METROLINK

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A8.16

Report on the ACP Tunnel Intervention Shaft

Contents

Executive Summary

Tunnel Fire safety legislation[1] dictates that there must be a form of emergency egress and access at regular intervals on a new-build underground railway such as MetroLink.

In general, access to or from metro tunnel sections is provided at the underground stations, which are designed to facilitate access and ventilation requirements. Typically, the location and spacing of underground stations aligns with international standards[1] on escape routes meaning that there is no requirement for an intermediate access points between stations.

For the MetroLink project, there are sections of the route where for reasons of transport planning, engineering or economics the stations cannot be located at the required spacing. In such cases intermediate access to the tunnel is to be provided by a tunnel intervention shaft.

This situation arises between the proposed Collins Avenue and Griffith Park Stations, where the distance between the stations is too long for effective ventilation and does not provide optimum access/egress access and egress arrangements in the event of an emergency.

For these reasons a tunnel intervention shaft in the section of the MetroLink route between Collins Avenue and Griffith Park Stations is required. The tunnel intervention shaft has the following primary functions:

- Allows emergency services to access the underground system in an emergency situation;
- Provides a safe route for passengers to escape from the tunnel during an emergency;
- Enables the control and management of smoke extraction in emergency situations; and
- Provides ventilation for passenger comfort in normal day-to-day operations
- Provides for draught relief during the normal operation of the line, enabling the movement of air in or out when a train passes through a section.

This report explains the need for the tunnel intervention shaft and the rational for its proposed location in the south- west corner of Albert College Park. The report includes a description of the surface features associated to the tunnel intervention shaft, an explanation of its function, a description of the typical construction methodology and the likely environmental impacts during and post construction.

[1] TSI 1303/2014: Technical Specification for Interoperability relating to 'safety in railway tunnels' of the rail system of the European Union and NFPA
130, Standard for Fixed Guideway Transit and Passenger Rail Systems, 2020 Edition

1. Introduction

TII held a non-statutory Public Consultation on the MetroLink Preferred Route in April 2019, during which the proposed location for the tunnel intervention shaft were presented to the general public and other stakeholders. At the time of the public consultation the concept design for MetroLink had not been progressed to the preliminary design stage and as a consequence TII had very limited design information on the size and form of the tunnel intervention shaft to present to members of the public.

Since then, TII and Jacobs Idiom have developed the preliminary design to take account of the feedback from the Public Consultation process and this report provides more detailed information for tunnel intervention shaft that will aid understanding of our current proposals. This report provides more detailed information on the:

- Purpose of a tunnel intervention shaft
- Safety standards for metro systems
- Tunnel access requirements.
- Need for a tunnel Intervention shaft between Collins Avenue and Griffith Park Stations
- Construction methodology
- Environmental Impact of the proposed works during and after construction

Appendix A includes Photomontages for the tunnel intervention shaft at Albert College Park shaft including;

- Before and after construction views from selected viewpoints
- An indication of the potential appearance of the surface features of the shaft.

2. The Purpose of a Tunnel Intervention Shaft

Fire safety legislation dictates that there must be a form of emergency egress and access at regular intervals on a new-build underground railway such as MetroLink.

In general, access to or from the tunnel sections is provided at the underground stations, which are designed to facilitate access and ventilation requirements. Typically, the location and spacing of underground stations aligns with international standards on escape routes meaning that there is there is no requirement for an intermediate access points between stations.

For the MetroLink project, there are sections of the route where for transport planning, engineering or economics the stations cannot be located at the required spacing. In such cases intermediate access to the tunnel is to be provided by a tunnel intervention shaft.

This situation arises between Collins Avenue and Griffith Park Stations, where the distance between the stations is too long for effective ventilation and does not provide optimum access/egress access and egress arrangements in the event of an emergency.

For these reasons a tunnel intervention shaft, in the section of the MetroLink route between Collins Avenue and Griffith Park Stations is required. The tunnel intervention shaft has the following primary functions:

- Allows emergency services to access the underground system in an emergency situation;
- Provides a safe route for passengers to escape from the tunnel during an emergency;
- Enables the control and management of smoke extraction in emergency situations; and
- Provides ventilation for passenger comfort in normal day-to-day operations
- Provides for draught relief during the normal operation of the line, enabling the movement of air in or out when a train passes through a section.

In the event of an emergency the fans housed in the tunnel intervention shaft are used to manage smoke from tunnel equipment or train vehicle fires. The fans will either blow smoke away from an incident to the ventilation shaft at stations, or extract smoke blown to it from the adjacent station fans.

The fans housed in the tunnel intervention shaft can also be used for general tunnel cooling. They can be operated continually at low capacity to provide tunnel ventilation and to prevent heat buildup within the tunnel.

3. Safety Standards for Metro Systems

3.1 Interpretation and Adoption of Standards

The relevant European Standard for safety in railway tunnels is TSI 1303/2014: Technical Specification for Interoperability relating to 'safety in railway tunnels' of the rail system of the European Union. We note that this standard is not entirely applicable to metro systems because it is intended for the heavy rail sector. However, we have examined the sections dealing with the maximum distance between tunnel emergency exits.

In addition to the European Standard, we have considered a commonly used non-European standard as a complementary and additional reference source. The NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems, 2020 Edition, is published by the National Fire Protection Association (NFPA). The NFPA is a global self-funded non-profit organization based in the USA, which is dedicated to the development of standards and codes related to fire safety. This standard is widely used for the design of fire safety systems for new metro lines around the world.

The German Bosra - § 30 Tunnel document is a further reference, but it makes only a brief mention of escape routes.

The review given below of these Standards concentrates on the need for emergency access and the recommended distances between them.

European TSI 1303/2014

The relevant section for surface access points is the Clause 4.2.1.5.2, copied below. This clause gives the requirement for emergency exits in tunnels of more than 1km in length, depending on the type of tunnel. Metrolink is designed as a single bore tunnel. Single bore tunnels, by their nature do not require the construction of cross passages. This means that emergency exits to the surface are required every 1000m as a minimum.

4.2.1.5.2 Access to the safe area

This specification applies to all tunnels of more than 1 km in length.

(a) Safe areas shall be accessible for people who commence self-evacuation from the train as well as for the emergency response services.

(b) One of the following solutions shall be selected for access points from a train to the safe area:

(1) Lateral and/or vertical emergency exits to the surface. These exits shall be provided at least every 1 000 m.

(2) Cross-passages between adjacent independent tunnel tubes, which enable the adjacent tunnel tube to be employed as a safe area. Cross-passages shall be provided at least every 500 m.

NFPA 130, 2020 Edition

The relevant section for surface access points is the Clause 6.3.1.4, copied below. This clause requires that the distance between emergency exits shall not exceed 762 m.

6.3.1.4. Within enclosed trainways the maximum distance between exits shall not exceed 762 m (2500 ft).

However, in the explanatory material included in the NFPA Appendix A (section A.6.3.1.4), the latest edition of this standard (2020 edition) allows for an extension of this value supported by an engineering analysis. The relevant extract is copied below:

The maximum distance between exits can be increased where supported by an engineering analysis that considers the following factors:

(1) Probability of a design fire event

(2) Probability of a train evacuation being conducted other than at a point of safety

(3) Probability that another compartment in the train is a point of safety for the design fire event

(4) Fire growth rate during the evacuation phase of the design fire event

(5) Maximum expected fire load during the evacuation phase of the design fire event

(6) Expected fire resistance characteristics of the rolling stock

(7) Maximum time necessary for evacuating the train after immobilization of the train

(8) Maximum time necessary for all passengers to reach the nearest station or point of safety

(9) Ability of the tunnel vent system to provide a tenable environment along the path to the nearest station or other point of safety

Based on the above assessment criteria, Jacobs Idiom has considered the distance between surface access points from first principles by using a risk assessment approach and considering a maximum spacing distance of more than 762m. We have conducted a detailed study of the real-life implications that the distance between emergency exits has on passenger safety, having regard to smoke, temperature, visibility and evacuation times.

The distance between emergency exits has a direct influence on tunnel evacuation times as well as emergency services access times. However, the proposed tunnel ventilation system will provide a smoke free evacuation route, which means that passengers escaping an incident train towards an emergency exit will not be exposed to smoke and high temperatures. The simulations have shown that safe evacuation from the tunnel can be achieved with a maximum spacing of 1000m between evacuation/intervention points.

Based on the review of the relevant standards outlined above and the assessments undertaken, Jacobs Idiom has recommended that MetroLink adopt the maximum spacing of 1000m between emergency exits that is compatible with the European Standard TSI 1303/2014.

The application of this design assumption to the MetroLink project is provided in Table 4.1 and requires the provision of tunnel intervention shafts at two locations along the MetroLink route, namely Albert College Park and Dublin Airport.

4. Tunnel Access Requirements

4.1 Station and Shaft Locations

Many factors such as passenger demand, environmental impact and passenger safety have been taken into consideration to determine the preferred route and underground station locations for MetroLink. The distances between each station are shown in table 1. As can be seen there are two locations along the route where the distance between stations exceeds the 1000m maximum spacing as required in TSI 1303/2014. These locations are between the Airport station and the south tunnel portal (which does not form part of this report) and between Collins Avenue and Griffith Park stations.

Table 4.1: Station Spacing along the Preferred Route

Section	Distance between Stations and Portals (m)	Comment
North Portal to Airport	919	
Airport to South Portal	**1325**	**Emergency exit tunnel required**
Northwood to Ballymun	852	
Ballymun to Collins Avenue	869	
Collins Avenue to Griffith Park	**1494**	**Intervention Shaft required**
Griffith Park to Glasnevin	976	
Glasnevin to Mater	683	
Mater to O´Connell Street	926	
O´Connell Street to Tara	655	
Tara to St. Stephens Green	989	
St. Stephens Green to Charlemont	785	

4.2 Tunnel Intervention Shaft Types

Where there is a requirement for a tunnel intervention shaft, a decision must be made on how to provide access from the tunnel to the surface. Typically, this can be achieved in one of two ways:

1. A vertical shaft providing direct access from the tunnel to the surface at the point were intervention is required (i.e., the current proposal for Albert College Park); or
2. A separate evacuation tunnel between the point where intervention is required and the closest underground station.

In specific circumstances, such as between the Airport station and the southern airport portal a separate evacuation tunnel is proposed by Jacobs Idiom. The proposed location for the shaft is within the airport restricted lands, which is not suitable for passenger evacuation or emergency vehicle access. For this reason, a tunnel solution is proposed for the intervention shaft between Airport station and the southern portal, with passenger evacuation and emergency vehicle access located land side and outside the airports restricted lands.

The provision of a separate evacuation tunnel requires significant levels of mining, which has associated risk, is more expensive and can add significantly to the construction duration. For these reasons the provision of a tunnel intervention shaft, providing direct access to the tunnel at the point where intervention is proposed at Albert College Park.

4.3 The need for a tunnel intervention shaft between Collins Avenue and Griffith Park Stations

In determining the location for the tunnel intervention shaft at Albert College Park, Jacobs Idiom considered possible locations for the shaft within a 1000m radius of Collins Avenue Station and Griffith Park Stations. Figure 4.1 shows the area between Collins Avenue Station and Griffith Park Station. The maximum distance of 1000m has been drawn from both stations with the shaded area in red hatching showing where an intervention shaft should be located to ensure there is less than 1000m between the shaft and the emergency exits at both Collins Avenue and Griffith Park Station.

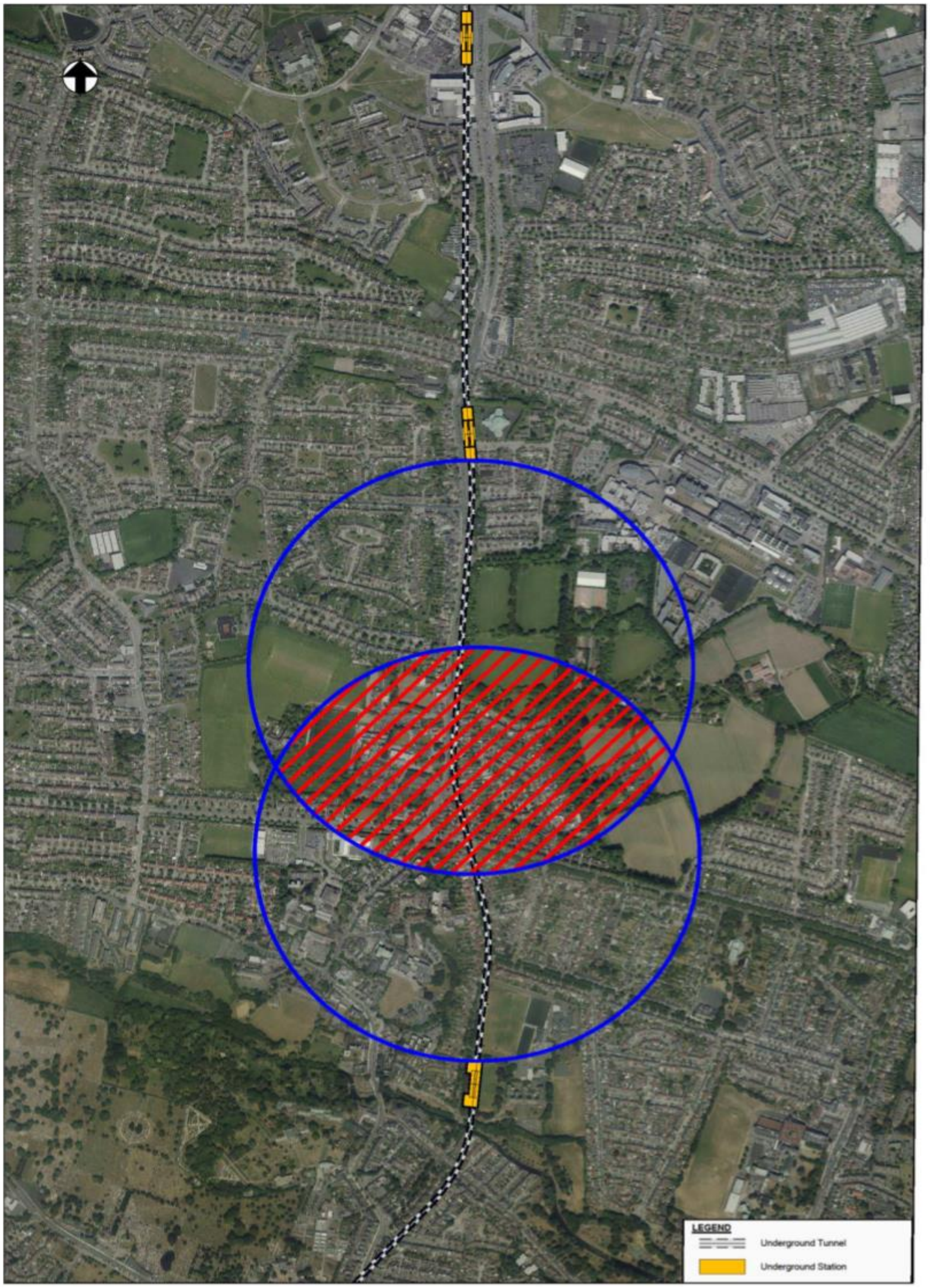

Figure 4.1: Intervention Shaft Location Identification

The red hatched area was then assessed to determine the best location for a shaft along the resulting section of the route. A closer view of the area is given in Figure 4.2 below.

Figure 4.2: Intervention Shaft Location Detail

The location assessment gave consideration to a number of factors including environmental impact, constructability, distance from the main tunnel and suitable road access. The rationale for selecting the location at Albert College Park for the Intervention Shaft is summarised below:

For the tunnel intervention shaft to be no more than 1000m from either Collins Avenue or Griffith Park Stations, it must be situated either immediately north of Hampstead Avenue in the south-west corner of Albert College Park; or within the residential area immediately south of Hampstead Avenue;

The tunnel intervention shaft should be adjacent to the tunnel on the west side of the park to reduce the length of connecting tunnel;

The Park area is the only open ground on the MetroLink route between the two stations; and

The tunnel intervention shaft can be accessed easily by emergency vehicles and there is enough area for safely congregating passengers in an emergency.

By locating the tunnel intervention shaft in the southwest corner of Albert College Park, it meets the spacing requirements of TSI 1303/2014 as shown in Figure 4.3 below.

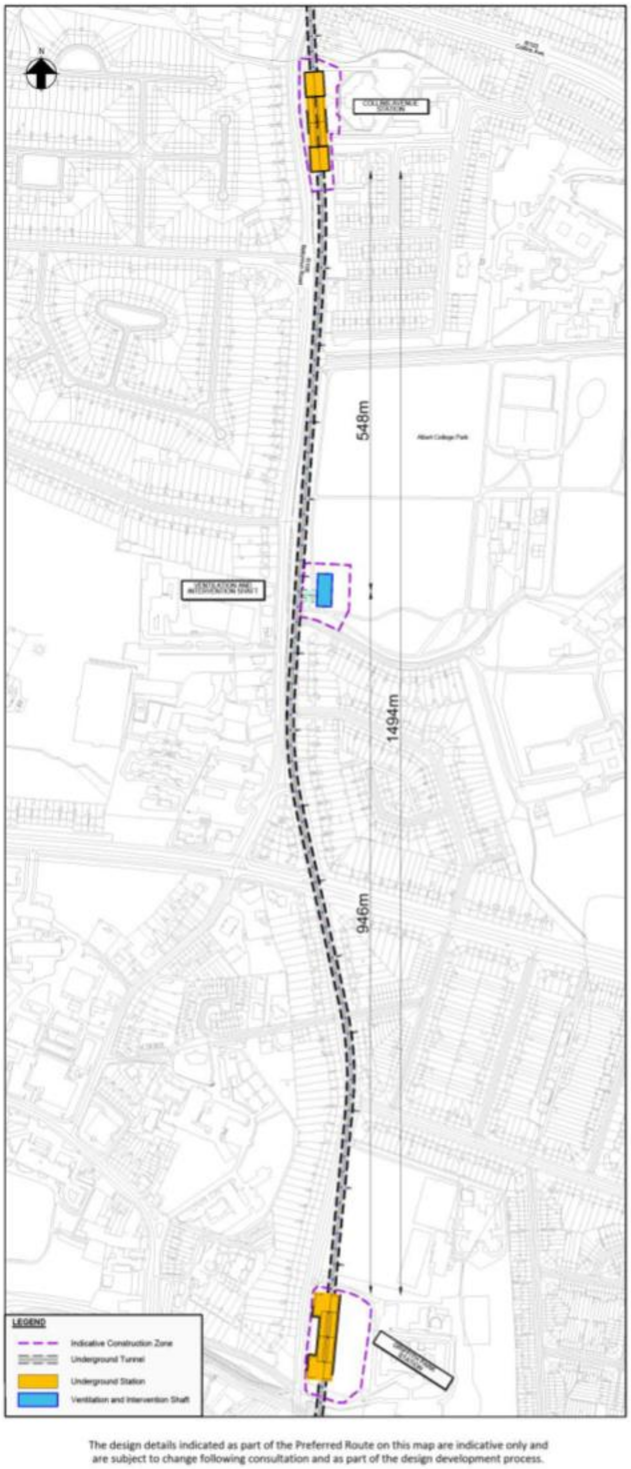

Figure 4.3: Tunnel Alignment between Collins Avenue and Griffith Park

4.4 Features of the Intervention Shaft at Albert College Park

As outlined previously the tunnel intervention shaft has three broad functions: emergency intervention, passenger evacuation and ventilation.

A diagram of the proposed tunnel intervention shaft and interface with the tunnel is shown in Figure 4.4 and Figure 4.5 below. As can be seen, a fire-fighting lift is provided for emergency services access and delivery of equipment, as well as to assist with the evacuation of disabled or injured passengers and staff in an emergency. Passenger egress is via a separate stairwell.

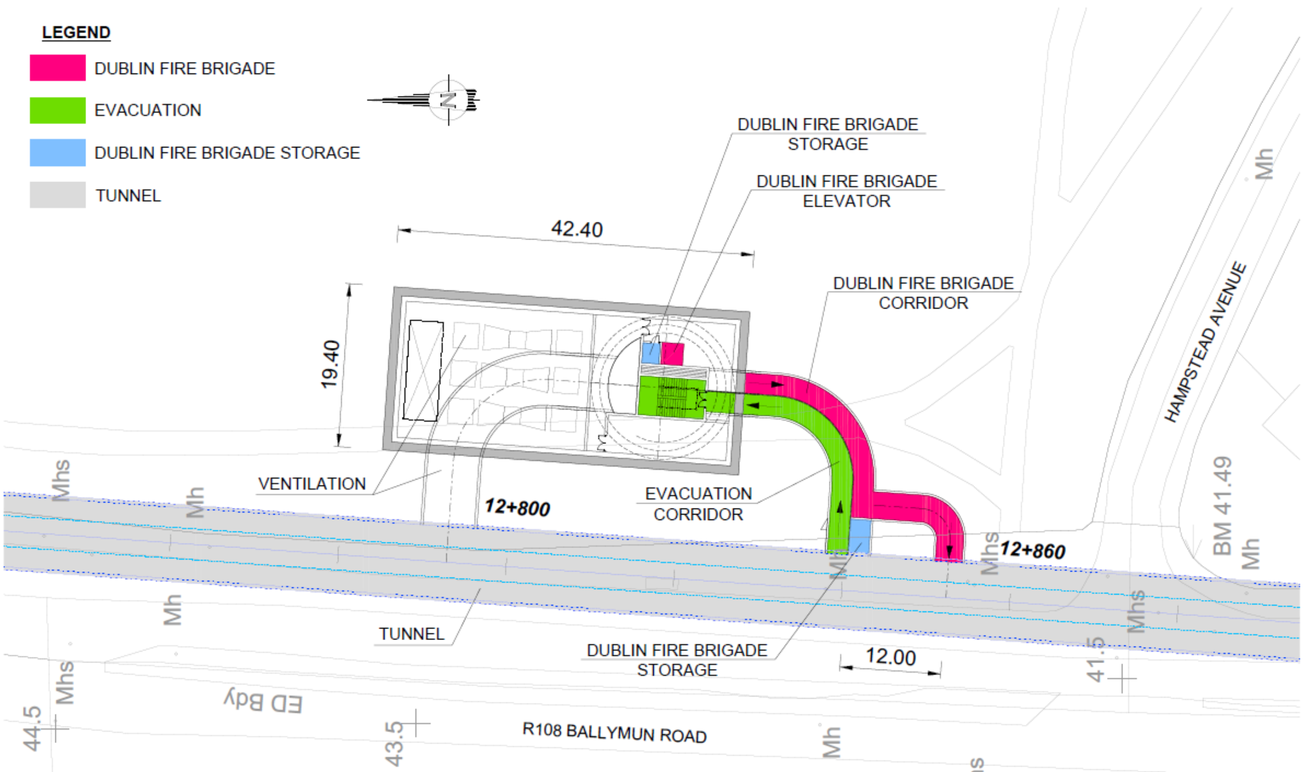

Figure 4.4: Shaft Layout and Tunnel Interface

The shaft and connecting passages are sited to the east off the main tunnel, which runs parallel and near to the R108 Ballymun Road. The ventilation passage is to the north of the shaft and is designed to handle the required airflow into and out of the tunnel. The evacuation and intervention passage are to the south of the shaft. The passage is divided by a wall along its centerline and will have separate fire doors for access into the tunnel. his means that the emergency services are impeded by evacuating passengers, or vice versa.

An electrical plant room and a fan room is located below ground to manage the tunnel ventilation system.

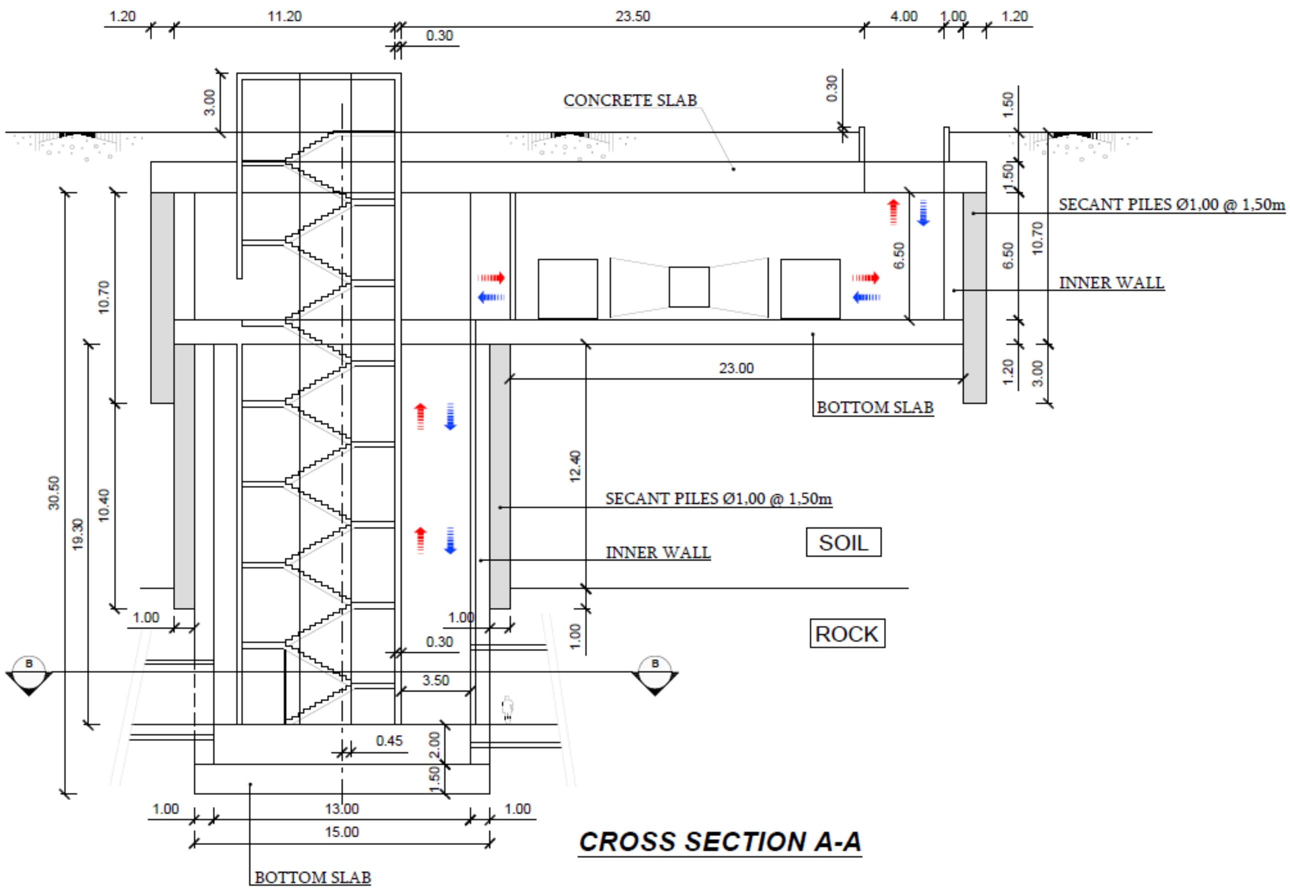

Figure 4.5: Shaft Cross Section

The stairwell and separate fire-fighting lift is housed in a secure building with remote access control and communication systems. A firefighting main with hydrant points at the lobbies of the shaft will be provided.

The shaft and stairwell will be appropriately lit to provide illumination for passenger evacuation and emergency personnel. In the event of a total power failure, backup power is available to sustain the lighting for the duration of the evacuation period. Emergency telephones in the shaft will be connected directly to the Operational Control Centre (OCC) and the back-up OCC.

Most of the tunnel intervention shaft's structure will be beneath ground however some features will extend above ground level and will be clearly visible to the public. An emergency staircase and a fire-fighting lift will be housed in a flat-roofed building with approximate dimensions 9m x 8m by 3m high. The below ground arrangement for the tunnel intervention shaft is shown in Figure 4.6. The above ground/ground level arrangement is shown in Figure 4.7, with elevations on the surface building shown in Figure 4.8 and Figure 4.9. The ground-level ventilation air intake and discharge will be fitted with suitable noise attenuation or reduction baffles.

In the event of an emergency, a safe area on the surface for evacuation of passengers will be available to accommodate up to 1000 persons.

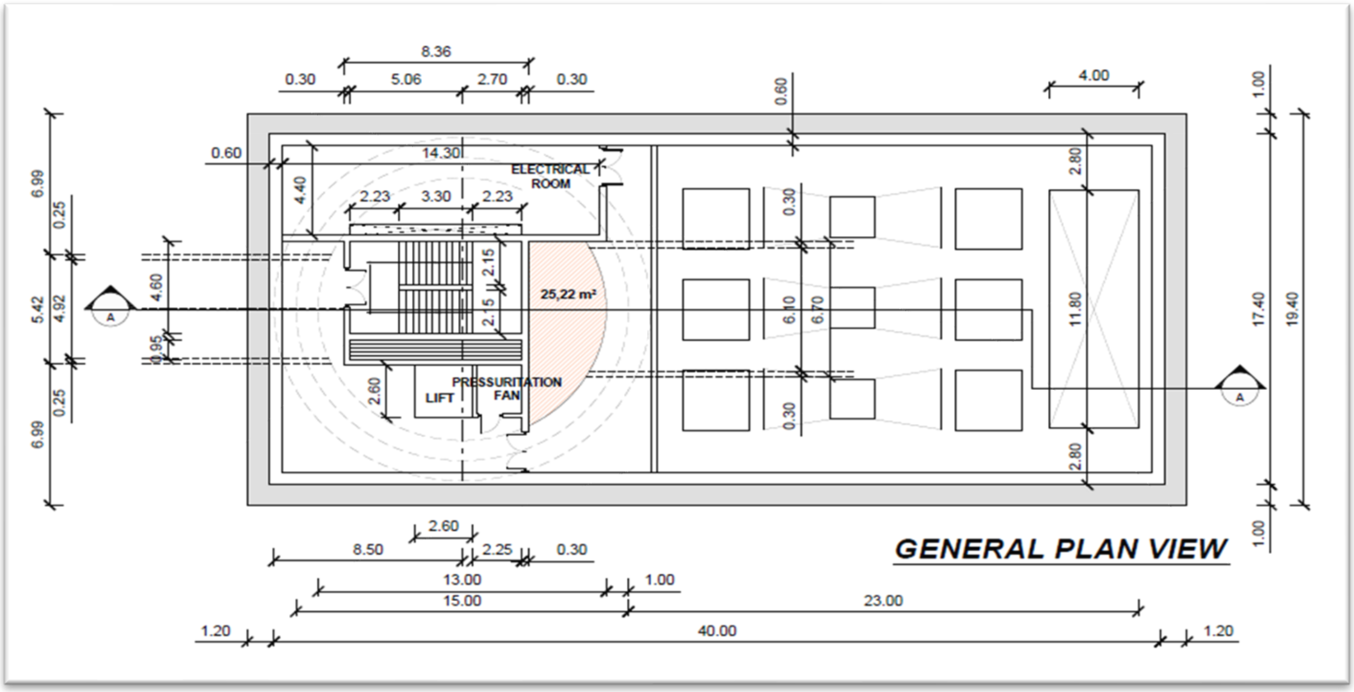

Figure 4.6: Plan View below ground level

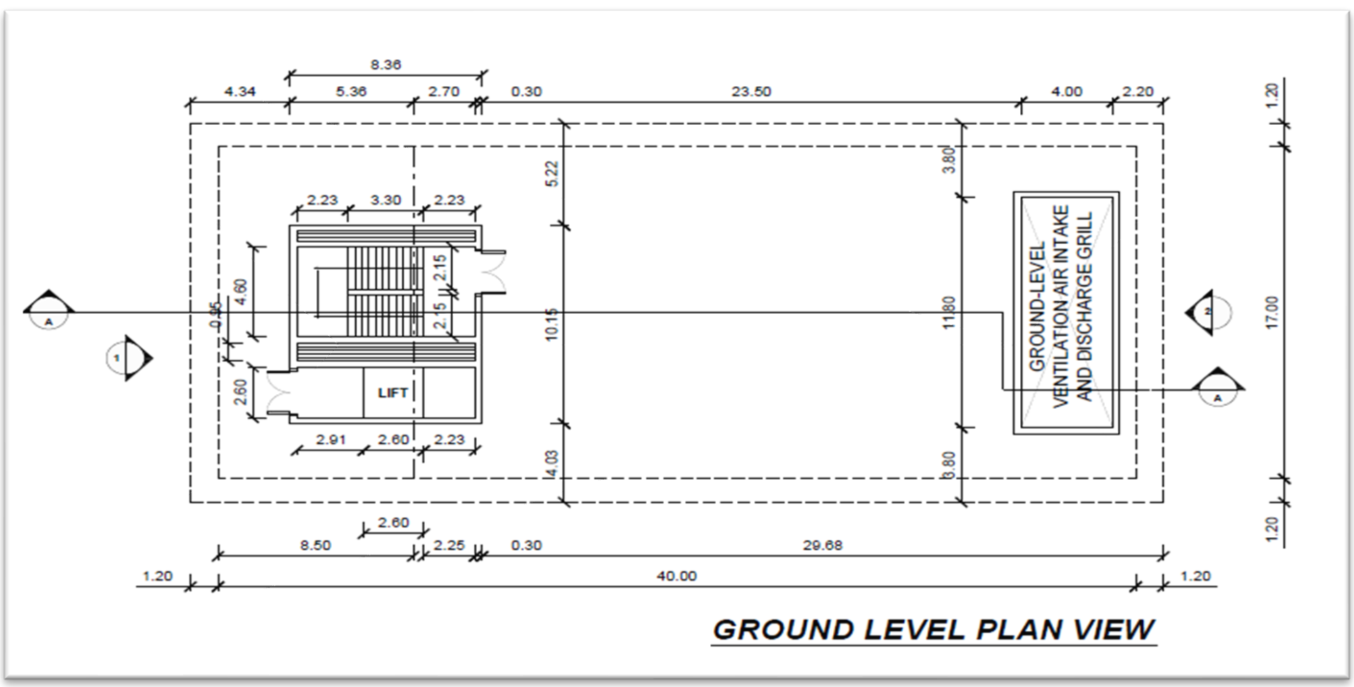

Figure 4.7: Ground Level Plan View

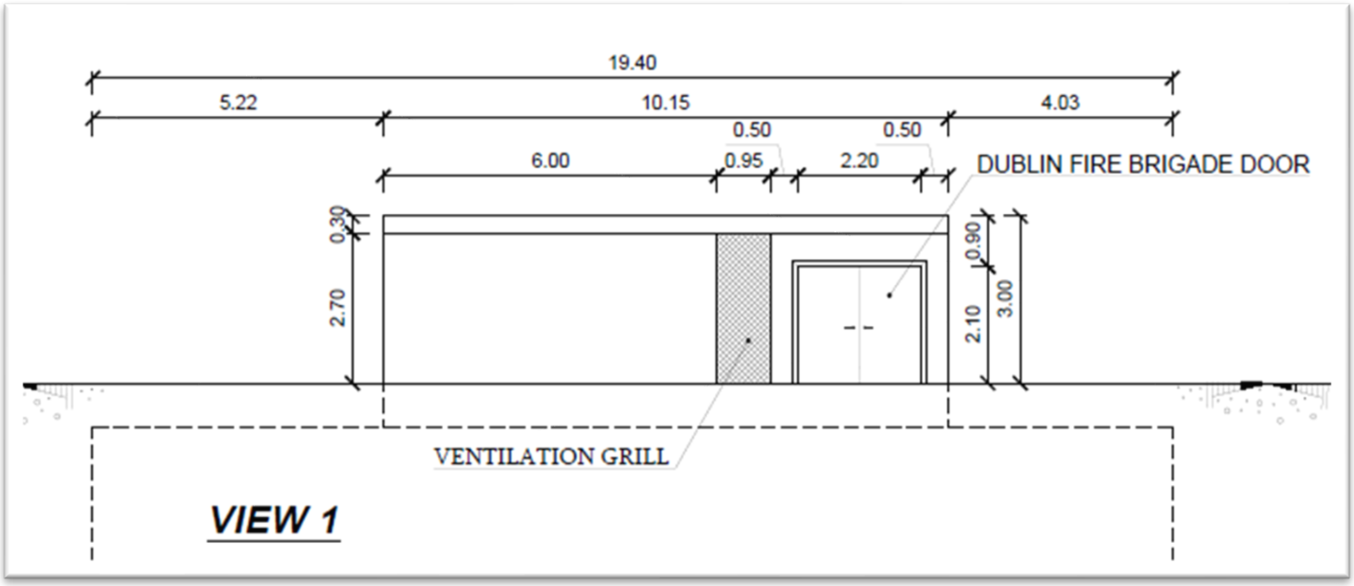

Figure 4.8: Elevation on Emergency Services Access

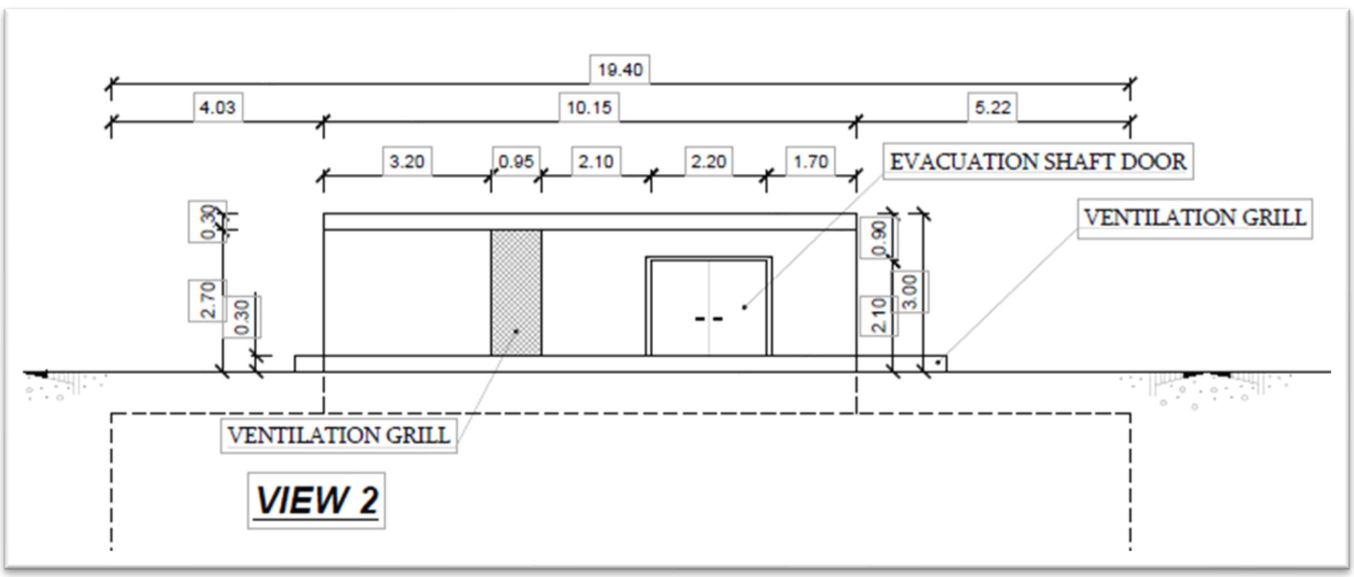

Figure 4.9: Elevation on Evacuation Shaft Door

4.5 Access for Operations and Maintenance

Provision for vehicular access to maintain, service and, if necessary, replace tunnel ventilation and emergency access equipment has been incorporated into the design. The main point of access will be from the Ballymun Road with a secondary access provide from Hampstead Avenue. A large area for parking of emergency vehicles and routine maintenance vehicles has been provided to the southern end of the site. The tunnel ventilation shaft and associated parking and structures will be contained within a secure fenced area. A diagram showing the indicative layout is shown in Figure 4.10.

Figure 4.10: Road Access and Emergency/Maintenance Vehicle Parking

An illustration of how the final the tunnel interventions shaft buildings might look in it surrounds on completion is provided in Figure 4.11.

Figure 4.11: Computer Generated Image of the Intervention Shaft Surface Appearance

5. Construction Methodology

The construction of the tunnel intervention shaft at Albert College Park is a significant construction project. It will require the mobilization of a substantial quantity of machinery, materials and other auxiliary equipment. Most of the construction work will be below ground level, including the vertical shaft and the plant and ventilation fan room.

The size of the vertical shaft is approximately 15m diameter and it will extend 30m below ground level. The shaft construction method will ultimately be selected by the works contractor. However, Jacobs Idiom consider that with rockhead approximately 20m below ground level, a mix of secant pile wall socketed into the weathered rockhead, followed by drill and blast methods below rockhead would be an appropriate methodology. Blasting methods may be required for the subsurface passage connections to the main tunnel because they will be located below rockhead level. An example of a typical shaft under construction using secant piling is shown in Figure 5.1 below.

The proposed intervention shaft at Albert College Park differs because it involves construction of an underground plant and fan room. This room has design dimensions of approximately 43m x 20m x 10m deep and it will be located above the shaft as shown in Figure 4.5.

Figure 5.1: Shaft being Constructed by Secant Piling Method

5.1 Site Compound

A temporary construction compound will be required for the construction of the shaft, the passages connecting the shaft to the main tunnel, and the associated mechanical and electrical work. The extent of the proposed compound is shown in Figure 5.2. The compound layout includes suitable areas for the access road off the Ballymun Road, offices and parking, construction material storage, workshops and excavated material storage. The temporary area required for the compound during construction period is greater than the area which will be ultimately required for the completed tunnel intervention shaft.

It is estimated that the overall construction period for the tunnel intervention shaft will be approximately 3 years.

The proposed site access is from the existing R108 Ballymun Road to the north of Hampstead Avenue. Existing roads would remain fully operational throughout the construction of the shaft.

Figure 5.2: Proposed Extent of Compound for Shaft Construction

The traffic volume generated by the shaft construction site will vary over the construction programme. The heaviest traffic is expected during the excavation phase where large volumes of spoil must be removed to an off-site location. A traffic management system will be developed and communicated with the local authorities to mitigate the impact on the traffic in the area.

Photomontages of the site before and after construction together with an indication of what the surface building could look like are included in Appendix A.

6. Environmental Impact

The Environmental Impact Assessment Report (EIAR) to be produced a later stage of project development will identify all environmental constraints and impacts arising from both the construction phase and the operational phase of the project. To minimise potential environmental impacts, mitigation measures will be prescribed in the

EIAR. The EIAR document will also specify the residual impacts that might remain following the implementation
of the proposed mitigation measures.

While environmental impacts during construction and operation need to be considered as discussed below, it is the short-term impacts during the construction phase that will be most significant. Although we recognised that medium to long-term effects will also occur because of the loss of trees during the construction phase and the establishment period required for replacement trees.

6.1 Construction Phase

All construction phase impacts and their effects on the receiving environment will be assessed later in the EIAR in the necessary detail. However, some of the potential impacts arising during the construction phases are as follows:

Population: In the absence of appropriate mitigation, the construction phase of the proposed intervention shaft could impact the surrounding population. The loss of amenity value due to the construction compound requirements within the public park area and is a short-term impact and the playing fields will remain operational during the construction period. We note that the pitches are owned by the DCC and are used by a local GAA club, and local schools and sports clubs. We can confirm that Albert College Park will be reinstated following the construction phase, which will return the amenity value of the park land.

Biodiversity: There will be a need to remove a number of trees from Albert College Park for the planned construction compound. The felling of these trees has a potential short to medium term impact until replacement trees are re-established. Furthermore, the removal of trees could impact the local breeding bird population. However, it should be noted that a key driver in determining the location of the intermediate shaft site and construction area within the park has been to minimise the number of trees to be felled, while maintaining the amenity value of the playing pitches and park. We note that most trees felled for the purposes of the construction phase will be replaced.

Noise & Vibration: The construction phase will result in the generation of ground borne noise and vibration as well as airborne noise due to the following activities:

- Drill & blasting techniques to break out rock;
- Movement and operation of heavy machinery within the construction site;
- Vehicular movements to and from the site; and
- Piling for the Diaphragm/Secant piled walls.

However, the effects of these activities will be mitigated by setting noise limits for the construction site at the nearest sensitive receptors (residential houses). These noise limits can be met in several ways including, controlling the working hours for noisy activity, by specifying certain construction methodologies, by controlling vehicular movements to and from the site and by using well maintained vehicles, plant and machinery.

Traffic: Traffic and public transport movements in the area could be impacted during the construction phase in the absence of appropriate mitigation measures, because Heavy Goods Vehicles (HGVs) will have to enter and

leave the site to remove excavated materials, import construction materials and remove waste from the site. A site-specific management plan will be implemented in the area surrounding the site to minimise the impact on the local transport network.

Landscape & Visual: The removal of several trees will result in a short to medium term impact on the visual amenity in the area, having regard to the views to the park from nearby residential properties, and for users of the park. However, the design team has sited the intervention shaft to minimise the number of trees to be felled while maintaining the amenity value of the park. Furthermore, replacement planting will be provided to mitigate the potential impacts following construction.

6.2 Operational Phase

Once the construction phase is complete the site will be returned to its existing ground level and only the ground- level ventilation air intake and discharge, together with the stair and lift access building will be visible at or above ground level. Although a permanent access road will be required so that emergency vehicles can access the site it is the case that the above-ground elements at this location will be limited.

The Park area utilized by the construction compound will be returned to its previous use. The intervention shaft compound will need to be accessed by MetroLink staff for occasional maintenance of the ventilation units and, as a very rare event, access by the emergency services.

It is considered that the operational impacts will be much less significant than the short-term impacts during the construction phase. However, all impacts will be assessed in full in the EIAR to be produced.

Suitable noise attenuation will be provided for the intermittent fan operation.

6.3 Photomontages & Intervention Shaft Surface Features

Appendix A includes a selection of photomontages to illustrate the intervention shaft location in Albert College Park. These show the:

Existing View;

- Proposed view upon project completion; and
- Proposed view following 30-40 years establishment of planting.

The photomontages are based on 5 viewpoints as shown on Figure 6.1:

- Viewpoint 1: From the north-eastern edge of the adjacent playing pitches;

- Viewpoint 2: From R108 roadway looking south towards the site;
- Viewpoint 3: From R108 roadway looking north towards the site;
- Viewpoint 4: From Hampstead Avenue looking north-westwards towards the site; and
- Viewpoint 5: From an internal park footpath looking north-westwards towards the site.

Figure 6.1: Photomontage Viewpoints

Appendix A also includes an indication of the potential appearance of the surface features of the Intervention Shaft.

7. Conclusions

The Preferred Route for MetroLink has been developed to optimize the alignment and station locations to best serve passengers and to deliver the resulting benefits to Dublin and the wider Irish economy. Station locations have been chosen for many reasons including transport planning, engineering and economics.

Based on a review of the standards used internationally in the design of underground metro systems, MetroLink have adopted the maximum spacing of 1000m between emergency exits. Where the distance between stations or tunnel portals exceeds this spacing, an additional intervention point is required.

This is the case for the tunnel section between the proposed Collins Avenue and Griffith Park stations. The function of the shaft is for intervention by emergency services, escape by passengers, and ventilation for smoke control during an incident and comfort in normal operations.

The assessment of a suitable location for the required intervention shaft to minimise construction and operational impacts has resulted in this Intervention Shaft being placed in the south-west corner of Albert College Park. The location assessment involved consideration of factors including environmental impact, constructability, distance from the main tunnel and suitable access.

Construction and environmental impacts will be mitigated as much as possible.

MetroLink are committed to working with the local community to ultimately deliver an acceptable design. This work will include consultation on materials and finishes used.

8. Appendix A. Photomontages & Intervention Shaft Surface Features

Photomontage viewpoints comprise:

- Viewpoint 1: From the north-eastern edge of the adjacent playing pitches;
- Viewpoint 2: From R108 roadway looking south towards the site;
- Viewpoint 3: From R108 roadway looking north towards the site;
- Viewpoint 4: From Hampstead Avenue looking north-westwards towards the site; and
- Viewpoint 5: From an internal park footpath looking north-westwards towards the site.

Photomontages:

- Viewpoint 1 – Current
- Viewpoint 1 – Anticipated view upon project completion
- Viewpoint 1 – Anticipated view following 30-40 years establishment of planting
- Viewpoint 2 – Current
- Viewpoint 2 – Anticipated view upon project completion
- Viewpoint 2 – Anticipated view following 30-40 years establishment of planting
- Viewpoint 3 – Current
- Viewpoint 3 – Anticipated view upon project completion
- Viewpoint 3 – Anticipated view following 30-40 years establishment of planting
- Viewpoint 4 – Current
- Viewpoint 4 – Anticipated view upon project completion
- Viewpoint 5 – Current
- Viewpoint 5 – Anticipated view upon project completion

Computer generated image of the Intervention shaft surface appearance

Photomontage viewpoints: V1 to V5 as shown below

Viewpoint 1 – Current

Viewpoint 1 – Anticipated view upon project completion

Viewpoint 1 – Anticipated view following 30-40 years establishment of planting

Viewpoint 2 – Current

Viewpoint 2 – Anticipated view upon project completion

Viewpoint 2 – Anticipated view following 30-40 years establishment of planting

Viewpoint 3 – Current

Viewpoint 3 – Anticipated view upon project completion

Viewpoint 3 – Anticipated view following 30-40 years establishment of planting

Viewpoint 4 – Current

Viewpoint 4 – Anticipated view upon project completion

Viewpoint 5 – Current

Viewpoint 5 – Anticipated view upon project completion

Computer generated image of the Intervention shaft surface appearance