20. Greenhouse gases

20.1 Overview

In South Australia the climatic effects attributed to climate change caused by anthropogenic carbon dioxide emissions include changes to rainfall patterns and an increase in average temperatures. Climate change impacts are being observed worldwide (see Figure 20.1), and there is substantial pressure for local, national and global action to reduce carbon dioxide emissions.

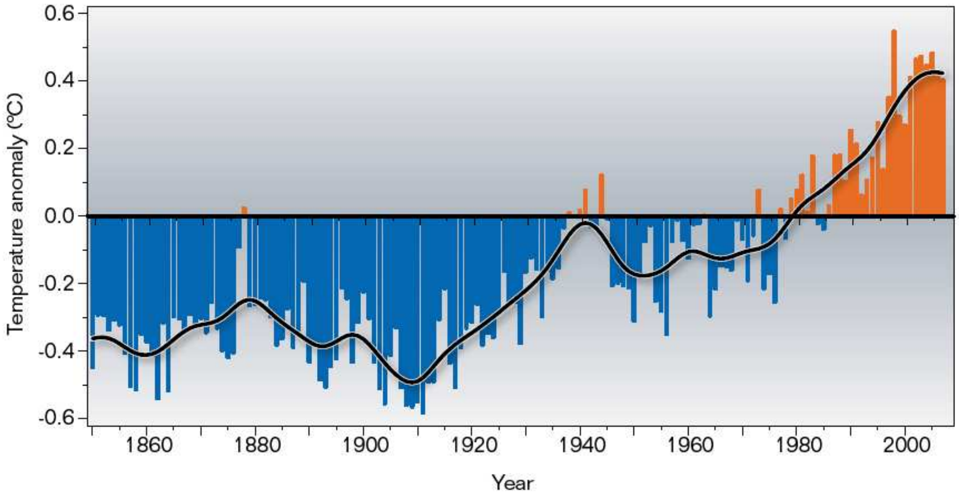

Figure 20.1 Average global air temperature anomalies, 1850–2005

Source Brohan et al. (2006, updated 2008)

South Australian average temperatures have risen by 0.95°C during the period 1910–2005: the minimum temperature by 1.04°C and maximum by 0.86°C. The rate of increase has accelerated since 1950 and appears to be faster than the Australian average rate of temperature increase (CSIRO 2006). Projected climate change impacts for the southern South Australia region are given at: www.climatechange.gov.au/impacts/regions/ssa.html.

Australian rainfall records for 1900–2005 show an increasing pattern for much of Australia, excluding southwestern Western Australia and some parts of coastal Queensland, Tasmania and southern South Australia. A stronger decreasing pattern is evident for the second half of the century, particularly in southwestern Australia and eastern Australia, with an observed increase in the northwest. Decadal fluctuations are very strong but in South Australia, much of the northern half has become wetter while southern regions have become drier.

CSIRO modelling suggests increased extinction of native flora and fauna, with detrimental impacts on some agricultural crops, water supplies and disease distribution. Other impacts expected from climate change include more frequent and prolonged droughts, more frequent bushfires, increased susceptibility to pestilence, increased spread of vector-borne diseases, more frequent heat waves, and more frequent and stronger storms with increased potential for storm surge along coastal developments.

Climate change will affect settlements and infrastructure through changes in the mean climate and changes in the frequency and intensity of extreme events. Severe weather events, such as storm surges with changing patterns and intensity, are likely to have significant impacts on settlements and infrastructure, including roads and ports. Increased bushfire hazard, rising sea level and sustained heat waves are also major impacts.

Other major impacts, such as a reduced uptake of CO_2 by warming oceans, could cause a positive feedback loop, which would amplify the existing effects of global warming. Possible catastrophic effects of uncontrolled global warming, termed 'high-consequence' climate outcomes, include destruction of coral reefs and their dependent marine life, and species extinction.

Proponents of infrastructure development, and other sectors, have become more concerned about climate change. In 2007, transport contributed 14.6% of Australia's net greenhouse gas (GHG) emissions or 78.8 megatonnes of CO_2 equivalent (Mt CO_2-e). Emissions from this sector were 26.9% higher in 2007 than in 1990, and have increased by about 1.5% annually on average. Between 2006 and 2007, transport emissions increased by 0.2%. Preliminary estimates indicate that transport emissions increased by 2.2% (1.7 Mt CO_2e) in 2008.

20.2 Legislative and policy requirements

Legislative and policy requirements are summarised in Table 20.1.

Table 20.1. Legislative and policy requirements for project

Legislation	Description	Relevance to proposed project
National		
Motor Vehicles Standards Act 1989	Imposes standards on road vehicles and their component parts and emission standards for exhaust fumes	The Act addresses energy consumption and emissions associated with motor vehicles. These factors are addressed in the design of the road layout and route, road texture, slope/gradient and the quantity of traffic.
National Greenhouse and Energy Reporting Act 2007	Sets a framework for reporting and disseminating information related to GHG emissions, GHG projects, energy consumption and energy production of corporations	The Act requires reporting of GHG emissions, energy use and energy production at a facility if the corporate group emits or produces GHGs at or above the specified thresholds for a financial (reporting) year. The design, construction and future use of the proposed road will comply with the Act and report, if required, on energy, industrial process, fugitive and waste emissions.
AS ISO 14064-2:2006 Greenhouse gases Part 2	Specifies, with guidance at the project level, quantification, monitoring and reporting of GHG emission reductions and removal enhancements	The construction and operation of the proposed road will comply with the Australian Standard specification, engaging a standardised approach for quantification, monitoring and reporting. The baseline scenario for GHG for the proposed road explaining the decisions/options taken will be consistent with the principles outlined in the Australian Standard, including conservativeness and accuracy.
Building Code of Australia (BCA)	Uniform set of technical provisions for the design and construction of buildings and other structures throughout Australia, allowing for variations in climate and geological or geographic conditions	For the environmental requirements for the design and construction of buildings and other structures, the BCA requires energy efficiency clauses, which include requirements for building fabric, glazing, mechanical and electrical services, and hydraulic requirements specifically for hot water. Designers must 'sign off' their designs as complying with the requirements of the BCA. An option for construction is the use of materials with a lower embodied energy than those used in the analysis. Recycled materials will be considered for use as part of a fully sustainable approach.

Legislation	Description	Relevance to proposed project
National Greenhouse Strategy (NGS)	Sets a strategic and comprehensive greenhouse response, tailored to address our particular national interests and circumstances Contributes to the global effort to stabilise GHG concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system, and within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, ensure that food production is not threatened and enable sustainable economic development	The strategy describes the requirements for energy-efficient transport and sustainable urban planning to address and mitigate GHGs. It includes eight modules with packages of measures to address issues and seek outcomes. The proposed road and construction will address the measures for efficient transport and sustainable urban planning (road route and layout), greenhouse sinks and sustainable land management, and greenhouse best practice: industrial processes and waste management. Energy efficiency is addressed in the design, reducing energy consumption through rolling resistance, gradient resistances, road layout and route, and traffic control on the road.
State		
Tackling Climate Change: South Australia's Greenhouse Strategy 2007–2020	Outlines a series of innovative and comprehensive strategies for the state to effectively address climate change Includes the Government Action Plan, a framework to guide the activities of government agencies for South Australia to meets its commitment to achieve the Kyoto emissions reduction target within the first commitment period of 2008–2012 Aims to meet the goal of reducing transport-related greenhouse emissions, in strategies and actions that: ▪ reduce trip lengths and the need for motorised travel through integrated land use and transport planning ▪ improve the emissions performance of vehicles and fuels ▪ shift transport towards low greenhouse emission modes Government Action Plan addresses: ▪ a climate change impact assessment process for major projects ▪ a plan for sustainable urban develop-ment that optimises previous investment in social and physical infrastructure, including existing public transport to accommodate the state government's population target of 2 million by 2050 ▪ new and existing road space designed to give greater priority to emission-efficient modes and use intelligent transport systems to improve fuel efficiency	The strategy's target is to limit GHG emissions to 108% of 1990 levels during 2008–2012, with a reduction of 60% (40% of 1990 levels) by 2050. An outcome of the South Road Superway will be to reduce travel times between the Port River Expressway and Regency Road, which will make a valuable contribution to South Australia's greenhouse objectives.

Legislation	Description	Relevance to proposed project
Climate Change and Greenhouse Emissions Reduction Act 2007	Made South Australia the first place in Australia to legislate targets to reduce greenhouse emissions Sets three targets to: ▪ reduce by 31 December 2050 GHG emissions within the state by at least 60% to an amount that is equal to or less than 40% of 1990 levels as part of a national and international response to climate change ▪ increase the proportion of renewable electricity generated to at least 20% of electricity generated in the state by 31 December 2014 ▪ increase the proportion of renewable electricity consumed to at least 20% of electricity consumed by 31 December 2014. The legislation also commits the government to work with business and the community to develop and put in place strategies that will put South Australia in a position to take early action to reduce greenhouse emissions and adapt to climate change.	The South Road Superway will reduce travel times between the Port River Expressway and Regency Road, addressing energy consumption through rolling resistance, gradient resistances, road layout and route and traffic control on the road. Maintenance vehicles may able to use low emissions fuels such as biodiesel.

20.3 Assessment methodology

A quantitative assessment of the net effect of the project has been undertaken to determine the GHG emissions from construction activities, maintenance, operation and decommissioning. Emissions associated with vegetation clearance and landscaping sequestration have not been assessed.

20.4 Effects of the project on greenhouse gas emissions

The GHG impact of the project over the life of its use (lifecycle impact) considers:

1. an emissions inventory (resulting from actions that are part of the construction of the road infrastructure)
2. ongoing maintenance of the constructed assets (including associated rail operations, ancillary facilities and street lighting as well as maintenance of the core asset – the road pavement and its surfaces)
3. emissions from vehicles using the roads (metropolitan Adelaide network-wide).

To determine the full lifecycle impact of the road asset it may also be necessary to examine the impact over its life (70–100 years). However, a nominal period of 30 years is applied to be consistent with the economic assessment period used in this report.

Emissions associated with the operation of road infrastructure are often many times greater than those associated with its construction. Emissions due to construction are still important; they are generally offset by savings in GHG emissions from operation of the project.

The efficiency of the vehicles themselves, as well as any improvement in the road design and construction properties of a facility, can also have a bearing on the carbon footprint and may include:

- rolling resistance (road texture and evenness)
- gradient resistances (road slope)

- road layout and route
- traffic control on the road.

These minor considerations will influence vehicle operating emissions only at the margins compared to the emissions related to the 'stop–start' and average speed of vehicles over the network.

20.4.1 Assessment of operational effects

In the operation of the South Road Superway, GHG emissions are largely those produced by the vehicles using it.

Total operational GHG emissions for the road network most closely depend on modelling of vehicle composition, and by extension fuel type and efficiency, vehicle trips (VT) and vehicle kilometres travelled (VKT).
Calculation of GHG emissions for two assessment years (2016 and 2031) is based on predictive traffic modelling by vehicle category. Greenhouse analysis is dependent on the extent to which the model can successfully predict future travel behaviour including any potential induced travel demand. The operational GHG model used for this assessment was developed from speed–greenhouse gas emission curves developed by the University of South Australia for the SA Environment Protection Authority.

The speed–greenhouse gas emission curves applied in this context are based on parameter values for all-day average vehicle speeds (Zito, Date Unkown). They have been used to develop 'base case' (i.e. if the project was not built) and 'project case' (i.e. if the project is built) fuel consumption estimates based on the total average speed across the Adelaide metropolitan transport network. With the operation of the project and resulting network improvements, total average speeds across the network improve with a commensurate improvement in fuel consumption. This is used to derive a kilogram per CO_2-e per kilometre for each vehicle type, per 24-hour period based on the 'fuel combustion emission factors' sourced by the University of South Australia that are consistent with the National Greenhouse Accounts factors report released by the Australian Department of Climate Change

Other assumptions used in the operational GHG model include the application of ABS data on fuel type breakdown by vehicle type.

Total savings in $C0_2$-e per annum (for both 2016 and 2031) are then used to determine annual savings (ramping up between 2016 and 2031) which are aggregated over a 30-year period (to coincide with economic forecast) from the year of operation.

Note that uncertainties in climate projections, future greenhouse emission trends, government policy direction and the impact of subsequent reduction strategies, limit the accuracy of any greenhouse modelling projections.

A breakdown of the South Road Superway project road transport properties and resulting GHG emissions for the assessed years (2016 and 2031) are presented in **Tables 20.2** and **Table 20.3** which also show the results of traffic modelling for the entire metropolitan Adelaide road network for both the base case and project case scenarios for traffic in the study area.

Table 20.2. Annual traffic modelling figures for metropolitan Adelaide road network

Vehicle type		2016		2031	
		Base case (without project)	**Project case (with project)**	**Base case (without project)**	**Project case (with project)**
Cars	VEH trips (24 hr VKT)	26,171,446	26,188,106	33,132,620	33,246,986
	Total annual GHG (kt CO_2-e)	**2,531**	**2,519**	**3,323**	**3,310**
	Average speed	44.8	45.2	42.3	42.8

Vehicle type		2016		2031	
		Base case (without project)	**Project case (with project)**	**Base case (without project)**	**Project case (with project)**
	over network (kmph)				
Total commercial vehicles	VEH trips (24 hr VKT)	1,432,331	1,432,467	2,189,990	2,187,996
Light commercial vehicles	Total annual GHG (kt CO_2-e)	**66.5**	**66.1**	**105.0**	**104.0**
	Average speed over network (kmph)	44.8	45.2	42.3	42.8
Rigid trucks	Total annual GHG (kt CO_2-e)	**52.5**	**52.0**	**85.0**	**84.0**
	Average speed over network (kmph)	50.1	50.4	45.7	46.2
Articulated vehicles	Total annual GHG (kt CO_2-e)	**258.3**	**257.7**	**410.0**	**408.0**
	Average speed over network (kmph)	50.1	50.4	45.7	46.2
Buses	VEH trips (24 hr VKT)	192,424	192,415	302,000	302,000
	Total annual GHG (kt CO_2-e)	**63.1**	**63.6**	**108.0**	**108.0**
	Average speed over network (kmph)	32.7	32.1	26.2	26.4

VKT = vehicle kilometres travelled; kt CO_2-e = equivalent kilotonnes of carbon dioxide); kmph = kilometres per hour

Table 20.3. Annual greenhouse gas inventory and profile for metropolitan Adelaide road network

	2016		2031	
	Base case (without project)	**Project case (with project)**	**Base case (without project)**	**Project case (with project)**
Total annual GHG (kt CO_2-e)	2,971	2,958	4,031	4,014
Change in emissions (without or with the project) Annual GHG savings (kt CO_2-e)		**-13.4**		**-17.0**

Annual GHG emissions from road traffic for the South Road Superway modelled for the years 2016 and 2031, showing limited savings with the project case scenario over the base case scenario.

With traffic volumes across the Adelaide metropolitan network expected to increase, the operation of the South Road Superway would save an estimated 13.4 kilotonnes (kt) CO_2-e across the network in 2016 (**Table 20.3**). In 2031, the operation of the South Road Superway would save an estimated 17.0 kt CO_2-e across the metropolitan Adelaide road network over the base case scenario (**Table 20.3**).

The total savings in kt $C0_2$-e per annum (for 2016 plus 2031) are used to determine the annual savings (ramping up between 2016 and 2031) aggregated over a 30-year period from the opening of the project. The overall savings (i.e. reduction) over a 30-year time frame is 381.2 kt CO_2-e.

20.4.2 Assessment of construction effects

GHG emissions from construction of the South Road Superway include those from construction vehicles fuel use, from the emissions associated with the production and transport of the materials used, and from other energy sources such as electricity. Predicted GHG emissions are based around the quantity of materials to be used in constructing the project.

Overall anticipated emissions from construction of the project are approximately 153,500 tonnes CO_2-e (**Table 20.4**).

Table 20.4. Anticipated emissions from construction of the project

Material	Greenhouse gas emissions (t CO_2-e)
Diesel	15,322
Electricity – SA grid	1,088
Concrete	48,175
Steel	30,560
Asphalt	3,180
Bitumen	54,800
Crushed aggregate	340
Total	153,500

20.4.3 Assessment of maintenance effects

A projection was made on the basis of the findings of Park et al. (2003). They found that emissions associated with maintenance were usually around 3.5% of construction emissions per annum, and emissions associated with decommissioning around 2.1% of the construction emissions. Projected emission are given in **Table 20.5.**

Table 20.5. Estimated maintenance and decommissioning greenhouse gas emissions

Phase	Greenhouse gas emissions
Maintenance emissions	5,300 t CO2-e per annum
Decommissioning emissions	3,200 t CO2-e

20.5 Mitigation measures to minimise effects

20.5.1 Reducing greenhouse gas emissions through design

In seeking to reduce the GHG footprint of a road or expressway, the main consideration is design and construction for reducing the emissions of vehicles travelling on the road, the area of the greatest emissions in the life of a road. This consideration does not form part of the overall carbon footprint calculation; it does demonstrate that every effort has been made during this process to reduce the greenhouse impact of the project though best practices in design.

The primary purpose of the South Road Superway is to improve traffic flows in the area, which will lower the rate of GHG emissions from the base case scenario.

Road design can reduce vehicle emissions by having a smooth surface to reduce the rolling resistance of tyres (while maintaining wet weather performance); minimising the curvature and gradient of the roads, interchanges and ramps; minimising the requirement for stopping and starting; and providing a direct route between major hubs in the metropolitan region.

Fuel and energy consumption associated with the use of the road could be further reduced by using renewable energy for electricity-consuming components of the highway such as lights and signage. LED traffic lights and energy efficient signage have lower electricity consumption than conventional lights. Maintenance vehicles should be well maintained and driven in an efficient manner; the use of alternative fuels could be investigated.

Overall GHG emissions of the road could be offset by planting trees in appropriate areas of road related land and/or by purchasing carbon sequestration credits.

20.5.2 Measures to minimise effects during construction

Pears (2005) recommends an 'ongoing reduction in embodied fossil fuel content of road structures, including maximising lifetime and design for recovery of resources'. The embodied emissions component of the materials for South Road Superway is 2% of full lifecycle emissions (if road use is included) or 89% of road construction emissions only.

Materials for road construction with a far lower embodied energy (and embodied emissions) will be investigated for use, provided they meet appropriate structural standards. For example, cement that uses byproducts such as flyash has a lower embodied energy (by using 'waste' material that is essentially emissions 'free' as filler) and redirects waste from landfill. Even greater savings in lifecycle CO_2 emissions can be gained by using geopolymer concrete for appropriate applications. Other materials, such as recycled concrete, could also be used.

20.6 Conclusion

Total GHG emission savings over a 30-year period associated with the South Road Superway project are given in Table 20.6. GHG emissions associated with the construction and maintenance phase will be offset by savings in emissions in the operation of the new project. Therefore, there is a net savings of 68.5 kt CO_2-e, network-wide, of the construction and 30-year operation of the South Road Superway.

Table 20.6. Greenhouse gas emissions and savings for the project

Project aspect	Greenhouse gas emissions (kt CO_2-e)
Construction emissions	153.5
30-year GHG emissions for maintenance	159.0
30-year GHG emission savings for operation of the road*	-381.0
Total 30-year emission savings based on construction, maintenance and operation*	-68.5

*i.e. a saving in GHG emissions compared to the situation if South Road Superway project was not built