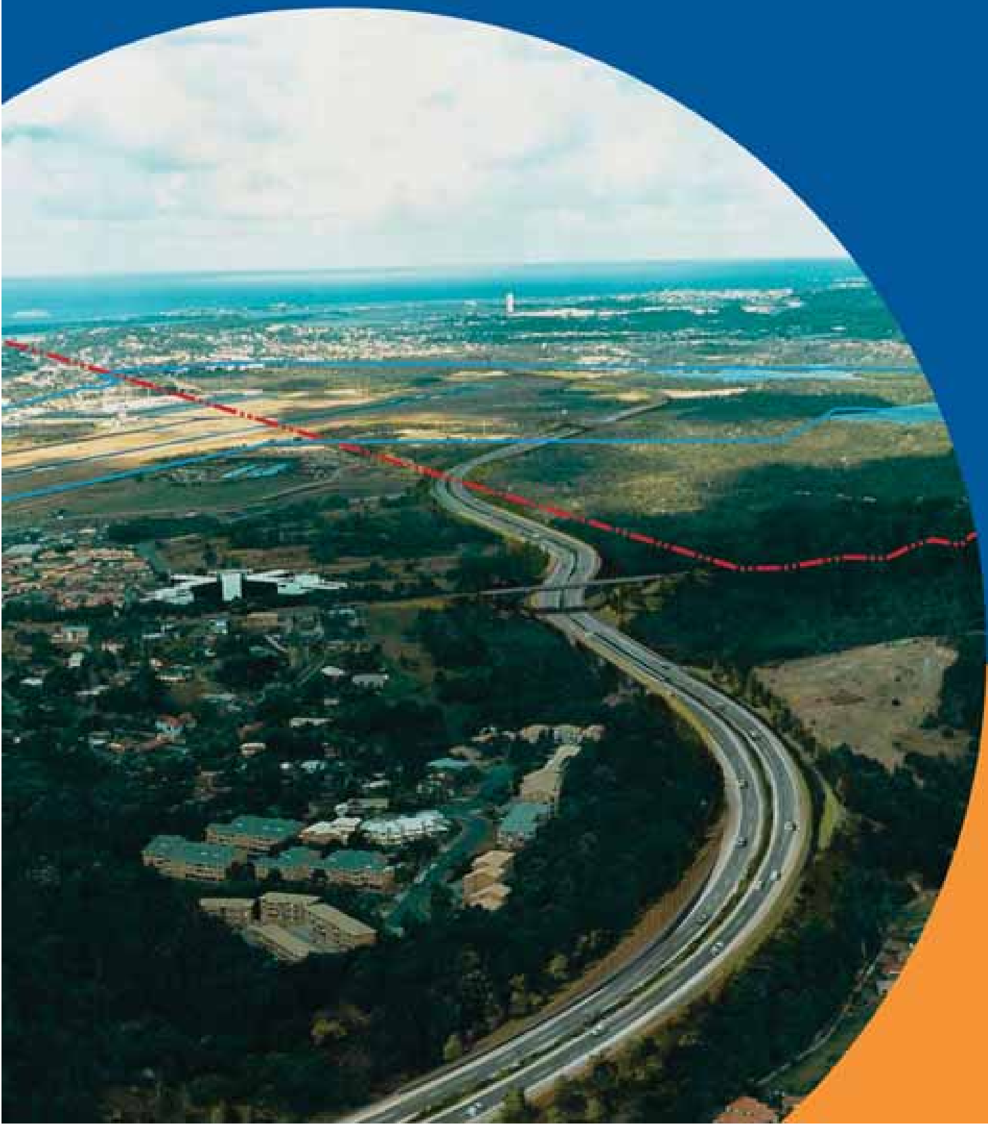
Australian Government
Department of Transport and Regional Services

RTA

Queensland Government
Department of Main Roads

TUGUN BYPASS

stewart road to kennedy drive



Technical Papers

December 2004

Tugun Bypass Environmental Impact Statement

Technical Paper Number 2
Engineering Design

Tugun Bypass Alliance

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1. Introduction

This technical paper defines the engineering design of the proposed Tugun Bypass, which is the subject of an environmental impact assessment.

1.1 General Description of the Proposal

The proposed Tugun Bypass would involve the development of a new road linking Stewart Road, Currumbin in south-east Queensland, to Kennedy Drive, Tweed Heads in northern NSW (Figure 1.1). The proposal passes to the west of existing coastal development and traverses rural and undeveloped hinterland and a section of the Gold Coast Airport. A section of the road would be constructed in a tunnel through part of the Gold Coast Airport to accommodate the obstacle limitation surface for the airport.

The proposal would be a motorway-standard road, similar to the existing sections of the Pacific Motorway. The road would initially be constructed as a four lane divided carriageway, with the capacity to expand to six lanes in the future.

The proposed Tugun Bypass project also includes provision for a future extension of the existing railway from Robina to the Gold Coast Airport. Construction of the future rail project would be the subject of a separate impact assessment process.

Figures 1.2a to 1.2e inclusive show perspectives depicted by photomontages of the Tugun Bypass proposal.

1.2 Summary of the Technical Paper

A summary of the details included in the various chapters of the technical paper is noted below.

Chapter 2 – Design criteria for the road design. This includes the road geometry, tunnel standards and systems, flooding and drainage, water quality management and other ancillary facilities for the bypass. Particular attention is given to design, safety and management measures for the tunnel proposed at the southern end of the bypass.

Chapter 3 – Design criteria used for the possible future rail. This is outlined in a similar way to the road design criteria and with appropriate attention to tunnel design and safety.

Chapter 4 – Constraints and needs. This includes planning, engineering, environmental and community issues. Constraints are described in general terms, with reference to other technical papers for further detail. Airport constraints have been derived from the Master Plan for Gold Coast Airport and associated documents.

Chapter 5 – Concept design for the Tugun Bypass. This chapter outlines the design of the road developed to satisfy the specified design criteria and identified constraints and needs. Detail covered by the concept design includes alignment, interchanges and connections to the local road network, property acquisition requirements, provision for fauna movements, management of flooding and other water regimes, pedestrian and cycle access, road pavements, provision for lighting and other services, noise, visual and landscape requirements.

Chapter 6 – Concept design of road structures. This includes bridges, tunnels and other major structures. Alternative structural concepts are included for future consideration in a number of cases. Particular attention is given to the road tunnel due to its significance for the whole proposal.

Chapter 7 – Construction issues. This includes project delivery and programming, construction methods, traffic management at interfaces, geotechnical issues, sources and transport of materials, workforce, environmental management and auxiliary construction facilities such as construction compounds and batch plants.

Chapter 8 – Cost Estimates. This chapter outlines the cost estimate for the Tugun Bypass.

1.3 Approach to the Description of the Proposal

This technical paper consists of a description for the proposed Tugun Bypass which is the subject of the environmental assessment. It is based on the preferred option which resulted from previous studies of alternatives for both road and rail alignments from Stewart Road to Kennedy Drive (Main Roads 1999). This preferred option was known as Option C4. During the course of the studies undertaken for the environmental assessment, additional constraints affecting the proposed alignment were identified, and the proposal refined as a consequence.

This refined option is subject to the environmental assessment and described in the technical papers. Occasional reference to and comparison with Option C4 is made in the paper.

1.4 Reporting of Study Findings in the EIS

The studies for the Tugun Bypass environmental impact assessment commenced in 2000. In the subsequent four years the results of the various studies have been used to refine the concept design of the proposal. Further studies were also commissioned to ensure that all aspects of the various environmental issues were fully understood.

The long time period of the assessment has meant that the content of some of the earlier reports has been superseded by newer work. Changes to the design of the bypass have also been introduced to take account of these studies.

In the event that there is a contradiction between the technical papers and the text of the EIS, the EIS takes precedence as it reports the current understanding of issues, impacts and the concept design.

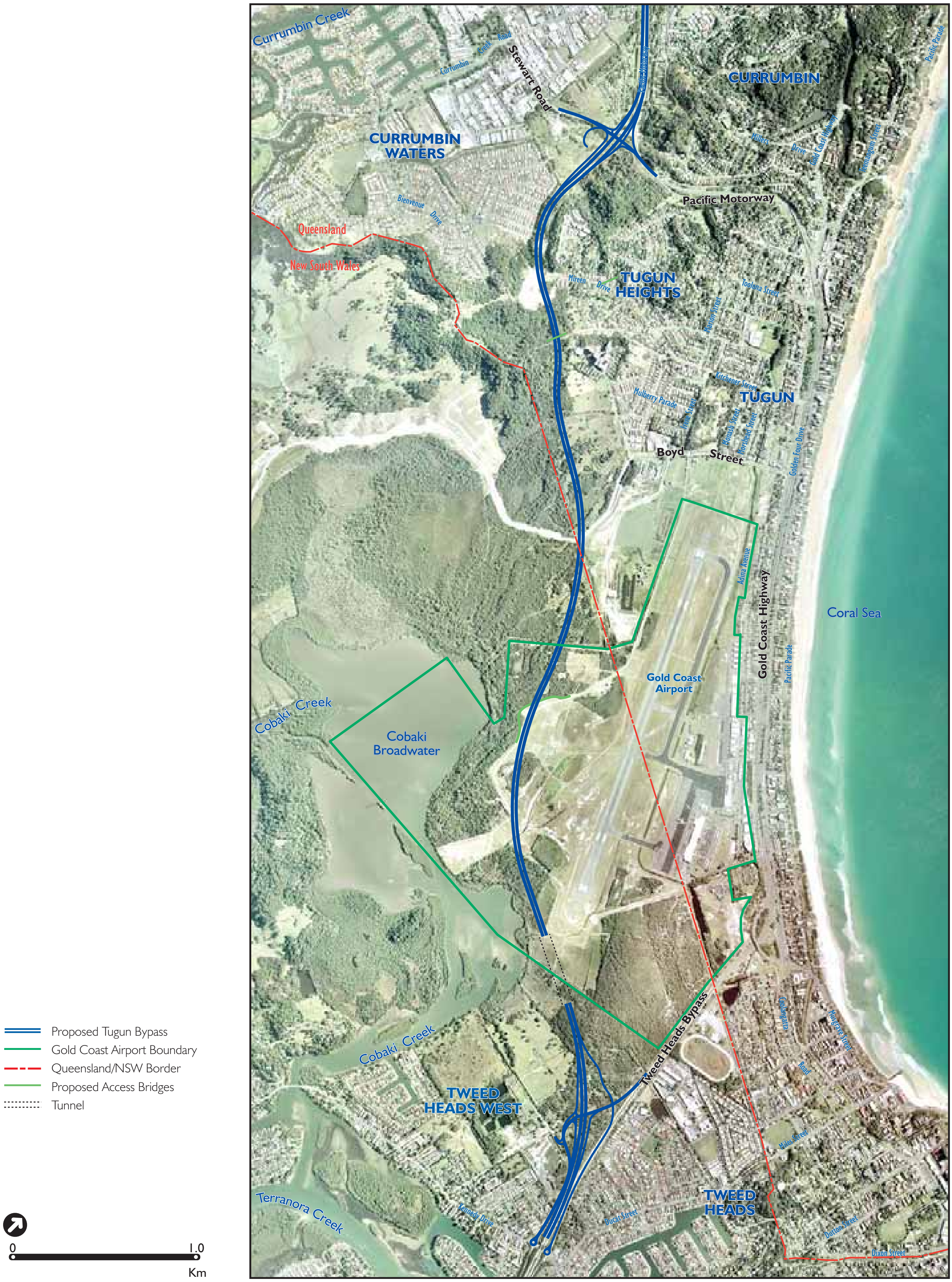


Figure 1.1 **Proposed Tugun Bypass**

Figure 1.2a **Stewart Road Interchange Looking Towards Tugun**

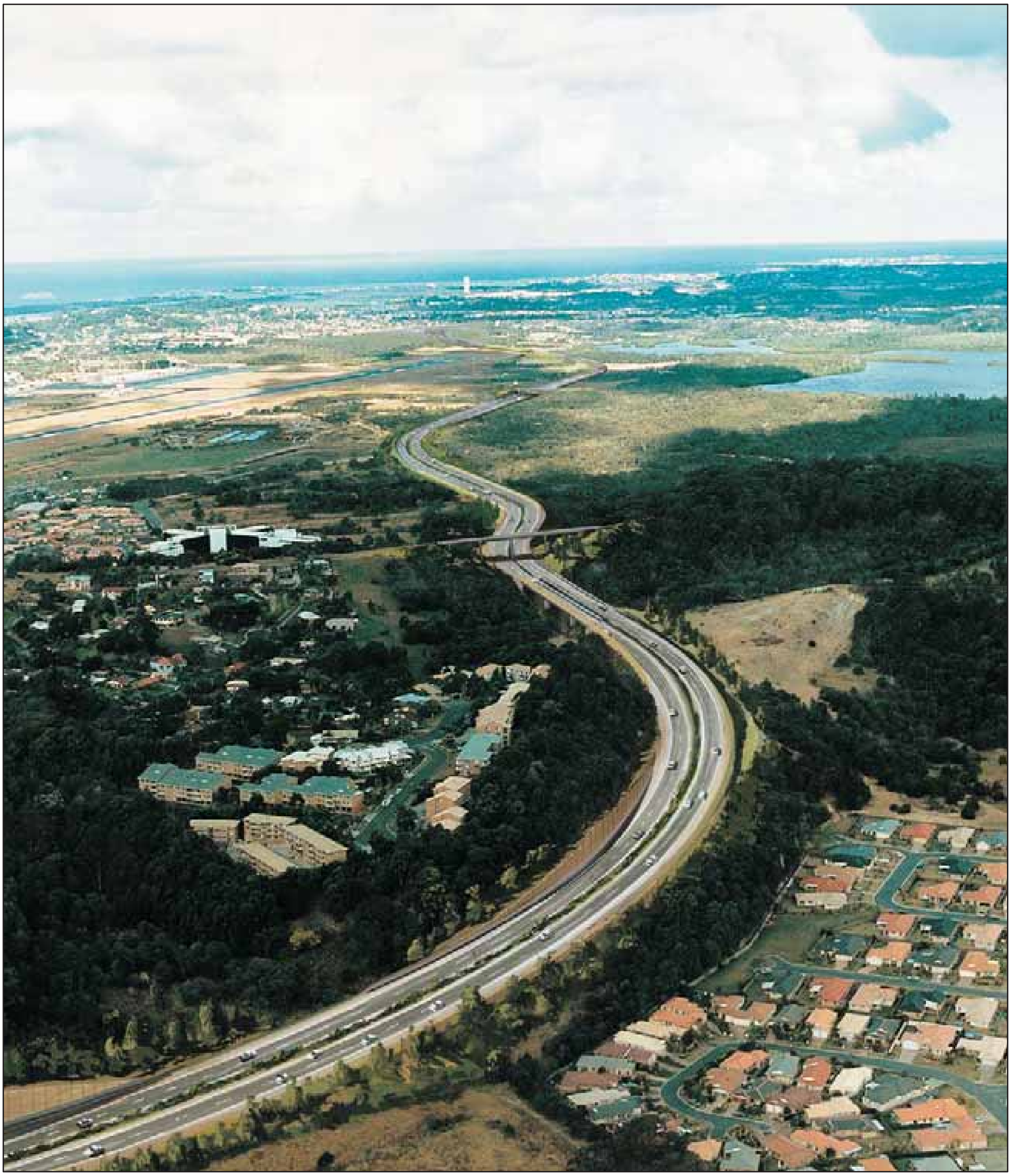


Figure 1.2b **The Tugun Bypass Looking South**

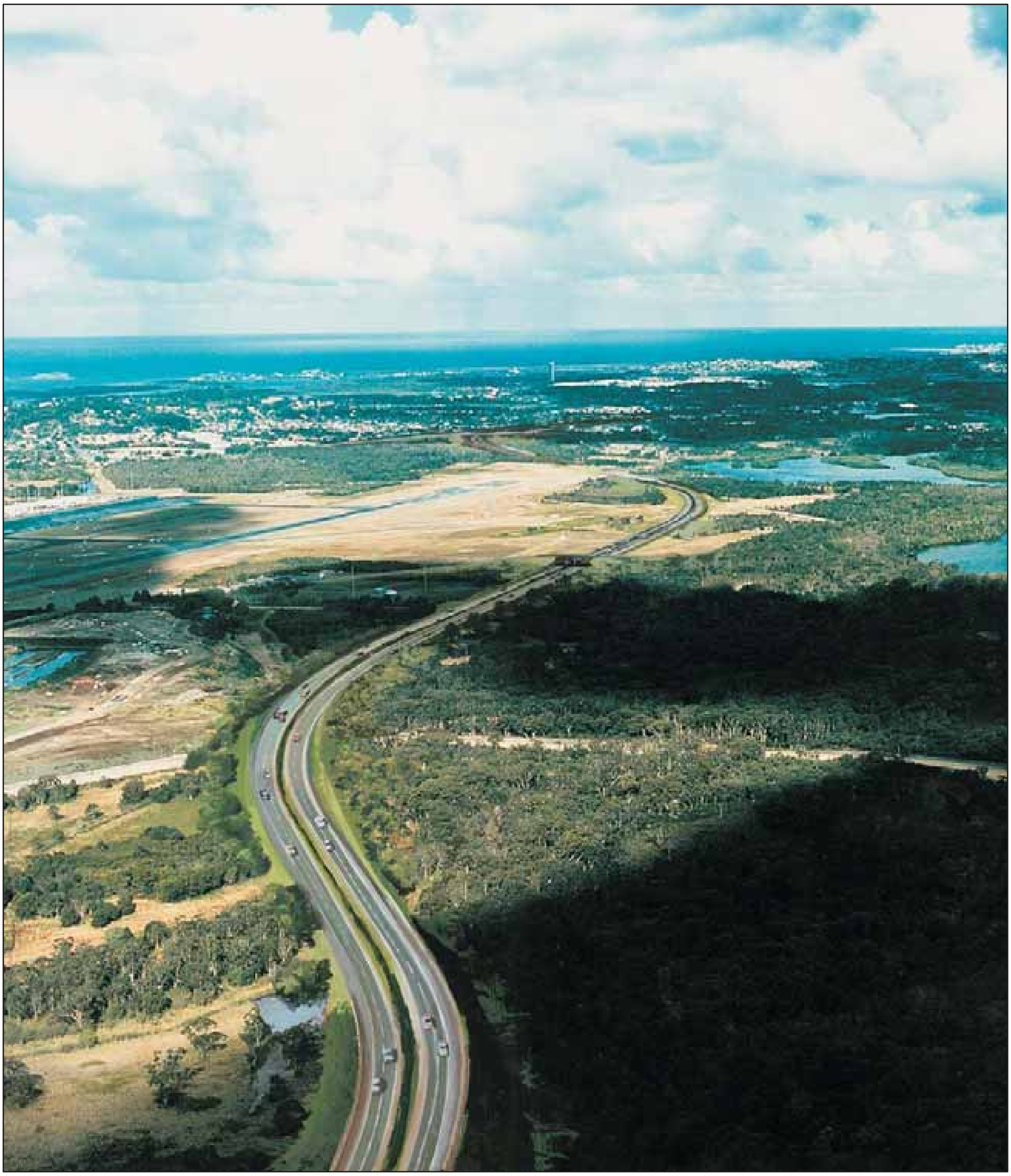


Figure 1.2c **The Tugun Bypass looking South from Tugun Heights**

Figure 1.2d **View of the Proposed Tugun Bypass Crossing Gold Coast Airport to Enter the Tunnel at the Southern End of the Main Runway**

Figure 1.2e **View of the Tweed Heads Bypass Interchange Looking Towards Coolangatta**

2. Design Criteria – Tugun Bypass

2.1 General

The Tugun Bypass has been designed in accordance with current design guides from AUSTROADS, Queensland Department of Main Roads (Main Roads) and the NSW Roads and Traffic Authority. These road design documents include the following:

- AUSTROADS 1989, Rural Road Design – Guide to the Geometric Design of Rural Roads;
- AUSTROADS (formally NAASRA) 1984, Grade Separated Interchanges – A Design Guide;
- Main Roads 2001, Road Planning and Design Manual;
- NSW Roads and Traffic Authority 1988, *Road Design Guide*.

In addition, appropriate standards for the road and tunnel sections have been determined for this project through research of Australian and international practices.

Further refinements of the adopted design standards are possible in consultation with Main Roads and NSW Roads and Traffic Authority at the detailed design stage.

Design criteria have been selected appropriate to high standard highways and motorways in both NSW and Queensland. Particular reference has been made to the Pacific Motorway/Highway north and south of the Tugun Bypass to achieve consistency of planning and design. Sections of the Pacific Motorway/Highway considered for comparison are as follows:

North:

- Currumbin to Nerang; and
- Nerang to Logan Motorway.

South:

- Tweed Heads Bypass; and
- Yelgun to Chinderah.

All elements of the bypass design are to be approved by both Main Roads and NSW Roads and Traffic Authority.

Design of the Tugun Bypass was undertaken in conjunction with the proposed extension of the rail line to Gold Coast Airport to guarantee compatibility of road and rail alignments. Rail design criteria are included in Chapter 3.

2.2 Road Geometry

2.2.1 Design Speed

The design speed proposed for the Tugun Bypass is 110 km/h with a posted speed of 100 km/h.

Adjacent sections of the Pacific Motorway/Highway, built or planned, from Nerang in Queensland to Chinderah in northern NSW, have design speeds of either 100 km/h or 110 km/h.

Adjacent sections of the highway to the north and south are likely to be limited to 110 km/h for all future upgrading. Hence consistency of design speed and alignment standards would also be achieved by adopting a design speed of 110 km/h on this section of the highway.

The design speed of adjacent local roads will be to Council requirements, generally 60 to 80 km/h.

2.2.2 Alignment Standards

The following alignment standards are appropriate for a multi-lane highway with 110 km/h design speed:

- Minimum stopping sight distance for cars on level grade — 210 m
- Minimum sight distance to nose of exit ramps — 300 m
- Desirable minimum radius of horizontal curves — 1,200 m
- Absolute minimum radius of horizontal curves (with provision of widened sight lines) — 620 m
- Superelevation for radius between 620 m and 1,000 m — 4 percent
- Superelevation for radii between 1,000 m and 3,000 m (superelevation not required for R > 3,000 m) — 3 percent
- Desirable maximum gradient (see below) — 3 percent
- Absolute maximum gradient (see below) — 5 percent
- Desirable radius of crest curves — 12,600 m
- Minimum radius of crest curves for sight distance — 9,500 m
- Minimum radius of sag curves for driver comfort — 5,000 m

The maximum gradients would be determined following consideration of the following:

- truck speed changes over long gradients – to ensure that safe traffic conditions are maintained, both up-hill and down-hill, and that the need for additional lanes is avoided; and
- truck speeds and momentum on the tunnel approach ramps – to ensure safe traffic conditions in the tunnel and approach ramp environs, and adjacent to the Tweed Heads Bypass interchange entry and exit ramps.
- These issues will need to be considered further during the detailed design of the project.
- Further comments on tunnel alignment standards are given in Section 2.4.2.

2.2.3 Cross Section

Typical open road cross-sections proposed for both the initial four-lane and ultimate six-lane bypass configurations are shown in Figure 2.1.

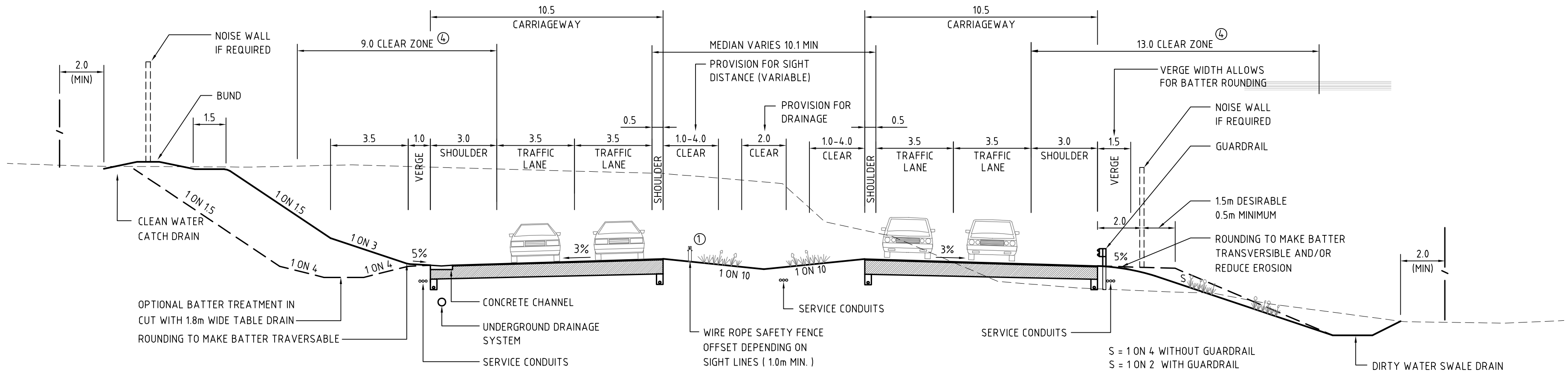
The design of the initial four-lane bypass is based on the following widths:

▪ Outer shoulder	3 m
▪ Traffic lanes	3.5 m (outer) 3.5 m (inner)
▪ Inner shoulder	0.5 m (minimum)
▪ Verge sight line widths (depending on horizontal radius)	1 m to 4 m
▪ Median (laneline to laneline)	10.1 m (minimum)
▪ Vegetated median	9.1 m (minimum)

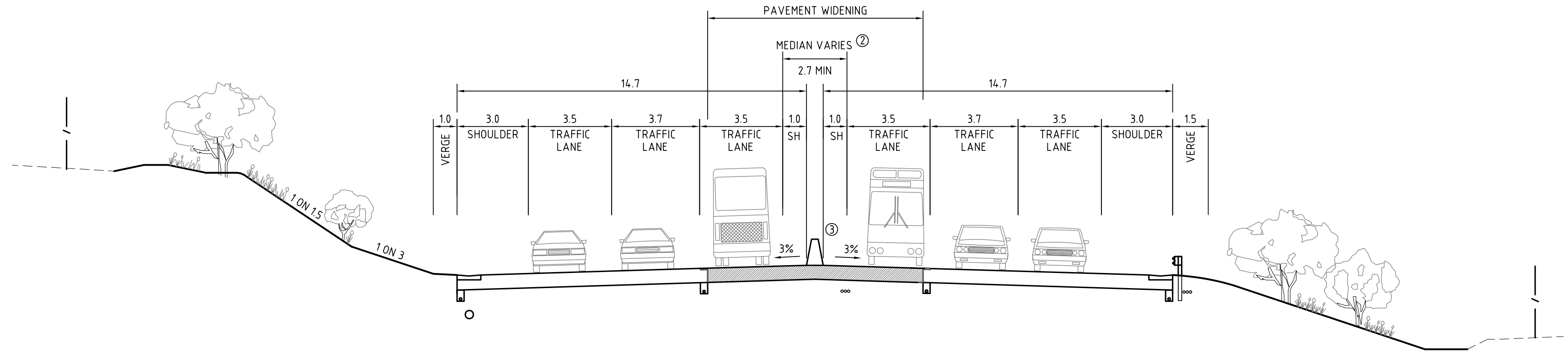
Planning for the ultimate six-lane bypass is based on the following widths:

▪ Outer shoulder	3 m
▪ Traffic lanes (general traffic)	3.5 m (outer) 3.7 m (central) 3.5 m (inner)
▪ Inner shoulder	1 m (minimum)
▪ Verge sight line widths (depending on horizontal radius)	1 m to 4 m
▪ Median (laneline to laneline)	2.7 m (minimum)
▪ Concrete median barrier (where required)	0.7 m

Reductions in shoulder widths are proposed for bridges and tunnels. Sections 2.3 and 2.4 provide further details.



TYPICAL FOUR LANE SECTION



FUTURE WIDENING FOR SIX LANES

NOTES

1. 1.5min. DISTANCE FROM EDGE LINE TO WIRE ROPE SAFETY FENCE TO ALLOW FOR DEFLECTION OF ROPE.
2. MEDIAN WIDTHS WILL VARY TO MEET SIGHT DISTANCE REQUIREMENTS AND ADJACENT TO BRIDGE PIERS
3. CONCRETE SAFETY BARRIERS USED TO MINIMISE CROSS-SECTION WIDTHS. NARROW PLANTED MEDIANS WITH WIRE ROPE SAFETY BARRIERS ARE POSSIBLE FOR SOME LENGTHS IN THE NORTHERN SECTION DUE TO WIDTHS REQUIRED FOR SIGHT LINES.
4. THE WIDTH OF CLEAR ZONE HAS BEEN BASED ON THE WEIGHTED AVERAGE OF CLEAR ZONE REQUIREMENTS FOR EACH INDIVIDUAL BATTER SLOPE. BATTERS WITHIN THE CLEAR ZONE SHOULD BE. KEPT RELATIVELY SMOOTH.

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Figure 2.1 Typical Cross Sections - Roads

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Planning for possible transit lanes for the ultimate six-lane bypass is discussed in Technical Paper Number 3. The warrant for transit lanes is marginal, and because the corridor is so constrained, it is not proposed to increase the width of the cross-section to allow for transit lane buffers and wide inner shoulders. (It should be noted however that the adoption of standard lane and shoulder widths would not preclude the introduction of transit lane operations at some future date if required.)

Safe roadside verges are a critical component of the cross-section. Wide flat obstacle-free clear zones are preferred. However, to minimise impacts on environmentally sensitive areas and properties, it is proposed to use safety barriers in many areas to minimise the footprint of the project.

For the four-lane bypass, guardrail is proposed for the outer verge and wire rope safety barrier for the inner verge. A mix of wire rope and concrete barrier is proposed for the median of the ultimate six-lane bypass.

Entry and exit ramp design is based on the following widths:

▪ Traffic lanes	4 m for single lane ramps 3.5 m for two lane ramps
▪ Outer shoulder	2 m
▪ Inner shoulder	1 m

For particularly constrained locations, such as tunnel approaches, entry and exit ramp widths could be reduced from 7.0 m to 6.0 m as follows:

▪ Traffic lane	3.5 m
▪ Outer shoulder	2 m
▪ Inner shoulder	0.5 m

Crossroads at the major interchanges (Stewart Road and Tweed Heads Bypass) are based on the following widths.

▪ Traffic lanes (the number of traffic lanes at each interchange is determined by traffic requirements)	3.5 m
▪ Outer shoulder (sufficient for cyclists)	1.5 m
▪ Inner shoulder	0.5 m
▪ Concrete median (sufficient for pedestrian refuge)	2 m
▪ Footpath (one side only)	2.5 m

The connecting two-lane two-way service roads between the Kennedy Drive and Tweed Heads Bypass interchange are based on the following widths:

▪ Traffic lanes	2 x 3.5 m
▪ Shoulders	2 m
▪ Footpath (property side only western service road)	4.5 m

2.2.4 Interchange and Intersection Geometry

All interchanges and intersections would be designed in accordance with Main Roads *Road Planning and Design Manual* (Main Roads 2001) and the NSW Roads and Traffic Authority *Road Design Guide* (1988).

The design vehicle to be used for the design of interchanges would be a 25.0 m B-double and for the design of other intersections would be a 19.0 m semi-trailer.

Provision is also required for B-triple operations for the Stewart Road interchange east to north movement, and Tweed Bypass interchange south to east and east to south movements.

2.3 Road Bridges

Bridges would be designed in accordance with following documents:

- *Roads Policy Manual* (Queensland Transport 1993);
- *Bridge Policy Manual* (NSW Roads and Traffic Authority 2000)
- *Australian Bridge Design Code* (AUSTROADS and Standards Australia 1992 – 1996); and
- Standards Australia 2000 Draft Bridge Design Codes DR00374 – DR00379.

Design loadings would be in accordance with the Draft Code DR00375, which replaces the AUSTROADS T44 and HLP320 loadings with M1600 and S1600 loadings. This results in significantly increased design loads for some bridge structures.

Current clearance requirements to the underside of highway bridges and tunnels are:

▪ Main Roads	5.5 m (with suitable bypass) 6.0 m (no suitable bypass)
▪ NSW Roads and Traffic Authority	5.3 m

A minimum bridge clearance of 5.5 m is proposed for this project.

A reduced clearance of 5.3 m is proposed for the tunnel, as discussed in Section 2.4.3.

Bridge widths are generally in accordance with road cross-section requirements detailed in Section 2.2.3. Reduction of the outer shoulder width from 3 m to 2 m is proposed for the Hidden Valley highway bridges.

Access bridges are also proposed for the property access bridge to the west of the John Flynn Hospital and Medical Centre, and the airport access bridge to the western side of the proposed bypass.

Concrete barriers would be used along the sides of all highway bridges, while on local roads, concrete barriers would be used as separators between traffic lanes and footpaths on bridges.

Throw-over protection barriers are proposed on all overpass bridges along the bypass to prevent objects being thrown onto the highway.

Anti-graffiti coating would be provided on all accessible services to a minimum of 3 m above the ground.

All bridges would include drainage systems to collect pollutants from the bridge decks for treatment prior to discharge into the waterways.

2.4 Road Tunnel and Approach Ramps

2.4.1 General Tunnel Requirements

The design of the road tunnel at the southern end of Gold Coast Airport is a major component of the proposal as there are significant operational, safety and structural issues to be addressed.

Worldwide research indicates that crash rates are significantly lower in tunnels than on equivalent sections of open roadways – due to heightened driver awareness, concentration and caution, reduced speeds and provision of additional safety features. However, when crashes occur in tunnels the consequences can be extreme. There have been a number of tunnel disasters overseas involving the loss of many lives due to fire and entrapment, and clear lessons can be learnt from reports on these incidents.

Modern tunnel systems and practices can prevent or minimise loss of life to a great extent. The planning and design of the tunnel must include a complete range of safety components, over a number of operational areas, including:

- road design;
- lighting;
- ventilation;
- flood protection and stormwater pumping;
- traffic management systems;
- incident and emergency response plans;
- smoke control;
- emergency egress facilities for evacuation of personnel;

- fire suppression;
- highly reliable power supplies;
- management of dangerous goods; and
- structural design, including fire-resistant construction technology.

Unlike roads and bridges, there are no Australian guides or codes for tunnels. In developing appropriate tunnel requirements for this project, reference has been made to the following:

- American National Fire Protection Association Standard for Road Tunnels (National Fire Protection Association 1998);
- other international standards and practices; and
- standards and practices employed or planned for Australian tunnels.

The references considered in the preparation of this section are as follows:

- Bendelius 2001, Life at the End of the Tunnel;
- British Institution of Civil Engineers 2001, St Gotthards's Tunnel Collapse and Safety Implications;
- Flett Steele 2001, Tunnelling to the Future;
- Highway Engineering in Australia Article 2000, *The New Adelaide Crafers Highway;*
- Hunnaball 1999, Clearing the Air;
- Kelly 1999, Tunnel Design – Performance and Safety Design Issues;
- Parsons Brinckerhoff Notes 2001, *Going Beneath the Surface;*
- PIARC Technical Committee Report Number 5 1987, *Road Tunnels;*
- Risk Corp Australia 1993, Review of Dangerous Goods Transportation through Tunnels for the Proposed M5 East Motorway;
- US Department of Transportation, Federal Highway Administration 1980, *Prevention and Control of Highway Tunnel Fires;* and
- Various reports on the Mont Blanc Tunnel fire 1999.

Additional consultation would be required with appropriate road and emergency services agencies in NSW, and a further report would be prepared at the detailed design stage of the project.

2.4.2 Tunnel Design Speed and Alignment Standards

It is proposed to maintain the highway posted speed of 100 km/h through the tunnel and approach ramps. It is proposed that the tunnel is straight and the approach ramps have comfortable vertical curves for 100 km/h speed of travel.

The design should provide easy viewing of all lanes of traffic through the tunnel and ramps. In addition, the design of the north-facing exit ramp of the Tweed Heads Bypass interchange requires particular care, as it is located within the southern end of the tunnel and approach ramp. The exit ramp and subsequent intersection are to be designed with surplus capacity to ensure that congestion which could cause traffic backup into the tunnel is an extremely rare occurrence.

The potential for driver distraction from adjacent aircraft (direct vision, noise and shadows) also exists on approach ramps and needs to be addressed by warning signs and other means.

Tunnel gradients no greater than 1.5 percent are recommended to reduce breakdown rates. The tunnel gradient currently proposed is well below this, apart from end sections and the open ramps linking back to the above ground sections of the bypass, where the maximum grades reach approximately 5 percent over very short lengths.

In conjunction with the speed and alignment standards described above, selected controls on traffic conditions should be considered to reduce the frequency and consequences of accidents in the tunnel. These controls would include:

- speed management, using 100 km/h under normal operating conditions and a range of lower speeds as required for traffic congestion and any other incidents;
- prohibiting lane changing within the tunnel and approach ramps;
- controls on dangerous goods transportation (see further discussion in Section 2.4.11); and
- enforcement of regulations such as the above.

2.4.3 Tunnel Cross Section

It is proposed that the tunnel is constructed to operate initially with four lanes only. Provision has been made within the cross section of the tunnel to suit an ultimate six-lane configuration.

Figure 2.2 shows a typical cross-section for the four-lane operation. The internal tunnel width of 12.0 m is based on the following:

▪ Outer concrete barrier and tunnel lining	0.6 m
▪ Outer shoulder	2.5 m
▪ Traffic lanes	2 x 3.5 m
▪ Inner shoulder	0.5 m
▪ Inner concrete barrier, emergency walkway and tunnel lining	1.4 m

The internal tunnel height of approximately 6.1 m is based on the following:

▪ Vehicle clearance	5.3 m
▪ Services allowance (ventilation fans, lighting and other services)	0.7 m (approximately)

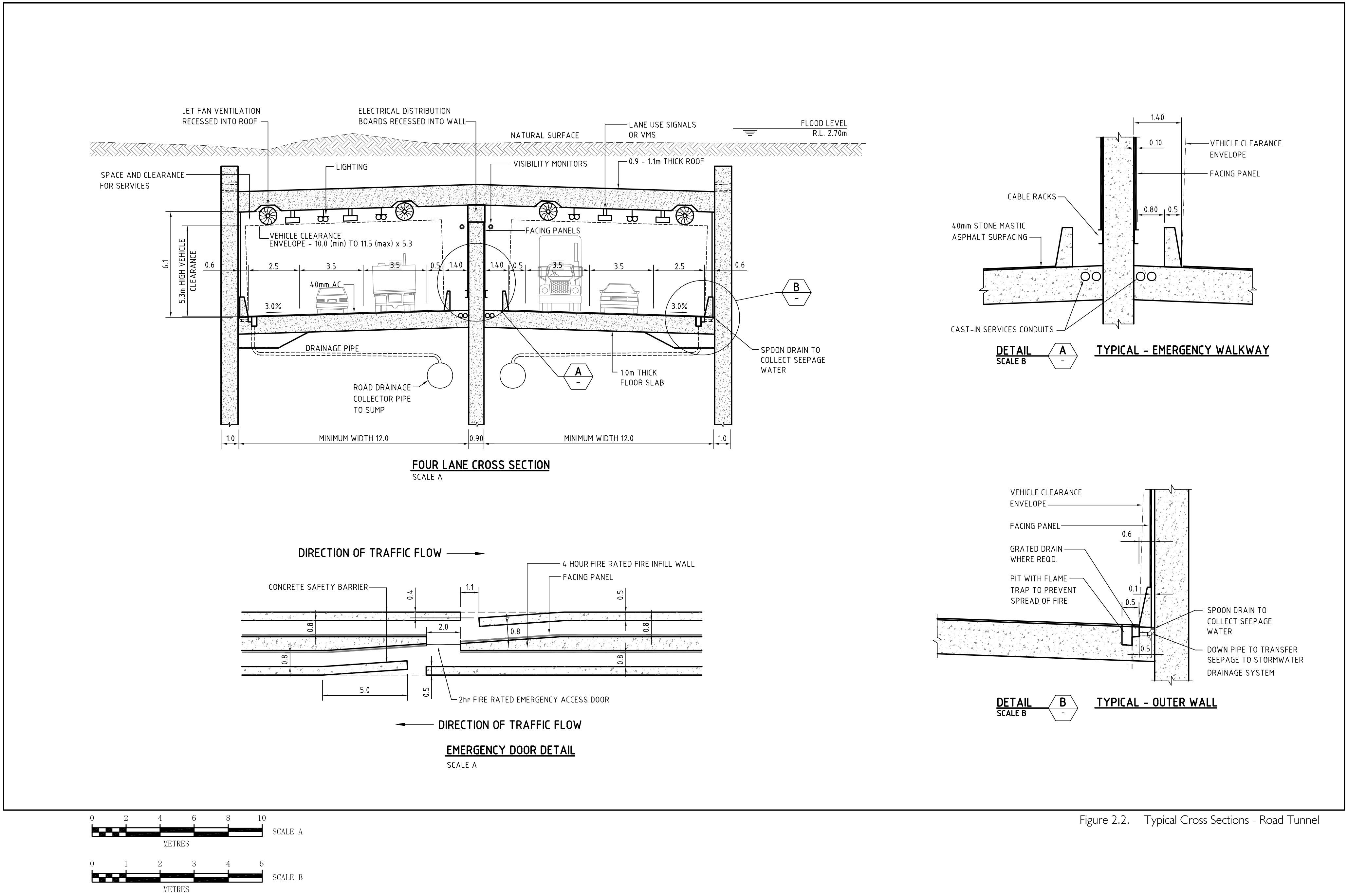

Figure 2.2. Typical Cross Sections - Road Tunnel

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- Asphalt wearing course (40 mm) plus safety margin to vertical clearance (60 mm) 0.1 m

In developing the above cross-section, research and evaluation has been undertaken into the following elements:

- Transit lane operations: no increase in width is proposed to allow for transit lane buffers and wide inner shoulders. This would not preclude the introduction of transit lane operations if required in the future.
- Outer shoulder width: The provision of wide outer shoulders is desirable in terms of overall traffic operations and safety within the tunnel. However the provision of wider outer shoulders is being questioned worldwide, and an assessment of traffic and safety benefits against the costs of additional structure widths is required. For the Tugun Bypass tunnel, the cost of providing additional widths would be significant and the savings in traffic delays and accident costs would not occur until the future six-lane conversion. Hence the provision of wide outer shoulders in the longer-term is difficult to justify. A range of other factors have also been taken into account in accepting narrow shoulders for the ultimate six-lane configuration. These include:
  - overseas research (Germany) which indicates that while tunnels with wide outer shoulders are safer by a factor of almost two for injury crash rates, this also shows that tunnels both with and without wide outer shoulders are safer than adjacent sections of highway (Brilon and Kerstin Lemke 2000);
  - high alignment standards would be maintained through the tunnel and approach ramps;
  - the tunnel is relatively short, reducing exposure to risk, and would contain the full range of safety facilities (lighting, incident detection, smoke control, emergency egress and fire suppression) employed in longer tunnels;
  - wider outer shoulders would be provided for part of the tunnel and approach associated with the entry and exit ramps of the Tweed Heads Bypass interchange;
  - sophisticated traffic management systems are proposed to detect breakdowns, advise motorists and arrange the removal of the disabled vehicle; and
  - with the longer-term six-lane operations, variable speed limits and other traffic management measures could be employed to enhance safety.
- Provision of emergency walkways: no outer emergency walkways are proposed. Inner emergency walkways are proposed, with concrete barrier protection and 800 mm clear width for wheelchair access. Entry points to the walkways and connecting cross-overs through the central wall are proposed at spacings of approximately 100 m. Figure 2.2 shows a suitable layout of the walkways, entry points and cross-overs. The inner walkways are essentially designed for safe and clear passage for:
  - emergency egress from the tunnel;
  - access for emergency services personnel to attend to incidents, including running out fire hoses and a range of other tasks; and
  - access for maintenance works.

The barrier protected inner walkway would only extend for a limited length on each approach ramp sufficient to marshal people evacuated from the tunnel in an emergency incident.

- Height requirements: the minimum traffic clearance specified by the NSW Roads and Traffic Authority of 5.3 m is proposed, along with a minimum practical height for intelligent transport systems (ITS) signage recognition of 0.7 m. To achieve this, ventilation fans would have to be carefully designed with streamlined recesses scalloped into the roof and/or walls of the tunnel. Detailed design would determine ventilation fan sizes and locations, together with roof design details, to confirm final internal tunnel height dimensions. Advance warning systems for over-height vehicles would be desirable, and a tunnel entrance beam set at exactly 5.3 m above the asphalt-wearing course should be considered.
- Service locations: services could be located anywhere clear of the traffic envelope, subject to care in not obstructing signage or ventilation requirements. The walkway would accommodate services within the floor slab to retain the walkway at road level. This is considered preferable to the common practice of having a services chamber above road level with an elevated walkway above this, thereby restricting access to many users.

At the time of conversion from four-lane to six-lane operations, asphalt wearing surfaces of the tunnel and approaches would require replacement to ensure that the changes in linemarking cannot cause any confusion.

2.4.4 Tunnel Lighting

Successful lighting of road tunnels requires a thorough and careful design process. Unlike normal road lighting installations, a tunnel lighting system is required to operate at its peak during daylight hours and react progressively to changes in external light levels throughout the day. The aim of the tunnel lighting is to allow motorists to enter, travel through and leave the tunnel with the same degree of confidence (and at the same travel speed) as on adjacent sections of open road. To do this, the tunnel lighting must be able to reduce the difference between the luminance levels inside the tunnel and those outside so that the drivers eyes have sufficient time to react to the tunnel environment.

Luminance in the tunnel approach zone is used to set all other luminance values within the tunnel. Light sensors located above the entrance portals to each tunnel would be used to register the external illuminance level. The intensity of the lights within the tunnel would then be adjusted according to the values registered by this device. Lighting control for each tunnel would be independent and automatic, catering for the different daylight conditions that occur at each portal. The location of the sun in relation to the tunnel would need to be taken into account when designing the threshold lighting. The use of semi-transparent screening to reduce the daylight levels prior to the tunnel portal can also assist in reducing the effects of contrasting light conditions.

Independent power sources would be provided for the lighting system. An additional backup power supply would be required for specified emergency lighting.

2.4.5 Tunnel Traffic Management and Intelligent Transport Systems

The use of intelligent transport systems to manage traffic through tunnels is more important than on the open road, due to the possible consequences of an incident.

Systems proposed for use in the tunnel and on the approach ramps may include:

- vehicle loop detectors – embedded in each traffic lane and used to monitor vehicle volumes, speed and headway;
- video detection – automated to detect stationary vehicles, pedestrians, objects on the pavement, smoke and other unusual incidents (powerful tool for rapid detection and response);
- variable message signs and changeable message signs – placed before and inside the tunnel to convey brief messages to motorists such as speed reduction, accidents, and lane closures;
- lane use signals – placed in advance and regularly through the tunnel, to give quick messages to motorists regarding lane availability ahead;
- closed circuit television cameras – ceiling or wall mounted, located so that full coverage of the tunnel is achieved, to monitor traffic operations and assist in incident management;
- speed cameras – to detect violations of speed limits;
- other cameras – to detect violations of other regulations such as a ‘no-lane changing’ rule; and
- oversized vehicle safeguards – a range of measures are employed to ensure that over-height vehicles do not enter the tunnel including over-height detectors, flashing over-height signs, last road exit signs, inspection signs and failsafe over-height barriers.

Additional ITS is proposed on the bypass in advance of the tunnel to extend warnings of tunnel incidents. Advance warnings through variable message signs could be located at selected distances (say 1 km and 2 km) and at Stewart Road, Tweed Heads Bypass and Kennedy Drive interchanges.

Backup power is required to maintain ITS operations in an emergency.

2.4.6 Tunnel Ventilation

The initial requirement of ventilation is to maintain air quality for the comfort, health and safety of motorists during normal operating conditions.

The most critical contaminants are carbon monoxide, nitrogen dioxide, and particulates. The tunnel requires sensors for each of these contaminants, linked to the ventilation system to enable automatic preservation of air quality within permissible limits.

The second and most demanding requirement of ventilation is to control smoke and other toxic fumes in the event of a fire. This is covered in fire life safety, Section 2.4.8.

The requirement for independent power sources is stressed to ensure continuing operations in an emergency.

2.4.7 Tunnel Flood Protection and Drainage System

Protection from flooding is proposed for the 1 in 100 year ocean and river flood level. Assessment of river flooding and ocean level rises are discussed in Technical Paper Number 7 and Section 2.6.

A tunnel drainage system is required to collect and control run-off from the following sources:

- rainfall entering the tunnel from the approach ramps;
- fire fighting operations;
- tunnel washdown operations;
- seepage flows; and
- accidental spills.

A drainage collection system of grates, pits and pipes is required, including baffle pits to act as flame traps in the event of flammable liquids spillage. Storage chambers are required prior to pump out. One small pump and three large pumps are envisaged to handle low and extreme flows respectively. Pumped out discharge would normally be directed into adjacent water quality treatment basins. Large quantities of pollutants, from spills for example, would not be pumped out into the water quality basins and would be collected and taken to appropriate off-site disposal depots.

The drainage system would be capable of handling a 1 in 100 year rainfall or fire fighting deluge event, with provision for automatic switching to an emergency power supply.

The pump station would be fitted with an hydrocarbon gas detector and analyser system to provide an automatic alarm when flammable or explosive gases are present in the drainage system.

2.4.8 Tunnel Fire Life Safety

In developing appropriate fire life safety requirements for the project, reference has been made to the following:

- American National Fire Protection Association (NFPA) Standard for Road Tunnels 502 (1998);
- other international tunnel standards and practices;
- Australian tunnel standards and practices; and
- consultation with Australian personnel from Fire Brigade, other emergency services and operation control centres.

A further fire life safety report would be developed at the detailed design stage and all necessary approvals would be obtained.

The essential components of fire life safety are summarised in the following sections.

Emergency Response Plan

Although tunnel fires have been rare, the potential for entrapment and resulting fatalities demonstrates the importance of installing fire life safety systems in tunnels of appreciable length. An effective program for fire life safety in tunnels depends on the coordinated interaction of several sub-systems including:

- detection;
- alarm;
- communications;
- smoke control;
- emergency egress and personnel evacuation; and
- fire suppression.

An emergency response plan is used to formalise and coordinate all systems and emergency procedures. The emergency response plan would be developed in conjunction with the operations control centre, Fire Brigade and other emergency services.

Roles and responsibilities for the tunnel owner/operator, the operations control centre and all other agencies would be defined in the emergency response plan.

A comprehensive list of credible incidents would be prepared, and the most effective response to each incident developed.

Primary and secondary approach routes to each portal would be mapped, including with-traffic and against-traffic options. Emergency access from external points to the ends of the tunnel ramps could also be considered.

The emergency response plan would also include:

- the need for full scale integrated emergency response exercises to be conducted on a regular basis; and
- provisions for periodic review and update.

Detection

The use of heat and smoke detectors for fires is limited, due to vehicle exhaust emissions and time delay between initiation of a fire and detection.

Closed circuit television cameras linked to the operations control centre (refer Section 2.4.9) are generally more useful for primary detection of fires.

Roadway loop detectors are an effective means of alerting the operations control centre staff of stopped traffic and potential problems. Roof mounted linear heat detectors would be installed as a secondary protection system. The loop and linear heat detectors should also be arranged in zones, to assist in determining the incident location. This can be a critical factor in emergency response operations.

Programmed closed circuit television cameras can rapidly and accurately detect a wide range of incidents, including stopped traffic, pedestrians, objects on the road surface and smoke. Camera detection using sophisticated closed circuit television cameras may be used in preference to some of the other detectors mentioned above.

Alarm

The alarm system would activate sound alarms within the tunnel, transmit alarms to the operations control centre and automatically activate appropriate ventilation. The alarm system would be capable of activation in a number of ways:

- manual activation by operations control centre staff;
- linear heat detectors in the tunnel roof;
- smoke alarms located in the switch rooms;
- programmed closed circuit television cameras; and
- manual activation of break-glass units provided in emergency egress pathways.

Communications

Incident management can be greatly improved with systems that provide effective communications to and from motorists. Communication systems to be considered for the Tugun Bypass tunnel include the following:

- closed circuit television cameras;
- mobile phone coverage and re-broadcast system within the tunnel;
- emergency telephones;
- variable message signs;
- traffic signals;
- lighting and signage of emergency pathways, doors and other facilities; and
- public address and radio re-broadcast systems.

Smoke Control

In the event of a fire, emergency ventilation would be activated to minimise the spread of smoke and to maintain safe conditions for evacuation.

The design of the ventilation system requires flexibility so that smoke in any area can be contained and removed from the tunnel effectively. Positive pressure must be maintained in the clean tunnel, and high velocity fully reversible jet fans are required to force smoke downwind from the fire at any point. The capacity of the ventilation system depends on the tunnel length, grade, cross-sections and size of the fire.

Alternatives to longitudinal ventilation would also be considered. Transverse extraction systems are preferred in some European countries.

Full scale fire testing was undertaken in the 1990s in an abandoned road tunnel in West Virginia. The 'Memorial Tunnel' program included some 100 tests simulating various intensities of fires and the effectiveness of different ventilation configurations in controlling the resulting flow of smoke and heat.

Based on full-scale tests such as these, computer modelling of ventilation for the control of smoke and heat would be undertaken during the detailed design phase.

Emergency Egress and Personnel Evacuation

A solid fire rated central wall would be required to separate each carriageway within the tunnel. In the event of an incident requiring personnel to be evacuated, traffic would be stopped in both carriageways, enabling motorists to evacuate from one tunnel into the other via emergency pathways and access doors. Ventilation would be automatically adjusted to keep escape areas clear of smoke and other toxic fumes. Emergency egress lighting and signage is used to direct personnel to the emergency access doors or tunnel portals. The spacing of the emergency access doors is anticipated to be approximately 100 m maximum and would be determined at the detailed design stage through consultation with the NSW Fire Brigade.

Personnel evacuation procedures would be developed and documented in the Emergency Response Plan .

Fire Suppression System

Road tunnels are usually provided with fire hose stations and fire extinguishers for fire suppression purposes.

Water suppression (sprinkler or deluge) systems would be considered carefully. These systems are generally not recommended in the United States for reasons such as steam production, spreading smoke throughout all levels of the tunnel and possible vapour explosions. This has been challenged however, in a recent technical paper which recommends adoption of current Australian practices. In Australia, water suppression systems have been recognised as an important technique for fighting fires and preventing major damage to the tunnel. Australian systems use manually controlled operations, activated after all people are successfully evacuated, focussing on the target area of the fire. Fire detection and fighting systems are divided into independent sections. Deluge systems capable of delivering 10 mm/m^2/minute are typically specified (Dandie and Briggs 2000).

Aqueous film-forming foam systems could also be considered in lieu of water-only suppression systems.

At the detailed design stage, full details of fire suppression systems would be determined in association with emergency services authorities. Approved systems including all emergency operations procedures would be documented in the Emergency Response Plan.

2.4.9 Tunnel Surveillance and Control Systems

The role of surveillance and control equipment for the systems described in the preceding sections is critical to rapid and effective operation of the emergency systems.

This equipment would be linked to an operations control centre where computer systems enable most of the tunnel operations to run automatically. Operators at the control centre would monitor all operations, with intervention only required when there is an abnormality. Automation for predetermined operational scenarios would still be maximised in the event of emergencies, to simplify and minimise operator decisions. This has proved to be of critical importance in ensuring rapid and effective deployment of warning systems, ventilation and other emergency actions, and in reducing operator error.

The location of the operations control centre would be determined through consultation with the NSW Roads and Traffic Authority. Use of an existing control centre is envisaged. This could be in Sydney (NSW Roads and Traffic Authority) or Nerang (Main Roads).

A small control room is proposed adjacent to the tunnel for use when emergency personnel have arrived on site. This control room would also be used for maintenance testing and practice exercises.

The tunnel control room would be limited in height due to the obstacle limitation surface, and would be constructed partially under ground level.

2.4.10 Tunnel Power Supply and Distribution

Highly reliable power supply is paramount to the majority of the fire life safety systems and other systems required for tunnel operations. Three independent power sources are recommended. Two of these would be high voltage mains from different parts of the electricity supply grid. The third source would be a diesel generator automatically started in the event of failure of the other two sources. The diesel generator would require sufficient capacity to drive essential components of the systems. An uninterruptible power supply facility, which stores power for use when other sources fail, would also be provided to cover any transition periods and to ensure that emergency systems remain operable.

2.4.11 Dangerous Goods Transportation Through the Tunnel

Number 16 includes a risk assessment of transporting dangerous goods via the proposed bypass or via the existing route.

Class 1 and 2 dangerous goods (explosives and liquid petroleum gas (LPG)) have been considered separately because of potential damage to the tunnel at the southern end of the airport. Compared to transporting all dangerous goods along the existing route, transporting dangerous goods with the exception of Classes 1 and 2 through the tunnel achieves a significant reduction in societal risk. The technical paper recognises the need to consider potential airport impacts in making a decision on Class 1 and 2 dangerous goods.

Subsequent consultation with emergency services agencies in Queensland and NSW indicated concern over permitting Class 1 and 2 dangerous goods through the tunnel. Consequently, for tunnel safety and the strategic value of the tunnel for highway and airport operations, it is proposed to ban Class 1 and 2 dangerous goods from using the tunnel. Transport of these classes of dangerous goods would continue to be via the existing highway route between Stewart Road and the Tweed Heads Bypass interchanges.

Industry regulation, including approvals to routes for various classes of dangerous goods, would be the primary method of control. Appropriate signage and enforcement would also be required to ensure compliance. The tunnel operating agency would be responsible for establishing and ensuring compliance of dangerous goods transportation requirements.

As further background, the following notes summarise current practices concerning control and management of the transportation of dangerous goods through road tunnels.

- International practices have varied from country to country and over time. Some countries banned or limited dangerous goods, some countries had virtually no restrictions, and others set restrictions depending on the type of tunnel – with long and underwater tunnels being of higher risk.
- The current international trend is for a more open policy on dangerous goods transportation through tunnels. Investigations include quantitative risk assessments of alternatives to estimate consequences, frequencies and hence relative risks. In general, unrestricted access of dangerous goods vehicles to tunnels will normally result in less risk to the public than alternate, longer and more densely populated routes. These assessments and a range of other factors are taken into account in reaching decisions on managing dangerous goods.
- Explosives, radioactive materials, toxic gases and flammable liquids may still be banned in some cases. Alternatively, restrictions can be imposed on vehicle design, loading methods, quantities or times of travel. Escorted travel is another alternative used.
- Tunnel design characteristics are a major factor in the prevention and management of incidents. Research on major incidents indicates that safe environments are typically provided by tunnels which are:
  - short in length;
  - dual tube;
  - large cross-section; and
  - well ventilated.
- Other key requirements for safe tunnels include:
  - adequate lighting;
  - flat grades;
  - avoiding sharp curves and transition points in the tunnel or near its portals;
  - traffic regulations and their enforcement;
  - sophisticated monitoring and automated response systems;
  - safe evacuation routes to fresh air;
  - rapid emergency services access;
  - adequate fire resistance of the tunnel structure and associated services required in emergencies;
  - continuous and consistent training for all operating personnel;
  - regular maintenance testing of all tunnel equipment and systems; and

  - full scale integrated emergency response exercises conducted on a regular basis.

- It should be noted that flammable/combustible goods comprise dangerous goods and a range of other goods (such as margarine and car tyres) which are not classified as dangerous goods. Ways of effectively managing these other flammable/combustible goods are currently being considered by tunnel operators.
- Historical incidents involving flammable/combustible goods have shown enormous heat intensity, rapid spread of toxic smoke and extended duration of uncontrolled fire. Most of these fires involved flammable liquids. However, major fire incidents can be successfully managed in terms of safe evacuation and fire suppression through current tunnel design and operational practices.

2.4.12 Tunnel Structural Requirements

As there are no specific design guides or codes for the structural design of tunnels in Australia, it is proposed to use Australian Standard Building and Bridge Codes.

A design life of 100 years is proposed for the main tunnel structure. Other replaceable components would have lower design lives.

The tunnel and approach ramps structures are subject to very high loadings, due primarily to their size and depth. The tunnel section would be approximately 27 m wide by 8 m high, located approximately 2 m below existing ground levels, with the top of the roof at about mean sea level and below groundwater levels.

The loadings to be considered in the design of these structures include:

- soil pressures – on all surfaces of the tunnel;
- hydrostatic pressures – 100 year flood levels;
- buoyancy forces – due to groundwater and flood waters;
- future additional airport loadings – from formations and aircraft loadings;
- temporary loadings during construction; and
- traffic incident impact forces.

The design must also accommodate a wide range of services including drainage, lighting, ventilation, ITS facilities, fire suppression and smoke control facilities. All services must be robust throughout the operational life of the tunnel and include easy access for maintenance. Materials of appropriate fire rating capacity would be used throughout the tunnel.

Fires can range from 5 MW for an average car to 100 MW for a tanker loaded with flammable material. Very high levels of energy and heat has been experienced in tunnel fires over many hours.

Current best practice (Australia and overseas) is to provide an emergency ventilation and evacuation system with a fire rating of 400 °C for up to two hours. Other emergency equipment (electrical cabling, fire suppression equipment, lighting, signage etc) should have equivalent fire ratings. Further, the design and layout of electrical circuits, communications and sprinkler/deluge systems should limit the risk of localised failure (through extreme temperature or other cause) leading to failure of unaffected parts of the system.

Major structural damage from heat has occurred in tunnel fires through concrete spalling and softening of reinforcing steel. To minimise tunnel damage (potentially including the planned runway extension) and an extended closure of the bypass to undertake repairs, appropriate fire resistant concrete technology, fire protection coating and structural allowances are required to withstand extended heat levels.

In the detailed design stage, modelling of temperatures would be undertaken in conjunction with ventilation and smoke control modelling described previously in Section 2.4.8.

Stone mastic asphalt is recommended in preference to open-graded asphalt for pavement surfacing based on superior fire resistance.

Although design can accommodate major fires and petrol explosions, research indicates that cut and cover tunnels will suffer structural failure in the event of major explosions such as these following large liquid petroleum gas leaks or TNT accidents. It is therefore proposed to ban the transportation of these materials through the tunnel and to direct them via the existing highway route.

Particular attention to construction methodology would be required during the detailed design phase. Practical and proven methods are clearly preferred, from which the project can be fully defined in terms of design, construction requirements, environmental impacts, safeguards and mitigation methods. Examples of temporary activities required to build the tunnel are listed as follows:

- establishing access to and around the site;
- controlling footprint impacts;
- working in conjunction with airport height, lighting and operational limitations;
- dewatering;
- sheetpiling;
- temporary strutting of walls;
- removal of potential acid sulphate soils; and
- management of ground and surface water.

Detailed discussion of structural design and construction methodology is provided in Chapters 6 and 7 of this technical paper.

2.4.13 Management of Tunnel Operations

The tunnel operating agency has the primary responsibility for safe and efficient management of all tunnel operations. Some of the key management tasks would be as follows:

- communications with the general public, transport industry associations, government agencies and other key stakeholders including Gold Coast Airport Control Tower;

- running an efficient operations control centre, with systems and procedures clearly documented, and with staff familiar with their tasks, responsibilities and priorities in various emergency and non-emergency situations;
- establishing and maintaining cooperation between all emergency services organisations;
- developing, together with the operations control centre and emergency services personnel, an emergency response plan;
- establishing and enforcing regulations on dangerous goods transportation;
- controlling and enforcing driver's actions in terms of speeding, lane changing or any other measures determined necessary for tunnel safety;
- running frequent practice exercises, involving all agencies, of both primary and emergency tunnel systems to promote familiarisation and proper maintenance; and
- implementing safe procedures for all required maintenance works considering both workers and the travelling public. (Safe procedures for example may involve stopping or diverting traffic in non-peak times well before the tunnel entrances and working within a tunnel tube with no traffic to contend with. Alternatively some works may be undertaken alongside traffic where reduced speeds and lane closures are applied).

2.5 Road Pavements

Heavy-duty, low maintenance pavements with a nominal design life of 40 years would be required on both through-carriageways. (Concrete or deeplift asphalt pavements are usually used to achieve these requirement.)

Flexible pavements with a nominal design life of 20 years are acceptable for interchange ramps, intersections and connecting local roads.

Acceptable highway pavement surfacings are:

- open-graded asphalt; and
- stone mastic asphalt.

Open-graded asphalt would be advantageous in areas where noise reduction is difficult. Open-graded asphalt also has the advantage of reducing hydroplaning potential and spray.

Stone mastic asphalt has the advantage of superior fire resistance to open-graded asphalt and is recommended for use within the tunnel.

2.6 Flooding and Drainage

Technical Paper Number 7 covers flooding and drainage in detail. The following paragraphs provide summary details from the technical paper.

Flooding of the bypass can occur from two sources:

- the Tweed River and Cobaki Broadwater system; and
- local upstream catchments.

Rising flood waters from the Tweed River spread over wide areas in the southern section of the bypass in major floods. From established flood modelling of the Tweed River floodplain, a 1 in 100 year flood level of 2.7 m has been adopted in the vicinity of the bypass by Tweed Shire Council.

This level is considered to be conservatively high, even allowing for future sea level rises due to greenhouse effects, as the flood is assumed to be coincident with an extreme storm surge and wave setup plus mean spring high tide level. In adopting the 2.7 m flood level, recent studies for Gold Coast City Council indicate that a 1 in 100 year flood protection would be easily achieved including an allowance of 0.3 m for future sea level rise due to greenhouse effects.

The particular significance of understanding recurrence intervals and sensitivities of flood levels on this project is the protection of the tunnel. In extreme flood events the tunnel could be closed well in advance of inundation to protect road users. However the tunnel could then remain closed for an extended time, several weeks perhaps, while mechanical and electrical equipment was tested, repaired or replaced. It is considered prudent to protect the tunnel to the Tweed Shire Council's adopted 1 in 100 year flood level of 2.7 m to achieve a low risk of extended closure of the highway.

Flood immunity of the road section of the bypass would be to 1 in 100 year levels for both river and local catchment flooding.

The formation of the bypass including cross drainage structures would not result in any significant afflux (increase in flood levels) to surrounding properties. Approval would be required by Tweed Shire Council, Gold Coast City Council and Gold Coast Airport Limited to any such effects.

Longitudinal drainage systems within the bypass would be designed to cater for 1 in 10 year storm events, so that all travel lanes remain operable.

Pavement drainage is required to ensure that hydroplaning potential is minimised. Main Roads guidelines include water film thickness checks with 50 mm/h rainfall intensity as follows:

- desirable maximum 2.5 mm
- absolute maximum 4 mm

NSW Roads and Traffic Authority criteria for hydroplaning are similar.

2.7 Water Quality Management

The design criteria for water quality management would be applied separately for the construction and operational phases of the project. During the construction phase, the key issue for water quality management would be the minimisation of erosion and sedimentation. During the operational phase, the key issue would be the treatment of run-off from the bypass to ensure that sediments, nutrients such as nitrogen and phosphorus, and pollutants including hydrocarbons and heavy metals do not exceed acceptable levels. The containment of potential spills from highway accidents is also a key issue for water quality management in the operational phase of the project.

Erosion and sediment control during the construction phase of the project would be undertaken in accordance with design guidelines *Managing Urban Stormwater: Soils and Construction* (NSW Department of Housing 1998) and *Road Drainage Design Manual* (Main Roads 2002). These guidelines specify design requirements for erosion and sediment control structures, based on the area of disturbance and soil type. The structures include sediment fences, water diversion structures, rock check dams, energy dissipaters, stabilised site access ramps and sediment basins. The guideline recommends that sufficient sediment basin capacity is provided to store the 75th percentile, five day rainfall event for Type F (fine sediment) soils. Sediment basins would have a length to width ratio of 2:1 or greater. It is proposed to use the 80th percentile five day rainfall event on this project due to the sensitive nature of the receiving waters.

The water quality control ponds for the operational phase would be designed in accordance with *The Constructed Wetlands Manual* (NSW Department of Land and Water Conservation 1998). The manual provides guidelines for the design and sizing of the various components of constructed wetlands including the inlet zone, the deep water (sedimentation) zone, the macrophyte zone and the outlet zone. The manual specifies that, as a preliminary method of sizing, the required wetland area should be 2 percent of the catchment area. Settlement tests have been undertaken and these confirm that 2 percent of the catchment area is sufficient for the soil types in this area.

Technical Paper Number 8 provides more detailed information on the above.

Management of potential acid sulphate soils would be critical during the construction phase. Technical Paper Number 5 provides detailed information on this.

2.8 Access Provisions and Controls

It is understood that the Queensland section of the bypass would be declared 'Motorway' and the NSW section of the bypass either 'Highway' or 'Freeway'. In either of these cases it is proposed to have fully controlled access along the length of the bypass. There would be no direct access other than at the two major interchanges at Stewart Road and the Tweed Heads Bypass.

Access across the bypass, but without access directly to or from the bypass, would be provided as follows:

- via an overbridge behind John Flynn Hospital and Medical Centre to reconnect access to properties to the west;
- via an overbridge within airport land to reconnect an existing access road to the west of the bypass; and
- on ground across the top of the tunnel.

An access bridge across the highway may be constructed as an extension of Boyd Street in the future by others. This would be subject to a separate impact assessment process.

Fencing would be provided along the bypass to prevent access by pedestrians or trail bike riders.

2.9 Shoulders, Emergency Lay-by Areas, Maintenance Areas and Median Cross-overs

Outer shoulder widths of 3 m are proposed along the Tugun Bypass apart from the following:

- the Hidden Valley bridges where 2 m outer shoulders are proposed; and
- the tunnel and approach ramps where 2.5 m outer shoulders are proposed.

This is considered to be adequate provision for most vehicles to pull over with safe clearance from through traffic in the event of breakdown or other incident. Further discussion and evaluation of tunnel traffic and safety measures, including narrow outer shoulder widths, has been covered previously in Section 2.4. No emergency breakdown bays are proposed through the tunnel sections.

Narrow inner shoulders (generally 0.5 m minimum) are proposed for the length of the four-lane bypass. Inner shoulders for the future six-lane configuration are proposed to be 1 m wide (minimum), apart from the tunnel and approach ramp sections.

Median cross-overs for emergency vehicles are required at 3 to 5 km intervals in accordance with both Main Roads and NSW Roads and Traffic Authority guidelines. Cross-overs, similar to those provided on the Pacific Motorway, will be provided.

Median cross-overs are also required for emergency access either side of the tunnel. An overlapping design or moveable barrier system would be required to facilitate short, low speed openings on these occasions. It should be noted however that general traffic diversions into opposite tunnel tubes will not be allowed, as the ventilation system and emergency signage will not be designed for reverse flows.

2.10 Rest, Service and Truck Parking Areas

Due to the highly constrained alignment, it is not proposed to provide a service centre within the project. However, respective local councils may consider providing service centre opportunities in adjacent areas. Rest areas and general service facilities would be available by turning off at either end of the bypass onto the Gold Coast Highway.

Rest, service and truck parking areas are available at regular intervals to the north between Tugun and Brisbane, including major service centres recently constructed at Coomera and Yatala.

Pacific Highway facilities are being developed to the south, in accordance with the NSW Roads and Traffic Authority's Draft Rest Area Strategic Plan. Details of the guidelines and requirements would be available when it is released. A service centre has been constructed at Chinderah, truck and car rest areas were recently constructed on the Yelgun to Chinderah project, a rest area for cars and trucks is proposed at Brunswick Heads and truck facilities are available at Ewingsdale (northbound) and St Helena (southbound).

2.11 Lighting

It is proposed that all interchanges and intersections are lit in accordance with Australian Standard for Road Lighting AS 1158 - 1997. Lighting of the tunnel and approach zones requires special consideration for both day and night time. Section 2.4.4 describes tunnel lighting requirements further.

Tunnel approach ramps would be lit due to the narrow shoulders and consequent danger of broken down vehicles or other traffic hazards.

It is not proposed to light intermediate sections of the bypass although ducting to permit future lighting would initially be constructed for the full length of the bypass.

Some lighting along the bypass will require appropriate shielding to comply with aviation safety regulations.

2.12 Cyclists and Pedestrians

No provision has been made for a separate cyclepath running parallel to the Tugun Bypass.

Cycling would not be permitted between the Stewart Road and Tweed Heads Bypass interchanges, due to the airport tunnel and approach ramps section. Cycling would not be permitted through the tunnel at the southern end of Gold Coast Airport due to unfriendly and unsafe conditions for cyclists within the tunnel and approach ramp sections. The existing on and off-road cycle facilities along the Gold Coast Highway together with service roads would provide an alternative to the bypass, with flat grades and significantly reduced traffic.

Highway cycling on the Tweed Heads Bypass would be linked to the Gold Coast Highway. Alternatively cyclists may choose to travel through Coolangatta and Tweed Heads connecting with the Pacific Highway further south.

Provision for local cyclists and pedestrians has been made to cross the bypass at the Stewart Road interchange and at the Tweed Heads Bypass interchange. Provision has also been made under the Hidden Valley bridges to allow for the future extension of the network connecting Currumbin Waters and Tugun.

2.13 Linemarking and Signs

Linemarking and sign proposals would be required as part of the detailed design and would be undertaken in accordance with Australian Standard AS 1742 - 1991. Specific Main Roads and NSW Roads and Traffic Authority requirements would also be taken into account.

In addition to standard signage, special provision could include access to Gold Coast beaches, Gold Coast Airport and signage to highlight the Queensland-NSW border crossing.

Special signage would be required prior to the tunnel to warn motorists of the confined tunnel environment and the potential distractions caused by aircraft landings and takeoffs. Lane changing could be prohibited through tunnel sections to improve safety, and this would require appropriate line marking and signage.

Directional signage between Coolangatta and northern destinations needs to consider both the existing route via the Gold Coast Highway and Stewart Road, and the bypass route and Tweed Heads Bypass.

2.14 Intelligent Transport Systems and Help Telephones

Apart from intelligent transport systems (ITS) associated with the tunnel, emergency phones and various ITS elements may be installed in the future to assist with traffic management along the bypass.

The following ITS applications may be used:

- variable message signs – located along the carriageway and used to display messages that keep motorists informed of current traffic conditions;
- changeable message signs – used to supplement variable message signs or for traffic control purposes;
- variable speed signs – allow speeds to be varied in response to changes in traffic conditions;
- vehicle loop detection – the vehicle detection data can be used to determine the speed, volume and occupancy of vehicles and can also be used to determine queue lengths;
- closed circuit television cameras – cameras may be installed at strategic locations along the route to monitor traffic operations and assist with incident management;
- environmental monitoring stations – can be used to measure temperature, precipitation rate, wind speed and direction. this information may be used in conjunction with variable message signs to warn motorists of adverse driving conditions. other environmental monitoring could include groundwater levels adjacent to the tunnel;
- weigh-in-motion - used to gather data regarding the weight and classification of vehicles using the route;
- speed cameras – may be installed by authorities to enforce speed limits; and
- help telephones – installed at regular intervals to provide motorists with the ability to call for assistance in the event of a breakdown or accident.

Provision for the future installation of a communications system to support the above ITS applications would include the installation of power and communications conduits during road construction.

Selected elements of the bypass ITS systems would be required to provide information in advance of the tunnel, and installation of these elements would occur in conjunction with the initial bypass construction.

3. Design Criteria – Rail

3.1 General

In addition to the proposed road, the Tugun Bypass project includes provisions for a future extension of the existing railway from Robina to the Gold Coast Airport.

While the provision of the railway will be subject to a separate impact assessment process, the environmental assessment for this project must consider the rail corridor in sufficient detail so that the following outcomes can be achieved:

- design compatibility between the road and rail components;
- identification of the cumulative impacts of future rail construction and operation;
- preservation of the rail corridor in statutory planning instruments appropriate to Queensland, and Commonwealth jurisdictions; and
- no major obstacles remain which would compromise future completion of the rail extension to Gold Coast Airport.

It is proposed that the rail extension from Robina to Gold Coast Airport would be entirely built and maintained by the Queensland Government. Consequently, planning and design criteria are based on Queensland Transport and Queensland Rail requirements.

Planning of this rail extension is based on the operation of Queensland gauge urban electric passenger trains only. This is consistent with recent rail construction to the north between Beenleigh and Robina, and current planning for the extension of the line from Robina to Tugun.

South of Robina, planning is for two rail tracks, with construction of one track with passing loops and stations proposed initially.

3.2 Rail Station Locations and Requirements.

Two stations have been planned in the southern section of the rail extension from Robina to Gold Coast Airport, providing different but complementary transport functions as follows:

- Tugun station, to be located just north of Boyd Street, would operate as a park and ride facility for all population catchments from Tugun to the south; and
- the station at Gold Coast Airport would form part of a multi-modal transport facility permitting rail, bus, taxi and air transport connections. No car parking would be provided at this station, although substantial areas of parking are available at the airport.

4. Constraints

4.1 Overview

The bypass corridor has a wide range of environmental, land use and engineering constraints.

This chapter of the technical paper considers the following constraints.

- existing road infrastructure;
- environmental;
- cultural heritage;
- geotechnical;
- hydrology, water quality and flooding;
- existing property ownership and usage;
- engineering services;
- John Flynn Hospital and Medical Centre;
- Tugun Landfill; and
- Gold Coast Airport.

Identification and analysis of these constraints contribute significantly to the development of the road concept designs described in subsequent chapters of this technical paper. These and other constraints are described in more detail in various technical papers as referenced.

Figures 4.1a and 4.1b show some of the constraints described in the following sections.

4.2 Existing Highway and Local Road Network

The proposed bypass is on a new alignment and is not constrained by the existing highway. At each end of the bypass, the existing highway would require realignment and construction of grade separated interchanges for connection to the new road.

Stewart Road is a two-lane two-way road, which intersects the existing highway at a 'T' intersection just south of the proposed northern connection. It is currently being realigned and constructed over the proposed bypass to form a crossroad with the existing highway continuing to the Gold Coast Highway. (The current construction is an early works package.)

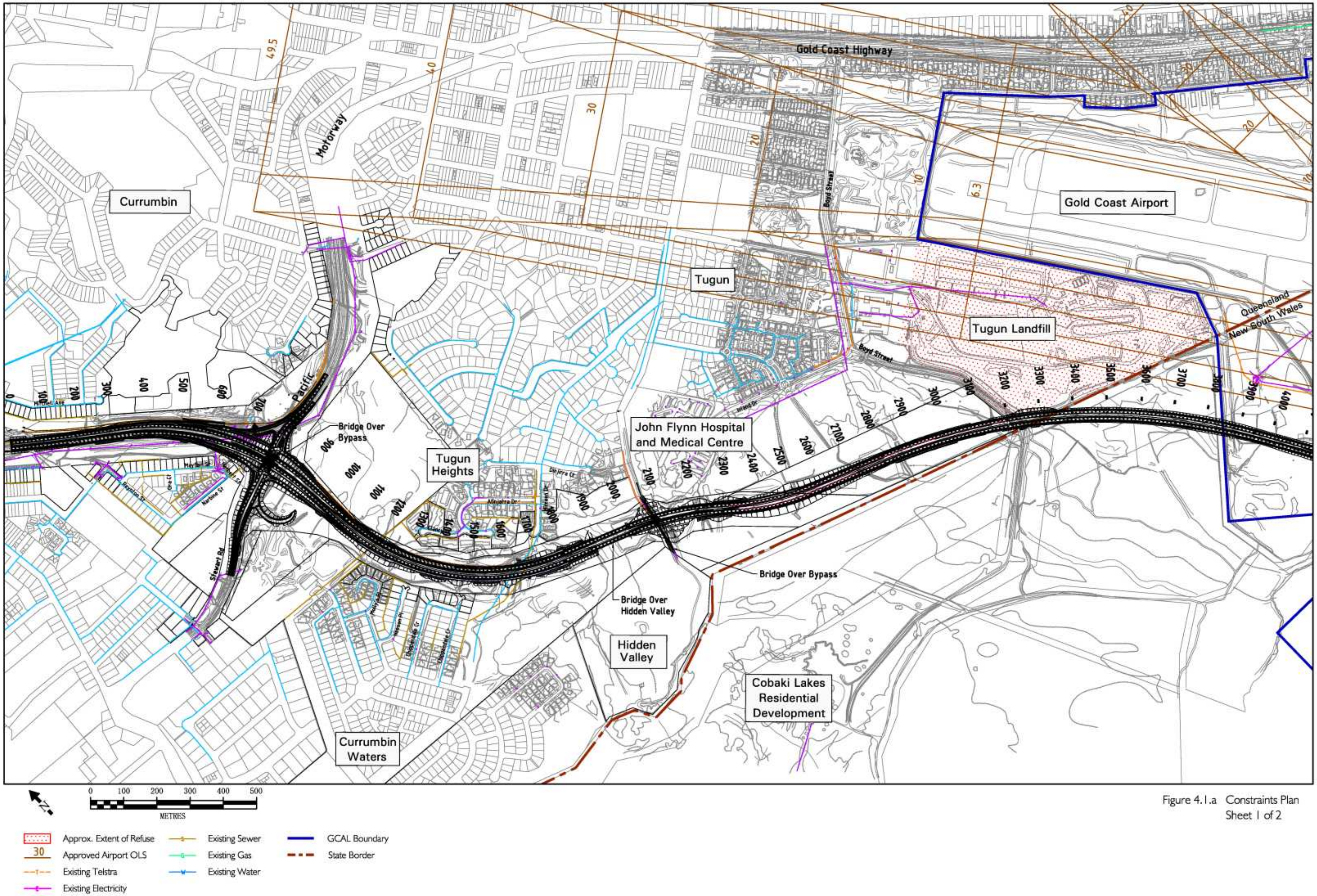

Figure 4.1.a Constraints Plan
Sheet 1 of 2

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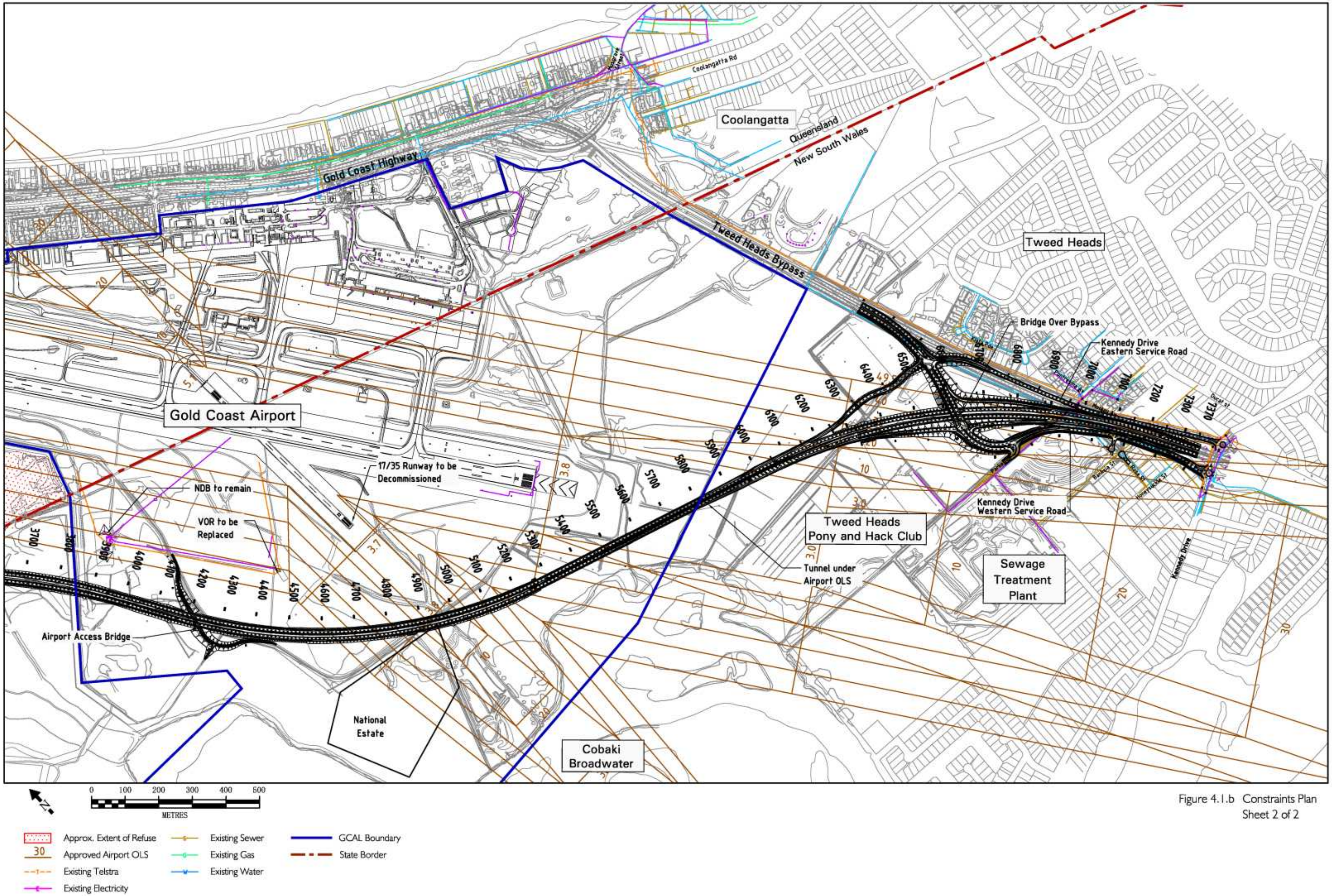

Figure 4.1.b Constraints Plan
Sheet 2 of 2

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The existing road reserve for Boyd Street/Piggabeen Road crosses the alignment of the proposed bypass about half way along the route adjacent to the Tugun Landfill. The last section of Boyd Street in Queensland is an unsealed gravel access track, closed off by a locked gate. This is only being used at present by construction traffic associated with the Cobaki Lakes development in NSW. This existing road reserve is a possible future cross-border link between Gold Coast City Council and Tweed Shire Council. The provision of this link is not part of the proposal for the bypass. The long-term planning of the road network does not preclude a possible overpass/interchange at this location.

Managing existing traffic at each end of the bypass (Stewart Road and Tweed Heads Bypass), would impose significant constraints and difficulties during the bypass construction. The rest of the bypass is virtually free of these constraints.

4.3 Environmental Constraints

Environmental constraints occur along and adjacent to almost the full length of the proposed corridor. A range of listed species of flora and fauna, together with key habitat, have been identified in various locations in Queensland, NSW and Commonwealth sections of the corridor.

Summary information is not provided in this section, and reference should be made to Technical Paper Number 12 for all information on flora and fauna constraints.

Other environmental constraints along the corridor alignment include noise and vibration and visual and landscape. Details on these issues are provided in Technical Paper Numbers 10 and 13 respectively.

4.4 Cultural Heritage

Technical Paper Number 14 provides information on cultural heritage issues in the study area.

The area has a rich history and contains an area included in the Register of the National Estate between the corridor and Cobaki Broadwater. Limited numbers of artefacts have been found to date along the proposed corridor, but further surveys and procedures would be agreed prior to any works commencing.

The location of the National Estate area is shown along with other constraints in Figure 4.1a and 4.1b.

4.5 Geotechnical Conditions

4.5.1 Geotechnical Summary

The northern section of the proposed bypass would pass through steeply sloping hills and ridges rising approximately 40 m above the surrounding area. The southern section is low and flat with ground levels varying by less than 4 m over 4.5 km.

Approximately 3 km of the southern section is flood prone, including airport land and NSW Crown land adjacent to the Cobaki Broadwater.

Geotechnical investigations have been carried out on a broad band along the C4 alignment. Technical Paper Number 4 describes the preliminary geotechnical assessments. A summary of the material types, from north to south along the proposed alignment, is provided as follows:

- fill materials were found near the proposed bypass crossing of Stewart Road;
- the hills adjacent to Tugun Heights were found to consist of extremely weathered low strength argillite and greywacke, all rippable by dozer;
- for the large cutting proposed through the ridge behind John Flynn Hospital and Medical Centre, it is estimated the slope stability will be achieved with batters at 1 on 1 (vertical to horizontal) with benches 4 m wide every 7 m in height;
- alluvial soils cover the southern section and are predominantly loose to medium dense silty sands;
- layers of cemented sands were intersected in various locations within the alluvial soils at depths varying from 1 m to 14 m, and thicknesses varying from 0.1 to 1.8 m;
- potential acid sulphate soils exist within the alluvial sands; and
- bedrock was encountered at depth in the southern boreholes.

4.5.2 Topsoil

Northern Section – Tugun Heights

The topsoils along the northern part of the alignment are generally residual soils of medium plasticity. These pale grey-yellow brown clays are very stiff to hard and can contain cobbles, boulders, and bands of extremely weathered argillite and greywacke. The thickness of the residual soils ranges from zero depth in most locations up to 6 m in particularly weathered sections of the alignment.

One section of the alignment from chainage 1,100 to chainage 1,300 contains fill material in the upper portion of the soil profile that is a pale brown gravely silty sand with fine to coarse gravel.

At cuts, the topsoil may be stripped, stockpiled and reused, however only small volumes of useable topsoil are expected to be recovered from this part of the alignment.

Southern Section – Deep Alluvial Soil Profile

Soils in this part of the alignment are predominantly alluvial brown-grey loose to medium dense sands.

Fill comprising gravely sands and sand has been placed in areas around the southern end of the runway down to depths of 0.9 m.

At cuts the topsoil may be stripped, stockpiled and reused.

Both Sections

In fills, a number of options are available:

- strip topsoil and stockpile for reuse on embankments. This removes potentially weak materials from the base of the fill and ensures that the same soil type is replaced in the same area; and
- leave topsoil in place. Place geotextile separation/reinforcing layer over topsoil and construct embankment directly on topsoil. This type of construction is best suited to embankments on soft soil foundations, and in areas where minimum disruption to the soil is required because of acid sulphate soils.

4.5.3 Subgrade Materials

Northern Section – Tugun Heights

Bedrock can be expected from the surface down in most cut areas in this part of the alignment. Bedrock materials consist of extremely weathered, very low to low strength argillite and greywacke rock, that will increase in strength with depth.

Materials won from cuts in these areas would be suitable for reuse in fills.

Southern Section – Deep Alluvial Soil Profile

The sub-surface profile in the southern section of the alignment generally comprises loose to medium dense silty sands with cemented dense to very dense silty sands at varying depths. Californian Bearing Ratio values measured in the top 1 m of the soil profile in these sands range from 9 percent to 22 percent.

Materials won from cuts in these areas would be suitable for reuse in fills.

4.5.4 Erodibility

Both Sections

Measurement of Emerson Class Numbers was carried out on the alluvial sands in the southern part of the alignment. Results from these tests indicate that the sands are neither dispersive nor susceptible to slaking.

In the northern sections of the alignment the argillite and greywacke would tend to weather rapidly on exposure creating the potential for erosion on the batters. Batters would need to be vegetated as soon as possible after construction to mitigate against erosion.

4.5.5 Acid Sulphate Soils

Technical Paper Number 5 deals with acid sulphate soils in detail.

Acid sulphate soils, both actual and potential, have been identified along the southern section of the alignment using the testing guidelines from the Acid Sulphate Soil Management Advisory Committee and the Queensland Environmental Protection

Agency. The areas most effected by these soils are in the cut and cover tunnel site where large volumes of soil are to be excavated and reused in road embankments.

Acid sulphate soils are suitable for reuse in the road embankments and as general fill provided the procedures set out in Technical Paper Number 5 are followed.

Soils in other areas of the southern section of the alignment are to be disturbed as little as possible, using methods outlined in Technical Paper Number 5.

4.6 Hydrology and Water Quality

4.6.1 Flow Regime

Local ecosystems are dependent on the existing hydrological regime at the site. A change to the flow paths or the volume of water available to various species could affect their ability to survive and reproduce. An increase or a decrease in the volume of water available would affect the balance of the ecosystem.

An important factor influencing the design is therefore the maintenance of the existing flow paths and volumes of the waterways wherever possible. In cases where ecosystems rely on sheet flow not yet concentrated into a stream, the sheet flow regime should be maintained. Detailed assessments of surface water and groundwater flow regimes are contained in Technical Paper Numbers 7 and 9 respectively.

4.6.2 Water Quality

The receiving water bodies for all run-off from the site are either Cobaki Broadwater or Currumbin Creek. Both of these provide important plant and animal habitats. Human recreational activities including boating, fishing and swimming also take place in these water bodies. The wetland ecosystems at the southern end of the bypass corridor are important fish and bird habitats.

Contaminants contained in road surface run-off or caused by construction activities have the potential to cause adverse impacts on the water bodies and ecosystems. A detailed description of the importance of these facilities, existing water quality and the potential impacts from road surface run-off are discussed in Technical Paper Number 8.

4.6.3 Flooding

The flooding constraints on the design relate to providing appropriate flood immunity for the road corridors, while maintaining existing flooding regimes and minimising any impacts on adjacent properties. Any increase in flood levels due to the construction of the bypass would be dependent on the characteristics of the particular catchment.

Flooding constraints for each catchment are dependent on existing land uses and the topography. The design criteria for each catchment affected by the bypass are defined in Technical Paper Number 7. This paper defines the design constraint as a maximum of 50 mm increase (afflux) in the 100 year average recurrence interval flood level for the Tweed River floodplain. In areas where there is little potential for an increase in flood level such as at Gold Coast Airport, a maximum increase in level of up to 200 mm has been adopted for the 100 year average recurrence interval flood. At the northern end of the site which has steep topography, a zero increase in flooding at adjacent properties has been adopted as the design constraint.

Detailed assessments of Tweed River flooding and local catchment flooding are provided in Technical Paper Number 7.

4.7 Existing Property Ownership and Usage

In the northern section of the bypass, land has been purchased by Main Roads to accommodate the bypass. The corridor is approximately 100 m wide and is curved and steep in places, providing tight geometric constraints. Residential properties in Currumbin Waters border the western side boundary. The eastern side of corridor is bordered by a narrow strip of Crown land providing a buffer to private properties in Tugun Heights.

South of the ridge adjacent to the John Flynn Hospital and Medical Centre the corridor connects to the Tweed Shire Council Local Environmental Plan corridor, which crosses NSW Crown land, airport land and a section of the Cobaki Broadwater. This route has now been abandoned in favour of the refined C4 alignment.

Current usage of the land required include:

- potential residential development adjacent to Inland Drive and Boyd Street;
- landfill operations near Boyd Street;
- airport operations;
- open space and recreation (Tweed Heads Pony and Hack Club); and
- existing residential development north of Kennedy Drive.

Some residential dwellings on the western side of the existing highway north of Kennedy Drive are affected by the proposed highway connection and service road alignment.

All properties within and adjacent to the proposed road corridor are described in detail in Technical Paper Number 15.

4.8 Existing Services

Initial details of existing or proposed services adjacent to the bypass corridor have been obtained from Gold Coast City Council, Tweed Shire Council, Country Energy, Energex, Telstra, Optus and Gold Coast Airport Limited. The services identified are shown in Figures 4.1a and 4.1b.

None of the existing services would be a major constraint to the construction of the bypass. Discussions have been held with service authorities and nominal allowances for service relocations have been made at this stage in the project estimate.

4.9 John Flynn Hospital and Medical Centre

The John Flynn Hospital and Medical Centre is situated towards the base of a ridge extending from the border range.

Noise and vibration issues need to be carefully considered in relation to the hospital, both during construction and following opening to traffic.

Current access to the hospital, from Inland Drive off Boyd Street, is not affected.

4.10 Tugun Landfill

The Tugun Landfill is operated by Gold Coast City Council on land south of Boyd Street adjacent to the NSW border. Technical Paper Number 6 addresses contamination issues associated with this landfill.

There are several methods of dealing with this constraint including:

- realignment of the bypass;
- bridging over the landfill; and
- relocation of landfill waste (both on-site and off-site);

The location of the alignment has been adjusted to minimise the area of landfill affected. However a corner of the landfill would still require removal, with appropriate practices required to ensure that exposed landfilled areas are adequately contained and covered.

4.11 Airport Constraints

The constraints to the proposal imposed by its proximity to the Gold Coast Airport are discussed below. The constraints were identified through consultation with Gold Coast Airport Limited.

4.11.1 Obstacle Limitation Surface

An obstacle limitation surface (OLS) is a shaped surface which identifies the lower limits of the available airspace at an airport. Anything protruding above this is considered to be a potential obstacle to aircraft operations. An OLS has particularly flat gradients at the ends of runways to protect airspace for landings and take-offs.

The Gold Coast Airport OLS is shown superimposed on the constraints plans in Figures 4.1a and 4.1b. The approved Gold Coast Airport OLS provides for long-term planning purposes. Gold Coast City and Tweed Shire Councils planning policies have ensured that this OLS has been protected.

Bypass design is required to allow for height restrictions imposed by the OLS during construction and operation of the road and rail. During construction, an OLS based on the current runway length would be used to allow transient machinery such as cranes and other rigs to work in the area of the tunnels. Further, this OLS may be breached at certain restricted times during construction, subject to agreement by Gold Coast Airport Limited and approval by the Civil Aviation Safety Authority and the Commonwealth Department of Transport and Regional Services. Generally these works would only be permitted during night time hours when there are few aircraft movements. Trained airport personnel would be required to provide full time supervision when these works are occurring.

Another airspace surface used in airport safety is the Procedures for Air Navigation Services – Aircraft Operations (PAN-OPS). This is similar to the OLS, but cannot be penetrated at any time. It gives pilots a surface that is guaranteed to be obstacle free at all times. The PAN-OPS surface is slightly higher than the OLS.

4.11.2 Main Runway 14/32

The main runway (runway 14/32) is 2,042 m long and 45 m wide.

Strip requirements outside the paved runway include the following:

- a graded area with a total width of 150 m for take off sections;
- a graded area with a total width of 210 m for landing sections; and
- a flyover area with a total width of 300 m for landing sections.

Obstacle limitation surface requirements apply to those areas.

Operational limitations currently apply to the existing runway.

4.11.3 Master Planning

The Final Master Plan for Gold Coast Airport, approved by the Commonwealth Minister for Transport and Regional Services in August 2001, is the latest formal document outlining long-term strategies for the development of the airport. The design of the Tugun Bypass should not preclude long-term airport strategies. The approved master plan and OLS (described in Section 4.11.1) are appropriate mechanisms for this purpose.

Cross Runway 17/35

The master plan addresses various issues associated with possible future closure of the cross runway, including impacts on general aviation (light aircraft) and the capacity of the main runway for all aircraft.

Navigational Aids

The primary navigational aid is the VHF Omni-Range Navigational Aid. This facility, known as a VOR, is a navigational beacon to assist aircraft on approach to the airport, generally during periods of inclement weather. The existing VOR structure is situated about 250 m north-west of the end of the cross runway.

Airservices Australia were engaged to:

- determine the minimum horizontal offset required from the existing conventional VOR (CVOR);
- determine the minimum horizontal offset required from a new Doppler VOR (DVOR) to the bypass;
- analyse the impact of installing a DVOR adjacent to the existing CVOR with the view to minimising impact on airport operations including approach procedures and flight paths; and
- assess the impact of the proposed road on the performance of the Non-Directional Beacon (NDB).

The existing VOR could be affected by the bypass through electrical interference. To avoid electrical interference the bypass needs to be about 300 m from the VOR. Due to other constraints, this offset between the bypass and the VOR is not possible.

A proposed DVOR was modelled by Airservices Australia at the site of the existing CVOR. Taking into account all technical and operational factors and including an appropriate safety buffer the assessment shows that the DVOR would perform within tolerance with the proposed Tugun Bypass Road located at least 168 m from the centre of the DVOR antenna array.

While the assessment shows the DVOR would technically perform within tolerance with the road located as close as 80 m from the DVOR, when considered with other technical and operational factors, alignment of the road closer that 168 m is considered a high risk to providing an adequate navigation service.

The bypass proposal would replace the existing CVOR with a new DVOR, with less sensitivity to electrical interference, at the same location. The advantages of keeping the same location include:

- power and communications are already available;
- the obstacle limitations impassed by the proximity of taxiway sand runways are met; and
- the site surrounds have previously been cleared and made suitable for operating a DVOR. Other sites would require grading and clearing before construction commenced.

The Distance Measuring Equipment (DME) siting requirements are met if the proposed road is located at least 115 m from the DVOR antenna. Therefore, the DME requirements are met by default if the proposed DVOR is installed and the minimum distance to the road is 168 m.

The NDB siting requirements have been examined and the proposed road must be located at least 150 m from the NDB so not to cause any unwanted signal degradation.

4.11.4 Aviation Rescue and Fire Fighting Service Requirements

The aviation rescue and fire fighting service require certain access conditions in order to meet the requirements set by the International Civil Aviation Organisation. Access in and around the airport has been maintained (refer Section 4.11.7).

4.11.5 Lighting

Ground lights can cause confusion or distraction to pilots by reason of their colour, position, pattern or intensity of light emission above the horizontal plane. The Civil Aviation Safety Authority has the power through Regulation 94 of Civil Aviation Regulations 1988, to require lights which may cause distraction, confusion or glare to pilots in the air, to be extinguished or modified. Lights that are most likely to be subject to the provisions of Regulation 94 are within a 6 km radius of a known aerodrome.

Within this area there also exists a primary area in which the intensity of light above the horizontal is likely to cause interference. This area is divided into four zones each with different maximum intensity limits. These zones are shown on Figure 4.2. All lighting should be designed to comply with the limits of these zones. Where this is not possible a screen should be fitted to limit the light emission to zero above the horizontal plane.

It is also noted that coloured lights are likely to cause conflict irrespective of their intensity as coloured lights are used to identify different aerodrome facilities.

During the detailed design phase of the project the Civil Aviation Safety Authority would be consulted regarding all the proposed Tugun Bypass lighting installations, plus lights of vehicles travelling along the bypass, as there may be overriding factors which require more restrictive controls that are not mentioned above.

Care would also be required to ensure that the road lighting structures do not penetrate the obstacle limitation surface.

4.11.6 Access

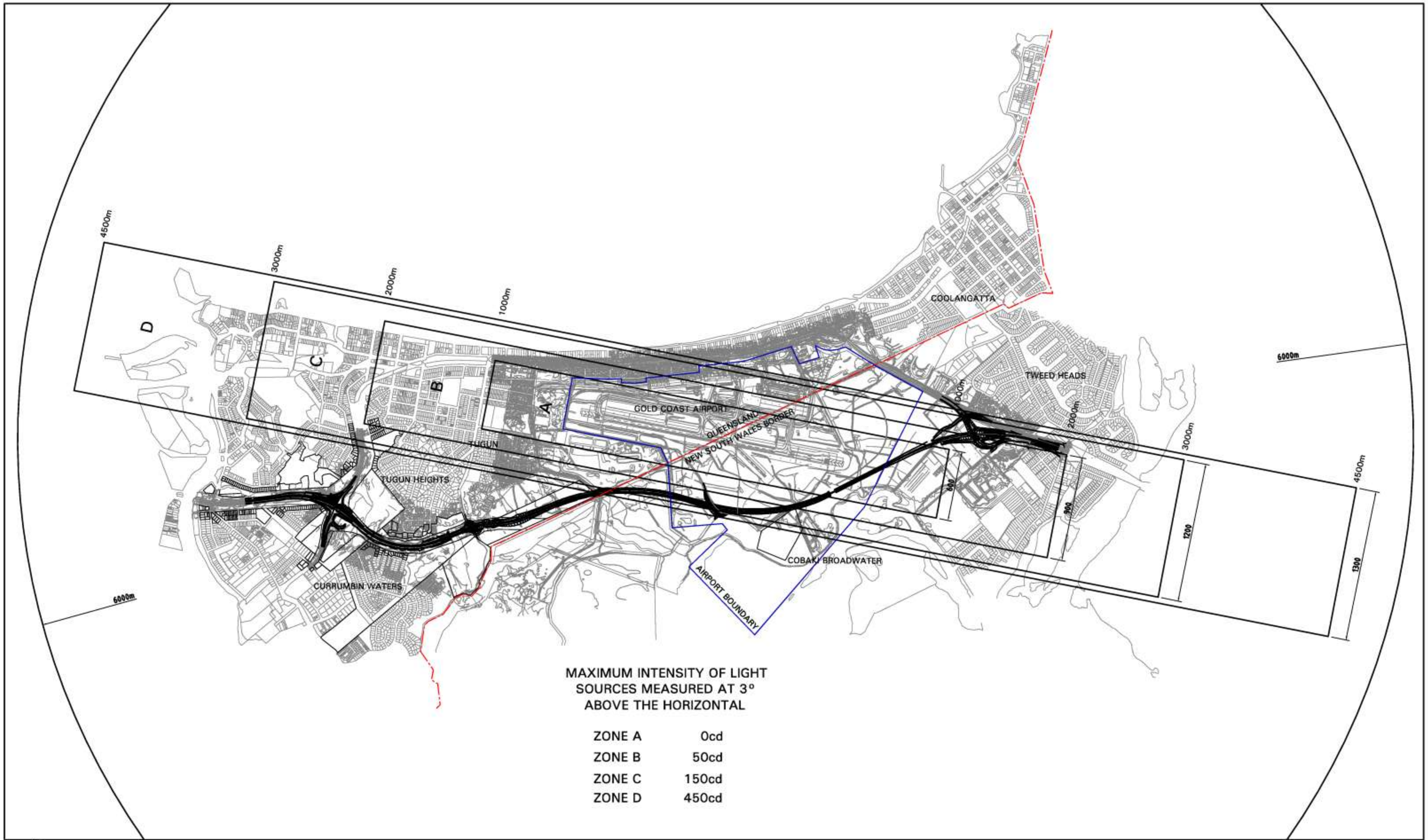
Several existing airport access tracks would be severed by the proposed bypass alignment. Gold Coast Airport Limited has requested that existing access conditions are retained or alternative access provided equivalent to the existing. This includes connection of an access road to the west of the proposed bypass. Appropriate access adjustments would be undertaken as part of this proposal.

4.11.7 Fencing

The Commonwealth Department of Transport and Regional Services requires that security fencing is provided around the airport for safety reasons. The bypass alignment crosses existing airport security fencing at several locations. Adjustments to security fencing would therefore be required.

4.11.8 Drainage

The bypass proposal would have no affect on current drainage standards at the airport or on its flood immunity.



NOT TO SCALE

Figure 4.2 Aerodrome Lighting Restrictions

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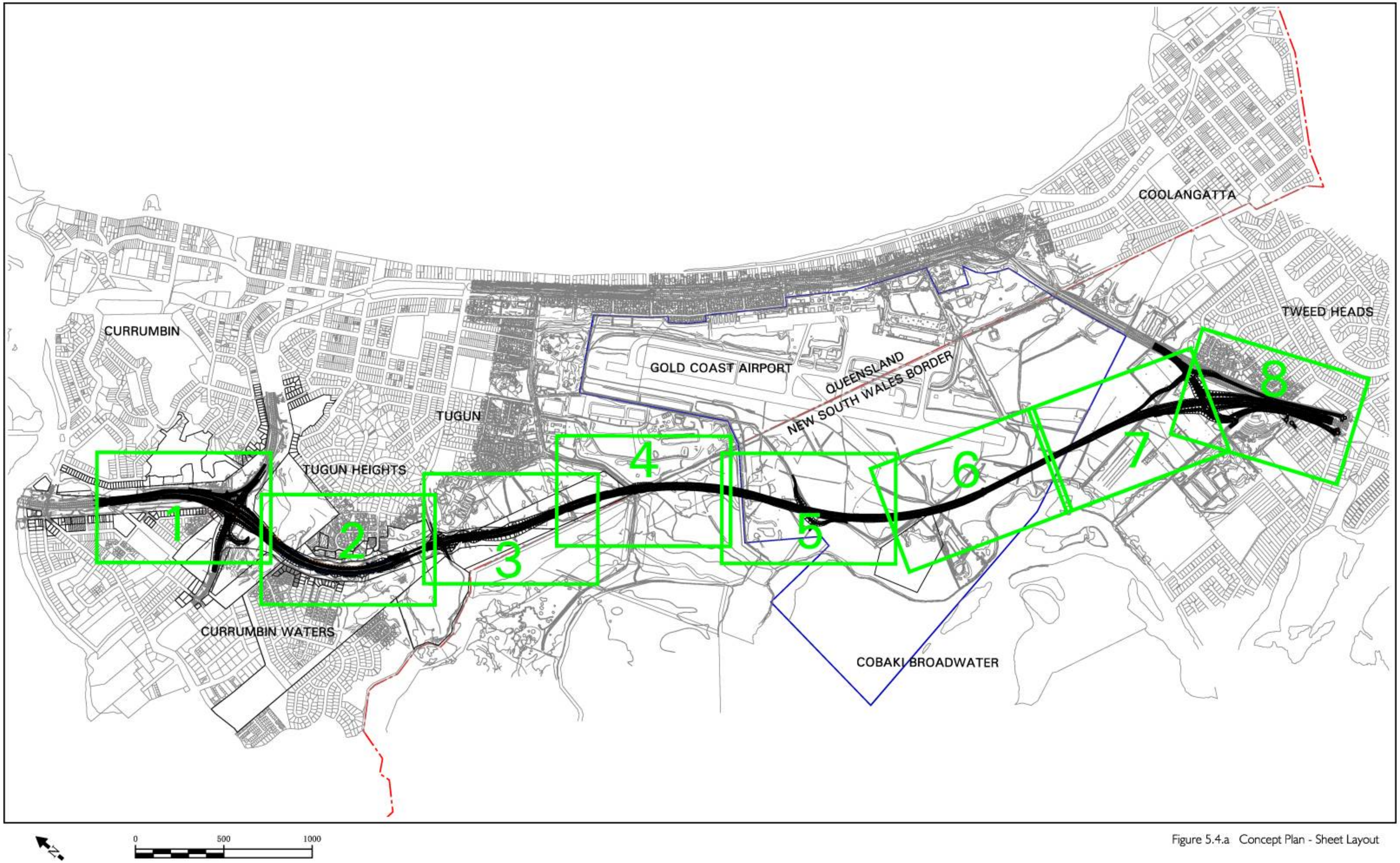

Figure 5.4.a Concept Plan - Sheet Layout

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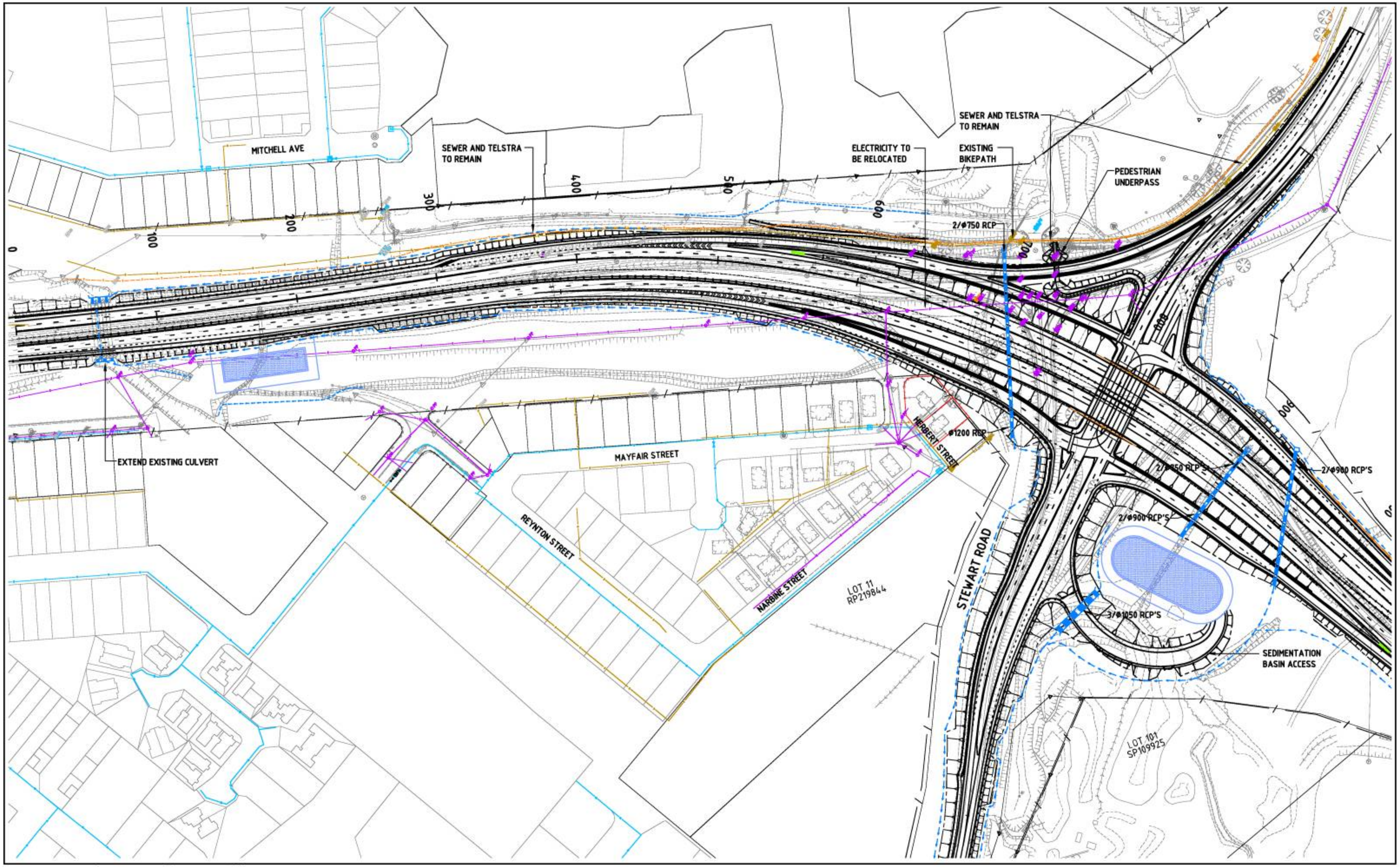

Figure 5.4.b Concept Plan
Sheet 1 of 8

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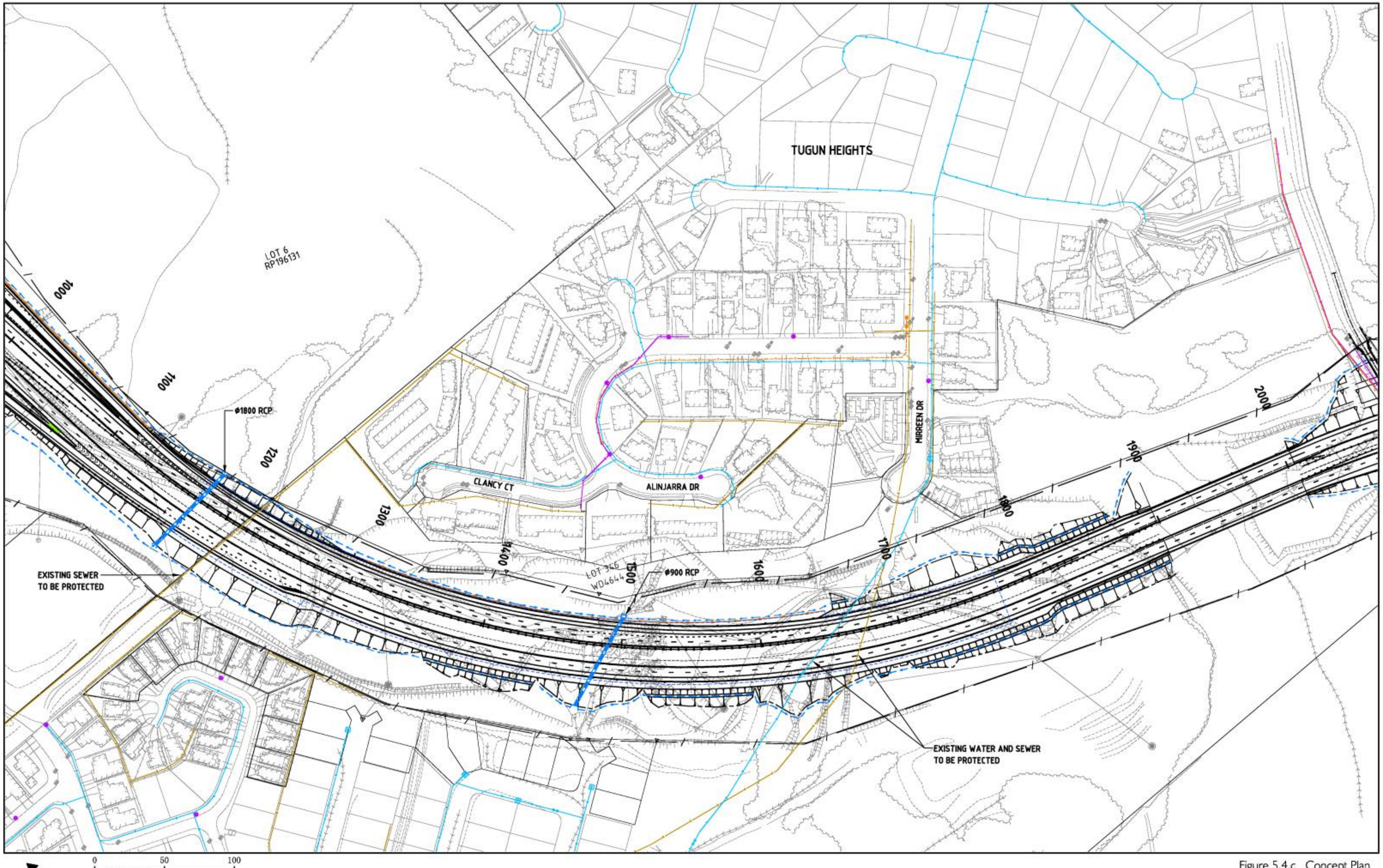

Figure 5.4.c Concept Plan
Sheet 2 of 8

LEGEND

CONCRETE BARRIER
GUARDRAIL
WIRE ROPE SAFETY FENCE
CRASH CUSHION
RETAINING WALL
PERIMETER FENCE
PROPERTY AQUISITION
NEW DRAINAGE CULVERT
EXISTING DRAINAGE CULVERT
CLEAN WATER DRAINS
WATER QUALITY CONTROL PONDS
WATER MAIN
SEWER MAIN
TELSTRA UNDERGROUND SERVICE
ELECTRICITY OVERHEAD SERVICE

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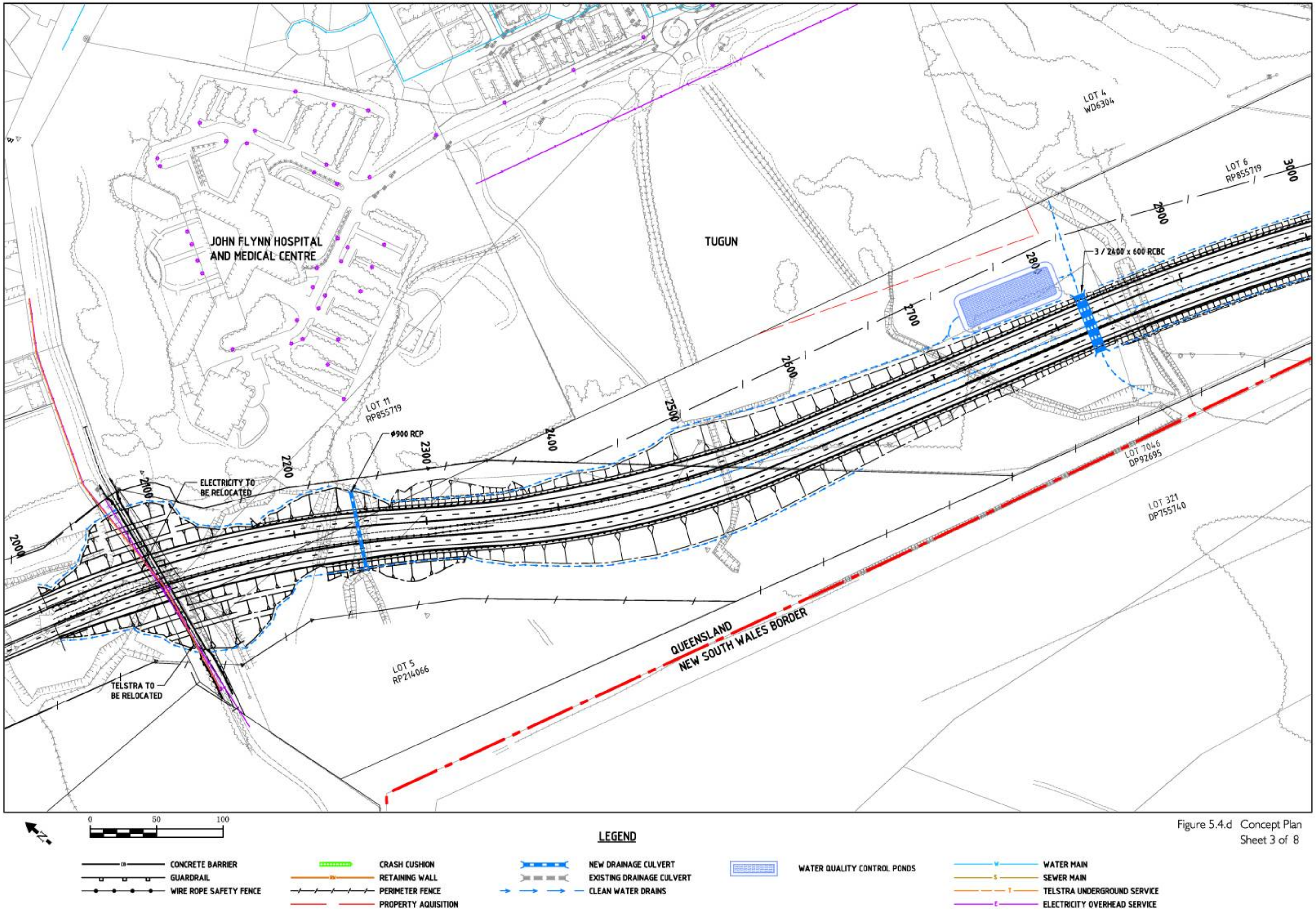

Figure 5.4.d Concept Plan
Sheet 3 of 8

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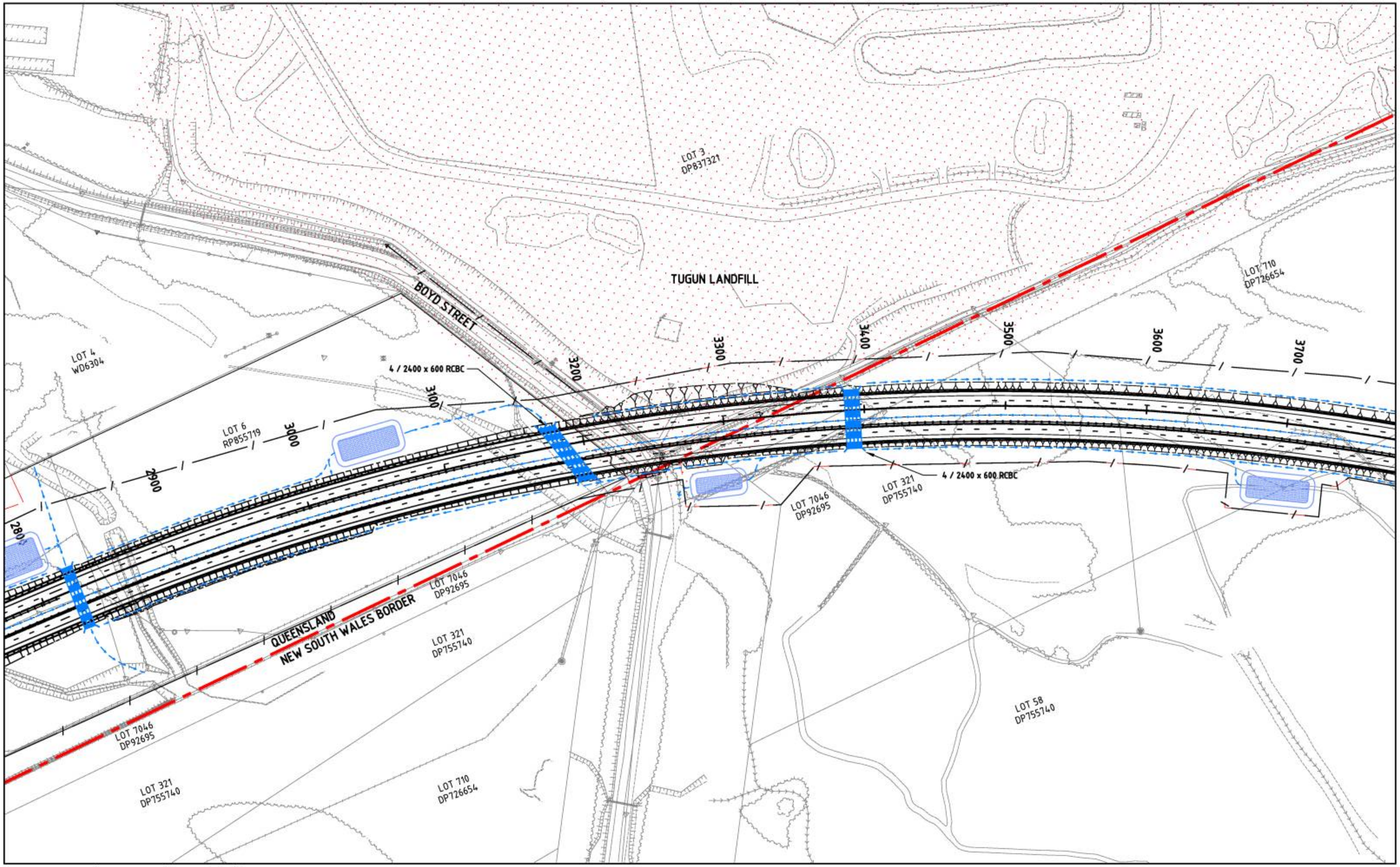

0 50 100

LEGEND

CONCRETE BARRIER	CRASH CUSHION	NEW DRAINAGE CULVERT	WATER QUALITY CONTROL PONDS
GUARDRAIL	RETAINING WALL	EXISTING DRAINAGE CULVERT	
WIRE ROPE SAFETY FENCE	PERIMETER FENCE	CLEAN WATER DRAINS	
	PROPERTY AQUISITION		

- WATER MAIN
- SEWER MAIN
- TELSTRA UNDERGROUND SERVICE
- ELECTRICITY OVERHEAD SERVICE

Figure 5.4.e Concept Plan
Sheet 4 of 8

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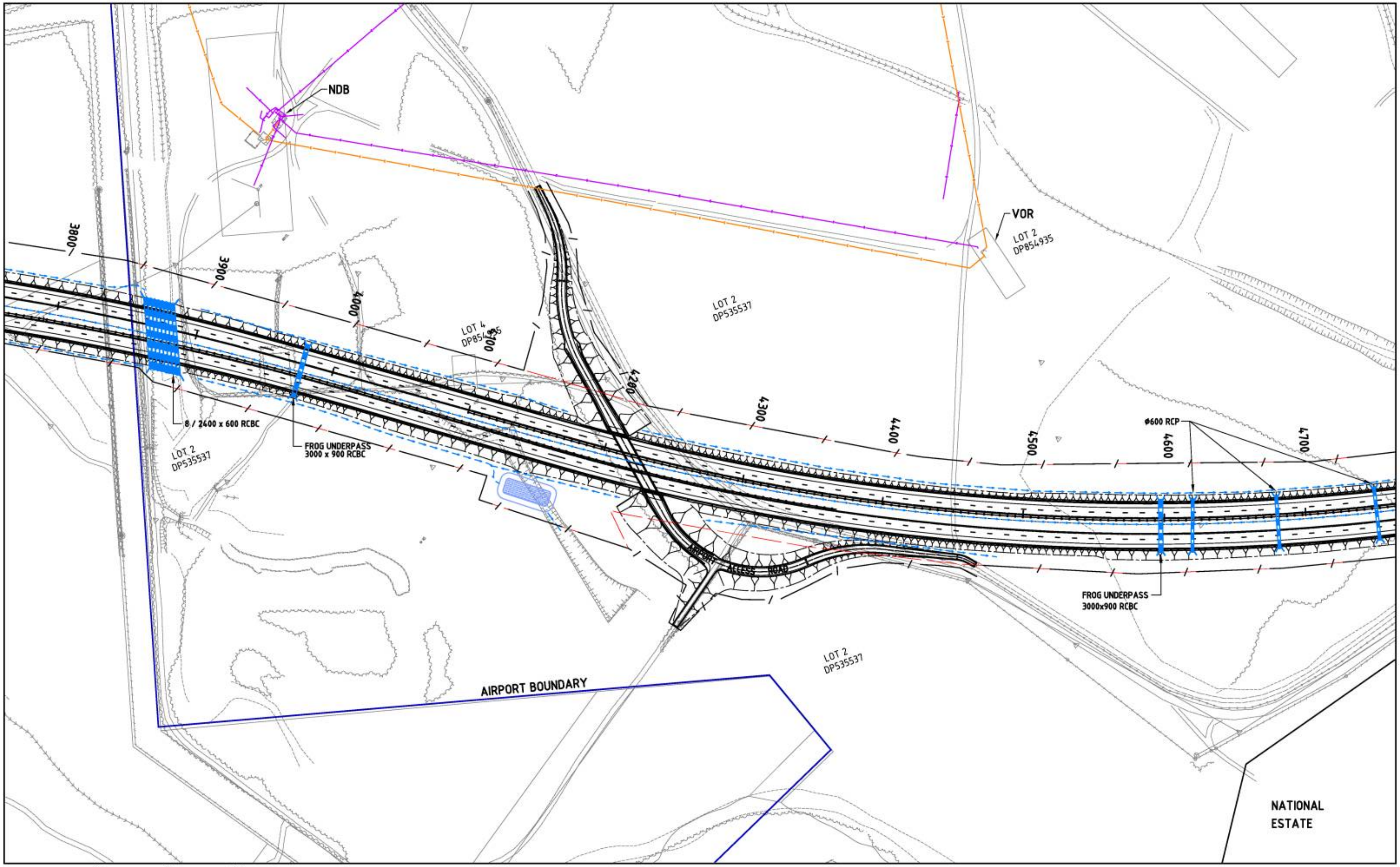

Figure 5.4.f Concept Plan
Sheet 5 of 8

LEGEND

- CONCRETE BARRIER
- GUARDRAIL
- WIRE ROPE SAFETY FENCE
- CRASH CUSHION
- RETAINING WALL
- PERIMETER FENCE
- PROPERTY AQUISITION
- NEW DRAINAGE CULVERT
- EXISTING DRAINAGE CULVERT
- CLEAN WATER DRAINS
- WATER QUALITY CONTROL PONDS
- WATER MAIN
- SEWER MAIN
- TELSTRA UNDERGROUND SERVICE
- ELECTRICITY OVERHEAD SERVICE

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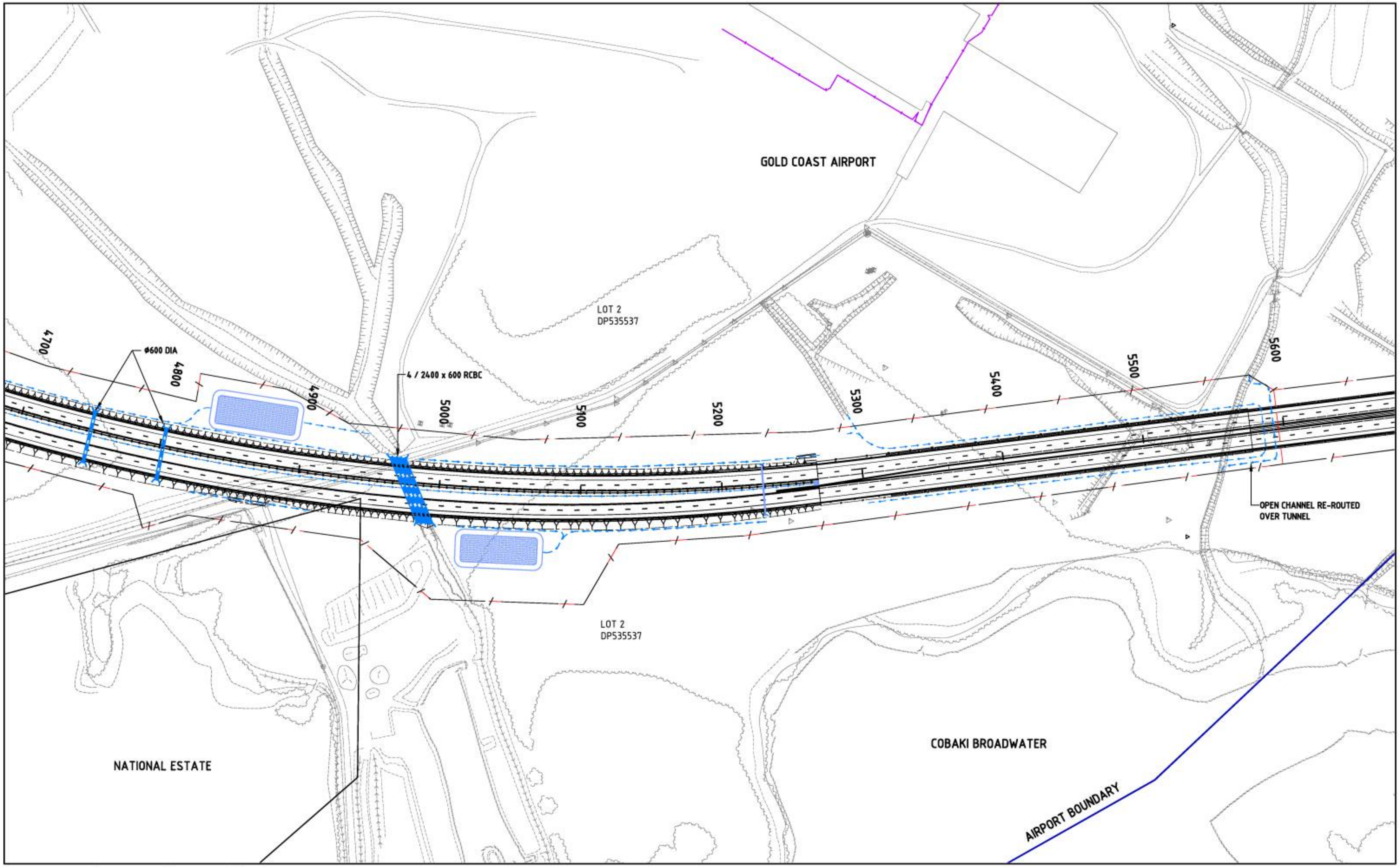

LEGEND

- CONCRETE BARRIER
- GUARDRAIL
- WIRE ROPE SAFETY FENCE
- CRASH CUSHION
- RETAINING WALL
- PERIMETER FENCE
- PROPERTY AQUISITION
- NEW DRAINAGE CULVERT
- EXISTING DRAINAGE CULVERT
- CLEAN WATER DRAINS
- WATER QUALITY CONTROL PONDS
- WATER MAIN
- SEWER MAIN
- TELSTRA UNDERGROUND SERVICE
- ELECTRICITY OVERHEAD SERVICE

Figure 5.4.g Concept Plan
Sheet 6 of 8

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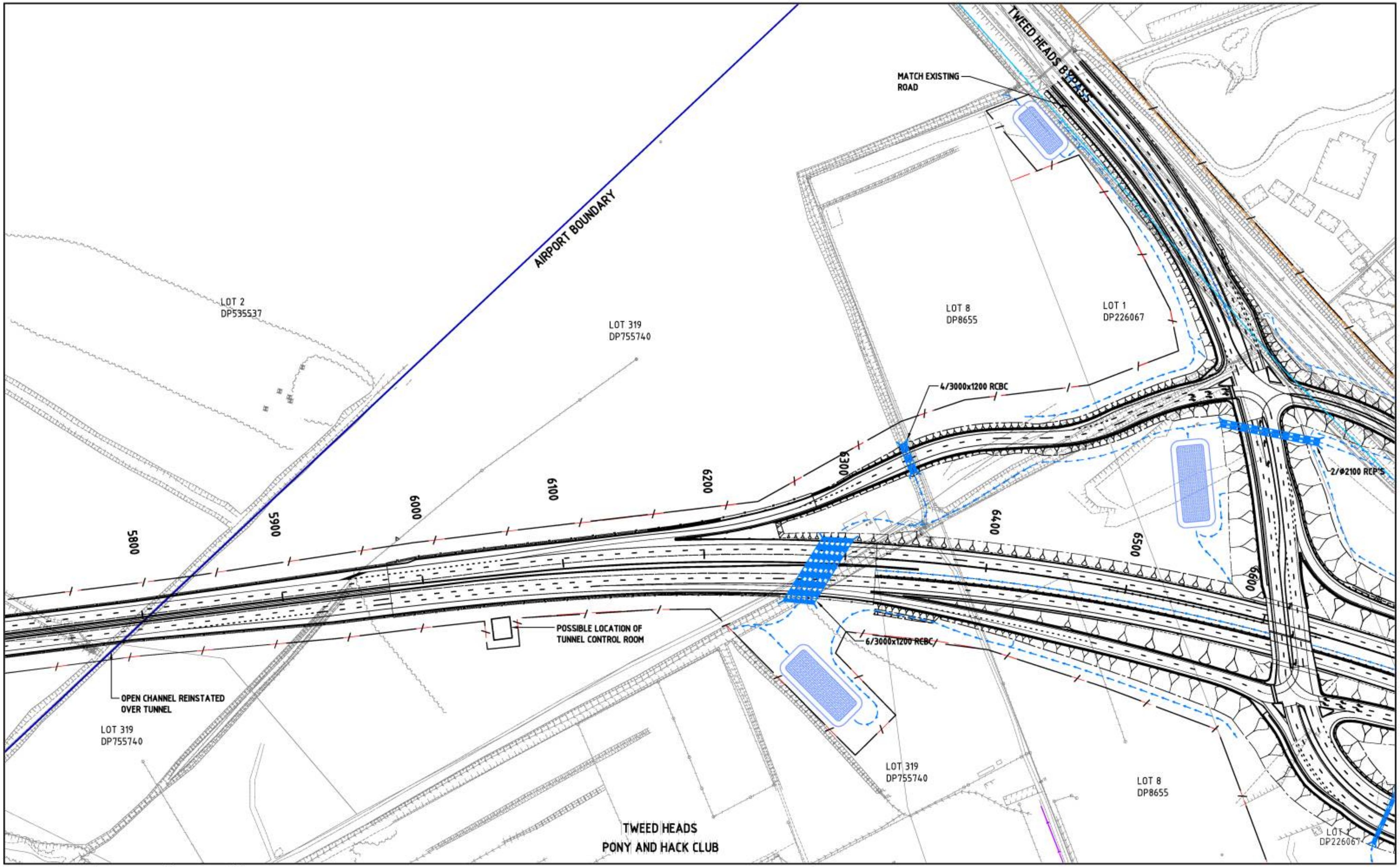

Figure 5.4.h Concept Plan
Sheet 7 of 8

LEGEND

- CONCRETE BARRIER
- GUARDRAIL
- WIRE ROPE SAFETY FENCE
- CRASH CUSHION
- RETAINING WALL
- PERIMETER FENCE
- PROPERTY AQUISITION
- NEW DRAINAGE CULVERT
- EXISTING DRAINAGE CULVERT
- CLEAN WATER DRAINS
- WATER QUALITY CONTROL PONDS
- WATER MAIN
- SEWER MAIN
- TELSTRA UNDERGROUND SERVICE
- ELECTRICITY OVERHEAD SERVICE

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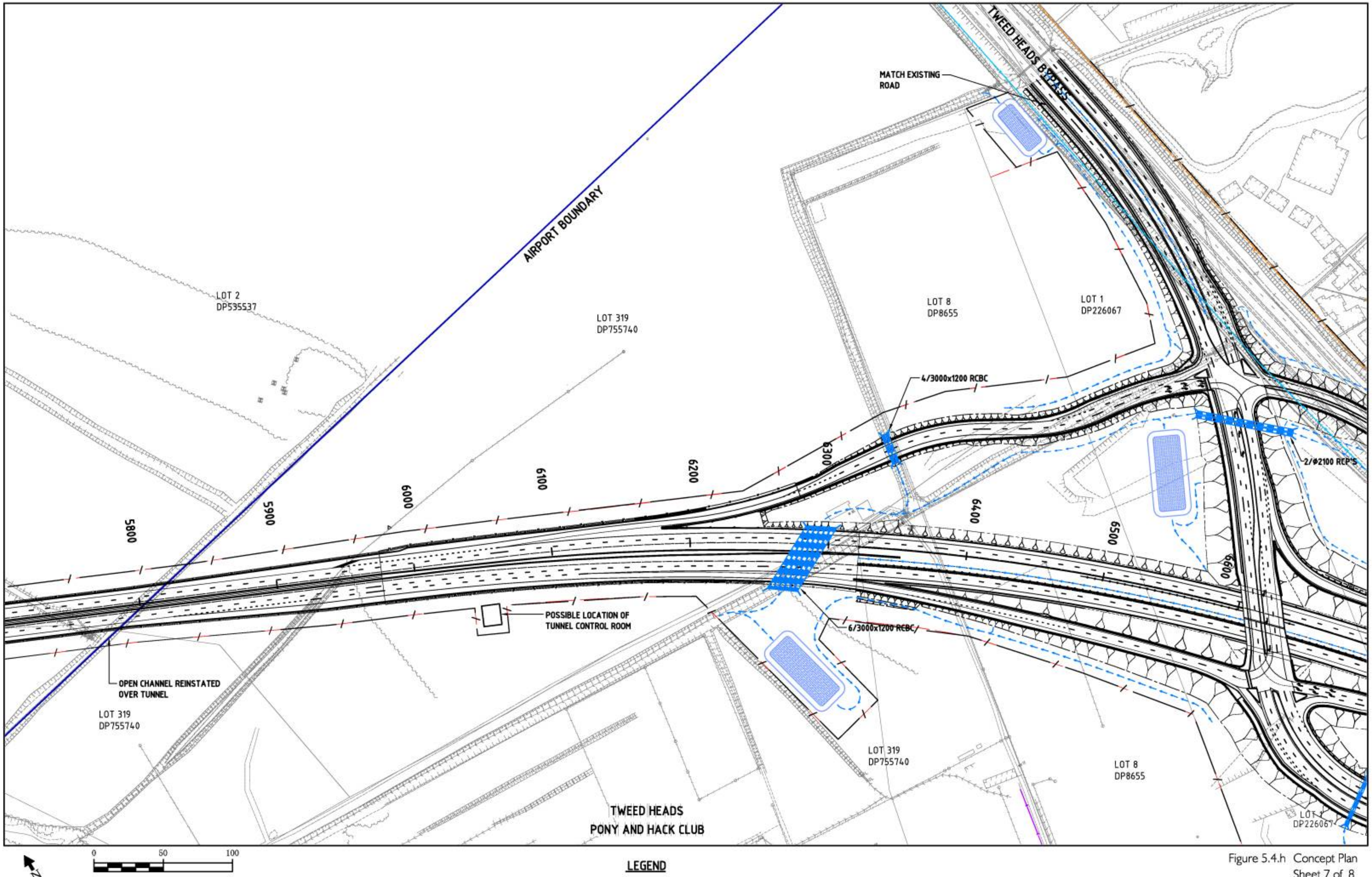

LEGEND

- CONCRETE BARRIER
- GUARDRAIL
- WIRE ROPE SAFETY FENCE
- CRASH CUSHION
- RETAINING WALL
- PERIMETER FENCE
- PROPERTY AQUISITION
- NEW DRAINAGE CULVERT
- EXISTING DRAINAGE CULVERT
- CLEAN WATER DRAINS
- WATER QUALITY CONTROL PONDS
- WATER MAIN
- SEWER MAIN
- TELSTRA UNDERGROUND SERVICE
- ELECTRICITY OVERHEAD SERVICE

Figure 5.4.h Concept Plan
Sheet 7 of 8

Plot Date: 11/11/04 - 18:00 Cad File: G:\2134070A\DRF\ACAD\FINAL\XREF\EIS_Figures\Fig 5.4.h.dwg

6. Concept Design of Structures

6.1 General

This chapter describes the major structures included in the proposal. Discussion is general because the detail of the structures would be subject to refinement during detailed design to achieve the most economic solution. While the detail may be amended, the location and general dimensions are unlikely to change significantly. Alternative design and construction methodologies are possible, subject to conforming with project objectives and environmental requirements.

In the following sections, concept plans are included to indicate the type and form of each structure. The scale of each structure is apparent at each location, with nominal dimensions shown on the concept plans.

The dimensions of the structures proposed are consistent with traffic and geometric design requirements outlined in Chapters 2 and 3 of this technical paper.

6.2 Stewart Road Interchange Bridge

Stewart Road crosses both road and rail alignments and two separate bridge structures are proposed, separated by approximately 35 m of road embankment. The bridge over the bypass is currently under construction as early works for this project.

Based on the topography, geotechnical data and road geometry, the Stewart Road overpass of the Tugun Bypass consists of two spans. The deck width provides for six lanes of traffic, a central median, outside shoulders to cater for cyclists, a pedestrian footpath and concrete barriers between the shoulders and footpath and at the bridge edges.

A pedestrian footpath is provided on the northern side of the bridge protected by concrete barriers and fitted with throw-over protection screens. Abutments are reinforced earth retaining walls concealing square concrete columns supporting the headstocks.

Figure 6.1 shows concept details of the Stewart Road interchange bridge.

6.3 Hidden Valley Bridges

Hidden Valley has been identified as an area of environmental significance and bridging over a length of approximately 100 m is proposed to minimise impacts. The proposed Hidden Valley bridge consists of three equal spans, with prestressed concrete ‘Teeroff’ units and a concrete deck slab with asphalt wearing surface.

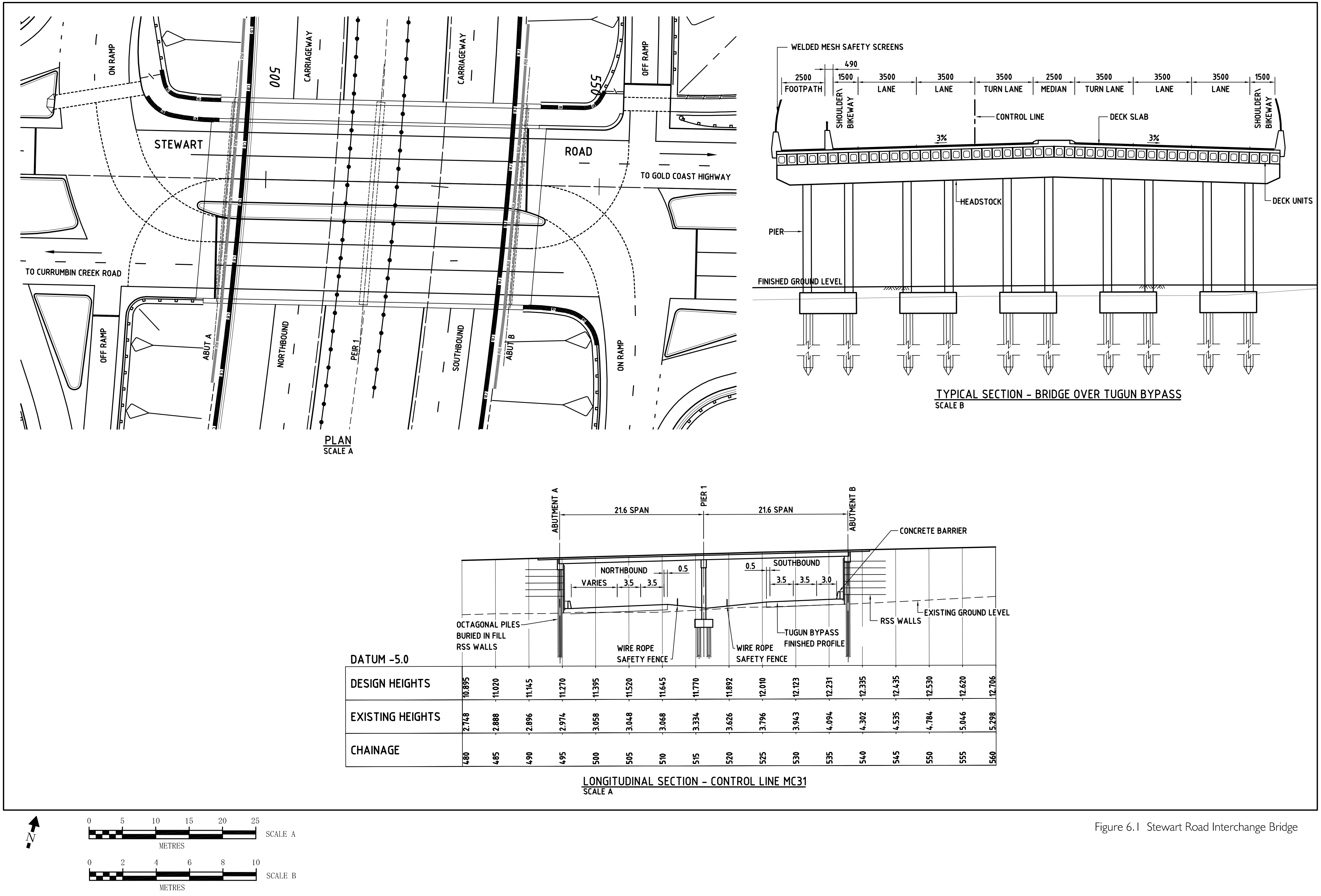

Figure 6.1 Stewart Road Interchange Bridge

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The initial construction stage would provide two northbound and two southbound traffic lanes with foundations, piers and headstocks adequate for future widening of the bridge decks by the addition of extra units. Deck joints would be limited in number and of special design to minimise noise within the valley. Abutment foundations would be expected to be spread footings with the piers either spread footings or bored, depending on which method provides the minimum construction footprint. Disturbance to vegetation in the valley would be kept to a minimum by using a launching truss for construction of the bridge decks. For the same reason, all concrete for the central piers would be pumped from the abutments.

Future widening of the bridge would be simplified by providing sufficient abutment and pier width to cater for the future widening. By doing that, no additional disturbance is required to the bed of the valley and construction related disturbance of the motorway traffic is minimised. The additional deck units could be placed at night with one lane closed (no launching truss) and two lanes closed for a short period during the actual lifting procedure.

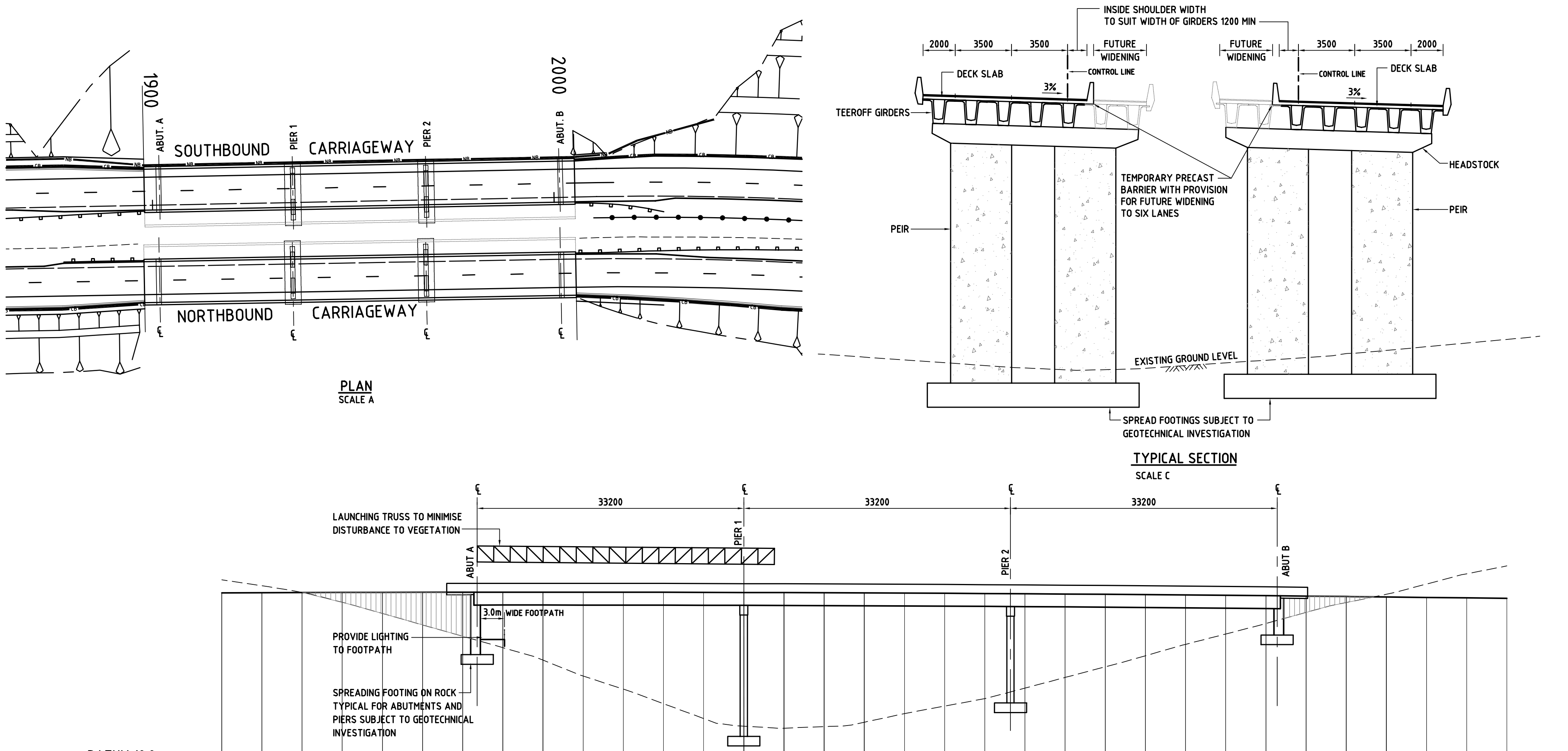
The issue of foundations within the valley was investigated with a view to minimising their number and optimising their location. Some options considered were:

- four spans of 24 m standard prestress concrete deck units, with three sets of foundations, two sets of which would result in impacts on the water course/soak;
- three spans of 33 m standard prestress concrete deck units, with two sets of foundations of which the corner of one would partially affect the water course/soak;
- two spans of 48 m using a purpose designed and built incrementally launched/ constructed prestressed concrete box girder bridge with a single centre foundation in the middle of the water course/soak; and
- single span of 96 m using a cable stayed incrementally constructed prestressed concrete box girder bridge, with no foundations in the valley.

The most economic design is the three span bridge which provides an acceptable balance between deck and foundation costs. Using a two span or single span bridge could move the design out of the range of the standard bridge designs and increase costs substantially.

The three span bridge, with two foundations within the valley, would be expected to result in only limited environmental impact. Additional reduction of impacts by eliminating or further reducing the number of foundations would result in limited benefits at significantly greater cost.

Figure 6.2 shows concept details of the proposed Hidden Valley bridges. Final foundation locations and spans would be determined at the detailed design stage. Short end spans instead of earthworks could also be considered at the detailed design stage.

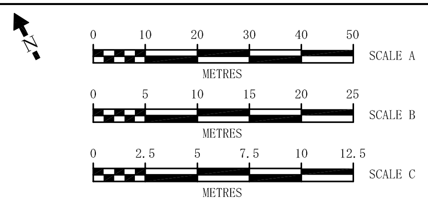


DATUM 10.0

CHAINAGE	DESIGN HEIGHTS	EXISTING HEIGHTS
1870	31.379	32.995
1875	31.398	32.264
1880	31.415	31.425
1885	31.428	30.198
1890	31.440	28.811
1895	31.448	27.390
1900	31.454	25.971
1905	31.458	24.555
1910	31.459	23.008
1915	31.457	21.020
1920	31.452	19.395
1925	31.445	17.583
1930	31.435	15.734
1935	31.423	14.783
1940	31.408	14.528
1945	31.390	14.729
1950	31.370	15.277
1955	31.347	16.343
1960	31.321	17.282
1965	31.293	18.216
1970	31.262	19.520
1975	31.229	20.845
1980	31.193	22.168
1985	31.154	23.551
1990	31.113	24.967
1995	31.069	26.254
2000	31.022	27.561
2005	30.973	28.937
2010	30.921	30.168
2015	30.866	31.198
2020	30.809	32.474
2025	30.749	33.750
2030	30.687	34.730

LONGITUDINAL ELEVATION
SCALE B

Figure 6.2 Bridges Over Hidden Valley



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6.4 Property Access Bridge Adjacent to John Flynn Hospital and Medical Centre

This bridge is required to connect an existing access road to properties on the western side of the bypass, which would be severed by a deep cutting along the Tugun Bypass alignment. No acceptable alternative access has been found to this area due to the steep topography. Two design options were considered for the access bridge.

Four Span High Level Bridge

Four span bridge with deck at existing access road level, approximately 22 m above the proposed Tugun Bypass.

Advantages

- four span structure would allow the natural surface to be used as false work and construction could occur prior to the start of the cutting minimising impacts on the main excavation;
- access to the property would be maintained during construction at little additional cost; and
- acceptable grading of the south-western approach.

Disadvantages

- higher cost.

Two Span Low Level Bridge

This bridge would have a deck level approximately 8 m below the existing access road level and approximately 14 m above the proposed Tugun Bypass.

Advantages

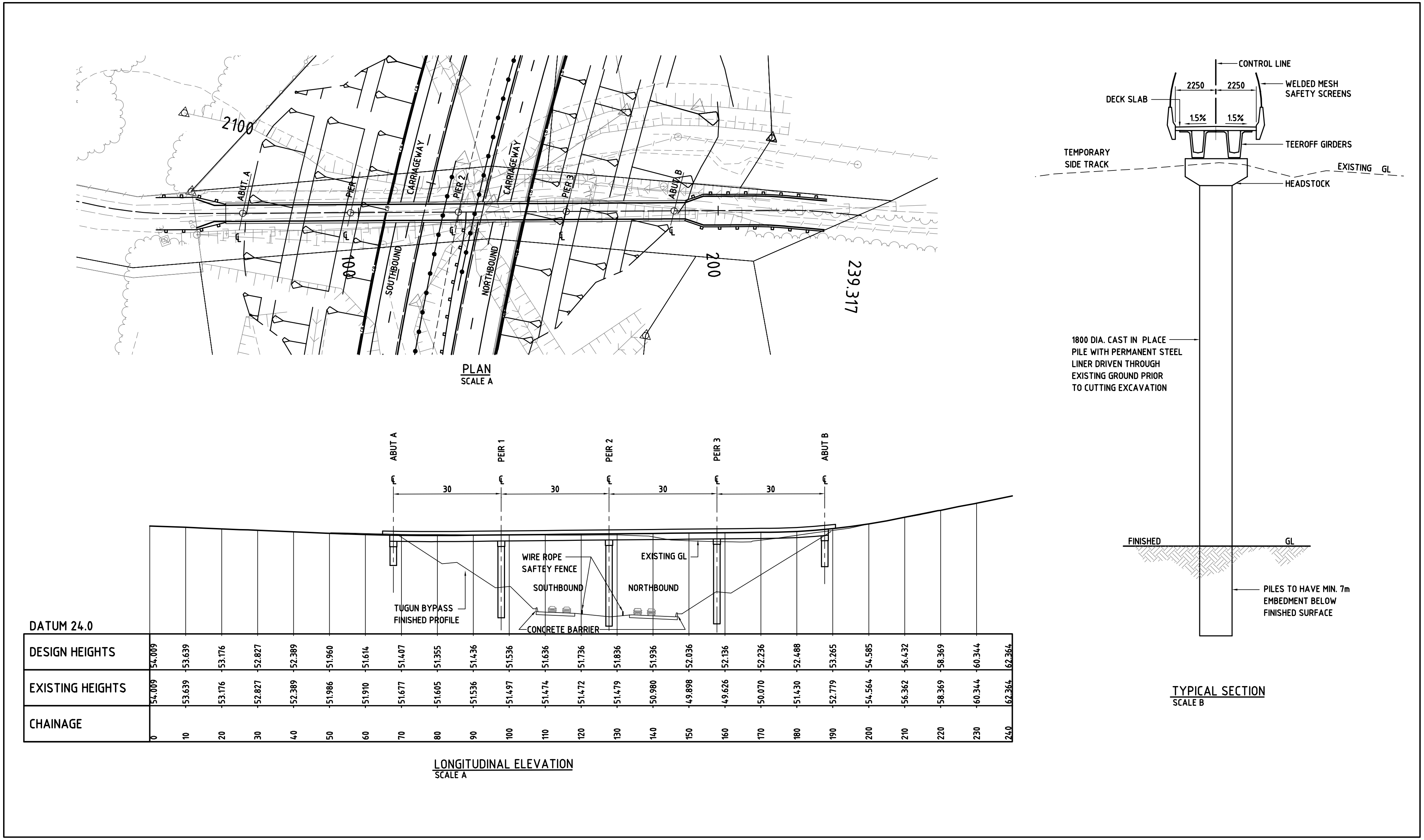
- reduced bridge length.

Disadvantages

- unacceptable road grading on the south-western approach; and
- access to the properties during construction would be difficult and costly.

The existing road at the location of the western end of the proposed four span bridge currently has an approach grade of approximately 17 percent. Due to this grade it is not feasible to lower the bridge deck below the existing access road level as this would further increase the steep approach and opportunities to regrade the road are restricted by the topography. The option of a four span access bridge, approximately 120 m long, at the existing access road level is therefore proposed. The access bridge would be built using a top down method to maintain access to the property during construction.

Figure 6.3 shows concept design details of the proposed property access bridge.



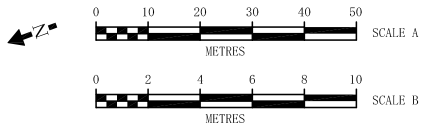


Figure 6.3 Property Access Bridge

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Refinements of this option are possible. During the design development consideration of sloping the bridge deck down from west to east to reduced the bridge height was considered but not examined in detail. This could be revisited as a possible alternative during the detailed design, but care is required not to increase impacts on the eastern side.

6.5 Gold Coast Airport Access Bridge

An existing road used to provide access to Commonwealth land to the west of the proposed alignment of the bypass would be cut by the proposal on a large skew.

A two-span bridge approximately 50 m long is proposed for crossing the bypass carriageways. All abutments and piers would be supported on piles and cast-in ground pile caps with columns above ground supporting headstocks, because the bridge and approach embankments are to be built above grade. Reinforced earth retaining walls would be used at both abutments to minimise deck spans and bridge length.

Figure 6.4 shows concept details of the proposed bridge. However it should be noted that plan details are conceptual and subject to change, in particular the width of the deck and alignment of the bridge approaches are to be determined appropriate to needs.

6.6 Gold Coast Airport Road Tunnel

6.6.1 Tunnel Length and Grade

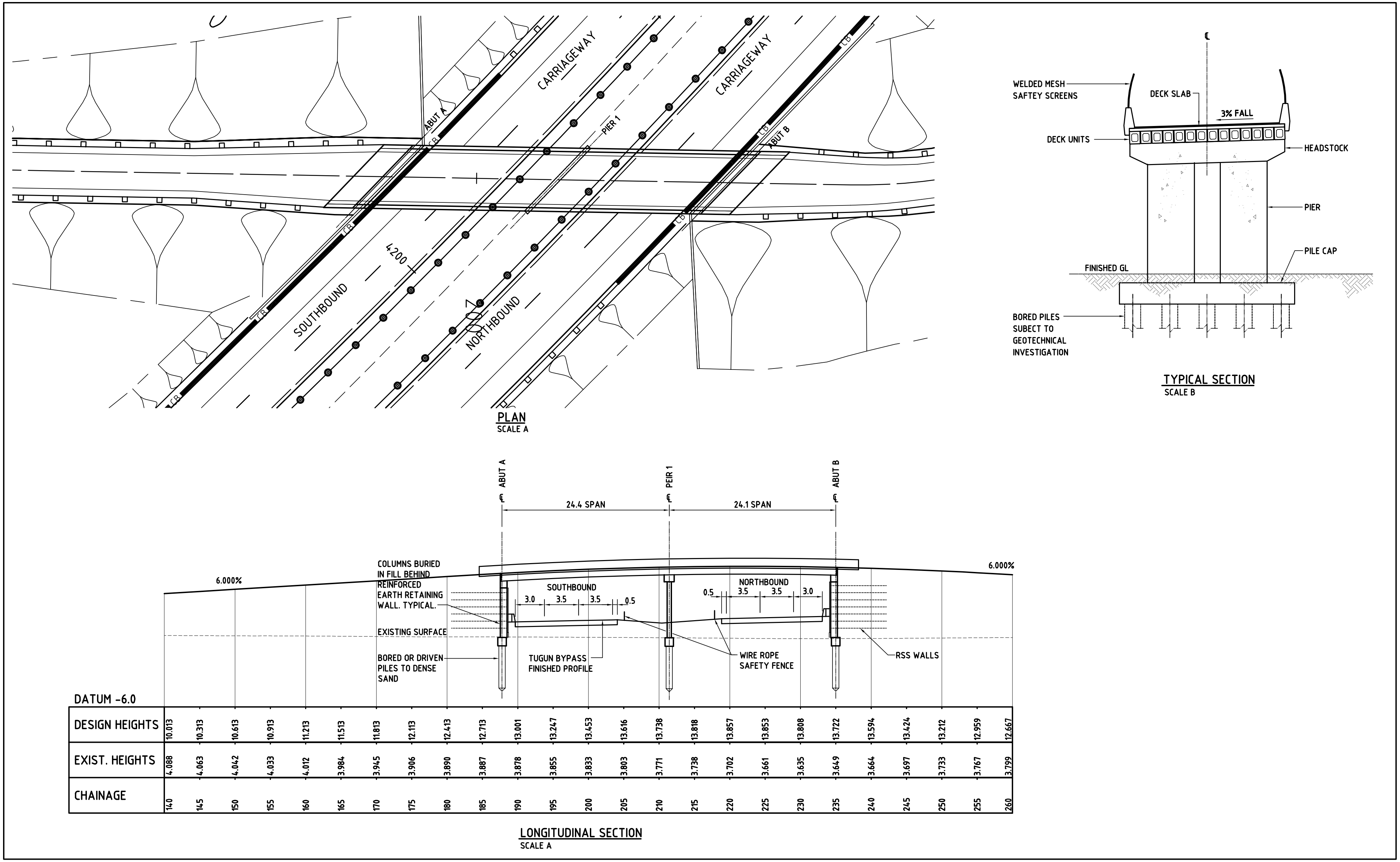
The road tunnel must pass under the airport's obstacle limitation surface. Achieving as short a tunnel as possible, including approach ramps, is important to the total project viability. Long-term tunnel safety risks are also directly related to the length of tunnel.

The length of the tunnel under the obstacle limitation surface is based on the following:

- air space for aircraft takeoffs and landings;
- width of the runway graded strip;
- width of taxiway graded strip; and
- any additional width required for fences, drainage paths, fauna and other general access.

A closed tunnel length of 400 m is currently proposed, subject to ongoing checks and negotiations with Gold Coast Airport Limited and the Civil Aviation Safety Authority.

Approach ramps with structural walls are approximately 300 m long each with maximum grades less than 5 percent. The proposed grade line of the tunnel is as shallow as possible to minimise tunnel and approach ramp costs.



DESIGN HEIGHTS	10.013	10.313	10.613	10.913	11.213	11.513	11.813	12.113	12.413	12.713	13.001	13.247	13.453	13.616	13.738	13.818	13.857	13.853	13.808	13.722	13.594	13.424	13.212	12.959	12.667
EXIST. HEIGHTS	4.088	4.063	4.042	4.033	4.012	3.984	3.945	3.906	3.890	3.887	3.878	3.855	3.833	3.803	3.771	3.738	3.702	3.661	3.635	3.649	3.664	3.697	3.733	3.767	3.799
CHAINAGE	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255	260

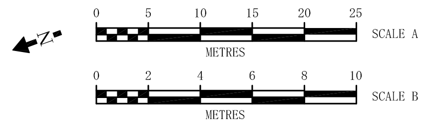


Figure 6.4 Gold Coast Airport Access Bridge

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6.6.2 Tunnel Structural Design

The proposed alignment traverses a sensitive environmental area, requiring attention to design detail and construction methodology to minimise the disturbance corridor and limit impacts on the surface and groundwater systems. Due to the low ground levels and the adjacent Cobaki Broadwater, the alluvial soil would be saturated for most of the proposed construction.

The tunnel would consist of two tubes of rectangular cross-section, which minimise the buoyancy forces exerted on the structure, because circular cross-sections displace more volume (hence more buoyancy) for the same trafficable area. The centre wall which separates the two tubes was added to limit the roof span. Groundwater, soil and aircraft are the principle design loads requiring a 1 m thick roof slab, 1 m thick walls and 1 m thick floor slab, all to be constructed from reinforced or post-tensioned concrete.

During concept design development the primary objective was to satisfy the following goals while minimising cost:

- minimise groundwater drawdown;
- maintain as narrow a construction footprint as possible; and
- minimise disruption to airport operations.

The control of groundwater and the forces that it would impose on the tunnel structure and approach structures are a major issue for its design. In order to ensure that groundwater does not infiltrate the tunnel, the floors and walls must form an impervious barrier. The provision of such a barrier imposes significant loads on the tunnel floor and would require a heavily reinforced concrete slab to resist hydrostatic forces. Another significant issue created by the high water table would be the buoyancy forces which it imposes on the tunnel cross-section. These must be resisted by a combination of tunnel weight, skin friction and grout injected tension piles if required.

Diaphragm walls are proposed as a major component of the tunnel. These are underground walls built from the surface. Conventional diaphragm walls are constructed by digging a trench, filling it with bentonite slurry, then displacing the slurry with steel reinforcement and tremie pouring concrete. Tremie pouring of concrete uses a tube lowered into the slurry so that when concrete is pumped it fills the excavated trench from the bottom up, forcing the slurry mixture out of the trench as the concrete level rises. The concrete hardens in the trench to form the wall, which is then used as an excavation support and foundation element. The walls also reduce groundwater flows and hence make construction easier.

Another form of diaphragm wall construction involving deep soil mixing is a feasible alternative but would require night work as rigs would impinge the airport obstacle limitation surface.

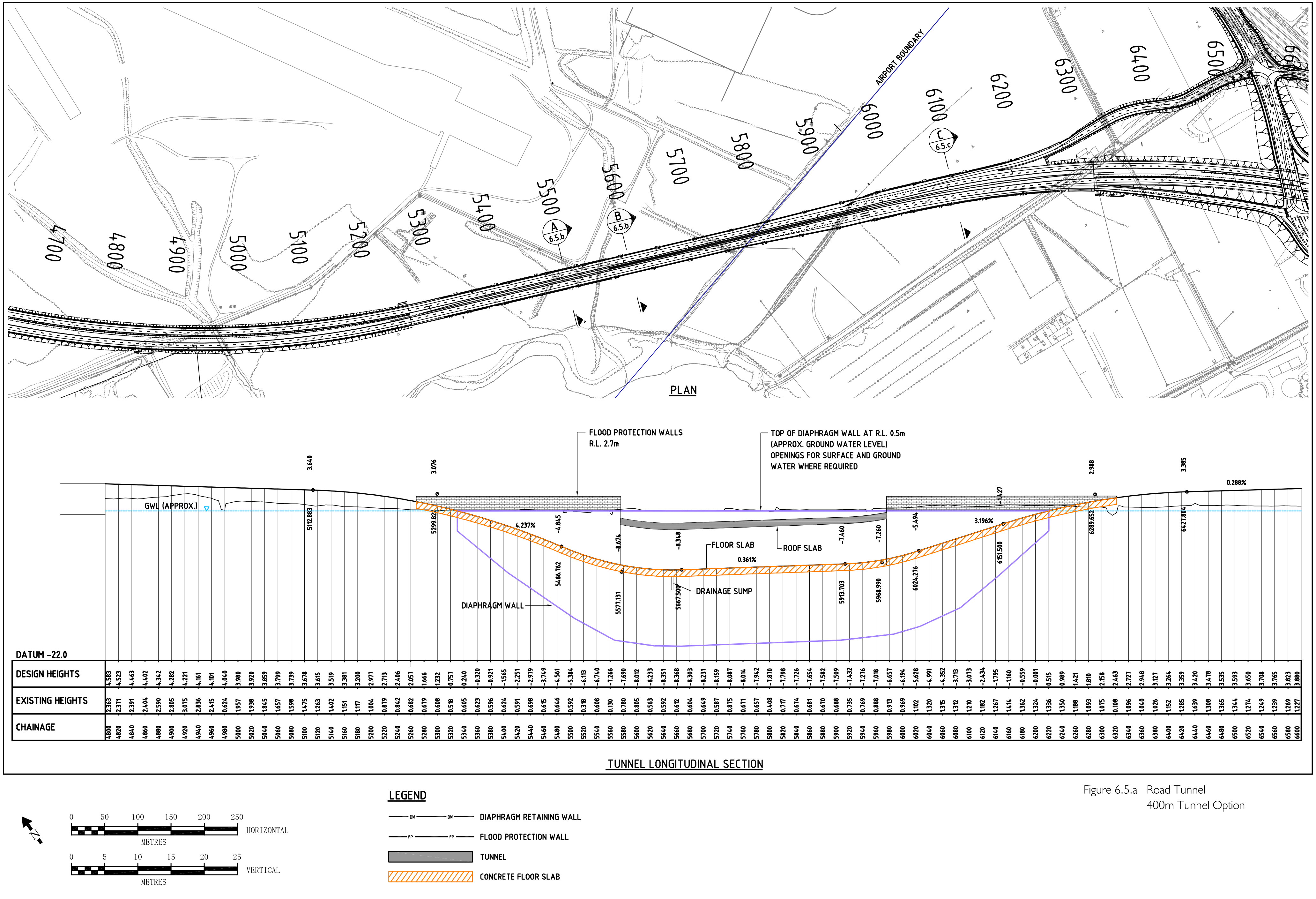

Figure 6.5.a Road Tunnel
400m Tunnel Option

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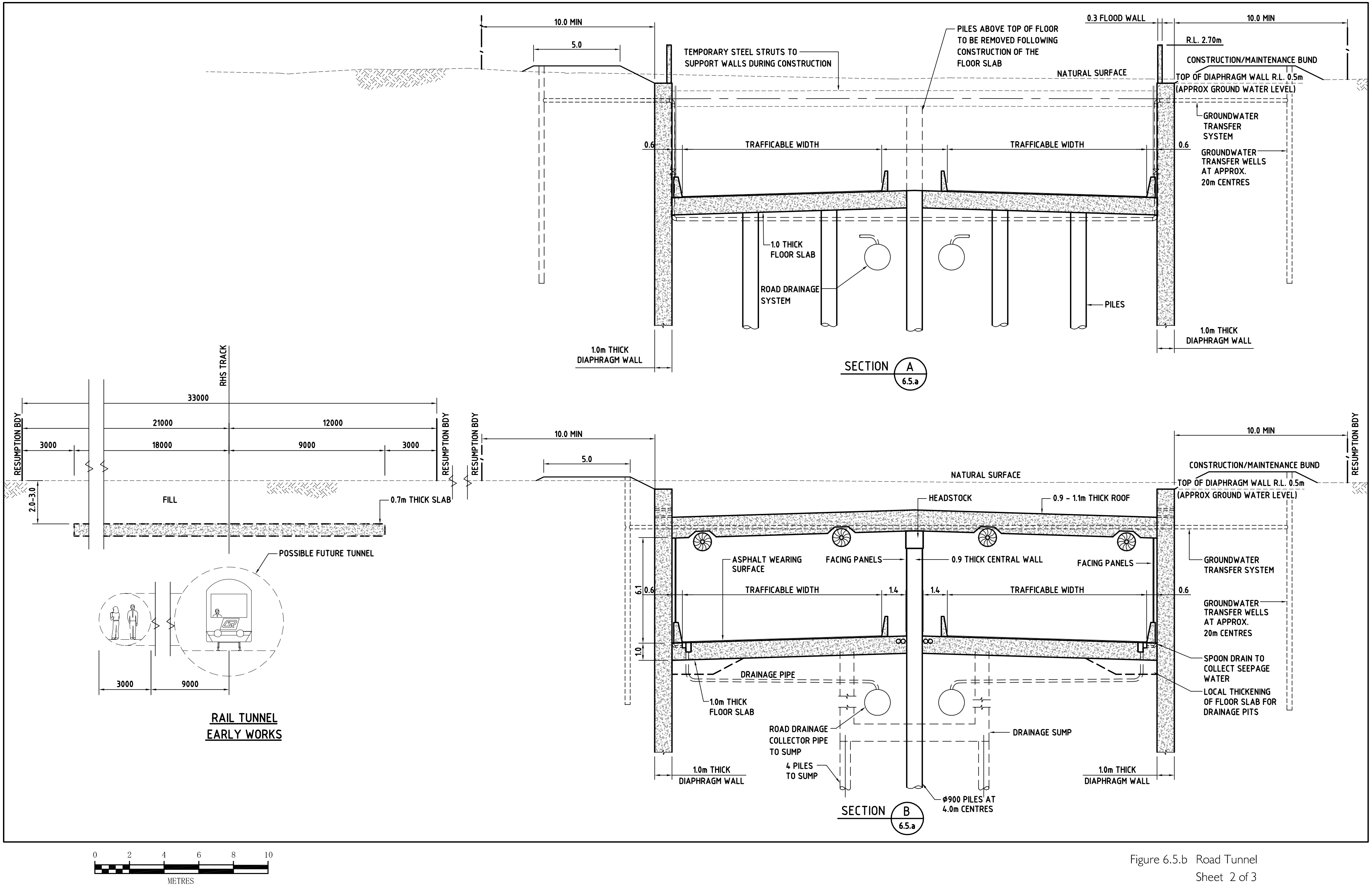

Figure 6.5.b Road Tunnel
Sheet 2 of 3

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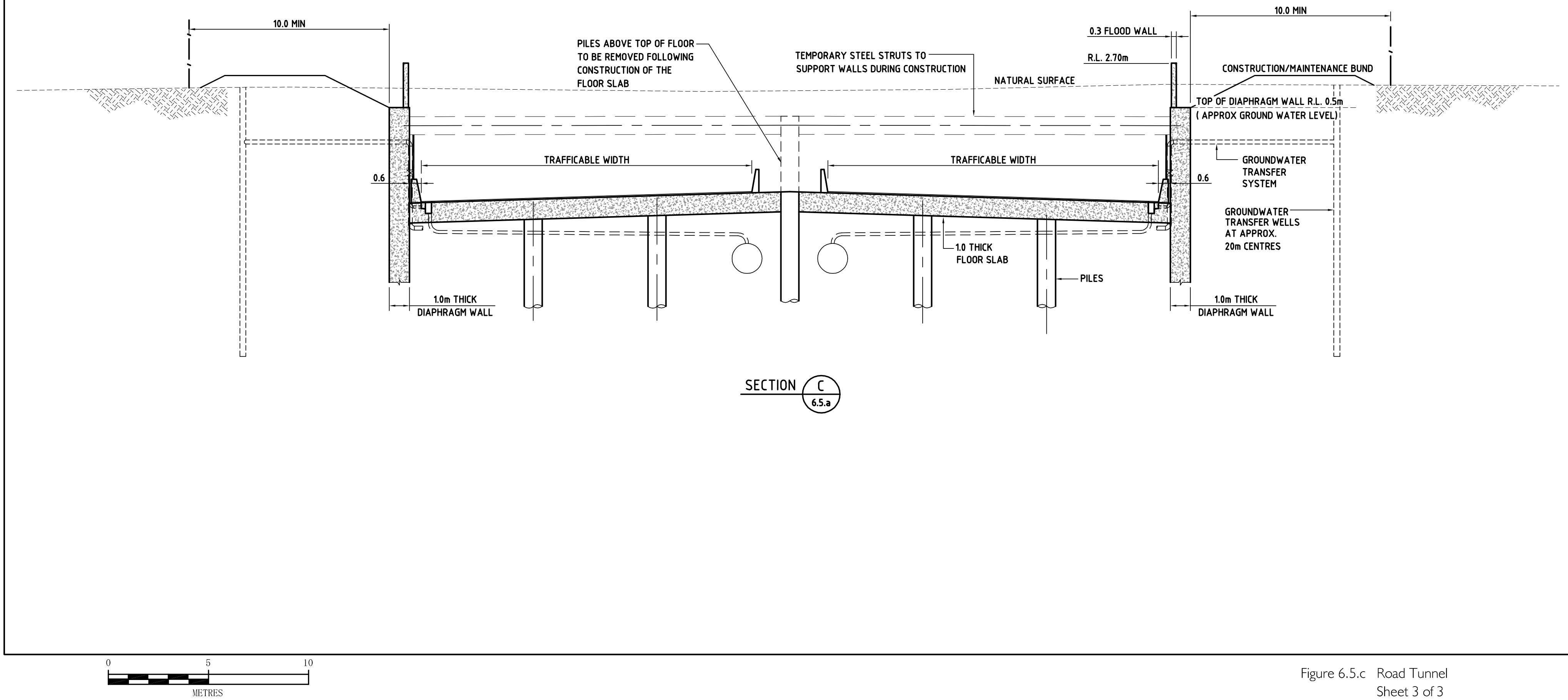

Figure 6.5.c Road Tunnel
Sheet 3 of 3

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Diaphragm walls would be used to form the external tunnel walls before any significant excavation occurs on site. Once completed, the tunnel roof would be cast along the enclosed tunnel section. At this stage the soil between the walls and under the tunnel roof would be excavated and the tunnel floor progressively cast to form the completed tunnel and ramp approaches. While the process is simple in principle, construction sequencing would be important. This is discussed in more detail in the section on construction staging.

While this type of construction would provide a wall which is virtually impervious, some infiltration would be expected. A small seepage control pump has been proposed to cater for this infiltration. The quantity of infiltration is expected to be minimal.

Other methods such as ground freezing were considered for construction. Ground freezing is suitable for sites where the groundwater level is close to the natural surface. This method would involve the freezing of two blocks of soil outside the proposed retaining wall locations to form solid stable blocks. Excavation can then be undertaken between. In situ retaining walls could be constructed against the frozen blocks. Problems with this method are the maintenance of sub zero temperatures in the soil in the warm South-east Queensland climate and the absence of the necessary deep cut-off walls to minimise effects of piping and ingress of groundwater. Buoyancy is another major factor, and would have to be resolved by alternate means to those described above.

Other alternative methods of tunnel construction are discussed briefly in Chapter 7.

Figure 6.5a, 6.5b and 6.5c shows concept details of the proposed Gold Coast Airport road tunnel.

6.7 Gold Coast Airport Rail Tunnel Early Works

The rail tunnel under the Gold Coast Airport would be required to service the proposed rail station adjacent to the existing terminal. Sufficient rail tunnel structure must be provided to allow the tunnel to be completed in the future with no impact on the obstacle limitation surface or the proposed main runway extension. Alternatively if a tunnelling method can be proposed to allow construction of the tunnel structure to take place under an operating runway in saturated sand, no current works would be required.

Currently it is proposed that a slab would be constructed for the existing obstacle limitation surface for the proposed runway/taxiway connection. This will provide provision for a future rail tunnel to be constructed underneath the slab without disruption to airport operations.

Figure 6.6 shows concept details of the proposed Gold Coast Airport rail tunnel early works.

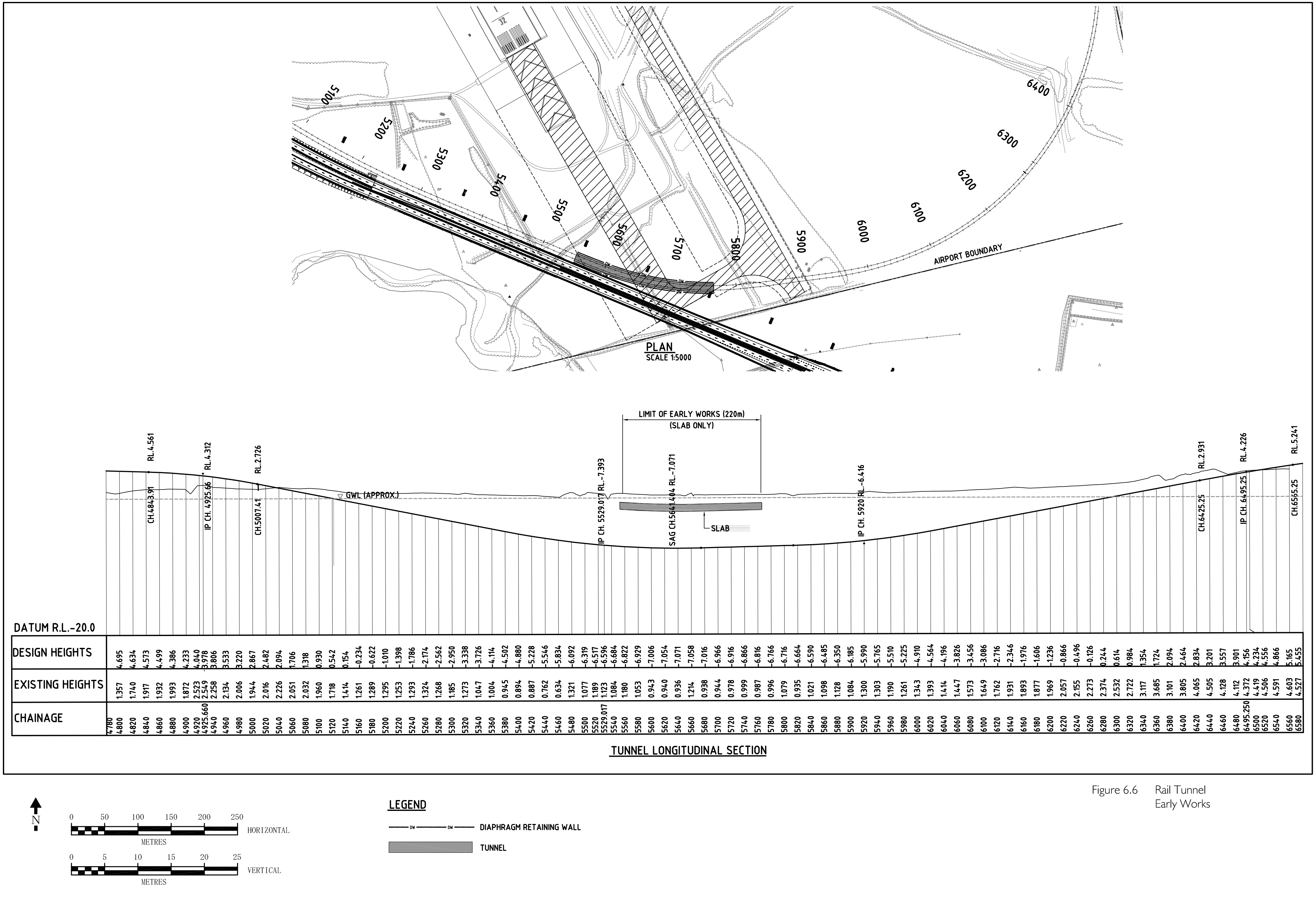

Figure 6.6 Rail Tunnel
Early Works

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6.8 Tweed Heads Bypass Interchange Bridge

The Tweed Heads Bypass interchange bridge would be approximately 45 m long and consist of two spans with prestressed concrete deck units with asphalt wearing surface. A pedestrian footpath on the northern side of the bridge would be provided. The abutments would comprise reinforced earth retaining walls concealing square concrete columns from the deck down to the foundation. Concrete piers would be located within the Tugun Bypass median. All foundations would be bored or driven piles to dense sand.

Figure 6.7 shows concept details of the proposed Tweed Heads Bypass interchange bridge.

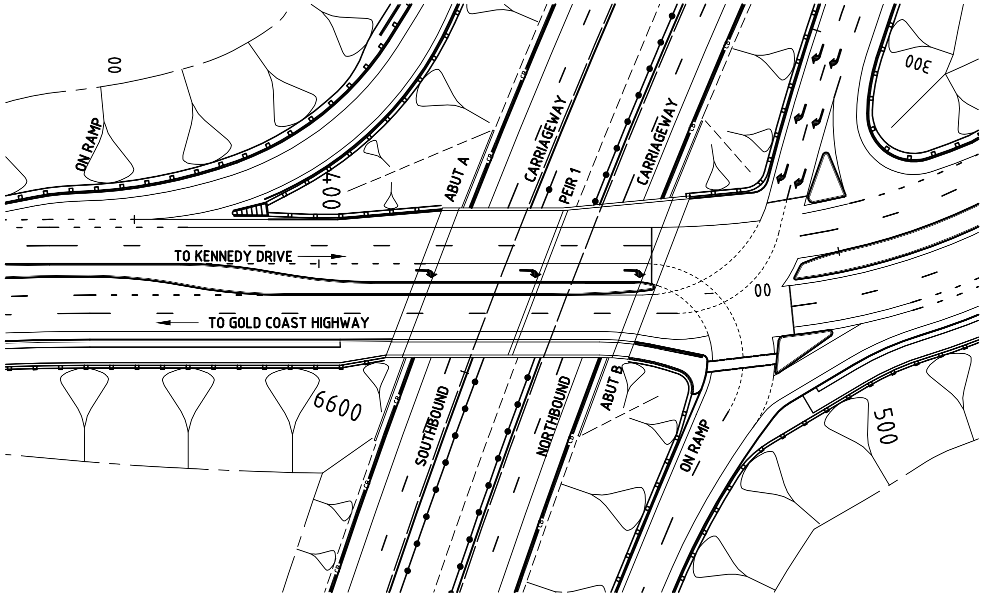
6.9 Culverts

The following indicative culverts are proposed as precast reinforced concrete pipes or box culverts.

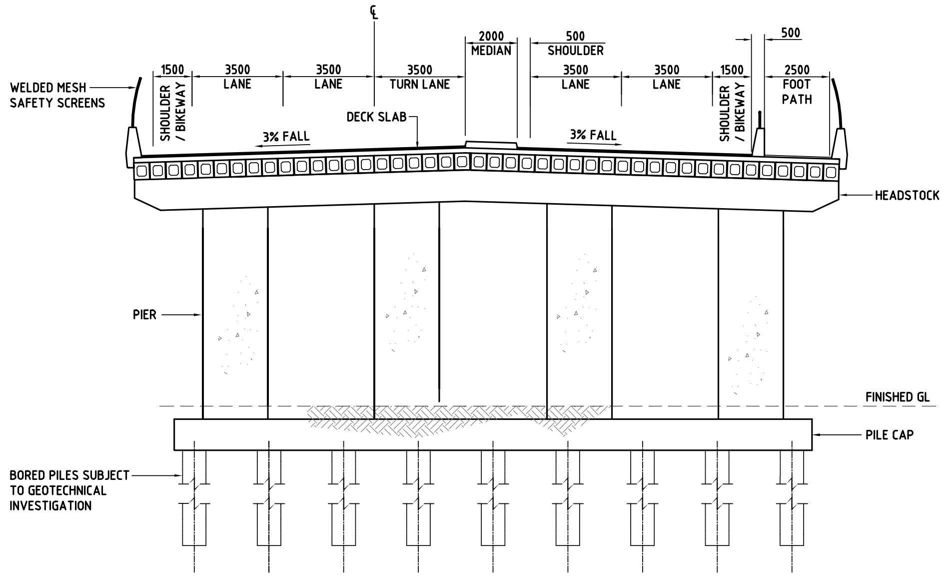
Table 6.1: Culverts

Approximate Chainage	Indicative Size	Type
700	2 x 750 mm diameter	Reinforced concrete pipes
900	2 x 750 mm diameter	Reinforced concrete pipes
950	2 x 900 mm diameter	Reinforced Concrete Pipes
1,200	1,800 mm diameter	Reinforced concrete pipe
1,500	900 mm diameter	Reinforced concrete pipe
3,250	900 mm diameter	Reinforced concrete pipe
2,800	3 x 2,400 mm x 600 mm	Reinforced concrete box culverts
3,200	4 x 2,400 mm x 600 mm	Reinforced concrete box culverts
3,400	4 x 2,400 mm x 600 mm	Reinforced concrete box culverts
3,900	8 x 2,400 mm x 600 mm	Reinforced concrete box culverts
4,600	3,000 mm x 900 mm	Reinforced concrete box culvert
4,600	600 mm diameter	Reinforced concrete pipe
4,700	600 mm diameter	Reinforced concrete pipe
4,750	600 mm diameter	Reinforced concrete pipe
4,800	600 mm diameter	Reinforced concrete pipe
5,000	4 x 2,400 mm x 600 mm	Reinforced concrete box culverts
5,550	Match Existing	Drain re-routed over tunnel
5,750	Match Existing	Drain reinstated over tunnel
6,300	6 x 3,000 mm x 1,200 mm	Reinforced concrete box culverts
6,750	3,600 mm x 2,100 mm	Reinforced concrete box culverts

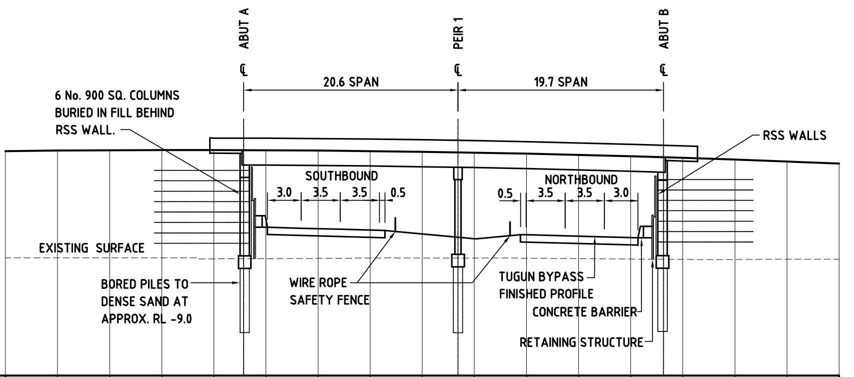
No waterways would be blocked during the installation of the culverts and fish passageway for culverts at approximate chainages 4,980 and 6,300 would be maintained during construction.



PLAN
SCALE A



TYPICAL SECTION
SCALE C



DATUM -10.0

DESIGN HEIGHTS	11.552	11.602	11.636	11.652	11.652	11.636	11.602	11.552	11.486	11.402	11.302	11.186	11.052	10.902	10.736	10.552	10.352
EXISTING HEIGHTS	1.299	1.301	1.304	1.306	1.205	1.216	1.248	1.280	1.288	1.284	1.263	1.225	1.187	1.148	1.138	1.182	1.175
CHAINAGE	400	405	410	415	420	425	430	435	440	445	450	455	460	465	470	475	480

LONGITUDINAL SECTION
SCALE B

0 10 20 30 40 50 METRES SCALE A

0 2 4 6 8 10 METRES SCALE C

0 5 10 15 20 25 METRES SCALE B

Figure 6.7 Tweed Heads Bypass Interchange Bridge

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6.10 Other Structures

Retaining walls varying in height up to 6 m (excluding walls immediately under bridge overpasses) have been detailed in the concept design. For walls less than 3 m in height gravity retaining wall systems would be likely to provide the most economic solution. It is proposed that reinforced earth walls would be used for the remainder of the walls.

Noise barrier structures would also be required at various locations. Details including alternative treatments in the northern section adjacent to Clancy Court are described in the EIS. Structural details of noise barriers would be determined at the detailed design stage.

7. Construction Issues

7.1 General

Throughout the development of the concept design for the Tugun Bypass discussions have been held with Main Roads, NSW Roads and Traffic Authority, Queensland Transport, Gold Coast Airport Limited and construction contractors to identify issues and techniques for construction that relate to this proposal. These include environmental constraints and the design and construction techniques which have the potential to affect the constructability of the project.

These issues are listed below, with discussion on options and identification of practical methods to undertake the works.

7.2 Project Delivery

The project delivery method will be the RTA system of design, construction and maintain (DCM) with a nominated maintenance contractor for a period of time (nominally 10 years).

The concept design and EIS are not predicated on any particular contract packaging delivery or construction method.

A range of construction techniques and methods has been considered and the concept design developed to provide:

- flexibility in final choice of design and delivery;
- flexibility in construction methods; and
- management of environmental impacts, through the development of construction methods in compliance with the requirements of appropriate environmental management plans.

A typical method of delivery and construction sequence for the project has been developed and the major issues described further in this chapter.

A comprehensive brief would be developed to ensure that the selected contractor complied with the technical and environmental constraints applying to the proposal.

7.3 Construction Programming

The typical program of construction for the proposed Tugun Bypass would involve the following activities. The construction period is anticipated to be approximately two years. A general representation of these elements is provided in Figure 7.1.

Elements would include:

- Preliminaries:
  < award of contract.

- Environmental:
  - developing of environmental management plans;
  - fauna mapping, monitoring and mitigation measures;
  - protection of sensitive environmental areas; and
  - noise mitigation measures.
- Site Establishment:
  - setout;
  - temporary environmental safeguards prior to any clearing:
    - fauna management measures;
    - water quality basins and diversion drains; and
    - selected fencing.
  - compound setup;
  - access road development; and
  - security fencing for the airport and other sections.
- Site Preparation:
  - clearing and grubbing;
  - mulching;
  - stripping and storage of topsoil; and
  - development of site accesses along the alignment.
- Earthworks:
  - cuttings;
  - fill embankments;
  - select zones; and
  - batter treatments.
- Structures:
  - Hidden Valley bridge;
  - property access bridge;
  - airport access bridge;
  - road tunnel (airport);
  - rail tunnel (early works);
  - retaining walls and noise barriers; and
  - interchange bridges.
- Interchanges:
  - Tweed Heads Bypass; and
  - Kennedy Drive interchange modification and service roads.
- Drainage:
  - cross drainage; and
  - pavement drains.

ID	Name	Start
1	**DECISION MADE AND APPROVAL GRANTED**	13/02
3	**PRE CONSTRUCTION/TENDER PREPARATION (Invite & Award DC&M project)**	
	Prepare registration of interest documents	01/09
	call for registration of interest	16/09
	Assess registration of interest and shortlist companies	14/10
	Call tenders for DC & M	16/11
	Tender period	16/11
	Decision made and dconditions of approval advised	13/02
	Close tenders for DC & M	14/03
	Assess tenders - establish recommended tenderer	14/03
	Negotiations/contract finalisation w/- recommended tenderer	08/05
	Award Contract	29/05
16		
17	**INDICATIVE CONSTRUCTION PROGRAM**	30/05
	DESIGN AND CONSTRUCTION*	
	Detailed Design (At least 3 months of design before major wors commence)	30/05
26	Site Establishment and preliminary project work - incl. Environmental tasks	29/05
	Commence Major Works	21/08
	Construct Bypass (Incl. structures in NSW & Qld	21/08
	STRUCTURES:	21/08
	NSW: Tweed Interchange/Road Tunnel (Airport)/ Access Bridge/Rail Tunnel Early Works	21/08
	QLD: Hidden Valley Bridges/Merchant Access bridge	21/08
	END of Construction/START of 10 year maintenance period)	20/06

Figure 7.1 Tugun Bypass Possible Construction Program

- Pavement construction;
- Road furniture; and
- Landscaping.

7.4 Construction Methods

7.4.1 General Roadworks

The methods used to construct general roadworks elements of the proposal are standard techniques employed on most highway engineering projects, modified to account for the high level of environmental constraints encountered along this alignment. A description is provided of each technique required to undertake construction of the proposal.

Generally activities would involve:

- mapping to confirm boundaries and locations of sensitive areas;
- planning environmental safeguards in accordance with the environmental management plan, to ensure protection of critical areas along the alignment. This would include monitoring and mitigation measures for soil and water, and flora and fauna;
- installation of fauna-exclusion fences and underpasses/culverts for the protection and passage of key species such as frogs;
- establishment of road fencing, construction compounds and access roads to the major elements of the project. Generally access roads can be provided along the alignment but there may be a need to provide some external access points due to property and environmental constraints;
- clearing and grubbing of vegetation with the mulching/recycling of material for reuse on the project;
- construction of diversion drains and sedimentation basins;
- construction of drainage structures, noting the need to retain surface water connections at all times;
- management of acid sulphate soils during any excavation works;
- topsoil stripping and placement into stockpiles for reuse. Natural topsoil would require environmental monitoring and reuse control as the site is divided into distinct vegetation patterns and mixing of topsoil from different communities could result in the failure of new vegetation. A topsoil management plan would be required for the project developed in parallel with the mapping of the affected areas; and
- earthworks – construction methods would vary as there are distinct types of material from north to south along the alignment. This is described further in the paragraphs below.

In the northern section (chainage 0 to 2,300) quantities of soil and rock formation would involve conventional earthmoving equipment undertaking:

- cutting by ripping with dozers;
- haulage by dump truck and scraper; and
- earthworks compaction by rollers.

As some of this material would be required for the select material zones, stockpiling, crushing and preparation would be undertaken during the earthworks to provide this material for the entire alignment.

In the southern section (chainage 2,300 to 7,000) soft soils and sands would be encountered and techniques required in this area would depend on the geotechnical conditions encountered. The majority of material to be utilised would be excavated silty sands from the tunnel excavation.

General methods of earthmoving in this section would involve:

- protection of the site using bunds in lower lying areas;
- controlled dewatering and recharge of groundwater;
- stripping of vegetation and topsoils to stockpiles;
- haul of excavated material with conventional off-road dump trucks; and
- placement and compaction of fill zones with vibrating rollers to construct earthwork embankments.

As the material in this section of the project has shown signs of potential acid sulphate deposits, special techniques in the treatment of this material would be required prior to placement. This is further discussed in Section 7.12.6 of this technical paper. Geotechnical conditions are described in Technical Paper Number 4 and the management of acid sulphate soil in Technical Paper Number 5.

7.4.2 Bridges

The description of methods is based on one particular construction technique, although alternatives that may change the sequence or type of construction are possible.

Hidden Valley Bridges

The following construction methodology would be used for the Hidden Valley bridges:

- an access track to the base of the bridge piers would be constructed for use during construction of the piers and headstock. The extent of disturbance to vegetation would be minimised during this work by limiting clearing to the access road and footing construction area only;
- spread footings have been selected to minimise the size of construction plant in the bed of the valley. An excavator with a rock breaker would excavate the spread footing with spoil disposed of as fill elsewhere on the project. Alternatively bored piles would be constructed for the bridge piers if suitable rock foundation is not available for spread footings;

- pile caps, pier columns and headstocks would be constructed. When this work has been completed all construction equipment would be removed and work areas rehabilitated within the valley floor;
- abutment footings and abutment structure would be constructed. The abutment footings would be spread footings on rock of sufficient strength;
- the bridge deck would be constructed from one abutment towards the other. A launching truss spanning from the abutment to the first pier would be used to place the 'Teeroff' units for the first bridge span; and
- the deck slab and traffic barriers would be constructed for the first bridge span. When construction of the first span has been completed and the structure obtained sufficient strength, the launching truss could be moved to the next bridge span and the construction sequence for the first span repeated.

Property Access Bridge

The following construction methodology would be used for the property access bridge.

- construction of a temporary access road around the bridge construction site to maintain access to the property;
- the natural surface would be stripped and excavated to the underside of the bridge deck or filled if necessary;
- the foundation for the north-eastern abutment would be excavated to suitable strength material and prepared for construction of the cast in situ reinforced concrete abutment;
- the three bridge piers would be bored a minimum of 5 m below the proposed finished motorway formation excavation level. An oversized hole would be bored to allow the installation of the 1.8 m diameter outer permanent steel liner;
- when the reinforcement cage has been installed to the full pier depth the outer steel liner would be filled with concrete;
- when the north-eastern abutment and pier have been completed the formwork for the first bridge span would be assembled. The formwork would be reused for each of the four spans;
- the first span of the bridge would be cast and post tensioned when the concrete has achieved sufficient strength. One span would be constructed at a time to allow reuse of the forms;
- the bored piers for the south-western abutment would be excavated to a suitable depth below the batter line of the future cutting. The cast in situ headstock would then be constructed;
- wingwalls to retain the material behind the abutment soldier pile walls or ground and facing would be constructed. Concrete barriers would be constructed along the access road on top of the wingwalls and immediate approaches;
- the existing property services along the access road would be relocated and attached to the bridge deck;
- when all bridge spans have been constructed and have achieved full strength, excavation under the bridge decks would commence; and

- when excavation below the bridge deck is complete, the outer lining of the piers would be cleaned and coated with an architectural anti-graffiti paint system.

Gold Coast Airport Access Bridge

The following construction methodology would be used fro the Gold Coast Airport access bridge:

- construct a temporary side road for the existing traffic;
- drive pier and abutment piles and cast pile cap beams to support the new bridge structure;
- construct reinforced concrete abutment and pier columns to the underside of the headstocks;
- construct reinforced earth retaining walls in front of the abutment columns to conceal the columns and retain the embankment fill. The reinforced earth retaining wall facing panels would be placed and fixed to the abutment columns and proprietary earth straps, as backfilling progresses;
- when the reinforced earth retaining walls at the abutments have been completed the abutment headstocks would be constructed. The pier headstocks would be constructed as the reinforced earth retaining walls are under construction; and
- once the abutment and piers have been completed the bridge deck units can be placed in position. The deck slab, relieving slabs and concrete barriers can then be cast and services installed.

Tweed Heads Bypass Interchange Bridge

The following construction methodology would be used for the Tweed Heads Bypass interchange bridge.

- the pier and abutment piles would be constructed down to dense sand, at approximately RL -9.0 m. The pile cap would then be constructed below existing ground level;
- the concrete columns and headstocks supporting the bridge deck at the abutments and central pier would then be constructed;
- the reinforced earth retaining walls at the abutments would be constructed in front of the abutment columns to conceal them. The reinforced earth retaining wall facing panels would be placed and fixed to the abutment columns or proprietary earth straps as backfilling progresses;
- once the abutments and pier have been completed, the bridge deck units can be placed in position. The deck slab, relieving slabs and concrete barriers would then be cast; and
- services would be installed.

7.4.3 Tunnels

This section of the report discusses the proposed construction sequence of the tunnel structures proposed for the bypass. Discussion is based on a viable construction method that, during the design and construction process, may change. While the detail may change, the location and major dimensions are unlikely to change.

Gold Coast Airport Road Tunnel

Clear definition of footprint limits would be established prior to construction commencing, and the construction site would be constrained to protect adjacent areas from contamination by silt, concrete or any other construction materials.

Groundwater and surface water would be carefully managed within and across the site. Acid sulphate soils would be managed appropriately to prevent contamination of water systems.

Environmental management plans would specify all requirements, including environmental measures and monitoring throughout the construction process.

The following indicative method is proposed for constructing the tunnel at significant depths through saturated sandy alluvial soil. Groundwater levels are anticipated to be close to the surface throughout this area, and rarely below 0.5 mAHD. (Note that alternative methods listed below are not precluded in future stages of design, so long as engineering and environmental criteria are satisfied).

Deep diaphragm walls (approximately 20 m) are proposed for the full length of the tunnel and approach ramps along each side and the centre.

This technique has been successfully used in alluvial situations such as those applying to Tugun. Trenching is undertaken with a specialised machine, with the excavated material being immediately replaced with a bentonite slurry to maintain the stability of the trench. Reinforcement is inserted into the trench, and the slurry is then displaced when structural concrete is pumped into the base of the trench. This work proceeds in short sections (of the order of 5 to 6 m and subject to the contractors preferred methodology) along the tunnel walls, with vertical formers (generally cylindrical and corrugated) at the end of each section to provide a positive key with the subsequent section.

Alternative diaphragm wall technology known as Deep Soil Mixing is being used successfully overseas and provides an opportunity for substantial cost reductions. Night work would be required as rigs would impinge the airport obstacle limitation surface. Further consideration of this alternative is required.

The deep diaphragm wall construction methodology has many advantages, including:

- narrow and controlled footprint;
- control of saturated alluvial soils during excavation;
- reduction in groundwater in-flows to the excavation;
- large mass/weight to counteract buoyancy;
- large surface areas to provide friction to counteract buoyancy;
- stability during different construction phases of the tunnel and approach ramps; and
- low height trenching machinery available, resulting in limited restrictions to the tunnel construction within the current flight path.

Possible alternative construction methods include the following:

- open (stepped) excavation;
- deep sheet piled excavation;
- ground freezing;
- cement grouting of the ground;
- excavation of a canal within deep sheet piling, sink precast sections of tunnel into place and hold down by anchors; and
- in situ construction of sections similar to the above alternative.

None of these alternatives match the simplicity of the diaphragm wall construction method. Most of these alternatives are impractical for a range of reasons, and are likely to have major engineering or environmental issues to resolve.

Nonetheless, further investigation of some of these alternatives, could be worthwhile. Further geotechnical information would be required, together with consultation with tunnelling contractors.

The following construction sequence has been proposed as suitable, practical and one which ensures groundwater control in adjacent areas upstream and downstream of the site. The proposed construction sequence has been simplified to four major stages. Figure 7.2 and Figure 7.3 show these four stages diagrammatically, for the closed section of the tunnel and the tunnel approach ramps respectively.

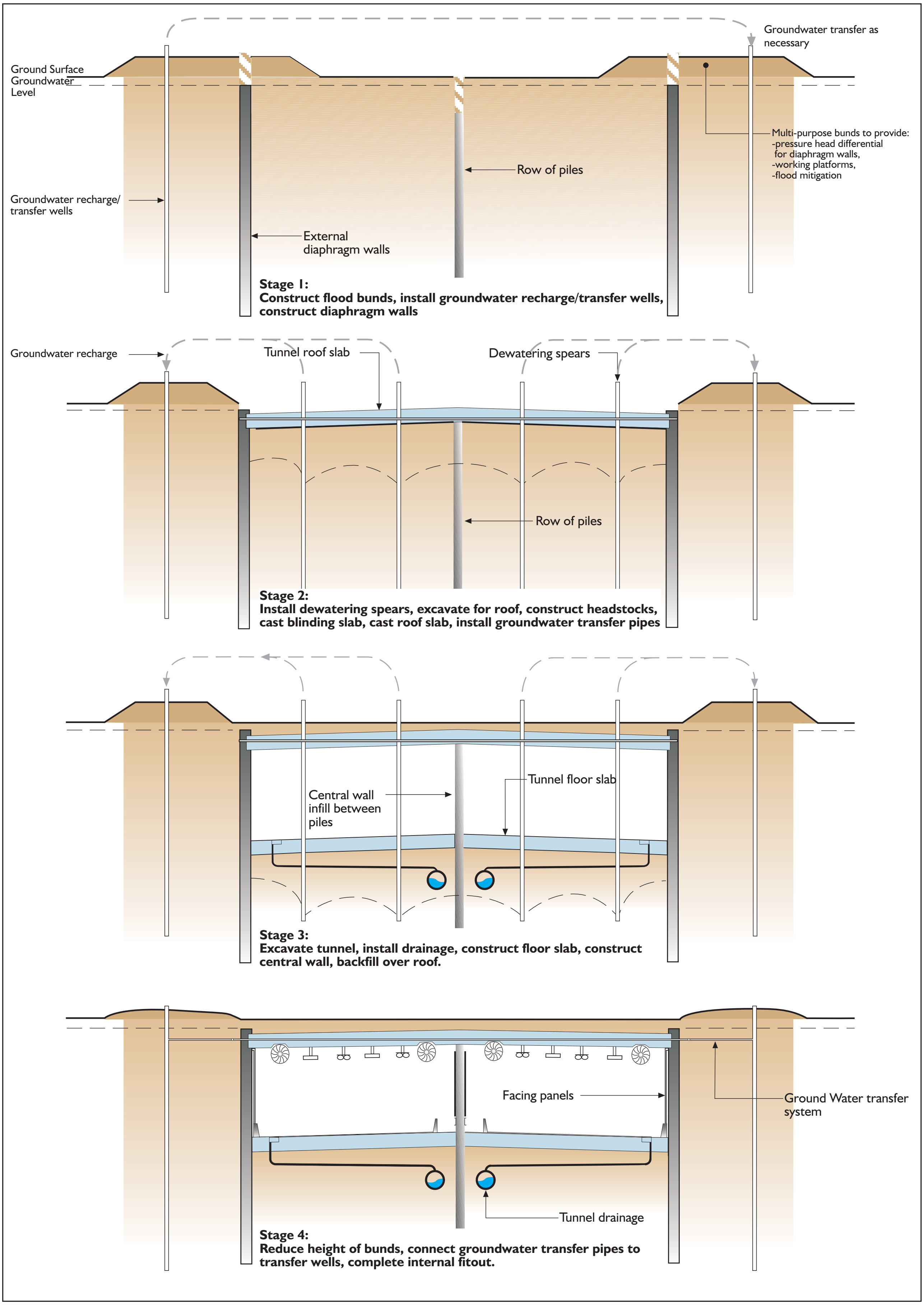
Stage 1: Diaphragm Wall Construction

- Preparation of the site for subsequent tunnel works would include:

    < construction of flood bunds/access tracks around the tunnel and approach ramps. The height (and width) of these bunds will vary with the topography. In low areas a minimum height of approximately 1.5 m to 2.0 mAHD is proposed to protect the site from flooding. In areas where the natural surface is higher, a nominal height of 0.5 m above the ground is proposed to provide construction access. A limiting footprint width of approximately 10 m beyond the tunnel walls is proposed for all sections of bunds;

    < installation of recharge/transfer wells along the outside of the flood bunds. Typical recharge/transfer well details are shown in Figure 7.4. Depths of approximately 10 m and spacings of 25 m are proposed;

    < dewatering along the site (in various stages) would be recycled to the ground through the wells on the flood bunds. The system would be designed to ensure that there is virtually no effect on existing groundwater flows and levels beyond the construction zone. Monitoring of groundwater levels would be undertaken to check and adjust recharge rates upstream and downstream as required. Detailed description and assessment of groundwater management is provided in Technical Paper Number 9;



Not to scale

Figure 7.2 **Construction Sequence of Road Tunnel (Closed Section)**

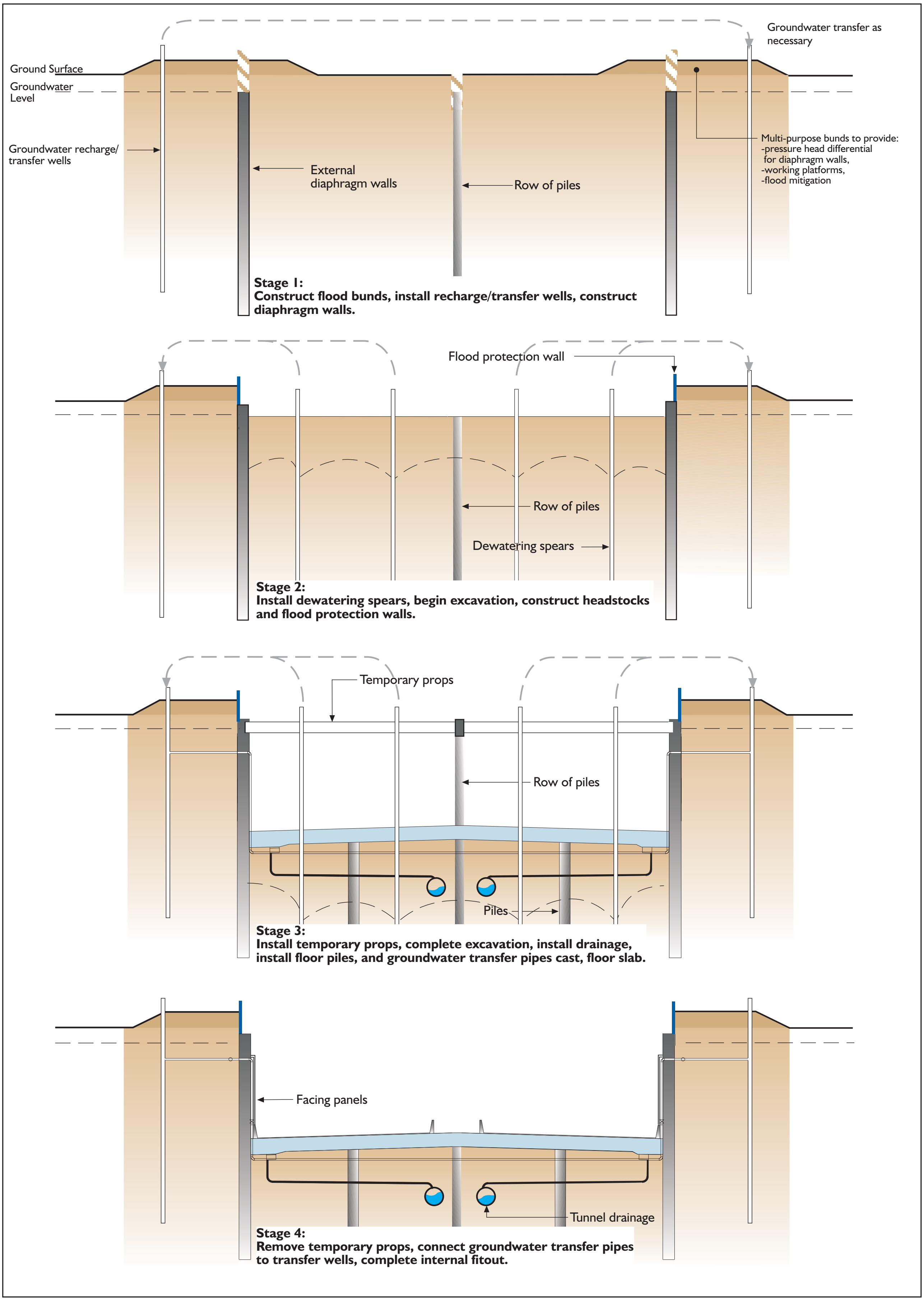


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Figure 7.3 **Construction Sequence of Road Tunnel Approach Ramps**

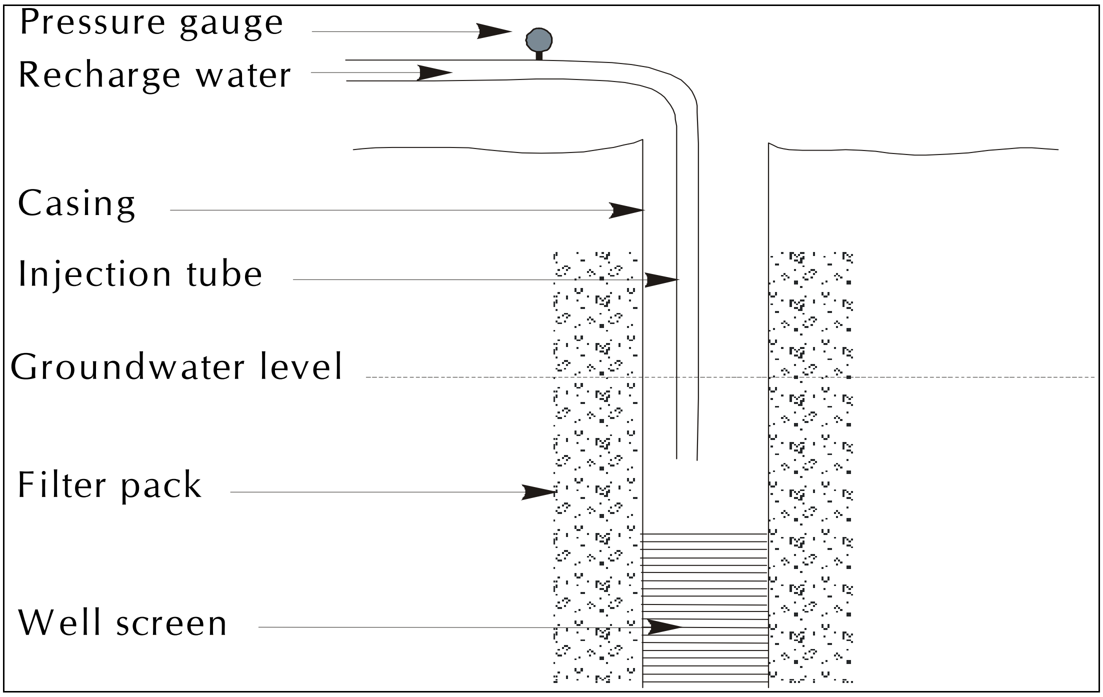


Figure 7.4: Typical Recharge/Transfer Well

- < to minimise footprint width and to assist in controlling groundwater, it is proposed to construct the diaphragm walls higher than the tunnel roof. This would perform the same role as the sheetpiling, but avoids problems with night construction within the obstacle limitation surface and associated noise impacts;
- < one metre thick outer diaphragm walls would be constructed, using a low head clearance wall excavation machine in areas where the airport obstacle limitation surface dictates. The diaphragm walls would be constructed down to a depth of approximately 20 m;

- the central wall in the tunnel would be constructed with close spaced piles, and sequential infill following roof and floor construction; and
- construction of the approach ramp diaphragm walls would be undertaken in the same way as those for the closed tunnel structure.

Stage 2: Tunnel Roof Construction

- excavate the covered tunnel area down to the underside of the tunnel roof level at approximately RL -1.1 m;
- the tunnel would be built using top down construction with the roof constructed on ground and the void below formed by excavation in the next stage;
- a temporary 100 mm blinding slab would be cast on the ground (shaped with the nominated crossfall) to provide a smooth, even surface for casting the tunnel roof. This slab would be removed during tunnel excavation;
- the tunnel roof would be cast on the blinding slab;

- the groundwater piping system would be installed, with connectors to the outer recharge/transfer walls and with connector stubs through the top of the side walls. This pipework would allow movement of groundwater to equalise groundwater levels upstream and downstream when construction is complete;
- the tunnel roof would then be backfilled to the original surface level; and
- on the tunnel approach ramps, diaphragm wall capping beams, in situ retaining walls (to RL 2.7 m) and tie beams would be constructed. Excavation of the approach road to the underside of the floor slab could then commence starting from either or both ends.

Stage 3: Tunnel Excavation and Floor Construction

- special consideration would be given to dewatering during the deep excavations in this stage. Dewatering of the tunnel excavation would involve the installation of groundwater spears connected to a suction pump;
- water quality monitoring/management of discharged groundwater would be required as recharge to the surrounding area occurs. Section 7.9 discusses groundwater water quality procedures. The contractor would be required to provide details of environmental safeguards and management procedures;
- as excavation to the underside of the approach ramp floor slab is achieved, construction of the piles through the floor slab would be undertaken. Where the height of the piling rig encroaches on the flight glide envelope for the airport, piling in those locations would have to be undertaken during designated periods at night;
- road drainage collection pipework would also be installed in trenches below the approach ramp floor slab. The pipework would be graded to the drainage sump;
- when excavation to the underside of the floor slab, installation of piles and drainage has been completed for a section of floor, the floor slab would be cast for the full width. This would prevent the ingress of groundwater and provide structural support for the side walls;
- excavation within the diaphragm walls at a depth greater than 5 m would require temporary steel struts to support the walls. The struts would span from the side diaphragm walls to the central wall pile system and would remain in place until the entire floor slab has reached full strength;
- tunnelling under the roof slab would commence as the tunnel approach ramps are excavated. Adequate ventilation would be provided during construction of the tunnel and tunnel approaches. Equipment to be used would include standard excavator, loader and off-road dump trucks;
- once the tunnel approach ramp floor slab is complete, tunnelling under the roof slab would continue to full depth from either or both ends;
- prior to casting the tunnel floor slab, the road drainage pipework would be installed in trenches below the tunnel floor slab. The road drainage pipework would be graded to a sump constructed below the tunnel floor slab. The sump chamber would house submersible pumps with maintenance covers accessible from the tunnel approaches; and
- the tunnel floor slab and central dividing wall would be cast in sections as tunnelling progresses.

Stage 4: Tunnel Finishing Works

- once the tunnel floor slab has been completed, the groundwater bypass drainage cross connecting pipework and services could be installed in the ventilation/ services zone above the traffic clearance envelope;
- installation of mechanical equipment and other services would occur next, including ventilation fans, lighting, fire safety system and emergency response monitoring equipment;
- concrete safety barriers would be installed at each shoulder edge;
- the asphaltic concrete wearing surface would be placed after the floor slab has been cleaned and prepared; and
- when all services have been installed along the diaphragm walls, facing panels would be installed and the internal fitout completed.

Gold Coast Airport Rail Tunnel (early works)

It would not be necessary to construct the complete rail tunnel including approach ramps. With careful planning and design, it would be possible to limit initial rail tunnel construction to a ground slab only, sufficient to satisfy the airport's obstacle limitation surface and to construct the tunnel later.

7.5 Traffic Management

7.5.1 General

Traffic management would involve a major interfaces with the existing Tweed Heads Bypass interchange and highway connection.

These locations would require staged construction and the provision of temporary roadworks undertaken under agreed traffic management and safety procedures. Other locations would be required to provide access for:

- workers, equipment and material delivery;
- early construction of critical bridges along the alignment;
- emergency and incident response; and
- maintenance of environmental elements along the alignment.

Most construction activities along the bypass would take place well clear of existing roads requiring only simple traffic management techniques at minor access points.

Critical areas requiring safe integration of the new work with the existing road network are discussed in the following section together with the staging methods proposed. It should also be noted that the stagings proposed represent one set of solutions only, and that other solutions may be developed prior to the commencement of construction.

The construction contractor would be required to submit detailed traffic management plans for each section.

7.5.2 Stewart Road Interchange and Highway Connection

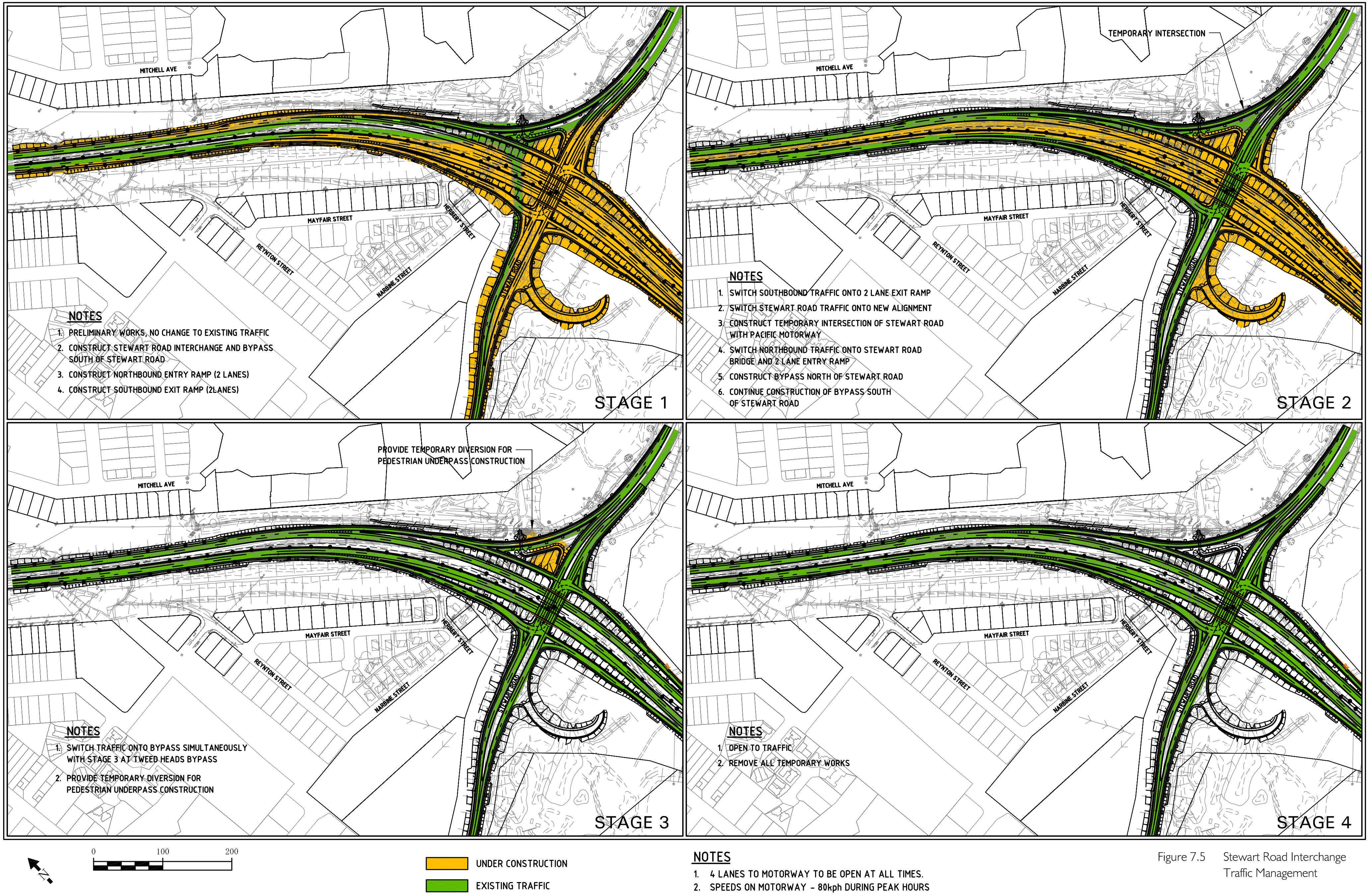
The Stewart Road interchange and northern highway connection works were constructed to facilitate the future of the proposed Tugun Bypass. No temporary works are required. The new works can be constructed without any traffic diversions. Once construction and open to traffic, the northbound loop would revert to an access road for maintenance vehicles.

7.5.3 Tweed Heads Bypass and Highway Connection

Tweed Heads Bypass interchange is situated offline from the existing highway, which would allow construction of the majority of the overpass, approach roads, and service roads to take place away from existing traffic. The following stages of traffic management and construction are proposed:

- Stage 1
  - preliminary works, no change to existing traffic;
  - widen southbound lanes in median to cater for four-lane/two-way;
  - construct Tweed Heads Bypass interchange and bypass north of Tweed Heads Bypass; and
  - additional works for temporary northbound entry ramp from Kennedy Drive.
- Stage 2
  - switch traffic onto southbound lanes;
  - continue construction of Tweed Heads Bypass interchange and bypass;
  - construct Kennedy Drive western service road;
  - using traffic management, construct highway under existing Kennedy Drive northbound on ramp; and
  - construct work at Kennedy Drive roundabout for western service roads.
- Stage 3
  - switch traffic onto bypass;
  - construct southbound lanes on Tweed Heads Bypass/Tugun Bypass, and service road;
  - construct Kennedy Drive eastern service road; and
  - construct work at Kennedy Drive roundabout for eastern service road.
- Stage 4
  - open to traffic; and
  - removal of all temporary works.

The contractor would be required to provide revised and detailed traffic management plans for these connections to ensure uninterrupted traffic movements. Figure 7.6 provides details of the proposed traffic management.



NOTES

1. 4 LANES TO MOTORWAY TO BE OPEN AT ALL TIMES.
2. SPEEDS ON MOTORWAY - 80kph DURING PEAK HOURS
   - 60kph AT OTHER TIMES.
3. 2 LANES TO BE OPENING ON STEWART ROAD DURING PEAK HOURS
   1 LANE OTHER TIMES WITH TRAFFIC MANAGEMENT
4. ALL TURNING MOVEMENTS AT STEWART ROAD TO BE MAINTAINED AT ALL TIMES.

Figure 7.5 Stewart Road Interchange Traffic Management

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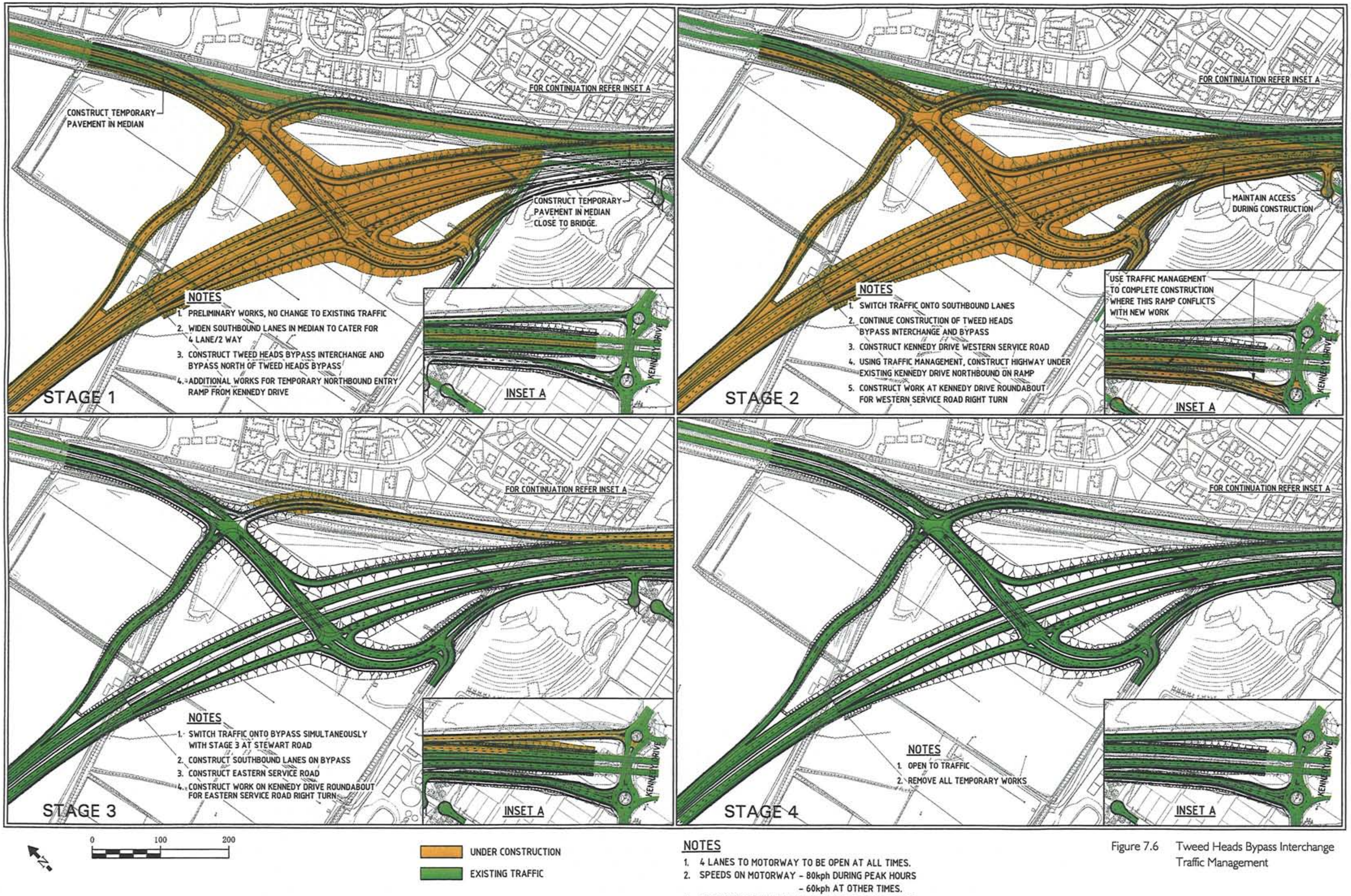

NOTES

1. 4 LANES TO MOTORWAY TO BE OPEN AT ALL TIMES.
2. SPEEDS ON MOTORWAY – 80kph DURING PEAK HOURS
   – 60kph AT OTHER TIMES.
3. ALL TURNING MOVEMENTS AT KENNEDY DRIVE TO BE MAINTAINED AT ALL TIMES.
4. ACCESS TO PROPERTIES TO BE MAINTAINED AT ALL TIMES.

Figure 7.6 Tweed Heads Bypass Interchange Traffic Management

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Minimum traffic operational requirements during these works are as follows:

- four lanes open at all times on motorway;
- motorway speeds, 80 km/h during peak hours, and 60 km/h at other times;
- all turning movements at Kennedy Drive maintained at all times; and
- access to properties to be maintained at all times.

7.6 Geotechnical Issues

7.6.1 Suitability and Treatments of Materials Encountered

The geotechnical investigation undertaken for this concept design and the EIS has investigated general site conditions and highlighted several issues that would influence construction techniques and progress.

The project is defined by two types of material generally. The northern portion, chainage 0 to 2,500, comprising medium strength rock overlayed with various levels of topsoil and clays. The geotechnical investigation to date indicates that the material from this section of the project would be reusable as general fill and select fill for the pavement throughout the project.

The southern portion of the project, chainage 2,500 to 7,700, is a low lying alluvial area. This would require elevated embankments, apart from the airport tunnel which would be in excavation below the Gold Coast Airport obstacle limitation surface. The embankments would be constructed out of excavated silty sands from the tunnel excavation. This material has been found to be reactive to tests undertaken for determination of potential acid sulphate soils.

The material to be excavated would have to be treated by controlled techniques as described in Technical Paper Numbers 4 and 5. The material would be utilised through placement into the embankments with standard earthmoving equipment. The construction methods required for treatment of potential acid sulphate soils is discussed in Section 7.6.3.

An area of landfill along the alignment has also been identified between chainages 3,200 to 3,500. This material would require removal prior to road construction. Special techniques included in the environmental management plan would be required to remove and dispose this material satisfactorily. Preliminary discussions with Gold Coast City Council have occurred and until work under its current program can be finalised, no firm availability of space on the current landfill can be guaranteed. If disposal off site is required, a potential location has been identified at Tweed Heads Landfill 15 km from site. Transportation off-site has been assumed at this stage.

Unsuitable material, in terms of use in road formations, has not been encountered in the current investigation, although all areas have not been investigated at this stage. The most likely location of unsuitable material requiring replacement is in old channels and swamps in the southern portion of the project. Removal of alluvial silty sand could encounter some pockets of unsuitable material not useable in the embankments. Most unsuitable material could be reused in bulk landscaping work and noise mound construction as appropriate. This could affect the earthwork balance, as a nominal allowance of 120,000 m^3 has been assumed at this stage. A more detailed geotechnical investigation would be carried out prior to detailed design, and the allowance adjusted as necessary.

7.6.2 Rock Cuttings

Rock cuttings (chainage 0 to 2,500) have been found to consist of highly fractured and weathered material. Some cut faces have the potential to disjoint over time requiring protection, pinning and securing to reduce the risk of dislodgment. Techniques such as rock bolting would secure faces in these locations. Further geotechnical investigation will identify the quantity and location of risk zones requiring treatment during detailed design.

The excavation of material in this portion of the project should be able to be removed by ripping with a D7/D8 Dozer and would not involve blasting.

7.6.3 Potential Acid Sulphate Soils

The handling and reuse of the material excavated from the southern half of the proposal would require working and monitoring of the material as potential acid sulphate soil. Initial investigation has found varying degrees of reactiveness to first stage testing. Treatment of the material would have to be undertaken by implementing a set of appropriate controls within the context of an environmental management plan for acid sulphate material to ensure that safeguards, monitoring and environmental constraints are maintained during the reuse of this material.

Treatment involves the mixing of agricultural lime, in varying proportions depending on the degree of soil acidity. The benefit of agricultural lime is that it reacts only as required and provides treatment over time.

A controlled cell of material would be excavated, hauled, placed into the embankment zone, tested for percentage addition of lime, and mixed mechanically with a large agricultural mixer (rotary hoe). Excavation would be continued cell by cell and placed into the embankment layers. Other techniques (not anticipated at this stage) could involve the mixing of material through stationary mixing equipment (pug mills) and placement in the embankment zone as general fill, compacted for consolidation.

As the treatment and reuse of the acid sulphate soil in embankments could generate small quantities of leachate through water being added for consolidation, there will be requirements to manage the quality of water leaving the embankment for a period of time during construction e.g. bunding, sediment basin and catch drain. Embankment sections would be compacted and sealed off as soon as practical with topsoil at each edge and select subgrade material across the full width of the formation. Details including monitoring would be fully developed in the environmental management plan for acid sulphate soil.

If material found during excavation could not be used in the embankment due to high levels of sulphuric acid, closed cell disposal or burying of material in landscape mounds capped with clays and soil would be undertaken. This would require close monitoring and has the potential to effect the earthwork balance.

Further details are contained in Technical Paper Numbers 4 and 5.

7.7 Sources of Material

7.7.1 General

Embankment material would be obtained from excavations within the alignment of the project. The allowances for unsuitable material would be monitored throughout to adjust the earthworks balance as construction proceeds. The current earthwork balance for the concept design is set out in Table 7.1.

Allowing for assumed cut to fill losses of 120,000 m^3 (due to unsuitable material, transportation and compaction), there would be an imbalance of earthworks of approximately 300,000 m^3. The final design would have to consider adjustment to provide sufficient fill on-site by adding retaining walls to reduce fill batters, flattening cuts to produce more fill material and importation of general fill. Sources of external fill are discussed in Section 7.7.3.

Table 7.1: Earthworks Summary

Location	Cut (m^3)	Fill (m^3)	Assumed Losses unsuitable etc (m^3)
Bypass – North Boyd Street	263,000	240,000	35,000
Bypass – South Boyd Street	6,500	170,000	65,000
Airport Road Tunnel	240,000	20,000	-
Stewart Road interchange	25,000	100,000	10,000
Tweed Heads Bypass interchange	15,500	200,000	10,000
	550,000	730,000	120,000
Others:			
Stormwater Culverts	4,000		
Totals	554,000	730,000	120,000
Total Fill Required (includes unsuitable)		850,000	
Balance (additional fill required)		296,000	

7.7.2 Select Subgrade Material

Select subgrade material (reference Section 5.8) required below the final pavement layers could be derived from within the project. Geotechnical investigation indicates material in the northern portion (chainage 1,200 to 2,500) would produce a California Bearing Ratio (CBR) of 15 percent or greater.

This material would require processing for size by crushing and would be used throughout the project as select material. The crushing could be undertaken within cuttings, adjacent to the site or simply as part of the fill placement and compaction process. The highly fractured and weathered nature of the material lends itself to easy and economical crushing.

Alternatively this better quality material could be used in general earthworks (wholly or partly) and select subgrade material could be imported in the required quantities.

7.7.3 Other Materials

Gravels, aggregates, sands and general fill would be required throughout the project for local roads, drainage structures, pavement materials, bedding sands, and erosion protection. Depending on the final pavement selection and design, varying quantities of sand and aggregates would be required for the concrete and asphalt pavements.

Assuming selection of a deeplift asphalt pavement, an indication of imported material requirements is set out in Table 7.2.

Table 7.2: Major Imported Material Requirements

Works	Product	Imported Materials	Quantity
Airport Tunnel:	Concrete	Sand	67,000 t
		Aggregate	92,000 t
		Cement	38,000 t
		Reinforcing Steel	8,500 t
Bridges and Other Structures:		Concrete	4,500 m^3
		Reinforcing Steel	700 t
		Deck Units	270 (no)
Pavements:		Select Subgrade	40,500 m^3
		Asphaltic Concrete	144,000 t
		Base (crushed rock)	25,000 m^3
Earthworks		General Fill	300,000 m^3

It is assumed that none of these materials would be available from within the project and that external sources would be required.

Sources of suitable material have been identified as set out in Table 7.3.

Table 7.3: Sources of Material

Material	Possible Source	Location	Approximate Distance (km)
General Fill (CBR >3 %)	Boral Quarry	West Burleigh	10
Select Fill (CBR >15 %)	CSR or Pioneer Quarries	Ormeau	50
Sand	Boral CSR or Hymix	Burleigh Tweed Heads	10 8
Aggregate	Hymix Quarry	Nerang	20
Cement	QCL	Brisbane	100
Concrete (Bridges etc)	Boral CSR or Hymix	Burleigh Tweed Heads	10 8
Base and Sub Base	Hymix Quarry	Nerang	20
Asphalt	Boral or Aztec	Andrews	15
Concrete Pipes & Concrete Box Culverts	Pioneer CSR Humes Rocla	West Burleigh Gold Coast Gailes	10 30 100
Bridge Deck Units & Piles	Various Suppliers	Brisbane & Wacol	100

Material	Possible Source	Location	Approximate Distance (km)
Reinforcing Steel	Neumann Steel Smorgon ARC	Currumbin Tweed Heads	10 8
Guardrail	RTCS	Brisbane	100
Wire Rope Safety Fence	Road and Construction Supplies	Gold Coast	20
Concrete Barrier Units	Various suppliers	Brisbane and Wacol	100
Other Fencing	Various Suppliers	Gold Coast	20

7.7.4 Traffic Generation

While construction is generally away from existing roads, haulage of material to the site would add to the traffic on the existing highway and some local roads used to provide access to the alignment. Estimates of generated traffic for several scenarios have been undertaken for the project.

General construction traffic from workforce, visitors and other deliveries would not result in a significant increase in the traffic currently using the highway. Boyd Street however, would be used as an access to the project and an increase during construction would require appropriate management. The construction contractor would be required to provide traffic management at this location.

During the importation of materials for pavement construction (assuming a central batching plant is located at the main works compound) a maximum of 150 trucks per day would be required to deliver material. This period is expected to cover approximately 12 months towards the end of the overall construction period, but large truck numbers for the delivery of pavement materials would only occur periodically within this period. The contractor would provide details of traffic management measures to ensure safe passage of vehicle movements around the site.

7.8 Workforce

7.8.1 Construction Workforce

The extent and make-up of the workforce would vary depending on location and construction activities at any given time.

The workforce would comprise a principal contractor providing construction management and a number of subcontractors. It is estimated that the management team would require up to 40 people and would involve professional, technical and administration support staff.

Each construction site along the alignment would engage specialist construction crews. These crews would include equipment and plant operators, form workers, steel fixers, concreters, labourers, tradespersons and truck drivers. It is estimated that an on-site workforce of approximately 200 people would be engaged during the construction period. The project would also require additional specialist support for geotechnical investigations, survey, design, environmental monitoring and construction management.

The inclusion of the workforce involved in other activities (manufacture and supply of materials, waste collection and removal, and other services to the project) could expand the total project workforce beyond 300 over the construction period.

7.8.2 Construction Hours

Standard construction hours for this proposal would require modification to achieve minimal disturbance to residents and businesses and to comply with airport operational restrictions.

In Queensland, construction hours are restricted to between 7:00 am and 7:00 pm, Monday to Friday and 8:00 am to midday Saturday. In NSW, construction hours are restricted to between 7:00 am to 6:00 pm, Monday to Friday and 8:00 am to 1:00 pm Saturday. No work would take place without prior approval outside these hours. Due to Gold Coast Airport operations, some work would be required between the hours of 11:00 pm to 6:00 am Monday to Saturday.

In order to ensure that activities undertaken outside normal working hours do not cause unreasonable nuisance to residents this work would be restricted to:

- delivery of material outside normal hours as requested by police and authorities for safety reasons;
- emergency work;
- work which would significantly delay traffic or cause traffic management problems;
- other works, where a need has been demonstrated; and
- work within the airport obstacle limitation surface/flight paths.

In any such cases, satisfactory environmental controls must be implemented to minimise impacts.

7.9 Soil and Water Management

As there are several sensitive environments along the alignment, high standard erosion and sedimentation control measures will be required. The proposal is adjacent to NSW *State Environmental Planning Policy Number 14* wetlands, other wetlands and watercourses which flow into the Cobaki Broadwater. This will require management controls to ensure that safeguards are put in place and maintained throughout the construction period.

Proposals for mitigation have been developed in the concept design, and would be further developed in detailed design. These include:

- site environmental management plans;
- silt fencing;
- sediment traps;

- water quality basins;
- groundwater monitoring; and
- maintenance/monitoring programs.

Further information is provided in Technical Paper Number 8.

Control and implementation of mitigation measures would be documented in contract conditions and construction environmental management plans provided by the contractor to ensure compliance with regulations and monitoring procedures for all authorities.

7.10 Construction Noise and Vibration

7.10.1 General

Full details of noise and vibration are contained in Technical Paper Number 10.

Construction working hours, noise criteria, noise generation and duration, mitigation and management measures are detailed in that technical paper.

7.10.2 Construction Noise

The duration of construction activities at a number of key locations is expected to be as follows:

- Stewart Road interchange - early works construction nearing completion
- Hidden Valley bridges - 12 months.
- Airport Road tunnel - 18 months.
- Tweed Heads Bypass interchange - 12 months.

The predicted levels of construction noise would vary according to existing background noise levels, location of construction work and the expected duration of works near a particular residence. Construction noise may exceed relevant criteria in some areas on occasions.

Proposed mitigation measures are described Technical Paper Number 10. These measures would generally involve modifying construction practices to reduce noise levels rather than constructing screens or other noise reduction measures at the residences concerned.

An alternative construction method to remove the need for sheetpiling at the airport road tunnel is proposed, which would further reduce construction noise.

7.10.3 Blasting

As described in Technical Paper Number 4, geotechnical investigations to date suggest that blasting would not be necessary as all rock in the northern section is highly fractured and would be rippable by normal methods. If blasting proves to be necessary, appropriate management would be prepared by the contractor and the appropriate approvals obtained.

7.10.4 Construction Vibration

The levels of vibration generated from various construction activities would be site specific and dependent on the ground type, the particular equipment used, and upon the proximity of the construction activity to the site boundary and the nearest residence.

Vibration from construction activities associated with general road construction is not expected to generate significant levels of vibration at nearby residences due to the distance between sites and the nearest building and the relatively small size of the necessary compaction equipment.

Preconstruction surveys would be undertaken and vibration monitoring and response plans would be implemented to minimise property impacts.

7.11 Auxiliary Construction Facilities

While the project is under construction, the construction contractor would require temporary areas for construction compounds, batch plant sites, storage facilities for material and equipment for a range of construction related activities.

The equipment used would depend on the contractor's requirements, final design elements and work method chosen. The approach taken has been to identify potential sites that could be utilised by the construction, to assess likely impacts and to describe mitigation measures.

Identification of suitable areas has been based on typical requirements for similar projects both in NSW and Queensland, combined with the environmental constraints identified.

While a number of potential sites have been nominated, the construction contractor would be responsible for selecting suitable sites for each type of activity according to the methods employed and final design. All work undertaken on temporary sites would be subject to satisfying site specific environmental criteria, mitigation measures and local authority requirements. It would be the contractor's responsibility to apply and have approved temporary facilities in accordance with all requirements of noise, dust, storage, environment and waste management.

The ancillary facilities would be temporary and would be removed on completion of the project. They would be for the exclusive use of the project. Once the facilities are no longer required, they would be removed and areas restored to acceptable conditions.

A description of the usage and requirements for each activity are provided below, followed by a summary table of potential locations and activities at each site.

7.11.1 Construction Compounds

The contractor would require several construction compounds along the proposed alignment for the safe and secure provision of demountable offices, ablutions, car parking, workshops, storage of material and equipment, servicing and repair facilities.

Each compound would be fenced and lit at night for security and protection. Fuel and chemical storage would be in accordance with environmental requirements.

7.11.2 Asphalt Batch Plant

A total of up to 60,000 m^3 of asphaltic concrete would be placed over a 12 month period and an on-site batch plant would most likely be employed.

The purpose of an asphalt plant is to receive bitumen, aggregate, sand and other material, mix these together and batch and load asphalt into trucks.

This facility could also be situated at Tugun Landfill, subject to Gold Coast City Council's satisfaction with environmental safeguards. The contractor would be responsible for obtaining all necessary permits and approval to install this facility.

7.11.3 Stockpile Area

The stockpiling of material on site would involve approximately 80,000 m^3 of topsoil. This would require storage in temporary locations for reuse during landscape work along the alignment of the proposal.

There may also be requirements for stockpiling general fill and select fill during the project. The contractor would be required to protect all stockpiles of erodable material against erosion by temporary seeding or mulching together with the provision of standard erosion control measures.

7.11.4 Disposal Areas for Unsuitable Material

The current earthwork calculations assume that approximately 120,000 m^3 of unsuitable material is expected to be generated. This would require disposal and replacement.

Proposals for landscaping have identified some areas where batter slopes could be flattened within the road reserve to integrate the proposal more effectively into the surrounding terrain. Unsuitable material could also be placed in mounds to help noise mitigation. These would be identified during detailed design.

Potential acid sulphate soil not treated in the embankment would either be buried promptly (below the water table) or treated before stockpiling as unsuitable material in the landscape mounds.

7.11.5 Selection Criteria for Auxiliary Construction Facilities

The following criteria have been used in determining potential sites for construction compounds and temporary batching facilities:

- central to a substantial portion of the works;
- located with ready access to local road network;
- within the road reserve or in areas where land use is permitted;
- separated from nearest residence by at least 200 m or it can be demonstrated that no adverse impact would occur at the nearest residence;
- not within 100 m of State Environmental Planning Policy Number 14 wetlands;
- not located within 100 m of any drain that discharges into the wetland or mitigation measures are provided;
- of low conservation significance for flora and fauna;
- sufficient room for effective operation of the plant;
- relatively level;
- above the 20 year flood level; and
- selected so that the use of construction facilities does not affect land use of adjacent properties.

7.11.6 Summary of Suitable Locations

Based on the above criteria, a range of potential sites for compounds, batch plants, topsoil stockpiles and other material stockpile areas have been selected. These sites are listed in Table 7.4.

It would be the responsibility of the contractor to obtain approval to use any of the sites, and to maintain all appropriate environmental measures in place throughout the contract.

Table 7.4: Potential Auxiliary Construction Sites

Site Location	Potential Area (m^2)	Comments/Purpose	Activity
Stewart Road (current construction)	10,000	Area adjacent to interchange	Works and Bridge Compound
Old Quarry Site (Tugun Heights)	20,000	Stockpile Site	Temporary Stockpiles
Old Quarry Site (Tugun Heights)	5,000	Hidden Valley Bridges	Bridge Compound
Tugun Landfill	100,000	Batch Plant - the only site available for this facility	Main Compound Area, Batch Plant Site
Airport land/NSW Crown land	20,000	Road Tunnel/Rail Tunnel Early works	Tunnel Compound
Tweed Heads Bypass	5,000	Interchange	Bridge Compound

7.12 Environmental Management During Construction

Main Roads and NSW Roads and Traffic Authority have cooperatively established environmental management systems based on NSW Roads and Traffic Authority *Environmental Management Guidelines*, (NSW Roads and Traffic Authority 1998) to achieve continual improvement to overall environmental performance including proper management of environmental risk.

The NSW Roads and Traffic Authority has developed a series of specifications and guidelines as sub-sections of their overall management system. The relevant sections proposed to be adopted on this project are:

- G35 Environmental Protection (Management Plan).
- G36 Environmental Protection (Management System).

7.12.1 Project Environmental Management Plans

The project environmental management plan would be developed for all environmental management issues relating to the project from the planning phase, through the construction of the proposal to operation and maintenance. The preparation and implementation of the project environmental management plan is the responsibility of the Project Manager. Environmental management plans prepared by the contractor and operator would be consistent with the project environmental management plan.

7.12.2 Contractor's Environmental Management System

The client would require contractors for the proposal to have a Contractor's Environmental Management System in accordance with the requirements of the *Environmental Management Systems Guidelines* (Construction Policy Steering Committee 1998) and NSW Roads and Traffic Authority's *Quality Assurance Specification G36* (November 2003).

7.12.3 Contractor's Environmental Management Plan

The successful contractor would be operating within the framework of its own environmental management system and would be required to prepare a Contractor's environmental management plan for the construction of the proposal specifically aimed at addressing the environmental issues raised by the proposal. The Contractor's environmental management plan would be the key management tool for control of environmental impacts during construction and operation of the proposal.

The Contractor's environmental management plan would contain procedures for effective communication with the client, government authorities, Gold Coast Airport Limited and the local community. The management plan would be consistent with the NSW Roads and Traffic Authority's *Quality Assurance Specification G36*. This specification details the requirements, including compliance with the NSW Government's *Environmental Management Guidelines* for preparation of the elements of the Contractor's environmental management plan. The elements of this plan would include:

- assignment of responsibilities for planning, approving, implementing, maintaining, assessing and monitoring environmental controls;
- copies of approvals, licences and permits to meet statutory requirements;
- details of potential environmental impacts and the operational control measures which are to be implemented to comply with statutory requirements and provide environmental protection;
- details of how environmental protection would be maintained for subcontractor activities;
- an environmental monitoring program and report forms for recording all monitoring activities including periodic inspections of the adequacy of operational controls, together with measurements for aspects where compliance limits have been specified;
- location of environmental controls;
- supplementary (specific) environmental management plans for environmental protection and operational control, including a noise management plan, and an air quality management plan as required;
- details of how non-conformances would be controlled and corrective and preventative actions implemented and closed out;
- objectives and targets for environmental performance;
- details of communications procedures including the methods proposed to undertake community consultation and communication with government authorities;
- emergency response procedures for mitigating environmental damage and procedures for planning restoration activities;
- details of training and awareness programs for personnel working on the proposal;
- details of how changes to environmental management documentation and data would be identified and communicated to relevant personnel;
- a formal document control procedure that details the process and authorised personnel for changing and issuing the contractor environmental management plan;
- mechanism for regular evaluation of environmental performance; and
- an environmental auditing program.

7.12.4 Supplementary Environmental Management Plans

The EIS has identified potential impacts on the environment and the controls required to avoid or minimise these effects. Supplementary environmental management plans would be developed as sub-components of the Contractor's environmental management plan to ensure that these actions and controls are implemented during construction. These would address:

- flora and fauna;
- air quality;

- topsoils;
- soils and surface water;
- groundwater;
- noise and vibration;
- waste management;
- cultural heritage;
- access and traffic;
- hazards and risks; and
- energy and resources.

The supplementary environmental management plans would detail how impacts of construction activities would be managed to avoid or minimise impacts on the surrounding environment. They would consider the impacts and proposed management measures identified in the EIS. The supplementary environmental management plans would be consistent with *Quality Assurance Specification G36* and would also include those actions and procedures to address compliance with any specific conditions of approval, licence conditions from the NSW Environment Protection Authority and Queensland Environmental Protection Agency and any other conditions of permits and approvals. They would include the following elements, which would be consistent with and link to the Contractor's environmental management plan framework:

- copies of approvals, licences and permits to meet statutory requirements;
- details of other voluntary requirements (for example, codes of practice);
- details of potential environmental impacts and the operational control measures which are to be implemented to comply with statutory requirements and provide environmental protection;
- assignment of responsibilities for planning, approving, implementing, maintaining, assessing and monitoring environmental controls; and
- monitoring required to determine the effectiveness of the control.

7.12.5 Management of Contaminated Soil

The management of contaminated soil and groundwater would be the subject of a specific waste management plan to be developed during the detailed design stage. Technical Paper Numbers 6 and 9 would be used as the basis of such plans.

Information is available on contamination of soil that may be encountered during the construction of the proposal (refer to Technical Paper Number 6). Further investigations would be undertaken during the detailed design stage of the proposal.

A soil-sampling plan was recommended in Technical Paper Number 6 to be prepared in accordance with the *Contaminated Sites: Sampling Design Guidelines* (NSW Environment Protection Authority 1995). The objective of the sampling plan would be to identify elevated concentrations of contaminants which may represent a potential risk of harm to human health or the environment. The results would be compared to available guidelines to assess the level of risk.

Where the soil sample results indicate that contamination is present, it would be assessed under the NSW *Contaminated Land Management Act 1997*. Depending on its source, location and nature, the fill or soil would be analysed for potential contaminants or indicators of contamination. If the fill or soil is found to be contaminated it would be kept separate from clean material and appropriate management and storage measures implemented in order to minimise risk to workers and the public. The contaminated fill or soil would be assessed and classified using the NSW Environment Protection Authority guidelines. If the material cannot be classified as inert waste it would be subjected to the toxicity characteristics leaching procedure (TCLP) test to assess the mobility of the contaminants in the waste and to determine how it would be managed.

Applicable Commonwealth and Queensland legislation and guidelines would be used where appropriate.

7.12.6 Acid Sulphate Soils

Soil with the potential to become acid sulphate soils would be assessed in accordance with the Acid Sulphate Soil Management Advisory Committee (ASSMAC) guidelines (Stone *et al*. 1998). Acid sulphate soils generated as a result of tunnel excavation would require controlled landfill disposal with pre-treatment depending on soil quality.

Fill or disturbed material has the potential to exhibit acid sulphate properties in the vicinity of the airport site. Works in these areas involving disturbance of soils are required to include the assessment of the material and the local groundwater for acid sulphate soils potential in accordance with the *Acid Sulphate Soil Manual* (Stone *et al*. 1998) and work undertaken in accordance with the management plan developed.

Applicable Commonwealth, NSW and Queensland legislation and guidelines would be used where appropriate.

Further details on acid sulphate soils and management are provided in Technical Paper 5.

8. Cost Estimates

8.1 Project Estimate Summary

Based on the concept design and construction methods described in this technical paper, the cost of the road proposal is estimated to be approximately $360M in out turn dollars. This includes $19M for the Stewart Road interchange.

This estimate is based on current dollar rates (2003) and to allow for inflationary cost rises from 2003 onwards, indices need to be applied to calculate the actual costs of works. The final cost in terms of out turn dollars is calculated by application of the Road Industry Construction Index (Main Roads) which is currently increasing at about 2 percent per annum.

Total project costs have been estimated by adding project costs associated with managing and implementing the project to the estimated construction cost. In accordance with Main Roads requirements, project costs have been prepared in the form of a Project Estimate Summary, which includes all costs associated with planning, design and construction of the project. Table 8.1 provides these costs in out turn dollars in summary format.

Table 8.1: Project Estimate Summary (Out Turn Costs)

Job Cost Item	Description	Estimated Out Turn Costs ($M)
A	Planning Design and Construction Admin	$35
B	Land Acquisitions	$40
C	Environmental Mitigation	$23
D	Construction Contract	$196
E	10-year Maintenance	$20
F	Contingency for Risk and Unknowns	$46
	Total	**$360**

As discussed in the preceding sections, the proposal has been developed to concept design stage only. This concept design has resulted from a process including broad studies, assessments and design assumptions. The proposal needs further development in many areas through to detailed design and construction, with particular reference to geotechnics, hydrology, geometric design, structural design and construction methodology.

Consequently the concept design estimate needs to be qualified in terms of unknowns which may add further to the total costs. Conversely there may be opportunities to reduce costs through subsequent processes of investigation and design. Contingency costs are included to cover these unknowns, which can be refined progressively in subsequent stages of developing the proposal.

8.2 Construction Cost Estimate

A detailed construction cost estimate has been prepared for the concept designs shown on the drawings.

The construction cost estimate is based on current construction contract rates (2003) plus inflation cost rises, and on quantities derived from the concept design drawings. The estimate has been reviewed against private sector rates and adjustments made as necessary.

Allowances for contingencies are included in the project estimate summary and have been assessed on an item by item basis as to the quality of the detailed design at estimate. Refinement of the design will allow reduction of the risk profile and the contingency allowed could reduce with further design.

A breakup of approximate road costs in five sections of the bypass is shown in Table 8.2.

Table 8.2: Project Costs in Sections (Out-turn Costs)

Section	Location	Estimated Cost ($M)
1	Tunnel and approaches	$110
2	Interchanges	$39
3	Hidden Valley Bridge	$6
4	Four-lane roadway	$41
	Total All Sections	**$196**

▸ The following sections outline the components that have been incorporated into the detailed project estimate.

8.2.1 Site Establishment

This item includes:

- site establishment;
- site compounds;
- insurances and statutory fees;
- geotechnical services;
- engineering survey set-out of works;
- community liaison;
- liaison with other public authorities and agencies;
- quality system requirements; and
- rehabilitation of temporary works areas on completion.

8.2.2 Bulk Earthworks

Bulk earthworks quantities have been measured from the concept design alignment using MOSS. Allowances for bulking/loss factors and unsuitable material have been made based on limited geotechnical advice.

8.2.3 Road Pavements

This includes subgrade preparation and pavements on all areas of the proposal.

A decision on the pavement type would be made during the detailed design based on a whole of life cost comparison. For the purposes of the cost estimate a full depth asphalt pavement has been assumed. Interchange exit and entry ramp pavements are assumed to be flexible/granular pavements with asphalt surfacing. The tunnel pavement comprises a structural concrete floor with an asphalt wearing surface. Open-graded asphalt would be provided along the bypass.

8.2.4 Structures

This includes major and minor bridges as well as reinforced concrete culverts, retaining walls, noise walls and the road tunnel and rail tunnel (early works).

Road Tunnel – Civil

This includes all major items, environmental controls, excavation, structural components and appropriate staging.

Elements - Diaphragm Walls and Piled Infill Wall;

- Structural Reinforced Roof;

- Structural Reinforced Floor Slabs;

- Drainage; and

- Pavements.

Road Tunnel – Mechanical/Electrical

This includes allowance for lighting, ventilation control and fixtures, fire services, monitoring and drainage pump out.

Bridges

This covers all components including piles and piers, bridge beam and decks, barrier and approach slab together with the approach abutments necessary to install the bridges at:

- Stewart Road interchange bridge;
- Hidden Valley bridges;

- Property access bridge;
- Gold Coast Airport access bridge; and
- Tweed Head Bypass interchange bridge.

Rail Tunnel (early works)

This includes the early works being the ground slab over the future tunnel works.

8.2.5 Drainage

Drainage quantities measured under this item include all culverts across the bypass and other roads as shown on the concept design drawings. Allowances for longitudinal road pavement, median drainage, kerbs, pipes and pits, subsoil drains, toe drains and cut-off drains have also been included as a percentage of construction costs.

8.2.6 Landscaping

The landscaping section allows for spreading topsoil and seed, including hydroseeding/mulching where batter slops are steeper than 3H: 1V. Allowance for extensive tree planting is also made.

8.2.7 Road Furniture

Allowance has been made for safety barriers, pavement markings and signage for all sections of the proposal.

8.2.8 Electrical

Lighting, traffic signals and appropriate power supplies to provide a functional motorway to current road design standards have been allowed for:

- lighting to intersections;
- lighting to exit and entry ramps; and
- intersection signals.

8.2.9 Intelligent Transport Systems

Optical fibre has been allowed along the bypass with appropriate signage to facilitate traffic control management. Some initial installations are assumed, particularly in conjunction with tunnel ITS, and deferral of other installations to future years has been assumed.

8.2.10 Environmental Protection

This section allows for costs associated with environmental protection. It includes establishing and monitoring the contractors environmental management plan, noise control and reduction measures, vibration level control, pre-construction inspection reports and air quality (dust etc) control.

8.2.11 Miscellaneous Items

This section includes:

- land acquisition;
- airport navigation aid adjustments; and
- Gold Coast Airport works supervision.

8.2.12 Public Utilities Relocation

This includes costs incurred in relocating or protecting existing services identified along the concept alignment.

An allowance is included in the construction cost estimate for works associated with utilities that would be carried out by the contractor, as well as an allowance for works undertaken by individual utility agencies.

Allowances have been made for each known utility adjustment, noting that further details of existing services are required in conjunction with detailed design.

8.2.13 Control of Traffic

This item allows for costs involved in working under existing traffic, including provision of any temporary access for property owners and local access roads, management of construction access from the existing highway, and allowances for works adjacent to or under traffic at the tie-in locations.

8.2.14 Client Project Costs

This item allows for the client project delivery costs and provides the following allowances:

- Contract Administration 3 percent of construction costs;
- Project Management 3 percent of construction costs; and
- Client Representation 1 percent of construction costs.

8.2.15 Local Road Upgrades

This includes minor works at tie-ins or where temporary traffic management is necessary.

8.2.16 Kennedy Drive Interchange

Removal of north facing ramps, conversion to two single roundabouts and construction of two, two-lane, two-way service roads north to the Tweed Heads Bypass interchange is included.

A minor traffic management item is allowed for redirecting traffic to the new alignment and managing local traffic.

8.2.17 Design

This item allows for the detailed engineering design of the project and has been included as a percentage of the construction cost estimate.

Allowance of 4 percent of the construction estimate has been assumed.

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