APPENDIX 16

Options to Avoid Areas of Environmental Value in Forrestfield (Public Transport Authority, 2014)

Included as a separate hard copy report

Government of **Western Australia**
Public Transport Authority

Forrestfield-Airport Link

Options to Avoid Areas of Environmental Value in Forrestfield

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1 Introduction

The Forrestfield–Airport Link Project (the Project) is an integral component of Perth's long-term public transport network. The proposed rail line to Forrestfield via Perth Airport will provide improved connectivity between the eastern suburbs and the Perth CBD, as well as a viable alternative to traditional car travel to the airport.

The Project will provide three (3) new stations on an 8.5 kilometre addition to the Perth rail network from Bayswater to Forrestfield in the Perth Eastern suburbs. The scope of the project includes the construction of stations at Airport West (within the Domestic Airport Precinct), Consolidated Airport Station (current International Terminal), and Forrestfield Station (in the foothills suburb of High Wycombe). Bus, pedestrian, taxi and cycle access facilities will be provided at Airport West and Forrestfield stations, with 2000 park and ride facilities proposed at Forrestfield and 500 park and ride facilities proposed at Airport West Station.

As part of the planning phase of the project, the Public Transport Authority (PTA) engaged GHD to undertake an Environmental Assessment of three proposed alignment options (GHD 2014). The study identified areas of environmental value in the Forrestfield Station precinct. These areas were communicated to the project team and in most cases were excluded from the footprint of the concept design. Two areas of environmental value remained within the Project footprint in Forrestfield.

Upon completion of the concept design, the project team undertook further work to develop alternative design options in an effort to avoid the remaining areas of environmental value in Forrestfield. This report details this work.

2 Background

Information obtained during the planning phase of the project, primarily from GHD's Environmental Investigation Report (GHD 2014) and consultation with the Department of Parks and Wildlife, identified the following environmental values in the Forrestfield Station precinct.

- Declared Rare Flora (DRF) - *Conospermum undulatum.* This species is protected by State and Federal legislation. It is classified as Threatened (State)/Vulnerable (Federal) meaning that it faces a high risk of extinction in the wild in the medium term.
- Threatened Ecological Community (TEC) - *Banksia attenuata* woodland over species rich dense shrublands (SCP20a). This ecological community is protected by State legislation. It is classified as Endangered meaning that it faces a very high risk of total destruction in the near future.
- TEC - *Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain (SCP20b). This ecological community is protected by State legislation and is classified as Endangered.
- TEC - Shrublands and woodlands of the eastern side of the Swan Coastal Plain (SCP20c). This ecological community is protected by State and Federal legislation. It is classified as Critically Endangered meaning that it faces an extremely high risk of total destruction in the immediate future.
- TEC - *Corymbia calophylla – Kingia australis* woodlands on heavy soils, Swan Coastal Plain (SCP3a). This ecological community is protected by State and Federal legislation and is classified as Critically Endangered.
- TEC - *Corymbia calophylla – Eucalytpus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain (SCP3b). This ecological community is protected by State legislation and is classified as Vulnerable.
- Black cockatoo foraging, night roosting and breeding habitat.
- A Bush Forever site.
- Areas of Aboriginal cultural heritage significance.

These areas were communicated to the project team and in most cases were excluded from the footprint of the concept design. This led to avoidance of the following areas of environmental value (Refer Figure 1):

- Poison Gully Creek (2.96 ha). This area was considered significant due to its status as a Bush Forever Site, presence of Aboriginal Heritage, DRF (12 *Conospermum undulatum* plants), TEC (SCP20a) and black cockatoo foraging, night roosting and breeding habitat.
- Lot 9 and Lot 12 Ibis Place (3.5 ha) which has been identified to contain TECs (SCP3a, 3b, 20c).

The areas of environmental value that remained within the Project footprint in Forrestfield are summarised below:

- A 0.75 ha area of vegetation north of Forrestfield station which contains 2 *Conospermum undulatum* plants and has been identified as a TEC (SCP20c).
- A 1.72 ha area of vegetation south of Forrestfield station which contains 13 *Conospermum undulatum* plants and has been identified as a TEC (SCP20a/b). This area was originally avoided; however it was included within the footprint following a decision by the PTA that a train stowage area is required south of Forrestfield station.

Design options to avoid these environmental values are presented in Sections 3 to 5.

3 Design Considerations

To develop alternative design options for the Forrestfield Station precinct, the following design considerations were taken into account:

- Constructability
- Station function
- Station access and integration
- Railway Design Criteria
- Safety
- Property access
- Cost
- Land take
- Future planning
- Traffic Management
- Impact on utilities

A description of each of these considerations is provided below.

3.1 Constructability

Redesign of the Forrestfield Station precinct must take into account the following factors:

- The restricted construction area for the transition structure and launch box
- Timing of the Dundas Road realignment to mitigate potential delays to construction
- Relocation of services to mitigate potential delays to construction
- The possibility for a split construction site and the associated potential implications (e.g. operational issues for supporting the construction of structures)

3.2 Station Function

The Forrestfield Station has been designed with only one station entrance. If additional entrances are required due to a redesign, there will be implications for cost, the number of car parking locations required and the requirement for additional staffing.

3.3 Station Access and Integration

Station access and its integration with the surrounding area must be considered when developing alternative design options. Key access and integration considerations include:

- Crossing the existing Dundas Road (if Dundas Road is not realigned)
- The location of the station to provide optimal proximity to park and ride, residents and bus routes

3.4 Railway Design Criteria

The following sections summarise key railway design criteria which must be considered when developing alternative design options.

3.4.1 Design Speed, Horizontal and Vertical Geometry

The railway horizontal and vertical alignments must be designed, where possible, to meet the requirements of the Code of Practice, Section 3.4, 'Track Alignment & Profile' and it's associated Appendix 3.4A. Variations from these standards are noted in the following paragraphs.

The track alignment has been designed to achieve geometry which permits, where possible, the rolling stock maximum speed. However, due to constraints within the corridor, potential speeds would be reduced in some sections of track. The original concept design has a minimum radius curve of 300m on the approach to Forrestfield, meaning a maximum speed on the approach to the station of 70km/hr.

In general, vertical curvature is within the $0.5V^2$standard. Maximum grades will be 3% curve compensated and have been adopted along with minimum radii of 3000m radius curves when descending and ascending from structures. However, in exceptional circumstances such as at Lord St, a minimum crest curve of 2100m has proven to be satisfactory and this has been utilised for the following design options.

3.4.2 Rail Infrastructure

The Tunnel Boring Machine (TBM) launch box is a constraint to the design, having a fixed horizontal geometry and vertical depth. An area of land $30m^2$ is required to be stabilised with grout behind the launch portal due to the shallow depth at which the TBM will launch. From the launch portal the alignment becomes bored tunnel to the North as it descends on maximum 3% grade under the Forrestfield rail yard. At this point, it is critical that a minimum depth of 1 x TBM diameter from ground level to the crown of the tunnel is achieved.

South of the TBM launch portal, the rail alignment ascends towards ground level on a maximum 3% grade. The horizontal alignment tapers from the bore tunnel track centres of 10.1m to 5.2m as it approaches the station. This is necessary to reduce the size of the diaphragm wall structure and the length of the turnback crossovers between the two tracks.

The position of the North end of the station is governed by the length of vertical curve at the end of the dive structure when transitioning from 3% grade to 0% grade into the station.

3.4.3 Turnback Crossovers

The crossovers are required to be placed on a length of parallel horizontal and level track and this requirement governs the horizontal geometry within the structure.

3.4.4 Stowage and On-tracking facility

250m of dual track is required south of the station to provide overnight storage of trains and an on track facility which allows maintenance vehicles to access the track. The stowage tracks will have service platforms directly adjacent to them in a similar layout to the station. These will be used as driver's walkways and access for cleaning and maintenance personnel.

3.5 Safety

Safety considerations which must be taken into consideration during the redesign of the Forrestfield Station precinct are summarised below:

- Requirements for construction traffic crossing existing roads may have safety implications such as the risk of collision
- Construction access required across Dundas Road (e.g. a conveyor bridge if Dundas Road is not realigned)
- Construction activities in close proximity to active rail, such as requirements for retaining walls
- Potential interface issues with services and road works
- Pedestrian station access across roads

3.6 Property Access

Redesign of the Forrestfield Station precinct must consider possible restrictions to property access, in particular, restricted access to properties opposite the transition structure during construction works. The potential for temporary access restrictions during construction of the new Dundas Road must also be considered during the design process.

3.7 Cost

The difference in cost between options considered during the design of the Forrestfield Station precinct was up to $5 million. The main cost implications include:

- Requirements for a pedestrian bridge across Dundas Road
- Extra tunnelling requirements (for example, an extra 22m of tunnelling was estimated to cost $5 million)
- Requirements for retaining walls
- Increased re-alignment length for Dundas Road

Costs were an integral component of the decision making process during the concept design of the Forrestfield Station precinct with the bored tunnel length reduced where possible and the realignment of Dundas Road in order to avoid the requirement for a pedestrian overpass or underpass.

3.8 Land Take

The primary land take consideration is the number of private properties requiring acquisition.

3.9 Future Planning

Redesign of the Forrestfield Station precinct must make provision for a future extension of the railway to allow for connections to be made to the wider network.

3.10 Traffic Management

Traffic management requirements during construction, especially adjacent to the launch and transition structures and for realignment of Dundas Road must be considered when developing alternative options.

3.11 Impacts on utilities

Impacts to utilities that must be considered when developing alternative design options the Forrestfield Station are summarised below:

- Utilities relocation
- Protection of services will be required
- Connection of road services into realigned major utilities

4 Design Options

4.1 Summary of Design Options

This section provides details of the original concept design and the options developed to avoid the areas of environmental value in Forrestfield and how these differ from the concept design. The option descriptions should be read in conjunction with Figures 2 to 8.

Although there is a strong preference from the PTA to realign Dundas Road, options were considered leaving Dundas Road in its existing position.

4.2 Concept Design Description

The concept design for the Forrestfield Station precinct, located the station as north as possible with the purpose of avoiding the southern area of TEC/DRF and providing a more central location within the station precinct (Refer Figure 1). This also reduced the length of bored tunnel on the approach to the station, whilst still being long enough for the rail alignment to achieve sufficient clearance under the Forrestfield rail yard without compromising the horizontal alignment.

The concept design has the turnback crossovers at grade on the approach to the station which allows for greater flexibility of the horizontal geometry as there was no need to provide a length of parallel and level track long enough to accommodate them.

The concept design includes for the realignment of the existing Dundas Road, removing any segregation of the station car park from the station. This consequently removes the need for a pedestrian footbridge or underpass.

4.3 Redesign Option 1 Description

The rail alignment for Option 1 has been designed to bisect the land between the existing Dundas Road and the TEC/DRF area to avoid as much severance as possible (Refer Figure 2).

The horizontal and vertical geometry of the track has been designed to accommodate the turnback crossovers within the dive structure. This allows for the station and stowage to move closer to the end of the transition structure, thus reducing the impact on the TEC/DRF area to the south of the station.

However, to achieve the geometry necessary to accommodate the crossovers on the structure, transition curves have been reduced resulting in a speed restriction of 60km/hr in comparison to 70km/hr on the original design.

The design provides an 18m utility corridor for the existing utilities to be diverted, which runs adjacent to the Forrestfield freight yard along the top of the embankment.

In summary, the Option 1 design requires the following:

- No additional tunnelling
- The platform moves 90m north from the current concept design location and slightly east towards the proposed car park.
- Compromised rail geometry to accommodate the turnouts resulting in a speed restriction of 60km/hr
- A pedestrian footbridge or underpass to cross the existing Dundas Road
- TEC resumption – 2,738m^2(North) and 5,443m^2(South)

4.4 Redesign Option 2 Description

The rail alignment for Option 2 has been designed as per Option 1. This option allows for the realignment of Dundas Road, with sections remaining open for local access to adjacent properties. This constrains the position of the rail infrastructure.

Option 2a has the road and utility corridor adjacent to the Forrestfield fright rail yard along the top of embankment. Option 2b allows for the corridor to be closer to the Forrestfield fright rail yard facilitated by the construction of a retaining wall and engineered fill alongside the existing embankment.

In summary, the Option 2a design requires the following:

- No additional tunnelling
- The platform moves 90m north from the current concept design location and slightly east towards the proposed car park.
- Dundas Road realignment with 18m utility corridor
- Compromised rail geometry to accommodate the turnouts resulting in a speed restriction of 60km/hr
- TEC resumption – 5,086m²(North) and 9,240m²(South)

In summary, the Option 2b design requires the following;

- No additional tunnelling
- The platform moves 90m north from the current concept design location and slightly east towards the proposed car park.
- Dundas Road realignment with 18m utility corridor and 1km of retaining wall and engineered fill
- Compromised rail geometry to accommodate the turnouts resulting in a speed restriction of 60km/hr
- TEC resumption – 4,663m²(North) and 8,618m²(South)

4.5 Redesign Option 3 Description

Option 3 locates the position of the TBM launch portal south of the northern area of TEC/DRF. The track alignment within the dive structure is similar to that of the previous options, again to facilitate the locations of the turnouts within the structure. As a result of moving the structure south, the station also moves south having a greater impact on the southern area of TEC/DRF.

Whilst the relocation of the launch box and a change in bearing allows the track alignment to take a more direct route towards the airport, additional tunnelling is required for this option.

This option leaves Dundas Road in its current position and provides an 18m corridor for the existing utilities to be diverted, which runs adjacent to the Forrestfield freight rail yard, along the top of the embankment.

In summary, the Option 3 design requires the following;

- 50m additional tunnelling
- The platform moves 95m south from the current concept design location and slightly east towards the proposed car park.
- 18m utility corridor
- Compromised rail geometry to accommodate the turnouts resulting in a speed restriction of 60km/hr
- A pedestrian footbridge or underpass to cross the existing Dundas Road
- TEC resumption – 2,278m²(North) and 7,856m²(South)

4.6 Redesign Option 4 Description

The rail alignment for Option 4 has been designed as per Option 3. This option allows for the realignment of Dundas Road, with sections remaining open for local access to adjacent properties.

Option 4a has the road and utility corridor adjacent to the Forrestfield rail yard along the top of embankment. Option 4b allows for the corridor to be closer to the rail yard facilitated by the construction of a retaining wall and engineered fill alongside the existing embankment.

In summary, Option 4a design requires the following;

- 50m additional tunnelling
- The platform moves 95m south from the current concept design location and slightly east.
- Dundas Road realignment with 18m utility corridor
- Compromised rail geometry to accommodate the turnouts resulting in a speed restriction of 60km/hr
- TEC resumption – 4,656m²(North) and 11,638m²(South)

In summary, Option 4b design requires the following;

- 50m additional tunnelling
- The platform moves 95m south from the current concept design location and slightly east.
- Dundas Road realignment with 18m utility corridor and 1km of retaining wall and engineered fill
- Compromised rail geometry to accommodate the turnouts resulting in a speed restriction of 60km/hr
- TEC resumption – 4,213m²(North) and 11,015m²(South)

4.7 Redesign Option 5 Description

The Option 5 design is similar to Option 4, with the rail infrastructure moving further east and a change of bearing between the launch box and the station. This change in bearing allows for Dundas Road to remain on the east side of the northern area of TEC/DRF and then realign past the west of the launch box and the proposed station. However, it increases the length of bored tunnel required. It also impacts more severely on the southern area of TEC/DRF.

In summary, Option 5 design requires the following;

- 70m additional tunnelling
- The platform moves 65m south from the current concept design location and slightly east towards the proposed car park.
- 18m utility corridor
- Compromised rail geometry to accommodate the turnouts resulting in a speed restriction of 60km/hr
- TEC resumption – 2,278m²(North) and 11,743m²(South)

5 Options Appraisal

Design Option	Constructability	Station function	Station access and integration	Railway Design Criteria	Safety	Property access	Cost	Land Take	Future planning	Traffic Management	Impact on utilities
1	Restricted construction area for the transition structure and launch box. Option necessitates a split construction site which will have significant operational issues for supporting the construction of structures as well as the TBMs.	Shifting the alignment east would result in station facilities to the west. This will require the station to have two entrances which adds to cost as well as the difficulty of monitoring two separate parking locations (possibly requiring additional staffing).	Dundas Road would segregate the station and park and ride/kiss and ride facilities resulting in poor integration.	The platform moves 90m north from the concept design location and slightly east towards the proposed car park. Compromised rail geometry to accommodate the turnouts resulting in a speed restriction of 60km/hr.	Construction access required across Dundas Road including possible conveyor bridge. Station requires access across Dundas Road resulting in a potential risk of collision.	Restricted access to local properties during construction works, especially opposite the transition structure.	Pedestrian bridge across Dundas Road to access station	No additional land take required.	Will impact on future extension of the railway southwards as it will make grade separation of Dundas Road and extended railway alignment difficult to achieve.	There will be some traffic management requirements during construction, especially adjacent to the Launch and transition structures.	Utilities re-location would need to be undertaken as forward works package to minimise potential main construction contract delays.
2A&B	In Option 2b a retaining wall is required for the full length of the Dundas Road re-alignment. Timing will be critical for the re-location of the services and Dundas Road works, ideally as forward works. Services re-location in proximity to existing Dundas Road at northern end will require careful management.	Shifting the alignment east would result in station facilities to the west. This will require the station to have two entrances which adds to cost as well as the difficulty of monitoring two separate parking locations (possibly requiring additional staffing).	A long slither of land between the railway and Dundas Road would be created. It may be difficult to find a functional use for this land.	The platform moves 90m north from the concept design location and slightly east towards the proposed car park. Compromised rail geometry to accommodate the turnouts resulting in a speed restriction of 60km/hr	Construction of retaining wall in close proximity to active railway. Rail Safety Plan required.	Possible access restrictions during the transition structure construction works.	Construction of approximately 1.5km of retaining wall along re-aligned Dundas Road.	No additional land take required.	Will impact on future extension of the railway southwards as it will make grade separation of Dundas Road and extended railway alignment difficult to achieve.	Traffic management will be required when re-aligned Dundas Road is tied into the existing road and when services are re-located. Additional tie-ins required to feed Maida Vale Road traffic to new Dundas Road.	Utilities will need to be re-located, ideally as forward works, including connections to Maida Vale services. Additional protection required if the services pass beneath the rail alignment.
3	Split construction site will be the main issue. Services re-alignment could be included in the main construction contract. No requirement for forward works. Temporary services protection will be required if re-location is not undertaken as forward works.	Shifting the alignment east would result in station facilities to the west. This will require the station to have two entrances which adds to cost as well as the difficulty of monitoring two separate parking locations (possibly requiring additional staffing).	Dundas Road would segregate the station and park and ride/kiss and ride facilities resulting in poor integration. Efforts have been made to push the station as far north as possible as this provides better proximity to park and ride, residents and bus routes to the area. Locating it further south will slightly add to travel time for the majority of trips to the station.	The platform moves 95m south from the concept design location and slightly east towards the proposed station car park. Compromised rail geometry to accommodate the turnouts resulting in a speed restriction of 60km/hr.	Construction traffic crossing existing Dundas Road to support dive structure construction and TBM operations.	None.	50m of additional tunnelling. Pedestrian bridge across Dundas Road to access station	No additional land take required.	Will impact on future extension of the railway southwards as it will make grade separation of Dundas Road and extended railway alignment difficult to achieve.	Traffic Management required for services tie-ins. Also construction site crossing to access dive structures and TBM support.	Connection of Maida Vale road services into re-aligned major utilities especially across rail alignment. Protection of services required if not undertaken as forward works.

4A&B	As per option 3 but without the split construction site. Consideration should be given to services re-location to mitigate potential construction delays due to interface issues with road re-alignment. Option 4b requires additional retaining wall along rail yard.	Shifting the alignment east would result in station facilities to the west. This will require the station to have two entrances which adds to cost as well as the difficulty of monitoring two separate parking locations (possibly requiring additional staffing).	Efforts have been made to push the station as far north as possible as this provides better proximity to park and ride, residents and bus routes to the area. Locating it further south will slightly add to travel time for the majority of trips to the station.	The platform moves 95m South from the concept design location and slightly east. Compromised rail geometry to accommodate the turnouts resulting in a speed restriction of 60km/hr	Potential interface issues with services and road works in close proximity.	None.	50m of additional tunnelling. Option 4b requires additional 1.5km of retaining wall.	No additional land take required.	Will impact on future extension of the railway southwards as it will make grade separation of Dundas Road and extended railway alignment difficult to achieve.	Traffic Management required for services tie-ins.	Connection of Maida Vale road services into re-aligned major utilities.
5	Services re-location will need to be completed prior to the Dundas Road diversion. The issue will be connecting the Maida Vale Road across the tunnel dive structure or around to the northern connection. The launch box could impinge upon the existing access to the properties north of Maida Vale road.	Shifting the alignment east would result in station facilities to the west. This will require the station to have two entrances which adds to cost as well as the difficulty of monitoring two separate parking locations (possibly requiring additional staffing).	Efforts have been made to push the station as far north as possible as this provides better proximity to park and ride, residents and bus routes to the area. Locating it further south will slightly add to travel time for the majority of trips to the station.	The platform moves 65m south from the concept design location and slightly east towards the proposed car park. Compromised rail geometry to accommodate the turnouts resulting in a speed restriction of 60km/hr	No significant safety issues noted.	Possible temporary access restrictions during construction of the new Dundas Road and railway dive structure.	70m of additional tunnelling required. Marginal increase in re-alignment length for Dundas Road.	No additional land take required.	Will impact on future extension of the railway southwards as it will make grade separation of Dundas Road and extended railway alignment difficult to achieve.	Minimal impact on the road impact apart from temporary construction impacts.	Issue with connecting the Maida Vale services in to the re-aligned Dundas Road services.

6 Conclusion

The alternative design options which have been developed have less direct impacts on the remaining areas of environmental value (TECs/DRF) in Forrestfield than the concept design. However, given the area of vegetation comprising the TECs and containing the DRF is already minimal and isolated, it is considered that any reduction in area is likely to reduce the future viability of the community/species. In particular, the proposed clearing will result in a narrower area of vegetation which will be increasingly subject to edge effects such as weed invasion.

The key design constraints associated with the alternative design options as identified in Section 5 and summarised in Table 1 are considered to outweigh the minimal environmental benefits expected from retaining small isolated pockets of TEC/DRF. Consequently, the alternative design options are not considered viable. It is therefore recommended that environmental approval is sought for the original design concept.

Table 1: Summary of Environmental Impacts and Key Design Considerations

Option	Environmental Impacts	Key Design Considerations	Comments
Concept Design	○ Clearing 0.75 ha of SCP20c ○ Clearing 1.72 ha of SCP20a / SCP20b. ○ Clearing 15 *Conospermum undulatum* plants.	○ No additional costs due to tunnelling or access infrastructure. ○ Good station access and integration, with no requirements for pedestrian footbridges or underpasses.	This station design is the most desirable option in regards to cost, accessibility and station and rail function. This option involves clearing the TEC and DRF located in the concept design footprint.
1	○ Impacts to 0.27 ha of SCP20c, with a narrow 0.48 ha strip of SCP20c being retained between the services corridor and proposed rail alignment. ○ Clearing 0.54ha along the western edge and north east portion of SCP20a / SCP20b. ○ Clearing 10 *Conospermum undulatum* plants.	○ Additional costs due to requirements for a pedestrian over or underpass. ○ Compromised rail geometry which will result in speed restrictions. ○ May impact future extension of the rail southwards.	Avoidance of impacts to the TECs and DRF were not considered significant enough to warrant the design constraints, reduced usability and increased costs involved with Option 1. The TECs comprise such a small area that even with the reduction of impacts from those predicted from the concept design, the long term viability of these communities is considered unlikely.

2a	○ Impacts to 0.5 ha of SCP20c, with a narrow 0.25 ha strip of SCP20c being retained between the services corridor and proposed rail alignment. ○ Clearing 0.92 ha along the western edge and north east portion of SCP20a / SCP20b, with 0.8 ha being retained. ○ Clearing 11 *Conospermum undulatum* plants.	○ Compromised rail geometry resulting in speed restrictions. ○ May impact future extension of the rail southwards. ○ Additional costs due to the extra 22m of tunnel required. ○ Will involve additional costs and potential impacts due to the additional potential acid sulfate soils which will be excavated from the proposed tunnel extension.	Avoidance of impacts to the TECs and DRF were not considered significant enough to warrant the design constraints, reduced usability and increased costs involved with Option 2. With the impacts expected from Option 2, the TECs comprise such a small area that even with the reduced impacts compared to the concept design, the long term viability of these communities is considered unlikely. Only 4 of those *Conospermum undulatum* plants originally identified in the concept design footprint will be retained through Option 2.
2b	○ Impacts to 0.47 ha of SCP20c, with a narrow 0.28 ha strip of SCP20c being retained between the services corridor and proposed rail alignment. ○ Clearing 0.86 ha along the western edge and north east portion of SCP20a / SCP20b, with 0.86 ha being retained. ○ Clearing 11 *Conospermum undulatum* plants.	○ Compromised rail geometry resulting in speed restrictions. ○ May impact future extension of the rail southwards. ○ Additional costs due to the extra 22m of tunnel required and construction of a 1 km retaining wall. ○ Will involve additional costs and potential impacts due to the additional potential acid sulfate soils which will be excavated from the proposed tunnel extension.	
3	○ Impacts to 0.28 ha of SCP20c, a narrow strip comprising 0.45 ha will be retained between Dundas Road and the existing rail and service corridor. ○ Clearing 0.79 ha along the western edge and north east portion of SCP20a / SCP20b, with 0.86 ha being retained between the proposed services corridor and rail alignment. ○ Clearing 10 *Conospermum undulatum* plants.	○ Compromised rail geometry results in speed restrictions. ○ Additional costs due to an extra 50m of tunnelling required and the pedestrian footbridge or underpass required to cross Dundas Rd. ○ Reduced station access and integration. ○ Will involve additional costs and potential impacts due to the additional potential acid sulfate soils which will be excavated from the proposed tunnel extension.	Avoidance of impacts to the TECs and DRF were not considered significant enough to warrant the design constraints, reduced usability and increased costs involved with Option 3. With the impacts expected from Option 3, the TECs comprise such a small area that even with the reduced impacts compared to the concept design, the long term viability of these communities is considered unlikely. Only 5 of those *Conospermum undulatum* plants originally identified in the concept design footprint will be retained through Option 3.

4a	○ Impacts to 0.47 ha of SCP20c, resulting in a small 0.28 ha area being retained between developed areas and proposed service corridor and realigned road. ○ Clearing 1.16 ha along the western edge and eastern edge of the TEC, resulting in a small strip of 0.56 ha being retained. ○ Clearing 11 *Conospermum undulatum* plants.	○ Compromised rail geometry results in speed restrictions. ○ Additional costs due to an extra 50m of tunnelling required. ○ May impact future extension of the rail southwards. ○ Will involve additional costs and potential impacts due to the additional potential acid sulfate soils which will be excavated from the proposed tunnel extension.	The areas of TEC avoided through this design option comprise such small, narrow parcels of land that the long term viability of these communities is likely to be compromised due to encroachment of weeds and disease and general vegetation damage through unauthorised access. Therefore, when compared to the design constraints involved with this option, the small reduction in environmental impacts from the design concept is not considered significant enough to warrant this design. Only 4 of those *Conospermum undulatum* plants originally identified in the Forrestfield footprint (over two locations) will be retained through Option 4.
4b	○ Impacts to 0.42 ha of SCP20c, resulting in a small 0.33 ha area being retained between developed areas and proposed service corridor and realigned road. ○ Clearing 1.1 ha along the western edge and eastern edge of the TEC, resulting in a small strip of 0.62 ha being retained. ○ Clearing 11 *Conospermum undulatum* plants.	○ Compromised rail geometry results in speed restrictions. ○ Additional costs due to an extra 50m of tunnelling required and construction of a 1 km retaining wall. ○ May impact future extension of the rail southwards. ○ Will involve additional costs and potential impacts due to the additional potential acid sulfate soils which will be excavated from the proposed tunnel extension.	
5	○ Impacts to 0.23 ha of SCP20c, resulting in a small 0.52 ha area being retained between road and rail alignments ○ Clearing 1.17 ha along the western edge and eastern edge of the TEC, resulting in a small strip of 0.55 ha being retained between road and rail alignments ○ Clearing 13 *Conospermum undulatum* plants	○ Compromised rail geometry results in speed restrictions ○ Additional costs due to an extra 70m of tunnelling required ○ May impact future extension of the rail southwards ○ Will involve additional costs and potential impacts due to the additional potential acid sulfate soils which will be excavated from the proposed tunnel extension	The areas of TEC avoided through this design option comprise such small, narrow parcels of land that the long term viability of these communities is likely to be compromised due to encroachment of weeds and disease and general vegetation damage through unauthorised access. Therefore, when compared to the design constraints involved with this option, the small reduction in environmental impacts from the design concept is not considered significant enough to warrant this design.

Figure 1 Original Concept Design

Government of Western Australia
Public Transport Authority

Legend

Declared Rare Flora

(#) Conospermum Undulatum (No of Plants)
State-Threatened, Federal-Vulnerable

TECs

- SCP 20a (State-Critically Endangered)
- SCP 20a / SCP 20b (State-Critically Endangered)
- SCP 20c (State-Critically Endangered, Federal-Endangered)
- SCP 3a / SCP 3b / SCP 20c

Proposed Infrastructure & Boundaries

- Rail Alignment
- Stowage
- Structures
- Dundas Re-aligned
- Approval Boundary
- Tunneling Footprint
- Construction Footprint

TBM LAUNCH BOX

TRANSITION STRUCTURE

Area 0.75 Ha

FORRESTFIELD STATION

DUNDAS ROAD RE-ALIGNED

STOWAGE AREA

Area 1.72 Ha

Map by: M. Nickerson

A3 scale: 1:3,000

0 50 100 m

Coordinate System: GDA 1994 Perth Coastal Grid 1994
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Date: 20/06/2014

Version: 0

FAL Options to Avoid Environmental Constraints in Forrestfield

Figure 1: TECs and DRF within the Forrestfield Construction Footprint

Figure 2 Redesign Option 1

Government of Western Australia
Public Transport Authority

Legend

ENVIRONMENTAL

- Threatened Ecological Community (2.47 Ha West of Dundas Rd)
- Construction Impact on TEC (0.82 Ha)
- Declared Rare Flora — *Conospermum undulatum* *State Threatened, Federal Vulnerable*
- Approval Boundary

RAIL INFRASTRUCTURE

- Turnback Crossovers
- Option 1 Track Alignment
- Forrestfield Station
- Service Platforms
- Transition Structure
- Bored Tunnels

UTILITIES

- Services Corridor
- Culvert Basin
- Culvert

MAIDA VALE ROAD

DUNDAS ROAD

Map by: M. NICKERSON

A3 scale: 1:3,000

0 50 100 m

Coordinate System: PCG94
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Date: 20/06/2014
Version 1

FAL Options to Avoid Environmental Constraints in Forrestfield

Figure 2: FAL Alignment Option 1

Figure 3 Redesign Option 2A

Government of Western Australia
Public Transport Authority

Legend

ENVIRONMENTAL

- Threatened Ecological Community (2.47 Ha West of Dundas Rd)
- Construction Impact on TEC (1.40 Ha)
- Declared Rare Flora — *Conospermum undulatum* *State Threatened, Federal Vulnerable*
- Approval Boundary

RAIL INFRASTRUCTURE

- Turnback Crossovers
- Option 1 Track Alignment
- Forrestfield Station
- Service Platforms
- Dundas Road Realigned
- Transition Structure
- Bored Tunnels

UTILITIES

- Services Corridor
- Culvert Basin
- Culvert

MAIDA VALE ROAD

DUNDAS ROAD

Map by: M. NICKERSON

A3 scale: 1:3,000

0 50 100 m

Coordinate System: PCG94
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Date: 20/06/2014
Version 1

FAL Options to Avoid Environmental Constraints in Forrestfield

Figure 3: FAL Alignment Option 2A

Figure 4 Redesign Option 2B

Government of Western Australia
Public Transport Authority

Legend

ENVIRONMENTAL

- Threatened Ecological Community (2.47 Ha West of Dundas Rd)
- Construction Impact on TEC (1.33 Ha)
- Declared Rare Flora — *Conospermum undulatum* *State Threatened, Federal Vulnerable*
- Approval Boundary

RAIL INFRASTRUCTURE

- Turnback Crossovers
- Option 1 Track Alignment
- Retaining Wall
- Forrestfield Station
- Service Platforms
- Dundas Road Realigned
- Transition Structure
- Bored Tunnels

UTILITIES

- Services Corridor
- Culvert Basin
- Culvert

MAIDA VALE ROAD

DUNDAS ROAD

Map by: M. NICKERSON

A3 scale: 1:3,000

0 50 100 m

Coordinate System: PCG94
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Date: 20/06/2014

Version 1

FAL Options to Avoid Environmental Constraints in Forrestfield

Figure 4: FAL Alignment Option 2B

Figure 5 Redesign Option 3

Government of Western Australia
Public Transport Authority

Legend

ENVIRONMENTAL

- Threatened Ecological Community (2.47 Ha West of Dundas Rd)
- Construction Impact on TEC (1.01 Ha)
- Declared Rare Flora — *Conospermum undulatum* State Threatened, Federal Vulnerable
- Approval Boundary

RAIL INFRASTRUCTURE

- Turnback Crossovers
- Option 1 Track Alignment
- Forrestfield Station
- Service Platforms
- Transition Structure
- Bored Tunnels

UTILITIES

- Services Corridor
- Culvert Basin
- Culvert

MAIDA VALE ROAD

DUNDAS ROAD

Map by: M. NICKERSON

A3 scale: 1:3,000

0 50 100 m

Coordinate System: PCG94
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Date: 20/06/2014
Version 1

FAL Options to Avoid Environmental Constraints in Forrestfield

Figure 5: FAL Alignment Option 3

Figure 6 Redesign Option 4A

Government of Western Australia
Public Transport Authority

Legend

ENVIRONMENTAL

- Threatened Ecological Community (2.47 Ha West of Dundas Rd)
- Declared Rare Flora *Conospermum undulatum* *State Threatened, Federal Vulnerable*
- Construction Impact on TEC (1.63 Ha)
- Approval Boundary

RAIL INFRASTRUCTURE

- Turnback Crossovers
- Option 1 Track Alignment
- Forrestfield Station
- Service Platforms
- Dundas Road Realigned
- Transition Structure
- Bored Tunnels

UTILITIES

- Services Corridor
- Culvert Basin
- Culvert

MAIDA VALE ROAD

DUNDAS ROAD

Map by: M. NICKERSON

A3 scale: 1:3,000

0 50 100 m

Coordinate System: PCG94
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Date: 20/06/2014
Version 1

FAL Options to Avoid Environmental Constraints in Forrestfield

Figure 6: FAL Alignment Option 4A

Figure 7 Redesign Option 4B

Government of Western Australia
Public Transport Authority

Legend

ENVIRONMENTAL

- Threatened Ecological Community (2.47 Ha West of Dundas Rd)
- Construction Impact on TEC (1.52 Ha)
- Declared Rare Flora — *Conospermum undulatum* *State Threatened, Federal Vulnerable*
- Approval Boundary

RAIL INFRASTRUCTURE

- Turnback Crossovers
- Option 1 Track Alignment
- Retaining Wall
- Forrestfield Station
- Service Platforms
- Dundas Road Realigned
- Transition Structure
- Bored Tunnels

UTILITIES

- Services Corridor
- Culvert Basin
- Culvert

MAIDA VALE ROAD

DUNDAS ROAD

Map by: M. NICKERSON

A3 scale: 1:3,000

0 50 100 m

Coordinate System: PCG94
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Date: 20/06/2014
Version 1

FAL Options to Avoid Environmental Constraints in Forrestfield

Figure 7: FAL Alignment Option 4B

Figure 8 Redesign Option 5

Government of Western Australia
Public Transport Authority

Legend

ENVIRONMENTAL

- Threatened Ecological Community (2.47 Ha West of Dundas Rd)
- Construction Impact on TEC (1.41 Ha)
- Delcared Rare Flora — *Conospermum undulatum* *State Threatened, Federal Vulnerable*
- Approval Boundary

RAIL INFRASTRUCTURE

- Turnback Crossovers
- Option 1 Track Alignment
- Forrestfield Station
- Service Platforms
- Dundas Road Realigned
- Transition Structure
- Bored Tunnels

UTILITIES

- Services Corridor
- Culvert Basin
- Culvert

MAIDA VALE ROAD

DUNDAS ROAD

Map by: M. NICKERSON

A3 scale: 1:3,000

0 50 100 m

Coordinate System: PCG94
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Date: 20/06/2014
Version 1

FAL Options to Avoid Environmental Constraints in Forrestfield

Figure 8: FAL Alignment Option 5