as an approximation for the manufactured pumps. Iron EF sourced from SimaPro based on Australian data for iron. Steel EF sourced from SimaPro based on Australian data for steel with a 10% recycled content.
Concrete	Quantity estimated by BWA engineering calculations as 1921.25 m^3. The density of concrete was assumed to be 2,500 kg/m^3. EF sourced from SimaPro based on Australian data for ready mix concrete.
Cement (other)	Quantity estimated by BWA engineering calculations as 2 t for miscellaneous works. Emission Factor (EF) sourced from SimaPro based on Australian data for Portland Cement.
Sand	Quantity estimated by BWA engineering calculations as 1957 m^3 compacted. The bulk volume delivered to site was assumed to be 20% greater than the compacted volume with a bulk density of 1442 kg/m^3, sourced from http://www.simetric.co.uk/si_materials.htm. EF sourced from SimaPro based on Australian data for sand from river.
Valves	Quantity estimated by BWA engineering calculations as 24 t. It was assumed that the valves were 100% iron. The EFs for the valves raw materials were used as an approximation for the manufactured pumps. EF sourced from SimaPro based on Australian data for iron..
Gravel	Quantity estimated by BWA engineering calculations as 2070 t for roads (3000 m^2 spray and chip, assumed depth of 300 mm and gravel density of 2.3 t/m^3) and 100 t for landscaping. EF sourced from SimaPro based on Australian data for gravel.
Reinforcing steel	Quantity estimated by BWA engineering calculations as 160 t. The density of steel was assumed to be 7,850 kg/m^3. EF sourced from SimaPro based on Australian data for steel with 10% recycled content.
Steel	Quantity estimated by BWA engineering calculations as 1.5 t for roller doors. The density of steel was assumed to be 7,850 kg/m^3. EF sourced from SimaPro based on Australian data for steel with 10% recycled content.

Parameter measured	Assumptions
Bitumen	Quantity estimated by BWA engineering calculations as 4.8 m^3 (3000 m^2 spray and chip roads). EF sourced from SimaPro based on Australian data for bitumen.
Transport to Site	
Pipes	It is assumed that pipes will be sourced from suppliers in Somerton, VIC and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks
Pumps	It is assumed that the pumps will be sourced from Germany, travel to Melbourne by ship and then to site by rigid truck. Ship distances have been estimated by using the website http://www.handytankers.com/handy/toolbox/distance/distance.asp. Road distances have been estimated by using the website http://maps.google.com.au. Ship EF sourced from SimaPro based on Australian data for international shipping freight. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Concrete	It is assumed that ready mix concrete will be sourced locally, within 40 km of site and transported by rigid truck. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks
Cement	It is assumed that cement will be sourced from suppliers in Sydney and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Sand	It is assumed that sand will be sourced from Bungendore, NSW and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Valves	It is assumed that valves will be sourced from China, transported to Perth by sea and then to site by rigid truck. Ship distances have been estimated by using the website http://www.handytankers.com/handy/toolbox/distance/distance.asp. Road distances have been estimated by using the website http://maps.google.com.au. Ship EF sourced from SimaPro based on Australian data for international shipping freight. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Gravel	It is assumed that gravel will be sourced from local suppliers within 40 km of the site and transported by rigid truck. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Reinforcing steel	It is assumed that reinforcing steel will be sourced from suppliers in Sydney and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.

Parameter measured	Assumptions
Steel	It is assumed that steel will be sourced from suppliers in Sydney and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks
Bitumen	It is assumed that bitumen will be sourced from Kurnell, NSW and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Diesel	It is assumed that diesel will be source from Kurnell, NSW and transported by tanker. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks and assumed to be same as a fuel tanker.
Petrol	It is assumed that petrol will be source from Kurnell, NSW and transported by tanker. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks and assumed to be same as a fuel tanker.
Construction	
Electricity consumption - site sheds	Quantity estimated by BWA based on 9 hours per day, 21 days per month for 8 months for offices containing lighting, heating, computers, microwave, hot water, refrigerator and miscellaneous electrical equipment. Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3.
Compressors	Quantity estimated by BWA based on 2 compressors (XAS120) operating for 9 hours per day, 21 days per month for 7.5 months and power rating 186 kW, sourced from http://www.sccompressors.com.au. Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3.
Diesel consumption - construction vehicles	The quantity of diesel consumed by construction equipment was estimated using Brake Specific Fuel Consumption data reported in US EPA's report *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition, Report No. NR-009c (2004)*. The hours of use for each construction vehicle/equipment was estimated by BWA based on 9 h per day, 21 days per month, an utilisation factor of 1 (i.e. vehicles/equipment used 100% of time). The number of months for each vehicle/equipment was estimated by BWA and varied between 0.5 to 8 months. The horsepower for each vehicle/equipment was obtained from manufacturer vehicle specifications, where the model to be used was known, or estimated based on similar vehicles (using Catapiller, John Deere specifications). EF from Table 3 of the DCC NGA Factors (January 2008) for diesel (Scopes 1 and 3).
Petrol consumption - generators	The quantity of diesel consumed by generators was estimated using Brake Specific Fuel Consumption data reported in US EPA's report *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition, Report No. NR-009c (2004)*. The hours of use were estimated by BWA based operation of 2 generators for 9 hours per day, 21 days per month for 2.5 months and power rating 2 kVA. EF from Table 1 of the DCC NGA Factors (January 2008) for motor gasoline (Scopes 1 and 3)

Parameter measured	Assumptions
Operations	
Electricity	Quantity of water supplied from ECD to CPS estimated by ActewAGL as 8,300 ML/year (average for first 30 years of supply) and electricity associated with pumping estimated by ActewAGL as 907 kWh/ML. Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3.

3.3 Greenhouse Assessment Results Analysis

Emissions were calculated based on Scope 1, 2 and Scope 3 emissions. These emissions were categorised as either occurring during the construction period or as an operational emission (annual basis).

3.3.1 Greenhouse Inventory

The greenhouse assessment indicates total construction emissions of approximately 4,000 tonnes of CO_2-e over a construction period of 8 months and annual emissions of 8,000 tonnes of CO_2-e per annum. Scope 1, 2 and 3 emissions are summarised in Table 11.

Table 11 Summary of Scope 1, 2 and 3 emissions for Cotter Pump Station

Scope	Quantity (t CO_2-e)
Construction	
1	350
2	500
3	3,250
Total emissions for construction	4,100
Annual operating emissions	
1	0
2	7,000
3	1,000
Total annual operating emissions	8,000
NSW & ACT total emissions 2006[1]	161,100,000

1. Total emissions for NSW and ACT based on DCC 'State and Territory Greenhouse Gas Inventories 2006'.

The emissions were also categorised as raw materials (i.e. emissions associated with the extraction and processing of raw materials), transportation of raw materials to site, and construction activities. Construction activities are estimated to contribute 25% of all emissions associated with the CPS, raw materials 67% and transportation 8%. The major sources of emissions are summarised in Section 3.3.2 and the total emissions inventory is given in Appendix B.

3.3.2 Major emission sources for construction

The emissions contributing to 90% of the total emissions for construction are listed in Table 12.

Table 12 Emissions contributing 90% of total emissions for Cotter Pump Station construction

Ranking	Source	Emissions (t CO2-e)	Fraction of emissions
1	Concrete	1,200	30%
2	Steel content of pipes	950	23%
3	Electricity for compressors	550	14%
4	Diesel consumption in construction vehicles	400	9%
5	Reinforcing steel	300	8%
6	Cement content of pipes	150	4%
7	Transportation of pipes	100	3%

Ranking	Source	Emissions (t CO2-e)	Fraction of emissions
Total		**3,750**	**91%**

Note: Values have been rounded. Only orders of magnitude should be compared.

4 Murrumbidgee to Googong Pipeline

4.1 Project Description

The assessment was undertaken on the following understanding of the M2G project:

- 13 km pipeline to transfer water from the Murrumbidgee River to Burra Creek,
- Construction of a low-lift pump station and high lift pump station near the Murrumbidgee River;
- Construction of a concrete outlet structure at Burra Creek;
- Pipeline to be buried in trench for entire length.

Table 13 summarises the key dates for then M2G.

Table 13 Key dates for Murrumbidgee to Googong Design

Item	Date
Design Freeze	January 2009
TOC Freeze	April 2009
Time to EIS	June 2009

4.2 Exclusions and Assumptions

4.2.1 Exclusions

The materiality of the omitted emission sources is difficult to accurately establish. The discrepancies in the total emissions inventory due to the exclusions and limitations of the assessment are anticipated to be minor.

Exclusions from the greenhouse gas assessment that are unlikely to be included in future assessments are:

- Emissions associated with the manufacturing of construction vehicles and equipment and their transportation to site. The construction period was considered minimal when compared to the life of the capital equipment required for construction activities such as excavators, dozers, trucks and cranes. Therefore, construction equipment is not manufactured primarily for this project and hence the emissions associated with manufacturing are not included. The emissions from use of the construction equipment were included.
- Emissions associated with travel of construction personnel to site as part of their normal work. These emissions are likely to occur regardless of whether the personnel are working on the M2G construction or working in another location as part of their everyday employment.
- Emissions associated with on-site refuelling infrastructure. It is understood that the re-fuelling infrastructure comprises a mobile plant. The emissions associated with the transportation and construction of the refuelling infrastructure and the fugitive emissions from fuel storage and refuelling activities were excluded.

The following exclusions could be included in future assessments. The magnitude of these exclusions is difficult to quantify, however the exclusions have been listed in the expected deceasing contribution to the inventory:

- Emissions associated with infrastructure for electricity distribution onsite (lines, substations etc).
- Emissions associated with minor construction items and materials such as cabling and associated electrical equipment within the pump station structures, rubber rings or flanges (if used) for pipe connections, and minor pipe work within pump station structures. These details were not available at the time of the assessment. Note that cabling details between the low-lift pump station and the high-lift pump station were provided and were included.
- Emissions associated with construction materials for the discharge structures in Burra Creek. These details were not available at the time of the assessment.
- Emissions associated with the consumption, treatment and disposal of water and wastewater during construction.
- Emissions associated with the maintenance of construction vehicles and the use of oils, grease, lubricants and replacement parts. Details of these items were not provided during the assessment and were therefore excluded. These items are likely to be included as the construction planning progresses.
- Emissions associated with establishing and maintaining vegetation planted after construction. Details of vegetation maintenance such as seedling growth, transportation to site, fertilisation and water use, weather protection measures and mulching were not available during the assessment.
- Emissions associated with the general maintenance of the pipeline and pump stations during operation. The emissions associated with general maintenance were considered low compared with anticipated electricity consumption and were therefore excluded. It was assumed that the life of the pumps was 50 years and would be replaced once during the operational life of the pump stations.
- Emissions associated with the upgrading of recreational facilities and Angle Crossing. It was unknown if these upgrades would form part of the project at the time of the assessment and have therefore been excluded.
- Emissions associated with decommissioning. Details of decommissioning procedures were not available at the time of the assessment. It was assumed that the infrastructure would be made safe and remain in place should operations cease in 100 years. The emissions associated with the decommissioning of minor items, such as pumps and valves are unlikely to be significant when annualised over the operating life of the pump stations and pipeline and were therefore excluded.

4.2.2 Assumptions

Assumptions used in estimating the activity levels and associated greenhouse gas emissions for the M2G are listed in Table 14.

Table 14 Greenhouse gas assessment assumptions for Murrumbidgee to Googong Pipeline

Parameter measured	Assumptions
Raw materials	
Pipes	Quantity estimated by BWA engineering calculations as 13,100 m of Mild Steel Cement Lined pipe, steel i.d. 1016 mm, steel wall thickness 8 mm, 10 mm layer cement. The density of cement was assumed to be 3150 kg/m^3. This is based on Portland cement and considered a conservative estimate. The EFs for the pipe raw materials were used as an approximation for the manufactured pipe. Steel EF sourced from SimaPro based on Australian data for steel

Parameter measured	Assumptions
	with a 10% recycled content. Cement EF sourced from SimaPro based on Australian data for Portland Cement.
Concrete	Quantity estimated by BWA engineering calculations as 1921.25 m^3. The density of concrete was assumed to be 2,500 kg/m^3. EF sourced from SimaPro based on Australian data for ready mix concrete.
Sand	Quantity estimated by BWA engineering calculations as 15846 m^3 compacted. The bulk volume delivered to site was assumed to be 20% greater than the compacted volume with a bulk density of 1442 kg/m^3, sourced from http://www.simetric.co.uk/si_materials.htm. EF sourced from SimaPro based on Australian data for sand from river.
Cables	Quantity estimated by BWA engineering calculations as 4,500 m of 25 mm^2 1.9/3.3 kV copper/PVC cable, with total cable mass of 690 kg/km. Copper mass, based on density of 8,960 kg/m^3, calculated to be 224 kg/km and mass of PVC was determined by difference. The EFs for the cable raw materials were used as an approximation for the manufactured cable. Copper EF sourced from SimaPro based on Australian data for copper. PVC EF sourced from SimaPro based on Australian data for PVC.
Pumps	Quantity estimated by BWA engineering calculations as 14.48 t. It was assumed that the pumps were 80% iron and 20% steel. The EFs for the pump raw materials were used as an approximation for the manufactured pumps. Iron EF sourced from SimaPro based on Australian data for iron. Steel EF sourced from SimaPro based on Australian data for steel with a 10% recycled content.
Reinforcing steel	Quantity estimated by BWA engineering calculations as 32.06 m^3. The density of steel was assumed to be 7,850 kg/m^3. EF sourced from SimaPro based on Australian data for steel with 10% recycled content.
Gravel	Gravel to be used as a road base for temporary construction roads. Quantity estimated by BWA engineering calculations based on 74,000 m^2 of roads, and assumed depth of 300 mm and gravel density of 2.3 t/m^3. EF sourced from SimaPro based on Australian data for gravel.
Transport to Site	
Pipes	It is assumed that pipes will be sourced from suppliers in Somerton, VIC and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks
Concrete	It is assumed that ready mix concrete will be sourced locally, within 40 km of site and transported by rigid truck. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Sand	It is assumed that sand will be sourced from Bungendore, NSW and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.

Parameter measured	Assumptions
Cables	It is assumed that the cables will be sourced from Liverpool, NSW and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Pumps	It is assumed that the pumps will be sourced from Germany, travel to Melbourne by ship and then to site by rigid truck. Ship distances have been estimated by using the website http://www.handytankers.com/handy/toolbox/distance/distance.asp. Road distances have been estimated by using the website http://maps.google.com.au. Ship EF sourced from SimaPro based on Australian data for international shipping freight. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Reinforcing steel	It is assumed that reinforcing will be sourced from suppliers in Sydney and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Gravel	It is assumed that gravel will be sourced from local suppliers within 40 km of the site and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Diesel	It is assumed that diesel will be source from Kurnell, NSW and transported by tanker. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks and assumed to be same as a fuel tanker.
Construction	
Diesel consumption - construction vehicles	The quantity of diesel consumed by construction equipment was estimated using Brake Specific Fuel Consumption data reported in US EPA's report *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition, Report No. NR-009c (2004)*. The hours of use for each construction vehicle/equipment was estimated by BWA based on 9 h per day, 21 days per month and an utilisation factor that varied depending on the vehicle. The number of months for each vehicle/equipment was estimated by BWA and varied between 6 to 24 months. The horsepower for each vehicle/equipment was obtained from manufacturer vehicle specifications, where the model to be used was known, or estimated based on similar vehicles (using Catapiller, John Deere specifications). EF from Table 3 of the DCC NGA Factors (January 2008) for diesel (Scopes 1 and 3).
Diesel consumption - generators	The quantity of diesel consumed by generators was estimated using Brake Specific Fuel Consumption data reported in US EPA's report *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition, Report No. NR-009c (2004)*. The hours of use were estimated by BWA based operation of 4 generators for 9 hours per day, 21 days per month for 8-12 months and power rating 3.3 kVA. EF from Table 1 of the DCC NGA Factors (January 2008) for diesel (Scopes 1 and 3).
Electricity consumption (site	Quantity estimated by BWA based on 3 small site locations (site office, crib shed, amenities) and one main site office. Items included in the estimate included heating, hot water, lighting, refrigerator and computers. The hours of use varied with each item.

Parameter measured	Assumptions
sheds etc)	Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3).
Vegetation clearance	The quantity of vegetation cleared during construction was estimated by BWA as 8 ha. Note only wooded forests were included in the assessment. EF sourced from FullCAM and based on native forests.
Construction waste to landfill	Quantity estimated by BWA engineering calculations as 62,262 t, based on the quantity of material not returned to the trenches after placement of the pipes. All waste was assumed to be inert in landfill. EF sourced from SimaPro based on Australian data for inert materials in landfill.
Transportation of construction waste to landfill	A landfill site within 40 km of the site was assumed and waste transported by rigid ruck. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Operations	
Electricity	Quantity of water transferred from Murrumbidgee to Googong estimated by ActewAGL as 8,877 ML/year (average for first 30 years of transfer) and electricity associated with pumping estimated by ActewAGL as 906 kWh/ML. Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3).
Revegetation of cleared land	Quantity replanted assumed to be the same as that removed during construction and located on the same site. The quantity of carbon stored by the replanted vegetation at 100 years was estimated using FullCAM The value was annualised over the 100 years to provide an estimate of the CO_2 emissions offset.
Replacement of pumps	It was assumed that the pumps have a life of 50 years are replaced once during the operation life of the pipeline. EFs were the same as detailed above.

4.3 Greenhouse Assessment Results Analysis

Emissions were calculated based on Scope 1, 2 and Scope 3 emissions. These emissions were categorised as either occurring during the construction period or as an operational emission (annual basis).

4.3.1 Greenhouse Inventory

The greenhouse assessment indicates total construction emissions of approximately 30,000 tonnes of CO_2-e over a construction period of 8 months and annual emissions of 8,500 tonnes of CO_2-e per annum. Scope 1, 2 and 3 emissions are summarised in Table 15.

Table 15 Summary of Scope 1, 2 and 3 emissions for Murrumbidgee to Googong Pipeline

Scope	Quantity (t CO_2-e)
Construction	

1	16,000
2	250
3	13,000
Total emissions for construction	29,250
Annual operating emissions	
1	0
2	7,000
3	1,500
Total annual operating emissions[1]	8,500
NSW & ACT total emissions 2006[2]	161,100,000

1. Includes annualised offset from revegetation.

2. Total emissions for NSW and ACT based on DCC 'State and Territory Greenhouse Gas Inventories 2006'.

Emissions for construction were also categorised as raw materials (i.e. emissions associated with the extraction and processing of raw materials), transportation of raw materials to site, and construction activities. Construction activities are estimated to contribute 62% of all emissions associated with the M2G, raw materials 31% and transportation 6%. The major sources of emissions during construction are summarised in Section 4.3.2 and the total emissions inventory is given in Appendix B.

4.3.2 Major emission sources

The emissions contributing to 90% of the total emissions for construction are listed in Table 16.

Table 16 Emissions contributing 90% of total emissions for Murrumbidgee to Googong Pipeline construction

Ranking	Source	Emissions (t CO_2-e)	Fraction of emissions
1	Diesel consumption in construction vehicles	15,000	51%
2	Steel content of pipes	5,000	19%
3	Vegetation clearance	2,000	7%
4	Cement content of pipes	1,000	4%
5	Gravel for temporary roads	1,000	3%
6	Concrete	1,000	2%
7	Transportation of pipes to site	1,000	2%
8	Transportation of waste to landfill	1,000	2%
Total		**30,000**	**90%**

Note: Values have been rounded. Only orders of magnitude should be compared.

5 Murrumbidgee to Cotter Pipeline

5.1 Project Description

The assessment was undertaken on the following understanding of the M2C project:

- Pipeline to transfer water from the Murrumbidgee River to Cotter River to maintain environmental flows;
- Construction of a low-lift pump station near the Murrumbidgee River; and
- New pipe sections to be laid above ground.

Table 17 summarises the key dates for the M2C.

Table 17 Key dates for Murrumbidgee to Cotter Design

Item	Date
Design Freeze	September 2008
TOC Freeze	September 2008
Time to EIS	January 2009

5.2 Exclusions and Assumptions

5.2.1 Exclusions

The materiality of the omitted emission sources is difficult to accurately establish. The discrepancies in the total emissions inventory due to the exclusions and limitations of the assessment are anticipated to be minor.

Exclusions from the greenhouse gas assessment that are unlikely to be included in future assessments are:

- Emissions associated with the manufacturing of construction vehicles and equipment and their transportation to site. The construction period was considered minimal when compared to the life of the capital equipment required for construction activities such as excavators, dozers, trucks and cranes. Therefore, construction equipment is not manufactured primarily for this project and hence the emissions associated with manufacturing are not included. The emissions from use of the construction equipment were included.
- Emissions associated with travel of construction personnel to site as part of their normal work. These emissions are likely to occur regardless of whether the personnel are working on the M2C construction or working in another location as part of their everyday employment.
- Emissions associated with on-site refuelling infrastructure. It is understood that the re-fuelling infrastructure comprises a mobile plant. The emissions associated with the transportation and construction of the refuelling infrastructure and the fugitive emissions from fuel storage and refuelling activities were excluded.

The following exclusions could be included in future assessments. The magnitude of these exclusions is difficult to quantify, however the exclusions have been listed in the expected deceasing contribution to the inventory:

- Emissions associated with infrastructure for electricity distribution onsite (lines, substations etc).
- Emissions associated with minor construction items and materials such as cabling and associated electrical equipment within the pump station structures, rubber rings or flanges (if used) for pipe connections, and minor pipe work within pump station structures. These details were not available at the time of the assessment.
- Emissions associated with the consumption, treatment and disposal of water and wastewater during construction.
- Emissions associated with the maintenance of construction vehicles and the use of oils, grease, lubricants and replacement parts. Details of these items were not provided during the assessment and were therefore excluded. These items are likely to be included as the construction planning progresses.
- Emissions associated with the removal, establishment and maintenance of vegetation planted after construction. Details of vegetation removal and revegetation were not available at the time of the assessment.
- Emissions associated with the general maintenance of the pipeline and pump station during operation. The level of maintenance for the pipeline and pump station was considered to be low and therefore items required for minor maintenance/repair, and waste disposal were excluded. An estimate of the electricity consumption during operations was included.
- Emissions associated with decommissioning. Details of decommissioning procedures were not available at the time of the assessment. It was assumed that the infrastructure would be made safe and remain in place should operations cease in 100 years. The emissions associated with the decommissioning of minor items, such as pumps and valves are unlikely to be significant when annualised over the operating life of the pump station and pipeline and were therefore excluded.

5.2.2 Assumptions

Assumptions used in estimating the activity levels and associated greenhouse gas emissions for the M2C are listed in Table 18.

Table 18 Greenhouse gas assessment assumptions for Murrumbidgee to Cotter Pipeline

Parameter measured	Assumptions
Raw materials	
Pipes	Quantity estimated by BWA engineering calculations as 300 m of Mild Steel Cement Lined pipe, steel i.d. 960 mm, steel wall thickness 8 mm, 10 mm layer cement. The density of cement was assumed to be 3150 kg/m^3. This is based on Portland cement and considered a conservative estimate. The EFs for the pipe raw materials were used as an approximation for the manufactured pipe. Steel EF sourced from SimaPro based on Australian data for steel with a 10% recycled content. Cement EF sourced from SimaPro based on Australian data for Portland Cement.
Concrete	Quantity estimated by BWA engineering calculations as 660 m^3. The density of concrete was assumed to be 2,500 kg/m^3. EF sourced from SimaPro based on Australian data for ready mix concrete.
Sand	Quantity estimated by BWA engineering calculations as 352.8 m^3 compacted. The bulk

Parameter measured	Assumptions
	volume delivered to site was assumed to be 20% greater than the compacted volume with a bulk density of 1442 kg/m^3, sourced from http://www.simetric.co.uk/si_materials.htm. EF sourced from SimaPro based on Australian data for sand from river.
Pumps	Quantity estimated by BWA engineering calculations as 2.68 t. It was assumed that the pumps were 80% iron and 20% steel. The EFs for the pump raw materials were used as an approximation for the manufactured pumps. Iron EF sourced from SimaPro based on Australian data for iron. Steel EF sourced from SimaPro based on Australian data for steel with a 10% recycled content.
Reinforcing steel	Quantity estimated by BWA engineering calculations as 10.29 m^3. The density of steel was assumed to be 7,850 kg/m^3. EF sourced from SimaPro based on Australian data for steel with 10% recycled content.
Steel (other)	Quantity estimated by BWA engineering calculations as 4.7 m^3 for trash rake and 6.93 m^3 for steel tank. The density of steel was assumed to be 7,850 kg/m^3. EF sourced from SimaPro based on Australian data for steel with 10% recycled content.
Transport to Site	
Pipes	It is assumed that pipes will be sourced from suppliers in Somerton, VIC and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks
Concrete	It is assumed that ready mix concrete will be sourced locally, within 40 km of site and transported by rigid truck. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Sand	It is assumed that sand will be sourced from Bungendore, NSW and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Pumps	It is assumed that the pumps will be sourced from Germany, travel to Melbourne by ship and then to site by rigid truck. Ship distances have been estimated by using the website http://www.handytankers.com/handy/toolbox/distance/distance.asp. Road distances have been estimated by using the website http://maps.google.com.au. Ship EF sourced from SimaPro based on Australian data for international shipping freight. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Reinforcing steel	It is assumed that reinforcing will be sourced from suppliers in Sydney and transported by rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Steel (other)	It is assumed that steel will be sourced from suppliers in Sydney and transported by

Parameter measured	Assumptions
	rigid truck. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks.
Diesel	It is assumed that diesel will be source from Kurnell, NSW and transported by tanker. Road distances have been estimated by using the website http://maps.google.com.au. Rigid truck EF sourced from SimaPro and is based on Australian data for rigid trucks and assumed to be same as a fuel tanker.
Construction	
Electricity consumption (site sheds etc)	Quantity estimated by BWA based on 9 hours per day, 21 days per month for 8 months for offices containing lighting, heating, computers, microwave, hot water, refrigerator and miscellaneous electrical equipment. Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3).
Compressors	Assumed same equipment used for M2C as for CPS. Quantity estimated by BWA based on 2 compressors (XAS120) operating for 9 hours per day, 21 days per month for 7.5 months and power rating 186 kW, sourced from http://www.sccompressors.com.au. Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3.
Diesel consumption - construction vehicles	Assumed same equipment used for M2C as for CPS . The quantity of diesel consumed by construction equipment was estimated using Brake Specific Fuel Consumption data reported in US EPA's report *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition, Report No. NR-009c (2004)*. The hours of use for each construction vehicle/equipment was estimated by BWA based on 9 h per day, 21 days per month, an utilisation factor of 1 (i.e. vehicles/equipment used 100% of time). The number of months for each vehicle/equipment was estimated by BWA and varied between 0.5 to 8 months. The horsepower for each vehicle/equipment was obtained from manufacturer vehicle specifications, where the model to be used was known, or estimated based on similar vehicles (using Catapiller, John Deere specifications). EF from Table 3 of the DCC NGA Factors (January 2008) for diesel (Scopes 1 and 3).
Petrol consumption - generators	Assumed same equipment used for M2C as for CPS The quantity of diesel consumed by generators was estimated using Brake Specific Fuel Consumption data reported in US EPA's report *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition, Report No. NR-009c (2004)*. The hours of use were estimated by BWA based operation of 2 generators for 9 hours per day, 21 days per month for 2.5 months and power rating 2 kVA. EF from Table 1 of the DCC NGA Factors (January 2008) for motor gasoline (Scopes 1 and 3)
Operations	
Electricity	Quantity of water transferred from Murrumbidgee to Cotter estimated by ActewAGL as 5,490 ML/year and electricity associated with pumping estimated by ActewAGL as 82 kWh/ML. Electricity sourced from grid. EF from Table 5 of the DCC NGA Factors (January 2008) for NSW and ACT (Scopes 2 and 3).

5.3 Greenhouse Assessment Results Analysis

Emissions were calculated based on Scope 1, 2 and Scope 3 emissions. These emissions were categorised as either occurring during the construction period or as an operational emission (annual basis).

5.3.1 Greenhouse Inventory

The greenhouse assessment indicates total construction emissions of approximately 2,000 tonnes of CO_2-e over a construction period of 8 months and annual emissions of 500 tonnes of CO_2-e per annum. Scope 1, 2 and 3 emissions are summarised in Table 19.

Table 19 Summary of Scope 1, 2 and 3 emissions for Murrumbidgee to Cotter Pipeline

Scope	Quantity (t CO_2-e)
Construction	
1	500
2	500
3	1000
Total emissions for construction	2,000
Annual operating emissions	
1	0
2	400
3	100
Total annual operating emissions	500
NSW & ACT total emissions 2006[1]	161,100,000

Emissions for construction were also categorised as raw materials (i.e. emissions associated with the extraction and processing of raw materials), transportation of raw materials to site, and construction activities. Construction activities are estimated to contribute 57% of all emissions associated with the M2C, raw materials 40% and transportation 3%. The major sources of emissions during construction are summarised in Section 5.3.2 and the total emissions inventory is given in Appendix B.

5.3.2 Major emission sources

The emissions contributing to 90% of the total emissions for construction are listed in Table 20.

Table 20 Emissions contributing 90% of total emissions for Murrumbidgee to Cotter Pipeline construction

Ranking	Source	Emissions (t CO2-e)	Fraction of emissions
1	Electricity for compressor	600	30%
2	Diesel consumption in construction vehicles	400	20%
3	Concrete	200	12%
4	Reinforcing steel	200	9%
5	Electricity for site sheds	100	7%
6	Steel content of pipes	100	6%
7	Steel for tank	100	6%
Total		**1,700**	**90%**

Note: Values have been rounded. Only orders of magnitude should be compared.

6 Summary

The emissions associated with construction of the ECD, CP, CPS, M2G and M2C are summarised in Table 21. The emissions for the construction of the ECD are an order of magnitude greater than the M2G, which in turn are an order of magnitude greater than CPS and M2C.

For the purposes of comparing operational emissions, the ECD and CPS projects have been combined, as the two projects are intrinsically linked. The emissions associated with operation of the ECD, CPS, M2G and M2C are summarised in Table 22. The total emissions for 30 years of operations are also provided in Table 22. The emissions associated with the inundation of the vegetation in the reservoir are included in the total, however, these emissions are likely to occur within the first 10 years. Emission factors for electricity consumption are likely to change in the future due to changes in the sources of electricity, hence extending the estimate of emissions past 30 years would provide misleading values.

The total emissions, including construction and operations for 30 years for ECD/CP/CPS, M2G and M2C are shown in Figure 2. The construction emissions contribute to 31% of the estimated emissions for ECD/CPS, 10% of the estimated emissions for M2G and 12% of the estimated emissions for M2C.

Table 21 Summary of Construction Emissions

Project	Emissions [t CO_2]			
	Scope 1	Scope 2	Scope 3	Total
ECD & CP	22,000	6,000	78,000	106,000
CPS	350	500	3,250	4,100
M2G	16,000	250	13,000	29,250
M2C	500	500	1000	2,000

Table 22 Summary of Operational Emissions

Project	Emissions [t CO_2/year]			Total emissions for 30 years [t CO_2]
	Scope 1	Scope 2	Scope 3	
ECD/CP/CPS	1,000[1]	7,000	1,000	241,000
M2G	0	7,000	1,500	255,000
M2C	0	400	100	15,000

1. Emissions associated with the inundation of vegetation during flooding of the reservoir. These emissions are total one-off emissions based on the current carbon stock in the reservoir, determined by FullCAM.

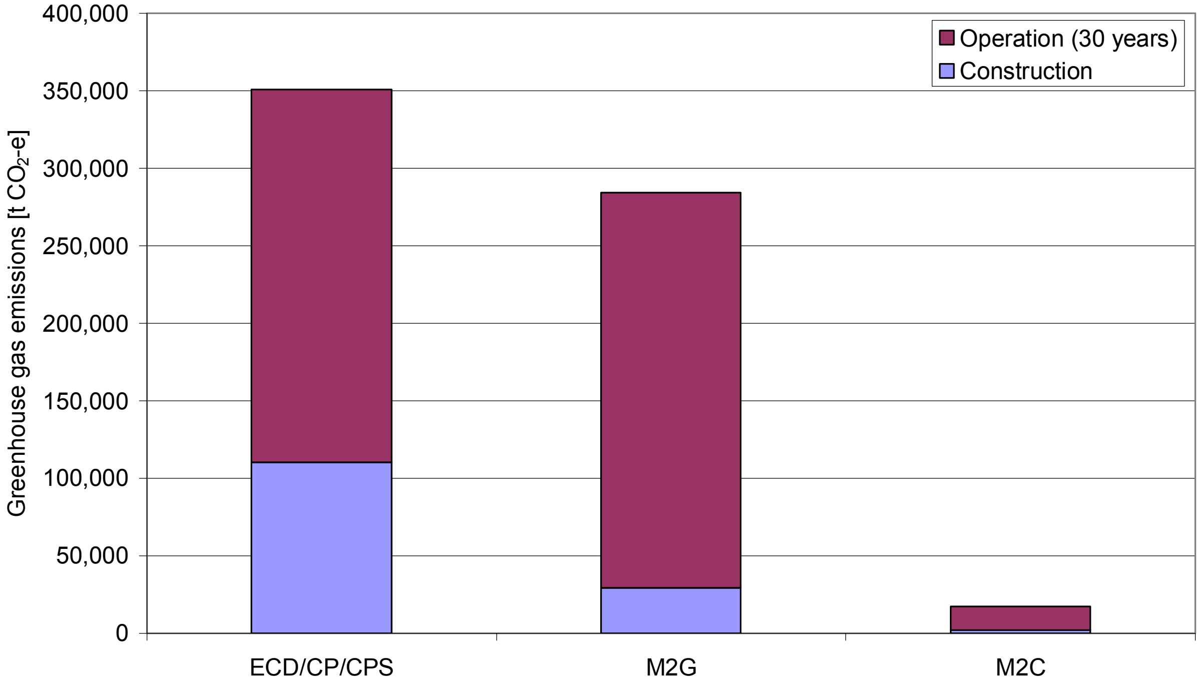

Figure 2 Emissions associated with construction and 30 years of operation of the Enlarged Cotter Dam, Cotter Precinct, Cotter Pump Station, Murrumbidgee to Googong Pipeline and Murrumbidgee to Cotter Pipeline.

7 Workshop Outcomes

Workshops to discuss the greenhouse assessments were held at the BWA site office on 5 September 2008. Attendees to the workshops are listed in Appendix C. The outline of the workshops were:

- Presentation of preliminary results of the assessment;
- Confirmation of project status (time to design freeze, TOC freeze, EIS and design capacities);
- Discussion of reduction opportunities.

It was identified during the workshop that the following data gaps and information issues need resolution to update the greenhouse gas assessment for ACTEW to understand its construction and operational emissions. Some data from the workshops have been included in this report, however, due to the unavailability of the remaining data a revised assessment is planned to be undertaken closer to TOC for each project.

A number of opportunities to reduce emissions during construction and operations were also identified. These opportunities have been outlined below. The highest priority opportunities, in terms of assessing feasibility have been indicated. The relevant projects are also indicated in parentheses.

7.1 Identification of key data gaps and concerns

1. Based on initial data provided, the emissions associated with vegetation removal were likely to be overestimated. The following steps were identified to refine the initial estimate (i) site visit at ECD to confirm species, age and density and/or aerial photography review of ECD and M2G (ii) re-run model with new data. The updated estimates have been included in this report. (ECD/M2G)
2. Pumping regimes for existing and new Cotter Pump Stations and therefore associated electricity consumption. Confirmation of the current use of existing pump station, in terms of how much is used for Cotter Dam and other sources was required. Updated values based on modeling by ActewAGL for the volumes of water supplied or transfer and the electricity consumption for pumping (based on current operating data) have now been included in this report.
3. Details of the extension of electricity infrastructure for the projects were still being determined. The extension of the high voltage line and construction of a substation for M2G pump stations to be constructed by ActewAGL Network. Details for electricity infrastructure is required from ActewAGL Network for off site infrastructure and from the BWA electrical team for onsite infrastructure. (ECD/CPS/M2G/M2C) ***(High Priority)***
4. Bio-emissions associated with flooding of the reservoir were presented during the workshop and have now been included in this report. (ECD)
5. Conceptual details of the discharge structure at Burra Creek were provided at the workshop. Specifics of material quantities to be obtained and included in the assessment for the updated assessment report. (M2G)
6. Details of oil use for maintenance of construction vehicles were provided during the workshop. This data will be included in the updated assessment. (ECD/CPS/M2G/M2C)
7. Details of the pipe work required for delivery of water to the batch plants was provided during the workshop. This data will be included in the updated assessment. (ECD)

7.2 Identification of opportunities to reduce construction related emissions through design

1. A cut and cover approach was proposed during the workshop for parts of the M2G pipeline as a means of reducing the quantity of excavation required (and consequently reducing fuel consumption). This approach would involve trenching where excavation is easy (e.g. soft ground) and use the excavated material to construct a surface trench over the harder ground. Greenhouse team to liaise with design and construction team to assess feasibility with regards to emission reduction opportunities and other opportunities and constraints. ***(High Priority)***
2. Aluminosilicate based cements were proposed as an alternative to Portland cement for general purpose concrete. Aluminosilicate based cements may have lower greenhouse emissions compared with Portland cement. The feasibility of using aluminosilicate based cements was unknown and requires further investigation.
3. The emissions associated with glass reinforced plastic pipes compared with mild steel cement lined pipes were raised during the workshop. A life cycle assessment of the two products would be required to determine the difference in emissions.
4. The emissions associated with concrete roads compared with bitumen roads were raised during the workshop. A life cycle assessment of the two road types would be required to determine the difference in emissions.

There may be other minor opportunities similar to points 3 and 4 that do not impact on the cost of the project. Provided data is readily available, these types of comparisons are relatively simple and do not require large amounts of time to complete.

7.3 Identification of opportunities to reduce construction related emission through construction activities

5. The constructors are considering sourcing and using bio-fuels for the works (across all projects). The use of sustainable bio-fuels may significantly reduce construction related emissions. It is recommended that the BWA greenhouse team liaise with the construction team to assess the feasibility of this opportunity. (ALL) ***(High Priority)***
6. Optimisation of the staging of the construction activities was raised during the workshop as a potential energy reduction opportunity. The example provided by the construction team was to always have the crushing plant located downstream of the quarry. Greenhouse team available for assistance on as needs basis. (ALL)
7. It was raised during the workshop that the conveyor system for delivery of concrete from the batch plant to the construction site be used to generate electricity (allow concrete to flow under gravity down the conveyer and connect the conveyor to a generator). This is standard practice, but has not been accounted for in the greenhouse assessment. An estimate on the quantity of electricity that could be generated and used has not been determined. Optimisation of this process may increase the quantity of electricity produced. Greenhouse team available for assistance on as needs basis. (ECD)
8. The opportunity to neutralise emissions associated with vegetation removal during construction through appropriate carbon sequestration re-vegetation. Greenhouse team to liaise with landscaping team. (ALL)

9. Opportunity for bio-sequestration of construction or operational emissions that are additional to proposed re-vegetation activities associated with the water security projects. Greenhouse team to liaise with landscaping team. (ALL)

7.4 Identification of opportunities to reduce operational related emission through design

7.4.1 M2G

10. Single mini-hydro for M2G at Burra Creek discharge;
    - Feasibility report due for completion towards the end of September.
11. Tunneling through Gibraltor Pass for M2G may reduce head by ~15 m.
    - We understand a tunneling contractor will assess the feasibility.
    - Assess suitability for mini-hydro based on reduced head due to tunnel and vice versa in the context of carbon emissions for construction and operation.

Optimisation of M2G requires a multi-variable analysis considering tunneling, mini-hydro, pipe size, configuration of inflows and outflows. Greenhouse team to liaise with design, hydro and construction teams. ***(High Priority)***

7.4.2 Across all projects

12. The efficiency gains through pump selection for CPS, M2C, M2G (understand up to 5% maximum).
    - Cost-benefit analysis (including cost of carbon) required to assist selection of pumps. Greenhouse team to liaise with design team as required.
13. It has been identified, at least conceptually, that any significant reduction in pumping requirements can only be achieved through the configuration of the inflow and outflow locations.
    - Recommended that this be given consideration for all pump station locations by the respective design teams.

7.5 Significant green energy generation opportunities

A “closed-loop” mini-hydro system located parallel to the M2G pipeline, which could be comprised of:

- Reservoir storage at Gibraltor Pass;
- Reservoir storage near Murrumbidgee pump station;
- Connectivity to the Murrumbidgee pump station and pipe line as required;
- Power to be supplemented with renewable energy sources (e.g. solar thermal, solar photovoltaic, mini wind).

The purpose of the system would be to produce electricity at least during peak electricity demand periods.

It was recommended that the feasibility of this opportunity be progressed as quickly as possible and will require input from pipeline team, mini-hydro team, environmental planners and community consultation, renewable energy personnel, ActewAGL. ActewAGL and renewable energy personnel would develop cost benefit analysis and economic models to confirm proposition.

Most of this expertise can be sourced from within the BWA and suggest that the Greenhouse team project manage this opportunity.

Note, of interest the Canberra Renewable Energy Park is to be located adjacent to this section of the pipeline.

7.6 Other opportunities/issues raised

Collaboration between Greenhouse team and BWA landscape/land management team regarding the biodiversity aspects of re-vegetation in the context of carbon sequestration opportunities.

8 Disclaimer

This report has been prepared at the request of ACTEW and is for the sole purpose of evaluating the greenhouse gas emissions associated with the construction activities and operation of the Enlarged Cotter Dam, Cotter Precinct, Cotter Pump Station, Murrumbidgee to Googong and Murrumbidgee to Cotter Water Security Projects.

This report is not for use by any related or third party or for any other project. The information and recommendations are to be read and considered as a whole and the content is not to be used selectively as this may misrepresent the content of the report and provide erroneous project or decision outcomes.

The recommendation, opinions, assessments, analyses and summaries presented in this report are based on preliminary design information, data, assumptions and advice provided by a variety of BWA project teams. This information may not reflect the final design and construction and operational activities and where assumptions are identified and recommendations made these need to be verified and tested.

Appendix A System Boundaries

Raw Materials →

Emissions associated with the inputs, outputs and energy use of raw material production.

- Cement
- Sand
- Gravel
- Steel (reinforcing, structural, valves, pumps, pipes)
- Explosives
- Bitumen
- Fly-ash
- Construction vehicle maintenance materials (oil/lubricants)
- Materials for electricity distribution infrastructure
- Materials associated with infrastructure to pump water from the dam to the batch plant.

Transport of Raw Materials to Site →

Emissions associated with the transportation of raw materials from their point of production to the site.

- Cement
- Sand
- Gravel
- Steel
- Pipes
- Explosives
- Fly-ash
- Diesel
- Bitumen
- Construction vehicle maintenance materials (oil/lubricants)
- Materials for on site electricity distribution infrastructure
- Materials associated with infrastructure to pump water from the dam to the batch plant

Construction Activities →

Emissions associated with the construction activities.

- Electricity (crusher plant, batch plant, compressors, tower crane, site offices)
- Diesel (construction vehicle and generators)
- Disposal of construction waste in landfill
- Transportation of construction waste to landfill
- Vegetation clearance
- Mains water
- Wastewater treatment
- Re-vegetation activities
- Viewing platforms and other minor public infrastructure
- Manufacture and transportation of construction vehicles and equipment to site.
- Onsite refuelling infrastructure and fugitive emissions.

Operation ↓

Emissions associated with the operation of the dam.

- Bio-emissions from flooding of reservoir.
- Abatement due to re-vegetation of cleared land
- Electricity for minor maintenance/operation
- Maintenance items and activities

Decommissioning

Emissions associated with decommissioning.

Items in blue are likely to be included in future assessments as the design progresses.

Items in red are unlikely to be included in future assessments.

Figure 3 System Boundary for the Enlarged Cotter Dam and Cotter Precinct

Raw Materials →

Emissions associated with the inputs, outputs and energy use of raw material production.

- Steel (pipes, pumps, reinforcement, valves, miscellaneous items)
- Concrete
- Cement (pipes, miscellaneous works)
- Sand
- Gravel
- Bitumen
- Construction vehicle maintenance materials (oil/lubricants)
- Materials for electricity distribution infrastructure
- Materials for minor construction items (cables and associated electrical equipment, flanges etc)
- Water

Transport of Raw Materials to Site →

Emissions associated with the transportation of raw materials from their point of production to the site.

- Steel (pipes, pumps, reinforcement, valves, miscellaneous items)
- Concrete
- Cement (pipes, miscellaneous works)
- Sand
- Gravel
- Bitumen
- Diesel
- Petrol
- Construction vehicle maintenance materials (oil/lubricants)
- Materials for electricity distribution infrastructure
- Materials for minor construction items (cables and associated electrical equipment, flanges etc)
- Water

Construction Activities →

Emissions associated with the construction activities.

- Electricity (compressors, site offices)
- Diesel (construction vehicle and generators)
- Disposal of construction waste in landfill
- Transportation of construction waste to landfill
- Wastewater treatment
- Vegetation clearance
- Re-vegetation activities
- Manufacture and transportation of construction vehicles and equipment to site.
- Onsite refuelling infrastructure and fugitive emissions.

Operation

Emissions associated with the operation of the dam.

- Electricity
- Maintenance items and activities

↓

Decommissioning

Emissions associated with decommissioning.

Items in blue are likely to be included in future assessments as the design progresses.

Items in red are unlikely to be included in future assessments.

Figure 4 System Boundary for the Cotter Pump Station

Raw Materials

Emissions associated with the inputs, outputs and energy use of raw material production.

- Steel (pipes, pumps, reinforcement, valves, miscellaneous items)
- Concrete
- Cement (pipes, miscellaneous works)
- Sand
- Gravel
- Copper (major cables)
- PVC (major cables)
- Construction vehicle maintenance materials (oil/lubricants)
- Materials for electricity distribution infrastructure
- Materials for minor construction items (cables and associated electrical equipment, flanges etc)
- Water

→

Transport of Raw Materials to Site

Emissions associated with the transportation of raw materials from their point of production to the site.

- Steel (pipes, pumps, reinforcement, valves, miscellaneous items)
- Concrete
- Cement (pipes, miscellaneous works)
- Sand
- Gravel
- Diesel
- Cables (major)
- Construction vehicle maintenance materials (oil/lubricants)
- Materials for electricity distribution infrastructure
- Materials for minor construction items (cables and associated electrical equipment, flanges etc)
- Water

→

Construction Activities

Emissions associated with the construction activities.

- Electricity (compressors, site offices)
- Diesel (construction vehicle and generators)
- Disposal of construction waste in landfill
- Transportation of construction waste to landfill
- Wastewater treatment
- Vegetation clearance
- Re-vegetation activities
- Discharge structure at Burra Creek
- Upgrade of recreational facilities at Angle Crossing
- Manufacture and transportation of construction vehicles and equipment to site.
- Onsite refuelling infrastructure and fugitive emissions.

→

Operation

Emissions associated with the operation of the dam.

- Electricity
- Abatement due to re-vegetation of cleared land
- Maintenance items and activities

↓

Decommissioning

Emissions associated with decommissioning.

Items in blue are likely to be included in future assessments as the design progresses.

Items in red are unlikely to be included in future assessments.

Figure 5 System Boundary for the Murrumbidgee to Googong Pipeline

Raw Materials

Emissions associated with the inputs, outputs and energy use of raw material production.

- Steel (pipes, pumps, reinforcement, valves, miscellaneous items)
- Concrete
- Cement (pipes, miscellaneous works)
- Sand
- Gravel
- Construction vehicle maintenance materials (oil/lubricants)
- Materials for electricity distribution infrastructure
- Materials for minor construction items (cables and associated electrical equipment, flanges etc)
- Water

→

Transport of Raw Materials to Site

Emissions associated with the transportation of raw materials from their point of production to the site.

- Steel (pipes, pumps, reinforcement, valves, miscellaneous items)
- Concrete
- Cement (pipes, miscellaneous works)
- Sand
- Gravel
- Diesel
- Construction vehicle maintenance materials (oil/lubricants)
- Materials for electricity distribution infrastructure
- Materials for minor construction items (cables and associated electrical equipment, flanges etc)
- Water

→

Construction Activities

Emissions associated with the construction activities.

- Electricity (compressors, site offices)
- Diesel (construction vehicle and generators)
- Disposal of construction waste in landfill
- Transportation of construction waste to landfill
- Wastewater treatment
- Vegetation clearance
- Re-vegetation activities
- Manufacture and transportation of construction vehicles and equipment to site.
- Onsite refuelling infrastructure and fugitive emissions.

→

Operation

Emissions associated with the operation of the dam.

- Electricity
- Maintenance items and activities

↓

Decommissioning

Emissions associated with decommissioning.

Items in blue are likely to be included in future assessments as the design progresses.

Items in red are unlikely to be included in future assessments.

Figure 6 System Boundary for the Murrumbidgee to Cotter Pipeline

Appendix B Construction Greenhouse Gas Inventories

Table 23 Greenhouse Gas Inventory for Construction of the Enlarged Cotter Dam and Cotter Precinct

Raw Materials	Value	Units	Scope 1 Emission Factor	Scope 2 Emission Factor	Scope 3 Emission Factor	Total Emission Factor	Units	Source	Method	Scope 1 Emissions	Scope 2 Emissions	Scope 3 Emissions	Total Emissions	Proportion of Total Inventory
	(Q)		(EF)	(EF)	(EF)	(EF)				(t CO2-e)	(t CO2-e)	(t CO2-e)	(t CO2-e)	%
Cement	37,475	t			0.804	0.804	kg CO2-e/kg	SimaPro Australian Database	Q x EF			30,130	30,130	28.36%
Flyash	43,125	t			0.000	0.000	t CO2-e/t	NA	Q x EF			0	0	0.00%
Sand	185,000	t			0.017	0.017	kg CO2-e/kg	SimaPro Australian Database	Q x EF			3,127	3,127	2.94%
Gravel - imported	61,120	t			0.017	0.017	kg CO2-e/kg	SimaPro Australian Database	Q x EF			1,033	1,033	0.97%
Reinforcing steel	3,200	t			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF			6,624	6,624	6.23%
Trash screens, shutters, valves, miscellaneous steel	15	t			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF			31	31	0.03%
Pipe work (steel)	30	t			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF			62	62	0.06%
Bitumen	77	m3			0.434	0.434	t CO2-e/m3	SimaPro Australian Database	Q x EF			33	33	0.03%
Total Raw Materials										**0**	**0**	**41,040**	**41,040**	**38.62%**
Transportation of Materials to Site														
Cement	37,475	t			76.4	76.44	kg CO2-e/t	Materials Delivery worksheet	Q x EF/1000			2,865	2,865	2.70%
Flyash	43,125	t			103.1	103.145	kg CO2-e/t	Materials Delivery worksheet	Q x EF/1000			4,448	4,448	4.19%
Sand	185,000	t			14.7	14.7	kg CO2-e/t	Materials Delivery worksheet	Q x EF/1000			2,720	2,720	2.56%
Gravel -imported	61,120	t			9.8	9.8	kg CO2-e/t	Materials Delivery worksheet	Q x EF/1000			599	599	0.56%
Reinforcing Steel	3,200	t			76.4	76.44	kg CO2-e/t	Materials Delivery worksheet	Q x EF/1000			245	245	0.23%
Trash screens, shutters, valves, miscellaneous steel	15	t			76.4	76.44	kg CO2-e/t	Materials Delivery worksheet	Q x EF/1000			1	1	0.00%
Pipe work	30	t			161.0	160.965	kg CO2-e/t	Materials Delivery worksheet	Q x EF/1000			5	5	0.00%
Explosives	650	t			181.3	181.3	kg CO2-e/t	Materials Delivery worksheet	Q x EF/1000			118	118	0.11%
Diesel	5,389	t			76.7	76.685	kg CO2-e/t	Materials Delivery worksheet	Q x EF/1000			413	413	0.39%
Bitumen	77	t			76.7	76.685	kg CO2-e/t	Materials Delivery worksheet	Q x EF/1000			6	6	0.01%
Total Materials Transportation										**0**	**0**	**11,419**	**11,419**	**10.75%**
Construction														

Use of explosives	650	t	0.18				t CO2-e/t	NGA Factors Jan 2008 Table 4	Q x EF	117			117	0.11%
Electricity for crushing plant	2,891,700	kWh		0.89	0.17	1.06	kg CO2-e/kWh	NGA Factors January 2008	Q x EF / 1000		2,574	3,065	5,639	5.31%
Electricity for batch Plant	2,346,289	kWh		0.89	0.17	1.06	kg CO2-e/kWh	NGA Factors January 2008	Q x EF / 1000		2,088	2,487	4,575	4.31%
Other electricity consumption (site sheds etc)	171,083	kWh		0.89	0.17	1.06	kg CO2-e/kWh	NGA Factors January 2008	Q x EF / 1000		152	181	334	0.31%
Compressors	1,268,456	kWh		0.89	0.17	1.06	kg CO2-e/kWh	NGA Factors January 2008	Q x EF / 1000		1,129	1,345	2,473	2.33%
Tower Crane	155,597	kWh		0.89	0.17	1.06	kg CO2-e/kWh	NGA Factors January 2008	Q x EF / 1000		138	165	303	0.29%
Diesel consumption - construction vehicles	5,768	kL	2694.28		204.58	2898.86	kg CO2-e/kL	NGA Factors January 2008	Q x EF / 1000	15,540	0	16,719	32,259	30.36%
Diesel consumption - generators	572	kL	2682.7		204.58	2887.28	kg CO2-e/kL	NGA Factors January 2008	Q x EF / 1000	1,535	0	1,652	3,187	3.00%
Construction waste to landfill	150	t			0.25	0.25	t CO2-e/t waste	NGA Factors January 2008	Q x EF			38	38	0.04%
Transportation of construction waste to landfill	150	t			9.8	9.8	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			1	1	0.00%
Pump operation water to batch plant (electricity)	25,433	kWh		0.89	0.17	1.06	kg CO2-e/kWh	NGA Factors January 2008	Q x EF / 1000		23	27	50	0.05%
Vegetation removal	13	ha	359.66			359.66	t CO2-e/ha	FullCam	Q x EF	4,819			4,819	4.54%
Total Construction										**22,011**	**6,104**	**25,681**	**53,796**	**50.63%**
Total emissions for construction period										**22,011**	**6,104**	**78,139**	**106,254**	

Table 24 Greenhouse Gas Inventory for Construction of the Cotter Pump Station

Raw Materials	Value	Units	Scope 1 Emission Factor	Scope 2 Emission Factor	Scope 3 Emission Factor	Total Emission Factor	Units	Source	Method	Scope 1 Emissions	Scope 2 Emissions	Scope 3 Emissions	Total Emissions	Proportion of Total Inventory
	(Q)		(EF)	(EF)	(EF)	(EF)				(t CO2-e)	(t CO2-e)	(t CO2-e)	(t CO2-e)	%
Pipes (cement content)	193	t			0.804	0.804	kg CO2-e/kg	SimaPro Australian Database	Q x EF			155.07	155.07	3.77%
Pipes (steel content)	452	t			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF			935.63	935.63	22.72%
Pumps (iron content)	9	t			1.180	1.180	kg CO2-e/kg	SimaPro Australian Database	Q x EF			11.14	11.14	0.27%
Pumps (steel content)	2	t			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF			4.89	4.89	0.12%
Concrete	8,647	t			0.141	0.141	kg CO2-e/kg	SimaPro Australian Database	Q x EF			1,219.21	1,219.21	29.61%
Cement (other)	2	t			0.804	0.804	kg CO2-e/kg	SimaPro Australian Database	Q x EF			1.61	1.61	0.04%
Sand	3,387	t			0.017	0.017	kg CO2-e/kg	SimaPro Australian Database	Q x EF			57.24	57.24	1.39%
Valves (Iron)	24	t			1.180	1.180	kg CO2-e/kg	SimaPro Australian Database	Q x EF			28.34	28.34	0.69%
Gravel - imported	2,170	t			0.017	0.017	kg CO2-e/kg	SimaPro Australian Database	Q x EF			36.67	36.67	0.89%
Reinforcing steel	160	t			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF			331.20	331.20	8.04%
Steel (other)	2	t			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF			3.11	3.11	0.08%
Bitumen	5	m3			0.434	0.434	t CO2-e/m3	SimaPro Australian Database	Q x EF			2.08	2.08	0.05%
Total Raw Materials										**0**	**0**	**2,786**	**2,786**	**67.66%**
Transportation of Materials to Site														
Concrete	8,647	t			10.0	10.045	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			86.86	86.86	2.11%
Mild Steel Cement Lined pipe	645	t			161.0	160.965	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			103.80	103.80	2.52%
Sand	3,387	t			14.7	14.7	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			49.79	49.79	1.21%
Gravel - imported	2,170	t			9.8	9.8	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			21.27	21.27	0.52%
Steel	162	t			76.4	76.44	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			12.35	12.35	0.30%
Pumps	12	t			278.4	278.39202	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			3.29	3.29	0.08%
Cement (other)	2	t			76.4	76.44	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			0.15	0.15	0.00%
Diesel	111	t			76.7	76.685	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			8.54	8.54	0.21%

Valves	24.02	t			955.2	955.2239339	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			22.94	22.94	0.56%
Petrol	0.44	t			76.7	76.685	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			0.03	0.03	0.00%
Bitumen	4.8	t			76.7	76.685	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			0.37	0.37	0.01%
Total Materials Transportation										**0**	**0**	**309**	**309**	**7.51%**
Construction														
Diesel use in construction vehicles	131.07	kL	2694.28		204.58	2898.86	kg CO2-e/kL	NGA Factors January 2008	Q x EF / 1000	353.15		26.82	379.97	9.23%
Petrol in generators	0.60	kL	2294.82		181.26	2476.08	kg CO2-e/kL	NGA Factors January 2008	Q x EF / 1000	1.37		0.11	1.48	0.04%
Electricity for site sheds	76036.8	kWh		0.89	0.17	1.06	kg CO2-e/kWh	NGA Factors January 2008	Q x EF / 1000		67.67	12.93	80.60	1.96%
Electricity (compressor)	528,523	kWh		0.89	0.17	1.06	kg CO2-e/kWh	NGA Factors January 2008	Q x EF / 1000		470.39	89.85	560.23	13.61%
Total Construction										**355**	**538**	**130**	**1,022**	**24.83%**
Total emissions for construction period										**355**	**538**	**3,225**	**4,118**	

Table 25 Greenhouse Gas Inventory for Construction of the Murrumbidgee to Googong Pipeline

Raw Materials	Value	Units	Scope 1 Emission Factor	Scope 2 Emission Factor	Scope 3 Emission Factor	Total Emission Factor	Units	Source	Method	Scope 1 Emissions	Scope 2 Emissions	Scope 3 Emissions	Total Emissions	Proportion of Total Inventory
	(Q)		(EF)	(EF)	(EF)	(EF)				(t CO2-e)	(t CO2-e)	(t CO2-e)	(t CO2-e)	%
Cement (in pipes)	1,304,156	kg			0.804	0.804	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			1,048.54	1,048.54	3.62%
Steel (in pipes)	2,646,554	kg			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			5,478.37	5,478.37	18.92%
Concrete (pump station structures and thrust blocks)	4,803,125	kg			0.141	0.141	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			677.24	677.24	2.34%
Sand	27,419,503	kg			0.017	0.017	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			463.39	463.39	1.60%
Copper in cables	1,008	kg			5.520	5.520	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			5.56	5.56	0.02%
PVC in cables	2,097	kg			2.410	2.410	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			5.05	5.05	0.02%
Pumps (iron component)	11,584	kg			1.180	1.180	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			13.67	13.67	0.05%
Pumps (steel component)	2,896	kg			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			5.99	5.99	0.02%
Reinforcing steel	251,671	kg			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			520.96	520.96	1.80%
Gravel	51,060,000	kg			0.017	0.017	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			862.91	862.91	2.98%
Total Raw Materials										**0**	**0**	**9,082**	**9,082**	**31.36%**
Transportation of Materials to Site														
Pipes	3,951	t			161.0		kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			635.93	635.93	2.20%
Concrete	4,803	t			10.0		kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			48.25	48.25	0.17%
Sand	27,420	t			14.7		kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			403.07	403.07	1.39%
Cables	3	t			67.9		kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			0.21	0.21	0.00%
Pumps	14	t			278.4		kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			4.03	4.03	0.01%
Reinforcing steel	252	t			76.4		kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			19.24	19.24	0.07%
Gravel	51,060	t			7.4		kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			375.29	375.29	1.30%
Diesel	4,374	t			76.7		kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			335.44	335.44	1.16%
Total Materials Transportation										**0**	**0**	**1,821**	**1,821**	**6.29%**
Construction														

Diesel use in construction vehicles	5,138	kL	2694.28		204.58	2898.86	kg CO2-e/kL	NGA Factors January 2008	Q x EF /1000	13,842.88		1,051.11	14,893.98	51.43%
Diesel in generators	8	kL	2682.7		204.58	2887.28	kg CO2-e/kL	NGA Factors January 2008	Q x EF /1000	22.10		1.69	23.78	0.08%
Electricity for site sheds	252,995	kWh		0.89	0.17	1.06	kg CO2-e/kWh	NGA Factors January 2008	Q x EF /1000		225.17	43.01	268.18	0.93%
Vegetation clearance	8	ha	253.23			253.23	t CO2-e/ha	FullCam	Q x EF	2,025.84			2,025.84	7.00%
Construction waste to landfill	62,262	t			0.00375	0.00375	t CO2-e/t	SimaPro	Q x EF			233.48	233.48	0.81%
Transportation to landfill	62,262	t			9.8	9.8	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			610.17	610.17	2.11%
Total Construction										**15,891**	**225**	**1,939**	**18,055**	**62.35%**
Total emissions for construction period										**15,891**	**225**	**12,843**	**28,959**	

Table 26 Greenhouse Gas Inventory for Construction of the Murrumbidgee to Cotter Pipeline

Raw Materials	Value	Units	Scope 1 Emission Factor	Scope 2 Emission Factor	Scope 3 Emission Factor	Total Emission Factor	Units	Source	Method	Scope 1 Emissions	Scope 2 Emissions	Scope 3 Emissions	Total Emissions	Proportion of Total Inventory
	(Q)		(EF)	(EF)	(EF)	(EF)				(t CO2-e)	(t CO2-e)	(t CO2-e)	(t CO2-e)	%
Cement (in pipes)	28,204	kg			0.804	0.804	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			22.68	22.68	1.21%
Steel (in pipes)	57,294	kg			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			118.60	118.60	6.35%
Concrete (pump station structures and thrust blocks)	1,650,000	kg			0.141	0.141	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			232.65	232.65	12.45%
Sand	610,485	kg			0.017	0.017	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			10.32	10.32	0.55%
Pumps (iron component)	2,144	kg			1.180	1.180	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			2.53	2.53	0.14%
Pumps (steel component)	536	kg			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			1.11	1.11	0.06%
Reinforcing steel	80,777	kg			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			167.21	167.21	8.95%
Steel (trash rack)	36,895	kg			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			76.37	76.37	4.09%
Steel (tank)	54,401	kg			2.070	2.070	kg CO2-e/kg	SimaPro Australian Database	Q x EF / 1000			112.61	112.61	6.03%
Total Raw Materials										**0**	**0**	**744**	**744**	**39.82%**
Transportation of Materials to Site														
Pipes	85	t			161.0	160.965	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			13.76	13.76	0.74%
Concrete	1,650	t			10.0	10.045	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			16.57	16.57	0.89%
Sand	610	t			14.7	14.7	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			8.97	8.97	0.48%
Pumps	3	t			278.4	278.39202	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			0.75	0.75	0.04%
Reinforcing steel	81	t			76.4	76.44	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			6.17	6.17	0.33%
Diesel	111	t			76.7	76.685	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			8.54	8.54	0.46%
Steel (trash rack and tank)	91	t			76.4	76.44	kg CO2-e/t	Materials Delivery worksheet	Q x EF / 1000			6.98	6.98	0.37%
Total Materials Transportation										**0**	**0**	**62**	**62**	**3.30%**
Construction														
Diesel use in construction vehicles	131	kL	2694.28		204.58	2898.86	kg CO2-e/kL	NGA Factors January 2008	Q x EF /1000	353.15		26.82	379.97	20.33%
Petrol in generators	1	kL	2682.7		204.58	2887.28	kg CO2-e/kL	NGA Factors January 2008	Q x EF /1000	1.60		0.12	1.72	0.09%

Electricity for compressor	528,523	kWh		0.89	0.17	1.06	kg CO2-e/kWh	NGA Factors January 2009	Q x EF /1000		470.39	89.85	560.23	29.98%
Electricity for site sheds	114,055	kWh		0.89	0.17	1.06	kg CO2-e/kWh	NGA Factors January 2008	Q x EF /1000		101.51	19.39	120.90	6.47%
Total Construction										**355**	**572**	**136**	**1,063**	**56.88%**
Total emissions for construction period										**355**	**572**	**942**	**1,869**	

Appendix C Workshop Attendees

Enlarged Cotter Dam and Cotter Precinct Workshop Attendees

5 September 2008 – 10:00 am – 11:30 am

- Andrew Dance (BWA)
- Ray Hezkial (BWA)
- Matthew Searson (BWA)
- Richard Frost (BWA)
- Zoe Baxter (BWA)
- Stuart Allinson (Exigency)
- Adrian Palmer (Exigency)
- Kirilly Dickinson (ACTEW)
- Damian Nott (BWA)
- Antony Sprigg (BWA)
- Andrew Maddocks (BWA)

Cotter Pump Station, Murrumbidgee to Googong and Murrumbidgee to Cotter Workshop Attendees

5 September 2008 – 11:30 am – 1:00 pm

- Steve Finch (BWA)
- Ruth Keizer (BWA)
- Matthew Searson (BWA)
- Stuart Allinson (Exigency)
- Adrian Palmer (Exigency)
- Gavin Morrison (BWA)
- Tanya Berg (BWA)
- Matt O'Rourke (BWA)
- Mike Rodd (BWA)
- Antony Sprigg (BWA)
- Andrew Maddocks (BWA)