OPTION FEASIBILITY STUDY (OFS)

Renewables in North Western NSW

OFS- 000000001904E revision 0.0

Option description:

Ellipse project description:
TRIM file: [TRIM No]

Project reason: Reliability - To meet connection point reliability requirements
Project category: Prescribed - Connection

Approvals

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Date submitted for approval	31 October 2017	

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1. Request

This Option Feasibility Study is provided in response to Need/Opportunity Statement & Option Screening Assessment 1904 Rev 0, Option E – Wollar – Gunnedah, Gunnedah – Tamworth, Gunnedah – Armidale East, Tamworth – Armidale East, Armidale East – Sapphire 330 kV single circuit transmission lines (+ 330 kV substations). The NOSA requests Project Development to undertake a desktop assessment of the works associated with the installation of five new 330kV transmission lines and associated substation works.

This report provides a desktop assessment of the works described above, taking into account the cost, timing of activities, environmental issues, risk analysis and practicality of being able to complete the works.

2. Considerations

2.1 Wollar to Gunnedah single circuit transmission line

2.1.1 Transmission line route

The development of a new 330kV single circuit line between Wollar and Gunnedah substations is shown in Figure 1 below. The proposed line route utilises a route parallel to the existing routes of lines 74 (Wollar to Tamworth), 969 and 875 (Gunnedah to Tamworth). The proposed alignment was developed via a desktop identification of potential constraints, such as major highways, waterways, large clusters of vegetation and residential receptors. Further work will be required at the Project Development stage in order to refine the route.

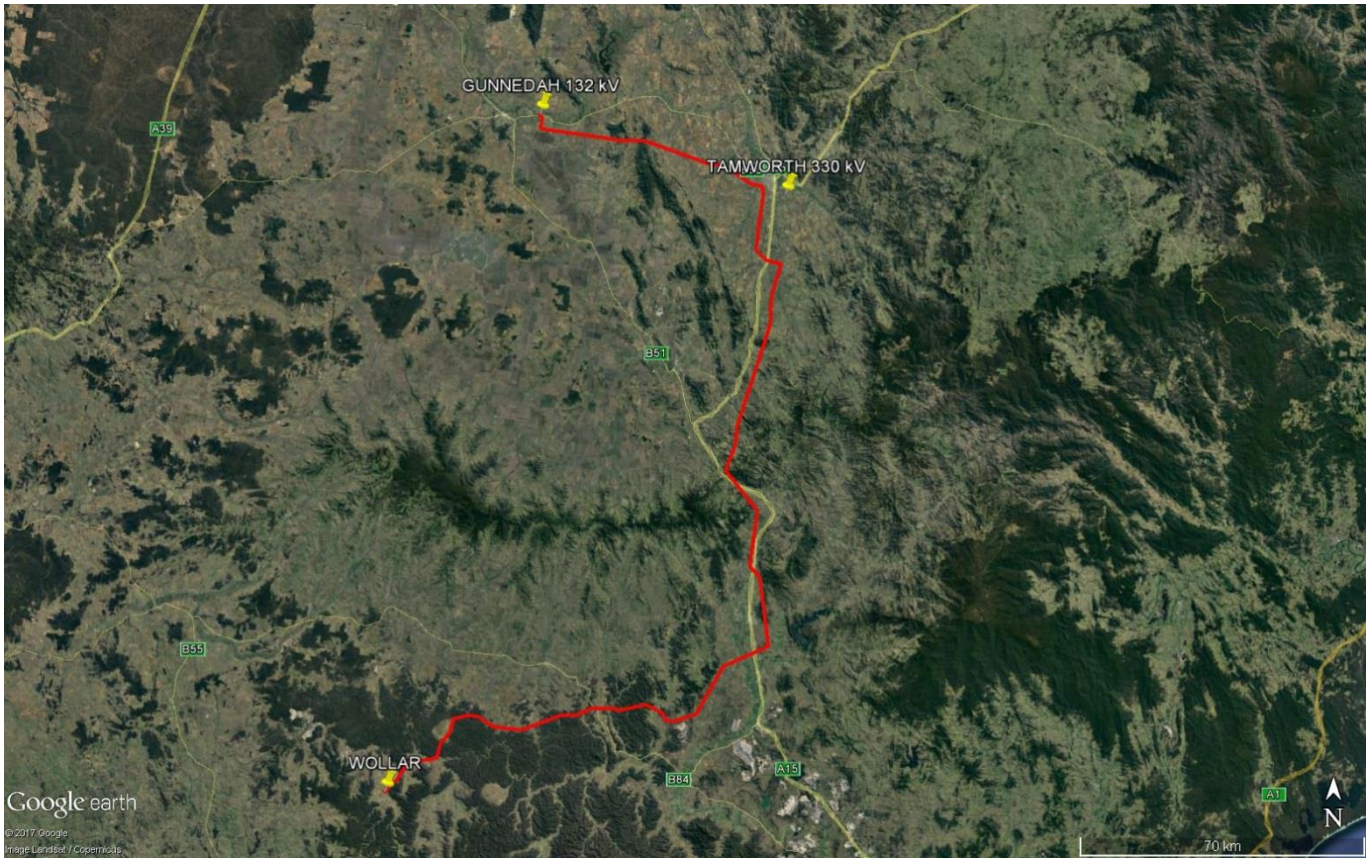

Figure 1 – Proposed Wollar to Gunnedah 330kV single circuit transmission line

2.1.2 Community and environmental issues

2.1.2.1 Land use

The proposed route utilises both public land and private property. A desktop assessment of the line route indicates the land use being primarily livestock grazing and agricultural uses with some potential forestry uses in an around the Goulburn River National Park. The route avoids the urban centres of both Wollar and Gunnedah but does pass nearby rural residences.

2.1.2.2 National parks

The current route does traverse parallel to the existing Line 74 (Wollar to Tamworth) through approx. 75km of the Goulburn National Park.

2.1.2.3 Extent of possible clearing

Standard clearing ratios have been accounted for in the estimate (10, 20, 40, 20, and 10 percent from light to heavy clearing).

A cleared easement parallel to the aforementioned existing lines (i.e. TL 74, 969 and 875) will be required. The actual extent of vegetation clearing will require further investigations at the Project Development stage of the project.

2.1.3 Transmission line design and works

The proposed transmission line is a 330kV single circuit transmission line with twin olive conductors designed for an operating temperature of 120 degrees Celsius. The transmission line will be equipped with OPGW.

2.1.4 Line connection works at Wollar substation

Refer to Section 2.6 “Wollar substation works” below.

2.1.5 Line connection works at Gunnedah substation

Refer to Section 2.7 “Gunnedah substation works” below.

2.2 Gunnedah to Tamworth single circuit transmission line

2.2.1 Transmission line route

The development of a new 330kV single circuit line between Gunnedah and Tamworth substations is shown in Figure 2 below. The proposed line route utilises a route parallel to the existing routes of lines 969 and 875 (Gunnedah to Tamworth) and line 86 (Tamworth to Armidale) for entry to the 330kV side of the substation. The proposed alignment was developed via a desktop identification of potential constraints, such as major highways, waterways, large clusters of vegetation and residential receptors. Further work will be required at the Project Development stage in order to refine the route.

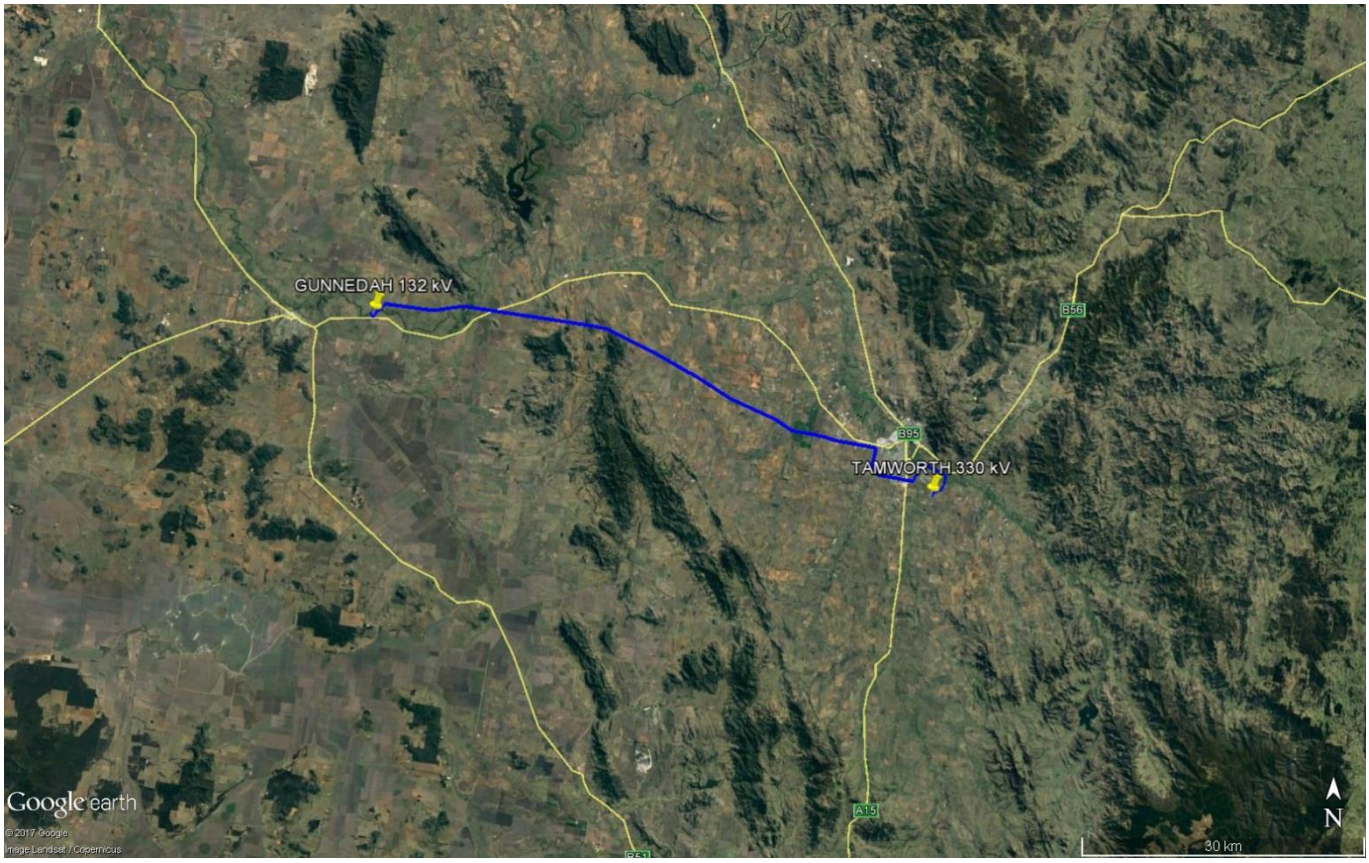

Figure 2 – Proposed Gunnedah to Tamworth 330kV single circuit transmission line

2.2.2 Community and environmental issues

2.2.2.1 Land use

The proposed route utilises both public land and private property. A desktop assessment of the line route indicates the land use being primarily livestock grazing and agricultural uses with rural residential clusters closer to the Tamworth township.

2.2.2.2 National parks

The current route traverses through a largely cleared rural landscape.

2.2.2.3 Extent of possible clearing

Standard clearing ratios have been accounted for in the estimate (10, 20, 40, 20, and 10 percent from light to heavy clearing).

A cleared easement parallel to the aforementioned existing lines (i.e. TL 969 and 875) will be required. The actual extent of vegetation clearing will require further investigations at the Project Development stage of the project.

2.2.3 Transmission line design and works

The proposed transmission line is a 330kV single circuit transmission line with twin olive conductors designed for an operating temperature of 120 degrees Celsius. The transmission line will be equipped with OPGW.

2.2.4 Line connection works at Gunnedah substation

Refer to Section 2.7 “Gunnedah substation works” below.

2.2.5 Line connection works at Tamworth 330kV substation

Refer to Section 2.8 “Tamworth 330kV substation works” below.

2.3 Gunnedah to Armidale East single circuit transmission line

2.3.1 Transmission line route

The development of a new 330kV single circuit line between Gunnedah and a new Armidale East substation is shown in Figure 3 below. The proposed line route utilises a route parallel to the existing routes of lines 969 and 875 (Gunnedah to Tamworth) and line 86 (Tamworth to Armidale) at the 330kv line of Tamworth before heading north towards Armidale substation. The proposed alignment was developed via a desktop identification of potential constraints, such as major highways, waterways, large clusters of vegetation and residential receptors. Further work will be required at the Project Development stage in order to refine the route.

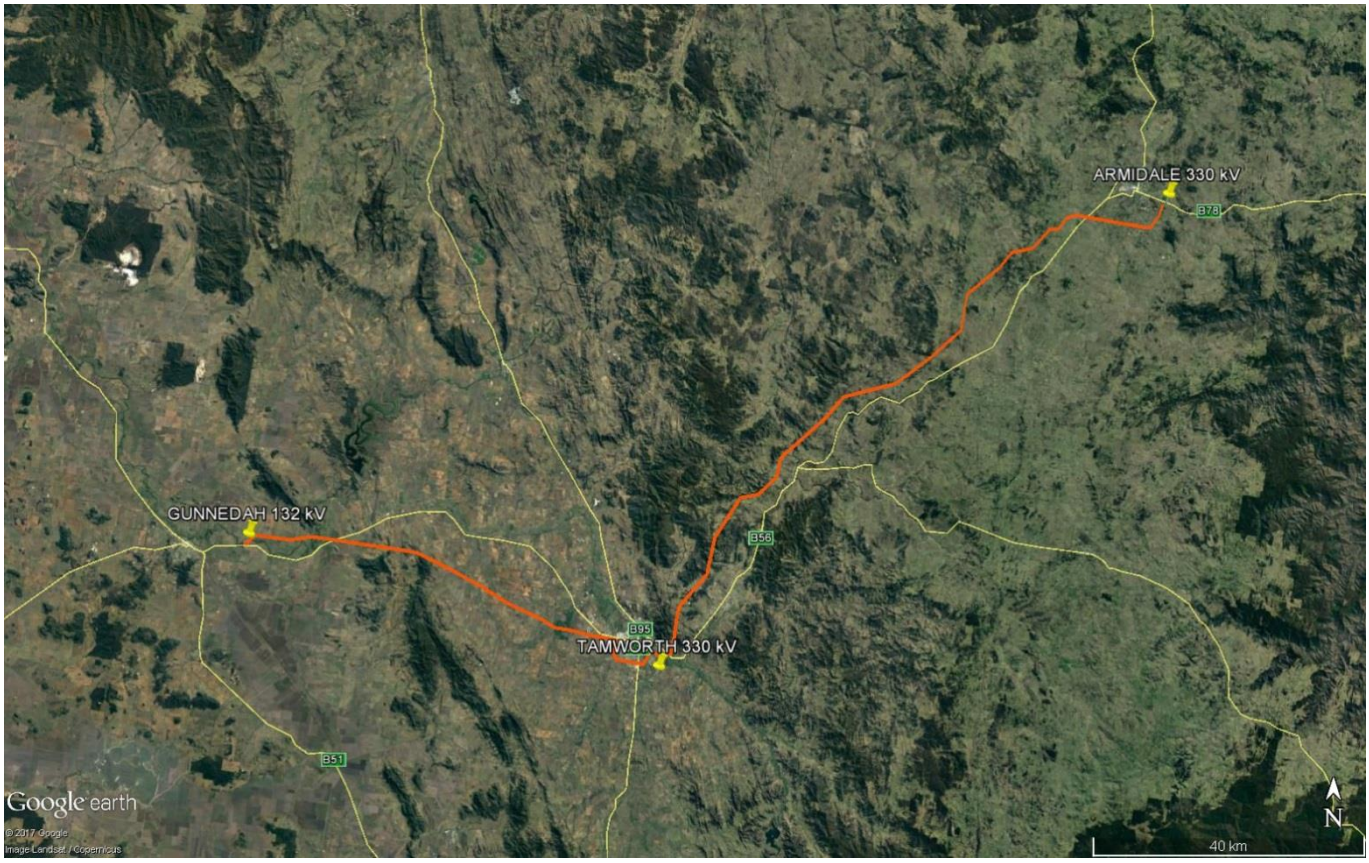

Figure 3 – Proposed Gunnedah to Armidale East 330kV single circuit transmission line

2.3.2 Community and environmental issues

2.3.2.1 Land use

The proposed route utilises both public land and private property. A desktop assessment of the line route indicates the land use being primarily livestock grazing and grain production with some potential forestry uses in the section between Tamworth and Armidale. The route does pass through some of the existing rural residential clusters closer to the Tamworth township, but avoids the major urban centres of both Tamworth and Armidale.

2.3.2.2 National parks

The current route avoids going directly through any listed State Forests or National Parks, but rather traverses through the cleared sections of vegetation along the south eastern edge of the ranges between Tamworth and Armidale.

2.3.2.3 Extent of possible clearing

Standard clearing ratios have been accounted for in the estimate (10, 20, 40, 20, and 10 percent from light to heavy clearing).

A cleared easement parallel to the aforementioned existing lines (i.e. TL's 969, 875 and 86) will be required. The actual extent of vegetation clearing will require further investigations at the Project Development stage of the project.

2.3.3 Transmission line design and works

The proposed transmission line is a 330kV single circuit transmission line with twin olive conductors designed for an operating temperature of 120 degrees Celsius. The transmission line will be equipped with OPGW.

2.3.4 Line connection works at Gunnedah substation

Refer to Section 2.7 "Gunnedah substation works" below.

2.3.5 Line connection works at Armidale East switching station

Refer to Section 2.9 "Armidale East switching station works" below.

2.4 Tamworth to Armidale East single circuit transmission line

2.4.1 Transmission line route

The development of a new 330kV single circuit line between Tamworth to Armidale East substation is shown in Figure 4 below. The proposed line route utilises a route parallel to the existing route of lines 85 (Tamworth to Armidale). The proposed alignment was developed via a desktop identification of potential constraints, such as major highways, waterways, large clusters of vegetation and residential receptors. Further work will be required at the Project Development stage in order to refine the route.

Figure 4 – Proposed Tamworth to Armidale East 330kV single circuit transmission line

2.4.2 Community and environmental issues

2.4.2.1 Land use

The proposed route utilises both public land and private property. A desktop assessment of the line route indicates the land use being primarily livestock grazing and grain production with some potential forestry uses along the ranges between Tamworth and Armidale. The route avoids the urban centres of both Tamworth and Armidale but does pass nearby rural residences.

2.4.2.2 National parks

The current route avoids going directly through any listed State Forests or National Parks, but rather traverses through the cleared sections of vegetation along the south eastern edge of the ranges between Tamworth and Armidale.

2.4.2.3 Extent of possible clearing

Standard clearing ratios have been accounted for in the estimate (10, 20, 40, 20, and 10 percent from light to heavy clearing).

A cleared easement parallel to TL 85 will be required. The actual extent of vegetation clearing will require further investigations at the Project Development stage of the project.

2.4.3 Transmission line design and works

The proposed transmission line is a 330kV single circuit transmission line with twin olive conductors designed for an operating temperature of 120 degrees Celsius. The transmission line will be equipped with OPGW.

2.4.4 Line connection works at Tamworth substation

Refer to Section 2.8 “Tamworth 330kV substation works” below.

2.4.5 Line connection works at Armidale East switching station

Refer to Section 2.9 “Armidale East switching station works” below.

2.5 Armidale East to Sapphire single circuit transmission line

2.5.1 Transmission line route

The development of a new 330kV single circuit line between Armidale East and Sapphire switching stations is shown in Figure 5 below. The proposed line route utilises a route parallel to the existing route of line 8C (Armidale to Dumaresq). The proposed alignment was developed via a desktop identification of potential constraints, such as major highways, waterways, large clusters of vegetation and residential receptors. Further work will be required at the Project Development stage in order to refine the route.

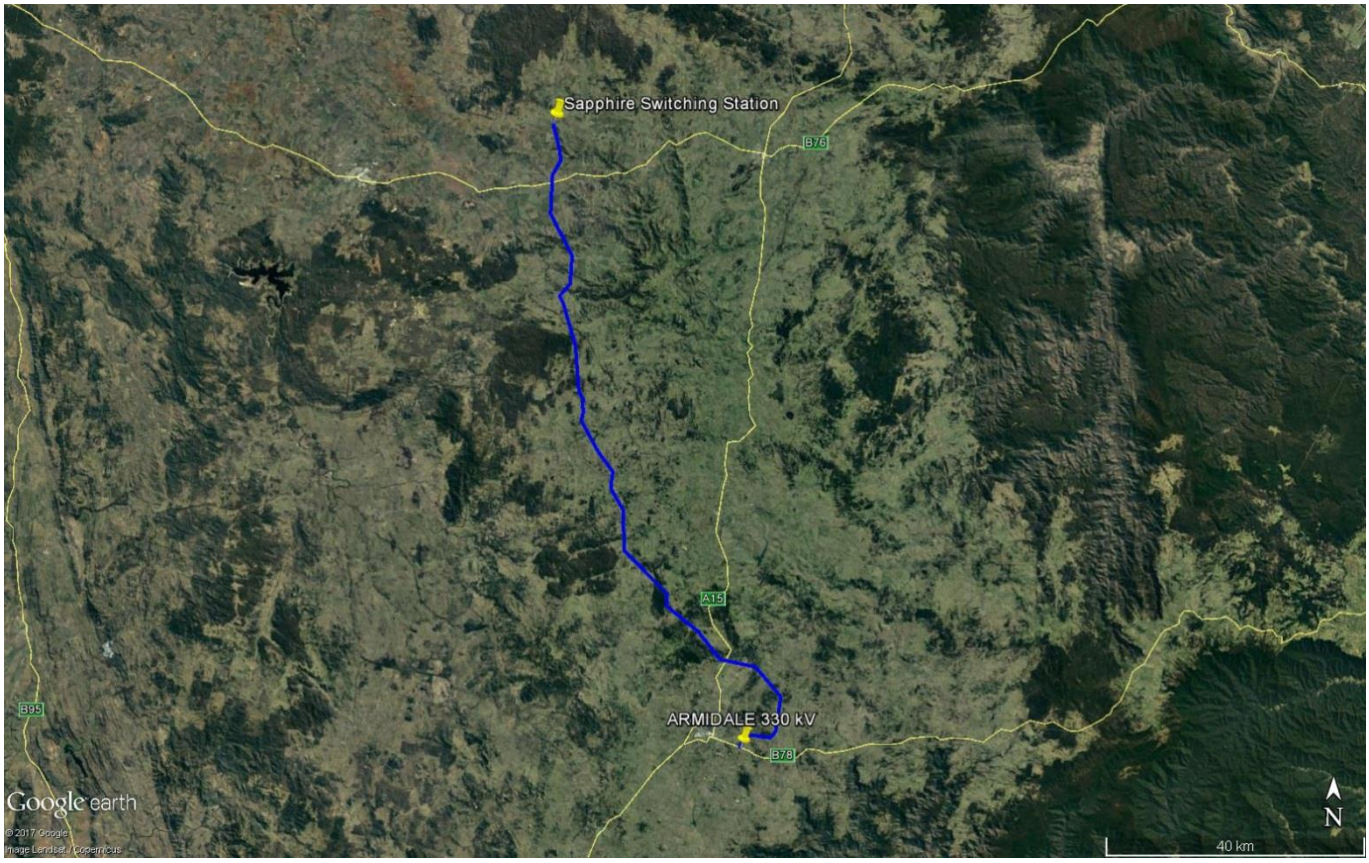

Figure 5 – Proposed Armidale East to Sapphire 330kV single circuit transmission line

2.5.2 Community and environmental issues

2.5.2.1 Land use

The proposed route utilises both public land and private property. A desktop assessment of the line route indicates the land use being primarily livestock grazing and grain production with some potential forestry uses along the ranges between Tamworth and Armidale. The route avoids the urban centre of Armidale but does pass nearby rural residences.

2.5.2.2 National parks

The current route avoids going directly through any listed State Forests or National Parks, but rather traverses through the cleared sections of vegetation along the north eastern edge of the ranges between Armidale and Sapphire switching station.

2.5.2.3 Extent of possible clearing

Standard clearing ratios have been accounted for in the estimate (10, 20, 40, 20, and 10 percent from light to heavy clearing).

A cleared easement parallel to TL 8C will be required. The actual extent of vegetation clearing will require further investigations at the Project Development stage of the project.

2.5.3 Transmission line design and works

The proposed transmission line is a 330kV single circuit transmission line with twin olive conductors designed for an operating temperature of 120 degrees Celsius. The transmission line will be equipped with OPGW.

2.5.4 Line connection works at Armidale East switching station

Refer to Section 2.9 “Armidale East switching station works” below.

2.5.5 Line connection works at Sapphire switching station

The new line from Armidale East to Sapphire will terminate at Sapphire in the new line switchbay to the northeast of the site. Further, the existing line 8J termination will be relocated to a new switchbay to the northwest of the site, adjacent to its current location. Relocating line 8J termination will provide space for the new Armidale East line termination, while avoiding the need for the new line to cross lines 8C and 8J. The new line connection at Sapphire substation is to be coordinated with the cut-in works for line 8C.

Refer to Section 2.10 “Sapphire switching station works” below for details of the required switching station works.

2.6 Wollar substation works

This option proposes to install a new 330kV bus and 330kV line connection from Gunnedah at Wollar substation. The site requires significant modifications as there is currently no provision for future 330kV connections at Wollar.

The proposed Wollar substation Single Line Diagram (SLD) is shown in Figure 6 below.

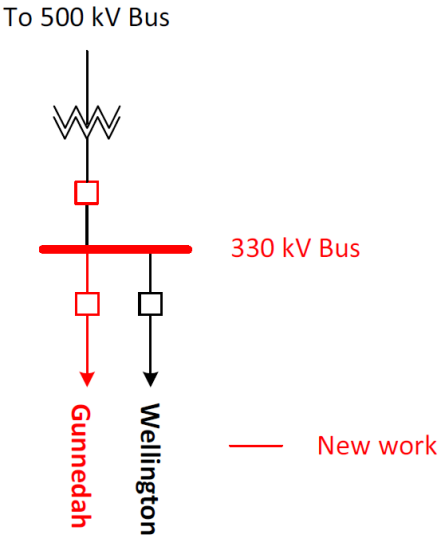

Figure 6 - Proposed Wollar substation - single line diagram

A bench extension is required to provide space for a new 330kV bus and new line switchbay. The existing 330kV switchbay is required to be relocated in order to make provision for the new 330kV busbar and new line switchbay. The relocation of the existing Line 79 switchbay will also require modifications to the line arrangement (relocation of structure 79-1). The new switchbay is proposed to be installed to the north of the existing 330kV switchbay location. The existing line modifications, bench extension, switchbay relocation, and installation of new equipment have been accounted for in the estimate.

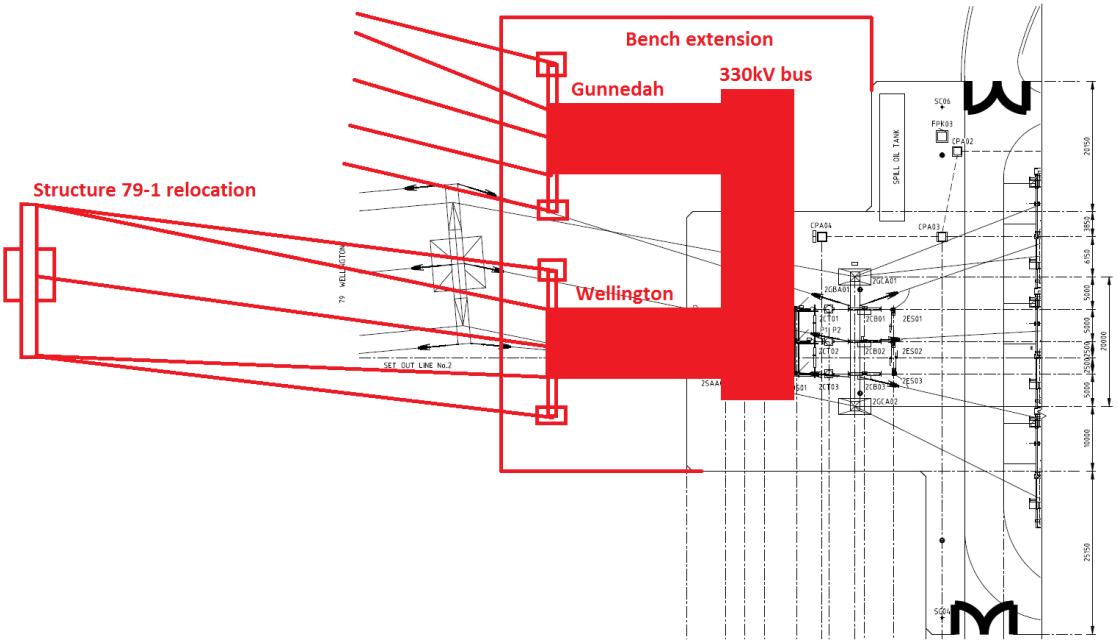

Figure 7 - Proposed Wollar substation - general arrangement

2.6.1 Property

No additional property acquisitions are required for the proposed Wollar substation works.

2.6.2 Civil works

A substation bench extension is required to relocate an existing 330kV switchbay, install a new 330kV bus and a new 330kV switchbay. Access, drainage, fencing and cable routes are required for the 330kV switchbays and 330kV bus. Standard cut and fill earthworks are assumed to be required; however the standard allowance for additional drainage works has been increased as the 330kV bench extensions may impact the earth diversion mounds. Detailed hydrology analysis is required in the Project Development stage.

2.6.3 Building works

It has been assumed that no new building works will be required at Wollar for the new line connection. Based on a desktop assessment, the control room contains sufficient space to install new secondary systems equipment.

2.6.4 Major plant and equipment

Nil.

2.6.5 Minor plant and equipment

Standard equipment will be required for a new 330kV switchbay and a 330kV bus including primary switchgear and associated secondary systems.

Primary equipment is proposed to be reused for the existing 330kV switchbay relocation.

A new transmission tower is required to replace existing structure 79-1.

2.6.6 Electrical works

The electrical works include the relocation of a 330kV line termination switchbay, installation of a new 330kV bus and a new 330kV line termination switchbay, as well as the relocation of structure 79-1.

2.6.7 Secondary systems

2.6.7.1 Protection

Standard protection is required for the new 330kV bus and new 330kV line connection.

2.6.7.2 Communications

It has been assumed that existing site communications infrastructure will not be affected by the proposed substation augmentations.

The OPGW associated with the new 330kV line to Gunnedah is required to interface with existing substation communications systems. For the purposed of this study it has been assumed that new terminal equipment will be required to interface with existing fibre communications system.

It has been assumed that Power Line Communications (PLC) is not required for the new line to Gunnedah. Wave traps are included to provide filtering from imposed PLC signals due to mutual coupling; the requirement for wave traps should be further explored in the Project Development stage.

2.6.7.3 Control systems

Standard control systems are required for the new 330kV bus and new 330kV line connection.

2.6.7.4 Auxiliary supplies

Based on a desktop assessment, it has been assumed that the existing auxiliary systems have sufficient capacity to provide the required auxiliary supplies to all new equipment. Further assessment is required during the Project Development stage to determine whether upgrades to the AC or DC supplies are required.

2.7 Gunnedah substation works

The proposed works at Gunnedah include a new 330/132kV transformer to establish a new 330kV bus. A new 132kV transformer switchbay is proposed to connect to the existing 132kV bus and a new bus-tie is proposed in the existing 132kV bus. The new 330kV bus includes three new switchbays for three new line terminations to Wollar, Armidale East, and Tamworth 330kV substation.

The proposed Gunnedah substation SLD is shown in Figure .

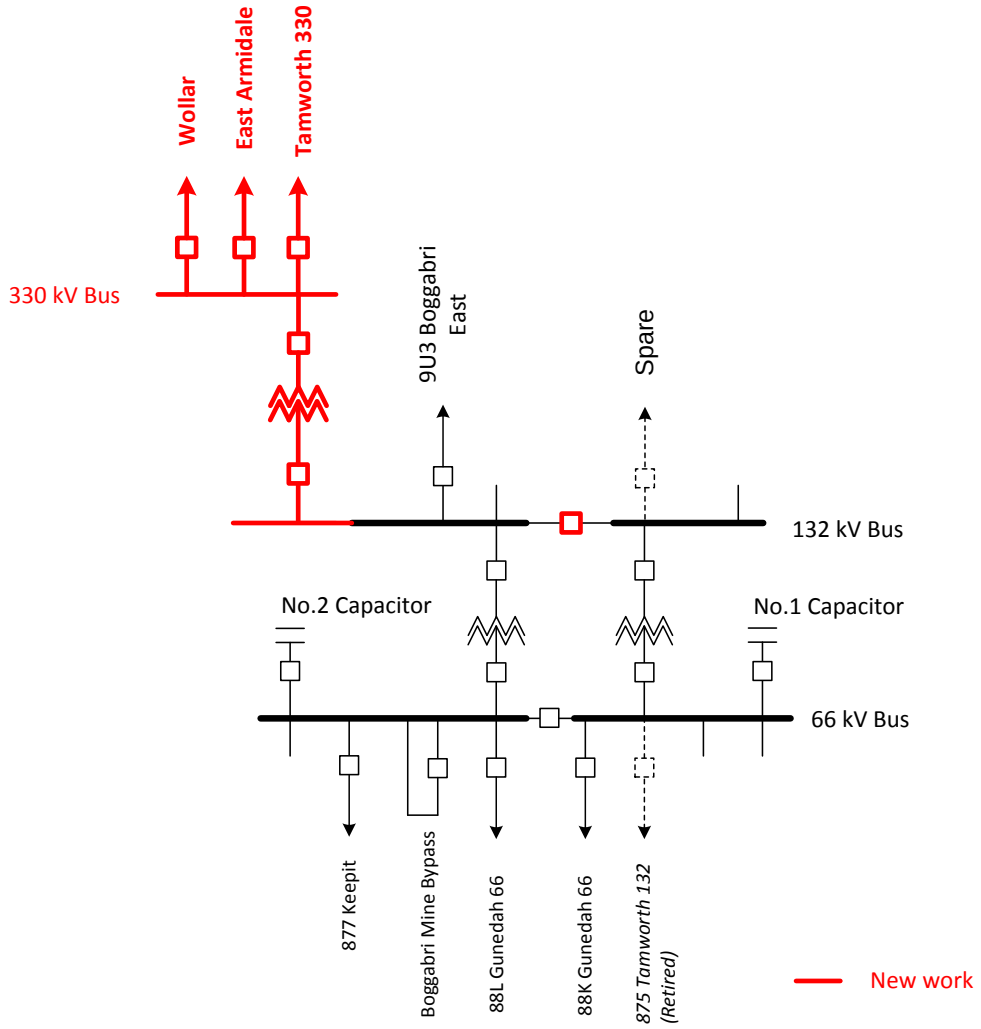

Figure 8 - Proposed Gunnedah substation - single line diagram

A substation bench extension is required to provide space for the new 330kV transformer, bus, switchbays and equipment. The substation compound is proposed to be extended to the north of the site beyond the existing property boundary. Bench extension earthworks have been included in the estimate.

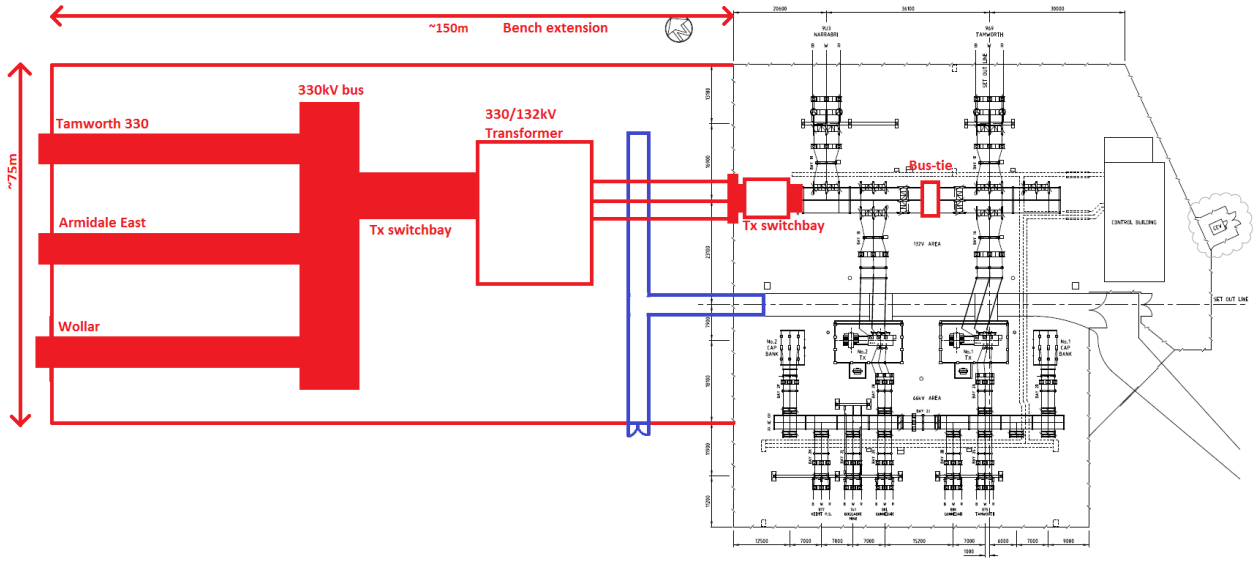

Figure 9 - Proposed Gunnedah substation - general arrangement

2.7.1 Property

Additional property acquisition is required for the substation bench extension, as shown in Figure . The required property acquisition costs have been included within the overall estimate.

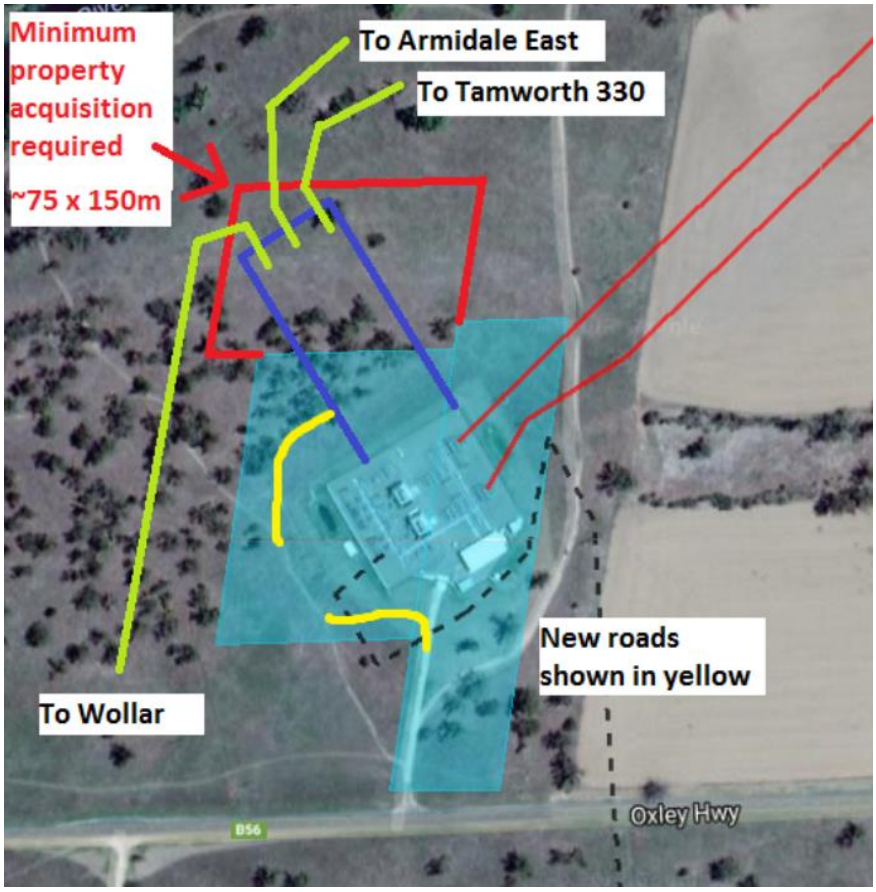

Figure 10 - Gunnedah property acquisition and line entry works

2.7.2 Civil works

Civil works are required for the substation bench extension to provide a new 330kV bus, three new 330kV switchbays for line terminations, one new 330kV transformer switchbay, one new 132kV transformer switchbay, and a new 132kV bus-tie. A new access road and access gate is required to access the new site compound for transformer delivery. Access, drainage, oil containment, fencing, cable routes, and footings are required for all new outdoor equipment.

2.7.3 Building works

This study assumes that there is sufficient space available in the existing communications building to house the new secondary systems for the substation 330kV development.

2.7.4 Major plant and equipment

One new 330/132kV transformer.

2.7.5 Minor plant and equipment

All primary and secondary equipment associated with a new 330kV bus, three new 330kV switchbays for line terminations, one new 330kV transformer switchbay, one new 132kV transformer switchbay, and a new 132kV bus-tie in the existing 132kV bus.

2.7.6 Electrical works

Electrical works are required to provide a new 330kV bus, three new 330kV switchbays for line terminations, one new 330kV transformer switchbay, one new 132kV transformer switchbay, and a new 132kV bus-tie within the existing 132kV bus.

2.7.7 Secondary systems

2.7.7.1 Protection

Standard protection systems are required for all new substation equipment, including a new 330/132kV transformer and associated switchbays, a new 132kV bus-tie, a new 330kV bus and three new 330kV line switchbays.

2.7.7.2 Communications

It has been assumed that existing site communications infrastructure will not be affected by the proposed substation augmentations.

The OPGW associated with the three new 330kV lines is required to interface with existing substation communications systems. For the purposed of this study it has been assumed that new terminal equipment will be required to provide full duplicate communications via OPGW.

It has been assumed that Power Line Communications (PLC) is not required for the new 330kV lines. Wave traps are included to provide filtering from imposed PLC signals due to mutual coupling; the requirement for wave traps should be further explored in the Project Development stage.

2.7.7.3 Control systems

Standard control systems are required for the new substation modifications, including a new 132kV bus-tie, a 330/132kV transformer, a 330kV bus and three 330kV line terminations.

2.7.7.4 Auxiliary supplies

Auxiliary supplies are assumed to have sufficient capacity for the proposed substation modifications. Note that the site currently includes two 200kVA 415V auxiliary transformers, supplied by the No. 1 and No. 2 132/66kV transformers. This study assumes that the LV AC capacity is sufficient and therefore an additional auxiliary transformer is not included in the scope.

2.8 Tamworth 330kV substation works

This option proposes two 330kV bus extensions at Tamworth to facilitate two new 330kV switchbays for new line connections to Gunnedah and Armidale East. Two bench extensions are required for the two new line switchbays. A new circuit breaker is proposed to be installed in the current 330kV Bus Section 3, to establish a new bus section.

The proposed Tamworth 330kV substation SLD is shown in Figure 11.

Note: The AARNET CEV Compound is required to be relocated, as the current location will be directly underneath the new 330kV line to Gunnedah.

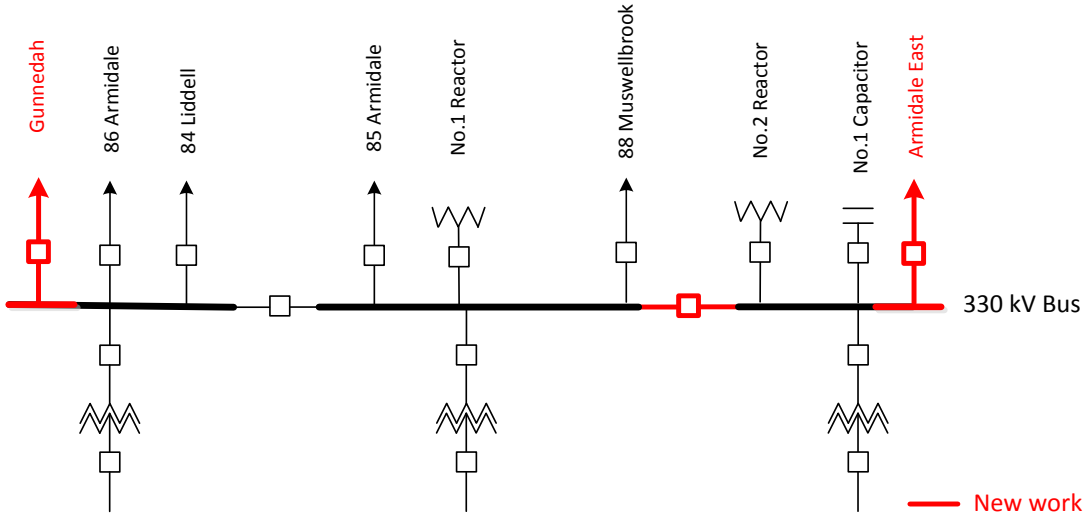

Figure 11 - Proposed Tamworth 330kV substation - single line diagram

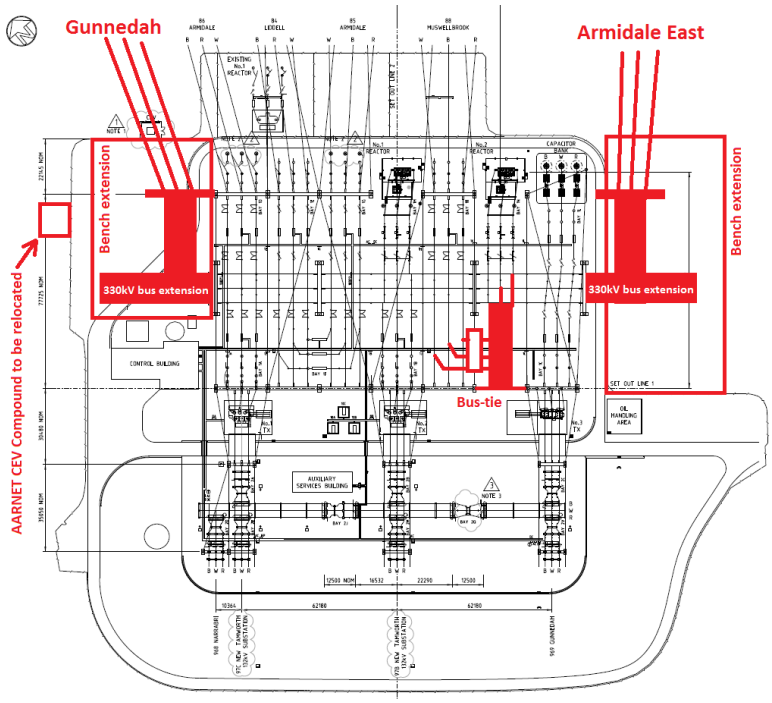

Figure 12 - Proposed Tamworth 330kV substation - general arrangement

2.8.1 Property

No additional property acquisitions are required for the proposed Tamworth 330kV substation works.

2.8.2 Civil works

Two new bench extensions are required for two new 330kV switchbays located either side of the existing 330kV bus, with one extension next to the existing Line 86 Armidale switchbay and the other bench extension next to the existing No. 1 Capacitor. Site access, drainage, fencing, cable routes and equipment footings are required for both of new switchbays.

Footings are required for all primary equipment associated with the new 330kV bus circuit breaker, the new 330kV Gunnedah line switchbay and the new 330kV Armidale East line switchbay.

2.8.3 Building works

It has been assumed that no new building works will be required at Tamworth 330kV substation for the new line connections and bay modifications. This option assumes that the control room contains sufficient space to install new secondary systems equipment.

2.8.4 Major plant and equipment

Nil.

2.8.5 Minor plant and equipment

All primary equipment required to establish two new 330kV switchbays, a new 330kV bus-tie, as well as associated secondary systems (panels, marshalling kiosks, cables).

2.8.6 Electrical works

Electrical works are required to establish two new 330kV line terminations in new switchbays and a 330kV bus-tie.

2.8.7 Secondary systems

2.8.7.1 Protection

Standard protection is required for the new line terminations for the lines to Gunnedah and Armidale East. Bus protection is required for the new 330kV bus section.

2.8.7.2 Communications

It has been assumed that existing site communications infrastructure will not be affected by the proposed substation augmentations.

The OPGW associated with the two new 330kV lines is required to interface with existing substation communications systems. For the purposed of this study it has been assumed that new terminal equipment will be required to interface with existing fibre communications system.

It has been assumed that Power Line Communications (PLC) is not required for the new lines. Wave traps are included to provide filtering from imposed PLC signals due to mutual coupling; the requirement for wave traps should be further explored in the Project Development stage.

2.8.7.3 Control systems

Standard control systems are required for two 330kV line terminations and a new 330kV bus-tie.

2.8.7.4 Auxiliary supplies

It has been assumed that the existing auxiliary systems have sufficient capacity to provide the required auxiliary supplies to all new equipment. Further assessment is required during the Project Development stage to determine whether upgrades to the AC or DC supplies are required.

2.9 Armidale East switching station works

This option proposes the establishment of new 330kV switching station at Armidale East, adjacent to the existing 330kV substation. The switching station is proposed to cut-in to line 87. The proposed site is a greenfield site, that will contain two 330kV busbars with breaker and a half arrangement for the five transmission lines terminating at the switching station.

The proposed Armidale East switching station SLD is shown in Figure 13.

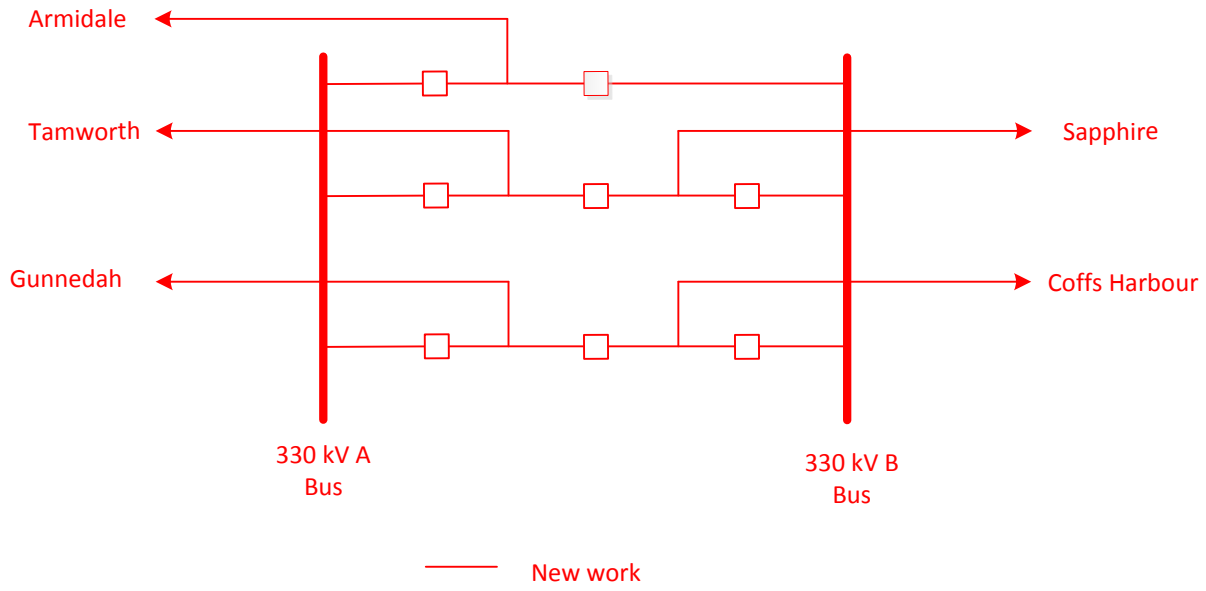

Figure 13 - Proposed Armidale East switching station - single line diagram

2.9.1 Property

No additional property acquisitions are required for the proposed Armidale East 330kV switching station development.

2.9.2 Civil works

The proposed switching station is a greenfield site; civil works are required for establishing a site compound, installing two new 330kV busbars and five switchbays with associated primary equipment and minor field equipment. Civil works will be required for establishing fencing, drainage, access, and site facilities including an Auxiliary Services Building (ASB) and a Secondary Systems Building (SSB).

2.9.3 Building works

A new ASB and a new SSB will be required to provide site amenities and a control room.

2.9.4 Major plant and equipment

Nil.

2.9.5 Minor plant and equipment

All equipment required to establish a new switching station including two 330kV buses, five switchbays for 330kV line terminations, secondary systems, an ASB and an SSB.

2.9.6 Electrical works

Electrical works are required to establish two new 330kV busbars and five switchbays for 330kV line terminations.

2.9.7 Secondary systems

Standard secondary systems are required for the new switching station, including protection and control for five new line connections. Duplicate communications systems based on multiple OPGW connections are required for the site, as well as standard auxiliary supplies as required.

2.10 Sapphire switching station works

This option assumes that the current Sapphire substation has been commissioned with the existing line 8J cut-in to the substation, creating line 8J to Dumaresq and a new line 8E to Armidale.

The proposed Sapphire switching station SLD is shown in Figure 14.

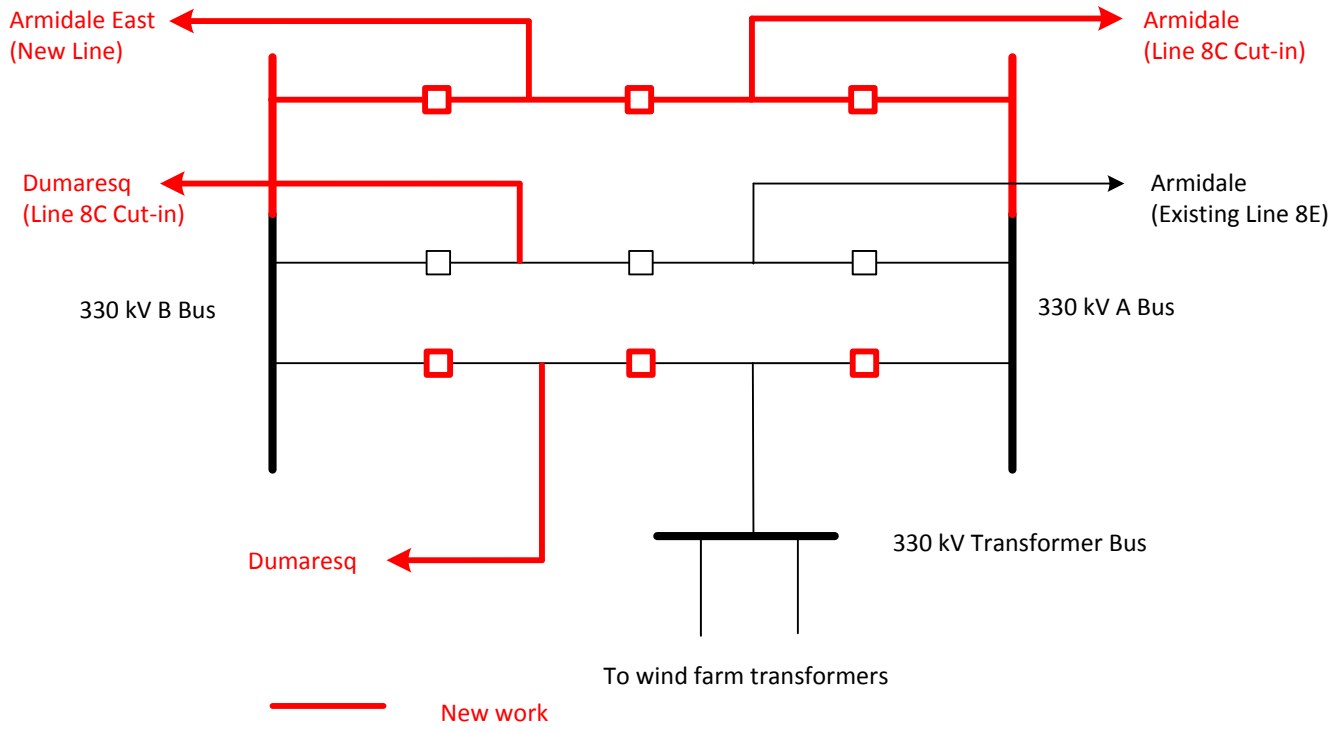

Figure 14 - Proposed Sapphire switching station - single line diagram

This option proposes to cut-in existing line 8C from Dumaresq to Armidale at Sapphire, as well as a line termination for a new line to Armidale East switching station. The scope of works includes relocating the line termination for 8J Dumaresq to the breaker and a half switchbay with the 330kV transformer bus connection, terminating the new line 8C Dumaresq in the bay previously used for line 8J Dumaresq, and a bus extension to install a new breaker and a half switchbay for the new Armidale East line termination and 8C Armidale cut-in.

Modifications are required for the bay connecting the 330kV Transformer Bus to A Bus and B Bus, in order to create a breaker and a half arrangement to terminate the new line to Armidale East in this bay.

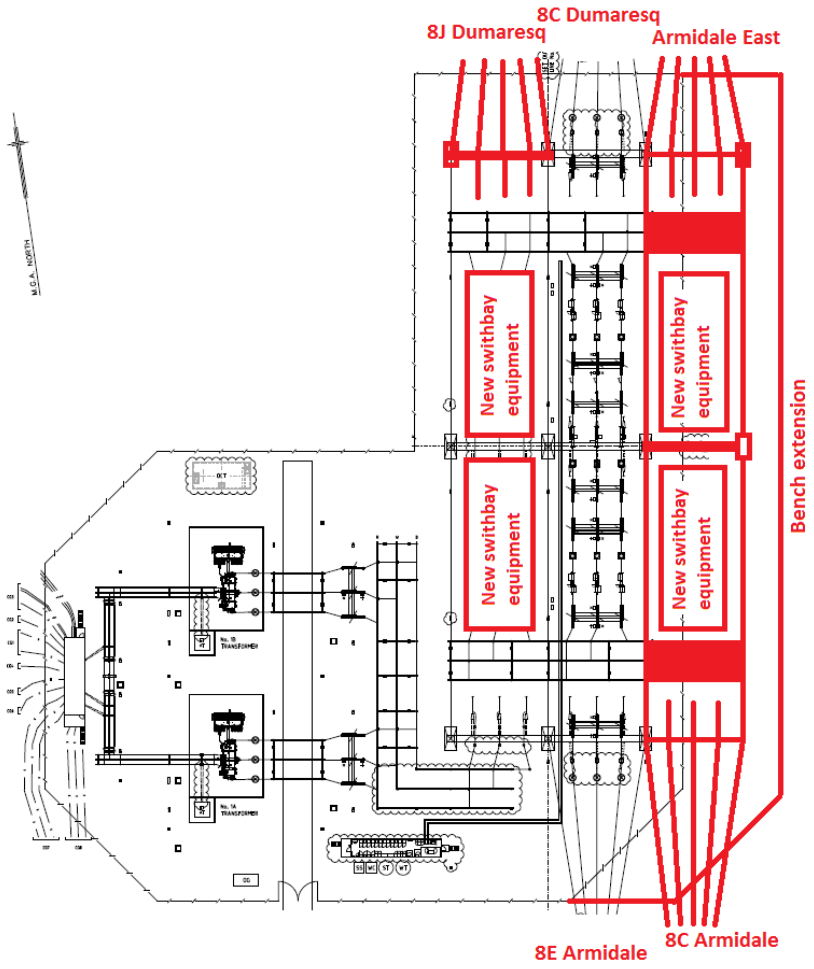

Figure 15 - Proposed Sapphire substation - general arrangement

2.10.1 Property

This study assumes that an additional property acquisition is required for the proposed Sapphire substation works. The additional property acquisition cost has been included in this estimate.

2.10.2 Civil works

It has been assumed that the modifications to the switchbay connecting to the 330kV Transformer Bus will not require significant civil works other than footings for primary equipment; it has been assumed that access and drainage are sufficient and that existing cable routes have additional capacity (trenches or spare conduits provided).

The bus extensions and the new breaker and a half switchbay for Armidale East and 8C Armidale require a substation bench extension. Standard civil works are required including access, fencing, drainage, cable routes, and equipment footings for the bus extensions.

2.10.3 Building works

It has been assumed that a new SSB will be required at Sapphire substation for the new line connections and bay modifications, with sufficient space to install new secondary systems equipment.

2.10.4 Major plant and equipment

Nil.

2.10.5 Minor plant and equipment

Primary and secondary equipment are required for three new line terminations and bus extensions, including six new circuit breakers and associated equipment as well as an SSB.

2.10.6 Electrical works

Modifications are required for the switchbays connecting Bus A and Bus B to the 330kV Transformer Bus, including three new circuit breakers and associated primary equipment that is typical for a 330kV line termination. A new breaker and a half switchbay is required including three new circuit breakers and associated equipment.

Bus A and Bus B are required to be extended to connect the new breaker and a half switchbay for the new Armidale East line and line 8C Armidale cut-in. This study assumes that four new poles are required to cut-in Line 8C, as well as the dismantling of existing structures 260, 262, and 263. Structure strengthening for structures 260 and 264 is included in this estimate.

2.10.7 Secondary systems

For this project it has been assumed that the secondary systems work required will be typical for the type of work being conducted (i.e. new control and protection panels will be required). It has also been assumed that existing secondary systems infrastructure, such as communications and metering, will not be affected by the proposed substation augmentations.

2.10.7.1 Protection

Standard protection is required for the new line terminations to Armidale East, as well as the new Line 8C cut-in.

2.10.7.2 Communications

It has been assumed that existing site communications infrastructure will not be affected by the proposed switching station augmentations.

The OPGW associated with the new 330kV line terminations is required to interface with existing substation communications systems. For the purposed of this study it has been assumed that new terminal equipment will be required to interface with existing fibre communications system.

It has been assumed that Power Line Communications (PLC) is not required for the new lines. Wave traps are included to provide filtering from imposed PLC signals due to mutual coupling; the requirement for wave traps should be further explored in the Project Development stage.

2.10.7.3 Control systems

Standard control systems are required for the three new line terminations at the site.

2.10.7.4 Auxiliary supplies

It has been assumed that the existing auxiliary systems have sufficient capacity to provide the required auxiliary supplies to all new equipment. Further assessment is required during the Project Development stage to determine whether upgrades to the AC or DC supplies are required.

2.11 Armidale substation works

2.11.1 Line 87

This option proposes to establish a new switching station that will cut-in to Line 87. Line 87 currently connects between Armidale to Coffs Harbour substations.

Line 87 switchbay at Armidale substation is required to be renamed from “Coffs Harbour” to “Armidale East”. In addition, the protection settings on Line 87 at Armidale substation may need to be reviewed.

This option assumes that there will be not be any major secondary systems works required at Armidale substation due to the new Armidale East switching station that will be cut-in to Line 87.

2.11.2 Line 8C

This option proposes to cut-in line 8C into Sapphire switching station. Line 8C currently connects to Dumaresq and Armidale.

Line 8C switchbay at Armidale substation is required to be renamed from “Dumaresq” to “Sapphire”. In addition, the protection settings on Line 8C at Armidale substation are required to be modified accordingly.

This option assumes that there will be not be any other major secondary systems works at Armidale substation due to the new cut-in of Line 8C to Sapphire substation

2.12 Coffs Harbour substation works

2.12.1 Line 87

This option proposes to establish a new switching station that will cut-in to Line 87. Line 87 currently connects between Armidale to Coffs Harbour substations.

Line 87 switchbay at Coffs Harbour substation is required to be renamed from “Armidale” to “Armidale East”. In addition, the protection settings on Line 87 at Coffs Harbour substation are required to be reviewed.

This option assumes that there will be not be any major secondary systems works at Coffs Harbour substation due to the new Armidale East switching station that will be cut-in to Line 87.

2.13 Dumaresq substation works

2.13.1 Line 8C

This option proposes to cut-in line 8C into Sapphire switching station. Line 8C currently connects between Dumaresq and Armidale substations.

Line 8C switchbay at Dumaresq substation is required to be renamed from “Armidale” to “Sapphire”. In addition, the protection settings on Line 8C at Dumaresq substation may need to be reviewed.

This option assumes that there will be not be any other major secondary systems works at Dumaresq substation due to the new cut-in of Line 8C to Sapphire substation.

3. Outage requirements

The preliminary assessment of outage requirements is as follows.

Equipment	Outage Duration	Recall	Availability	Comment
Wollar No. 1 Tx (includes site Aux Tx) and line 79 Wellington	5 days	N/A	All year (avoid clashes with other local outages)	Required to install new 330kV bus switchbay in place of existing Line 79 switchbay
Wollar 330kV bus (new bus) including line 79 Wellington	5 days	N/A	All year (avoid clashes with other local outages)	Required to commission two new 330kV line switchbays and new 330kV bus, relocate structure 79-1
Gunnedah 132kV bus including line 9U3 Boggabri East	1 day each	4 hours	All year (avoid clashes with other local outages)	Required to install new 132kV bus-tie in existing bus section.
Gunnedah 132kV bus including line 9U3 Boggabri East	1 day each	4 hours	All year (avoid clashes with other local outages)	Required to install new 132kV bus-tie to new section of 132kV bus.
Tamworth 330kV bus section 3 including No. 1 Capacitor, No. 1 & No. 2 Reactor, line 85 Armidale, line 88 Muswellbrook	1 day each	4 hours	All year (avoid clashes with other local outages)	Required to install new 330kV bus-tie in existing bus section.
Tamworth 330kV bus section 1 including line 84 Liddell and line 86 Armidale	1 day each	4 hours	All year (avoid clashes with other local outages)	Required to install new 330kV bus extension and commission new 330kV switchbay.
Tamworth 330kV bus section 3 including No. 1 Capacitor and No. 2 Reactor	1 day each	4 hours	All year (avoid clashes with other local outages)	Required to install new 330kV bus extension and commission new 330kV switchbay.
Line 87 – Cut-in to new Armidale East switching station	5 days	8 hours	All year (avoid clashes with other local outages)	Required to cut-in Line 87 into the new Armidale East switching station.
Sapphire substation 330kV A Bus	5 days	4 hours	All year (avoid clashes with other local outages)	Required to install new 330kV A Bus extensions and commission new switchbays. Line 8J termination relocated to different switchbay.
Sapphire substation 330kV B Bus	5 days	4 hours	All year (avoid clashes with other local outages)	Required to install new 330kV B Bus extensions and commission new switchbays.
Line 8C – Cut-in to Sapphire substation	5 days	8 hours	All year (avoid clashes with other local outages)	Required to cut-in Line 8C into the Sapphire substation.

4. Environmental and development approvals

The construction of the new single circuit 330kV transmission lines has the potential to have a significant impact on both the environment and community.

This project will most likely require an Environmental Impact Study (EIS) in accordance with Director General Requirements and may require ministerial approval.

A more detailed assessment of environmental risk at an early stage of this project should be undertaken as timeframes for approval and potential biodiversity offsetting may be significant. The EIS will need to further consider the alternatives outlined in this study and associated environmental constraints.

Public consultation is a statutory requirement of this process.

5. Property considerations

Purchasing of additional land adjoining the existing substations at Gunnedah and Sapphire will be required.

This option will require the acquisition of approximately 754km of new 60m wide easement for the entirety of the new transmission line routes.

The proposed transmission line routes run through existing and new sections of vegetation and consequently there are potential timing risks in acquiring the needed easements.

Acquisition will generally be by private treaty but compulsory acquisition will be used where necessary or appropriate, for example, when acquiring public land. It is not anticipated that options will be taken over land prior to purchase.

The cost for purchasing the required substation land and transmission line easements has been included, based on estimates provided by Manager/Property.

6. Cost estimate

6.1 Capital expenditure

Based on the program provided in section 7, the estimated project capital cost for completing works for the required scope is detailed below:

Item	Unescalated ($m)	Escalated ($m)
Substation works		
– Wollar	6.4	7.5
– Gunnedah	20.5	23
– Tamworth 330	8.7	9
– Armidale East	26	28
– Sapphire	12.8	14
– Coffs Hbr sec sys	0.23	0.26
– **Sub-Total**	**74.6**	**82**
TL works		

– Wollar – Gunnedah	322	370
– Gunnedah – Tamworth 330	85	95
– Gunnedah – Armidale East	197	221
– Tamworth 330 – Armidale East	119	132
– Armidale East – Sapphire	126.4	140
– **Sub-Total**	**849.4**	**958**
Total Project P50 Cost	**924**	**1,040**

The expected expenditure profile for this project based on standard spending curve distribution is as follows:

	Total Project Base Cost	Year -7	Year -6	Year -5	Year -4	Year -3	Year -2	Year -1	Year 0
Estimated Cost– non-escalated ($m 2017-18)	924	2	4	9	24	149	434	222	80

Notes:

1. The detailed breakdown provided in the above table is approximate only and is based on the total scope and nature of works included in the option. Individual numbers cannot be used for estimation of other projects or to separately cost components of this estimate.
2. The cost has been estimated from a scope of work determined by a limited review of the project, as detailed in section 2.
3. The values used in the estimate were generally obtained using TransGrid's Estimating Database.
4. The estimate has been prepared on the basis of standard bays and allowances for the works, with adjustments as detailed in this study for the specific option scope.
5. The estimate has a nominal uncertainty of ±25%. There is some risk that final costing may be outside these bounds due to the low level of investigation able to be completed in the time for preparation of this OFS.
6. The following factors have been applied to the estimates:
   - "Transmission Line – 500kV New" for 330kV line options due to the large capital values associated with the works.
   - "Substation – 330kV New" for all substation works. New factors were used rather than augmentation to more accurately reflect costing for large scale capital works.
   - No factors were applied to protection change works at Coffs Harbour which were developed from standard asset replacement estimates.
7. No allowance has been included in the estimate for exchange rate variations.
8. No adjustment for forward escalation has been included in the totals above. Based on forecast commodity escalation, the nominal estimated cost in each year (i.e. the amount in 2018-19 is in forecast $2018-19) is as follows:

	Total Project Budget Cost	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Nominal escalated cost ($m)	1,040	2	4	10	26	162	487	255	94

7. Project and implementation method

7.1 Single circuit transmission lines and associated substation works

The substation and transmission line works are expected to be completed in an estimated 85 months from the initiation of a detailed Option Feasibility Study (OFS), allowing 31 months for completion of Project Development activities and issue of the PAD and 54 months for project completion following issue of the PAD.

The key dates for this program are detailed below:

Milestone	Duration (Months)	End of Month
Issue of Project Development Initiation (PDI)	0	0
Transmission line route identification	6	6
Concept design complete – Substations	4	4
Concept design complete – Transmission line	12	18
Environmental approval	24	30
Detailed design complete – Substations	9	13
Detailed design complete – Transmission line	12	30
Order of Major Plant and Equipment	12	25
Issue PAD (DG2)	1	31
Site Works -		
Prepare specifications	3	34
Call tenders, evaluation and award of contracts	3	37
Possession of site – Substations	3	40
Possession of site – Transmission lines	3	40
Practical completion – Substations		
Wollar Substation 330kV Works	10	50
Sapphire Switching Station 330kV Works	10	50
Tamworth Substation 330kV Works	12	52
Gunnedah Substation 330kV Works	15	55
Armidale East Substation 330kV Works	18	58

Practical completion – Transmission lines		
Gunnedah to Tamworth TL – 76km	12	52
Tamworth to Armidale East 330kV TL – 103km	16	56
Armidale East to Sapphire 330kV TL – 114km	17	57
Gunnedah to Armidale East 330kV TL – 176km	27	67
Wollar to Gunnedah 330kV TL – 290km	44	84
In-service date	1	85

7.2 Project implementation assumptions

The above programs have been based on the standard program templates for a Line – New (EIS) project and Substation – Augmentation project, with the following adjustments:

- All switchyard augmentation works are expected to be completed in parallel with the associated transmission line works program, with work occurring simultaneously at both connecting substations/switching yards.

The timeframes assume the completion of the following steps prior to issue of the PAD:

- Environmental Approval complete;
- Property acquisition has commenced and negotiations are expected to be complete within twelve months. Approval has been given for compulsory acquisition of those properties where negotiated settlements are not deemed possible.
- Transmission Line design has been completed;
- Substation design completed;
- Regulatory Approval processes complete.

For this option the following key risks to the program have been identified:

a) Environmental Approval of the project is subject to the level of community feedback and decisions by the Department of Planning and the Minister. Standard time frames allow for a “typical” process, however, if there is significant opposition to the project delays of up to 12 months could occur. It is likely that this risk could occur and the DG1 funding approval should be issued with sufficient float to allow for this while still meeting the project needs date.

b) Property acquisition is likely to require some level of compulsory acquisition. The timing of this acquisition is subject to both completion of the environmental approval process and approval to progress to the stage of compulsory acquisition. Further delays could be experienced in this process which may delay Possession of Site for parts of the route. This risk is considered unlikely to occur due to the significant float allowed in the program.

c) The nominated construction period is based on a preliminary line route and assessment of terrain and conditions. No geotech or detailed environmental studies have been completed. As a result, the estimated construction period could vary for a number of reasons including, but not limited to:

    1. The final line route may require additional line length,

2. Non-standard construction methods, piled foundations or alternative access methods may be required;

3. Significant environmental works may need to be completed depending on the results of EIS processes;

4. Final approvals may impose restrictions on the way in which the line is constructed.

It is possible that this risk could occur and the DG1 funding approval should be issued with sufficient float to allow for this while still meeting the project needs date;

d) The project development period is dependent on completion of the Regulatory Approval process. Delays in this approval will impact on project completion.

e) The program makes allowance for normal inclement weather. If periods of abnormal rainfall occur the program will be delayed.

Transmission line works programs are inherently uncertain until such time as detailed studies and community consultation processes are completed. Accordingly it is likely that delays may occur to this project that result in a program that varies from that detailed above.

The program is based on the specific scope included in this report. If this option is combined with other options on the same site, the total project construction time frame will extend by a period that will be dependent on the availability of outages and staging of the total package of works. This should be allowed for when determining the date for issue of the DG1 approval.

The project program and costing is based on the following implementation method:

- Project development including design, environmental assessment, and estimating to be managed by Project Development. Specification, HV plant procurement and contracting managed by Works Delivery and competitive bids being called for the switching station, substation and transmission line works.

- Site construction works completed by contractors.

- Construction supervision, site management, testing and commissioning by Works Delivery.

8. Project delivery risks

The key risks outlined in the table below have been identified and will need to be managed as part of this project. In the event that these risks occur there could be impacts to both project cost and time for completion. These risks should be assessed at all stages of project development and delivery.

Risk	Treatment
Safety Risks	
There are the normal risks associated with working on a construction project or in a live high voltage station.	Ensure that all works are carried out in accordance with TransGrid's Safety Rules and standard policies and procedures. All site works are to be managed using a site specific safety management plan.
There are normal risks associated with the design of substations.	Ensure that all design works are carried out in accordance with TransGrid's standard designs, policies and procedures. Ensure that all design work is carried out in accordance with TransGrid's safety in design processes.
There are risks associated with access to site locations for new transmission line work.	Access to be assessed in Project Development stage to identify issues and resolve save access. Access plans to be developed in detail and included in relevant safety management plans.
Environment Risks	
There are the normal risks associated with the delivery of large capital projects that may impact on the environment.	Conduct an Environmental Assessment of Project in accordance with TransGrid's standard policies and procedures.
Property Risks	
There are the normal risks associated with significant easement acquisition and property acquisition.	Conduct an Environmental Assessment of Project in accordance with TransGrid's standard policies and procedures.
Community Risks	
There are the normal risks associated with the delivery of large capital projects that may impact on local communities.	Implement a Communication Strategy in accordance with TransGrid's standard policies and procedures.
Project Delivery and Program Risks	
There are the normal risks associated with the delivery of capital projects.	Implement TransGrid's standard policies and procedures during all phases of the work.
Program may be delayed if Regulatory Approval has not been completed in time	Ensure that Regulatory Approval is completed in a timely manner.
Program may be delayed if the equipment orders are not placed with sufficient lead time	Ensure that equipment is ordered as early as possible to suit the project program.
Program may be delayed if outages cannot be obtained	Prepare an implementation plan and providing the earliest possible notification of the required outages.
Project may be delayed if appropriate resources are not available	Ensuring that the project is given the appropriate priority.

9. Change history

Revision	Approver	Amendments
0	J. Howland	Initial Issue