Airport Link

Phase 2 – Detailed Feasibility Study

CHAPTER 17

HAZARD AND RISK

- October 2006

Contents

17. Hazard and Risk

This chapter addresses Section 5.13 of the Terms of Reference. It employs an all-hazards approach to:

- *Handling, transport, storage and use of hazardous goods by reference to applicable Codes of Practice and Australian Standards;*
- *Identifying the environmental and social values which may be affected by hazardous materials and activities;*
- *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;*
- *Identifying management strategies to avoid or minimise flooding of the works as well as upstream flood impacts;*
- *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; 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.

Although risks associated with tunnel collapse and subsidence are dealt with elsewhere in the EIS, they are also assessed in this section 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 not addressed.

17.1 Description of Existing Environmental Values

The study corridor identified for the project is shown in Chapter 1 - Introduction. It comprises the area of the proposed tunnel works and adjoining areas where there may be some possible effects 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;
- 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;
- Groundwater and surface receiving water catchments, including Enoggera Creek and Kedron Brook; and
- Ecological communities of Enoggera Creek and Kedron Brook, as well as remnant terrestrial vegetation areas protected by Council VPOs.

17.2 Hazardous Materials and Activities

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

17.2.1 Construction

Construction activities which may generate a hazard 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; and
- Flooding and inundation during construction.

17.2.2 Operation

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.

17.3 Potential Impacts and Mitigation Measures

17.3.1 Impact Assessment

Risk analysis addresses two issues:

- 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 17-1**. 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 17-2**.

- **Table 17-1 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 17-2 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

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 17-3**.

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

17.3.2 Mitigation Measures

Construction

Safety management measures to be put in place during construction comprise:

- 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 Construction Environmental Management Plan (refer Chapter 19 – Environmental Management Plan) to be developed will contain the Hazardous Goods Management Plan as well as the Incident Management Plans and these will 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 will be included in sedimentation and erosion control plans developed as part of the Construction Environmental Management Plan (refer Chapter 19 – Environmental Management Plan);
- Construction of portal entrances to minimise the time the tunnel is exposed to inundation from flooding and provide protection to the tunnel portal worksites against a Q100 flood event;
- Installation of an appropriate pumping system as part of management strategy to deal with groundwater inflow; and
- Flood protection bunding, of key areas including the construction area upstream of the railway, the construction area and subsequent road alignment between the railway embankment and Sandgate Road alignments and areas encroaching on the Schulz Canal floodplain adjacent to the East-West Arterial.

Table 17-3 Risk Assessment Matrix

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	M	H	H	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.	M	H	H	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.	M	M	M	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 heavy vehicle fumes in the tunnel or use of hazardous materials.	Fume emissions. Contamination of soil and surface or ground water. Air contamination	L	H	M	Control volume of vehicles inside the tunnel; Provide appropriate ventilation; Monitor fume levels at work.
Spillage from transport of spoil to placement areas	Water pollution through sedimentation of waterways	M	M	M	Transport as with standard practice eg Covered trucks. Implement 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 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	M	M	M	Respond in accordance with EMP and dangerous goods standards and guidelines. Implement

Hazard	Potential environmental impact	Frequency of occurrence	Impact or consequence	Risk Level	Proposed mitigation measures
	spillage or due to accident				clean up procedures
Fire or explosions in the tunnel 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	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
Flooding of tunnels	Death and injury of motorists	L	H	M	Tunnel design and construction to appropriate standards
Upstream flood effects	Impacts on upstream residential areas	L	M	L	Structure design to prevent adverse flooding impacts.

Hydraulic Assessment of Construction Flood Conditions

Construction activities for the Project affect areas of the Kedron Brook and Schulz Canal watercourses and floodplains. Therefore, there is a potential for short term impacts on the characteristics of flooding in the investigation area. Hydraulic modelling was undertaken to assess these impacts and provide adequate mitigation.

Construction impacts will include:

- Truncation of the Eagle Junction Creek alignment and blockage of the existing creek culverts under the railway.
- Flood protection bunding of the construction area upstream of the railway.
- Construction site access under the railway at the existing railway underpass location requiring localised lowering of the terrain to pass tall vehicles.
- Flood protection bunding of the construction area and subsequent road alignment between the railway and Sandgate Road alignments.
- Construction of earth embankments encroaching on the Schulz Canal floodplain adjacent to the East-West Arterial Road.
- Construction Period Flooding Characteristics

The flooding characteristics of the investigation area were modified due to the construction activities. The balance of the impacts are manageable considering the short duration of the construction phase.

Upstream of the Railway

The modelling found that the creek diversion could be managed so as to cause minimal impacts on regional flooding upstream of the railway. The diversion delivered the creek flow directly to the construction vehicle underpass through the railway embankment. Increased flooding would have been experienced due to the blockage of the Eagle Junction Creek culverts under the railway. However, the lowering of terrain at the vehicle underpass generally increased the capacity of the area to pass flooding under the rail alignment and the impact was mitigated. Conveying Eagle Junction Creek in a broad channel under the railway rather than via culverts provided a better solution in this large Q100 event.

Flood protection bunding of the construction area removed a large area of floodplain storage upstream of the railway and flooding depths were sensitive to this. Generally, water levels upstream of the railway were increased by 40 - 70mm. The impact would have been greater without increasing the capacity of the underpass through excavation for construction vehicle access.

Given that the planned construction period is short and that the impacts are small, it is considered that the level and extent of potential impact upstream of the railway alignment are acceptable.

Railway to Sandgate Road

The flooding depths between the North Coast railway and Sandgate Road were increased as the construction activities encroached upon areas of high velocity flow in the floodplain. The level of impact was measurable with levels increasing by approximately 120mm in some areas.

Mitigation measures were put in place by increasing the capacity of Eagle Junction Creek to act as a better conveyor of floodplain flow that passes through the railway underpass. This assisted in the reduction of the flood levels however the full extent of the impacts could not be removed.

The North Coast railway and the Sandgate Road bridges over Kedron Brook are very inefficient in the Q100 flood. Therefore, they are also inefficient at passing impacts of the encroachment upstream and downstream. Some of the increased flood levels upstream of the railway may be attributed to the increased flooding in the area between the bridges. However, the flooding impacts were largely limited to that zone.

Downstream of Sandgate Road

Flooding depths downstream of Sandgate Road were generally not affected by construction. Some minimal impact occurs in the southern carpark of the Toombul Shopping Centre with maximum impacts of 30mm in this area. It has been recommended that the Kedron Brook/Schulz Canal channel downstream of Sandgate Rd be widened in the developed case to mitigate long-term impacts. If this were to be constructed at the beginning of the construction phase, flood impacts in this area would be minimised. This could also potentially help improve upstream impacts.

Operation

Measures incorporated into the design and operation of the tunnels to manage accidents and hazardous incidents during tunnel operation are outlined below. The safe and effective operation of the tunnel would be monitored and controlled from the Tunnel Control Centre. All data collected by the in-tunnel monitoring systems will be processed and all services 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

Dangerous Goods vehicles would be precluded (by regulation) from access to the tunnel. In the event that they use the tunnel and are involved in an accident, the Incident Management Plans (dealing with spillage of dangerous goods and fire) incorporated in the Operation Environmental Management Plan will be implemented.

Traffic Management and Control System

The traffic management and control system would enable operators in the tunnel's Traffic 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.

A Closed Circuit Television (CCTV) system would provide "real time" visual information to the tunnel operators, with cameras installed at the portals, in the cross passages and at 150m intervals in the tunnels. The cameras will be remotely controlled, with those in the tunnels having pan, tilt and zoom capability. The images collected by all of the cameras will be fed to a central processor in the Tunnel Control Centre. 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 will 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.

Loop detectors installed in the pavement at distances about 150 metres apart may also detect incidents in the tunnel. In a manner similar to that of the CCTV, 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.

All vehicles approaching the tunnel 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 with instruction 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 control 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 centres 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 500 metre spacings, which will be used mainly in the event of incidents in the tunnel.

Adjustable speed limit signs would be installed in the tunnel and along the approaches. Weigh-in-Motion detectors will 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 may also be delivered to tunnel occupants via radio rebroadcast breakthrough or a Public Address system. The Public Address system would be separately controllable 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, communications point containing three telephones would contain a Motorist Help Telephone, an Operation and Maintenance Telephone and a Fire Coordination Telephone.

Fire Protection

Heat detectors would be the primary method of detecting a fire in the tunnels, with visual backup provided by the Closed Circuit Television (CCTV). 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

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 120 metre intervals link the main running tunnels. These provide access to, or means to arrive at, a place of safety in the event of an incident. In the portal areas beyond the final cross passage location, an egress tunnel is provided to allow access to the surface. 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 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 of the tunnel. In the region of the fire, smoke dampers on the underside of 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 on several factors.

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 will take place automatically, as the pressure in the fire main will 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:

- 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 are:

- Threats to the integrity of the structure (e.g. 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 apparently low, the consequence has a potentially high rating. Implementation of a suite of countermeasures is recommended to mitigate both the potential threat and consequences. Countermeasures 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.

The following are recommended approachs to mitigate threats:

- 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 and incorporated into the Operation Environmental Management Plan.

Flooding (Works Inundation) Control

Given the susceptibility and the potential implications of inflows to the tunnel, a flood study was undertaken (refer to Technical Paper No 8 – Flooding and Drainage Issues in Volume 3 of the EIS) to investigate and 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 10,000 year ARI design 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 100 year ARI design event as a minimum.

Upstream Flooding

Southern Connection

The additional structures erected in the flood plain for the southern connection have the potential to increase flood levels upstream of the construction work. Given the height of the proposed connections in linking with existing networks and the requirement for 10,000-year ARI flood immunity for tunnel portals, the decks of new bridges would need to be designed to be above the existing 100-year flood levels. The NSBT design requires numerous new structures, whereas the Airport Link design requires just one. Therefore, Airport Link is likely to have a negligible cumulative effect. The main potential impacts for additional structures are attributable to approach embankments that can impede existing flow paths and additional piers in the waterway causing additional head loss. To minimise hydraulic impact of structures, consideration would need to be given to the use of embankments versus construction on a minimum of piers within the floodplain.

North-western Connection

At the north-western connection the Kedron Brook 100-year ARI flows are conveyed entirely within the channel, the hydraulic impact of the proposed construction under that event is limited to the impact of the abutment and pier configurations of additional structures adding to flow impedance within the channel section. New bridge works across Kedron Brook would be designed with:

- Removal of the embankment from the channel through the new downstream bridges;
- Construction of pier groups with a similar or smaller profile than the existing bridge; and
- Soffit elevation higher than existing structure above the design Q100 flood level.

These works are required to reduce upstream water levels under extreme flood events and to achieve the immunity requirements (10,000year ARI) for the tunnels. The impact of the proposed additional structures at the north-western connection was assessed using the Austroads Bridge Calculation (AustRoads, 1994). The upstream impact of the additional structures was calculated to be less than 40mm, using conservative estimates. Increases in peak flood levels of this magnitude would be acceptable, as no adjacent property would be adversely affected because the 100ARI flood level remains within the Kedron Brook channel. The detailed design stage requires further hydraulic modelling to accurately define the 100 year ARI peak water surface level upstream of the bridge and this would be required as input to the design of soffit and deck levels of the proposed structures.

There is potential for catchment flooding to be affected by the protection of the tunnel portals from the 10,000 year ARI flood. The portal is outside the Kedron Brook 100 year ARI floodplain but local drainage patterns may be affected. The impact on local catchment flooding can be managed through relatively minor stormwater drainage works. A key component of the drainage design would be maintaining adequate drainage routes for the existing Gympie Road and Stafford Road overland flow paths to Kedron Brook.

North-eastern Connection

Existing Flooding Characteristics

Hydraulic modelling of Kedron Brook in the vicinity of the north-eastern connection found that existing flooding characteristics are extensive. The main waterway areas experienced very fast moving flows (over 2 m/sec) exacerbated by water throttling through the bridge structures of the North Coast railway and Sandgate Road.

The five zones of flooding are:

- Eagle Junction Creek;
- Upstream of the railway embankment;
- Between the railway and Sandgate Road bridges;
- Downstream of Sandgate Road; and
- South of the East-West Arterial Road.

Eagle Junction Creek is only a minor contributor to flooding upstream of the North Coast railway. Flood flow backs up this channel from Kedron Brook with this volume creating the majority of flooding impacts in this area.

Upstream of the railway embankment, flood flow is not contained within bank and breaks out to cover the whole floodplain. The railway causes a significant obstruction to this flow. The bridges under the railway are relatively small compared with the floodplain width and this reduction in conveyance causes water to pond upstream of the railway embankment and increases water velocities through the bridge openings. The Sandgate Road bridge also acts as a major restriction to flow. Flooding between the railway and Sandgate Road is entirely controlled by these two structures as there is not sufficient distance between the two bridges to allow flowpaths to completely expand after the railway bridge before it is forced to contract through the Sandgate Road bridge.

Downstream of Sandgate Road, the majority of the flood flow is contained within the channel, although the East West Arterial Road acts as a barrier along the southern edge of the floodplain. The area to the south of the East West Arterial is predominantly inundated by flow backing up from Kedron Brook via large culverts under the East West Arterial and the Widdop Street underpass. The road embankment blocks this flow, resulting in ponding on the southern side. Some local catchment flooding occurs in this area.

Technical Report No. 8 – Flooding and Drainage Issues in Volume 3 of the EIS details the basis for the flood modelling of the north-eastern connection area during operation. Important points are that the opening under the railway embankment would be deepened to accommodate flow during flood events, and the channel of Schulz Canal between the North Coast railway and Widdop Street would be widened by up to 15 metres to increase flow volume. The modelling indicates that diverting Eagle Junction Creek back to its original alignment and removing the construction area removed flooding impacts upstream of the railway alignment. Some reduction of water surface levels occurs in some areas upstream of the railway. This reduction could be as much as 30mm.

Flooding impacts would remain in the corridor between the railway and Sandgate Road as the on ramp and off ramp transition structures encroach on the floodplain of Kedron Brook that flows at high velocity. Additional floodplain capacity could be added by widening Kedron Brook channel. However, this has minimal (allowing more water to pool) effect between the two structures as the flow is trapped by the two structures.

There are no houses or properties on the southern floodplain in this reach. On the northern floodplain, there would be some limited property impacts, with possible increases in water levels of up to 60-70mm on properties already affected by flooding. Localised mitigation works that will be identified through detailed design are able to avoid adverse impacts on these properties.

Downstream of Sandgate Road, it was found that earth embankments which transition out of the main tunnel onto the East West Arterial encroached on the floodplain. Their impact on flood levels would be mitigated through the increase of the main Schulz Canal cross section, and was not propagated downstream.