EASTLINK TUNNELS ENVIRONMENTAL IMPROVEMENT PLAN (TEIP) TJ-G-PLN-EN-0002

Rev	Date	Prepared by	Reviewed by	Approved by	Remarks
A	14/07/05	SCF		CH	Draft issued for comment.
B	13/01/06	SCF			Issued for WAA Assessment
C	16/01/06	SCF			Issued for WAA Assessment

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1. INTRODUCTION

1.1. Project Overview

The EastLink Project is Australia's largest road project and is also the largest urban infrastructure project undertaken in Australia. On its completion in 2008, the EastLink Project will connect Melbourne's south-eastern and eastern suburbs.

ConnectEast has been awarded the contract to finance, design, construct and operate EastLink for a concession period of approximately 39 years, including a construction period of four years.

The $2.5 billion design and construction contract for the project has been awarded to Thiess John Holland, a joint venture between two of Australia's construction industry leaders.

The project will involve the construction of 45 kilometres of freeway-standard road of predominantly three-lane capacity, with 17 interchanges, over 80 bridges and twin 1.6 kilometre three-lane tunnels under Mullum Mullum Creek. Over 35 kilometres of continuous bicycle and pedestrian paths and extensive urban design and landscaping will also be incorporated in the project.

As part of these works, Thiess John Holland will construct the Ringwood Bypass and Dandenong Southern Bypass. Fully integrated into EastLink, these non-tolled bypasses will enhance traffic flows and deliver the infrastructure necessary to accommodate growth in the region.

Incorporated into the project is an urban design and landscaping solution, developed by Wood Marsh and Tract, that is sympathetic to the environment, non-intrusive to the natural landscape and fully integrated with the existing and future road network. The urban design solution is drawn from the surrounding native vegetation using greens and yellows against a charcoal and off-white backdrop with extensive noise attenuation barriers and broad-massed plantings of native grasses and groundcovers.

Throughout the project's construction, Thiess John Holland will establish and maintain cooperative, responsive relationships with the surrounding community, local government, authorities and agencies. There will be high community involvement through community connect forums, one-on-one consultation and regular letterbox drops. ConnectEast will operate a permanent public display centre and a mobile display program.

The delivery of the EastLink Project will be based on proven environmentally sustainable work practices. Thiess John Holland will actively work to protect and conserve flora and fauna and protect sites of known Aboriginal and other historical significance from disturbance wherever possible.

Thiess John Holland is referred to in this remainder of this document as the 'Designer and Constructor'.

1.2. Context

This document, known as the EastLink Tunnels Environment Improvement Plan (TEIP) has been developed by the Designer and Constructor as a requirement of the Works Approval process administered by the Victorian Environment Protection Authority under the Environment Protection (Scheduled Premises & Exemptions) Regulations 1996 ('the Regulations'). The requirement to develop an EIP can be found in Section 31(c) of the Environment Protection Act 1970 ('the Act').

Due to the commercial structure of EastLink, the Designer and Constructor is a separate commercial entity to the Operator (see Figure 1 below).

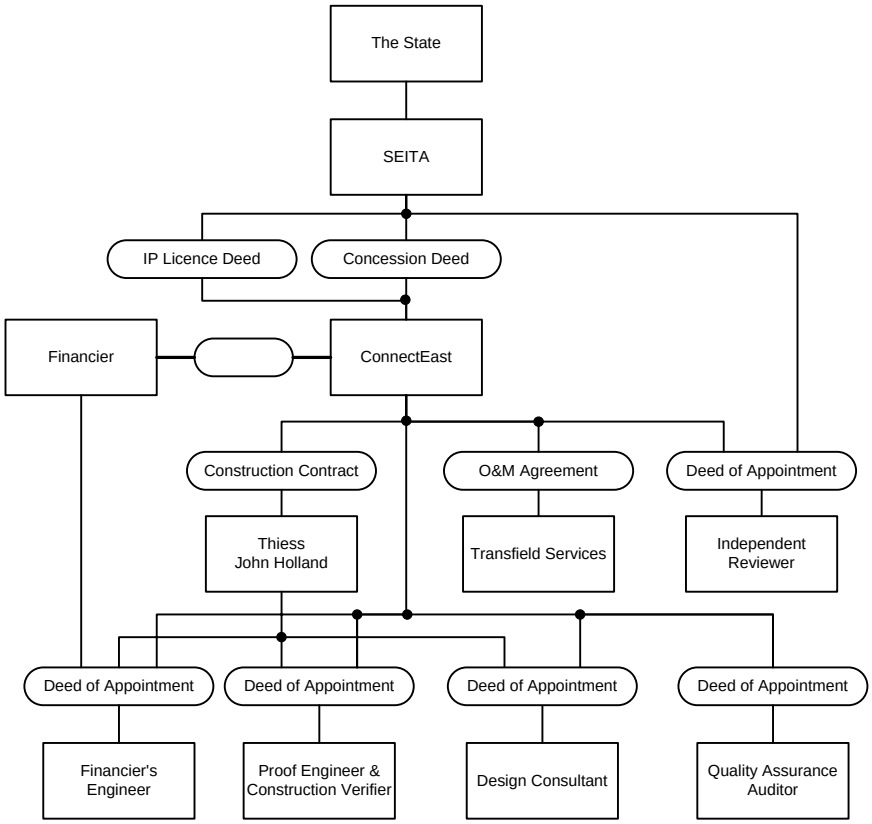

Figure 1 – Project Structure

Consequently, due to the differing responsibilities of Designer and Constructor and the Operator, the Designer and Constructor of the tunnels is responsible for obtaining a Works Approval prior to construction and a Commissioning Approval prior to opening of the tunnels to traffic. Once commissioning is complete and the EPA is satisfied that the conditions of the Works Approval and Commissioning Approval have been met the operator and maintainer is responsible for obtaining a Waste Discharge Licence ('Licence') for the operation of the Tunnel Ventilation System.

Once a Licence to operate the tunnels ventilation system is issued to the Operator the TEIP will become a component of the Operator's overall Environmental Management Plan (Figure 2 below).

1.3. Development and Scope

The TEIP will be developed in two stages:

- Stage 1 – Tunnel Design, Construction and Commissioning Phase
- Stage 2 - Post-Commissioning and Operating Phase
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The focus of the Stage 1 TEIP for the WAA is the identification of operational issues that are to be addressed through the tunnel design and commissioning processes. Once Stage 1 is complete the Operator will take ownership of the TEIP.

A key input in the development of the TEIP has been the identification and assessment of the environmental risks associated with the operation of the EastLink Tunnels. The resultant register of environmental risks can be found in Appendix A of the TEIP.

The TEIP addresses each of these risks and outlines both design requirements and operational measures to be employed to effectively manage the identified risks.

Guidance in developing the TEIP was obtained from EPA Publication 739 – 'Guidelines for the preparation of Environment Improvement Plans' ('the Guidelines').

As described in the Guidelines, Environment Improvement Plans often form a component of an Environmental Management System, and this is the approach that has been adopted when developing the TEIP. Consequently, the TEIP should be read in conjunction with the Designer and Constructor's Environmental Management Plan during the design, construction and commissioning phases of the project, and in conjunction with the Operator's Environment Management and Emergency Management Plans during the post-commissioning and operation phase of the project.

Both of the Environmental Management Plans described above form components of the overall ConnectEast Management Plan:

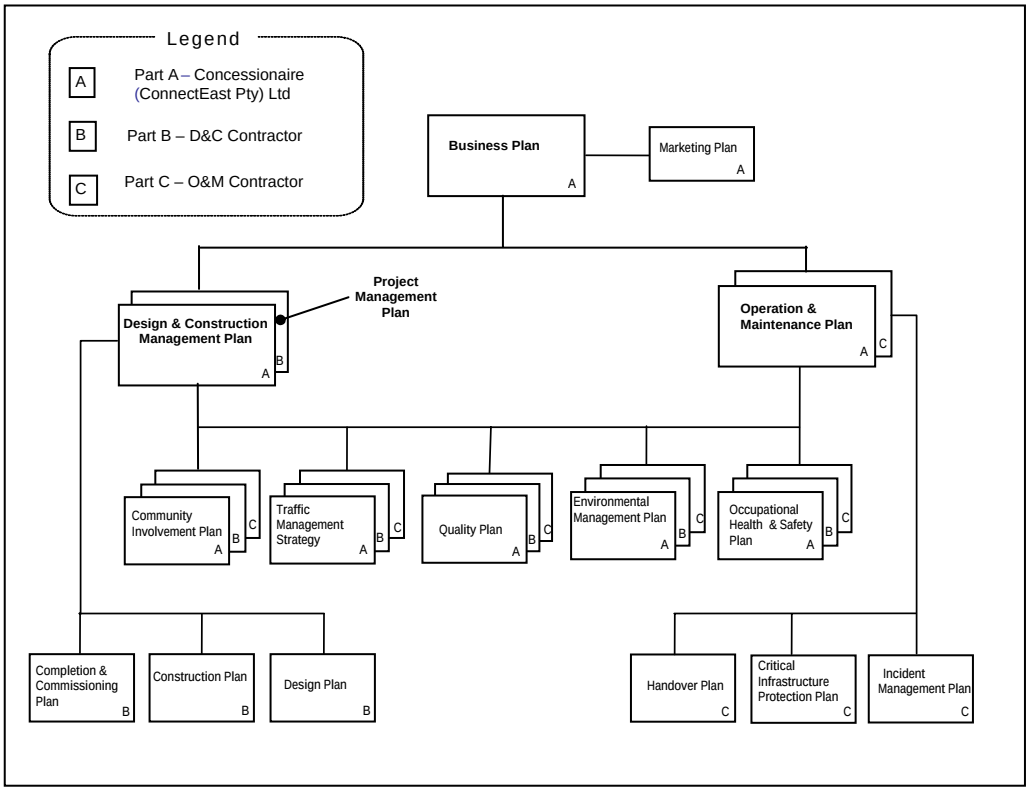

Figure 2 – EastLink Management Plan Structure

The TEIP is a 'living document' and as such will be subject to continual revision throughout the life of the project. Potential triggers of subsequent revisions include the final design of tunnel systems, changes in the Regulatory environment, community concerns, changed operating requirements, opportunities for improved operation, and outcomes of incident investigations.

2. REFERENCES

- TJ-G-PLN-EN-0001 Environment Management Plan
- Environment Protection Act 1970
- Environment Protection (Scheduled Premises & Exemptions) Regulations 1996
- EPA Publication 739 – 'Guidelines for the preparation of Environment Improvement Plans'
- Greenhouse Gas & Energy Efficiency - EastLink Project Tunnels (Energetics Pty Ltd)
- Air Quality Assessment for EastLink – Update of October 2003 Assessment (SEITA/CEE)

Future reference documents for the operations phase will include:

- TSL Environmental Management Plan
- TSL Emergency Management Plan

3. DEFINITIONS AND ABBREVIATIONS

ConnectEast	ConnectEast Nominee Company Pty Limited [ACN 108 736-9920 ["Trustee"] as trustee of ConnectEast Asset Trust [the "Trust"] and ConnectEast Pty Limited [CAN 101 213 263], together the "Concessionaires" being party to the Concession Deed for EastLink dated 13 October 2004.
Control Room Operators	The TSL employees responsible for day to day control room and tunnel operations, and responsible for initiating and coordinating incident management, including notifying emergency services and TSL Managers, in the event of an emergency incident, and where an extended or escalated response is required.
EastLink Project	45 kilometres of freeway-standard road of predominantly three-lane capacity, with 17 interchanges, over 80 bridges and twin 1.6 kilometre three-lane tunnels under Mullum Mullum Creek.
Emergency	As defined in the Emergency Management Act 1996, means an emergency due to the actual or imminent occurrence of an event which in any way endangers or threatens to endanger the safety or health of any person in Victoria or which destroys or damages, or threatens to destroy or damage, any property in Victoria or endangers or threatens to endanger the environment or an element of the environment in Victoria including, without limiting the generality of the foregoing- (a) an earthquake, flood, wind-storm or natural event; (b) a fire; (c) an explosion; (d) a road accident or any other accident; (e) a plague or an epidemic: (f) a warlike act, whether directed at Victoria or part of Victoria or at any other State or Territory of the Commonwealth; and (g) a hi-jack, siege or riot.
EPA	Victorian Environment Protection Authority.
Incident	An event that is causing or has the potential to cause a hazardous situation. These can be either routine or emergency situations.
MFESB	Metropolitan Fire and Emergency Services Board.
EastLink Operations Centre	The 24 hour centre contact point for the EastLink Motorway where the operation of the Motorway and TSL resources are co-ordinated.
Designer and Constructor	Thiess John Holland JV, the joint venture awarded the contract for the design and construction of EastLink.

Operator Transfield Services Pty Ltd, who is the Operator and maintainer of EastLink under contract to ConnectEast Limited, the owner of EastLink.

SEPP State Environment Protection Policy.

4. BACKGROUND INFORMATION

4.1. Air Quality in Melbourne

The air quality in the Melbourne airshed is affected by a variety of sources, which are typical of most major industrialised cities. These sources include emissions from manufacturing and petrochemical industries, domestic solid fuel heating, and motor vehicles.

The daily concentration of pollutants may vary depending on meteorological conditions. For examples, wind speed and seasonality are major influences on pollutant concentrations. In winter, weather conditions are more favourable for the accumulation of roadside pollutants, however in summer, conditions are frequently more dispersive.

It has been documented that during a typical summer week day, almost 80% of the Nitrogen oxides (NOx), 50% of the Volatile Organic Hydrocarbons (VOHs), over 90% of carbon monoxide (CO), and 46% of the airborne particulates are due to the exhaust and evaporative emissions from motor vehicles[1]. However, a number of reports have established that smoother driving, through fewer deceleration/acceleration actions reduces fuel consumption. Driving smoothly can therefore be expected to reduce CO2 emissions, with complementary reductions in VOHs and NOx emissions. The reported estimates of potential reductions in fuel consumption through smoother driving can be up to 15%.

While emissions from vehicles still contribute significantly to air pollution, the good news is that Melbourne's air quality has been steadily improving. Despite a doubling of Victoria's car fleet, a 25 per cent increase in the population of the Port Phillip Region, and an increase in economic activity, the region's air is considerably cleaner than it was 20 years ago[2]. Motor vehicles still remain a large source of pollutants, accounting for approximately three quarters of Melbourne's emissions of oxides of nitrogen and carbon monoxide. However despite motor vehicle usage increasing on a year-to-year basis, improvements in fuel standards and vehicle performance have resulted in an overall improvement in air quality[3].

More stringent emissions standards for new motor vehicles will ensure that the emissions performance from all new vehicles entering the Australian market will continue to improve. In addition, national fuel quality standards that will come into place between 2004 and 2008 will improve emissions from vehicles – in particular, particle emissions from diesel vehicles[4]. Consequently, it can reasonably be expected that regional air quality will improve with time as the total emissions from vehicles decreases in the Melbourne region.

[1] Reference: *Motor Vehicle Emissions In Melbourne*, EPA Publication No. 329, 1994.
[2] Reference: *Motor Vehicles And Air Quality*, , EPA Publication No. 636.1, 2002.
[3] Reference: *Victoria's Air Quality - 2004*, , EPA Publication No. 1000, 2005.
[4] Reference: *CityLink – Review of Air Quality Monitoring*, , EPA Publication No. 958, 2004.

4.2. Legislative Background

The Designer and Constructor, and the Operator, are subject to the Environment Protection Act 1970 ('the Act'). The Designer and Constructor is subject to the requirements of Sections 19 of the Environment Protection Act 1970 ('the Act'), with respect to obtaining a Works Approval to construct the Tunnels Ventilation System. Section 20 of the Act details the requirements applicable to the Operator with respect to obtaining a Waste Discharge Licence.

Works Approvals and Licences control particular types of activities or industries identified in Environment Protection (Scheduled Premises & Exemptions) Regulations 1996 ('the Regulations') to prevent pollution. A Works Approval is required prior to commencing construction of major new or modified facilities. A Waste

Discharge Licence must be obtained prior to its operation and may contain emission limits, environmental monitoring, reporting requirements and operating conditions.

State Environment Protection Policies (SEPPs), declared under the Act, provide a statutory framework of environmental objectives and programs, often used to formulate Licence conditions. The objectives of the SEPPs form the basis for the environmental requirements applied to the design of plant such as the EastLink Tunnels Ventilation System.

The EastLink Tunnels Ventilation System is a Scheduled Premise under Section 12(a) of the Regulations. Therefore, a Works Approval is required for the EastLink Tunnels Ventilation System, which is being designed to extract vehicle emissions from the tunnels. A Waste Discharge Licence for the operation of the EastLink Tunnels Ventilation System is required by the Operator. The Licence may contain operating requirements such as stack emission limits, in-tunnel and ambient air quality monitoring, reporting and the submission of an operations stage Environmental Improvement Plan (ie. the Stage 2 TEIP).

4.3. Tunnels Risk Assessment

The Designer and Constructor conducted a risk identification and assessment workshop to identify and assess potential failure modes which could result in adverse environmental impacts. Inputs to the workshop included both design and operational perspectives.

The key areas of environmental risk identified were:

- Air quality;
- Water quality;
- Noise; and
- Energy Management

A copy of the Risk Assessment can be found at Appendix A to this document.

4.4. Potential EPA Waste Discharge Licence Conditions

The EPA Waste Discharge Licence that the Operator will require for the operation of the Tunnel Ventilation System may include the following:

- Conditions for the discharge of waste to the environment and specific discharge limits.

- Production of an Air Quality Environmental Management Plan subject to regular review;
- Demonstration of environmental performance;
- Arrangements for the submission of performance monitoring reports and other reports to EPA; and

- A plan of the Scheduled Premises covered by the EPA Waste Discharge Licence, including discharge points.

5. AIR QUALITY MANAGEMENT

5.1. Design of the Tunnels Ventilation System

5.1.1. Background

The Tunnel Ventilation System is being designed to provide the Operator with the ability to rapidly respond to changing traffic conditions in the tunnels to maintain acceptable air quality within and discharging from the tunnels, as well as the surrounding environs.

In the event of an emergency such as a fire in either of the tunnels, the ventilation fans will be used to remove smoke from the tunnel.

The Works Approval issued by EPA is expected to include requirements for monitoring equipment to be installed within the tunnels as follows:

- Equipment used to measure the temperature of the air emissions;
- Equipment used to continuously monitor the flow of air, CO and temperature inside the tunnels; and
- Equipment used to monitor total nitrogen oxides and nitrogen dioxide, CO, particulates as PM_{10} and $PM_{2.5}$, air velocity and temperature from each stack.

5.1.2. Tunnel Ventilation System Design

The EastLink Tunnels will be ventilated by a longitudinal system using a number of fully reversible jetfoil fans mounted on the structural lining of the Tunnel. The ventilation air will generally flow in the direction of traffic, except at the exit portal where the airflow will be against the flow of traffic. Large axial exhaust fans and a high level ventilation stack (ie, exhaust chamber), will be provided at each exit portal. The air intake is via the entry portal for each tunnel.

The Tunnels Ventilation System will be designed so that under normal operating conditions the outdoor air will be drawn in from the portals and vitiated air discharged vertically through the ventilation stack. Air quality analysers including CO and visibility detectors, will be installed inside the tunnel to monitor the air quality and control the operation of the Tunnels Ventilation System. The Tunnels Ventilation System control algorithm will use inputs from the monitors to adjust the number of jetfoil and axial fans in operation to ensure that the tunnel's concentrations of vehicle pollutants comply with the environmental design requirements and any additional EPA Waste Discharge Licence conditions.

As part of the design process the Designer and Constructor has and will continue to review existing and planned road tunnels around the world to identify current best practice in design to ensure that the Operator can achieve 'best practice in operation. The current status of pollution control equipment for use in road tunnels will be subjected to ongoing review.

5.2. Management Of The Tunnels Ventilation System Under Normal Operating Conditions

5.2.1. Introduction

The EastLink Tunnels Ventilation System shall be designed so that it can be operated by the Operator in accordance with the expected conditions of the EPA Waste Discharge Licence issued to the Operator prior to opening. In addition to the automatic operation of the ventilation system, the Operator will have in place standard operating procedures, including in response to alarms, to ensure the following during normal operation:

- Air management at the exit portals will ensure that vehicle emissions discharges from the exit portals are as required by the Licence;
- The in-tunnel Carbon Monoxide air quality objectives are not exceeded under the terms of the Licence; and
- The emissions of CO, particulates as PM_{10} and $PM_{2.5}$, Total nitrogen oxides and nitrogen dioxide and other specified indicators discharged through the Tunnels Ventilation Stacks are in accordance with Licence conditions.

5.2.2. Water Vapour Emission Plume

Under certain atmospheric conditions, light refraction may cause a plume discharging from the ventilation stack to be visible to the general public, who may perceive smoke to be emanating from the ventilation stack whereas the actual emission visible is water vapour. When atmospheric conditions are such that a water vapour plume is likely to be perceived as smoke, operational staff will verify that the plume is not smoke. In

response to any public enquiries or concerns a community relations protocol managed by ConnectEast and the Operator will be implemented.

5.2.3. Operator Skills Training

Initial operator training on tunnel systems will be carried out during the construction and commissioning phases. As part of ongoing skills training for operators including in regard to emergency response situations, the Operator will undertake periodic refresher training of its Control Room Operators in the operation of the Tunnel Ventilation System. The refresher training is to ensure that operator's skills are maintained at a high level, including in regard to response to any emergency situations. The refresher training will generally be undertaken at times of low traffic volumes and low vehicle emissions.

Additional training will also be provided where system changes or upgrades are made, or significant new procedures introduced.

5.2.4. System Software Upgrades

System Software upgrades may be required at certain times that include improvements and upgrades of the systems, including the Tunnels Ventilation System. Following the implementation of System Software upgrades that impact on the Tunnels Ventilation System there is a requirement to perform testing of the ventilation system including operation in smoke extraction mode. Such testing will generally be undertaken at times of low traffic volumes.

5.2.5. Maintenance

Routine maintenance of the Tunnel Ventilation System is a statutory requirement and also part of the Operator's maintenance obligations. Routine in-tunnel maintenance activities will generally be undertaken at times of low traffic volumes, or during prescribed tunnel closures. An exception to this rule may be the calibration and servicing of the air monitoring equipment installed at the vent stack which would generally be conducted during the hours of daylight, and where practicable outside traffic peaks. Ambient air monitoring stations would also be serviced and maintained during daylight hours.

During some routine maintenance activities there is the potential that emissions to atmosphere may be discharged from the entry or exit portals. For example Occupational Health and Safety considerations may dictate that exhaust fans and jet fans be turned off during certain maintenance activities. In the event of any emission from the portals during routine maintenance activities, the Operator may be required to notify the EPA in accordance with its procedures or the Licence.

Unscheduled or reactive maintenance (to avoid an emergency situation) of the Tunnel Ventilation System may be required from time to time. Where practical such unscheduled or reactive maintenance activities are to be undertaken at times of low traffic volumes. However, due to the unplanned nature of such works it is possible that on occasion these works will need to be conducted at times of peak traffic volumes and emissions.

5.2.6. System Testing

Testing of the Tunnel Ventilation System may be required following maintenance works and system software upgrades. Testing activities will generally be undertaken at times of low traffic volumes and low vehicle emissions.

5.2.7. System Optimisation

From time to time the Operator may identify opportunities for improving the performance of the Tunnel Ventilation System, including the reduction of energy usage and hence Greenhouse Gas emissions. Such opportunities will be reviewed by ConnectEast and the Operator for viability, environmental benefit and cost

implications. Any optimisation activities will be conducted in accordance with the requirements of any Licence issued to the Operator and in accordance with any other legislated requirements.

5.3. Management Of The Tunnels Ventilation System Under Abnormal Operating Conditions

5.3.1. Introduction

Ambient air quality in Melbourne varies significantly during the year due to seasonal variations, as well as varying significantly year to year due to global meteorological conditions. Numerous studies have been undertaken on the quality of air in Melbourne, and ongoing air quality data is collected by the EPA at seven locations scattered throughout Melbourne.

5.3.2. Days of Poor Ambient Air Quality

Days of poor ambient air quality in a major city is typically characterised by a photochemical smog event. Photochemical smog is caused by emissions from industry, solid fuel fired heaters, open burning, and motor vehicles, accumulating under certain meteorological conditions. The EPA has developed a smog alert system to forecast days of significant photochemical smog and to encourage motorists to refrain from the unnecessary use of their motor vehicles on such days. In addition, the public is also encouraged not to burn off or light incinerators. On the day prior to a smog alert, the media is advised, and therefore the public is able to respond accordingly.

A smog alert day (as nominated by EPA) is an indicator of poor ambient air quality, where there is the potential for an exceedence of the SEPP (The Air Environment) criteria. A potential exceedence of the PM10 objectives may occur in the ambient air due to abnormal ambient conditions such as bushfires and dust storms. On such days, the Operator may operate the Tunnels Ventilation System so as to mitigate the contribution of emissions from the tunnel ventilation stack on the local ground level concentrations by taking the opportunity to increase the number of tunnel axial fans operating (as opposed to the number normally operating) to increase ventilation stack discharge velocity and hence improve plume dispersion.

5.3.3. Increased Contaminant Load to the Tunnels Ventilation System

As is the case on any motorway, incidents involving vehicles losing their loads, in part or whole, may occur within the Tunnels. Where such an incident may occur, there could be the liberation of contaminants into the tunnel air, which may be subsequently entrained into the tunnel ventilation system. Such an incident may involve the loss of bags containing dry powder chemicals such as cement, lime or flour (not Dangerous Goods). The environmental impact of such an incident may be an increased particulate loading, either instantaneously or over a short period of time being discharged from the tunnel ventilation stack. Should airborne contaminants be in such a concentration that driver visibility is compromised, the Operator will initially respond by initiating its incident management procedures. As well as initiating incident management procedures, the Operator will also ensure appropriate procedures are implemented to minimise the further release of particulates into the atmosphere, such as traffic management and clean up procedures once it is safe to do so.

As there is continuous monitoring of air quality from within the tunnel and the emission discharging from tunnel ventilation stack, it is anticipated there will be a variation recorded in the concentration of contaminants. The concentration may, or may not, result in a breach of any Licence conditions. The Operator may be required to report the incident to EPA, providing details of the incident and the associated monitoring results at the time of the incident.

5.4. Management Of The Tunnels Ventilation System During Emergency Conditions

5.4.1. Introduction

The definition of 'emergency' can be found in the Emergency Management Act 1996, which states:

'an emergency due to the actual or imminent occurrence of an event, which in any way endangers or threatens to endanger the safety or health of any person in Victoria or which destroys or damages, or threatens to destroy or damage, any property in Victoria or endangers or threatens to endanger the environment or an element of the environment in Victoria including, without limiting the generality of the foregoing –'

(a) an earthquake, flood, wind-storm or natural event;
(b) a fire;
(c) an explosion;
(d) a road accident or any other accident;
(e) a plague or an epidemic;
(f) a warlike act, whether directed at Victoria or part of Victoria or at any other State or Territory of the Commonwealth; and
(g) a hi-jack, siege or riot.

Contained in the definition above, as well as reference to health and safety of any person, there is also reference to the environment. This may imply that during the management of an emergency event within the tunnels, in ensuring people are protected, the environmental impacts, such as the discharge of fumes from the Tunnels Ventilation System, are also considered.

An emergency event in the tunnels should be considered to include the following:

- A vehicle accident resulting in a fire or the potential for such an outcome;
- A vehicle accident involving injury or fatality;
- Vehicle(s) losing load and causing accidents or potential accidents;
- Vehicle(s) losing load and causing or potentially causing a breach of the EPA Licence;
- Tunnels Ventilation System plant failure or fire (including monitoring equipment);
- Vehicle(s) carrying EPA Prescribed Industrial Wastes;
- Vehicle(s) carrying Dangerous Goods;
- Power failure;
- Vehicle breakdowns resulting in potential vehicle accidents; and
- Any other occurrence within the EastLink tunnels which has the potential to endanger the health or safety of any person.

In the event of an emergency where there are associated discharges to the environment, which result in a breach of the EPA Licence or the Act, Section 30B of the Act recognises the emphasis placed on preventing danger to 'life or limb'. However, emergency incident procedures shall be followed when emissions are discharged to the air during an emergency event.

5.4.2. Prohibition of Dangerous Goods from Entering the Tunnels

Incidents may occur where there is an event such as a spill, leak or fire that involves hazardous materials or dangerous goods as defined in the Dangerous Goods Act 1985, or any waste material prescribed under the Environment Protection Act 1970. Hazardous materials include flammable gases, liquids or solids; poisons; and infectious, radioactive, corrosive and oxidising substances. The most common type incident involving hazardous materials include:

- chemical spills;
- chemical fires; and
- toxic vapour or gas release.

Under section 13 of the Commonwealth Road Transport Reform (Dangerous Goods) Act 1995, applying as a law of Victoria by virtue of section 5 of the Road Transport (Dangerous Goods) Act 1995) under section 9AA of the Road Transport (Dangerous Goods) Act 1995, a Competent Authority within the meaning of section 13 of the Road Transport Reform (Dangerous Goods) Act 1995 may, by Notice in a Government Gazette prohibit absolutely the transport by road of dangerous goods which are placarded loads, by all vehicles, in or through –

(i) any tunnel which forms a part of the Link road; or

(ii) any carriageway that forms an entrance ramp to such a tunnel.

Prior to opening to traffic it is expected that such a notice will be sought for the EastLink tunnels by the Operator.

In the event that a Notice is in force as described above, potential tunnel users who may transport Dangerous Goods shall be made aware of their obligations through various means, including strategically located road signage, an awareness campaign advising motoring organisations, and may include but will not be limited to the publication of information bulletins and media releases. The Operator will conduct checks from time to time via CCTV.

5.4.3. Management of Emissions from the Tunnels During an Emergency Incident

An emergency event may arise, which results in the emission of large quantities of gases and/or particulates, such as smoke from a fire, to be exhausted out of the tunnel environment. In the case of such an emergency, the jetfoil fans will all be used to exhaust contaminated air from the tunnels through the exit portal of the affected tunnel. In addition, other emergency incidents as described in 5.4.1 above may also require the discharge of smoke and other emissions to atmosphere through either portal.

In the event of emissions of gases and/or particulates, such as smoke from a fire, to be exhausted out of the tunnel environment, the Operator shall follow its Emergency Management Procedures (to be developed by the Operator).

5.4.4. Tunnel Surveillance

Operational personnel will respond to incidents, with responsibilities including:

- Responding to the Control Room Operators incident notifications as a result of the continual tunnel surveillance at the Control Room level;
- On location incident spotting and reporting;
- Provision of incident response, including for vehicle break-downs.
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5.4.5. Emergency Repairs

Emergency maintenance repairs to the Tunnel Ventilation System may be required from time to time. Where practical, emergency repair activities are to be undertaken at times of low traffic volumes. However, due to the unplanned nature of such works it is possible that on occasion these works will need to be conducted at times of peak traffic volumes and emissions.

5.5. Air Quality Monitoring And Reporting

5.5.1. Introduction

The risk assessment conducted on environmental risks associated with the EastLink Tunnels has identified 3 areas of the air environment which requires the air quality to be monitored:

- The In-Tunnel air environment;
- The quality of air discharged from the ventilation stacks; and
- The ambient air quality in the vicinity of the ventilation stacks.

5.5.2. Monitoring of In-Tunnel Air Quality

The In-Tunnel Carbon monoxide quality will need to be maintained in accordance with any EPA Waste Discharge Licence issued and containing air quality objectives designed to ensure that there are no adverse health effects upon commuters and people working in the tunnels. Any Licence issued by the EPA is expected to outline monitoring and reporting requirements.

5.5.3. Monitoring of Ventilation Stack Emissions

The ventilation stack emissions will need to be maintained in accordance with the EPA Waste Discharge Licence emission limits and discharge requirements which are designed to ensure that there are no adverse environmental effects on the surrounding environs. The EPA Waste Discharge Licence may outline the monitoring and reporting requirements.

When an EPA Waste Discharge Licence is issued it is anticipated that the Operator will be required to ensure the following is undertaken:

- The submission of regular reports.
- Notification to the EPA within a set time period of any performance monitoring result breach. The notification would include an outline of the cause, remedial action undertaken and preventive measures adopted;
- Accurate measurement and recording in accordance with EPA Publication No. 440 of the following:
  (a) carbon monoxide;
  (b) total nitrogen oxides and nitrogen dioxide;
  (c) particles as PM_{10} and $PM_{2.5}$;
  (d) temperature; and
  (e) velocity.
- The recording in writing and signing by a the Operators designated Responsible Officer of the date, time and results of all sampling, analysis, inspections and maintenance works; and
- The making available of the results of the monitoring program to an Authorised Officer of the EPA upon request.

5.5.4. Monitoring of Ambient Air Quality – Construction and Commissioning Phases

The Designer and Constructor of the EastLink tunnels is required to:

- Develop and undertake an air quality monitoring program, to be agreed with the Environment Protection Authority, to monitor and measure the air quality impacts of the Freeway. This must include near road air quality monitoring and meteorological monitoring.
- Undertake a pre-operation air quality monitoring program in consultation with the Environment Protection Authority.
- Undertake near-road air quality monitoring at sites along the Freeway, prior to Tolling Completion of the final Freeway Section, at, as a minimum, the following sites;
  - Schwerkolt Cottage; and
  - at other sites between Ringwood and Frankston at locations to be agreed between ConnectEast, the Environment Protection Authority and the State;
- Undertake meteorological monitoring (including measuring wind speed, wind direction, sigma theta, ambient air temperature, temperature gradient and solar radiation) prior to Tolling Completion of the final Freeway Section, at, as a minimum, the following sites:
  - Schwerkolt Cottage; and
  - the 'hill' station at Warrock Avenue; and

- other sites at locations to be agreed between ConnectEast, the Environment Protection Authority and the State.

The air quality monitoring program must be managed in accordance with Environment Protection Authority Publication 440.1 (*A guide to sampling and analysis of air emissions and air quality*), siting criteria AS2922 (*Ambient air guide for the siting of sampling units*) and AS2923 (*Ambient air guide for the measurement of horizontal wind for air quality applications*), and tenure of sites must be assured to ensure adequate pre and post-construction monitoring can be performed.

ConnectEast must report the results of all measurements to the Environment Protection Authority on a regular basis (frequency to be agreed with the Environment Protection Authority as part of the development of the monitoring plan) and at the conclusion of monitoring submit a report summarising the monitoring results and providing conclusions based on the monitoring results, including recommendations as to whether further monitoring is required.

5.5.5. Monitoring of Ambient Air Quality – Operations Phase

The air quality monitoring stations used to measure ambient air quality shall be operated in accordance with any EPA Licence monitoring requirements designed to evaluate the ambient air quality in the vicinity of the ventilation stacks. As is the case for ventilation stack monitoring, the EPA Licence will outline operations-phase monitoring and reporting requirements.

If an EPA Waste Discharge Licence is issued it is expected that the Operator will be required to ensure the following is undertaken:

- The submission of regular reports, which will provide trend information;
- Accurately measure and record in accordance with EPA Publication No. 440 at all times for the following:

  (a) carbon monoxide continuously;
  (b) total nitrogen oxides and nitrogen dioxide continuously;
  (c) particles as PM_{10} and $PM_{2.5}$ measured daily;
  (d) meteorological parameters - wind speed & direction, and temperature.

- The unvalidated ambient air quality monitoring data collected daily for inclusion on the EPA Ambient Monitoring Website;
- The date, time and results of all sampling, analysis, inspections and maintenance works are accurately recorded in writing; and
- The results of the monitoring program to be made available to an authorised officer of the EPA upon any request. Monitoring of the meteorological and pollutant concentration data to obtain an accurate assessment of the ambient conditions and the subsequent impact of the ventilation stack emissions may be required. The composition of any ambient air quality monitoring program used to assess the impact of the ventilation stack emissions shall be in accordance with any EPA Waste Discharge Licence issued.

In addition to the above, the Project Scope and Project Requirements specifies that the Operator must continue the ambient air monitoring program initiated by the Designer and Constructor for a further two years post-opening.

5.5.6. Monitoring Equipment Failure and Routine Maintenance

Monitoring equipment installed in the tunnels and the tunnel ventilation system shall require maintenance and calibration, and may be subject to failure due to a loss of power supply, equipment failure, data transmission failure, etc. Such equipment which requires repair shall result in a break in continuous monitoring. In the event that equipment will be unavailable for more than 48 hours, the Operator may implement the following contingency measures:

- Notify EPA as soon as practical upon becoming aware, and provide in writing details regarding equipment failure, remedial works implemented, and the expected time required to reinstate monitoring;
- Install replacement equipment as soon as is practicable;
- Where a replacement or repair cannot be achieved within a timeframe acceptable to the EPA, the Operator may apply in writing for an exemption under Section 30A of the Act; and
- Should monitoring just prior to a break down indicate a potential emergency situation, the Operator shall implement its Emergency Management Procedures (to be developed by the Operator).

5.6. Contingencies in Managing Emissions into the Future

5.6.1. Introduction

The EastLink project is conscious of the impact of vehicle emissions on ambient air quality, and the need to minimise these impacts as far as practical. The Tunnels Ventilation System will be designed based on current technological options, and will cater for foreseeable future options for improved management of emissions at a later date due to improvements in technology and/or changes in design philosophy.

In managing the EastLink motorway, studies may be undertaken to plan for controlling air emissions from tunnels into the future and appropriate contingencies developed.

5.6.2. Ventilation Stack Height

The ventilation stacks shall be designed to ensure that options exist for increasing the height of these structures to allow better dispersion of emissions from the tunnels if required as a result of ambient monitoring exceedences associated with the Tunnels Ventilation System.

5.6.3. Traffic Management

Traffic management measures may be implemented which assist the EastLink Tunnels Ventilation System to operate in accordance with any EPA licence conditions imposed. Traffic management measures which may be instigated could include:

- Advisory signage;
- Controlling vehicle speed;
- Partial tunnel closure (reduced number of lanes); and
- Total tunnel closure.

5.6.4. Property Development Controls Surrounding the Ventilation Stacks

In addition to managing and planning for emissions to atmosphere, EastLink may need to work with local planning authorities to ensure that the use of land around the ventilation stacks is compatible with the presence of these stacks in relation to environmental legislative instruments such as the SEPP (The Air Environment).

5.6.5. Ongoing Research

In managing the environmental performance of the EastLink Tunnels Ventilation System, the Operator will keep abreast of changes in pollution control technology, and together with ConnectEast assess the viability of incorporating such technology. Such technology shall be assessed with regard to predicted future emission trends, which will have been continually developing as a result of the comprehensive monitoring program. For example, on a selected and informed basis air pollution control equipment suppliers, co-operative research centres and, where appropriate, tertiary institutions in Australia and/or overseas will be periodically contacted, and reports prepared summarising emergent changes in technology.

6. NOISE MANAGEMENT

6.1. Introduction

The EastLink Project is very much aware of the impact that noise emissions can have on the natural environment and residential areas. With this in mind the Tunnels Ventilation System is being designed and constructed with passive noise attenuation devices associated with the exhaust fans and vent stack to ensure that noise levels, as measured at the nearest noise sensitive sites, meet the noise limits as determined by SEPP (Control of Noise from Commerce, Industry and Trade) No N-1.

6.2. Noise Sensitive Design

Investigations by specialist noise consultants have identified residences nearest to the tunnels vent stations as potentially being the most sensitive to noise generated by the operation of the tunnel ventilation systems.

The identified sites most sensitive to operational noise have been considered in the detailed design of the ventilation and portal structures to ensure that the requirements of SEPP (Control of Noise from Commerce, Industry and Trade) No N-1 will be met during operation of the tunnels. Measures taken include noise attenuating structures either side of axial fans and acoustic treatments applied to the interior surfaces of the ventilation system structures. In addition, noise walls have been designed to protect the identified sensitive sites from noise from the operation of the Tunnels ventilation System.

6.3. Management of Noise during Operation of the Tunnels

6.3.1. Operations

To ensure that noise limits and objectives are not exceeded during operation of the Tunnel Ventilation System, regular maintenance and surveillance of the operations of the Tunnel Ventilation System will be undertaken. Where plant or equipment is found to be operating in a manner which may result in an exceedence, remedial works will be instigated to return equipment to normal operating condition..

6.3.2. Maintenance

To minimise the effect of noise from maintenance activities on residences the following measures may be implemented by the operator:

- Restrict repair or maintenance works to times other than during the night, where possible.
- Use equipment, where possible, to effect repairs, which have low noise output ratings and are fitted with effective silencers.
- When repair or maintenance works are scheduled and ongoing, provide written advice in the form of an information bulletin to residents living in the vicinity of the works, EPA and the Local Council, of anticipated dates, times and duration of the works.
- Adopt measures outlined in the EPA Technical Guideline TG 302/92, ‘Noise Control Guidelines’ to control or reduce nuisance noise when repair or maintenance works that may impact upon nearby residents is required to be undertaken.

6.4. Contingencies in Managing Noise into the Future

6.4.1. Improvements in noise attenuation technology

In managing EastLink the Operator may identify opportunities to delivery a better noise attenuation outcome. Such opportunities could involve the introduction of improved technology. Any such opportunities would be evaluated by ConnectEast and the Operator taking into account viability, net environmental benefit, and cost.

6.4.2. Improvements in pavement technology

In managing EastLink the ConnectEast will be required to resurface the top layer of the roadway at intervals due to normal wear and tear. During planning for these works the Operator will evaluate any changes in asphalt technology which may deliver a reduction in roadway noise when compared to current technology. Any such opportunities would be evaluated by ConnectEast and the Operator taking into account viability, net environmental benefit, and cost.

7. WATER MANAGEMENT

7.1. Design of the Tunnels Water Management System

The EastLink project is conscious of water as a sustainable resource, and the need to avoid using it unnecessarily or inefficiently. With this in mind the EastLink tunnel system is being designed as a fully' tanked' tunnel, meaning that the tunnel is designed to minimise groundwater inflows through an impervious membrane system covering the length of the tunnel. This system will ensure that groundwater is excluded from the tunnel as far as practical, and that surface rainfall runoff and wastewaters are kept separate from groundwater. This design approach has been widely researched and is considered by the designers to be 'best practice' for the context in which the EastLink tunnels are being designed and built.

The benefits of this design include:

- avoidance of drawdown and associated surface settlement impacts;
- protection of the groundwater aquifer from potential cross-contamination;
- avoidance of discharge of groundwaters to the Mullum Mullum Creek;
- avoidance of the use of excessive quantities of potable water for groundwater recharge; and
- minimisation of the quantities of wastewaters created as the result of incident management or maintenance activities.

The overall tunnel drainage system will be designed to collect and keep separate the following water:

- "**Groundwater**" – water that seeps into the tunnel from the ground water;
- "**Wastewater**" – water that may contain significant contaminants, water used to clean the tunnel, water from fire fighting sources such as the deluge system and fire hydrants, and spilled liquids arising from accidental spills; and
- "**Surface water**" – run off water from rainfall events draining into the tunnel portals or brought into the tunnel on vehicles.

In general terms, the system can be broken down into the following groups of elements:

- Elements associated with pavement drainage;
- Elements associated with groundwater drainage;
- Groundwater collection sump;
- Wastewater collection sumps;
- Clean water sump; and
- Associated pumps and pipe mains for the groundwater and clean water.

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The volume of groundwater to be disposed of will be approximately 1 litre per second and this will be achieved by construction of a fully tanked tunnel to prevent ingress of all but minor seepage.

Surface water flow is limited by provision of diversion and collector drains immediately outside the tunnel portals to limit stormwater inflow.

Wastewater discharge can be either from controlled wash down, testing of the fire deluge and hydrant systems or from emergency incident (fire of spillage). This will be an occasional occurrence only.

7.1.1. Tunnel Pavement Drainage

The tunnel pavement drainage system will collect and discharge water and other fluids from the following sources:

- Stormwater runoff entering the portals;
- Stormwater runoff being tracked into the tunnels by vehicles;
- Fire deluge system;
- Fire hydrants;
- Tunnel wash-down and maintenance; and
- Accidental fuel or chemical spillage from a tanker or other sources.

Water that finds its way onto the road pavement will be collected via inlet pits, located at 60m intervals on the low side of the pavement. The grate and covers provided are positioned such that they do not protrude into the roadway.

Below the grate is a pit that serves to transfer water to a longitudinal sub-surface collector pipe. Each pit is fitted with a trash rack to prevent gross pollutants finding their way into the sumps and ultimately the pumps. These pits will be flame-proof and explosion resistant, through the provision of an inverted weir. The inverted weir is placed such that a fire resulting from a spill is contained and is prevented from propagating along the tunnel to the sump.

The longitudinal collector pipe is a reinforced concrete pipe which discharges into the tunnel sumps at the low point of the tunnel. The collection pipe will be located under the road pavement and is designed to be maintenance free.

7.1.2. Groundwater Seepage Drainage

The sub-surface drainage system consists of a central longitudinal slotted drain in a porous medium placed below the pavement layers. Seepage water will be collected at the tunnel low point in the central drain. Groundwater will be collected in side spoon drains and will be directed to the central drain at various points. In addition, connections will also be available to allow cleaning of the central drain. The central drain has been significantly oversized to allow for the possibility of a degree of carbonate/calcite build up. This design provides a low maintenance drainage system with a high degree of flow redundancy.

All tunnel drainage is directed to sumps.

7.1.3. Sumps

All water from the tunnels will be collected at the tunnel low point. Water will normally be drained to sumps under the floor of the cross-passage at the tunnel low point. An emergency wastewater sump is provided under the eastbound carriageway.

There is a separate groundwater sump that operates independently from the pavement drainage water system.

For the pavement drainage, the first sump acts as a sediment trap before transferring the water to the surface water sump via an oil trap, for pumping to a wetland. If contaminants are suspected or detected, the contaminated water can be diverted into a wastewater sump. Water in the wastewater sump is stored until it can be tested and if required it can be pumped out by tanker and taken to a suitable disposal site. All sumps are also fitted with hydrocarbon detectors.

The drainage system incorporates electric submersible sump pumps including duty and standby units. The entire system is designed to operate automatically although manual override is available for testing and maintenance.

The wastewater sump is of sufficient volume to contain a tanker spill and a coincident fire fighting resulting deluge of about 20 minutes. If the fire fighting system continues operation the overflow water passes into the clean water sump and is pumped to the wetland. This will allow the fire-fighting deluge to continue for approximately an hour without flooding the road surface.

7.2. Management of Water During Operation of the Tunnels

7.2.1. Use of water for maintenance

Maintenance activities within the tunnels will require the use of potable water for cleaning and other activities. These activities are necessary to ensure the continued performance of the roadway drainage systems, the maintenance of light reflectance levels, and the testing of fire systems.

Wherever possible the operator will use water-efficient processes (eg high-pressure cleaners) to minimise the volume of water required.

7.2.2. Water management

Groundwater seepage will be collected via the drainage elements described above and will flow into its' own sump at the low point of the tunnel. Groundwater collected in the sump will then be pumped out via a rising main to Huggins Road to the local sewer system for disposal as Trade Waste under a Trade Waste Agreement with Yarra Valley Water (where the water quality is at a level that defines it as Trade Waste).

Surface water is treated by a wetland external to the tunnel at the east end prior to discharge to Mullum Mullum Creek.

Wastewater will be processed via the wetland treatment system where its quality is acceptable, or other wise if it is contaminated it is stored on site prior to disposal.

7.3. Contingencies in Managing Water into the Future

The water management systems within the tunnels will be designed based on current technological options and consequently may present options for improved management of surface, waste or groundwaters at a later date due to improvements in technology and/or changes in design philosophy

It is a project objective to minimise the wastage of water, and to recycle water where possible for return after pond treatment to waterways, and for use at landscaping if required. Particular care will be taken to ensure that the system is capable of providing the opportunity to reuse surface and other waters with or without treatment in the EastLink pondages.

In the even that the Operator identifies opportunities to improve water management, including opportunities involving improved technology, these opportunities will be evaluated by ConnectEast and the Operator on the basis of general viability, net environmental benefit, and cost.

8. ENERGY MANAGEMENT

8.1. Tunnels Systems

The EastLink tunnels will incorporate a number of electrical and mechanical systems necessary for the safe and efficient operation of the tunnels in both normal operations and emergency situations. These systems can be grouped under the following headings:

- Ventilation;
- Water Management;
- Tunnel Lighting;
- Electrical Supply;
- Communications; and

- Traffic Management.

The ventilation system will be the majority consumer of electricity in the tunnels during operation.

8.2. Energy Efficient Design

The principles of energy efficiency will be applied during the design of all of the systems identified above. Particular measures relating to particular items of plant, such as lighting controllers and ventilation system components, have been identified by the designers.

8.3. Greenhouse Gas Emissions

The EastLink project is conscious of the air as a sustainable resource, and the need to avoid unnecessarily polluting it. As part of the Works Approval, Energetics Pty Ltd has produced a report entitled 'Greenhouse Gas & Energy Efficiency - EastLink Project Tunnels' reviewing the Greenhouse Gas emissions associated with the various tunnel systems as designed. The report includes the following:

- Annual Energy Use and Greenhouse Emissions of the Tunnel Design. Only includes energy (i.e. electricity usage) associated with the energy services of the tunnel (i.e. Ventilation, lighting etc) and not any construction or vehicles using the tunnel.

- The energy and greenhouse emissions baseline calculated and modelled against various operating scenarios

- Best Practice - the report presents the various energy efficiency design inclusions and their energy and greenhouse impacts.

The opportunities identified to reduce Greenhouse Gas emissions associated with operation will feed into the design process for assessment of viability. The review may, within its terms of reference, review the implementation of alternative modes of operation of the Tunnels Ventilation System in suitable conditions where it is demonstrated they have no detrimental environmental effect.

8.4. Contingencies in Reducing Energy Usage into the Future

In managing EastLink the Operator may identify opportunities to reduce energy usage, and such opportunities may include the introduction of improved technology delivering improved energy efficiency and hence a reduction in the associated Greenhouse Gas emissions. Any such opportunities will be evaluated by ConnectEast and the Operator at the appropriate time on the basis of viability, net environmental benefit, and cost.

9. CONSULTATION

This first release of the Tunnels Environmental Improvement Plan has been developed in consultation with ConnectEast, the Designer and Constructor, and the Operator.

Following completion of design of the EastLink tunnels it is envisaged that the TEIP will be reviewed in a formal forum and in consultation with the Environment Protection Authority, local Community and other stakeholders as appropriate .

10. REVIEW OF THE TEIP

This Environmental Improvement Plan forms a component of the Designer and Constructor's ISO 14001-compliant Environmental Management System, and as such will be reviewed in accordance with the review requirements of the entire system. At present, this will require the TEIP to be reviewed at six-monthly intervals. In addition, the TEIP will require review following completion of the design of the EastLink tunnels.

APPENDIX A – TUNNELS RISK ASSESSMENT

WAA Table 14.1 – Tunnel Risks and Mitigation Measures

	Tunnel System	Failure Mode	Primary Consequence	Risk Mitigation
	Normal Operation			
1	Tunnel ventilation	Partial failure: components of system fail	Deterioration of air quality, especially when heavy traffic/congestion	- Redundant fans on operating system - Emergency replacement – adequate spares kept in stock
2	Tunnel ventilation	Total control system failure	Tunnel traffic flow severely affected; tunnel closure required	- Redundancy built into Control systems; manual control systems available; - Incident Management Plan, (including testing of the plan) Training; Diversion plans
3	Tunnel ventilation	Inadequate fans operated - impact on emissions to atmosphere	Pollution levels exceed requirements of SEPP / EPA Licence conditions	- Control systems designed for auto fan operation; - Operating procedures for manual over-ride by operators Training
4	Monitoring System failure	In-tunnel / stack monitoring fails	Loss of Data; loss of input to ventilation system automatic control	Manual control available; contingency operations process
		Ambient monitoring system failure	Loss of Data	Monitoring station maintenance arrangements to promptly remedy failures
5	Electrical Power Supply	Total failure of power supply	Loss of tunnel lighting, ventilation and traffic management. Tunnel closure required until power restored	- Redundant power supply provided (ring main /separate substations) - UPS on essential services, traffic control system - close tunnel if necessary
6	Noise Control	Fans operating mode	Noise levels exceed requirements of SEPP / EPA Licence conditions	Design to SEPP N1 criteria; conformance a pre-requisite for successful commissioning.
7	Tunnel lighting	Tunnel lighting failure - traffic	Drivers confused / fearful after lighting failure event - causing accident	- Traffic Management -Emergency lighting provided in design as per international / Australian design code
8	Traffic management hardware	Partial failure – components of system	Tunnel traffic flow control unavailable	Procedures & training - Manual control available if required

	Tunnel System	Failure Mode	Primary Consequence	Risk Mitigation
			.	Patrols by operator
9	Water management	Failure to meet standards	Drainage system fails to comply with S6 Env Requirements	- Procedures - Testing of water - Monitoring of spillage event & and removal of contaminated water as required
10	Water management	Pumped water - surface retention system failure	Overflow occurs, polluting waterway	- Adequate design for retention of drainage water –allow for prescribed flood event.
11	Water management	Sump pump systems failure	Flooding of tunnel	Redundant pumps, systems
12	Water management	Groundwater - seepage management systems deteriorate from aggressive water	Pavement saturation and deterioration of pavement or drainage system blockage (calcification)	Inspection and maintenance procedures for drainage system
13	Energy Management	Inefficient electrical equipment selection and operation	Excessive generation of greenhouse gases	- Design of operating control system - Greenhouse Gases review as part of design process and Works Application
	Emergency Mode			
14	Emergency Equipment	Inadequate facilities	Failure to meet standard of relevant Auth / Emergency Services - fails to gain approval	Coordination of development with all relevant authorities' Approvals – Ind Reviewer/ Proof Engineer; in-tunnel smoke testing prior to commissioning
15	Fire	Inadequate emergency operational capability	Failure to meet standard of relevant Auth / Emergency Services - fails to gain approval	Coordination of development with all relevant authorities' Approvals – Independent Reviewer/ Proof Engineer; in-tunnel smoke testing prior to commissioning
16	Fire	Normal ventilation not operating or lacking capacity	Fails to control fire smoke, heat sufficiently to allow pedestrian egress	- Design codes applied; In-tunnel hot smoke test CFD modelling; - Operating procedures & training
17	Fire		Fails to control fire smoke, heat sufficiently to allow emergency service access	
18	Fire		Fails to control fire and smoke sufficiently to protect trapped	

	Tunnel System	Failure Mode	Primary Consequence	Risk Mitigation
		Extraction mode ventilation failure	persons (fails to change operating mode on demand, tunnel operator fails to demand change of operating mode).	- Redundancy in fan numbers Operating procedures & training - Emergency Management Plans
19	Fire	Structures fail in fire emergency	Injury to persons, vehicle damage / loss	- Design to PS&PR – 2 hr fire rating for ventilation system equipment, 4 hr fire rating for structures; verified approach to fire protection - Emergency Management Plans
20	Fire	Tunnel fails to provide adequate emergency egress	Persons unable to evacuate in fire /other emergency event	- Provision of emergency cross passages (120m spacing); redundant independent-charging signage; - Incident response program (MFB); smoke control / ventilation - Operational procedures - Emergency Management Plans
21	Fire	Terrorist attack- explosion results in fire event	Fire event that creates a combination of other fire event consequences; tunnel systems failure, tunnel blockage and closure	- as for other fire events - Critical infrastructure Protection Plan - Incident & Emergency Management Plans
22	Fire Protection	Detection system fails	Fire not controlled quickly	Relevant design codes applied; ; heat sensitive cable /smoke detecting CCTV; Reporting redundancy Incident & Emergency Management plan
23	Fire Protection	Communication system fails	driver confusion caused by lack of controls or contradictory advice	-Redundancy in systems – fire phones, Help phones, radio, CCTV / PA system - Regular testing - Procedures
24	Fire Protection	Communication system fails	Delay in notification of emergency services	- Auto communications to emergency services; testing by emergency services provider (eg Wormald) - Alternative communications procedures
25	Tunnel lighting	Tunnel lighting failure – emergency system	Fails to provide illumination for pedestrian egress.	Emergency lighting provided in design as per international / Australian design code
26	Tunnel Power	Power loss	All systems stop – Fans, groundwater management and lighting	- Redundant power supply provided (ring main /separate substations) - UPS on essential services, traffic control

	Tunnel System	Failure Mode	Primary Consequence	Risk Mitigation
				system - Tunnel closure for complete power failure
27	Traffic management	Total system control failure due to total loss of power	No remote traffic monitoring or control	- As for # 26 - Manual control available if required - Procedures & training - patrols
28	Water management	Water supply main burst	Flooding of tunnel, causing closure	- Operating procedures - Sump pumps and storage capacity provides sufficient time to close main supply valve