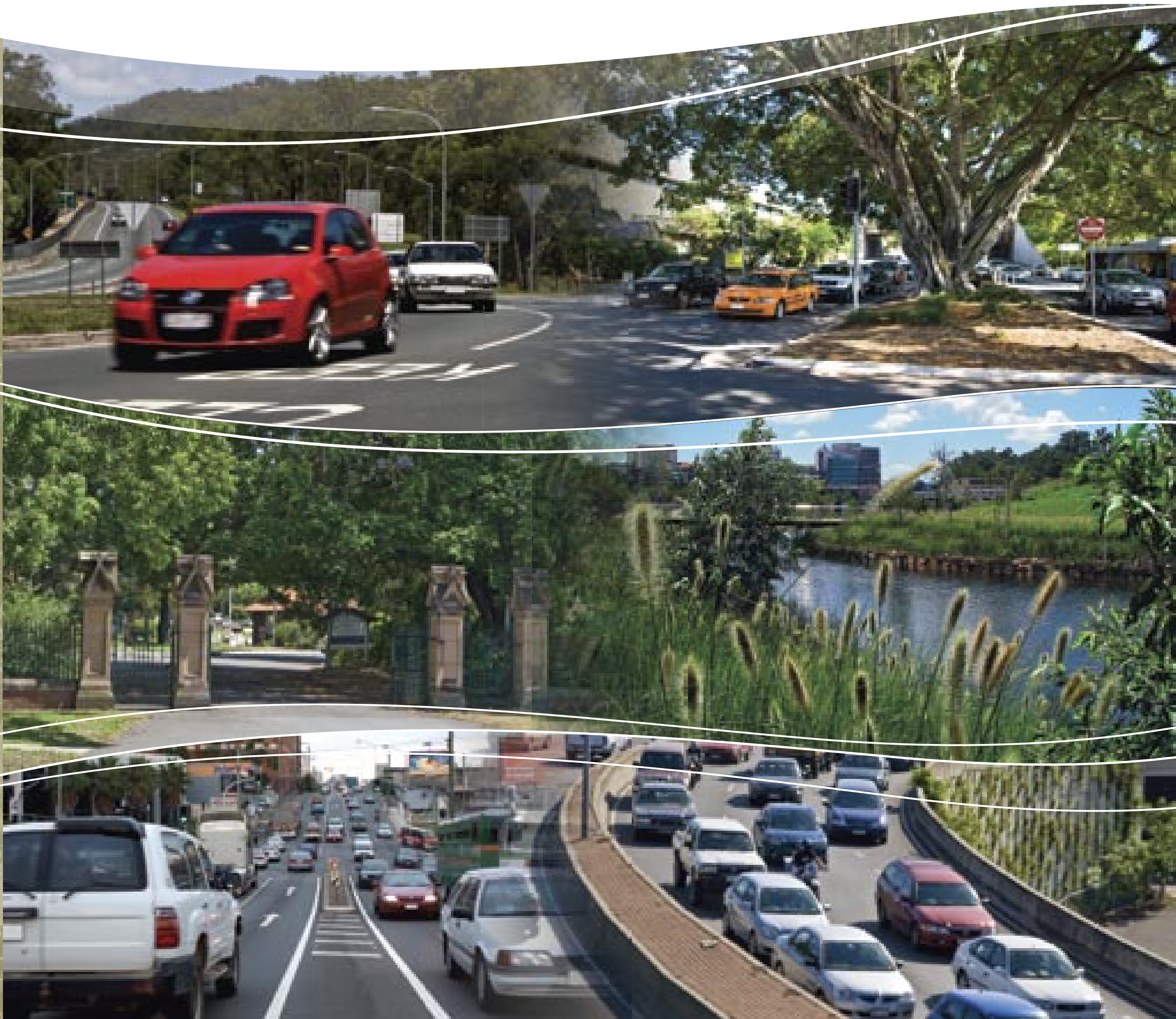
Northern Link

16. Hazard and Risk



Northern Link

Phase 2 – Detailed Feasibility Study

CHAPTER 16

HAZARD AND RISK

- September 2008

Contents

16. Hazard and Risk

This chapter addresses Part B, Section 5.12 of the Terms of Reference (ToR). It employs an all-hazards approach to the construction and operational stages of the project, including:

- *handling, transport, storage and use of hazardous goods by reference to applicable Codes of Practice and Australian Standards;*
- *identifying hazardous events or activities which may occur during the construction and operational phases of the Project;*
- *undertaking a risk assessment of the identified hazards in terms of consequences and probability arising from potential hazards, events and situations;*
- *identifying hazardous materials likely to be used in the operation of the Project and their storage and transportation;*
- *identifying management strategies to avoid or minimise flooding of the works;*
- *identifying management strategies for emergency disaster and evacuation plans for access and egress for emergency vehicles;*
- *identifying management strategies for containment procedures for the spillage of goods and hazardous substance;*
- *analysing of the consequences of the risk to the community within and adjacent to the project area; and*
- *risk treatment options and possible prevention and mitigation measures. These include design features such as fire and life safety provisions and incident management procedures.*

The adequacy of hydrant water systems and the specific details of the traffic management system to deal with emergencies are outlined. Throughout the chapter consideration is given to the needs of persons with disabilities who may experience access problems.

The risks associated with tunnel collapse and subsidence are assessed so far as they have environmental or social consequences. Risks associated with occupational health and safety of construction workers, engineering risk and project risk are addressed elsewhere.

16.1 Description of Existing Environmental Values

The study corridor identified for the project is shown in Figure 1-1 (Chapter 1, Introduction). It comprises the area of the proposed tunnel works and adjoining areas where there may be some potential impacts on the community or environment from the proposed works. The environmental and social values in those areas have been identified in the relevant chapters of the EIS. These ‘environmental values’ that are subject to potentially hazardous events include:

- the residential communities and other sensitive land uses adjacent to the tunnel portals, work sites, transport routes and spoil placement areas and above the tunnels;
- culturally significant community assets in the vicinity of the project works (eg: Mt Coot-tha Botanic Gardens, Toowong Cemetery, Victoria Park Golf Course, St Brigid’s Church).
- the motorists who would use the tunnel;
- the motorists, pedestrians and cyclists who would use the road network and footpaths near the portals and roads which result from the tunnel; and

- remnant terrestrial vegetation areas protected by Council VPOs.

16.2 Hazardous Materials and Activities

Potentially hazardous events which may occur during the construction and operational phases of the project are described below.

Hazardous activities associated with the construction of the tunnel include:

- operation of vehicles and construction equipment in the tunnel – especially fire or leakage or spillage of oils, fuels and other dangerous goods including explosives;
- operation of vehicles and construction equipment and storage of dangerous goods in the compound areas – fire or leakage or spillage of oils, fuels or other dangerous goods;
- transport of dangerous goods to the compound areas – spillage and accidents;
- transport of spoil to spoil placement areas – accidents leading to spillage;
- tunnel collapse or subsidence;
- flooding and inundation during construction; and
- related community action or protest.

Hazardous activities associated with the operation of the tunnel include:

- transportation of Dangerous Goods, both in the tunnel and on surface routes;
- minor vehicles accidents and incidents in the tunnel leading to fuel spillage or small fires;
- major vehicle accidents in the tunnel or acts of 'terrorism' leading to major fires and explosions;
- tunnel collapse or subsidence; and
- flooding and inundation during operation.

16.3 Potential Impacts and Mitigation Measures

16.3.1 Impact Assessment

Risk analysis addresses two issues:

- The likelihood of an event to take place (frequency); and
- consequences which would arise if the event occurs.

These are described in the risk matrix in **Table 16-1**. They are then combined (as the product of frequency and consequence) to yield a risk rating which provides a guide to areas of risk that require attention, as described in **Table 16-2**.

Table 16-1 Risk Matrix

Likelihood	Consequence		
	High	Medium	Low
High	H	H	M
Medium	H	M	L
Low	M	L	L

Table Note: H: High priority – urgent attention required; M: Moderate priority – attention required; L: Low priority – management by routine procedures

Table 16-2 Risk Assessment Methodology

Risk Element	Definition
Frequency or Likelihood	L: low, almost never occurs M: medium, occurs occasionally H: high, occurs frequently
Impact or Consequence	L: low, environmental nuisance* M: medium, material environmental harm* H: high, serious environmental harm*

Table Note: * Defined to match the provisions of the Environmental Protection Act, 1994

16.3.2 Mitigation Measures

The likely risk outcomes for the main hazards providing a medium or higher level of risk associated with the construction and operation of the tunnel are shown in **Table 16-3** and **Table 16-4**.

The mitigation measures indicated in the tables are explained in detail below.

Construction

A variety of safety management measures would be put in place during construction.

- Containment and Hazardous Goods Management Plan in the event of spillage of fuels and other dangerous goods within either the tunnel or the surface construction sites during transport or storage. The detailed Construction Environmental Management Plan to be developed during the detailed design phase would contain the Hazardous Goods Management Plan as well as the Incident Management Plans (Chapter 19, Environment Management Plan) and these would include provision for access and egress of emergency vehicles, particularly inside the tunnels.
- Containment and clean up procedures dealing with prevention of and management of spillage of spoil during transport to spoil placement areas. These would be included in sedimentation and erosion control plans developed as part of the Construction Environmental Management Plan.
- Construction of portal entrances to minimise the time the tunnel is exposed to inundation from flooding.
- Structural analyses and risk assessment prior to blasting within the confines of the tunnel. A Blast Management Plan and an Emergency Response Plan be developed that would contain information relating to blast design configuration.
- Community consultation and information sessions to help mitigate any action or protest that may take place during the construction of the tunnel.

Table 16-3 Risk Assessment Matrix- Safety and Environmental

Hazard	Potential environmental impact	Frequency of occurrence	Impact or consequence	Risk Level	Proposed mitigation measures
Construction					
Spillage or emission from use of dangerous/ hazardous materials in the tunnel	Contamination of soil and ground or surface water Injury to workers	L	M	L	Ensure compliance with safety work requirements in confined spaces. Training of workforce in storage and handling of dangerous goods and spill containment procedures.
Spillage from storage of dangerous goods in tunnel or compound areas	Contamination of soil and ground or surface water from leakage. Emission of fumes. Injury to workers	L	M	L	Storage in accordance with EMP and dangerous goods standards and guidelines. Implement clean up procedures.
Spillage from transport of dangerous goods en route to compound areas	Contamination of soil and ground or surface water by chemicals. Injury to workers	L	M	L	Transport in accordance with dangerous goods standards. Implement clean up procedures. Train workforce in handling of hazardous goods and spill containment procedures. Ensure adequate spill kits are available. Prepare Emergency Response Plan.
Infrastructure collapse due to uncontrolled blasting	Dust emission Death or injury to workers Vibration damage to nearby houses	L	H	M	Conduct structural analysis and risk assessment prior to blasting; Appropriate blast design configuration to suit locality of blast; Prepare an Emergency Response Plan.
Explosion/fire from build up of vehicle fumes in the tun-nel or use of haz-ardous materials.	Fume emissions. Contamination of soil and/or or water. Air contamination	L	H	M	Control volume of vehicles inside the tunnel; Provide appropriate ventilation; Monitor fume levels at work.
Spillage from tran-sport of spoil to placement areas	Water pollution through sediment-ation of waterways	L	L	L	Use standard practice (eg: Covered trucks) clean up procedures.
Flood and inundation	Water pollution	L	H	M	Tunnel design and construction to appropriate standards.
Operation					
Transportation of dangerous goods in the tunnel	Fire leading to death and injury of motorists, water pollution by chemicals.	L	H	M	Exclude dangerous goods vehicles (ie placarded vehicles) from the tunnel. If this fails for whatever reason employ measures as in next line.
Spillage from transport of dangerous goods on road network	Contamination of soil and ground or surface water by chemicals from spillage or due to accident	L	M	L	Respond in accordance with EMP and dangerous goods standards and guidelines. Implement clean up procedures,

Hazard	Potential environmental impact	Frequency of occurrence	Impact or consequence	Risk Level	Proposed mitigation measures
Fire or explosions in the tunnel or the surrounding road network due to accidents or acts of terrorism	Death and injury of motorists, water pollution with toxic chemicals, air pollution through smoke emissions	L	H	M	Traffic Management and Control System. Incident management plan. Counter Terrorism Measures.
Tunnel collapse and subsidence	Death and injury of motorists. Property damage at ground surface above.	L	H	M	Tunnel design and construction to appropriate standards
Flood and inundation	Death and injury of motorists	L	H	M	Tunnel design and construction to appropriate standards

Table 16-4 Risk Assessment Matrix- Community

Hazard	Potential community impact	Frequency of occurrence	Impact or consequence	Risk Level	Proposed mitigation measures
Construction					
Spillage from storage of dangerous goods in tunnel or adjacent areas	Contamination of soil and ground- or surface water from leakage. Emission of fumes. Injury to community	L	M	L	Implement appropriate clean up procedures
Spillage from transport of dangerous goods en route to compound areas	Contamination of soil and ground- or surface water by chemicals. Injury to community	L	M	L	Transport in accordance with dangerous goods standards. Implement clean up procedures. Train workforce in handling of hazardous goods and spill containment procedures. Ensure adequate spill kits are available. Prepare Emergency Response Plan.
Infrastructure collapse due to uncontrolled blasting	Dust emission Death or injury to community members Vibration damage to nearby houses	L	H	M	Conduct structural analysis and risk assessment prior to blasting; Appropriate blast design configuration to suit locality of blast; Prepare an Emergency Response Plan.
Explosion/fire from build up of heavy vehicle fumes in the tunnel or use of hazardous materials.	Fume emissions. Contamination of soil and surface or ground water. Air contamination Injury to community	L	H	M	Control volume of vehicles inside the tunnel; Provide appropriate ventilation; Monitor fume levels at work.
Flood and inundation	Water pollution Property damage to nearby residences	L	H	M	Tunnel design and construction to appropriate standards
Operation					
Transportation of	Fire leading to	L	H	M	Exclude dangerous goods

Hazard	Potential community impact	Frequency of occurrence	Impact or consequence	Risk Level	Proposed mitigation measures
dangerous goods in the tunnel	death and injury of motorists, impacts on health of nearby residents				from the tunnel. If this fails for whatever reason employ measures as in next line.
Spillage from transport of dangerous goods on road network	Impacts on health of community	L	M	L	Implement clean up procedures.
Fire or explosions in the tunnel or the surrounding road network due to accidents or acts of terrorism	Death and injury of motorists, pollution with toxic chemicals and smoke emissions, health impacts on community	L	H	M	Incident management plan. Counter Terrorism Measures.
Tunnel collapse and subsidence	Death and injury of motorists. Property damage at ground surface above.	L	H	M	Tunnel design and construction to appropriate standards.
Flood and inundation	Property damage to nearby residences	L	H	M	Tunnel design and construction to appropriate standards.

Operation

Outlined below are the measures incorporated into the design and operation of the tunnels to manage accidents and hazardous incidents during tunnel operation. The Tunnel Control Centre would monitor and control operation of the tunnel to ensure its safe and effective operation. In-tunnel monitoring systems would collect and process data and ensure that all services are controlled. Water tankers for the tunnel wash down operations, the pressure booster for use by the fire brigade, and parking and marshalling areas for maintenance and emergency vehicles equipped with spill kits are to be provided most probably adjacent to the Tunnel Control Centre.

Control of Dangerous Goods Vehicles

Regulations would preclude Dangerous Goods vehicles from access to the tunnel. In the event that they use the tunnel and are involved in an accident, relevant procedures (dealing with spillage of dangerous goods and fire) incorporated in the Operation Environmental Management Plan (Chapter 19, Environment and Management Plan) would be implemented. The in-tunnel drainage is designed to deal with this specific requirement as noted in Chapter 4 Project Description.

Traffic Management and Control System

The traffic management and control system would enable operators in Tunnel Control Centre and the Brisbane Traffic Management Control Centre to monitor, control and respond to the traffic conditions within the tunnel and on the approaches. This would be achieved using an integrated system of visual and electronic surveillance, motion recognition and incident detection software, and remotely controlled signs and signals. In the event of an emergency all traffic ingress to the tunnels would be halted from the Tunnel Control Centre.

'Real time' visual information to the tunnel operators, would be provided via a Closed Circuit Television (CCTV) system which would include cameras installed at the portals, in the cross passages and at 150m intervals in the tunnels. The cameras would have pan, tilt and zoom capability and be remotely controlled. A central processor in the Tunnel Control Centre would receive, process and display the images collected by all of the cameras. This processor can determine vehicle speeds, identify stationary objects, and track unauthorised pedestrians, raising alarms where appropriate. When an alarm is raised, the display would automatically show the feed from the relevant camera. If the object is moving, the display would track it along the tunnel. All video output would be recorded at one frame per second unless an alarm has been raised. In this case the video would be recorded continuously.

Incidents in the tunnel would also be detected by loop detectors installed in the pavement at distances about 150m apart. In a manner similar to that of the CCTV system, the central processor would identify an incident by either a permanent presence above a loop or a lack of any presence, indicating a blockage upstream. Again, the result would be an alarm and the relevant camera feed shown on the display.

On approach to the tunnel all vehicles would have their height checked using optical beam detectors located on all approaches, some distance before the traffic flow into the tunnel becomes isolated from the neighbouring lanes. When an over-height vehicle is detected, a warning message displays on a large variable message sign notifying the driver instructing them to merge out of the tunnel lane. If a second optical beam at the start of the trough structure detects the continued presence of the over-height vehicle, the lane control signal at the portal would turn red, instructing the vehicle to stop. Failing this, the collision protection beam installed in front of the portal structure would prevent damage to tunnel structures.

The lane usage signals would have three settings, a green arrow to signify open, a flashing red cross meaning ‘prepare for closure’, and a constant red cross to indicate a closed lane. These signals are placed over every lane at 500m intervals and at the portals. Additional information is supplied to drivers via variable message signage. The largest of these, with three lines, are placed at the tunnel approaches. These inform drivers of traffic conditions, closures, alternative routes, congestion and estimated travel times, among others. Within the tunnel, single line variable signs would be installed at 500m intervals, which would be used mainly in the event of an incident in the tunnel.

Adjustable speed limit signs would be installed in the tunnel and along the approaches. Weigh-in-Motion detectors would be installed in the tunnel floor, detecting overweight vehicles. Allowance would be made in the infrastructure for the addition of police speed cameras.

Communications Systems

A communication system would convey information through both visual and audio means. Apart from the signage described previously, information or instructions could also be delivered to tunnel occupants via radio rebroadcast breakthrough or a Public Address system. The Public Address system would be separately controlled between each tunnel and the cross passages, enabling different messages to be broadcast in each area. Emergency Services would be provided with two-way radio repeater systems. Three landline telephone systems would be installed. At intervals of 120m, midway between cross passages, communication points containing three telephones would contain a Motorist Help Telephone, an Operation and Maintenance Telephone and a Fire Coordination Telephone. Aerials would be installed to maintain mobile phone coverage within the tunnel.

Fire Protection

Heat detectors would be the primary method of detecting a fire in the tunnels, with visual backup provided by the CCTV system. In the cross passages, equipment rooms and other areas, the detection system would be similar to standard buildings, with a combination of heat and smoke detectors.

In the event of a fire, four different fire protection systems would be provided within the tunnel. The primary system is a deluge system, which is mounted in the roof. The deluge system would be activated only in the zone containing the fire. Since vehicle fires normally occur in sheltered components such as underneath a hood, the main objective would be to contain the fire since full extinguishing may not be possible. Other fire protection systems comprise fire extinguishing equipment provided at 60m spacings along the tunnel, including a fire hydrant for use by the fire brigade, as well as hose reels and hand held extinguishers for use by the general public.

Emergency Procedures

Design of the infrastructure and formulation of emergency procedures to be employed in the event of an emergency evacuation have been carried out as part of the reference design and in on-going consultation with the Department of Emergency Services. These discussions have included design of elements to cater for persons with disabilities both in-tunnel in cross passages etc and on the surface in maintaining pedestrian and wheel-chair access around the project worksites and constructions. The results of the consultation are incorporated into the reference design evident in Volume 2 of the EIS. It is intended that this consultation will be maintained as an integral part of the project well beyond the commencement of the operational phase.

The primary concern during an incident is occupant safety. The secondary concern is to clear the incident and restore the tunnel to operation. Pressurised cross passages provided at 120m intervals, as in NSBT and Airport Link tunnel designs, link the main running tunnels. These provide access, or means, to arrive at a place of safety in the event of an incident. In the portal areas beyond the final cross passage locations, egress tunnels are provided to allow access to the surface. Because of the variable vertical alignments of adjacent on and off ramps at the Toowong and Kelvin Grove Road connections the provision of the cross passages is not a practical safety design so concrete-lined egress tunnels are provided parallel to the ramps to allow pedestrian access to the surface adjacent to the tunnel portals. Provision for disabled persons is to be included in the design.

The response taken by the tunnel operators in an emergency may depend upon the nature, severity, location and time of day of the incident. In the event that vehicle occupants are required to leave their cars and proceed on foot, both tunnels would be closed to entering traffic to ensure pedestrian safety. Visibility, air speed and gas monitors (for CO and NO/NO_2), installed in the tunnel, would feed to an automated control system capable of responding by switching individual jet fans and axial fans on and off to regulate the overall air flow in the tunnel.

In the event of a fire in the tunnel, air is automatically extracted through the smoke duct in the roof or beneath the floor of the tunnel. In the region of the fire, smoke dampers on the smoke duct are opened to allow the smoke to be drawn in. The two ventilation stations at each end of the affected tunnel are activated, drawing the smoke out at both ends of the duct. Through the control of jet fans, the air speed in the tunnel would be regulated to ensure the smoke plume upstream of the fire is held steady, while smoke downstream of the fire would be mixed with the airflow. Smoke not extracted through the smoke duct may flow out of the portal depending primarily on the location of the fire in relation to the portals.

Spillage, fire deluge and wash-down water would be captured by the tunnel stormwater drainage system, diverted to and stored in dedicated 'waste water' sumps at the tunnel sag points. In the case of fire deluge or a ruptured fire main, the diversion would take place automatically, as the pressure in the fire main would drop, indicating that the fire system has been turned on and any water entering the drainage system may be contaminated. In the event of a spillage, or during the wash-down process, the drainage system would be switched over manually from the operations centre. From the waste sump, water would be pumped out by a tanker and removed for treatment.

Acts of Terrorism

Recent events have highlighted the vulnerability of public transportation to acts of violence from terrorists. Risk assessment involves prioritisation of surface transportation or tunnel assets, determination of vulnerabilities and identification of cost-effective operational security measures and engineering design standards to reduce its vulnerability.

Relative risk can be assessed, based on the:

- relative target attractiveness (an assessment of the target's importance and consequences);
- relative likelihood of occurrence (likelihood of occurrence as compared to the other scenarios); and
- vulnerability (a measure of how likely the terrorist is to achieve the threatening act given that an attempt is made).

Like all major public infrastructure used by large numbers of people a potential risk of terrorist attack exists.

Potential consequences identified for tunnels include:

- threats to the integrity of the structure (eg: resulting in replacement of the facility or major repairs);
- damage that inhibits the structure's functionality for an extended period of time, such as closure of the facility for 30 days or more;
- contamination of a tunnel resulting in extended closure or loss of functionality; and
- catastrophic failure resulting from an attack based on the threats described above.

Although the likelihood of occurrence is assessed as low, the consequence has a potentially high rating. Implementation of a suite of countermeasures is recommended to mitigate both the potential threat and consequences. Counter measures are often grouped into actions or technologies to deter attack, deny access, detect presence, defend the facility, or design structural hardening to minimise consequences to an accepted level. Often non-design countermeasures is the most appropriate and cost-effective solution for a given facility.

Recommended approaches to mitigating threats include:

- establishing a secure perimeter using physical barriers;
- inspection, surveillance, detection and enforcement (ie: CCTV); and
- visible security presence.

Appropriate terrorist counter measures are to be developed in conjunction with the operator, QPS, DES and other appropriate agencies and incorporated into the Operation Environmental Management Plan.

Flooding (Works Inundation) Control

A study of the potential for flooding of the infrastructure has been undertaken and is reported in Chapter 7, Hydrology in the EIS (refer also to *Technical Report No. 6 – Flooding in Volume 3* of the EIS). This investigation aimed to understand:

- the likelihood of flooding events; and
- the risks associated with the events.

A risk-based approach was employed to recommend appropriate design criteria (portal flood immunity and drainage infrastructure capacities) and to develop the preliminary design. The design criterion recommended for the operational phase of the project was that the tunnel ramps should provide immunity to a one in 10,000 Average Exceedance Probability (AEP) flood event as a minimum. This would reduce the likelihood of flood occurrence during the design life of the infrastructure to one percent. The measures to achieve this have been incorporated into the design of the tunnel and its adjoining structures. To achieve this level of flood immunity at each connection, flood protection walls are recommended around the entrances to on ramps and off ramps. The design criterion recommended for the construction phase of the project was that the tunnel ramps should provide immunity to a one in 100 AEP event as a minimum.