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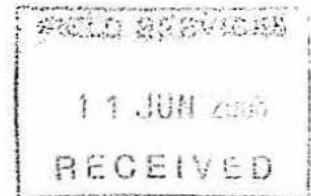
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AIRPORT LINE TUNNEL PROTECTION GUIDELINES

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06/07/05

Guidelines for Development Within the Vicinity
of the Airport Line

Part A: Planning and Design Matters



Rail Access Corporation

2000

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1.0 Introduction

Airport Line

The Airport Line ('AL') is an underground railway system, running from Central Station to CityRail's East Hills Line near Turrella. The AL tunnel is approximately 10km in length, and at varying depths below natural (existing) ground level.

Within the Sydney Airport Boundary the AL alignment runs from the Joyce Drive intersection to Alexandria Canal as shown on drawing 00K106 provided in Appendix A. Depths to the Crown below existing ground levels are between 13.5m and 18.0m.

Domestic Terminal and International Terminal Station are located within the Sydney Airport Boundary. Domestic Terminal Station is at the Domestic Terminal at the corner of Keith Smith Avenue and Fourth Street, and International Terminal Station is at the International Terminal on the north side of Terminal B.

The tunnel is generally constructed through soft ground including sands, clays and shales. There is potential for developments above and close to the AL tunnel to damage the tunnel structure. A zone of influence has been defined within which developments could impact on the integrity of the AL tunnel. The zone of influence includes all land within 25m of the centre line of the AL tunnel.

Purpose of Guidelines

These Guidelines have been prepared to assist Sydney Airport and its tenants and allows the Airport Buildings Controller to determine the requirements for development within 25m of the AL tunnel centreline. Applicants are required to contact the Rail Access Corporation (RAC) for additional information or details regarding specific sites in the Sydney Airport boundary.

Terms and Definitions

'Sydney Airport' means the Sydney Airport Corporation Limited

'Airport Buildings Controller' means the representative of the Sydney Airport Building Control office

'AL' means the Airport Line

'RAC' means the Rail Access Corporation

'Zone of Influence' means all land within 25m of the centre line of the AL tunnel as identified on maps accompanying these Guidelines.

2.0 Development Activity and Planning Requirements

AL Tunnel Zone of Influence

Development within 25m of the centre line of the AL tunnel has the potential to impact on the structure and/or integrity of the tunnel. Accordingly, this area has been defined as the zone of influence on the tunnel. Affected lands are shown on the Airport Line Tunnel Notification Zone (Aug 00) maps provided in Part C of these Guidelines.

The location of the AL tunnel below a development site is not a restriction on the development potential of the land. Rather, appropriate design and construction measures are required to ensure the integrity of the AL tunnel is retained. Applicants are required to ensure that a tunnel engineering expert is involved in the design process.

Referral Requirements

The majority of development activity within the zone of influence will require the submission of a development application to the Sydney Airport Buildings Control Office. The Sydney Airport Buildings Control Office, when assessing a development application that applies to land within this zone and has the potential to have an impact on the tunnel structure, will refer the application to the RAC for consideration. In assessing the application the RAC will consider the following:

- (a) the siting, size and depth of any proposed building or work, including any proposed excavation, in relation to their effects on the structure of the transport tunnel beneath, and
- (b) the proposed access for maintenance of existing or proposed structures forming part of the transport tunnel, and
- (c) potential for impacts to the structural integrity of the tunnel or associated structures from construction activity, and
- (d) any potential cumulative impacts from developments in the vicinity of the site.

Development activity relating to the use of an existing building or a minor development (such as additions or alterations not involving ground penetration) which, in the opinion of the Sydney Airport Buildings Control Office has no relevance to the matters listed above, will not require referral to the RAC.

Documentation to Support Referral Submission

One additional set of drawings and related reports is required to accompany development applications which are subject to referral requirements of the Sydney Airport Buildings Control Office.

3.0 Matters for Consideration

The following matters shall be taken into consideration in the case of development proposals within the zone of influence of the AL tunnel, and where relevant, be included in DA submissions.

- Full design details of the development within 25m of the tunnel centre line and any revisions made.
- Verification survey of structural elements with relationship to AL infrastructure.
- Means of ensuring acceptable effects on tunnel/station structure.
- Calculations of effects in relation to:
 - (a) ground stresses
 - (b) tunnel lining stresses
 - (c) effect on water table
 - (d) effect on noise and vibration within the tunnel.
- Geotechnical considerations.
- Type of piling and/or excavation proposed.
- Dilapidation survey before and after.
- Programme of works including notification of daily progress within zone of influence.
- Construction method details.
- Marking of tunnel/infrastructure at ground level.
- Works as executed documents including final report.

4.0 Technical Details

Interface between Developers and RAC

The following sheets set out the required process for interface between developers and RAC to ensure the design and documentation of projects within the zone of influence of the AL tunnel achieve the optimum outcome for the longer term integrity of the tunnel infrastructure.

Tunnel Details

A detailed description of the AL tunnel is included in Part B of this document, including a description of the tunnel, sources of information, drawings and examples of acceptable loading patterns.

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**AIRPORT LINE
TUNNEL PROTECTION GUIDELINES**

**Guidelines for Development within the Vicinity
of the Airport Line**

Part B: Technical Matters

Rail Access Corporation

2000

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Figures

- Figure No. 1 Airport Line Railway, Zone Definitions, Certificate of Compliance, Version 2, July 1999
- Figure No. 2 Airport Line Railway, Example of Acceptable External Loading Patterns - Hard Rock Tunnel, Version 2, July 1999
- Figure No. 3 Airport Line Railway, Example of Acceptable External Loading Patterns - Green Square Station Platform Tunnels, Version 2, July 1999
- Figure No. 4 Airport Line Railway, Example of External Loading, Soft Ground Tunnel Version 2, July 1999

Appendices

- A. Summary Tables 1 to 13
Brief Structure Descriptions and Water Management Methods
- B. List of Geotechnical Investigation and Groundwater Study Reports
- C. Extensive Civil Engineering Airport Line Railway Project Drawing List

1.0 Introduction

Purpose of Technical Guidelines

The purpose of these Guidelines is to set out the technical and engineering requirements of the Airport Line ('AL') tunnel and associated infrastructure. These Guidelines support Part A (Planning and Design Matters) and provide details on the location and construction of the tunnel.

Terms, Definitions and Abbreviations

'AL' means the Airport Line
'ESR' means the Eastern Suburbs Railway
'HRT' means Hard Rock Tunnel
'RAC' means the Rail Access Corporation
'SACL' means Sydney Airport Corporation Limited
'SGT' means Soft Ground Tunnel
'TBM' means tunnel boring machine

Technical Drawings

Details of the AL tunnel alignment are available on the following drawings:

Horizontal Track Alignment (Sheets 1 to 3):
Drawing No. 00 K 0180.289 584km to 4.0km
Drawing No. 00 K 0194km to 8.41km
Drawing No. 00 K 0208.4km to 10.657 984km

Survey control and tunnel grid:
Drawing No. 00 R 065

Vertical Alignment (including Geological Stratum):
Drawing No. 00 R 126

The AL vertical datum is 100m below Australian Height Datum (AHD). To convert to AHD subtract 100m from tunnel datum.

An extensive, though not complete list of civil engineering Airport Line drawings is given in Appendix C. This drawing list is provided for information purposes only. All project 'As Built' drawings are available from Rail Access Corporation.

2.0 Performance Criteria

The AL tunnel was constructed to satisfy the following performance criteria:

Design Life

The structural ground support in the tunnels and stations of the AL have been designed and constructed to have a design life of 100 years. This includes the following elements:

- Diaphragm walls in the station boxes
- Concrete arch and shotcrete walls in the HRT
- Segmental lining in the SGT
- Concrete elements in cut and cover tunnel sections

Waterproofing

All AL tunnels have been designed and constructed to be water tight, with no drips or discernible flows of water over concrete surfaces.

Waterproofing has a significant bearing on the tunnel protection criteria. The key concern relates to the prevention of groundwater leakage into the tunnel, particularly above track level. The penetration of groundwater inflows into the tunnel has major maintenance implications to the tunnel, stations and infrastructure fixtures, including the rail track and ballast. Minor cracking of the concrete or shotcrete tunnel lining may not affect its structural performance.

Drainage

The drainage system inside the AL tunnel and stations has been designed and constructed with the capacity to manage any water flows in the tunnel. The design also enables the drainage system to be easily maintained.

The AL tunnel drainage system will generally not be relevant to the design of structures in the vicinity of the tunnel. Circumstances where it may require consideration include situations where some repair to the tunnel lining becomes necessary. It will not be acceptable to diminish the capacity of the drainage system behind the tunnel lining. This is considered in more detail in Section 7 of these Guidelines.

3.0 Description of Tunnel Sections

The main sections of the AL are described below. Figures 1 to 4 enclosed show the zone definitions around the tunnels and examples of acceptable external loading of the tunnel linings. Tables A1 to A13 in Appendix A summarise information about the various structures that make up the AL tunnel infrastructure. The tables include information about the waterproofing methods used and associated drainage issues. Appendix B is a list of geotechnical site investigation and groundwater study reports, which are available as reference material.

Prince Alfred Park Cut and Cover Tunnel

The Prince Alfred Park cut and cover tunnel section is 114m long and consists of a structural slab supported by piles spaced at 3m intervals along its eastern and western walls. A shotcrete arch between piles supports either shale or stiff clay which overlies the shale.

The shotcrete covering the shale is drained by a vertical slotted pipe which is wrapped in a geotextile.

Hard Rock Tunnel

General

The Hard rock tunnel portal is at project chainage 774m under Cleveland Street. The tunnel route follows an alignment south under George Street, through to Green Square Station, and includes the station platform tunnels. It terminates under 15-21 O'Riordan Street, some 200m beyond the station at chainage 3000m.

The rock tunnel has been constructed in a variety of ground conditions with varying ground cover. The permanent support and waterproofing methods vary along its length. The rock arch on the Green Square Station platforms is also wider than at other locations of the tunnel.

Sections of the HRT are described in turn below.

Chainage 744m to 915m

The tunnel is excavated in residual soil or Ashfield Shale Class III and IV. The tunnel is located under George Street and there is approximately 6m between the side walls of the tunnel and the building line of properties along the street. The tunnel has a permanent lining of unreinforced concrete over the crown arch and walls and has a flexible waterproofing membrane. This membrane was installed between the shotcrete applied over the ground during initial excavation, and the permanent in-situ concrete lining. During heading excavation, the tunnel crown was supported by steel sets and steel canopy tubes installed over the arch of the tunnel.

This section of tunnel is located under the George Street road alignment, except for the section under the school at Green Square.

Between chainages 790m and 840m the AL tunnel crosses the Eastern Suburbs Railway (ESR) tunnels 2m from the intersection at George and Cleveland Streets Redfern. With the proximity of these additional tunnels and potential for interaction between the AL and ESR tunnels, it is not possible to specify potential requirements for future development above or adjacent to the tunnel. Individual projects, as they arise, will require consideration at the time of documentation.

Hard Rock Tunnel Chainage 915m to 1960m

This section of tunnel is excavated in Ashfield Shale Class I and II, with Hawkesbury Sandstone Class I and II occurring towards chainage 1960m.

The tunnel has a permanent concrete arch with shotcrete walls. Circumferential drains spaced at 2m intervals are embedded in the concrete arch against the rock. The initial ground support for the tunnel consists of pattern steel rock bolting.

This section of tunnel is also located under the George Street road alignment, and is therefore unlikely to be subject to any major excavations above, or direct footing loads on, the tunnel lining.

Hard Rock Tunnel Chainage 1960m to 2628m

This tunnel section is excavated in Hawkesbury Sandstone Class I and II with ground cover varying from 20m to 25m above the tunnel crown.

From chainage 1960m to 2280m the tunnel continues to follow the George Street road alignment. From chainage 2280m to 2600m the alignment begins to curve, passing under commercial property as it heads towards the Bourke and Botany Road intersection and Green Square Station.

Figure 2 shows examples of the loading and excavation requirements relevant to this tunnel section. Any development within 25m of the tunnel centreline in this section of the AL would be required to accommodate these engineering requirements in the design and construction process. The specified loading and excavation restrictions are necessary to minimise the risk of damaging the tunnel lining.

Hard Rock Tunnel Chainage 2796m to 3000m

This tunnel section is excavated in Hawkesbury Sandstone Class I and II with ground cover varying from 20m to 25m above the tunnel crown.

The tunnel is under sites with commercial development potential between chainages 2276m and 3000m. Figure 2 shows examples of the loading and excavation requirements relevant to this tunnel section. Any development within

25m of the tunnel centreline in this section of the AL would be required to accommodate these engineering requirements in the design and construction process. The specified loading and excavation restrictions are essential to minimise the risk of damaging the tunnel lining.

Green Square Station Platform Tunnels

Green Square Station is a 170m long underground structure with two 14m wide platform tunnels excavated on either side of the central station box, which contains the concourse and booking areas. These areas were constructed in an open excavation.

Four (4) pedestrian emergency exit tunnels have been excavated at platform level in sandstone rock parallel to the platform tunnel.

Figure 3 shows examples of the loading and excavation requirements for all tunnel structures associated with Green Square Station. Any development within 25m of the tunnel would be required to accommodate these engineering requirements in the design and construction process. The specified loading and excavation restrictions are essential to minimise the risk of damaging the tunnel lining.

Soft Ground Tunnel

Between chainages 3010m and 8997m the AL tunnel is constructed as a circular bored tunnel supported by eight concrete segments forming a circular ring.

Figure 4 sets out the loading and excavation requirements for developments within 25m of the AL SGT centreline. Relevant construction considerations are described in Section 4 of these Guidelines.

Additional Information

Drawings to assist the assessment of loading impacts and determine appropriate construction methods for sites in the vicinity of the AL can be obtained from the Rail Access Corporation. A drawing list is provided in Appendix C. Drawings are available for the following structures:

- All types of tunnel
- Stations, including Green Square Station Central Box
- Southern structures, including Cooks River Crossing

4.0 Protection of Station Structures

Including Diaphragm Walls and other Retaining Structures

The following comments apply to the concourse structure and ventilation shafts at Green Square Station, and to the reinforced concrete earth retaining structures, which include the diaphragm walls, at Mascot Station, the Domestic and International Terminal Stations and at Wollli Creek Station.

The diaphragm walls and other earth retaining structures of the above ground stations have been designed to carry external loads from earth pressure and groundwater plus additional loads due to surface loading. The design surface loads applied in the design of these structures was either a uniform dead load surcharge of 10Kpa, applied from the back of the wall, or a concentrated live load e.g. due to trucks, equivalent to a uniform surcharge loading of 20Kpa.

Future buildings adjacent to the stations are allowed to impose an additional lateral pressure on the station walls, due to their foundation loads, equivalent to a lateral pressure due to a uniform surface loading of 10Kpa. If the lateral pressure, from the proposed future building foundations exceeds the lateral pressure, due to a uniform surface loading of 10Kpa, then the building foundations must be designed to transfer the building loads past the base of the station wall.

Where a major excavation is to be carried out adjacent to a station structure, the new excavation must be strutted, if the existing station structure has intermediate slabs acting as wall restraints. The strut levels in the new excavation must correspond with the station structural slab levels where they are retaining the walls of the station structure.

In all stages of construction, for new excavations adjacent to any existing station structure, continuous support may also be required to ensure that the existing lateral earth and groundwater pressure acting on the station structure is balanced by an equivalent and opposing force on the opposite side of the structure where lateral earth and groundwater pressure is being progressively removed.

5.0 Construction Matters

Construction Vibrations

Vibrations due to pile driving (where permitted) or other foundation construction methods shall not have a peak particle velocity exceeding 25mm/sec measured at the tunnel lining. Where pile driving and pile removal is to be used, evidence is required to be provided showing that the proposed equipment will not cause the vibration limit to be exceeded. Generally, RAC will need this evidence to be provided prior to commencement of any work on site.

Continuous vibration monitoring on the tunnel lining may be required to ensure compliance.

Dilapidation Surveys

Development consent will require dilapidation surveys of the existing tunnel linings to be undertaken prior to the commencement of any major bulk excavation. A post construction dilapidation survey will be required to confirm the effectiveness of the protection measures employed and determine the need for any remedial works to the AL infrastructure. Refer to Section 7 of these Guidelines for further details on repairs to the tunnel lining.

Track Alignment

Any excavation adjacent to the AL tunnel shall not cause the track alignment to distort in excess of 3mm in the vertical or horizontal directions.

Utility Services

Construction or modification of utility services at depths greater than 5m in roadways and other land within 25m of the centreline of the bored tunnels have the potential to impact on the structural integrity of the AL infrastructure. Any work of this type must be carried out in accordance with these Guidelines in consultation with RAC.

All excavation for utility services above the cut and cover tunnel sections must be carried out in accordance with these Guidelines in consultation with RAC.

Surface Loading

There is no restriction on temporary surface loading above the driven tunnels. A limit of 75% of T44 truck loading applies to cut and cover tunnels and station structures.

Hard Rock Tunnel

Deep open excavations for building basements in areas of Sydney sandstone have the potential to impact on the tunnel structure. The major concerns are stress release in the rock, and rock block movements which could potentially conflict with the protection of the tunnel lining and surrounding rock mass. These impacts can be avoided by various means including:

- Installation of tensioned near-horizontal ground anchors to reduce lateral ground movement and therefore reduce the magnitude of induced stress in the tunnel lining
- Construction of a pattern of cement-grouted vertical dowels across horizontal bedding planes and joints in the rock mass across which movement may occur without doweling.

Vertical building foundation loads can be transferred past the tunnel by isolating the piles or caissons from the surrounding rock and transferring loads past the tunnel.

Construction methods must protect the drainage system behind the lining in the HRT.

Soft Ground Tunnel

The lining of the SGT consists of concrete segments which form an articulated lining (ie. small rotations at the radial segments joints are possible). Excavation in soft ground adjacent to the tunnel raises risks of localised ground collapses, presenting a danger to the integrity of the tunnel lining.

Ground collapses are possible in many circumstances, and can even occur under bentonite (caissons and diaphragm walls). It is critical that appropriate construction methods are employed for site specific conditions. This may include steel liners in caisson excavations, particularly near the surface. Bentonite may also be necessary in poorer ground conditions.

The tunnel lining may be protected from building foundation loads by transferring the loads past the tunnel by piles founding at rock level.

Limiting the depth of excavation above the tunnel will also protect the tunnel from changes in applied earth pressure which could potentially cause distortion of, and hence movements in, the tunnel lining.

Tunnel Protection Analysis

The RAC will require details to be submitted to support estimates of the impact that any proposed building structure will have on the AL infrastructure. This

should form part of the requirements of development consent, and should be prepared by a suitably qualified tunnelling engineer.

6.0 Documentation

The following information may be required by RAC to satisfy development consent requirements:

- Verified Survey Details
- Design tunnel protection methodology (including predicted effects)
- Construction method details
- Construction programme details
- Construction monitoring results (where measured at surface and/or in tunnel)
 - Displacements
 - Water levels
 - Noise and vibration
 - Ground stresses
 - Tunnel lining stresses
- Pre and post construction dilapidation surveys
- Works as executed drawings

The level of detail required will depend on the size of the proposed development and its potential to impact on the AL infrastructure. Where piling takes place near the tunnel, the project developer will be required to ensure that the following matters are met:

1. The piling contractor must be made aware that the site is above or adjacent to the railway tunnel.
2. The position of the outside tunnel walls must be marked clearly on the ground in a visible manner (such as by paint or other means of marking).
3. RAC, or its appointed representative, must be kept informed of piling progress on a daily basis.

7.0 Repairs to Tunnel Lining

General

Major construction activity involving excavation adjacent to a tunnel may cause some cracking of the concrete or shotcrete forming the tunnel lining. Cracks or damage to the tunnel lining resulting from an adjacent development site will be required to be repaired by the developer, at its cost.

The following criteria is used to determine whether crack repair is required:

Width of Crack	Action
Less than 0.20mm	Acceptable if no water leakage occurs
Between 0.20mm and 0.30mm	Determined by length: <ul style="list-style-type: none"> ▪ Less than 300mm no further work required if no water leakage occurs ▪ Greater than 300mm repairs required
Greater than 0.30mm	Repair required

Leaky concrete cracks less than 0.20mm wide may heal autogenously.

Note that access to the tunnels is only available for limited periods between midnight and dawn.

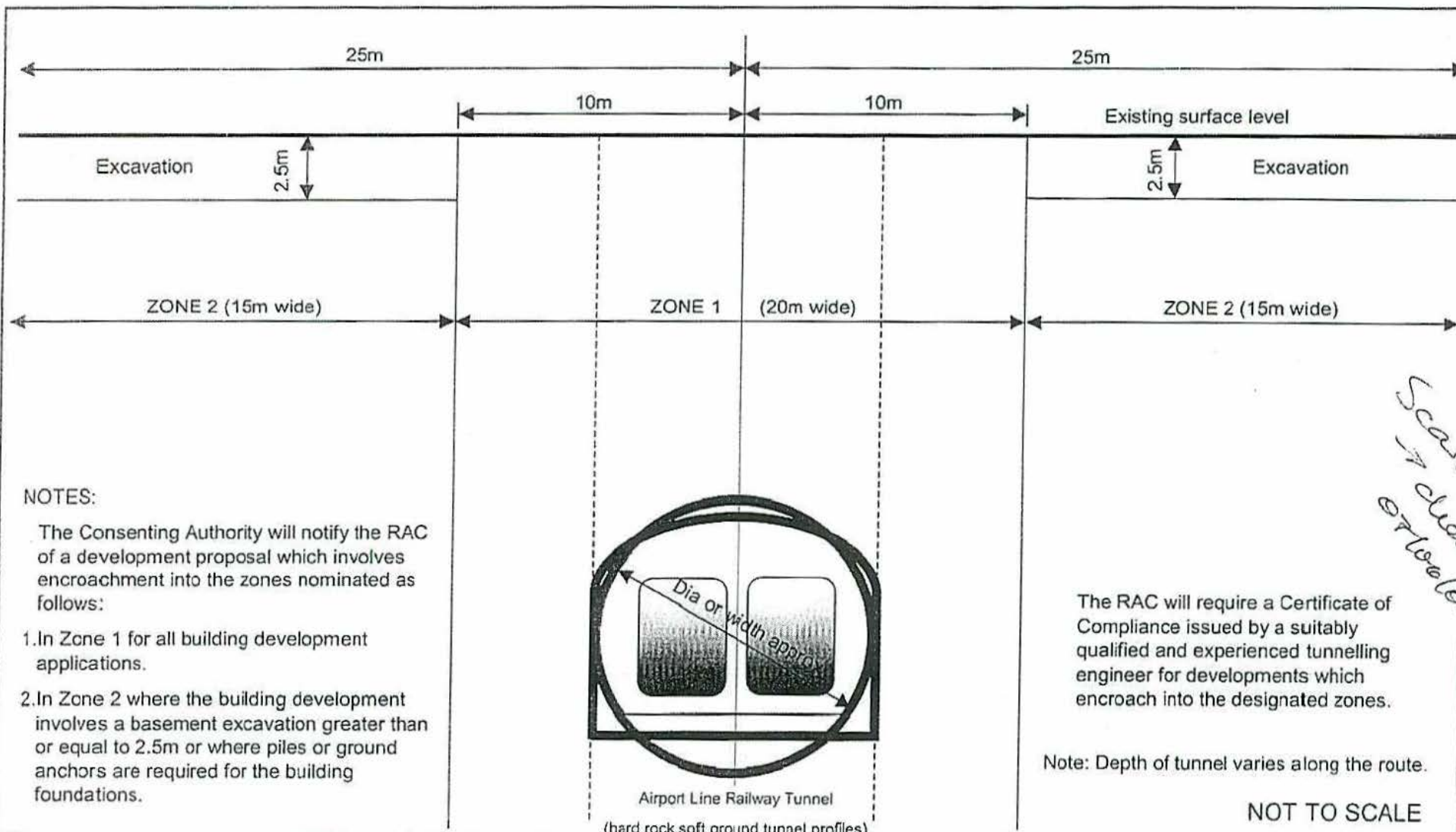
Hard Rock Tunnel

In sections of the HRT the concrete lining is drained by strip drains which must not be blocked by any proposed repair method. Some sections of the HRT have a waterproof membrane as described in Section 3.

Soft Ground Tunnel

The SGT lining consists of eight segments. The SGT lining segment joints are sealed by gaskets which will remain sealed even if rotations occur at the joints due to small changes in the diameter of the lining.

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NOTES:

The Consenting Authority will notify the RAC of a development proposal which involves encroachment into the zones nominated as follows:

1. In Zone 1 for all building development applications.
2. In Zone 2 where the building development involves a basement excavation greater than or equal to 2.5m or where piles or ground anchors are required for the building foundations.

The RAC will require a Certificate of Compliance issued by a suitably qualified and experienced tunnelling engineer for developments which encroach into the designated zones.

Note: Depth of tunnel varies along the route.

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THIS FIGURE APPLIES TO THE HARD ROCK AND SOFT GROUND BORED TUNNELS AND THE CUT AND COVER TUNNELS

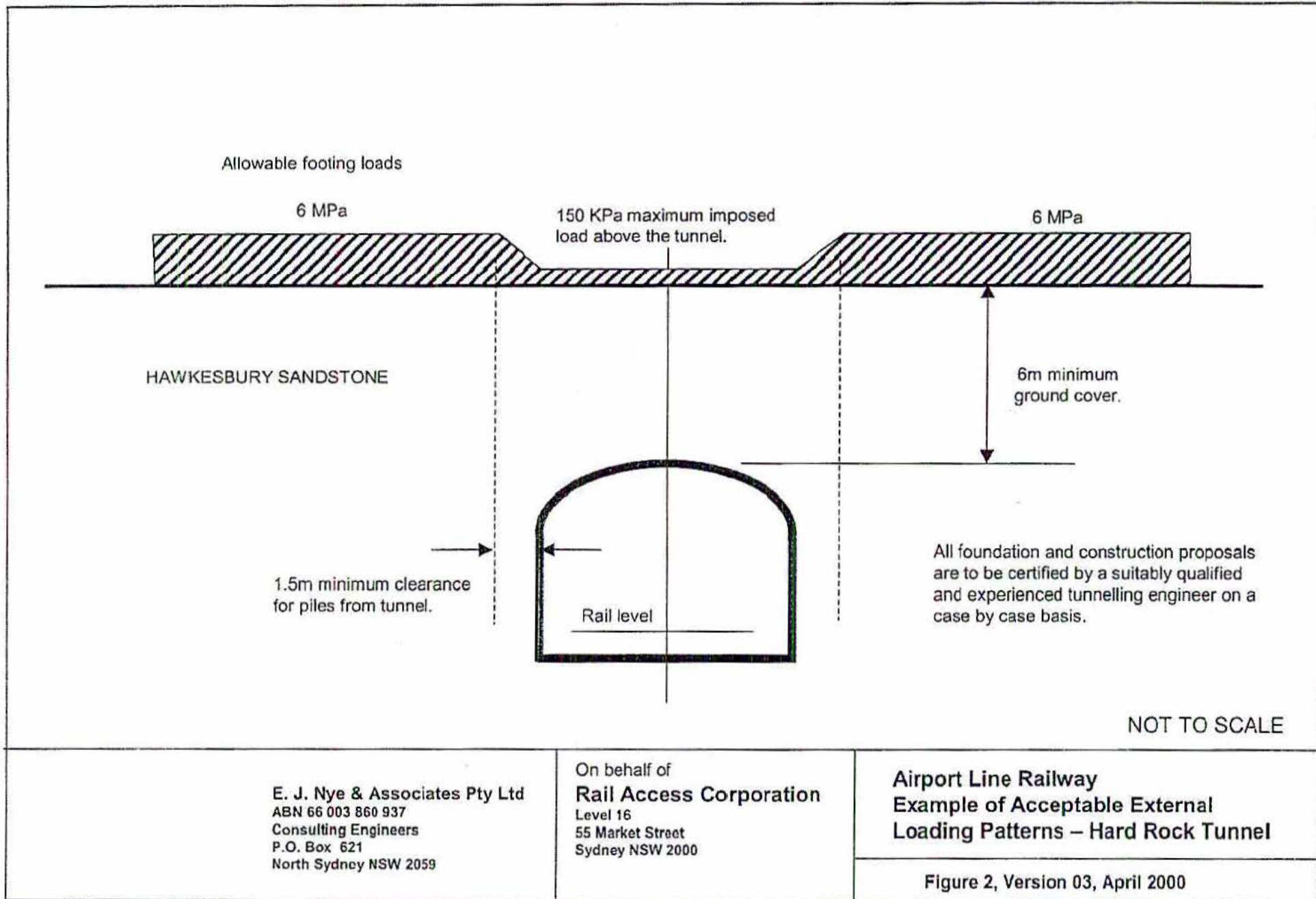
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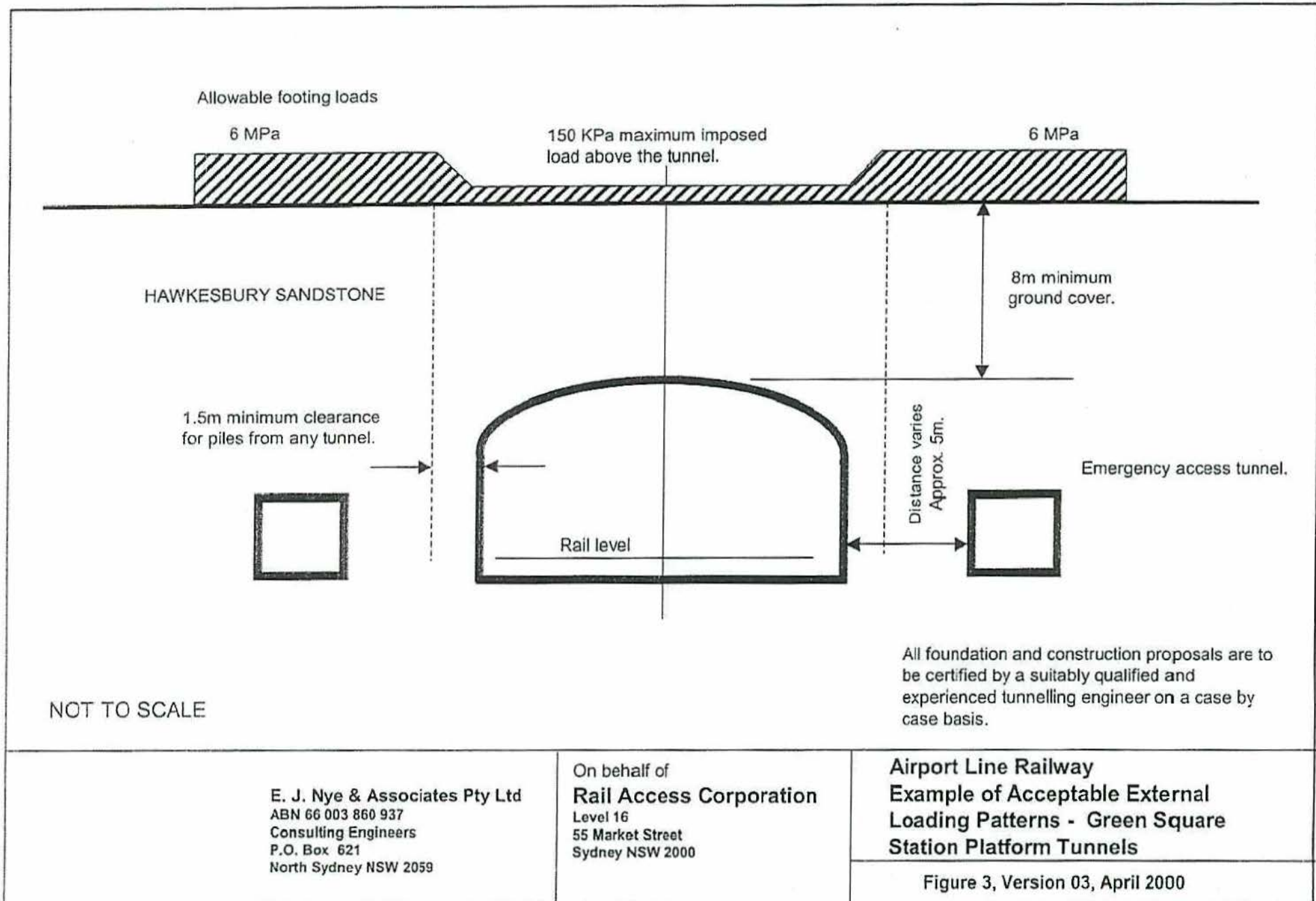
**Airport Line Railway
 Zone Definitions
 Certificate of Compliance**

Figure 1, Version 03, April 2000

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