January 2026

# Powerlink 2027-32 Revenue Proposal

## Project Pack

## CP.03144 Chalumbin 132kV Substation Reinvestment

*Project Status: Unapproved*

## Network Requirement

The Chalumbin 275/132kV Substation was established in the 1988 as part of the extension of the 275kV network north of Townsville to reinforce supply to Cairns and the Atherton Tablelands. The substation has undergone feeder and bay extensions and modifications since its original construction, that has resulted in a range of primary plant and secondary systems equipment with the majority dating from 1998 to 2014. There are two 275/132kV transformers located in Chalumbin enabling power transfer into the local 132 kV network in the Atherton Tablelands and Cairns hinterland area and north to Cooktown through two 132kV feeders. Kareeya Hydro Power Station connects through a further two 132kV feeders.

The primary plant from the original substation construction is now approaching 40 years old and requires selective replacement. A number of instrument transformers are oil filled and in porcelain housing and due to their age, now have an increased probability of explosive failures with catastrophic safety consequences. Several circuit breakers have recurring SF6 leaks originating from failed dashpots for which no replacements are available [1].

Ageing secondary systems, which are no longer supported by the manufacturer are increasingly at risk of failing to comply with Schedule 5.1.9(c) of the National Electricity Rules, AEMO's Power System Security Guidelines and the reliability standard included in Powerlink's Transmission Authority. A condition assessment of the Chalumbin Substation secondary systems identifies various secondary systems components requiring replacement due to their obsolescence and lack of support [2].

Powerlink's 2025 Central scenario load forecasts confirm an enduring need for an ongoing supply of bulk electricity to the Cairns hinterland and Atherton Tablelands area. To achieve this there is an enduring need to maintain the 132kV supply from Chalumbin Substation and provide a 132kV connection to the Kareeya Hydro Power Station.

The removal or reconfiguration of the Chalumbin 132kV Substation would violate Powerlink's N-1-50MW/600MWh Transmission Authority reliability standard. In addition, an outage of a critical transmission line due to equipment failure at Chalumbin Substation will significantly impact generation from Kareeya Hydro Power Station and result in altered dispatch outcome in the National Electricity Market (NEM) and higher total system costs. Powerlink has undertaken market modelling to quantify the changes in costs for market participants due to those different dispatch outcomes [3].

## Recommended Option

As this project is currently 'Unapproved', project need and options will be subjected to the public RIT-T consultation process to identify the preferred option closer to the time of investment. The objective is to address the asset condition issues identified with the selected primary plant and to undertake bus uprating works to meet future demand requirements.

The current recommended option involves the replacement of selected 132kV primary plant and replacement of selected 132kV secondary systems in the existing building by December 2031 [4].

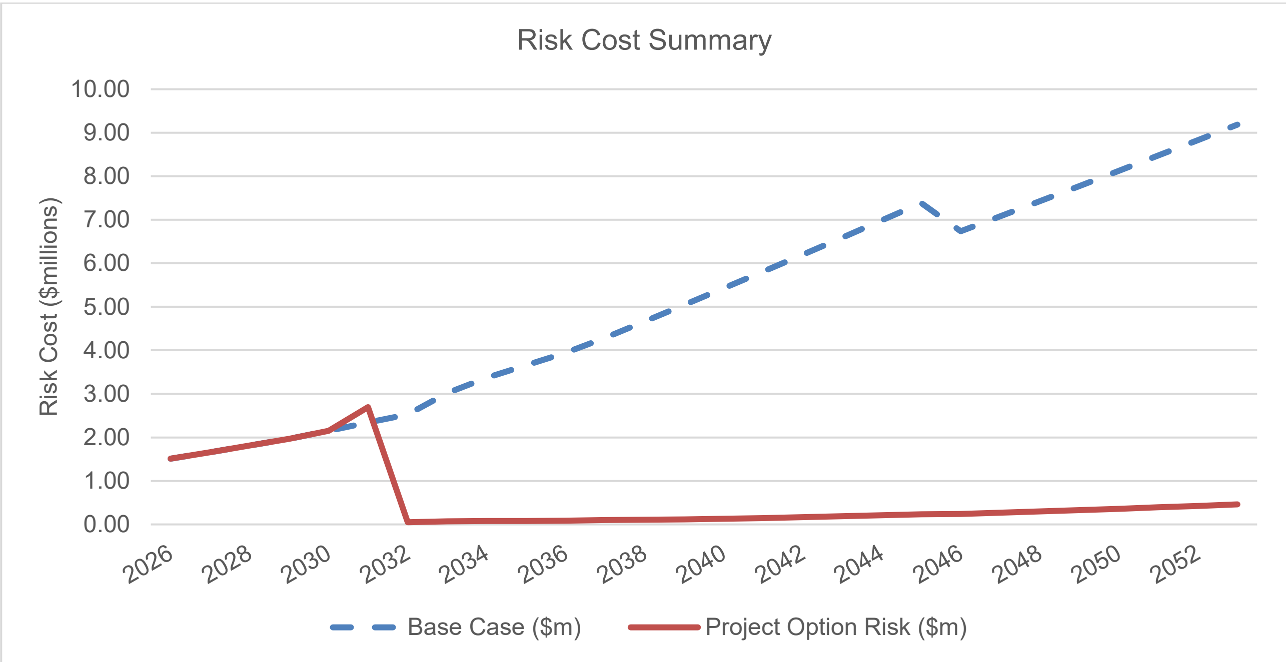
Options considered but not proposed include:

- Do Nothing – rejected due to non-compliance with reliability obligations;
- Selected primary plant replacement with deferred selected secondary system replacement – expected to be greater overall cost;

- Construct one or two new 132kV switching bays and replace selected equipment in selected existing switching bays to minimise outages and staging – expected to be greater overall cost;
- New 132kV supply point at or near Walkamin 275kV Substation – considered to be not economically viable at this time; and
- Non-network option – no viable non-network options have been identified at this time.

Figure 1 shows the current recommended option reduces the forecast risk monetisation profile of the Chalumbin Substation primary plant from around $2.7 million per annum in 2031 to less than $0.05 million from 2032 [6]. In addition to this benefit of reduction in risk cost there are benefits available from lower cost market dispatch outcomes due to improved reliability and availability of Chalumbin 132kV Substation primary plant and secondary systems.

*Figure 1 Annual Risk Monetisation Profile ($ Real, 2025/26)*




## Cost and Timing

The estimated cost to replace selected 132kV primary plant and selected 132kV secondary systems is $30.8 million ($2025/26) [5].

Target Commissioning Date: December 2031.

## Documents in CP.03144 Project Pack

### Public Documents

1. H032 Chalumbin Substation Condition Assessment Report
2. H032 Chalumbin Substation Secondary Systems Condition Assessment Report
3. CP.03144 Chalumbin 132kV Substation Reinvestment – Planning Statement

4. CP.03144 Chalumbin 132kV Substation Reinvestment – Project Scope Report
5. CP.03144 Chalumbin 132kV Substation Reinvestment – Concept Estimate
6. CP.03144 Chalumbin 132kV Substation Reinvestment – Risk Cost Summary Report

# SITE CONDITION ASSESSMENT REPORT

## H032 Chalumbin

| | | | | | |
|---|---|---|---|---|---|
| Asset Category: | Substation primary | Author: | [redacted] | Authorisation: | [redacted] |
| Reviewed by: | [redacted] | | Review Date: | 17/02/2020 | |
| Activity: | Condition assessment -275/132 kV primary substation plant and site infrastructure, incl. civil components – SITE BASED | | | | |
| Document Type: | Report | Team: | Substation team | | |
| Authorisation date: | | Date of site visit: | 24&25/9/2019 | | |

| Date | Version | Objective ID | Nature of Change | Author | Authorisation |
|---|---|---|---|---|---|
| 15/12/2019 | V1 | A3187087 | Original Report | [redacted] | [redacted] |
| 1/05/2025 | V2 | A5638035 | Updated with desktop information for primary plant replacement project | [redacted] | [redacted] |

***Note:*** *Where indicator symbol ☼# is used (# referring to version number) it indicates a change/addition was introduced to that specific point in the document. If the indicator symbol ☼# is used in a section heading it means the whole section was added/ changed.*

**IMPORTANT**: - The condition assessment report provides an overview of the condition of all structures and equipment (excluding protection relays, control systems and telecommunication equipment)as stated in the scope and high level recommendations for their timely replacement. As it is snapshot in time and subject to the accuracy of prediction methodology, it is valid for 3 years form site visit date or issue date (whichever is later) stated above.

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# EXECUTIVE SUMMARY

This report provides an overview assessment of the condition of the Powerlink owned high voltage equipment and site infrastructure only at H032 Chalumbin substation.

The report is intended to assist with determining the future strategies for refurbishment or replacement of high voltage equipment and site infrastructure in Chalumbin substation.

The assessment has been formulated based on the data extracted from computerised maintenance management system (SAP) including notifications and work orders, dissolved gas analysis (DGA) and other test and measurement results, equipment age information combined with available photos, historical data analysis, site inspection and civil condition assessment report dated 29/10/2019 (Objective Id. A3237809).

The summary of recommendations is contained in Section 3 of this report and is updated based on the review of maintenance and project data updated to September 2024.

# 1. INTRODUCTION

This condition assessment is based on a site visit conducted on 25/9/2019, information provided in civil engineering condition assessment report dated 29th October 2019, available design data and drawings, SAP data and information provided by the maintenance service providers. This report was further updated in September 2024 with information available from a desktop review.

## 1.1 System information

Chalumbin Substation is located in Far North Queensland (FNQ) and has 275/132kV operating voltages in one yard.

Chalumbin Substation is connected via four 275kV feeders to Woree and Ross substations and is the major substation in 275kV in land power transfer corridor between Central Queensland and FNQ.

There are two 275/132kV transformers located in Chalumbin enabling power transfer into local 132 kV network in Cairns region through two 132kV feeders (F7165 and F7166) connected to the Turkinje substation and connection of 88MW of power generated at Stanwell Kareeya hydro power station through two 132 kV feeders (F7191 and F7192).

Chalumbin Substation was established in 1988. The majority of Primary equipment is the original installation and is now around 30 years old.

[redacted]

Figure 1 - Single Line Diagram

H032 Chalumbin substation consists of:

- two 275 kV busbars,
- two 275kV transformer bays,
- four 275 kV feeder bays,
- three 275 kV bus coupler bay and
- one 275kV reactor bay.

It also has:

- two 132 kV busbars,
- two132kV transformer bays,
- four 132kV feeder bays,
- one 132kV bus coupler bay,
- one 132kV capacitor bank bay and

- three 19 kV bays (two for substation supply transformers connection and one 19kV reactor bay).

In addition, there are:

- two power transformers 275/132 kV (2 X 150/200 MVA),
- one 132 kV capacitor bank (48.3 MVAr),
- one 19kV air core reactor,
- two 35MVA oil filled line reactors,
- one 35MVA oil filled bus reactor and
- two local supply transformers 19.1 /0.433 kV (1X315 kVA and 1X 200 kVA).

**Figure 2 – Aerial view**

[redacted]

**Figure 3 – General Arrangement**

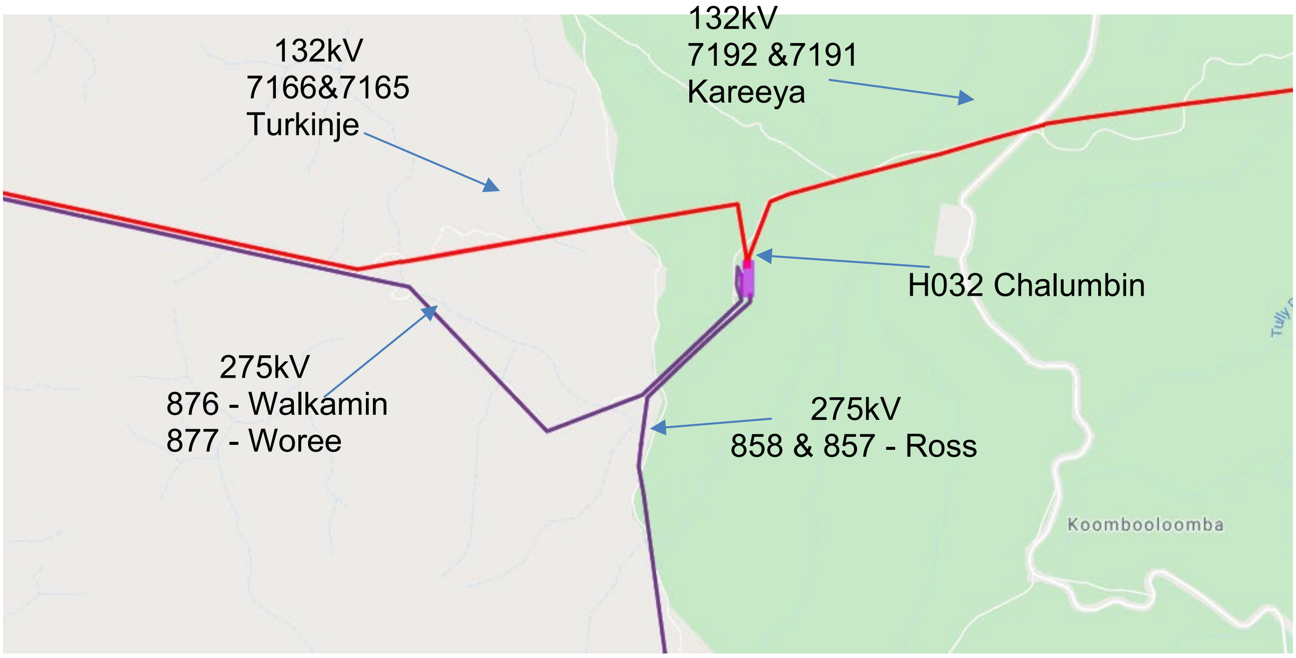


Figure 4 - Overview of HV Supply Network

## 1.2 Ratings

The maximum fault levels calculated in 2024 are:

- 19.1kV 3 phase – 9.99 kA
- 132kV L-G – 8.54 kA
- 275kV L-G – 5.60 kA

Below table provides overview of continuous current and fault current ratings of all high voltage bays in Chalumbin substation, incl. recommendations.

| Functional Loc. | Bay Description | Start-up date | Bay Cont. Rating (A) | Bay Fault Current Rating (kA) | Fault Current Period (s) | Comments on rating |
|---|---|---|---|---|---|---|
| H032-D03-411 | 132KV 1-2 Bus Section | 01/07/1996 | 1600 | 31.5 | 1.0 | Limited by the CT's and Disconnectors. |
| H032-D04-441 | 132kV 1 TRNSF | 01/07/1988 | 1157 | 31.5 | 1.0 | Bay limits 2H short term transf. rating |
| H032-D05-7191 | 7191 FEEDER | 01/07/1996 | 1275 | 31.5 | 1.0 | Sufficient rating |
| H032-D06-442 | 132kV 2 TRANSF | 01/07/1997 | 1275 | 31.5 | 1.0 | Bay limits 2H short term transf. rating |
| H032-D06-7192 | 7192 FEEDER | 01/07/1988 | 1200 | 31.5 | 1.0 | Sufficient rating |
| H032-D07-7166 | 7166 FEEDER | 01/07/1988 | 1200 | 31.5 | 1.0 | Sufficient rating |
| H032-D08-7165 | 7165 FEEDER | 01/07/1996 | 1200 | 31.5 | 1.0 | Sufficient rating |
| H032-D09-481 | 132kV 1 Capacitor | 01/09/2001 | 1000 | 40 | 1.0 | Sufficient rating |
| H032-C03-503 | 3 Coupler 275kV | 01/07/1989 | 2500 | 31.5 | 1.0 | Sufficient rating |
| H032-C03-541 | 275kV 1 TRANSF | 01/07/1988 | 1250 | 31.5 | 1.0 | Sufficient rating |
| H032-C03-857 | 857 Feeder | 01/07/1988 | 1600 | 31.5 | 1.0 | Sufficient rating |
| H032-C04-504 | 4 Coupler 275kV | 01/07/1993 | 2500 | 31.5 | 1.0 | Sufficient rating |
| H032-C04-542 | 275kV 2 TRANSF | 01/07/1997 | 1250 | 31.5 | 1.0 | Sufficient rating |
| H032-C04-858 | 858 Feeder | 01/07/1993 | 1600 | 31.5 | 1.0 | Sufficient rating |
| H032-C05-575 | 1 Bus 5 Reactor | 10/04/2014 | 2500 | 40 | 1.0 | Sufficient rating |
| H032-C06-506 | 6 Coupler 275kV | 04/10/2004 | 2500 | 40 | 1.0 | Sufficient rating |
| H032-C06-876 | 876 Feeder | 31/07/2007 | 2500 | 40 | 1.0 | CT ratio limits summer emergency rating |
| H032-C06-877 | 877 Feeder | 04/10/2004 | 2500 | 40 | 1.0 | Sufficient for UGC |
| H032-F01 | 1 Stn Transformer | 15/12/2018 | 2 | 31.5 | 1.0 | Sufficient rating |
| H032-F02 | 2 Stn Transformer | 30.09.2001 | 25A | 31.5 | 1.0 | Sufficient rating |
| H032-KC1 | 275kV 1 Bus | 01/07/1996 | 3500 | 31.5 | 1.0 | Sufficient rating |
| H032-KC2 | 275kV 2 Bus | 01/07/1996 | 3500 | 31.5 | 1.0 | Sufficient rating |
| H032-KD1 | 132kV 1 Bus | 01/07/1996 | 1600 | 31.5 | 1.0 | Potential upgrade to 4000A |
| H032-KD2 | 132kv 2 Bus | 01/07/1996 | 1600 | 31.5 | 1.0 | Potential upgrade to 4000A |

**Table 1: H032 Chalumbin Bay Ratings**

All equipment at this site are rated adequately for the calculated fault levels at present and for the next 10 years.

**Recommendation:**

1. 1-2 Bus Section bay is below the standard rating of 3150A, however it appears sufficient for the maximum expected load for the coupler during a contingency. It is recommended the Planning Team should review the future expected load for the coupler for a range of credible contingencies and the bay should be uprated if required.
2. 132kV T1 and T2 bay limits the 2 hour short term and 10 minute rating of the transformer. The data show that limiting element is the transformer flexible connection for T1 and the interplant connections for T2. The present rating appears sufficient for the transformer to handle the maximum load whilst the other transformer is OOS. It is recommended the Planning Team should review the future expected load for the transformers to identify any need to increase the rating.
3. 876 Feeder bay is limited by the CT ratio to 1600A, this is below the feeder rating of 2284A (winter 2m/s). Loading appears to be significantly less that 1600A and is therefore unlikely to exceed the bay limits. It is recommended the Planning Team to review the future expected load for the feeder to identify any need to increase the rating.
4. 132 kV 1 Bus and 2 Bus are limited to 1600A, this is below our standard rating of 4000A, however this appears sufficient for the maximum expected load on the bus during a contingency. It is recommended for the Planning Team to review the future expected load for the Bus 1 and Bus 2 for a range of credible contingencies and uprated if required.

Note: the loading assumptions are based on historical loading from the past 12 months and may not represent future loads especially if new generation is added to the area.

## 1.3 **Asset age**

The Chalumbin 275/132kV substation was established in 1988, with some equipment replacements/upgrades detailed below.

Major upgrades in the last 20 years include:

- CP.00576 Chalumbin 132kV Cap bank No.1
- CP.00577 Chalumbin 132kV Cap Bank No. 2
- CP.01047 Chalumbin 18kV Reactor Replacement
- CP.02000 132kV 50MVAr Capacitor Bank
- CP.02095 Chalumbin No.1 Bus Reactor
- CP.02476 Chalumbin No.2 Bus Reactor
- CP.00526 Chalumbin Transformer Augmentation.
- CP.01566 Chalumbin secondary systems modification
- CP.02786 Chalumbin secondary systems modification
- CP.01042 Ross-Chalumbin 275kV line switching

## 1.4 Scope of site condition assessment

The site condition assessment is restricted to Powerlink owned and operated high voltage equipment and site infrastructure in H032 Chalumbin substation with the **exclusion** of:

- Power transformers T1&T2, and all reactors (subject of separate condition assessment report)
- H032-C04-542- 275kV 2 Transformer bay (established in 1997)
- H032-C05-575- 1 BUS 5 Reactor bay (established in 2014)
- H032-C06-506 - 275kV 6 Coupler Bay (established in 2004)
- H032-C06-876- 876 Feeder Bay (established in 2007)
- H032-D06-442 - 132kV 2 Transformer Bay ( established in 1997)
- H032-D09- 481- 1 Capacitor Bank Bay (established in 2001)
- Protection and control systems which are subject to a separate condition assessment report

# 2. CONDITION ASSESSMENT

## 2.1 Buildings

### 2.1.1 *Building layout and usage*

This site has two control buildings; a demountable 132kV control building and a brick built 275 kV control building. The Powerlink owned 275 kV control building is used to house Powerlink 275kV control panels, the 125V and 50V DC supply systems and telecommunication equipment. It consists of control/relay room, telecommunications room, battery room, amenities room and toilet. The control, battery and telecomms rooms are all air conditioned. The building is equipped with intruder alarm system, has sufficient lighting, access to protection and control panels and is maintained in good condition. There are some vacant spaces in this building and at high level it is assessed that only minor substation extensions to protection system can be done within the space available.

Figure 5 – Substation buildings

The substation asbestos register indicates that no asbestos was detected in the brick built building.

The demountable building is relatively new as it was installed in 2012 under the secondary system project upgrade. The building is in as new condition and no issues were detected.

***Recommendation:*** Based on the condition it is recommended that the brick and demountable building have estimated remaining service lives of 40 years with maintenance.

## 2.2 Primary Plant Bays

The insulator sheds of all the primary in this bay has mould which requires cleaning, this mould is due to the tropical weather condition in FNQ region.

### 2.2.1 *H032-C03-503 - 275kV 3 Coupler Bay*

The equipment for this Bay is listed in the Table 2, including a health index value for each item.

The original equipment comprising circuit breaker, disconnectors and current transformers was installed in early to mid-1989.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-C03-503--5030-1 | EARTH SWITCH | MORLYNN | VSB | 28.02.1989 | 6 |
| H032-C03-503--5030-2 | EARTH SWITCH | MERLIN GERIN | | 10.09.1993 | 5 |
| H032-C03-503--5032 | CIRCUIT BREAKER | ASEA | HPL300/25B1 | 28.02.1989 | 8 |
| H032-C03-503—5032CTA | CT | HAEFELY | IOSK300/1050 | 28.02.1989 | 7 |
| H032-C03-503—5032CTB | CT | HAEFELY | IOSK300/1050 | 28.02.1989 | 7 |
| H032-C03-503—5032CTC | CT | HAEFELY | IOSK300/1050 | 28.02.1989 | 7 |
| H032-C03-503--5038 | DISCONNECTOR | EGIC | DR | 10.09.1983 | 2 |
| H032-C03-503--5039 | DISCONNECTOR | MORLYNN | HCB | 28.02.1989 | 4 |

**Table 2**

ABB HPL300 circuit breaker 5032 is in service for 30 years and started to develop notable gas leaks in 2014 and has been topped up with gas at least once a year since then. There is no on line SF6 leak rate monitoring for this circuit breaker (CB). Powerpatch was applied to try to stop gas leak.

There are 44 circuit breakers of this type in service currently and 18 of these have developed gas leaks at various levels and at least four poles had to be replaced. There are only two spare poles available in stock and refurbishing/repairing these CBs has not proven to be cost effective. The recommended strategy for these ASEA CBs is to replace those that are already leaking and recover good poles of replaced CBs to increase spare holdings to assist in managing others in the fleet.

Figure 6 – 5032- Repair (Belzona) applied

Figure 7 - CB5032

Considering that leaks are slow, but persistent and a number of times this CB has been topped up with SF6 gas, it is expected that condition of this CB will continue to deteriorate and will require high maintenance. Rectification works have been unsuccessful in stopping the leaks and multiple low SF6 alarms have occurred in the past 5 years. Two pole discrepancy trips have also occurred in the previous 5 years which have required rectification works both times. Although replacement is not considered urgent, it is considered to be eminent and therefore it is recommended to replace this CB 5032 in the next 5 years. Considering the fleet of this CBs, the fleet approach should be developed and when prioritisation of this CB replacement, the difficulty of obtaining prolonged outages and network consequence of such outages should be considered.

The Haefely oil filled current transformers (CTs) are in reasonable condition considering they have been in service for 30 years and the DGA/moisture in oil analysis is satisfactory. There are no identified issues with oil seal integrity. Considering their age and the fact these have porcelain housing, leading to a high consequence in case of catastrophic failures, it is recommended to replace these in 5 years. This way the replacement of CTs can be combined with replacement of circuit breaker in this bay, reducing the impact of outage on the network.


Figure 8 –CTs

The two disconnectors 5018 and 5019 installed in this bay are in good condition and maintenance records show some minor corrosion issues associated with these and 5018 has also had issues with the open contactor coil which has had to be replaced. It is believed that in the next 10-20 years some refurbishment maybe required on these. All high voltage equipment insulators in this bay have dirt or fungus that should be removed.

The associated structures and foundations are in good condition and are expected to last for another 20 years.

***Recommendation:*** Based on the above observations, it is recommended that the CB and CTs incl. structures and foundations are replaced within the next 5 years preferably using dead tank CB.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years.

### 2.2.2 *H032-C03-541- 275kV 1 TRANSF BAY*

The equipment for this Bay is listed in the Table 3, including a health index value for each item. This bay was augmented in 2002 with addition of new CB and disconnectors under project CP.01402 Ross-Chalumbin 275kV line switching. The 16VT was also replaced in 2021 as part of OR.01581 275kV Trench Replacement project. The only originally installed equipment in this bay are the surge arrestors which have been in service for 35 years.

The equipment installed in 2002 are in good condition. The AEM disconnectors had corroded swivel connection on operating rods, which were replaced with stainless steel units. The CTs in this bay were replaced in 2016 and are in good condition.

The associated structures and foundations are in good condition and are expected to last for another 30 years except for those supporting CVTs & surge arrestors which has a remaining life of 20 years.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-C03-541--16VT | CAPACITOR VOLTAGE TRANSFORMER | TRENCH LIMITED | TCVT300C | 16/06/2021 | 1 |
| H032-C03-541-1SAA | SA (GAPLESS) | ASEA | XAQ300A2 | 28.02.1989 | 6 |
| H032-C03-541-1SAB | SA (GAPLESS) | ASEA | XAQ300A2 | 28.02.1989 | 6 |
| H032-C03-541-1SAC | SA (GAPLESS) | ASEA | XAQ300A2 | 28.02.1989 | 6 |
| H032-C03-541--5410 | EARTH SWITCH | AEM AUSTRALIA | SE362 | 02.04.2002 | 2 |
| H032-C03-541--5410-1 | EARTH SWITCH | AEM AUSTRALIA | SE362 | 02.04.2002 | 2 |
| H032-C03-541--5410-2 | EARTH SWITCH | AEM AUSTRALIA | SE362 | 02.04.2002 | 2 |
| H032-C03-541--5410-3 | EARTH SWITCH | AEM AUSTRALIA | SE362 | 02.04.2002 | 2 |
| H032-C03-541--5411 | DISCONNECTOR | AEM AUSTRALIA | DB362 | 02.04.2002 | 2 |
| H032-C03-541--5412 | CIRCUIT BREAKER | SIEMENS | 3AP1-F1-300kV | 02.04.2002 | 4 |

| | | | | | |
|---|---|---|---|---|---|
| H032-C03-541--TRFCTA | CT | ABB | IMB300C5H3 | 17.06.2016 | 7 |
| H032-C03-541--TRFCTB | CT | ABB | IMB300C5H3 | 17.06.2016 | 7 |
| H032-C03-541--TRFCTC | CT | ABB | IMB300C5H3 | 17.06.2016 | 7 |
| H032-C03-541--5413 | DISCONNECTOR | AEM AUSTRALIA | DB362 | 02.04.2002 | 2 |
| H032-C03-541--5417 | DISCONNECTOR | AEM AUSTRALIA | DB362 | 02.04.2002 | 2 |

**Table 3 –Bay C03- 541 Equipment**

The surge arrestors are in good condition but are not tested to the current standards and do not provide adequate protection for the equipment in this bay. Therefore these should be replaced at the same time as IMB300 CTs to make it more cost effective and reducing outages impact on the network and customers.

The earth switches 5410 and 5410-1 and isolators 5411 and 5417 all had corrosion rust through that required replacement of their impacted parts. Earth switch 5410-3 had a gear box leak develop which required rectification.

The [redacted] have been identified to be a defective model that has a higher probability of catastrophic failure. As such these should be replaced within the next 5 years to minimise the risk that they pose. Currently the DGA and moisture test have assessed these as being satisfactory.

***Recommendation:*** Based on the above observations, the primary plant in this bay is in good condition and only replacement of CTs and SAs is recommended to be replaced in the next 5 years.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years.

### 2.2.3 *H032-C03-857 – 857 Feeder*

The equipment for this Bay is listed in the Table 4, including a health index value for each item. This bay consists of equipment related to F857 and the equipment associated with feeder reactor.

The original equipment comprising disconnector 8579 and surge arrestors were installed in early to mid-1989 and have been in service for 30 years.

This bay was augmented in 2006 with addition of new CBs and disconnectors under project CP.01402 Ross-Chalumbin 275kV line switching.

The associated structures and foundations are in good condition and are expected to have a remaining life of 40 years.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-C03-857--1VTA | CVT | TRENCH LIMITED | TEMP287 | 31.07.2001 | 6 |
| H032-C03-857--1VTB | CVT | TRENCH LIMITED | TEMP287 | 31.07.2001 | 6 |
| H032-C03-857--1VTC | CVT | TRENCH LIMITED | TEMP287 | 31.07.2001 | 6 |
| H032-C03-857--2VTB | CVT | TRENCH LIMITED | TEMP287 | 08.05.2006 | 6 |
| H032-C03-857--8570 | EARTH SWITCH | ABB | ES300 | 08.05.2006 | 2 |

| | | | | | |
|---|---|---|---|---|---|
| H032-C03-857--8570-1 | EARTH SWITCH | ABB | ES300 | 08.05.2006 | 2 |
| H032-C03-857--8570-2 | EARTH SWITCH | ABB | ES300 | 08.05.2006 | 2 |
| H032-C03-857--8570-3 | EARTH SWITCH | ABB | ES300 | 08.05.2006 | 2 |
| H032-C03-857--8570-4 | EARTH SWITCH | MORLYNN | VSB | 28.02.1989 | 5 |
| H032-C03-857--8501 | DISCONNECTOR | ABB | DBRP 300 | 08.05.2006 | 3 |
| H032-C03-857--8572 | CIRCUIT BREAKER | ABB, SWEDEN | HPL300B1 SPAR | 08.05.2006 | 4 |
| H032-C03-857—8572-1 | CIRCUIT BREAKER | ABB, SWEDEN | HPL300B1 SPAR | 17.06.2016 | 3 |
| H032-C03-857--8577 | DISCONNECTOR | ABB | DBRP 300 | 08.05.2006 | 3 |
| H032-C03-857--8579 | DISCONNECTOR | MORLYNN | VSB | 28.02.1989 | 5 |
| H032-C03-857--857CTA | CT | ARTECHE | CA300 | 10.12.2004 | 4 |
| H032-C03-857--857CTB | CT | ARTECHE | CA300 | 10.12.2004 | 4 |
| H032-C03-857--87CTC | CT | ARTECHE | CA300 | 10.12.2004 | 4 |
| H032-C03-857--857CDB | COUPLING DEVICE | TRENCH ELECTRIC | K9514XS | 16.12.2005 | 9 |
| H032-C03-857--857CDC | COUPLING DEVICE | TRENCH ELECTRIC | K9514XS | 16.12.2005 | 9 |
| H032-C03-857--8503 | DISCONNECTOR | ABB | DBRP 300 | 08.05.2006 | 2 |
| H032-C03-857--8507 | DISCONNECTOR | ABB | DBRP 300 | 08.05.2006 | 2 |
| H032-C03-857—857RESAA | SA (GAPLESS) | ABB | XAQ300A2 | 28.02.1989 | 7 |
| H032-C03-857—857RESAB | SA (GAPLESS) | ABB | XAQ300A2 | 28.02.1989 | 7 |
| H032-C03-857—857RESAC | SA (GAPLESS) | ABB | XAQ300A2 | 28.02.1989 | 7 |
| H032-C03-857—857SAA | SA (GAPLESS) | ABB | XAQ300A2 | 28.02.1989 | 7 |
| H032-C03-857—857SAB | SA (GAPLESS) | ABB | XAQ300A2 | 28.02.1989 | 7 |
| H032-C03-857—857SAC | SA (GAPLESS) | ABB | XAQ300A2 | 28.02.1989 | 7 |

**Table 4 – Bay C03-857 Equipment**

All the equipment in this bay are in good condition. Maintenance records indicate that in 2016 the entire pole of CB 8572-1 had to be replaced. Whilst the pole was replaced in 2016, the year of manufacture of this CB indicates that it is 26 years old. In either case, it should not be necessary to have it replaced in the next 10 years. Circuit breaker 8572 also had a spring charge timer fault that required replacement in 2024.

The CVT models installed in this bay are the defective Trench models and should be replaced within the next 5 years. The surge arrestors are nearing the end of their technical design life and should be replaced at the same time as the CVTs.

The associated structures and foundations are in good condition and are expected to last for another 30 years except for disconnector 8579 and circuit breaker 8572-1, which all have a remaining service life of 15-20 years.

***Recommendation:*** Based on the above observations, the primary plant in this bay is in good condition and no replacements are required in the next 10 year outlook aside from the CVTs and surge arrestors. It is recommended to also rearrange the two coupling devices which are redundant to ensure their failure does not result in loss of CVTs earthing. Although their start-up date in 2005 these have been manufactured in 1989.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 15-20 years along the circuit breaker 8572-1.

### 2.2.4 *H032-C04-504 - 275kV 4 Coupler Bay*

The equipment for this Bay is listed in the Table 5, including a health index value for each item.

This bay was established in 1993 and the only original equipment remaining are the Merlin Gerin disconnectors and associated earth switches.

The circuit breaker was installed in 2015 and the SF6 CTs were installed in 2014 as a part of ABB twin leg CT replacement project. It is noted that this coupler bay has CTs installed only on one side of CB.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-C04-504--5040-1 | EARTH SWITCH | MERLIN GERIN | | 10.09.1993 | 3. |
| H032-C04-504--5040-2 | EARTH SWITCH | MERLIN GERIN | | 10.09.1993 | 2 |
| H032-C04-504—5042 | CIRCUIT BREAKER | ABB | HPL300/25B1 | 19.08.2015 | 4 |
| H032-C04-504—5042CTA | CT | TRENCH | SAS300/2G | 31.08.2014 | 3 |
| H032-C04-504—5042CTB | CT | TRENCH | SAS300/2G | 31.08.2014 | 3 |
| H032-C04-504—5042CTC | CT | TRENCH | SAS300/2G | 31.08.2014 | 3 |
| H032-C04-504—5048 | DISCONNECTOR | MERLIN GERIN | DR | 10.09.1993 | 2 |
| H032-C04-504—5049 | DISCONNECTOR | MERLIN GERIN | DR | 10.09.1993 | 6 |

**Table 5 – C04-504 Equipment**

All the equipment in this bay are in reasonable condition. Circuit Breaker 5042 required replacement of the seal in 2021 however this seems to have been effective in stopping the SF6 leak as no further loss of SF6 has been reported. Isolator 5048 was also unable to be electrically operated which required replacement of the defective parts.

The associated structures and foundations are in good condition and are expected to last for another 40 years for CB and CTs and another 30 years for the rest of the equipment.

***Recommendation:*** Based on the above observations, the primary plant in this bay is in good condition and no replacements are required in the next 10 year outlook.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 30-40 years.

### 2.2.5 *H032-C04-858 – 858 Feeder*

The equipment for this Bay is listed in the Table 6, including a health index value for each item. This bay consists of equipment associated with switching of F858 and of equipment associated with switching of feeder reactor.

This bay was built in 1993 and was augmented in 2003 with addition of new CBs and disconnectors under project CP.01402 Ross-Chalumbin 275kV line switching

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-C04-858--5VTA | CVT | TRENCH LIMITED | TCVT300C | 02.09.2016 | 3 |
| H032-C04-858--5VTB | CVT | TRENCH LIMITED | TCVT300C | 02.09.2016 | 3 |
| H032-C04-858--5VTC | CVT | TRENCH LIMITED | TCVT300C | 02.09.2016 | 3 |
| H032-C04-858--9VTB | CVT | TRENCH LIMITED | TEMP287 | 08.05.2006 | 7 |
| H032-C04-858—8580 | EARTH SWITCH | ABB | ES300 | 08.12.2003 | 4 |
| H032-C04-858--8580-1 | EARTH SWITCH | ABB | ES300 | 08.12.2003 | 4 |
| H032-C04-858--8580-2 | EARTH SWITCH | ABB | ES300 | 08.12.2003 | 4 |
| H032-C04-858--8580-3 | EARTH SWITCH | ABB | ES300 | 08.12.2003 | 4 |
| H032-C04-858--8580-4 | EARTH SWITCH | MERLIN GERIN | | 28.02.1993 | 4 |
| H032-C04-858—8581 | DISCONNECTOR | ABB | DBRP 300 | 08.12.2003 | 4 |
| H032-C04-858—8582 | CIRCUIT BREAKER | ABB, SWEDEN | HPL300B1 SPAR | 08.12.2003 | 5 |
| H032-C04-858—8582-1 | CIRCUIT BREAKER | ABB, SWEDEN | HPL300B1 SPAR | 31/03/2023 | 1 |
| H032-C04-858—8587 | DISCONNECTOR | ABB | DBRP 300 | 08.12.2003 | 4 |
| H032-C04-858—8589 | DISCONNECTOR | MERLIN GERIN | VSB | 28.02.1993 | 4 |
| H032-C04-858--858CTA | CT | ARTECHE | CA300 | 10.12.2004 | 4 |
| H032-C04-858--858CTB | CT | ARTECHE | CA300 | 10.12.2004 | 4 |
| H032-C04-858--858CTC | CT | ARTECHE | CA300 | 10.12.2004 | 4 |
| H032-C04-858—858RESAA | SA (GAPLESS) | ABB | EXLIM Q240 | 10.09.1993 | 4 |
| H032-C04-858—858RESAB | SA (GAPLESS) | ABB | EXLIM Q240 | 10.09.1993 | 4 |
| H032-C04-858—858RESAC | SA (GAPLESS) | ABB | EXLIM Q240 | 10.09.1993 | 4 |
| H032-C04-858—858SAA | SA (GAPLESS) | ABB | EXLIM Q240 | 10.09.1993 | 4 |
| H032-C04-858—858SAB | SA (GAPLESS) | ABB | EXLIM Q240 | 10.09.1993 | 4 |
| H032-C04-858—858SAC | SA (GAPLESS) | ABB | EXLIM Q240 | 10.09.1993 | 4 |

**Table 6 – C04-858 Bay equipment**

ABB HPL300 Reactor Circuit Breaker 8582-1 is in service for 2 years and has no issues reported.

The isolators 8587 and 8589 has had corrosion noticed which still requires rectification. Isolator 8589 also could not be electrically operated and the isolator motor required replacement.

The 858--9 CVT installed in this bay has since been identified to be a defective model and should be replaced within the next 5 years.

The surge arrestors are in good condition but are not tested to the current standards and do not provide adequate protection for the equipment in this bay. Therefore these should be replaced at the same time as Trench CVTs to make it more cost effective and reducing outages impact on the network and customers.

All the other equipment in this bay is in good condition. Maintenance records does not show any major issues with the equipment in this bay apart from 858-9VTB. The associated structures and foundations are in good condition and are expected to last at least another 20 years.

***Recommendation:*** Based on the above observations, the primary plant in this bay is in good condition and only replacement of 858—9 VT and surge arrestors is required in the next 10 year outlook.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years. It is expected that 8582 circuit breaker in this bay will not develop gas leaks due to no history present of it occurring. This should continue to be monitored however.

### 2.2.6 *H032-C06-8932 – 8932 Feeder*

The equipment for this Bay is listed in the Table 7, including a health index value for each item.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-C06-8932-13VTA | CVT | ASEA | CPEE300F-C | 11.08.1997 | 8 |
| H032-C06-8932-13VTB | CVT | ASEA | CPEE300F-C | 11.08.1997 | 8 |
| H032-C06-8932-13VTC | CVT | ASEA | CPEE300F-C | 11.08.1997 | 8 |
| H032-C06-8932-18VTB | CVT | TRENCH LIMITED | TEMP287 | 04.10.2004 | 7 |
| H032-C06-8932-8932 | EARTH SWITCH | ABB | ES300 | 04.10.2004 | 3 |
| H032-C06-8932—8932-1 | EARTH SWITCH | ABB | ES300 | 04.10.2004 | 3 |
| H032-C06-8932—8932-2 | EARTH SWITCH | ABB | ES300 | 30.09.2002 | 3 |
| H032-C06-8932—8932-3 | EARTH SWITCH | ABB | ES300 | 04.10.2004 | 3 |
| H032-C06-8932—8932 | DISCONNECTOR | ABB | DBRP 300 | 04.10.2004 | 3 |
| H032-C06-8932—8932 | CIRCUIT BREAKER | ABB, SWEDEN | HPL300B1 SPAR | 07.11.2003 | 4 |
| H032-C06-8932—8932 | DISCONNECTOR | ABB | DBRP 300 | 30.09.2002 | 3 |
| H032-C06-8932—8932 | DISCONNECTOR | ABB | DBRP 300 | 04.10.2004 | 3 |
| H032-C06-8932-89322CTA | CT | ARTECHE | CA300 | 10.12.2004 | 4 |
| H032-C06-8932--89322CTB | CT | ARTECHE | CA300 | 10.12.2004 | 4 |
| H032-C06-8932-89322CTC | CT | ARTECHE | CA300 | 10.12.2004 | 4 |

Table 7- C06-877 Bay Equipment

Although this bay was built in 2004, according to SAP records all three CVTs across the 3 phases in this bay have been manufactured in 1981. It seems that these were issued from warehouse and installed in 2004 at this site. This means that their

service age is 20 years and nameplate age is 33 years. Apart from dark oil colour which was attributed to the type of sight glass, maintenance records does not show any other major condition issues related to the equipment in this bay. The specific ASEA CPEE300F-C CVT model has had an issue noticed and shared to Powerlink regarding increased likelihood to explode during over voltages. Due to the porcelain bushing housing this poses a significant to anyone within the explosive vicinity. The 8932-18VTB Trench CVT installed in this bay has also been identified to be a defective model with an increased likelihood of failure and is recommended to be replaced.
In 2018 the circuit breaker suffered restrike after lightning storm during auto-reclose and flashover marks were noted across palms of B phase. It's condition should be closely monitored.

The associated structures and foundations are in good condition and are expected to have a remaining life 30 years

***Recommendation:*** Based on the above observations, it is recommended that all four CVTs are replaced within the next 5 year outlook. The other primary plant in this bay is in good condition and no replacements are required in the next 10 year outlook.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-30 years

### 2.2.7 *H032-D03-411 - 132kV 1-2 BUS SECTION BAY*

The equipment for this Bay is listed in the table below, including a health index value for each item. This bay was installed in 1996, and all of the original equipment is still in service.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-D03-411--1BUSCTA | CURRENT TRANSFORMER | ABB | 169869 | 2/09/1996 | 4 |
| H032-D03-411--1BUSCTB | CURRENT TRANSFORMER | ABB | 169869 | 2/09/1996 | 4 |
| H032-D03-411--1BUSCTC | CURRENT TRANSFORMER | ABB | 169869 | 2/09/1996 | 4 |
| H032-D03-411--2BUSCTA | CURRENT TRANSFORMER | ABB | 169869 | 2/09/1996 | 4 |
| H032-D03-411--2BUSCTB | CURRENT TRANSFORMER | ABB | 169869 | 2/09/1996 | 4 |
| H032-D03-411--2BUSCTC | CURRENT TRANSFORMER | ABB | 169869 | 2/09/1996 | 4 |
| H032-D03-411--4112 | CIRCUIT BREAKER | AEG | S1-145F1 3PAR P | 23/08/1996 | 8 |
| H032-D03-411--4117 | ISOLATOR | STANGER | HDBC | 2/09/1996 | 3 |
| H032-D03-411--4118 | ISOLATOR | STANGER | RDB | 2/09/1996 | 3 |

The circuit breaker in this bay has had a history of SF6 leaks originating from the dashpot along with the dashpot not operating correctly. This dashpot is unable to be replaced as the manufacturer does not provide a support/system to complete these works. This is resulting in very harsh and violent operation. It is recommended that this circuit breaker is replaced in the next 5 years.

The current transformers have had some minor oil leaks that required rectification however these are considered to be in good condition for their age. However, these are oil paper current transformers with porcelain housing and after 30-35 years tend to develop catastrophic failure modes likely attributed to the exposure of insulation to electric field and present potential high safety risk for personnel. Therefore, these should be preventively replaced along the circuit breaker in this bay.

Both isolators have had some minor corrosion reported however these are also considered to be in good condition for their age.

**Recommendations:** It is recommended that the circuit breaker and current transformers are replaced within the next 5 years, taking opportunity to use dead tank CB and further reduce a number of post type CTs in the network. The other equipment in this bay is considered to be in good condition and no replacement is expected to be needed within the next 10 year outlook.

### 2.2.8 *H032-D04-441- 132kV 1 Transformer Bay*

The equipment for this Bay is listed in the Table 8, including a health index value for each item.

This bay was built in 1989 and most of high voltage equipment have been in service for 30 years. The 3VTA and 3VTB CVTs in this bay were replaced in 2024 as part of an ETR project due to the discolouration of there oil.

The associated structures and foundations are in good condition and are expected to have a remaining life of at least 20 years.

The insulator sheds of all the primary in this bay has mould which requires cleaning, this mould is due to the tropical weather condition in FNQ region.

The Tyree oil filled current transformers are in reasonable condition considering they have been in service for 35 years and the DGA/moisture in oil analysis is satisfactory. According to the maintenance records, there are no identified issues with oil seals integrity. Considering their age and housing material being porcelain and the potential safety impact of their catastrophic failure, it is recommended to replace these in 5 years. Current transformers with paper and oil have an increased probability of explosive failure occurring after 36 years in service. It is recommended to replace these CTs in the next 5 years.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-D04-441-1SAA | SA | ASEA | XAR145A2 | 28.02.1989 | 6 |
| H032-D04-441-1SAB | SA | ASEA | XAR145A2 | 28.02.1989 | 6 |
| H032-D04-441-1SAC | SA | ASEA | XAR145A2 | 28.02.1989 | 6 |
| H032-D04-441-4410 | EARTH SWITCH | SIEMENS | SSBIII-AMB145 | 28.02.1989 | 4 |
| H032-D04-441-4412 | CIRCUIT BREAKER | ASEA | HLR145/2501E | 28.02.1989 | 8 |
| H032-D04-441-4413 | DISCONNECTOR | WESTRALIAN | DBR132 | 28.02.1989 | 4 |
| H032-D04-441-1TRFCTA | CT | TYREE | 06/145/50 | 28.02.1989 | 8 |
| H032-D04-441-1TRFCTB | CT | TYREE | 06/145/50 | 28.02.1989 | 8 |

| | | | | | |
|---|---|---|---|---|---|
| H032-D04-441-1TRFCTC | CT | TYREE | 06/145/50 | 28.02.1989 | 8 |
| H032-D04-441-3VTA | CVT | GE GRID SOLUTIONS INDIA | CCV 170 | 23/02/2024 | 1 |
| H032-D04-441-3VTB | CVT | GE GRID SOLUTIONS INDIA | CCV 170 | 23/02/2024 | 1 |
| H032-D04-441-3VTC | CVT | TRENCH | TCVT145C | 24.04.2015 | 2 |

**Table 8 –Bay D04-441 Equipment**

Considering the age of the CTs in this bay and due to the possible safety risk associated with the porcelain housed oil type configuration that is present it is recommended to replace these within the next 5 years.

In addition, the circuit breaker in this bay is a minimum oil circuit breaker containing 165 kg of oil rated for 2000 operations (according to SAP record had done only 155 operations). Although it is in good condition for its age, it is recommended to replace it within next 5-10 years to reduce presence of oil and to enable installation of dead tank circuit breaker to reduce maintenance associated with current transformers. Dead tank circuit breakers contain toroidal CTs which are maintenance free.

**Figure 9 – HLR Circuit Breaker**

***Recommendation:*** Based on the above observations, it is recommended that the CTs and CB, inclusive of structures and foundations are replaced within the next 5 years using dead tank circuit breaker. In addition to this the Surge Arrestors should also be replaced as they are reaching there end of technical design life.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20 years.

### 2.2.9 ***H032-D05-7191 – 7191 Feeder Bay***

The equipment for this bay is listed in the table below, including a health index value for each item. This bay was installed in 1996 with all original equipment still in service except for the VTs which were replaced in 2023 due to A phase failing and the other phases being replaced at the same time due to being defective.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-D05-7191-71910 | EARTH SWITCH | STANGER | KLR | 23/09/1996 | 4 |
| H032-D05-7191-71911 | ISOLATOR | STANGER | HDBC | 2/09/1996 | 3 |
| H032-D05-7191-71912 | CIRCUIT BREAKER | AEG | S1-145F1 3PAR P | 23/08/1996 | 8 |
| H032-D05-7191-71913 | ISOLATOR | STANGER | HDBC | 2/09/1996 | 3 |
| H032-D05-7191-7191CTA | CURRENT TRANSFORMER | ABB | 169869 | 2/09/1996 | 5 |
| H032-D05-7191-7191CTB | CURRENT TRANSFORMER | ABB | 169869 | 2/09/1996 | 5 |
| H032-D05-7191-7191CTC | CURRENT TRANSFORMER | ABB | 169869 | 2/09/1996 | 5 |
| H032-D05-7191-7191SAA | SURGE ARRESTOR (GAPLESS) | ABB POWER TRANSMISSION | EXLIM R120-AM145M | 23/08/1996 | 3 |
| H032-D05-7191-7191SAB | SURGE ARRESTOR (GAPLESS) | ABB POWER TRANSMISSION | EXLIM R120-AM145M | 23/08/1996 | 3 |
| H032-D05-7191-7191SAC | SURGE ARRESTOR (GAPLESS) | ABB POWER TRANSMISSION | EXLIM R120-AM145M | 23/08/1996 | 3 |
| H032-D05-7191-7VTA | CAPACITOR VOLTAGE TRANSFORMER | GE GRID SOLUTIONS INDIA | CCV 170 | 8/09/2023 | 1 |
| H032-D05-7191-7VTB | CAPACITOR VOLTAGE TRANSFORMER | GE GRID SOLUTIONS INDIA | CCV 170 | 29/11/2023 | 1 |
| H032-D05-7191-7VTC | CAPACITOR VOLTAGE TRANSFORMER | GE GRID SOLUTIONS INDIA | CCV 170 | 29/11/2023 | 1 |

The circuit breaker in this bay has had a history of SF6 leaks originating from the dashpot along with the dashpot not operating correctly. This dashpot is unable to be replaced as the manufacturer does not provide a support/system to complete these works. This is resulting in very harsh and violent operation. It is recommended that this circuit breaker is replaced in the next 5 years.

The earth switch 71910 and isolator 71913 have had some history of corrosion though both are considered to be in good condition.

All current transformers test results are considered satisfactory. The current transformers have had some minor oil leaks that required rectification however these are considered to be in good condition for their age. However, these are oil paper current transformers with porcelain housing and after 30-35 years tend to develop catastrophic failure modes likely attributed to the exposure of insulation to electric field and present potential high safety risk for personnel. Therefore, these should be preventively replaced along the circuit breaker in this bay.

**Recommendations:** It is recommended that the circuit breaker and CTs are replaced within 5 years. All other equipment is considered to be in good condition and does not require replacement in the next 10 year outlook.

### 2.2.10 *H032-D06-442 - 132kV 2 TRANSF BAY*

The equipment for this bay is listed in the table below, including a health index value for each item. This bay was built in 1997, and all of the original equipment is still in service.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-D06-442--2SAA | SURGE ARRESTOR (GAPLESS) | ABB POWER TRANSMISSION | EXLIM R120-AM145M | 25/11/1997 | 4 |
| H032-D06-442--2SAB | SURGE ARRESTOR (GAPLESS) | ABB POWER TRANSMISSION | EXLIM R120-AM145M | 25/11/1997 | 4 |
| H032-D06-442--2SAC | SURGE ARRESTOR (GAPLESS) | ABB POWER TRANSMISSION | EXLIM R120-AM145M | 25/11/1997 | 4 |
| H032-D06-442--2TRFCTA | CURRENT TRANSFORMER | ABB | 169869 | 25/11/1997 | 5 |
| H032-D06-442--2TRFCTB | CURRENT TRANSFORMER | ABB | 169869 | 25/11/1997 | 5 |
| H032-D06-442--2TRFCTC | CURRENT TRANSFORMER | ABB | 169869 | 25/11/1997 | 5 |
| H032-D06-442--10VTA | CAPACITOR VOLTAGE TRANSFORMER | EMEK ELEKTRIK | KGT-145 | 25/11/1997 | 5 |
| H032-D06-442--10VTB | CAPACITOR VOLTAGE TRANSFORMER | EMEK ELEKTRIK | KGT-145 | 25/11/1997 | 5 |
| H032-D06-442--10VTC | CAPACITOR VOLTAGE TRANSFORMER | EMEK ELEKTRIK | KGT-145 | 25/11/1997 | 5 |
| H032-D06-442--4422 | CIRCUIT BREAKER | AEG | S1-145F1 3PAR P | 25/11/1997 | 8 |
| H032-D06-442--4420 | EARTH SWITCH | STANGER | KLR | 31/12/1997 | 3 |
| H032-D06-442--4423 | ISOLATOR | STANGER | RDB | 31/12/1997 | 3 |

The circuit breaker in this bay has had a history of SF6 leaks originating from the dashpot along with the dashpot not operating correctly. This dashpot is unable to be replaced as the manufacturer does not provide a support/system to complete these works. This is resulting in very harsh and violent operation. It is recommended that this circuit breaker is replaced in the next 5 years.

There has been some corrosion noticed on the isolator, earth switch and VTs, however this has all been rectified and has been considered successful with no further defects raised.

The CTs have had one high moisture reading in 2004, however this high result has not been repeated since and all oil test results have since been satisfactory. However, these are oil paper current transformers with porcelain housing and after 30-35 years tend to develop catastrophic failure modes likely attributed to the exposure of insulation to electric field and present potential high safety risk for personnel. Therefore, these should be preventively replaced along the circuit breaker in this bay.

**Recommendation:** It is recommended that the circuit breaker and CTs are replaced within the next 5 years due to the known defects with this model. All of the other equipment in this bay is in good condition and is expected to not require replacement within the next 10 year outlook.

### 2.2.11 *H032-D06-7192 - 7192 Feeder Bay*

The equipment for this Bay is listed in Table 9, including a health index value for each item.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-D06-7192--2SAA | SA (GAPLESS) | ASEA | XAR145A2 | 28.02.1989 | 7 |
| H032-D06-7192--2SAB | SA (GAPLESS) | ASEA | XAR145A2 | 28.02.1989 | 7 |
| H032-D06-7192--2SAC | SA (GAPLESS) | ASEA | XAR145A2 | 28.02.1989 | 7 |
| H032-D06-7192—7192CTA | CT | ABB | IMBM145 | 30.04.2005 | 2 |
| H032-D06-7192—7192CTB | CT | TYREE | 06/145/56 | 28.02.1989 | 7 |
| H032-D06-7192—7192CTC | CT | TYREE | 06/145/56 | 28.02.1989 | 7 |
| H032-D06-7192—6VTA | CVT | TRENCH | TCVT145 | 03.04.2015 | 2 |
| H032-D06-7192—6VTB | CVT | TRENCH | TCVT145 | 03.04.2015 | 2 |
| H032-D06-7192—6VTC | CVT | TRENCH | TCVT145 | 03.04.2015 | 2 |
| H032-D06-7192--71920 | EARTH SWITCH | WESTRALIAN | KLR | 28.02.1989 | 4 |
| H032-D06-7192--71922 | CIRCUIT BREAKER | ASEA | HLR145 | 21.02.1989 | 7 |
| H032-D06-7192--71920 | DISCONNECTOR | WESTRALIAN | DBRP132 | 28.02.1989 | 4 |
| H032-D06-7192--71923 | DISCONNECTOR | WESTRALIAN | DBRP132 | 28.02.1989 | 4 |

**Table 9- Bay H032-D06-7192 Equipment**

This bay was established in 1989, majority of high voltage equipment in this bay are in service for just over 30 years. The circuit breaker is minimum oil filled circuit breaker having issues with the operations counter and spring charge motor. It is recommended to replace within the next 10 years period as it is expected to develop more issues. The similar applies to two Tyree CTs, especially considering their age and the fact these have porcelain housing and therefore the safety consequence of their potential catastrophic failures could be significant. IMBM145 CTs have increased failure rate and therefore these CT should also be replaced. All three CVTs failed in service and were replaced in 2015. In addition there is a well-developed corrosion of various parts of earth switches and disconnectors.

The associated structures and foundations are in good condition and are expected to have a remaining life of at least 20 years.

***Recommendation:*** Based on the above observations, it is recommended to replace the CB and all three CTs with dead tank circuit breaker inclusive of structures and foundations in 5 years' time. Consider refurbishment requirements for earth switches and disconnectors. It is prudent due to their age and technical design life to also replace the surge arresters during the same period.

It is recommended to continue monitoring condition of all other structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20 years.

### 2.2.12 ***H032-D07-7166 - 132kV Feeder Bay***

The equipment for this Bay is listed in Table 10, including a health index value for each item.

This bay was established in 1989, so majority of the high voltage equipment in this bay have been in service for just over 30 years. In 2015, the small oil leak was noticed from circuit breaker and few smaller parts of it had to be replaced, indicating that aging process has started. In addition there is a well-developed corrosion of various parts of earth switches and disconnectors. In 2016 all three CVTs failed in service (high moisture content in base box) and were replaced using CVTs manufactured in 2008. As obvious from Figure 11 A phase has bottom of base tank heavily corroded. It is presumed that tank is made of aluminium so the source of corrosion could be hold down bolts.

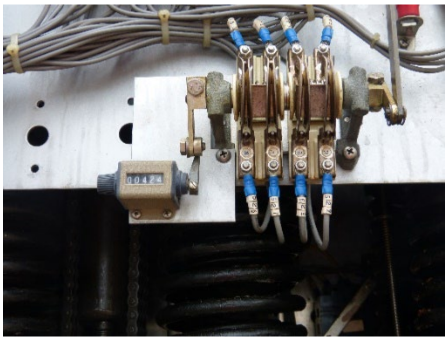

**Figure 10– CB71662**

**Figure 11 - CVT corrosion**

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-D07-7166--7166SAA | SA (GAPLESS) | ASEA | XAR145A2 | 28.02.1989 | 7 |
| H032-D07-7166--7166SAB | SA (GAPLESS) | ASEA | XAR145A2 | 28.02.1989 | 7 |
| H032-D07-7166--7166SAC | SA (GAPLESS) | ASEA | XAR145A2 | 28.02.1989 | 7 |
| H032-D07-7166—7166CTA | CT | TYREE | 06/145/56 | 28.02.1989 | 7 |
| H032-D07-7166—7166CTB | CT | TYREE | 06/145/56 | 28.02.1989 | 7 |
| H032-D07-7166—7166CTC | CT | TYREE | 06/145/56 | 28.02.1989 | 7 |
| H032-D07-7166—4VTA | CVT | TRENCH | TEMP138HC | 31.01.2008 | 7 |
| H032-D07-7166—4VTB | CVT | TRENCH | TEMP138HC | 03.04.2015 | 7 |

| | | | | | |
|---|---|---|---|---|---|
| H032-D07-7166—4VTC | CVT | TRENCH | TEMP138HC | 03.04.2015 | 7 |
| H032-D07-7166--71660 | EARTH SWITCH | WESTRALIAN | KLR | 28.02.1989 | 5 |
| H032-D07-7166--71662 | CIRCUIT BREAKER | ASEA | HLR145 | 21.02.1989 | 7 |
| H032-D07-7166--71661 | DISCONNECTOR | WESTRALIAN | DBRP132 | 28.02.1989 | 5 |
| H032-D07-7166--71663 | DISCONNECTOR | WESTRALIAN | DBRP132 | 28.02.1989 | 5 |

Table 10 – Bay H032-D07 Equipment

The three Tyree oil filled current transformers have increasing moisture content in oil samples, possibly indicating aged seals. Considering their age and potential safety consequence in case of catastrophic failure (which is hard to predict based on the available condition monitoring techniques), it is recommended to plan their replacement along with CB in the next 10 years.

The associated structures and foundations are in good condition and are expected to have a remaining life of at least 20-25 years.

***Recommendation:*** Based on the above observations, it is recommended that the CTs and CB inclusive of structures and foundations are replaced within next 5 years using dead tank circuit breaker. Due to the age and technical design life of the surge arresters in this bay it is considered prudent to also replace them at the same time. The CVTs are of the defective Trench model identified and should be replaced in the same period.

It is recommended to continue monitoring condition of structures and foundations in this bay for another 10-15 years (if not replaced with the equipment) and plan their replacement in 20-25 years.

### 2.2.13 *H032-D08-7165 7165 Feeder Bay*

The equipment in this bay is listed in the table below, including a health index values for each item. This bay was installed in 1996 with the B phase VT being replaced in 2019 due to failing in service. A and C phase VTs were subsequently replaced in 2024 due to discolouration of the oil in A phase and both models being identified as being defective models.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-D08-7165-71650 | EARTH SWITCH | STANGER | KLR | 23/09/1996 | 4 |
| H032-D08-7165-71651 | ISOLATOR | STANGER | HDBC | 2/09/1996 | 4 |
| H032-D08-7165-71652 | CIRCUIT BREAKER | AEG | S1-145F1 3PAR P | 23/08/1996 | 8 |
| H032-D08-7165-71653 | ISOLATOR | STANGER | HDBC | 2/09/1996 | 4 |
| H032-D08-7165-7165CTA | CURRENT TRANSFORMER | ABB | 169869 | 2/09/1996 | 4 |
| H032-D08-7165-7165CTB | CURRENT TRANSFORMER | ABB | 169869 | 2/09/1996 | 4 |
| H032-D08-7165-7165CTC | CURRENT TRANSFORMER | ABB | 169869 | 2/09/1996 | 4 |
| H032-D08-7165-7165SAA | SURGE ARRESTOR (GAPLESS) | ABB POWER TRANSMISSION | EXLIM R120-AM145M | 23/08/1996 | 4 |
| H032-D08-7165-7165SAB | SURGE ARRESTOR (GAPLESS) | ABB POWER TRANSMISSION | EXLIM R120-AM145M | 23/08/1996 | 4 |
| H032-D08-7165-7165SAC | SURGE ARRESTOR (GAPLESS) | ABB POWER TRANSMISSION | EXLIM R120-AM145M | 23/08/1996 | 4 |

| | | | | | |
|---|---|---|---|---|---|
| H032-D08-7165-8VTA | CAPACITOR VOLTAGE TRANSFORMER | GE GRID SOLUTIONS INDIA | CCV 170 | 23/02/2024 | 1 |
| H032-D08-7165-8VTB | CAPACITOR VOLTAGE TRANSFORMER | TRENCH LIMITED | TCVT145C | 11/05/2019 | 1 |
| H032-D08-7165-8VTC | CAPACITOR VOLTAGE TRANSFORMER | GE GRID SOLUTIONS INDIA | CCV 170 | 23/02/2024 | 1 |

The circuit breaker in this bay has had a history of SF6 leaks originating from the dashpot along with the dashpot not operating correctly. This dashpot is unable to be replaced as the manufacturer does not provide a support/system to complete these works. This is resulting in very harsh and violent operation. It is recommended that this circuit breaker is replaced in the next 5 years.

The isolators 71651 and 71653 have had some history of corrosion however these are considered to be in fair condition for their age and are not expected to be requiring replacement.

The current transformers are in good condition and all oil test results have returned satisfactory. Considering their age and potential safety consequence in case of catastrophic failure (which is hard to predict based on the available condition monitoring techniques), it is recommended to plan their replacement along with CB in the next 5 years.

Due to the age and technical design life of the surge arresters in this bay it is considered prudent to also replace them at the same time.

**Recommendations:** Based on the above observations it is recommended the circuit breaker, CTs and surge arrestors are replaced within the next 5 years. The other equipment in this bay is in good condition and is not expected to require replacement within the next 10 year outlook.

### 2.2.14 ***H032-F01- 271- 19kV 1 Reactor Bay***

The equipment for this Bay is listed in Table 11, including a health index value for each item.

All the other equipment is in good condition and maintenance records show no associated problems. It is likely that surge arrestors are not tested to the latest standards and considering their age and these being one of the first generation of ZnO based surge arrestors in porcelain housing, it may be prudent to plan their replacement in next 10 years, assuming the reactor is still required.

The associated structures and foundations in this bay are in good condition and are expected to have a remaining life 25 years.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-F01-271—1SAA | SA | MEIDENSHA | ZSE-C1Z | 28.02.1989 | 6 |
| H032-F01-271—1SAB | SA | MEIDENSHA | ZSE-C1Z | 28.02.1989 | 6 |
| H032-F01-271—1SAC | SA | MEIDENSHA | ZSE-C1Z | 28.02.1989 | 6 |
| H032-F01-271—2711 | ISOLATOR | ESSANTEE | 67-7470 | 01.03.1989 | 4 |
| H032-F01-271—2712 | CB | ALSTOM | S1-72.5F1 | 28.02.1999 | 5 |

Table 11- H032-F01 Bay equipment

Although the records do not indicate that circuit breaker was replaced after bay was established based on its manufacturing details, it seems that it is indeed 10 years younger and in good condition.

***Recommendation:*** Based on the above observations, it is recommended to plan replacement of three surge arrestors in next 10 years, assuming the reactor is still required. Please note that the rector was replaced in 2003 after one phase failed in service.

## 2.3 Bus Diameters

### 2.3.1 *132kV Bus*

As mentioned above there are two 132 kV buses and the equipment associated with these is listed in Table 12, including a health index value for each item.

| .Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-KD1-1BU4-4910 | EARTH SWITCH | WESTRALIAN | | 28.062.1989 | 4 |
| H032-KD2-2BU4-4920 | EARTH SWITCH | STANGER | KLR | 28.062.1989 | 3 |

Table 12 –H032-KD1 and H032-KD2 Bay equipment

The earth switches as well as bus support post insulators are in good condition and the associated structures (predominantly made of tubular steel) and foundations are also in good condition. There is minor corrosion and paint fading on earth switches, which is reasonable to expect the maintenance crews to deal with.

The structures and foundations are estimated have a remaining lives of 25 years.

***Recommendation:*** Based on the above observations, the primary plant in this bay is in good condition and no replacements are required in the next 10-year outlook.

### 2.3.1 *275 kV Bus*

The equipment associated with the 275kV bus are listed in Table 13, including a health index value for each item. Similarly to other earth switches, these two also have issues with minor corrosion, paint fainting on flags and high resistance on contacts.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-KC1-1BU5-14VTA | CVT | TRENCH LIMITED | TEMP287 | 31.12.2003 | 7 |
| H032-KC1-1BU5-14VTB | CVT | TRENCH LIMITED | TEMP287 | 31.12.2003 | 7 |
| H032-KC1-1BU5-14VTC | CVT | TRENCH LIMITED | TEMP287 | 31.12.2003 | 7 |
| H032-KC1-1BU5-5910 | EARTH SWITCH | ABB | ES300 | 08.12.2003 | 2 |
| H032-KC2-2BU5-15VTC | CVT | TRENCH LIMITED | TEMP287 | 26.08.2004 | 7 |
| H032-KC2-2BU5-15VTC | CVT | TRENCH LIMITED | TEMP287 | 26.08.2004 | 7 |
| H032-KC2-2BU5-15VTC | CVT | TRENCH LIMITED | TEMP287 | 26.08.2004 | 7 |
| H032-KC2-2BU5-5920 | EARTH SWITCH | AEM AUSTRALIA | SE362 | 06.09.2002 | 3 |

**Table 13 – H032-KC1 and H032-KC2 Bay Equipment**

The bus support post insulators are in good condition and the associated structures and foundations are in good condition. The structures and foundations in KC1 and Kc2 have an estimated remaining service lives of 25 and 30 years, respectively.

The CVTs in this bay have been identified to be the defective trench models and as such are recommended to be replaced within the next 5 years.

***Recommendation:*** Based on the above observations and condition indicators, it is recommended that the CVTs are replaced within the next 5 years.

## 2.4 Strung Bus and Structures

Both 132kV and 275kV strung bus conductors and connectors over the bays appear to be in good condition.
As per civil condition assessment report the lattice type towers and beams were found to be in a good condition. The structures and foundations are estimated to have remaining lives of at least 20 years.
The overhead earth wires above all strung buses appear to be in good condition. The connections of the earth wire to their strain towers vary in configuration, the original ones being bolted connection and the later ones compression joints.

## 2.5 Site Infrastructure

### 2.5.1 *AC supply*

The AC supply is via two 19/0.433 kV transformers auxiliary transformers connected to the 11 kV tertiaries of the power transformers 1T and 2T. The setup is shown in figures 13 & 14. These provide adequate and reliable local supply for this substation.

One station transformers was installed in 2003 is pad mounted as per Fig 14. Two Station transformer was installed in 2018 and is pole mounted type as shown in Fig.13.

Figure 12 -2 T station supply transformer

Figure 13 – 1 T station supply transformer

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H032-SIN-ACSU-1STN | LOCAL SUPP TRF | TYREE | MODEL93 | 05.07.2018 | 2 |
| H015-SIN-ACSU-2STN | LOCAL SUPP TRF | WILSON | MODEL93 | 02.01.2003 | 5 |

Table 14 – AC supply transformers

#### 2.5.1.1 *AC Change overboard*

The AC changeover board was replaced under CP.01043 along with the AC distribution boards in 2009 and all appear to be in good condition. During OR.02429 Arc Flash Studies, the ACCO board was calculated to require PPE category 3. To allow for discrimination between the transformer fuse and MCCB within the ACCO board it is recommended that the MCCB settings are lowered. The transformer fuses for the transformer are also recommended to be replaced with T1 having a NH3F-500 fuse installed and T2 having a NH3F-400 fuse installed.

#### 2.5.1.2 *Diesel Generator*

The diesel generator along with 7 day fuel tank was installed under project CP.01403 in 2009 and appear to be in good condition.

| Functional Loc. | Description | Manufacturer | Model number | Start-up date | HI |
|---|---|---|---|---|---|
| H015-SIN-DIES-1DIESEL | DIESEL ALTERNATOR | JOHN DEERE / STAMFORD | 250 kVA MEGA–GEN | 24.07.2009 | 2 |

Table 15 – Diesel generator

### 2.5.2 *Security Fence*

The substation security fence consists of a standard chain wire fence and an electric fence mounted on the inside of the chain wire fence, installed in 2017. The chain wire fence is approximately 2.4m tall and has a bottom rail and an additional rail at approximately one metre above the ground. It is estimated that both chain wire and electric fence should last until 2032. Then it should be replaced to suit new substation security standard.


Figure 14- Substation gate

Figure 15 –Substation security fence

### 2.5.3 *Substation Access and Internal Roads and Signage*

The Chalumbin Substation is accessed by a road from town Ravenshoe. The last several kilometres are unsealed. The internal roads are not sealed. While some internal roads are obvious due to difference in the surface colour, other are poorly delineated. It is recommended to rectify this as it may lead to electrical exclusion zones encroachments.

### 2.5.4 *Substation Yard, Platform and Site Drainage System*

The substation platform is covered in gravel and is generally well maintained. No surface water pooling was observed on the platform. However, identifying any drainage issues was unlikely as the inspection occurred in dry weather.

Figure 16 – Gravel and unmarked internal roadways

### 2.5.5 *Cable Trenches*

There is no indication in the maintenance records of any issues related to the cable trench covers. The cable ducts and the associated cable covers were in good condition and the covers were neatly placed without significant gaps that could present a tripping hazard.

Figure 17 – Cable trenches

### 2.5.6 *Yard Lights*

The 132kV and 275kV switchyard lights are weatherproof low level floodlights. They are in good condition and apart from minor corrosion on holding down bolts no other issues were identified on site.

### 2.5.7 *Substation earthing*

#### 2.5.7.1.1 Structure and equipment earthing

The insulated earthing cables have lost their insulation whilst the copper straps above ground level are in good condition. The lowest rated earth tail is suitable to conduct fault current of 27 kA for 500 ms, which is suitable for fault current level for this site.

#### 2.5.7.1.2 Earth grid

Grid injection test was performed in October 2013 and the results were satisfactory- no issues were identified.

## 3. OVERVIEW OF RECOMENDATIONS

| Asset | Equip./ comp. replacement Recom. (Y/N) | Refurb./Maintenance Recom. (Y/N) | Comments |
|---|---|---|---|
| H032-D03-411 | Y | N | Replace CB & CTs in 5 years Incl. found and str. |
| H032-D04-441 | Y | Y (ESW and ISOL) | Replace SAs, CTs and CB in 5 years. Incl. found and str. |
| H032-D05-7191 | Y | N | Replace CB & CTs in 5 years Incl. found and str. |
| H032-D06-442 | Y | N | Replace CB & CTs in 5 years Incl. found and str. |
| H032-D06-7192 | Y | Y (ESW and ISOL) | Replace SAs, CTs and CB in 5 years. Incl. found and str. |
| H032-D07-7166 | Y | Y (ESW and ISOL) | Replace SAs, CTs and CB in 5 years. Incl. found and str. |
| H032-D08-7165 | Y | N | Replace CB, SAs & CTs in 5 years Incl. found and str. |
| H032-C03-503 | Y | Y (ESW and ISOL) | Replace CTs and CB in 5 years. Incl. found and str. |
| H032-C03-541 | Y | Y (ESW and ISOL) | Replace CTs and SAs with found and str. |
| H032-C03-857 | N | Y (ESW and ISOL) | Replace CVTs, coupling devices and |

| | | | |
|---|---|---|---|
| | | | SAs with found and str. |
| H032-C04-504 | N | Y (ESW and ISOL) | No replacement in next 10 years. |
| H032-C04-858 | N | Y (ESW and ISOL) | Replace 858-9 CVT, SA's and 8582-1 CB with found and str. |
| H032-C06-8932 | N | Y (ESW and ISOL) | Replace all CVTs with found and str. |
| H032-F01 | Y | Y (ESW and ISOL) | Replace SAs in 10 yrs. |
| H032-F02 | N | Y (ESW and ISOL) | No replacement in next 10 years. |
| H032-KC1 | N | Y (ESW and ISOL) | No replacement in next 10 years. |
| H032-KC2 | N | Y (ESW and ISOL) | Replace CVTs in the next 5 years incl. found and str. |
| H032-KD1 | N | Y (ESW and ISOL) | No replacement in next 10 years. |
| H032-KD2 | N | Y (ESW and ISOL) | No replacement in next 10 years. |
| Site infrastructure | N | | No replacement in next 10 years. |

**Table 16 – Overview of recommendations**

In addition to the above listed please note that:

1. It is recommended for the Planning Team to review the future expected load for the1-2 Bus Section bay (coupler) for a range of credible contingencies and the bay should be uprated if required.
2. It is recommended for the Planning Team to review the future expected load for the transformers to identify any need to increase the rating of the 132 kV transformer bays (T1 and T2).
3. It is recommended for the Planning Team to review the future expected load for the feeder 876 (presently limited to 1600 A by CT ratio in the feeder bay) to identify any need to increase the rating.
4. It is recommended for the Planning Team to review the future expected load for the 132 kV Bus 1 and Bus 2 (presently limited to 1600 A) for a range of credible contingencies and uprated if required.

## 3.1 Conclusions

The condition assessment of H032 Chalumbin 275/132kV substation revealed issues related to the condition of some equipment and of some assets. The site was developed and expended over time and a number of equipment failed in service and was replaced through maintenance activities. Whilst the condition of all site was reviewed, the scope of this report was reduced to focus only on the assets established prior to 2001 and having health indices over 4. The recommendations are based purely on condition and the forecast of the condition deterioration expected in the next 10 years. The additional issues taken into account include availability of spares, maintainability of the equipment, potential for significant safety risks and potential for significant damage of adjacent equipment. The recommendations exclude any consideration given to the enduring need for the assets on this site regardless whether their condition is deteriorated or not. It is believed that recommended replacements or de-energisation of the equipment and assets in deteriorated condition within next 5-10 years would reduce risks to an acceptable level.

## 4. APPENDICIES

### Appendix No.1

- Asbestos Register (Objective Id A1999885)

### Other reference information

- *Civil condition assessment report (Objective Id A3237809).*
- *Equipment list (SAP)*
- *Notifications, work orders and measurement documents (SAP)*
- *275kV & 132kV operating diagram*
- *Switchyard earth grid layouts*
- *Equipment, bay and feeder ratings*
- *Discussions with Powerlink technical staff*
- *Discussions with the maintenance service provider*
- *Relevant Powerlink drawings*

### 4.1 Replacement Index Methodology

*Replacement index for bays and other substation assets is based on the condition of the equipment in the bay, condition of structures and foundations (all being assigned health index as condition indicator), ay voltage level and type, bay location criticality and bay compliance with legislation and standards. It provides an indication of the remaining life based on its condition and criticality, rather than based on it time in service.*

| RI | Estimated Remaining Life(yrs) | Action | Comment | Comment |
|---|---|---|---|---|
| 10 | 1 -2 | condition assessment (CA) required on annual basis (or special maintenance regime) | project scoped and approved, included in the current Reset period | **Poor condition needs urgent action.** |
| 9 | 2-3 | CA required on annual basis (or special maintenance regime) | project scoped and in final approval stages, included in the current Reset period | Poor condition, needs prompt, planned action. |
| 8 | 3 – 5 | CA required on annual basis (or special maintenance regime) | project scoping, options analysis | |
| 7 | 5 – 10 | high level project scoped | high level project scoped for regulator, CA done | |
| 6 | 10 – 20 | CA trigger | CA to be done within 1 year and ready for next Reset, scope project before next Reset | Deteriorating condition, future replacement required, but in a planned fashion. |
| 5 | 20 – 25 | plan CA in 5 yrs | | Aged satisfactory condition. |
| 4 | 25 – 30 | mid life CA (desktop) | Desktop assessment of notified issues | Needs some replacements, typically only few, minor components |
| 3 | 30 – 35 | annual review of HI and RI begins | aging - good condition | |
| 2 | 35-40 | good condition, annual review of notifications, dealing with infant mortality issues | | |
| 1 | ≥40 | New | | |

Table 17 – RI Methodology

# H032 Chalumbin 275/132kV

# Secondary Systems Condition Assessment Report

| Document Details | | | |
|---|---|---|---|
| **Version Number** | 2.0 | **Principal Author** | [redacted] |
| **Objective ID** | A3245187 | **Site Visit** | 25/09/2019 |
| **Issue Date** | 09/10/2019 | **Authorised by** | [redacted] |
| **Previous Document** | Version 1.0 | **Team** | Secondary Systems and Telecommunications Strategies |

| Date | Version | Nature of Change | Author | Authorisation |
|---|---|---|---|---|
| 07/01/2009 | 1.0 | New document | [redacted] | [redacted] |
| 09/10/2019 | 2.0 | Update the whole document | [redacted] | [redacted] |

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# 1. Introduction

This report is pertinent to H032 Chalumbin substation 275/132kV secondary systems and associated site infrastructure. The report is provided to assist with determining the future strategy and scope for refurbishment and replacement works of Chalumbin 275kV and 132kV secondary systems equipment.

The assessment has been formulated with the assistance of data extracted from SAP, SPF, Forced Outage Database (FOD), discussion with maintenance staff and a site inspection. Photographs of items are included in the text and all photographs taken during the site visit have been retained for future reference.

H032 Chalumbin substation is an essential 275kV/132kV switching station for feeders into the Cairns and Atherton Tableland areas. The substation was established in 1988. Switchyard augmentation with load growth has resulted a mixer of Secondary systems from 2004 to 2014. Secondary systems for  275kV bus zones, coupler 506, 275kV Feeder 857, 858, 876 and 877 were replaced/refurbished between 2004 and 2007 while secondary systems for all 132kV and partial 275kV including 1 Transformer, 2 Transformer, coupler 503, 504 and 5 Rector were installed/replaced between 2012 and 2014.

[redacted]

H032 Chalumbin operating diagram

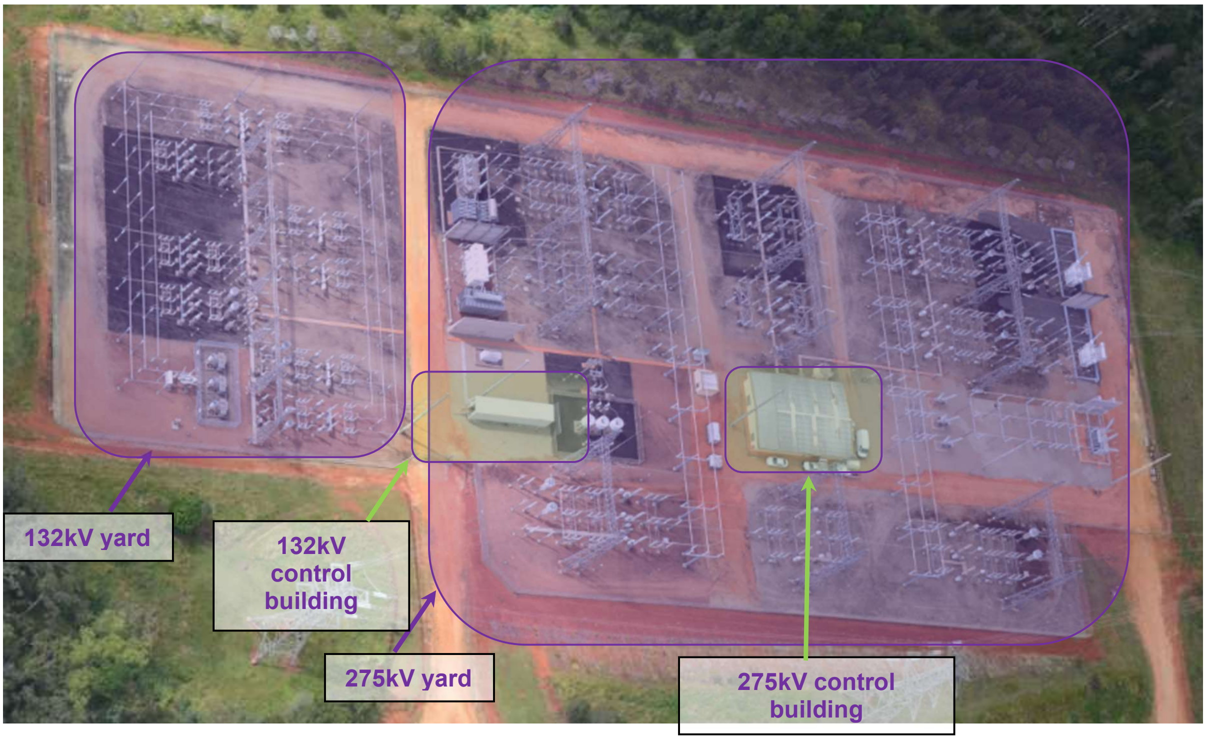
# 2. Site infrastructure

Chalumbin substation consists of one yard of 275kV and 132kV operating voltage enclosed by the one perimeter fence. The substation was built in 1988. The substation has undergone feeder and bay extensions and modifications since its original construction. This leads to the current installation of secondary systems from 2004 to 2014.

H032 Chalumbin Substation is an essential transmission yard, with:-

- 2 x 275kV bus bays;
- 3 x 275kV bus coupler bays;
- 2 x 275/132kV transformer bays;
- 4 x 275kV feeder bays;
- 1 x 275kV bus reactor bay;
- 2 x 275kV feeder reactor bays;
- 2 x 132kV bus bays;
- 1 x 132kV bus coupler bay;
- 4 x 132kV feeder bays;
- 1 x 132kV Capacitor bank bay
- 1 x 19kV reactor bay.

4 x 275kV feeder bays are energised through Woree and Ross substation. 4 x 132kV feeder bays are connected to Turkinje substation and Kareeya Power Station.




Chalumbin substation yard bird view

The existing Chalumbin substation site is located at south of Ravenshoe off Tully Falls Road. Emergency and routine maintenance of the secondary systems is done by Ergon MSP at the Cairns Depot. Secondary systems are housed in a one level besser block building for 275kV systems and a demountable building for 132kV system adjacent to the switchyard as shown above.

# 3. Secondary System Assessment Methodology

Secondary systems including protection and control equipment are required to operate the transmission network and prevent any damages to primary systems when adverse events occur. Under the National Electricity Rules, Transmission Network Service Providers are required to provide sufficient secondary systems to ensure the transmission system is protected. A health index of secondary system asset plays an essential role for secondary system reliability, availability and security.

An asset health index rating method has been developed to describe secondary system asset conditions considering:-

- Secondary system equipment functional failure rate
- Operating environment of the secondary system equipment
- Secondary system equipment physical age

Secondary system asset health Index is modelled in the range from a score zero (0) to ten (10), where zero represents new assets and then indicates the asset requires immediate action to address its increasing risk of equipment failure.

The impacts of equipment obsolescence on availability is also considered when determining the recommended replacement actions. This ensures that secondary systems can be returned to service in the event of a failure within sufficient timeframes to meet regulatory requirements.

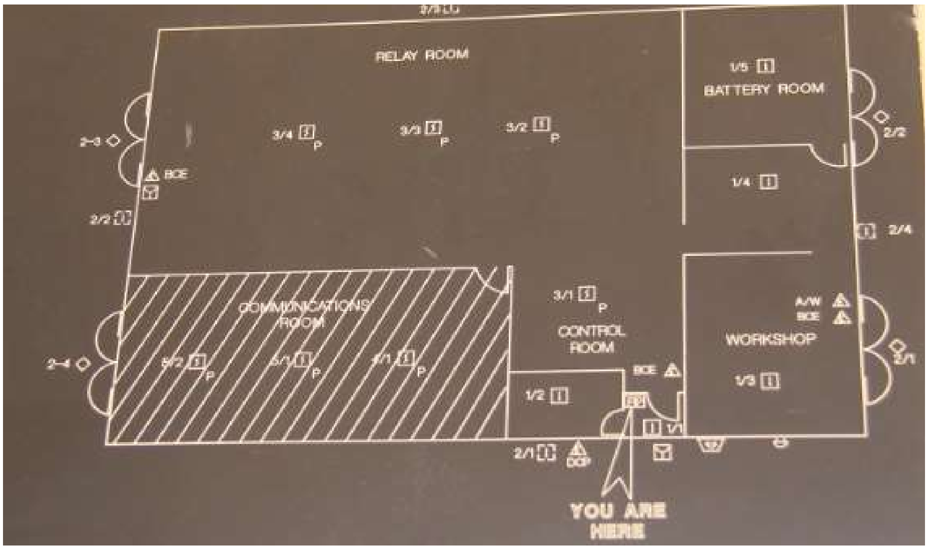
# 4. Condition Assessment

## 4.1 Buildings

The condition assessment of buildings at H032 Chalumbin is included in a separate document and carried out by Substation Strategies. The following details are for information only.

There are two buildings at H032 Chalumbin, besser block building +1 (including a communication room) and demountable building +4. Building +1 is a one level besser block construction that contains a protection/control room for secondary systems for 275kV network, communication rooms, battery room, and toilet. The building was built in 1988.

Chalumbin control building +1




Control building +1 floor plan

There are plenty of spaces available for future secondary system secondary system replacement or substation augmentation in the existing building +1. This building is air-conditioned.

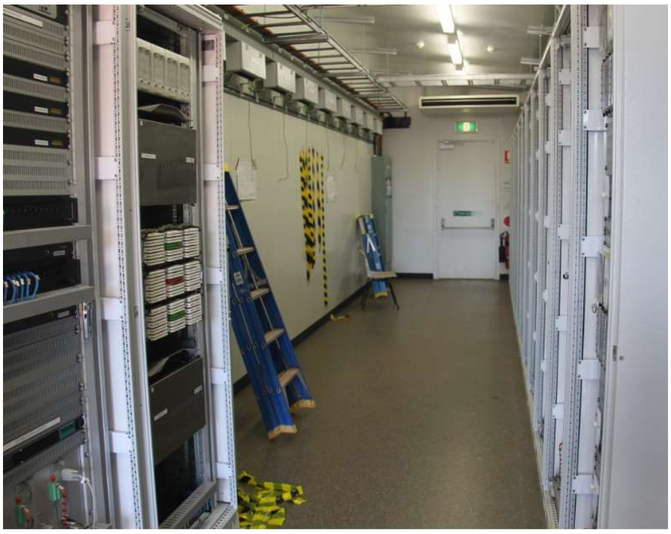
Building +1 air-conditioner

Control building +1 inside

The 132kV demountable building, Building +4 was built in 2012 and is air-conditioned.. It houses all secondary systems for 132kV bays, including 132kV bus zones, feeder 7165, 7166, 755, 7191 and 7192.

Chalumbin control building +4

There are 11 x spare panel spaces in building +4 for future secondary system replacement.



132kV Demountable building +4 inside

## 4.2 Trench, marshalling cubicles and control cables

Trenches are part of primary assets. Conditions of cable trenches are not included in this report.

Substation trenches

### 4.2.1 275kV yard

275kV bus marshalling kiosks and VT boxes were installed between 2003 and 2004. Marshalling kiosks and associated control cables are in fair condition. There are no condition driven replacements required until 2043-2044.

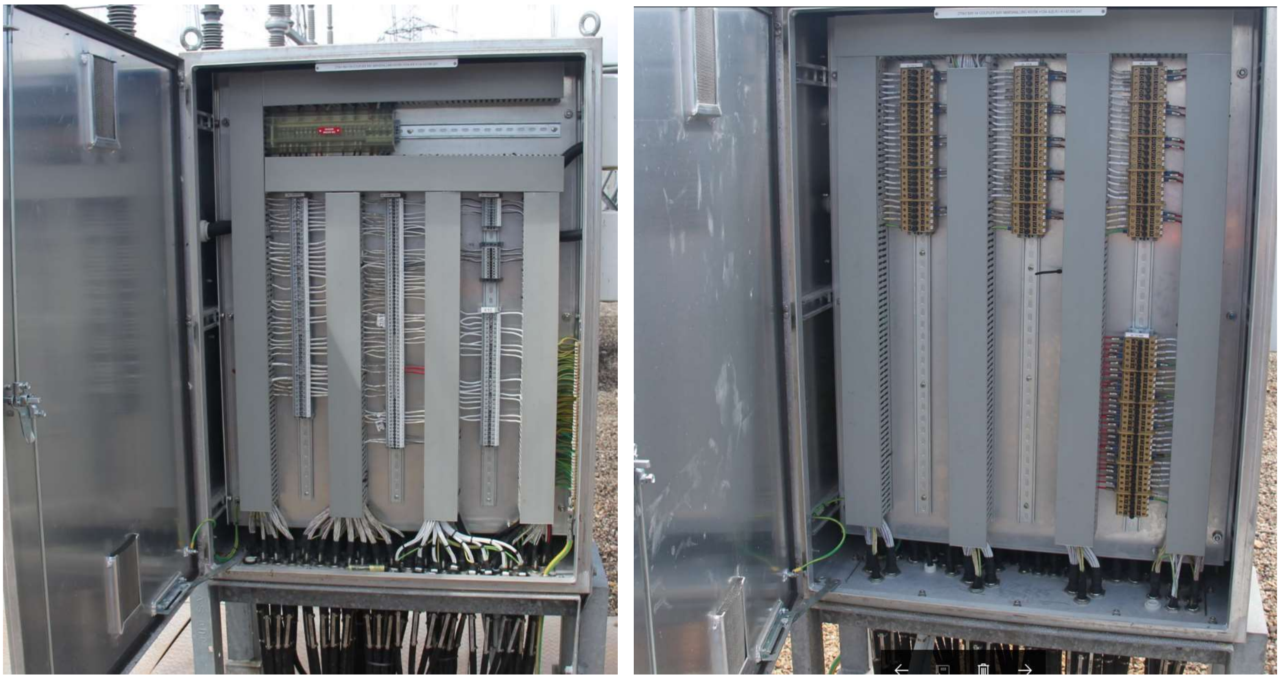
275kV bus 1 CT marshalling kiosk

275kV Bus 2 CT marshalling kiosk

275kV Bus 1 and 2 VT box

Marshalling kiosks for 275kV bus coupler 503 and 504 were replaced under CP.01566 Chalumbin secondary system replacement in 2011. Marshalling kiosks and associated control cables are in good condition. There are no condition driven replacements required until 2051.

275kV Bay 3 coupler bay marshalling kiosk


275kV Bay 4 coupler bay marshalling kiosk

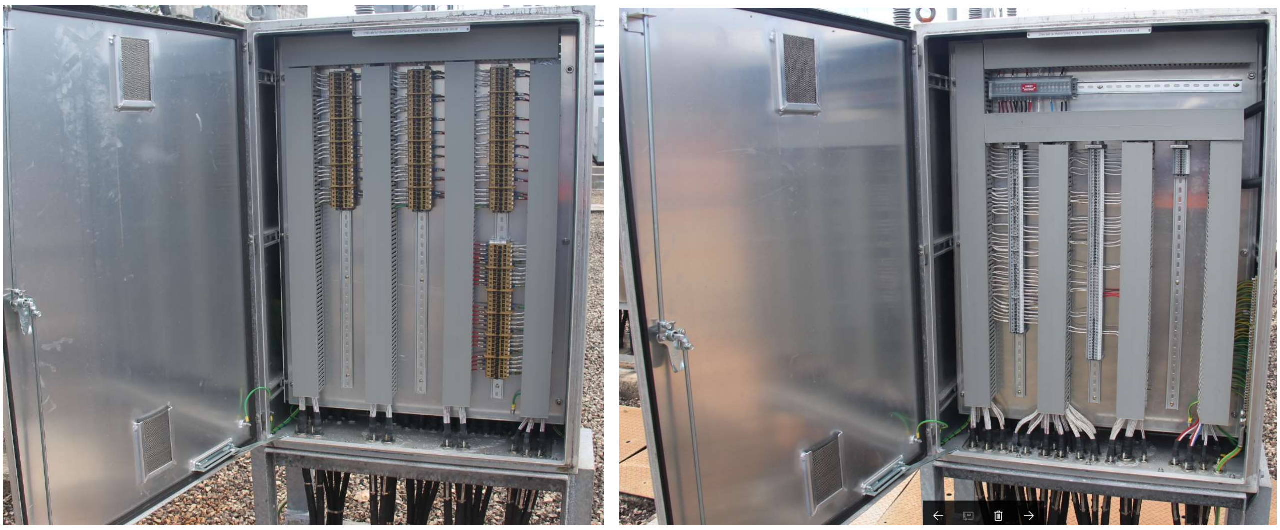
Marshalling kiosk for 275kV bus coupler 506 was installed in 2003. Marshalling kiosks and associated control cables are in fair condition. There are no condition driven replacements required until 2043.

275kV Bay 6 coupler bay marshalling kiosk

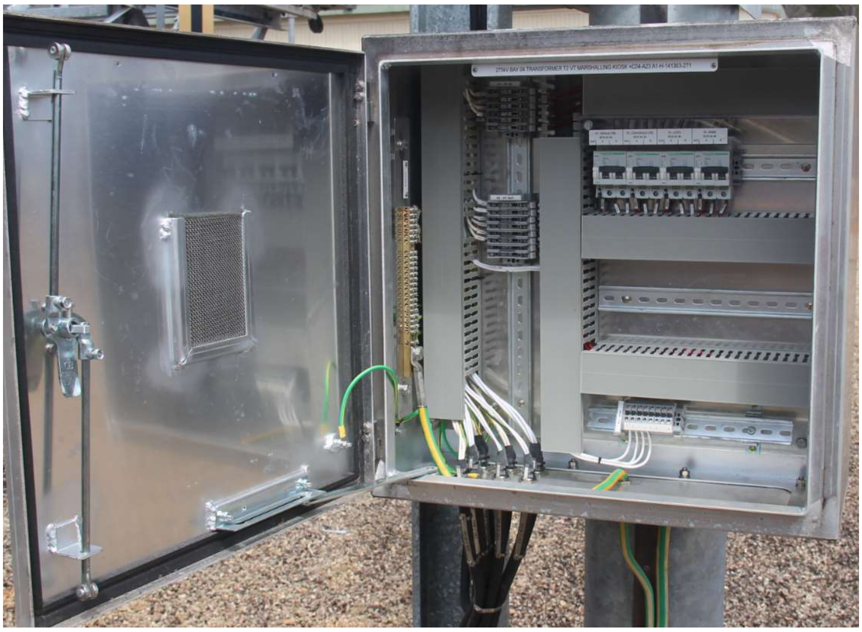
Marshalling kiosks and VT boxes for 275kV 1 and 2 Transformer were replaced under CP.01566 Chalumbin secondary system replacement between 2011 and 2012. Marshalling kiosks and associated control cables are in good condition. There are no condition driven replacements required until 2051.

275kV 1T bay marshalling kiosk

275kV 1T 16VT box

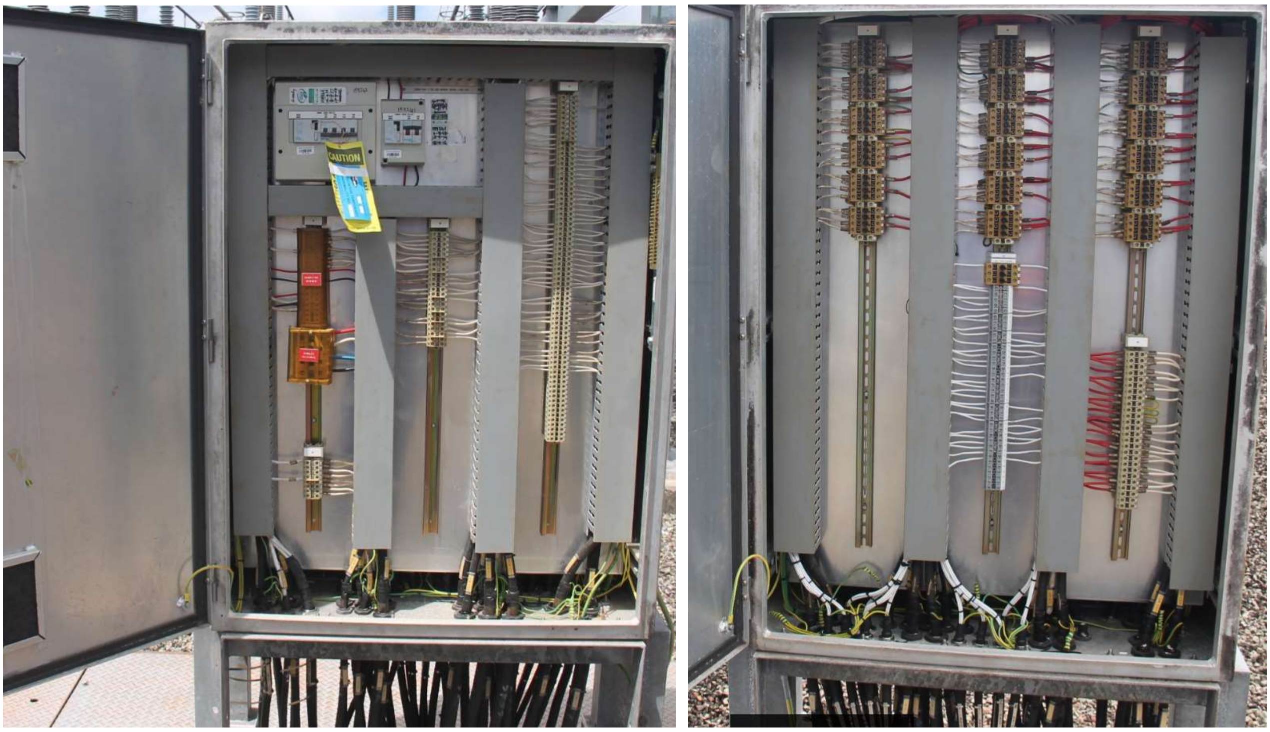


275kV 2T bay marshalling kiosk

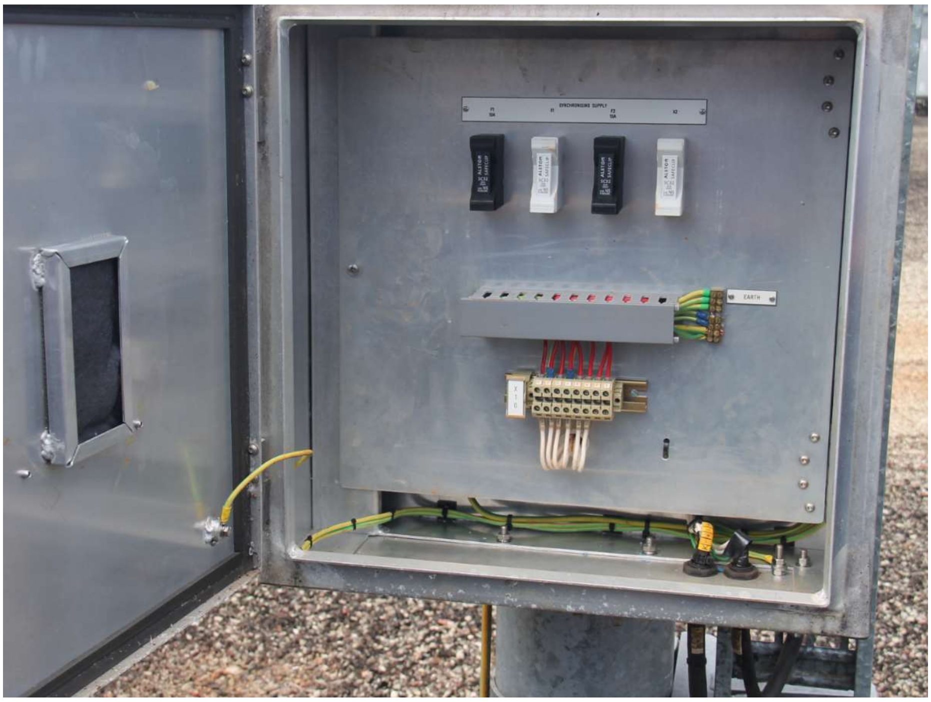


275kV 2T 17VT box

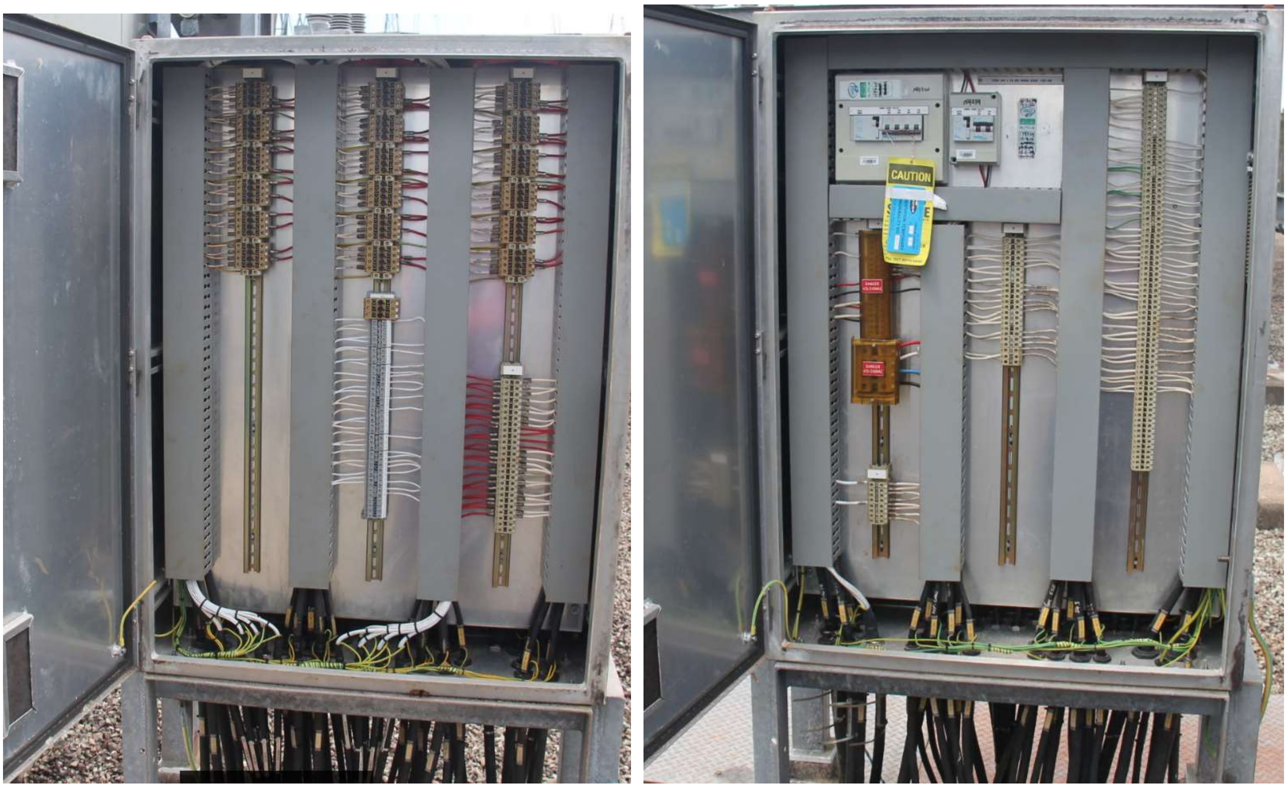
Marshalling kiosks and VT boxes for 275kV feeder 857, 858 and 877 were installed between 2003 and 2004. Marshalling kiosks are in fair condition and there is no condition driven replacement until 2043/2044. VT boxes utilise fuses to protect the circuitry. Fuses do not provide safety and monitoring features and make the event investigation more difficult. Maintenance on these fuses is expensive. These fuses should be replaced with MCBs to improve the performance of circuitries according to current design standard with major secondary system replacement.



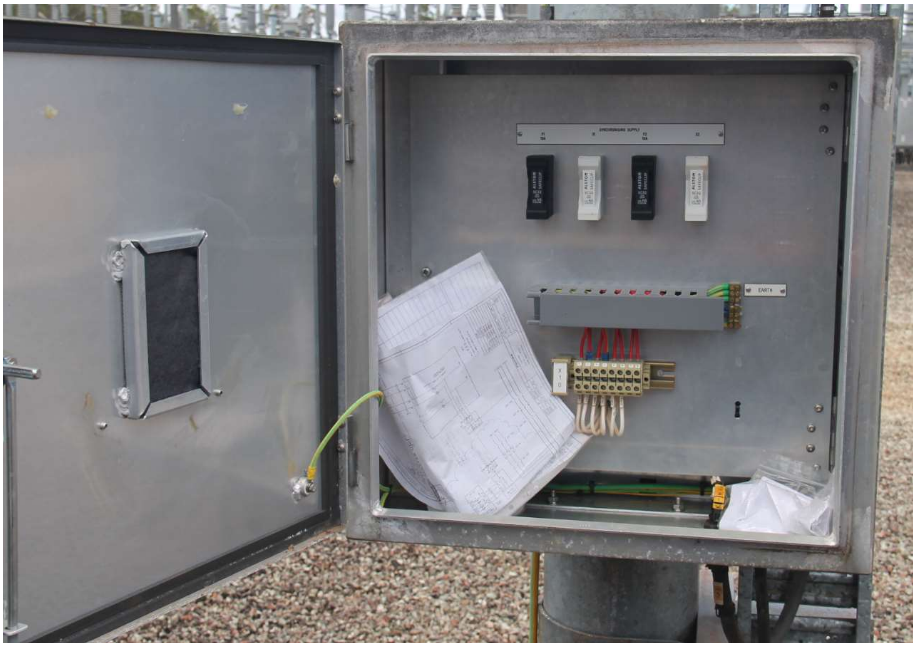
275kV Feeder 857 bay marshalling kiosk



275kV Feeder 857 2VT marshalling kiosk

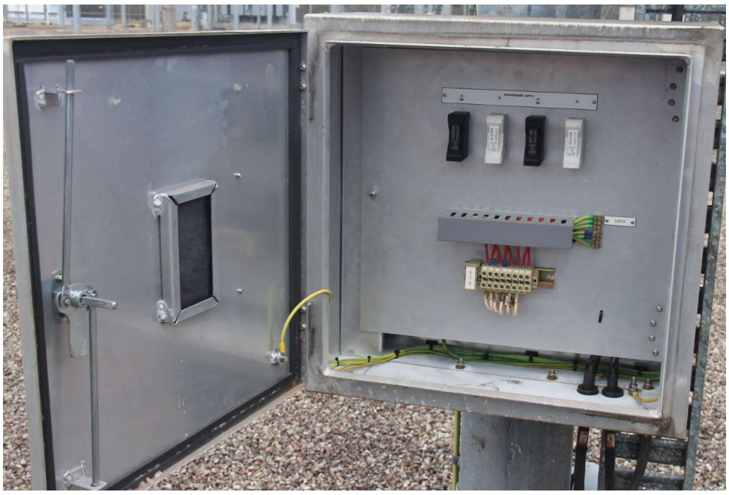



275kV Feeder 858 bay marshalling kiosk



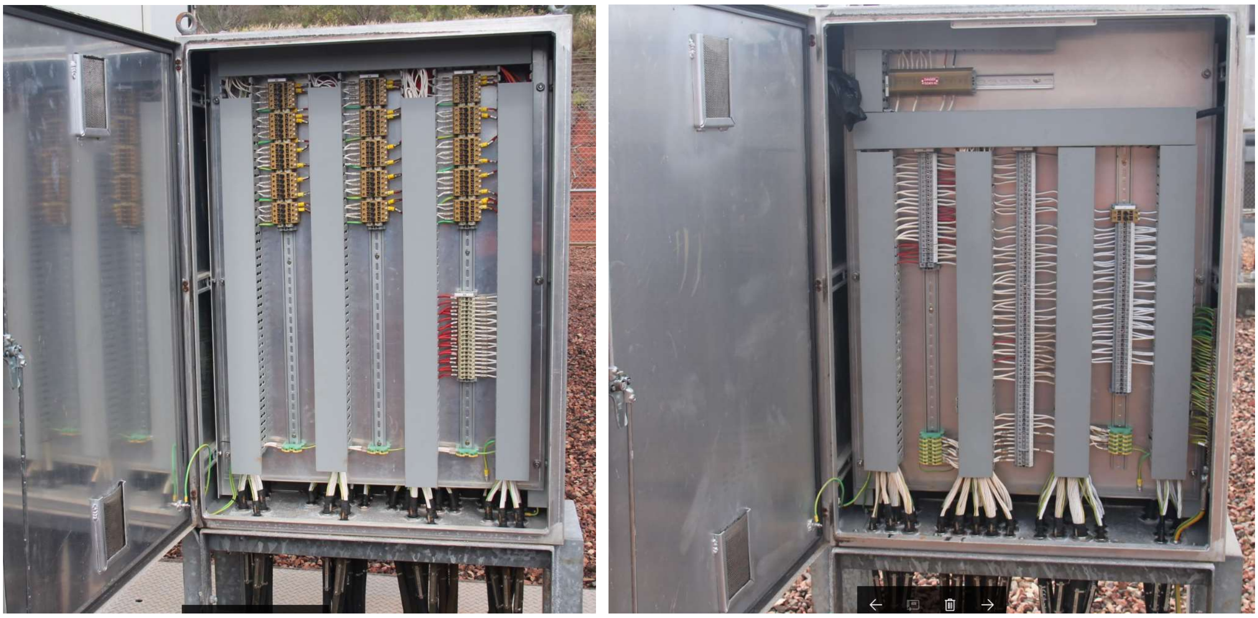
275kV Feeder 858 9VT marshalling kiosk


275kV Feeder 877 bay marshalling kiosk

275kV Feeder 877 13 and 18 VT marshalling kiosk

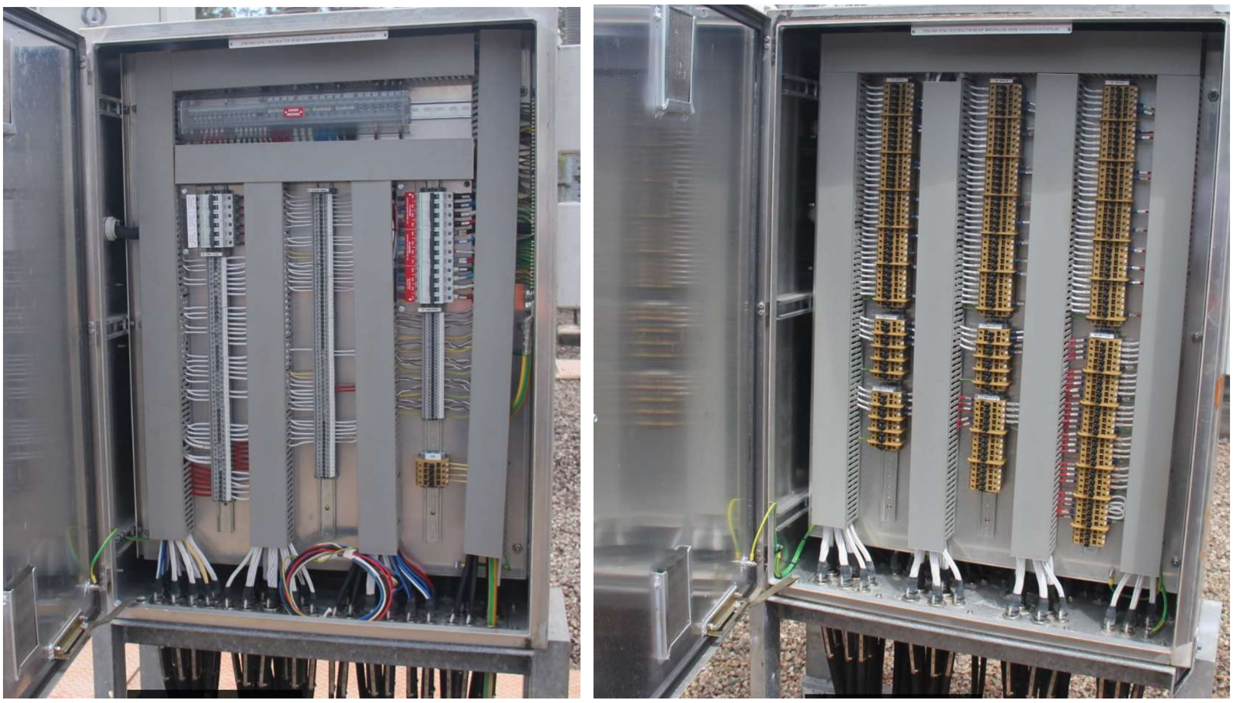
Marshalling kiosks and VT boxes for 275kV feeder 876 were installed in 2007 and are in good condition. There are no condition-driven required replacement until 2047.



275kV Feeder 876 bay marshalling kiosk

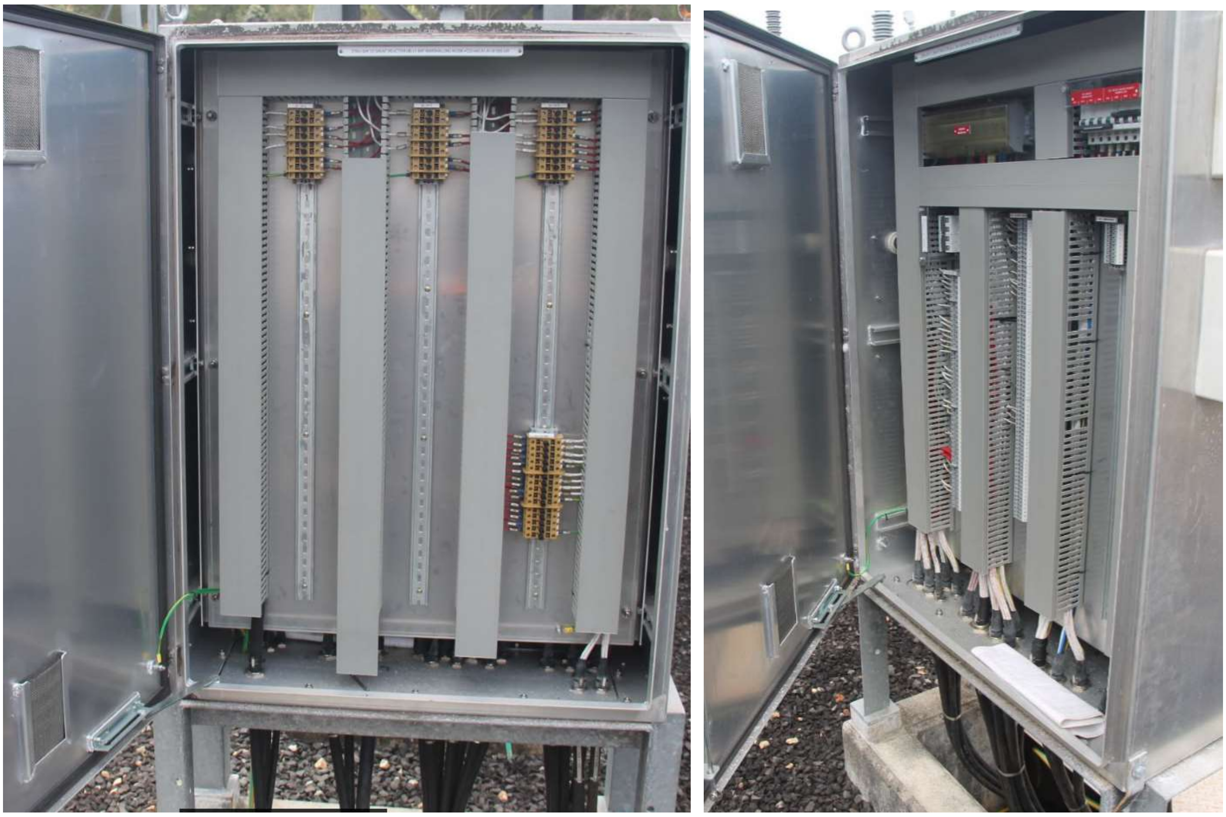

275kV feeder 876 19 and 20 VT marshalling kiosk

Marshalling kiosk for 275kV bus reactor 5 was installed in 2012/2013 and are in good condition. There are no condition-driven required replacement until 2052.

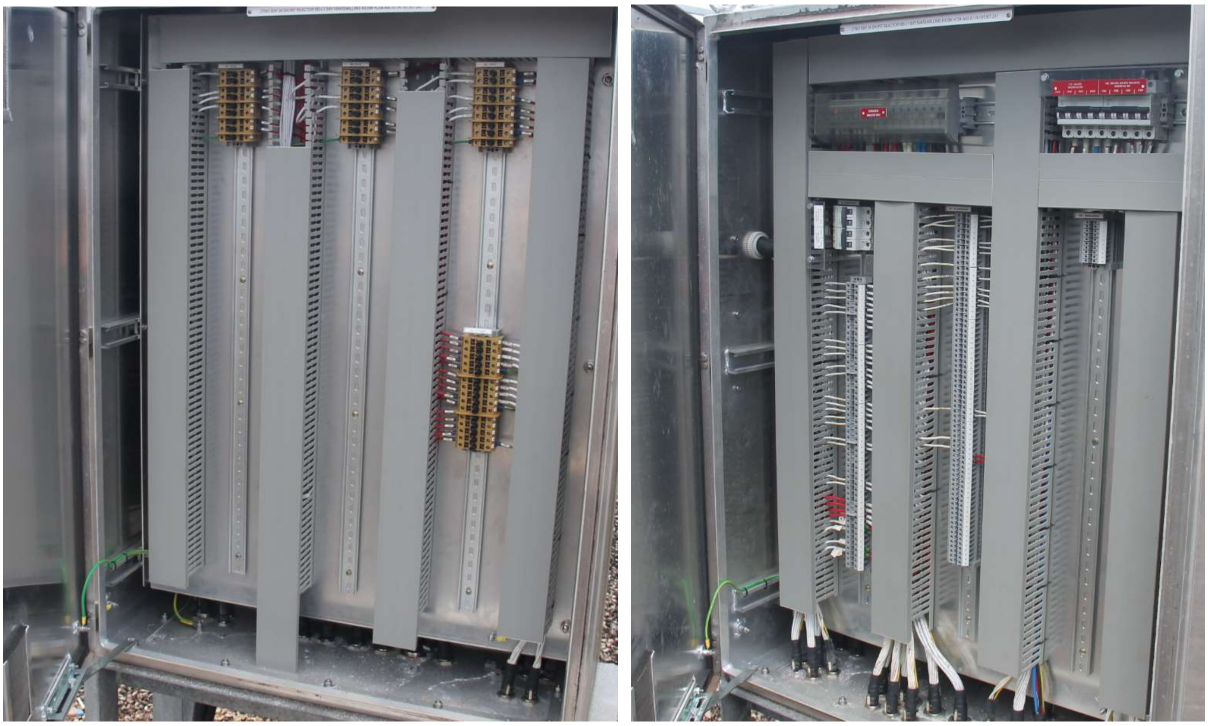


275kV bus reactor 5 bay marshalling kiosk

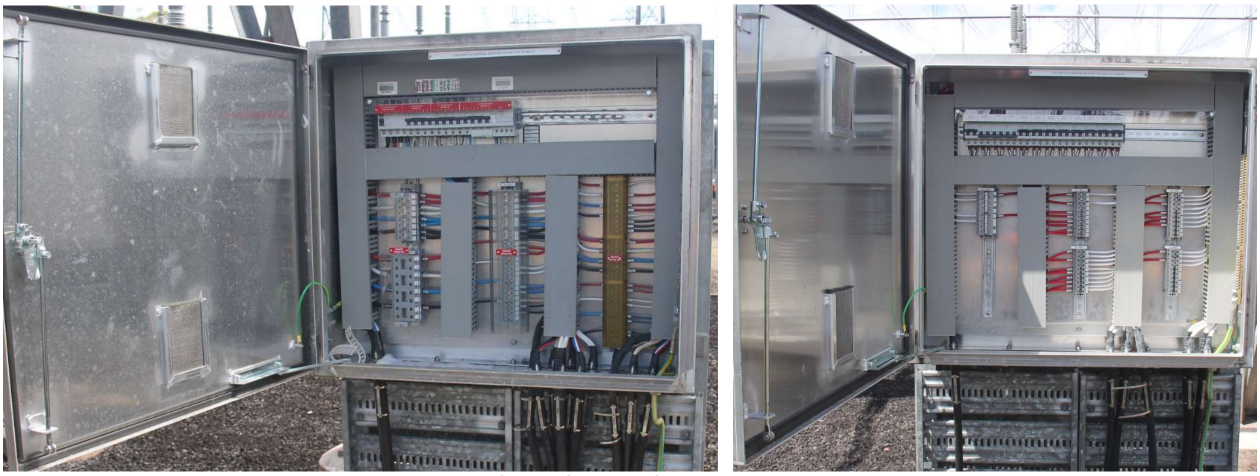
Marshalling kiosks for 275kV Feeder 857 and 858 reactor were replaced in 2011/2012 and are in good condition. There are no condition-driven required replacement until 2051.



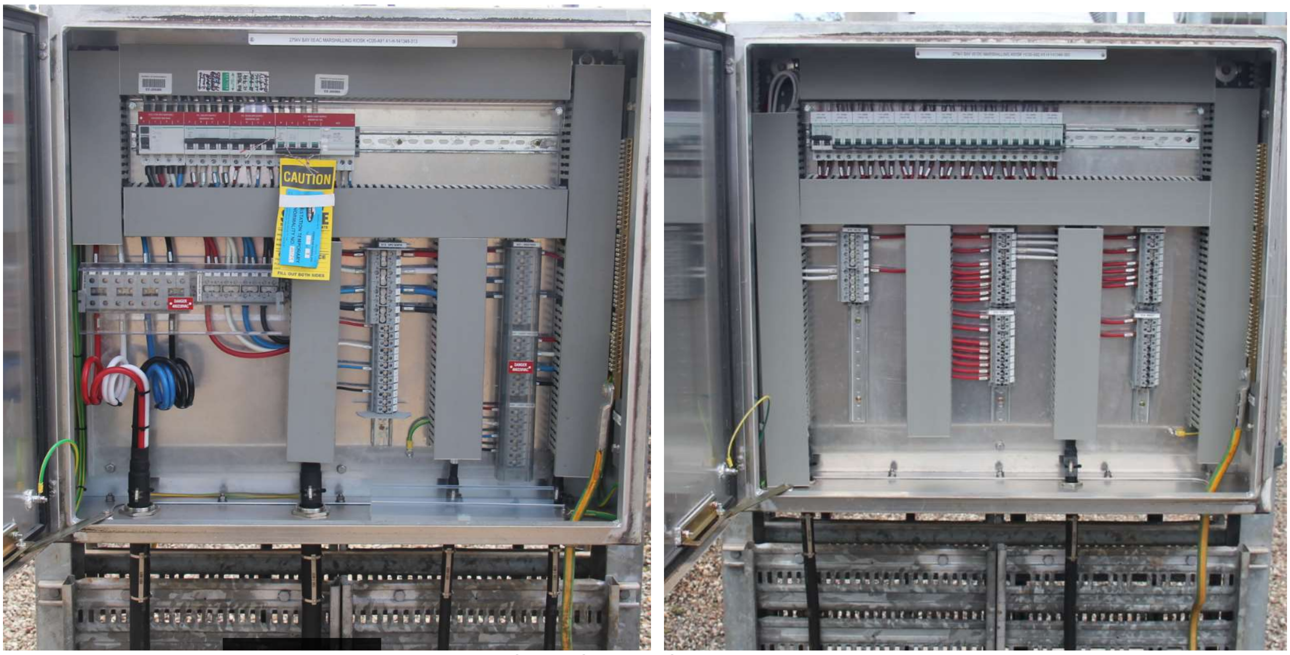
275kV Feeder 857 reactor marshalling kiosk


275kV Feeder 858 reactor marshalling kiosk

Auxiliary kiosks for 275kV diameter =C03, =C04 and =C05 were commissioned/replaced between 2011/2012. Marshalling kiosks and associated cables are in good condition. There are no condition driven replacement required until 2051.

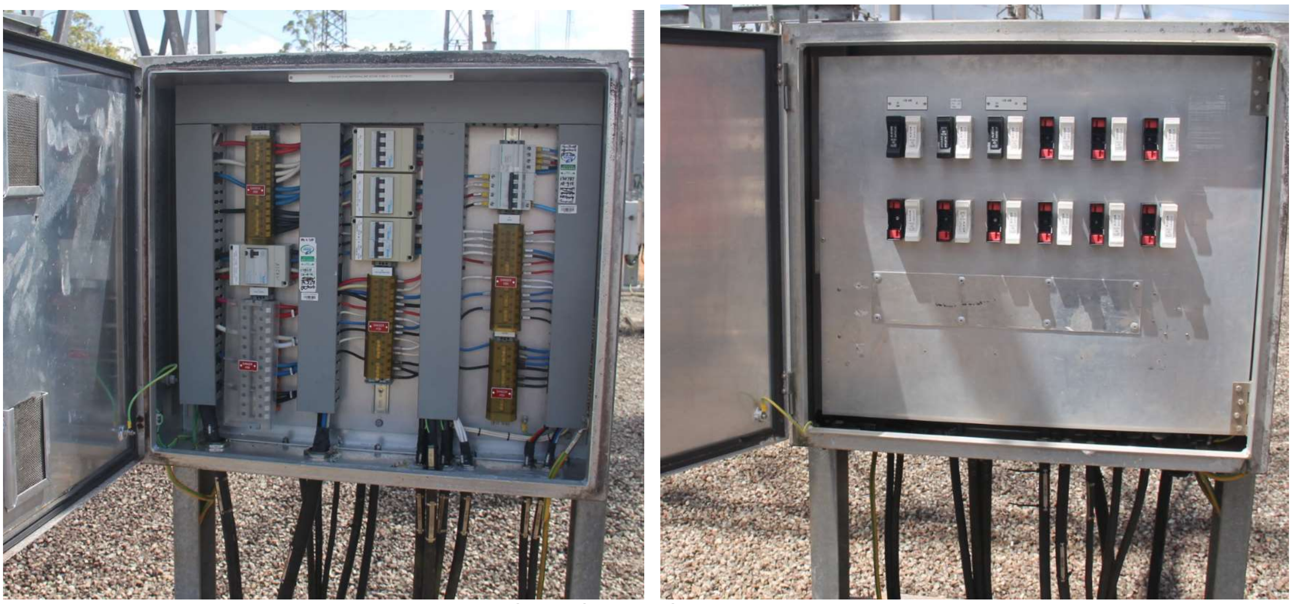

275kV =C03 AC and DC marshalling kiosk

275kV =C04 AC and DC marshalling kiosk




275kV =C05 AC and DC marshalling kiosk

AC marshalling kiosk for 275kV diameter =C06 was commissioned in 2007. Marshalling kiosks and associated cables are in fair condition. There are no condition driven replacement required until 2041. The DC marshalling kiosk for diameter =C06 was installed in 2003. Associated fuses do not provide safety and monitoring features and make the event investigation more difficult. Maintenance on these fuses is expensive. These fuses should be replaced with MCBs to improve the performance of circuitries according to current design standard with major secondary system replacement.



275kV =C06 AC and DC marshalling kiosk

It is a cable termination rack arrangement in Building +1 at H032 Chalumbin. But majority of control cables up to the marshalling kiosks have been wired directly to the protection and control panels and haven't been terminated via the terminal racks. The floor and support structure are intact. Termination racks were built in 1988 and old terminals need to be replaced if these rack are utilised for future secondary system replacement.

Termination racks

### 4.2.2 132kV yard

132kV bus and bus coupler marshalling kiosks (including VT boxes) were replaced under CP.01566 Chalumbin secondary system replacement in 2011. These kiosks and associated control cables are in good condition and there are no condition-driven replacements required until 2051.

132kV 1 Bus CT marshalling kiosk

132kV 1 bus VT box

132kV 2 Bus CT marshalling kiosk

132kV Bay =D03 coupler 411 marshalling kiosk

Marshalling kiosks and VT boxes of 1 and 2 Transformer LV were replaced under CP.01566 Chalumbin secondary system replacement in 2011. These kiosks and associated control cables are in good condition and there are no condition-driven replacements required until 2051.



132kV Bay =D04 1 Transformer LV bay marshalling kiosk


132kV Bay =D04 1 Transformer LV bay 3 VT box

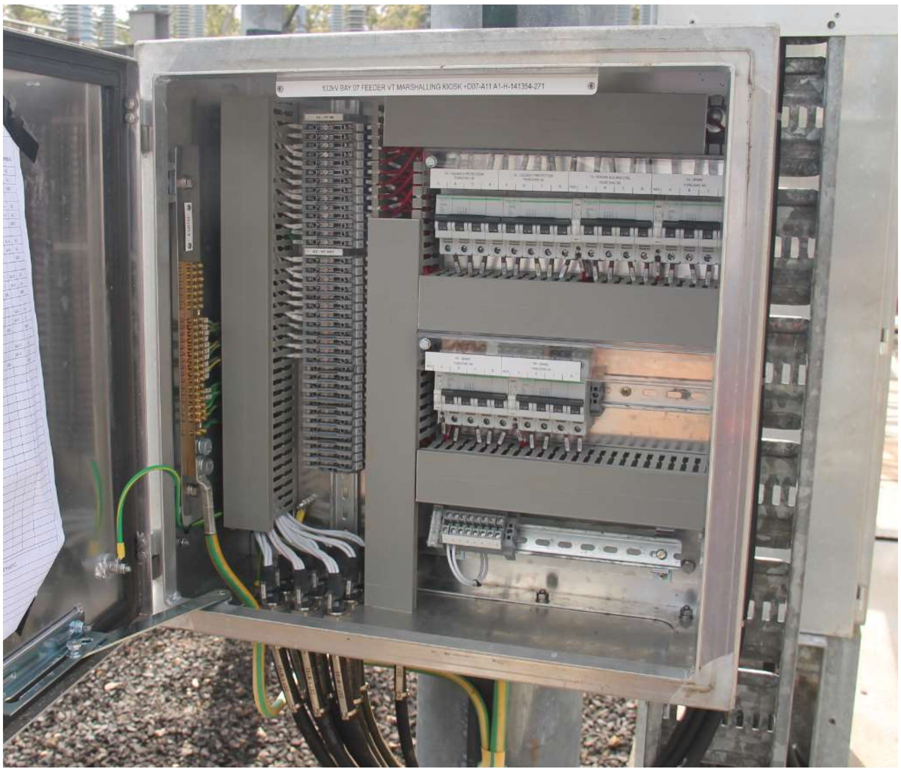

132kV Bay =D06 2 Transformer LV bay marshalling kiosk

Marshalling kiosks and VT boxes for feeder bay =D08, =D07, =D05 and =D06 were replaced under CP.01566 Chalumbin secondary system replacement in 2011. These kiosks and associated control cables are in good condition and there are no condition-driven replacements required until 2051.


132kV Bay =D08 Feeder 7165 bay marshalling kiosk

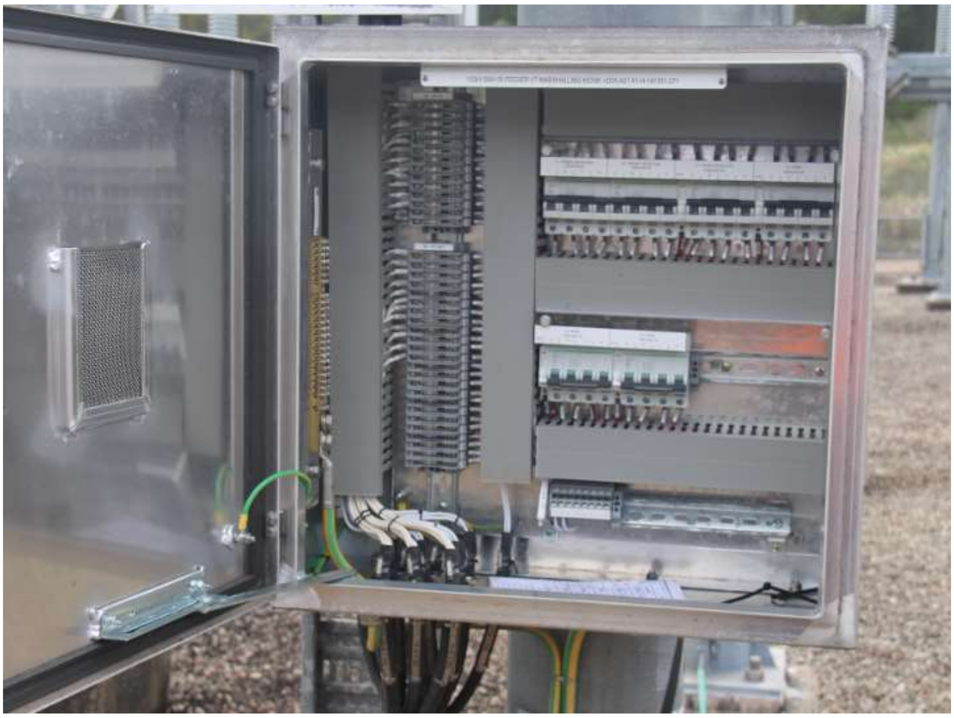
132kV Bay =D08 Feeder 7165 8VT box

132kV Bay =D07 Feeder 7166 bay marshalling kiosk



132kV Bay =D07 Feeder 7166 4VT box

132kV Bay =D05 Feeder 7191 bay marshalling kiosk



132kV Bay =D05 Feeder 7191 7VT box

132kV Bay =D06 Feeder 7192 bay marshalling kiosk

132kV Bay =D06 Feeder 7192 6VT box

AC/DC marshalling kiosks for 132kV bay =D04, =D06 and =D08 and marshalling kiosks for 1 CAP and 1T shunt reactor were replaced under CP.01566 Chalumbin secondary system replacement in 2011. These kiosks and associated control cables are in good condition and there are no condition-driven replacements required until 2051.

132kV Bay =D04 AC and DC marshalling kiosks


132kV Bay =D06 AC and DC marshalling kiosks


132kV Bay =D08 AC and DC marshalling kiosk

132kV =D09 1 CAP bay marshalling kiosk

132kV 1T shunt reactor marshalling kiosk

Electrical fence was installed at H032 Chalumbin in 2017 and associated control cubicles are in good condition.

Electric fence and associated control cubicle

## 4.3 Control and protection bays

### 4.3.1 Protection and control panels

Secondary systems at Chalumbin are housed in a type of swing frame panel. There are safety in design concerns on the type of swing frame panel, such as isolation issues and potential termination falling loose risks. Updates on the panel are required to be conducted with major secondary system replacement according to SU0020 Updates to SDM8 Panels to Mitigate Safety in Design Concerns (Obj ID: A2753457) .

### 4.3.2 275kV Bus zones and couplers

Equipment details of 275kV bus zones and couplers are given below:

| 275kV Bus and coupler | Relay & control | Model | Startup Date | Still Manufactured? | Manufacture Support? | PLQ Spares | Health Index |
|---|---|---|---|---|---|---|---|
| 1 Bus | X | [redacted] | 2004 | Yes | Yes | Yes | 7.50 |
| | | | 2004 | Yes | Yes | Yes | 7.50 |
| | | | 2004 | Yes | Yes | Yes | 7.50 |
| | | | 2004 | Yes | Yes | Yes | 7.50 |
| | Y | | 2004 | Yes | Yes | Yes | 7.50 |
| | | | 2004 | Yes | Yes | Yes | 7.50 |
| | | | 2004 | Yes | Yes | Yes | 7.50 |
| | | | 2004 | Yes | Yes | Yes | 7.50 |
| 2 Bus | X | | 2004 | Yes | Yes | Yes | 7.50 |
| | | | 2004 | Yes | Yes | Yes | 7.50 |
| | | | 2004 | Yes | Yes | Yes | 7.50 |
| | | | 2004 | Yes | Yes | Yes | 7.50 |
| | Y | | 2004 | Yes | Yes | Yes | 7.50 |
| | | | 2004 | Yes | Yes | Yes | 7.50 |
| | | | 2004 | Yes | Yes | Yes | 7.50 |
| | | | 2004 | Yes | Yes | Yes | 7.50 |
| Coupler 503 | X | | 2013 | No | No | Yes | 4.74 |
| | Y | | 2013 | No | Yes | Yes | 3.39 |
| | RTU | | 2011 | No | Yes | Limited | 5.25 |
| Coupler 504 | X | | 2013 | No | No | Yes | 4.74 |
| | Y | | 2013 | No | Yes | Yes | 3.39 |
| | RTU | | 2013 | No | Yes | Limited | 6.25 |
| Coupler 506 | X | | 2004 | No | No | Yes | 7.5 |
| | Y | | 2004 | Yes | Yes | Yes | 7.5 |
| | RTU | | 2004 | No | Yes | Limited | 7.5 |

High impedance differential relays [redacted] are used to protect 275kV 1 and 2 bus. Powerlink has recovered modules of [redacted] RTU such as the CPU, ACT and ADI card. But these cards have been in service for more than 20 years and the capacitor electrolyte might have been dried out. These recovered parts would be utilised only for emergency replacement. Powerlink has conducted a last buy in 2014 and are relying on these RTUs for maintenance spares. Health Index indicates that all protection and control systems for 275kV 1 and 2 Bus will reach the end of technical asset life and need to be replaced by 2024.

275kV 1 & 2 Bus protection and CB fail bus trip panel

Secondary systems for 275kV coupler 503 and 504 were replaced under CP.01566 Chalumbin secondary system replacement in 2013. These secondary systems are in fair condition and there are no condition driven replacements required until 2033.

Coupler 503 protection/control panel

Coupler 504 protection/control panel

Secondary systems for 275kV coupler 506 were commissioned in 2004. Health Index indicates that all protection and control systems for 275kV Coupler 6 will reach the end of technical asset life and need to be replaced by 2024.

Coupler 506 protection/control panel

### 4.3.3 275/132kV transformer bays

Equipment for 275/132kV transformer bays is detailed below.

| Transformer | Relay & control | | Model | Startup Date | Still Manufactured? | Manufacture Support? | PLQ Spares | Health Index |
|---|---|---|---|---|---|---|---|---|
| 1T | 275kV | X | [redacted] | 2013 | Yes | Yes | Yes | 5.03 |
| | | Y | [redacted] | 2013 | No | Yes | Yes | 5.15 |
| | | Local RTU | [redacted] | 2013 | No | Yes | Limited | 6.25 |
| | 132kV | X CB MGMT | [redacted] | 2013 | No | No | Yes | 4.74 |
| | | Y CB MGMT | [redacted] | 2013 | No | Yes | Yes | 3.39 |
| | | Local RTU | [redacted] | 2013 | No | Yes | Limited | 6.25 |
| 2T | 275kV | X | [redacted] | 2013 | Yes | Yes | Yes | 5.03 |
| | | Y | [redacted] | 2013 | No | Yes | Yes | 5.15 |
| | | Local RTU | [redacted] | 2013 | No | Yes | Limited | 6.25 |
| | 132kV | X CB MGMT | [redacted] | 2013 | No | No | Yes | 4.74 |
| | | Y CB MGMT | [redacted] | 2013 | No | Yes | Yes | 3.39 |
| | | Local RTU | [redacted] | 2013 | No | Yes | Limited | 6.25 |

Protection and control equipment including the panel for 1& 2 275/132kV transformer were replacement under CP.01566 Chalumbin secondary system replacement in 2013. These secondary systems are in good condition. Health index indicate that there are no condition-driven replacements required until 2033.

1 Transformer 275/132kV protection and control panel

2 Transformer 275/132kV protection and control panel

### 4.3.4 275kV feeder bays

Protection and control equipment for 275kV feeder bays are detailed in the following table.

| Feeder | Relay & control | Model | Startup Date | Still Manufactured? | Manufacture Support? | PLQ Spares | Health Index |
|---|---|---|---|---|---|---|---|
| 857 | X | [redacted] | 2006 | No | No | Yes | 7.77 |
| | | | 2009 | No | Yes | Yes | 5.35 |
| | Y | | 2006 | No | No | Yes | 6.71 |
| | CVT Monitoring | | 2006 | No | No | Yes | 6.71 |
| | Bay control | | 2006 | No | Yes | Limited | 6.71 |
| 858 | X | | 2005 | No | No | Yes | 7.02 |
| | | | 2009 | No | Yes | Yes | 5.35 |
| | Y | | 2006 | No | No | Yes | 6.60 |
| | CVT Monitoring | | 1999 | No | No | Yes | 10.00 |
| | Bay control | | 2005 | No | Yes | Limited | 7.11 |
| 876 | X | | 2018 | No | Yes | Yes | 0.61 |
| | Y | | 2009 | No | No | Yes | 5.27 |
| | Bay control | | 2007 | No | Yes | Limited | 6.25 |
| 877 | X | | 2012 | No | Yes | Yes | 5.77 |
| | | | 2004 | No | No | Yes | 7.50 |
| | | | 2012 | No | Yes | Yes | 5.77 |
| | | | 2012 | No | Yes | Yes | 3.71 |

| Feeder | Relay & control | Model | Startup Date | Still Manufactured? | Manufacture Support? | PLQ Spares | Health Index |
|---|---|---|---|---|---|---|---|
| | Y | [redacted] | 2004 | No | No | Yes | 7.50 |
| | Bay control | | 2004 | No | Yes | Limited | 7.50 |

Majority of protection and control equipment (except [redacted] for feeders 857 and 858 were commissioned between 2005 and 2006. These devices have become obsolete and manufacturers have ceased the support. Health index shows that they will reach the end of technical asset life and need to be replaced between 2025 and 2026.

Feeder 857 protection and control panel

Feeder 858 protection and control panel

Feeder bay 876 was built as part of Woree 275kV reinforcement in 2007. X protection was replaced under CP.02613 Walkamin Sub in 2018. The bay controller RTU and Y protection were installed/refurbished between 2007 and 2009. Associated health index indicates that both Y protection and [redacted] RTU will reach the end of technical asset life and need to be replaced between 2027 and 2029.

Feeder 876 bay protection/control panel

Secondary systems for feeder 877 were commissioned in 2004 (except X protection P546 was replaced under CP.02059 Woree-Chalumbin SPAR in 2012). Health index indicates that these equipment (Communication interface [redacted] RTU) will reach the end of technical asset life and need to be replaced in 2024.

Feeder 877 bay protection/control panel

There is a special arrangement for Woree-Chalumbin feeder 877 on Single Pole Auto-reclose (SPAR) due to the underground cable section. Associated protection [redacted] and protection signalling [redacted] were installed in 2012 and are in fair condition. But associated protection and comms devices are housed within a tunnel type of construction which has constrained spaces. The panel has exposed terminal in the rear of the panel which could cause safety issues. This type of construction is vulnerable to cause human error on mis-tripping of primary plant when maintenance is conducted and it is also expensive to modify because of the inter panel wiring. These equipment with the panel should be replaced with major secondary system replacement on that bay.

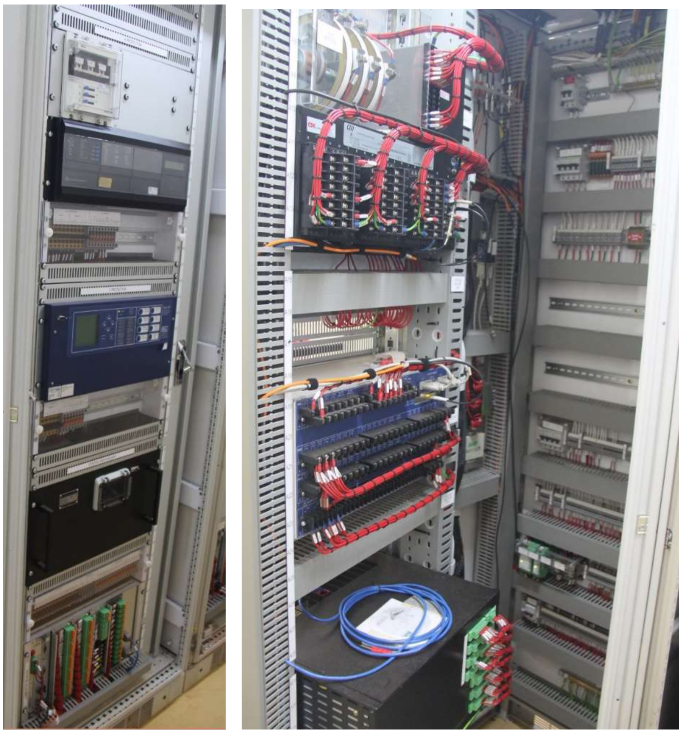
Feeder 877 SPAR scheme panel

### 4.3.5 275kV Reactors

Secondary systems for 275kV reactors are detailed in a table below.

| Reactor | Relay & control | Model | Startup Date | Still Manufactured? | Manufacture Support? | PLQ Spares | Health Index |
|---|---|---|---|---|---|---|---|
| Bus reactor | X | [redacted] | 2014 | Yes | Yes | Yes | 2.74 |
| | | | 2014 | No | No | Yes | 4.74 |
| | Y | | 2014 | No | Yes | Yes | 4.80 |
| | POW | | 2014 | Yes | Yes | Yes | 6.45 |
| | Local RTU | | 2014 | No | Yes | Limited | 6.25 |
| 857 Feeder reactor | X | | 2014 | Yes | Yes | Yes | 2.70 |
| | | | 2014 | No | No | Yes | 4.74 |
| | Y | | 2014 | No | Yes | Yes | 3.39 |
| | POW | | 2014 | Yes | Yes | Yes | 7.54 |
| | Local RTU | | 2014 | No | Yes | Limited | 6.25 |
| 858 Feeder reactor | X | | 2014 | Yes | Yes | Yes | 2.67 |
| | | | 2014 | No | No | Yes | 4.74 |
| | Y | | 2014 | No | Yes | Yes | 3.39 |
| | POW | | 2014 | Yes | Yes | Yes | 7.54 |
| | Local RTU | | 2014 | No | Yes | Limited | 6.25 |

High Impedance [redacted] and CB management relay [redacted] and [redacted] are used to protect 275kV bus reactor, Feeder 857 and 858 reactor and mounted on a swing frame panel. These relays have been providing reliable services. There are no condition-driven replacements required until 2034.



275kV Bus reactor protection and control panel

857 feeder reactor protection and control panel

858 feeder reactor protection and control panel

### 4.3.6 132kV Bus zones and coupler bays

Secondary systems for 132kV bus zones and coupler bays are listed in a table below.

| 132kV Bus | Relay & control | Model | Startup Date | Still Manufactured? | Manufacture Support? | PLQ Spares | Health Index |
|---|---|---|---|---|---|---|---|
| 1 Bus | X | [redacted] | 2013 | Yes | Yes | Yes | 2.95 |
| | | | 2013 | Yes | Yes | Yes | 2.95 |
| | | | 2012 | Yes | Yes | Yes | 2.95 |
| | | | 2012 | Yes | Yes | Yes | 3.57 |
| | Y | | 2012 | Yes | Yes | Yes | 3.57 |
| | | | 2012 | Yes | Yes | Yes | 3.57 |
| | | | 2012 | Yes | Yes | Yes | 3.57 |
| | | | 2012 | Yes | Yes | Yes | 3.57 |
| | Bay control | | 2012 | No | Yes | Limited | 6.25 |
| 2 Bus | X | | 2012 | Yes | Yes | Yes | 3.57 |
| | | | 2012 | Yes | Yes | Yes | 3.57 |
| | | | 2012 | Yes | Yes | Yes | 3.57 |
| | | | 2012 | Yes | Yes | Yes | 3.57 |
| | Y | | 2012 | Yes | Yes | Yes | 3.57 |
| | | | 2012 | Yes | Yes | Yes | 3.57 |
| | | | 2012 | Yes | Yes | Yes | 3.57 |
| | | | 2012 | Yes | Yes | Yes | 3.57 |
| | Bay control | | 2012 | No | Yes | Limited | 6.25 |
| Coupler 411 | X | | 2012 | No | No | Yes | 6.25 |
| | Y | | 2012 | No | Yes | Yes | 4.74 |
| | Bay control | | 2012 | No | Yes | Limited | 3.57 |

Secondary systems for 132kV bus zones and the bus coupler were replaced under CP.01566 Chalumbin secondary system replacement between 2012 and 2013. They are in good condition. There are no condition-driven replacements required until 2032.

132kV 1 Bus zone protection and control panel

132kV 2 Bus zone protection and control panel

132kV Bus coupler protection and control panel

### 4.3.7 132kV feeder bays

Secondary systems for 132kV feeder bays are detailed in a table below.

| Feeder | Relay & control | Model | Startup Date | Still Manufactured? | Manufacture Support? | PLQ Spares | Health Index |
|---|---|---|---|---|---|---|---|
| 7165 | X | [redacted] | 2013 | No | Yes | Yes | 5.77 |
| | | | 2013 | No | Yes | Yes | 3.60 |
| | Y | | 2013 | Yes | Yes | Yes | 5.36 |
| | Bay control | | 2013 | No | Yes | Yes | 6.25 |
| 7166 | X | | 2013 | No | Yes | Yes | 5.77 |
| | | | 2013 | No | Yes | Yes | 3.60 |
| | Y | | 2013 | Yes | Yes | Yes | 5.36 |
| | Bay control | | 2013 | No | Yes | Yes | 6.25 |
| 7191 | X | | 2012 | No | Yes | Yes | 5.77 |
| | | | 2012 | No | Yes | Yes | 3.60 |
| | Y | | 2012 | Yes | Yes | Yes | 5.36 |
| | | | 2012 | Yes | Yes | Yes | 3.44 |
| | Bay control | | 2012 | No | Yes | Yes | 6.25 |
| 7192 | X | | 2012 | No | Yes | Yes | 5.77 |
| | | | 2012 | No | Yes | Yes | 3.60 |
| | Y | | 2012 | Yes | Yes | Yes | 5.36 |
| | | | 2012 | Yes | Yes | Yes | 3.42 |

| Feeder | Relay & control | Model | Startup Date | Still Manufactured? | Manufacture Support? | PLQ Spares | Health Index |
|---|---|---|---|---|---|---|---|
| | Bay control | [redacted] | 2012 | No | Yes | Yes | 6.225 |

Secondary systems for 132kV Feeder 7165, 7166, 7191 and 7192 were replaced under CP.01566 Chalumbin secondary system replacement between 2012 and 2013. They are in good condition. There are no condition-driven replacements required until 2032-2033.

Feeder 7165 protection and control panel

Feeder 7166 protection and control panel

Feeder 7191 protection and control panel

Feeder 7192 protection and control panel

### 4.3.8 132kV 1 Capacitor bank

Secondary systems for 132kV 1 capacitor bank are detailed in a table below:

| Capacitor | Relay & control | Model | Startup Date | Still Manufactured? | Manufacture Support? | PLQ Spares | Health Index |
|---|---|---|---|---|---|---|---|
| 1 CAP | X | [redacted] | 2004 | Yes | Yes | Yes | 7.53 |
| | | | 2013 | Yes | Yes | Yes | 3.21 |
| | | | 2013 | No | No | Yes | 4.74 |
| | Y | | 2013 | Yes | Yes | Yes | 3.39 |
| | Point On Wave | | 2013 | No | Yes | Yes | 4.51 |
| | Bay control | | 2013 | No | Yes | Yes | 6.25 |

Secondary systems on 132kV 1 Capacitor bank were replaced in 2013. There are no condition-driven replacements required (except [redacted] O/C relay) until 2033. The O/C relay, [redacted] needs to be replaced in 2024 based on associated health index.

1 CAP protection and control panel

### 4.3.9 19kV Reactor

Secondary systems for 19kV Reactor are detailed in a table below.

| Reactor | Relay & control | | Model | Startup Date | Still Manufactured? | Manufacture Support? | PLQ Spares | Health Index |
|---|---|---|---|---|---|---|---|---|
| 1 Reactor | 19kV | X | [redacted] | 2011 | No | No | Yes | 4.74 |
| | | | | 2013 | Yes | Yes | Yes | 3.15 |
| | | Y | | 2013 | Yes | Yes | Yes | 3.39 |
| | | Bay control | | 2013 | No | No | Yes | 6.25 |

Secondary systems for 19kV reactor were replaced under CP.01566 Chalumbin secondary system replacement 2013. There are no condition-driven replacements required until 2033.

19kV Reactor protection and control panel

### 4.3.10 Power System Control and Monitoring

Power system control and monitoring equipment is detailed in a table below:

| Power System Control and monitoring | Relay & control | Model | Startup Date | Still Manufactured? | Manufacture Support? | PLQ Spares | Health Index |
|---|---|---|---|---|---|---|---|
| Monitoring | Fault locator | [redacted] | 2010 | No | Yes | Yes | 5.00 |

Travelling wave based fault locator was installed in 2010 and is in fair condition. Health index indicates that there is no condition-driven replacement required within 10 years.


Hathaway travelling wave fault locater

## 4.4 Metering

There are no revenue metering for the electricity market at H032 Chalumbin.

## 4.5 Non-bays

Secondary systems for Non-bays at H032 Chalumbin are detailed in the following table:

| NBay | Relay & control | Model | Startup Date | Still Manufactured? | Manufacture Support? | PLQ Spares | Health Index |
|---|---|---|---|---|---|---|---|
| Local control (+1) | HMI Terminal | [redacted] | 2012 | Yes | Yes | Yes | 7.00 |
| | Common RTU | [redacted] | 2014 | No | Yes | Yes | 5.24 |
| Local control (+4) | HMI | [redacted] | 2012 | No | No | Limited | 8.35 |
| | Common RTU | [redacted] | 2012 | No | Yes | Yes | 6.25 |
| Master OpsWAN (+1) | Router | [redacted] | 2009 | No | Yes | Yes | 10.00 |
| | Ethernet Switch | [redacted] | 2001 | No | No | Yes | 10.00 |
| | Serial Port Server | [redacted] | 2001 | No | No | Yes | 10.00 |
| | | [redacted] | 2001 | No | No | Yes | 10.00 |
| | Terminal Server | [redacted] | 2001 | No | Yes | Yes | 10.00 |
| Station OpsWAN (+4) | Ethernet Switch | [redacted] | 2012 | Yes | Yes | Yes | 6.89 |
| | | [redacted] | 2012 | Yes | Yes | Yes | 6.89 |
| | Serial Port Server | [redacted] | 2012 | Yes | Yes | Yes | 6.89 |
| SCADA (+4) | NSC1 | [redacted] | 2012 | No | Yes | Yes | 6.25 |
| | NSC2 | [redacted] | 2012 | No | Yes | Yes | 6.25 |
| Timing Clock | GPS Clock (+1) | [redacted] | 1989 | No | Yes | Yes | 10.00 |
| | GPA Clock (+4) | [redacted] | 2012 | Yes | Yes | Yes | 5.47 |

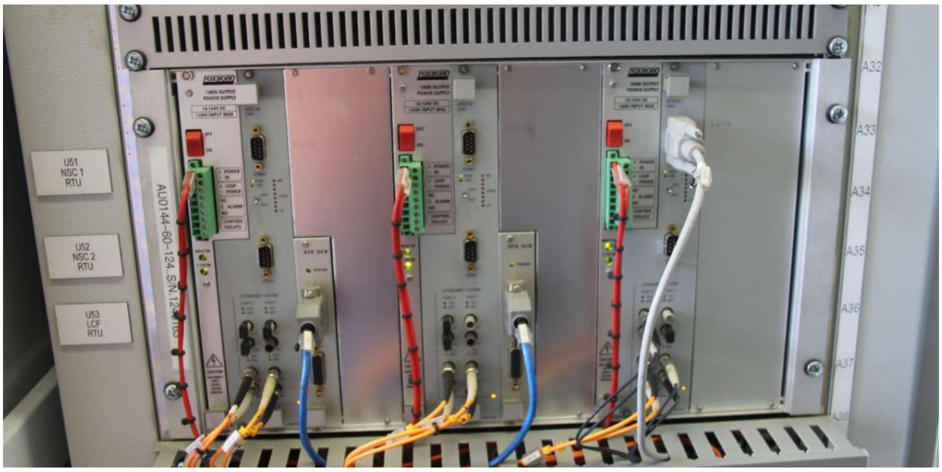
### 4.5.1 SCADA, Control and OpsWAN

Both 275kV and 132kV OptoNet ring were merged into one under CP.01566 Chalumbin secondary system replacement in 2012.

[redacted]

Optonet  network overview

Dedicated SCADA paths have been implemented for 275/132kV secondary systems at H032 Chalumbin. The SCADA system has independent NSC1 and NSC2 RTU to implement 2 x dual SCADA paths based on DNP serial protocol. The serial SCADA is being phased out because of expensive serial infrastructures and will be migrated to DNP over IP under major secondary system replacement.



SCADA NSC1/NSC2 RTU and LCF RTU

[redacted]n Workstation is used for the local control. There are only limited spares available. This equipment needs to be replaced with major secondary system replacement.

[redacted]

[redacted]

Master OpsWAN network in +1 was installed in 2001. Health index indicates that these equipment have reached the end of technical asset life need to be replaced in 2020. Powerlink's strategy is to carry out associate replacement with major secondary system replacement projects.

Master OpsWan panel in Building +1

OpsWAN equipment in Building +4 was installed in 2012 and are in fair condition. Health index indicates that these equipment will reach the end of technical asset life and need to be replaced between 2024 and 2025.

Station OpsWAN panel in Building +4

### 4.5.2 Auxiliary supply

The 415VAC auxiliary supplies are derived from two Powerlink 19.1/433V 315kVA and 200kVA station transformers. Standby AC supply is from an on-site 150kVA diesel generator. Suitable monitoring and changeover arrangement are available for the site. The arrangement is considered acceptable for the situation.


Station transformer 1 and 2

AC change over board was installed in 2009 and is in fair condition.

AC changeover board

On site diesel generator

The AC distribution boards in building +1 were installed in 2012 and are in good condition.

AC distribution board in Building +1

The dual 125VDC and dual 48VDC systems and associated distribution board were replaced in 2014 and 2012 respectively. There are no condition driven replacements required until 2026 and 2024.

125VDC Batteries and charger


48VDC Batteries and charger in building +1

AC distribution boards and associated DC distribution boards in Building +4 were installed in 2012 and are in good condition. There are no condition driven replacements required within 10 years. Dual 125VDC will reach the end of technical asset life and need to be replaced by 2024.

AC distribution boards in building +4


125VDC Batteries and charger in building +4

# 5. Telecommunication

Communication systems at H032 Chalumbin consist of fibre optic technology with Nokia PDH and Huawei SDH MUX equipment. They have been providing reliable services for protection and control systems. Nokia no longer manufacturers the PDH equipment, and support for hardware replacement is provided by AVARA.

SDH and PDH at Building +1

PDH at Building +4

MPLS network has been installed at H032 Chalumbin substation. It can be used by future secondary systems such as SCADA and metering implementation.

MPLS network panel

# 6. Summary of Asset Health

The asset health of H032 Chalumbin secondary system assets is determined by an assessment of the equipment aging profile, reliability, conditions (including the condition of panel wirings, control cables and marshalling cubicles) and obsolescence. Asset health index of equipment at H032 Chalumbin are summarized in the table below:-

| Bay | Functional Loc. | Description | Model number | In Service Date | Health Index | Still Manifactured? | Sec Sys Equipment to be replaced | Protection/control panel HI | Protection/control panel to be replaced | Marhsalling kiosks and Control cables HI | Marshalling kiosks and Control cables to be replaced |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 132kV 1 Bus | H032-SSS-1BU4-BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 15/08/2012 | 6.25 | No | 2032 | 1.75 | 2052 | 1.97 | 2051 |
| | H032-SSS-1BU4-XPROT | RELAY TRIPPING SUPPLY FAIL ALSTOM MVAX12 | | 13/11/2013 | 2.95 | Yes | | | | | |
| | H032-SSS-1BU4-XPROT | RELAY TRIPPING LOW BURDEN ALSTOM MVAJ13 | | 13/11/2013 | 2.95 | Yes | | | | | |
| | H032-SSS-1BU4-XPROT | RELAY CB FAIL BUS TRIP RACK | | 15/08/2012 | 3.57 | Yes | | | | | |
| | H032-SSS-1BU4-XPROT | RELAY DIFF ALSTOM MFAC34 RANGE 25-325VAC | | 13/11/2013 | 2.95 | Yes | | | | | |
| | H032-SSS-1BU4-YPROT | RELAY TRIPPING SUPPLY FAIL ALSTOM MVAX12 | | 15/08/2012 | 3.57 | Yes | | | | | |
| | H032-SSS-1BU4-YPROT | RELAY CB FAIL BUS TRIP RACK | | 15/08/2012 | 3.57 | Yes | | | | | |
| | H032-SSS-1BU4-YPROT | RELAY TRIPPING LOW BURDEN ALSTOM MVAJ13 | | 15/08/2012 | 3.57 | Yes | | | | | |
| | H032-SSS-1BU4-YPROT | RELAY DIFF ALSTOM MFAC34 RANGE 25-325VAC | | 15/08/2012 | 3.57 | Yes | | | | | |
| 275kV 1 Bus | H032-SSS-1BU5-BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | | 04/10/2004 | 7.50 | No | 2024 | 3.75 | 2044 | 3.92 | 2043-2044 |
| | H032-SSS-1BU5-XPROT | RELAY DIFF ALSTOM MFAC34 RANGE 25-325VAC | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-1BU5-XPROT | RELAY CB FAIL BUS TRIP RACK | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-1BU5-XPROT | RELAY TRIPPING LOW BURDEN ALSTOM MVAJ13 | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-1BU5-XPROT | RELAY TRIPPING SUPPLY FAIL ALSTOM MVAX12 | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-1BU5-YPROT | RELAY DIFF ALSTOM MFAC34 RANGE 25-325VAC | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-1BU5-YPROT | RELAY CB FAIL BUS TRIP RACK | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-1BU5-YPROT | RELAY TRIPPING LOW BURDEN ALSTOM MVAJ13 | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-1BU5-YPROT | RELAY TRIPPING SUPPLY FAIL ALSTOM MVAX12 | | 04/10/2004 | 7.50 | Yes | | | | | |
| 19kV 1 Reactor Bay | H032-SSS-271--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | | 19/06/2013 | 6.25 | No | 2033 | 1.50 | 2053 | 1.97 | 2051 |
| | H032-SSS-271--XPROT | RELAY CB MGMT GE C60 (5.22) 100BASE FX | | 28/12/2011 | 4.74 | No | | | | | |
| | H032-SSS-271--XPROT | RELAY DIFF ALSTOM MFAC34 RANGE 25-325VAC | | 19/06/2013 | 3.15 | Yes | | | | | |
| | H032-SSS-271--YPROT | RELAY CB MGMT SEL-451 1A, 125VDC | | 19/06/2013 | 3.39 | No | | | | | |
| 132kV 2 Bus | H032-SSS-2BU4-BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | | 15/08/2012 | 6.25 | No | 2032 | 1.75 | 2052 | 1.97 | 2051 |
| | H032-SSS-2BU4-XPROT | RELAY CB FAIL BUS TRIP RACK | | 15/08/2012 | 3.57 | Yes | | | | | |
| | H032-SSS-2BU4-XPROT | RELAY DIFF ALSTOM MFAC34 RANGE 25-325VAC | | 15/08/2012 | 3.57 | Yes | | | | | |
| | H032-SSS-2BU4-XPROT | RELAY TRIPPING LOW BURDEN ALSTOM MVAJ13 | | 15/08/2012 | 3.57 | Yes | | | | | |
| | H032-SSS-2BU4-XPROT | RELAY TRIPPING SUPPLY FAIL ALSTOM MVAX12 | | 15/08/2012 | 3.57 | Yes | | | | | |
| | H032-SSS-2BU4-YPROT | RELAY TRIPPING SUPPLY FAIL ALSTOM MVAX12 | | 15/08/2012 | 3.57 | Yes | | | | | |
| | H032-SSS-2BU4-YPROT | RELAY CB FAIL BUS TRIP RACK | | 15/08/2012 | 3.57 | Yes | | | | | |
| | H032-SSS-2BU4-YPROT | RELAY TRIPPING LOW BURDEN ALSTOM MVAJ13 | | 15/08/2012 | 3.57 | Yes | | | | | |
| | H032-SSS-2BU4-YPROT | RELAY DIFF ALSTOM MFAC34 RANGE 25-325VAC | | 15/08/2012 | 3.57 | Yes | | | | | |
| 275kV 2 Bus | H032-SSS-2BU5-BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | | 04/10/2004 | 7.50 | No | 2024 | 3.75 | 2044 | 3.92 | 2043-2044 |
| | H032-SSS-2BU5-XPROT | RELAY DIFF ALSTOM MFAC34 RANGE 25-325VAC | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-2BU5-XPROT | RELAY CB FAIL BUS TRIP RACK | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-2BU5-XPROT | RELAY TRIPPING LOW BURDEN ALSTOM MVAJ13 | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-2BU5-XPROT | RELAY TRIPPING SUPPLY FAIL ALSTOM MVAX12 | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-2BU5-YPROT | RELAY DIFF ALSTOM MFAC34 RANGE 25-325VAC | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-2BU5-YPROT | RELAY CB FAIL BUS TRIP RACK | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-2BU5-YPROT | RELAY TRIPPING LOW BURDEN ALSTOM MVAJ13 | | 04/10/2004 | 7.50 | Yes | | | | | |
| | H032-SSS-2BU5-YPROT | RELAY TRIPPING SUPPLY FAIL ALSTOM MVAX12 | | 04/10/2004 | 7.50 | Yes | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2T | H032-SSS-2TRF-CONTSYS | OLTC / COOLER / ALARM PLC | [redacted] | 11/11/2015 | 1.95 | Yes | 2035 | 1.00 | 2055 | \ | \ |
| 132kV 1-2 bus coupler | H032-SSS-411--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 15/08/2012 | 6.25 | No | 2032 | 1.75 | 2052 | 1.97 | 2051 |
| | H032-SSS-411--XPROT | RELAY CB MGMT GE C60 (5.22) 100BASE FX | [redacted] | 15/08/2012 | 4.74 | No | | | | | |
| | H032-SSS-411--YPROT | RELAY CB MGMT SEL-451 1A, 125VDC | [redacted] | 15/08/2012 | 3.57 | No | | | | | |
| 132kV 1T | H032-SSS-441--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 19/06/2013 | 6.25 | No | 2033 | 1.50 | 2053 | 1.97 | 2051 |
| | H032-SSS-441--XPROT | RELAY CB MGMT GE C60 (5.22) 100BASE FX | [redacted] | 19/06/2013 | 4.74 | No | | | | | |
| | H032-SSS-441--YPROT | RELAY CB MGMT SEL-451 1A, 125VDC | [redacted] | 19/06/2013 | 3.39 | No | | | | | |
| 132kV2T | H032-SSS-442--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 13/08/2013 | 6.25 | No | 2033 | 1.50 | 2053 | 1.97 | 2051 |
| | H032-SSS-442--XPROT | RELAY CB MGMT GE C60 (5.22) 100BASE FX | [redacted] | 13/08/2013 | 4.74 | No | | | | | |
| | H032-SSS-442--YPROT | RELAY CB MGMT SEL-451 1A, 125VDC | [redacted] | 13/08/2013 | 3.39 | No | | | | | |
| 132kV 1 CAP | H032-SSS-481--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 13/11/2013 | 6.25 | No | 2024 | 1.50 | 2044 | 1.97 | 2051 |
| | H032-SSS-481--POWAVE | RELAY POINT ON WAVE ABB E213 | [redacted] | 13/11/2013 | 4.51 | No | | | | | |
| | H032-SSS-481--XPROT | STABILISED INST O/C RELAY | [redacted] | 14/09/2004 | 7.53 | Yes | | | | | |
| | H032-SSS-481--XPROT | RELAY CB MGMT GE C60 (5.22) 100BASE FX | [redacted] | 13/11/2013 | 4.74 | No | | | | | |
| | H032-SSS-481--XPROT | RELAY CAP PROTN ABB SPAJ160C | [redacted] | 13/11/2013 | 3.21 | Yes | | | | | |
| | H032-SSS-481--YPROT | RELAY CB MGMT SEL-451 1A, 125VDC | [redacted] | 13/11/2013 | 3.39 | No | | | | | |
| 275kV 503 Coupler | H032-SSS-503--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 08/08/2011 | 6.25 | No | 2033 | 1.50 | 2053 | 1.96 | 2051 |
| | H032-SSS-503--XPROT | RELAY CB MGMT GE C60 (5.22) 100BASE FX | [redacted] | 19/06/2013 | 4.74 | No | | | | | |
| | H032-SSS-503--YPROT | RELAY CB MGMT SEL-451 1A, 125VDC | [redacted] | 19/06/2013 | 3.39 | No | | | | | |
| 275kV 504 Coupler | H032-SSS-504--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 13/08/2013 | 6.25 | No | 2033 | 1.50 | 2053 | 1.96 | 2051 |
| | H032-SSS-504--XPROT | RELAY CB MGMT GE C60 (5.22) 100BASE FX | [redacted] | 13/08/2013 | 4.74 | No | | | | | |
| | H032-SSS-504--YPROT | RELAY CB MGMT SEL-451 1A, 125VDC | [redacted] | 13/08/2013 | 3.39 | No | | | | | |
| 275kV 506 Coupler | H032-SSS-506--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 04/10/2004 | 7.50 | No | 2024 | 3.75 | 2044 | 3.98 | 2043 |
| | H032-SSS-506--XPROT | RELAY CBMAN GE C60 (WITH W6T MODULE) | [redacted] | 04/10/2004 | 7.50 | No | | | | | |
| | H032-SSS-506--YPROT | RELAY CBMAN SEL-352 (1A) (3U) | [redacted] | 04/10/2004 | 7.50 | Yes | | | | | |
| 275kV 1T | H032-SSS-541--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 19/06/2013 | 6.25 | No | 2033 | 1.50 | 2053 | 1.97 | 2051 |
| | H032-SSS-541--XPROT | RELAY TX BIAS DIFF SIEMENS 7UT635 | [redacted] | 19/06/2013 | 5.03 | Yes | | | | | |
| | H032-SSS-541--YPROT | RELAY BIASED DIFF SEL-387-5 (1A) (3U) | [redacted] | 19/06/2013 | 5.15 | No | | | | | |
| 275kV 2T | H032-SSS-542--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 13/08/2013 | 6.25 | No | 2033 | 1.50 | 2053 | 1.97 | 2051 |
| | H032-SSS-542--XPROT | RELAY TX BIAS DIFF SIEMENS 7UT635 | [redacted] | 13/08/2013 | 5.03 | Yes | | | | | |
| | H032-SSS-542--YPROT | RELAY BIASED DIFF SEL-387-5 (1A) (3U) | [redacted] | 13/08/2013 | 5.15 | No | | | | | |
| 275kV 1 Bus Reactor | H032-SSS-575--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 10/04/2014 | 6.25 | No | 2034 | 1.25 | 2054 | 1.71 | 2052 |
| | H032-SSS-575--POWAVE | RELAY POW SS CONTROLLER MITSUBISHI DTCB | [redacted] | 10/04/2014 | 6.45 | Yes | | | | | |
| | H032-SSS-575--XPROT | RELAY DIFF ALSTOM MFAC34 RANGE 25-325VAC | [redacted] | 10/04/2014 | 2.74 | Yes | | | | | |
| | H032-SSS-575--XPROT | RELAY CB MGMT GE C60 (5.22) 100BASE FX | [redacted] | 10/04/2014 | 4.74 | No | | | | | |
| | H032-SSS-575--YPROT | RELAY CB MGMT SEL-451-5 1A, 125VDC | [redacted] | 10/04/2014 | 4.80 | No | | | | | |
| 132kV Feeder 7165 | H032-SSS-7165-BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 23/04/2013 | 6.25 | No | 2033 | 1.50 | 2053 | 1.97 | 2051 |
| | H032-SSS-7165-XPROT | RELAY CURR DIFF DISTANCE MICOM P546 | [redacted] | 23/04/2013 | 5.77 | No | | | | | |
| | H032-SSS-7165-XPROT | COMMS INTERFACE UNIT ALSTOM P591 | [redacted] | 23/04/2013 | 3.60 | No | | | | | |
| | H032-SSS-7165-YPROT | RELAY DISTANCE SCHW'ZER 421-5 1A 24 LED | [redacted] | 23/04/2013 | 5.36 | Yes | | | | | |
| 132kV Feeder 7166 | H032-SSS-7166-BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 15/04/2013 | 6.25 | No | 2033 | 1.50 | 2053 | 1.97 | 2051 |
| | H032-SSS-7166-XPROT | RELAY CURR DIFF DISTANCE MICOM P546 | [redacted] | 15/04/2013 | 5.77 | No | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | H032-SSS-7166-XPROT | COMMS INTERFACE UNIT ALSTOM P591 | [redacted] | 15/04/2013 | 3.60 | No | | | | | |
| | H032-SSS-7166-YPROT | RELAY DISTANCE SCHW'ZER 421-5 1A 24 LED | [redacted] | 15/04/2013 | 5.36 | Yes | | | | | |
| 132kV Feeder 7191 | H032-SSS-7191-BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 14/11/2012 | 6.25 | No | 2032 | 1.75 | 2052 | 1.97 | 2051 |
| | H032-SSS-7191-PSLEO | MODULE REMOTE I/O SEL-2506 (15KM RANGE) | [redacted] | 14/11/2012 | 3.44 | Yes | | | | | |
| | H032-SSS-7191-XPROT | RELAY CURR DIFF DISTANCE MICOM P546 | [redacted] | 14/11/2012 | 5.77 | No | | | | | |
| | H032-SSS-7191-XPROT | COMMS INTERFACE UNIT ALSTOM P591 | [redacted] | 14/11/2012 | 3.60 | No | | | | | |
| | H032-SSS-7191-YPROT | RELAY DISTANCE SCHW'ZER 421-5 1A 24 LED | [redacted] | 14/11/2012 | 5.36 | Yes | | | | | |
| 132kV Feeder 7192 | H032-SSS-7192-BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 30/11/2012 | 6.25 | No | 2032 | 1.75 | 2052 | 1.97 | 2051 |
| | H032-SSS-7192-PSLEO | MODULE REMOTE I/O SEL-2506 (15KM RANGE) | [redacted] | 30/11/2012 | 3.42 | Yes | | | | | |
| | H032-SSS-7192-XPROT | RELAY CURR DIFF DISTANCE MICOM P546 | [redacted] | 30/11/2012 | 5.77 | No | | | | | |
| | H032-SSS-7192-XPROT | COMMS INTERFACE UNIT ALSTOM P591 | [redacted] | 30/11/2012 | 3.60 | No | | | | | |
| | H032-SSS-7192-YPROT | RELAY DISTANCE SCHW'ZER 421-5 1A 24 LED | [redacted] | 30/11/2012 | 5.36 | Yes | | | | | |
| 275kVkV Feeder 857 | H032-SSS-857--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 08/05/2006 | 6.71 | No | 2026 | 3.25 | 2046 | 3.98 | 2043 |
| | H032-SSS-857--SUPERV | CVT MONITOR | [redacted] | 08/05/2006 | 6.71 | No | | | | | |
| | H032-SSS-857--XPROT | CURR DIFF RELAY ALSTOM P544 + 2ND PORT | [redacted] | 08/05/2006 | 7.77 | No | | | | | |
| | H032-SSS-857--XPROT | COMMS INTERFACE UNIT ALSTOM P591 | [redacted] | 23/01/2009 | 5.35 | No | | | | | |
| | H032-SSS-857--YPROT | RELAY DISTANCE SEL-421 (1A) (5U) | [redacted] | 08/05/2006 | 6.71 | No | | | | | |
| | H032-SSS-857--YPROT | RELAY DISTANCE SEL-421 (1A) (5U) | [redacted] | 08/11/2007 | 5.96 | No | | | | | |
| Feeder 857 Reactor | H032-SSS-857--BAYCONTR | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 09/05/2014 | 6.25 | No | 2034 | 1.25 | 2054 | 1.96 | 2051 |
| | H032-SSS-857--POWAVE | POINT ON WAVE RELAY F236 ABB | [redacted] | 09/05/2014 | 7.54 | No | | | | | |
| | H032-SSS-857--XPROTR | RELAY DIFF ALSTOM MFAC34 RANGE 25-325VAC | [redacted] | 09/05/2014 | 2.70 | Yes | | | | | |
| | H032-SSS-857--XPROTR | RELAY CB MGMT GE C60 (5.22) 100BASE FX | [redacted] | 09/05/2014 | 4.74 | No | | | | | |
| | H032-SSS-857--YPROTR | RELAY CB MGMT SEL-451 1A, 125VDC | [redacted] | 09/05/2014 | 3.39 | No | | | | | |
| 275kVkV Feeder 858 | H032-SSS-858--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 17/07/2005 | 7.11 | No | 2025 | 3.50 | 2045 | 3.98 | 2043 |
| | H032-SSS-858--SUPERV | F858 CVT MONITOR | [redacted] | 30/06/1980 | 10.00 | No | | | | | |
| | H032-SSS-858--XPROT | CURR DIFF RELAY ALSTOM P544 + 2ND PORT | [redacted] | 23/09/2005 | 7.02 | No | | | | | |
| | H032-SSS-858--XPROT | COMMS INTERFACE UNIT ALSTOM P591 | [redacted] | 23/01/2009 | 5.35 | No | | | | | |
| | H032-SSS-858--YPROT | RELAY DISTANCE SEL-421 (1A) (5U) | [redacted] | 28/07/2006 | 6.60 | No | | | | | |
| Feeder 858 Reactor | H032-SSS-858--BAYCONTR | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 30/05/2014 | 6.25 | No | 2034 | 1.25 | 2054 | 1.96 | 2051 |
| | H032-SSS-858--POWAVE | POINT ON WAVE RELAY F236 ABB | [redacted] | 30/05/2014 | 7.54 | No | | | | | |
| | H032-SSS-858--XPROTR | RELAY DIFF ALSTOM MFAC34 RANGE 25-325VAC | [redacted] | 30/05/2014 | 2.67 | Yes | | | | | |
| | H032-SSS-858--XPROTR | RELAY CB MGMT GE C60 (5.22) 100BASE FX | [redacted] | 30/05/2014 | 4.74 | No | | | | | |
| | H032-SSS-858--YPROTR | RELAY CB MGMT SEL-451 1A, 125VDC | [redacted] | 30/05/2014 | 3.39 | No | | | | | |
| 275kVkV Feeder 876 | H032-SSS-876--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 31/07/2007 | 6.25 | No | 2027 | 3.00 | 2047 | 3.16 | 2047 |
| | H032-SSS-876--X2ARBLK | COMMS INTERFACE UNIT ALSTOM P591 | [redacted] | 07/02/2012 | 3.83 | No | | | | | |
| | H032-SSS-876--XPROT | CURR DIFF RELAY MICOM P544 + 2ND PORT | [redacted] | 03/04/2012 | 5.16 | No | | | | | |
| | H032-SSS-876--XPROT | RELAY CURR DIFF DISTANCE MICOM P546 | [redacted] | 23/07/2018 | 0.61 | No | | | | | |
| | H032-SSS-876--YPROT | RELAY DISTANCE SEL-421 (1A) (5U) | [redacted] | 29/03/2009 | 5.27 | No | | | | | |
| 275kVkV Feeder 877 | H032-SSS-877--BAYCONT | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 04/10/2004 | 7.50 | No | 2024 | 3.75 | 2044 | 3.98 | 2043 |
| | H032-SSS-877--POWAVE | CAT CONTROLLER ABB POW BREAKERS | [redacted] | 19/07/2012 | 3.61 | Yes | | | | | |
| | H032-SSS-877--X2ARBLK | RELAY CURR DIFF DISTANCE MICOM P546 | [redacted] | 01/05/2012 | 5.77 | No | | | | | |
| | H032-SSS-877--X2ARBLK | COMMS INTERFACE UNIT ALSTOM P591 | [redacted] | 01/05/2012 | 3.71 | No | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | H032-SSS-877--XPROT | COMMS INTERFACE UNIT ALSTOM MITZ01 | [redacted] | 04/10/2004 | 7.50 | No | | | | | |
| | H032-SSS-877--XPROT | RELAY TRIP MONITORING RMS 3A20K26 | [redacted] | 04/10/2004 | 7.50 | No | | | | | |
| | H032-SSS-877--XPROT | RELAY CURR DIFF DISTANCE MICOM P546 | [redacted] | 26/05/2012 | 5.77 | No | | | | | |
| | H032-SSS-877--YPROT | RELAY DISTANCE SEL-421 (1A) | [redacted] | 04/10/2004 | 7.50 | No | | | | | |
| | H032-SSS-NBAY-DATCONV | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 06/09/2002 | 8.54 | No | | | | | |
| | H032-SSS-NBAY-LCF | LOCAL CONTROL FACILITY SUN BLADE (REV.7) | [redacted] | 30/11/2012 | 8.35 | No | | | | | |
| | H032-SSS-NBAY-LCFINT4 | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 15/08/2012 | 6.25 | No | | | | | |
| | H032-SSS-NBAY-NSCLNK14 | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 15/08/2012 | 6.25 | No | | | | | |
| | H032-SSS-NBAY-NSCLNK24 | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 15/08/2012 | 6.25 | No | | | | | |
| | H032-SSS-NBAY-OWCAM1 | VIDEO CAMERA | [redacted] | 12/06/2001 | 10.00 | Yes | | | | | |
| | H032-SSS-NBAY-OWCAM2 | VIDEO CAMERA | [redacted] | 12/06/2001 | 10.00 | Yes | | | | | |
| | H032-SSS-NBAY-OWNTWK | PORT SERVER | [redacted] | 12/06/2001 | 10.00 | No | | | | | |
| | H032-SSS-NBAY-OWNTWK | PORT SERVER | [redacted] | 12/06/2001 | 10.00 | No | | | | | |
| | H032-SSS-NBAY-OWNTWK | SWITCH | [redacted] | 08/06/2001 | 10.00 | No | | | | | |
| | H032-SSS-NBAY-OWNTWK | ROUTER CISCO 2811 48VDC - OPSWAN | [redacted] | 20/05/2009 | 10.00 | No | | | | | |
| | H032-SSS-NBAY-OWNTWK4 | SWITCH E/NET 32PRT RUGGED RSG2300 OPSWAN | [redacted] | 14/11/2012 | 6.89 | Yes | | | | | |
| Non Bay | H032-SSS-NBAY-OWNTWK4 | SWITCH E/NET 18PRT RUGGED RSG2100 OPSWAN | [redacted] | 14/11/2012 | 6.89 | Yes | To be replaced with major secondary system replacement | \ | \ | \ | \ |
| | H032-SSS-NBAY-OWNTWK4 | SWITCH E/NET 18PRT RUGGED RSG2100 OPSWAN | [redacted] | 14/11/2012 | 6.89 | Yes | | | | | |
| | H032-SSS-NBAY-OWNTWK4 | SERVER PORT 48VDC PERLE 04030450 -OPSWAN | [redacted] | 14/11/2012 | 6.89 | Yes | | | | | |
| | H032-SSS-NBAY-OWNTWK4 | SERVER PORT 48VDC PERLE 04030450 -OPSWAN | [redacted] | 14/11/2012 | 6.89 | Yes | | | | | |
| | H032-SSS-NBAY-OWPRINT | PRINTER | [redacted] | 23/04/2001 | 10.00 | Yes | | | | | |
| | H032-SSS-NBAY-OWSERV | SERVER | [redacted] | 06/06/2001 | 10.00 | No | | | | | |
| | H032-SSS-NBAY-OWSERV | MONITOR | [redacted] | 06/06/2001 | 10.00 | Yes | | | | | |
| | H032-SSS-NBAY-RTUCOM2 | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 06/03/2014 | 6.25 | No | | | | | |
| | H032-SSS-NBAY-RTUCOM4 | REMOTE TERMINAL UNIT FOXBORO C50 | [redacted] | 15/08/2012 | 6.25 | No | | | | | |
| | H032-SSS-NBAY-RTUINVRT | INVERTER 125VDC/240VAC 1600W | [redacted] | 09/06/2006 | 10.00 | Yes | | | | | |
| | H032-SSS-NBAY-TIMING | GPS CLOCK - ARBITER 1088B | [redacted] | 01/07/1989 | 10.00 | No | | | | | |
| | H032-SSS-NBAY-TIMING4 | GPS CLOCK TEKRON TCG01-D:1 | [redacted] | 14/11/2012 | 5.47 | Yes | | | | | |
| | H032-SSS-NBAY-TWFL | FAULT LOCATOR HATHAWAY TWS 4 CIRCUIT | [redacted] | 11/06/2010 | 5.00 | No | | | | | |

# 7. Conclusion

Based on the condition assessment, the main recommendations for the replacement of secondary systems equipment at H032 Chalumbin are:-

1. Conduct following secondary system replacements by 2024:-
   - Replace all fuses with MCBs for =C06 AC/DC marshalling kiosks
   - Replace 275kV 1 and 2 Bus protection and control equipment and update the protection and control panel according to SU0020
   - Replace 275kV coupler 506 protection and control equipment and update the protection and control panel according to SU0020
   - Replace 275kV Feeder 877 protection and control equipment and update the protection and control panel according to SU0020 (including the special SPAR scheme)
   - Upgrade the SDACA DNP serial to NP/IP
   - Replace [redacted] workstation
   - Replace OpsWAN in Building +1 and Building +4
   - Replace 125VDC battery and associated chargers in Building +1
   - Replace 125VDC battery and associated chargers in Building +4
   - Replace Arbiter GPS clock in building +1

2. Conduct following secondary system replacements by 2026:-
   - Replace all fuses with MCBs for Feeder 857 and 858 VT boxes
   - Replace protection and control equipment for Feeder 857 and update the protection and control panel according to SU0020
   - Replace protection and control equipment for Feeder 858 and update the protection and control panel according to SU0020
   - Replace protection and control equipment for Feeder 876 and update the protection and control panel according to SU0020
   - Replace dual 48VDC battery and associated chargers in Building +1

3. Carry out following secondary system replacements by 2033:-

   - Replace all secondary systems for 275kV coupler 503 and 504
   - Replace all secondary systems for 275/132kV 1T and 2T
   - Replace all secondary systems for 275kV bus reactor
   - Replace all secondary systems for 275kV Feeder 857 reactor
   - Replace all secondary systems for 275kV Feeder 858 reactor
   - Replace all secondary systems for 132kV 1 and 2 Bus
   - Replace all secondary systems for 132kV bus coupler
   - Replace all secondary systems for 132kV feeder 7165
   - Replace all secondary systems for 132kV feeder 7166
   - Replace all secondary systems for 132kV feeder 7191
   - Replace all secondary systems for 132kV feeder 7192
   - Replace all secondary systems for 132kV 1 Cap
   - Replace all secondary systems for 1T 19kV Reactor
   - Replace SCADA RTU [redacted] and common RTUs [redacted] in building +1 and +4
   - Replace the TWS fault locator
   - Replace [redacted] GPS clock in building +4

# 8. References

(1) National Electricity Rules (NER) Version 106, AEMC, 27/02/2018
(2) AM-POL-0463 Protection Design, Powerlink, 25/02/2014
(3) AM-POL-0970 Secondary Systems Design, Powerlink, 05/05/2009
(4) OSD - SCADA Requirements for Operational Purposes - Standard, Powerlink, 13/01/2016
(5) AM-POL-0169 Secondary Systems Maintenance Policy, Powerlink, 3/11/2008
(6) AM-POL-0053 AC and DC Supplies, Powerlink, 08/05/2014
(7) SU0023 Clearance Requirements for Panels, Switchboard and Kiosks, ID&TS, 06/05/2016
(8) SU0020 Updates to SDM8 Panels to Mitigate Safety in Design Concerns (Obj. ID: A2753457), 09/2017

| **Planning Report** | | **9 June 2025** |
|---|---|---|
| Title | CP.03144 Chalumbin 132kV Substation Reinvestment | |
| Zone | Far North Queensland | |
| Need Driver | Emerging compliance risks arising from condition and obsolescence of ageing primary plant in the Chalumbin 132kV substation. | |
| Network Limitations and statutory requirements | Chalumbin 132kV Substation is needed to meet Powerlink Queensland's N-1-50MW/600MWh Transmission Authority reliability standards and connection of generation. | |
| Pre-requisites | None | |

## Executive Summary

Ageing and obsolete primary plant and secondary systems at Chalumbin Substation are increasingly at risk of failing to comply with Schedule 5.1.9(c) of the National Electricity Rules and AEMO's Power System Security Guidelines[1].

Energy Queensland forecasts confirm there is an enduring need to maintain electricity supply into the Turkinje area. There is also a continuing requirement to connect Kareeya Power Station. The removal or reconfiguration of the Chalumbin 132kV Substation due to asset failure/obsolesce would violate Powerlink's N-1-50MW/600MWh Transmission Authority reliability standard and impact the generation capability in the Far North region. The preferred network solution for Powerlink to continue to meet its statutory obligations is the replacement of the at-risk primary plant and secondary systems.

*1 AEMO, Power System Operating Procedure SO_OP_3715, Power System Security Guidelines, V95, September 2019 (the Rules require AEMO to develop and publish Power System Operating Procedures pursuant to clause 4.10.1(b) of the Rules, which Powerlink must comply with per clause 4.10.2(b)).*

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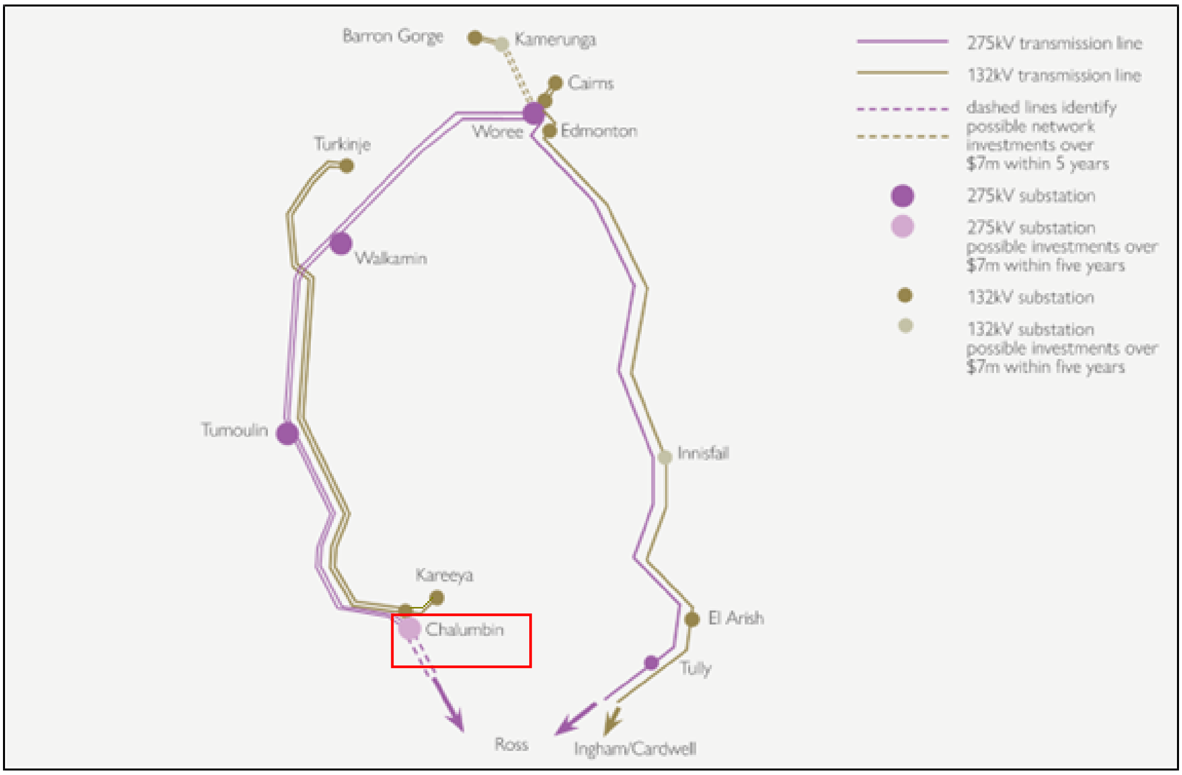
# 1. Introduction

Chalumbin Substation (H032) is located in Far North Queensland (FNQ) and has both 275kV and 132kV operating voltages in one yard. Chalumbin Substation is cut in to both 275kV feeders to Woree and is the major substation in the 275kV power transfer corridor between Ross and FNQ. There are two 275/132kV transformers located in Chalumbin enabling power transfer into the local 132 kV network in the Turkinje region through two 132kV feeders and generation from Kareeya Power Station through another two 132kV feeders.




[redacted]

Figure 2. Chalumbin 132kV Single Line Diagram

Figure 3 shows the existing configuration of the Chalumbin 132kV Substation.

[redacted]

Figure 3. Chalumbin 132kV Substation Diagram

[redacted]

*Primary Plant to be replaced under this project (CP.03144)*

*Plant to be decommissioned under this project (CP.03144)*

Figure 4. Chalumbin 132kV plant in scope

Chalumbin Substation was established in 1988. The majority of primary equipment was part of the original installation and is now around 35 years old. A condition assessment was carried out in 2020 and identified issues related to selected primary plant with replacement recommended in the next 5 to 10 years. Similarly, a secondary systems condition assessment was conducted in 2019 and recommended that the secondary systems be replaced within the next 5 to 12 years.

Increasing failure rates, along with the increased time to rectify faults due to the obsolescence of the equipment, significantly affects the availability and reliability of these systems and their ability to continue to meet the requirements of the National Electricity Rules (the Rules).

This condition driver has triggered the need to assess the enduring network need for the Chalumbin Substation configuration and function.

This report assesses the impact that removal of the at-risk plant would have on the performance of the network and Powerlink's statutory obligations. It also establishes the indicative requirements of any potential alternative solutions to the current services provided by Chalumbin Substation.

## 2. 132kV Chalumbin Demand Forecast

The Chalumbin to Turkinje 132kV feeders 7165 and 7166 supply the EQL customers from the Atherton Tablelands up to Cooktown, including Turkinje, Craiglie, Mossman (new) and Lakeland. Figure 5 shows that the maximum demand for these loads is expected to continually increase over the coming years.

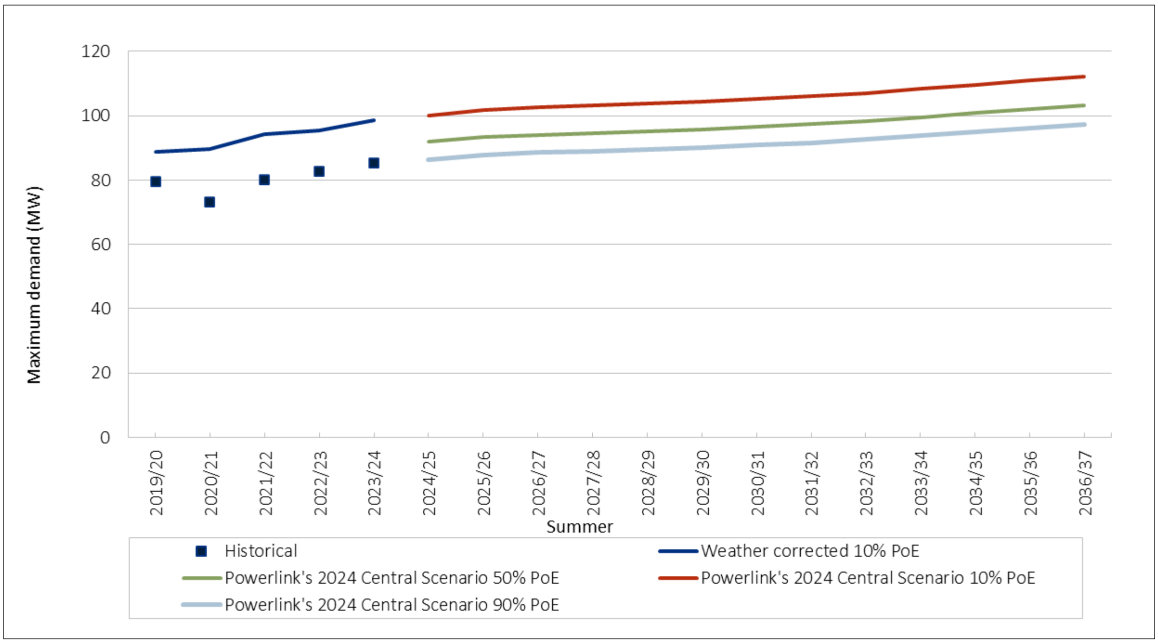



Figure 5. Chalumbin 132kV Load Growth

Figure 6 is the duration curve for the loads connected to Chalumbin network.

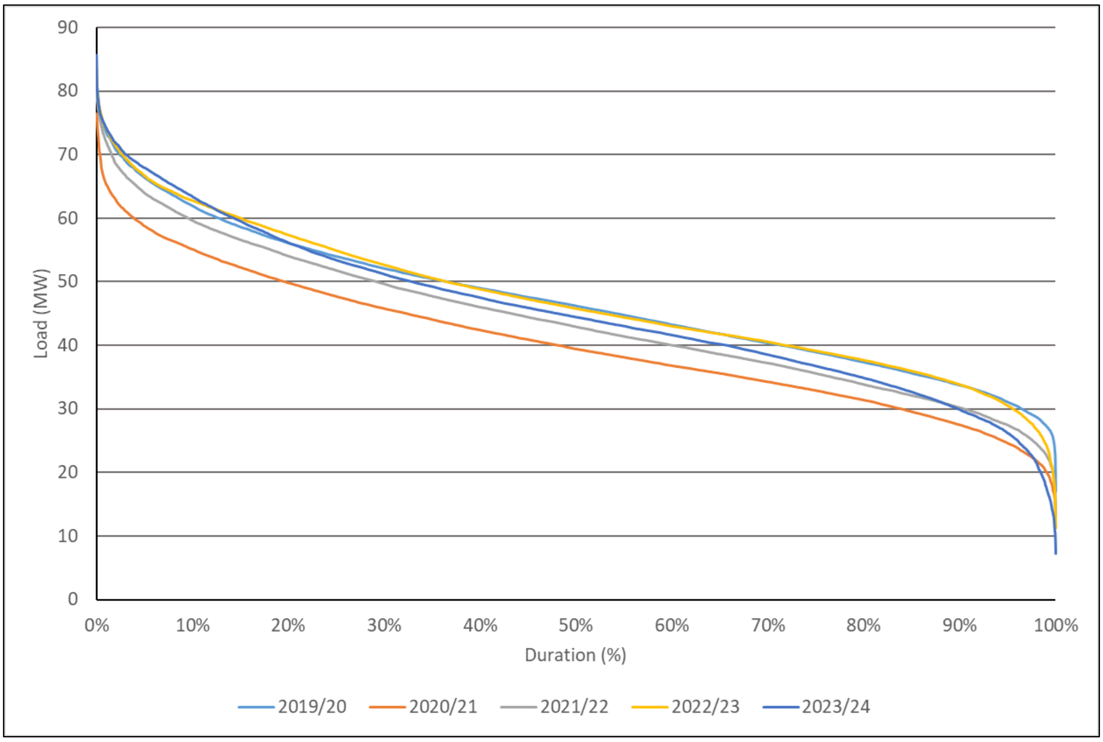



Figure 6. Chalumbin 132kV Load Duration Curve

With rooftop PV in the area, the maximum ‘underlying’ demand may be significantly greater than what metering sees as ‘native’ or ‘delivered’ demand. Figure 7 below shows the average summer daily load profile that includes PV generation, resulting in a peak during the middle of the day rather than in the evening. The reason including the PV in the graph is to demonstrate the actual load at risk at Chalumbin.

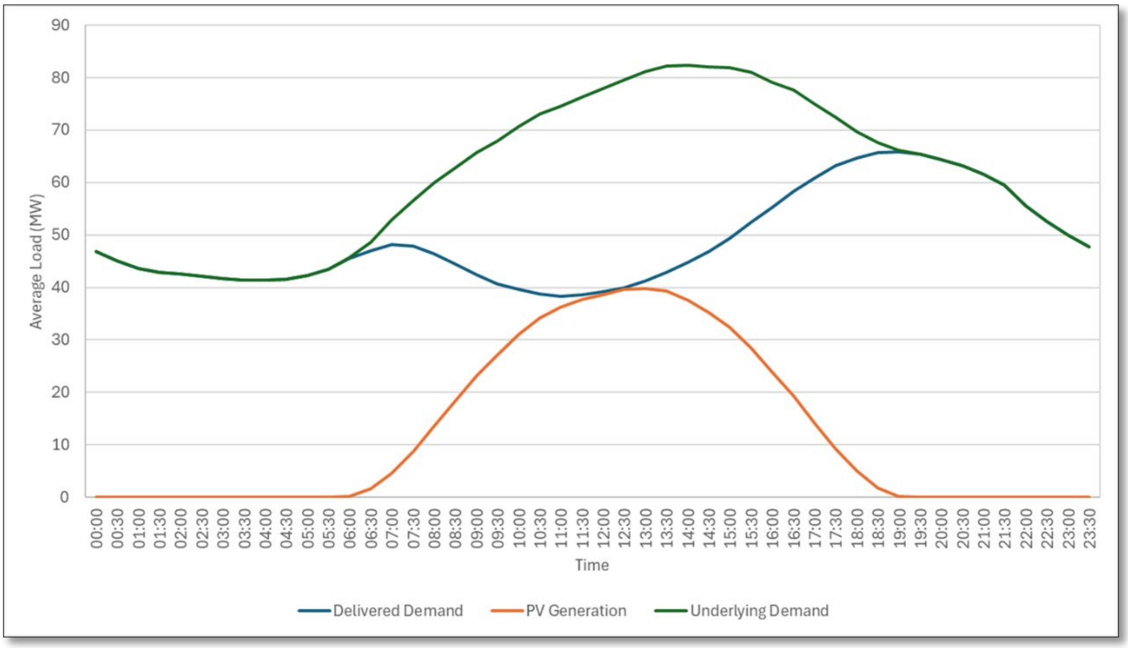



Figure 7. Chalumbin 132kV Summer 2024 Average Daily Load Profile with Rooftop PV

## 3. Statement of Investment Need

As outlined in Section 2, the Chalumbin 132kV substation is the supply point for loads on the Atherton Tablelands up to Cooktown in the Far North area and is also the connection point for Kareeya Power Station and other embedded generation in the area.

Removing the functionality of this substation would have a major impact on the reliability of supply to the Turkinje, Craiglie, Mossman and Lakeland 132kV substations, as well as the ability to dispatch generation from Kareeya Power Station.

## 4. Network Risk

Table 1 summarises results of analysis to determine the load and energy at risk, if the Chalumbin substation is decommissioned.

Table 1 – Chalumbin 132kV Load at Risk

| At Risk | Contingency | Metric | 2023/24 | | 2033/34 | |
|---|---|---|---|---|---|---|
| | | | Delivered | Underlying Demand | Delivered | Underlying Demand |
| Turkinje Craiglie Lakeland (new) Mossman | D7.1 equipment followed by outage of 7165 or D8.2 CB followed by outage of 7166 or D6.2 CB followed by outage of 1T or D4.1 CB followed by outage of 2T | Max (MW) | 86 | 119 | 94 | 156 |
| | | Average (MW) | 46 | 57 | 45 | 70 |
| | | 24h Energy Unserved Max (MWh) | 1465 | 1833 | 1691 | 2267 |
| | | 24h Energy Unserved Average (MWh) | 1091 | 1369 | 1069 | 1681 |

## 5. Market impact

The Kareeya Hydro Power Station connects to Chalumbin 132kV Substation via a double circuit 132kV line. Each circuit is transformer-ended at Kareeya and connects two generating units via a dual-secondary winding transformer.

The combined capacity of the four units is 76MW.

Table 2 defines the maximum and average difference in total system costs (including emission reduction benefits) per 24-hour period with Kareeya Hydro Power Station unit/s removed from service.

Furthermore, the embedded generation from Lakeland Solar Farm (15MW) would also pose market impacts if unable to be fed into the network. Lakeland Solar Farm impact has not been included in Table 2.

The analysis assumes that there is not impact on the generation investment pathway as a result of this outage.

The methodology used to assess these market impacts is outlined in Appendix A.

Table 2. Chalumbin 132kV Market Impacts

<table>
<tr><th>At Risk</th><th>Contingency</th><th>Metric</th><th>$M</th></tr>
<tr><td rowspan="2">Kareeya Power Station</td><td rowspan="2">D6.2 CB followed by outage of 1T<br>or<br>D4.1 CB followed by outage of 2T<br>or<br>D6.1 CB followed by outage of 7191<br>or<br>D5.2 CB followed by outage of 7192</td><td>Max 24h incremental system cost ($m)</td><td>0.511</td></tr>
<tr><td>Average 24h incremental system cost ($m)</td><td>0.056</td></tr>
<tr><td rowspan="2">½ Kareeya Power Station</td><td rowspan="2">D6.1 CB<br>or<br>D5.2 CB</td><td>Max 24h incremental system cost ($m)</td><td>0.256</td></tr>
<tr><td>Average 24h incremental system cost ($m)</td><td>0.028</td></tr>
</table>

## 6. Non-Network Options

It isn’t really considered feasible for a non-network solution to fully replace the need for a switching station with both 275kV injection, 132kV feeders and connected generation.

To meet the 132kV demand alone, the non-network solution must be capable of delivering over 90MW of power and 1700MWh of energy in a day. (Refer Table 1 Max Delivered demand)

Powerlink is not aware of any Demand Side Solutions (DSM) in the Far North area supplied from Chalumbin Substation. However, Powerlink will consider any proposed solution that can contribute significantly to the requirements of ensuring that Powerlink continues to meet its required reliability of supply obligations as part of the formal RIT-T consultation process prior to project approval.

## 7. Network Options

### 7.1 Proposed Option to address the identified need

Planning recommends the replacement of all primary plant and secondary systems reaching end of life at Chalumbin Substation. This option ensures that all reliability of supply and asset condition criteria are met.

Further details of condition assessment for the Chalumbin Substation primary plant and secondary systems and their recommended replacement timing can be found in Reference 1 and 2.

### 7.2 Option Considered but Not Proposed

This section discusses alternative options that Powerlink has investigated but does not consider technically and/or economically feasible to address the above identified issues, and thus are not considered credible options.

### 7.2.1 Do Nothing

"Do Nothing" would not be an acceptable option as the primary driver (secondary systems condition and obsolescence) and associated safety, reliability and compliance risks would not be resolved. Furthermore, the "Do Nothing" option would not be consistent with good industry practice and would result in Powerlink breaching their obligations with the requirements of the System Standards of the National Electricity Rules and its Transmission Authority.

### 7.2.2 New 132kV substation at or near existing Walkamin 275kV

A significant change in network connectivity may have merit in the long term however is not cost justified now.

## 8. Recommendations

Powerlink has reviewed the condition of the primary plant and secondary systems at Chalumbin 132kV Substation and anticipates they are reaching end of technical service life and recommends that the plant and systems be replaced.

Retaining Chalumbin Substation will allow Powerlink to continue to meet its required reliability obligations (N-1-50MW/600MWh) to load in the Far North area and retain important generation connectivity.

## 9. References


1. H032 Chalumbin Electrical Condition Assessment Report
2. PIF Primary Plant Replacement H32 Chalumbin Substation
3. CP.03144 Chalumbin 132kV Substation Reinvestment - Project Scope Report
4. Transmission Annual Planning Report 2024
5. Asset Planning Criteria Framework

## 10. Appendix A – Network Risk methodology

### Feeders 7165 & 7166

Feeders 7165 and 7166 are the only supply to Turkinje, and associated loads. The embedded generation at Lakeland will also be lost.

### Feeders 7191 & 7192

If Feeder 7191 and 7192 are taken out of service, Kareeya Power Station will be disconnected from the grid, meaning a loss of up to 94MW of generation in the Far North area.

[redacted]

## 11. Appendix B – Market Impact Assessment

Market modelling was used to assess the operational market impact of constraining off units at the Kareeya Hydro Power Station as a result from outages of primary system equipment at the Chalumbin 132kV Substation.

The market modelling approach is consistent with the regulatory investment test for transmission requirements that a market benefit "must be a benefit to those who consume, produce and/or transport electricity in the market, that is, the change in producer plus consumer surplus." Critically, a market benefit must not "include the transfer of surplus between consumers and producers".[2]

As such, the market impact is assessed by comparing the changes in costs for market participants due to the differences in the operational and maintenance costs (including fuel costs), changes in involuntary load shedding (at the value of customer reliability [VCR] [3]), and changes in greenhouse gas emissions (at the value of emissions reduction [VER] [4])

The market modelling simulations considered committed and anticipated generators were commissioned on time, coal units closed according to their announced dates (as of December 2025), and modelled generation and storage projects consistent with the Queensland Energy Roadmap 2025.[5] The profiles of demand and energy available for variable energy resources followed the 2015 weather reference year as published by AEMO, as being a year found to result in 'median' outcomes.

A schedule of generator planned outages was modelled. However, generator forced outages were not considered. Instead, a reserve requirement is maintained via a reserve constraint equation, and therefore unserved energy may be underestimated in some circumstances.

Appropriate network detail (in the form of network constraints or sub-regional transfer limits) was added to adequately represent the network capability across major grid sections.

The outage (Kareeya Hydro Power Station unit/s as a result of the failure of primary equipment at Chalumbin Substation) was modelled as occurring in perpetuity to approximately capture the effect of this occurring at any time.

The market impact was then quantified as the differential total system cost (as above) for each hour between a base case with Kareeya Hydro Power Station available against the state of the world with an outage of unit/s of the hydro power station. Both the hourly and a moving 24-hour differential cost were determined.

The values in the report tables capture the maximum differential total system cost for any 24-hour period (averaged over the 5-year analysis period) and the average differential total system cost for a 24-hour period (over the 5-year analysis period).

[2] AER, November 2024, "Regulatory investment test for transmission", p4

[3] AER, December 2024, "Values of customer reliability: Final report on VCR values" available at

[4] AER, May 2024, "Valuing emissions reduction: AER guidance and explanatory statement"

[5] The State of Queensland (Queensland Treasury), October 2025, "Energy Roadmap"

# Project Scope Report

# CP.03144

# H032 Chalumbin 132kV Substation Reinvestment

## Concept – Version 3

## Document Control

Change Record

| Issue Date | Revision | Prepared by | Reviewed by | Approved by | Background |
|---|---|---|---|---|---|
| 6/3/25 | 1 | [redacted] | [redacted] | [redacted] | |
| 25/6/25 | 2 | [redacted] | [redacted] | [redacted] | Option 3 added<br>Added replacement of additional CTs and SAs (highlighted in Attachment 1) |
| 4/9/25 | 3 | [redacted] | [redacted] | [redacted] | Option 4 added |

Related Documents

| Issue Date | Responsible Person | Objective Document Name |
|---|---|---|
| 3/9/24 | [redacted] | PIF Primary Plant Replacement H32 Chalumbin Substation (A2886203) |
| 31/10/24 | [redacted] | H032 Chalumbin Electrical Condition Assessment Report Rev 2 (A5638035) |
| 9/10/19 | [redacted] | H032 Chalumbin Secondary Systems Condition Assessment Report (A3245187) |

## Document Purpose

The purpose of this Project Scope Report is to define the business (functional) requirements that the project is intended to deliver. These functional requirements are subject to Powerlink's design and construction standards and prevailing asset strategies, which will be detailed in documentation produced during the detailed scoping and estimating undertaken by DTS (or OSD), i.e. it is not intended for this document to provide a detailed scope of works that is directly suitable for estimating.

## Project Contacts

| | |
|---|---|
| Project Sponsor | [redacted] |
| Strategist – HV/Digital Asset Strategies | [redacted] |
| Planner – Main/Regional Grid | [redacted] |
| Manager Projects | [redacted] |
| Project Manager | [redacted] |
| Design Manager | TBA |

## Project Details

### 1. Project Need & Objective

Chalumbin Substation is located in Far North Queensland (FNQ) and has 275 and 132kV operating voltages in one yard. Chalumbin Substation is connected via four 275kV feeders and is the major substation in the 275kV power transfer corridor between Central Queensland and FNQ. There are two 275/132kV transformers located in Chalumbin enabling power transfer into the local 132 kV network in the Cairns region through four 132kV feeders.

Chalumbin Substation was established in 1988. The majority of Primary equipment was part of the original installation and is now around 35 years old. A condition assessment was carried out in 2020 and identified issues related to selected primary plant with replacement recommended in the next 5 to 10 years.

The substation has undergone feeder and bay extensions and modifications since its original construction, that has resulted in the staged installation of secondary systems from 2004 to 2014. A condition assessment conducted in 2019 has identified that the 132kV secondary systems installed in demountable building +4 in 2012 is due for replacement by 2032. In addition to the 132kV secondary systems, selected 275kV secondary systems also require replacement by this time.

The 132kV Capacitor Bank (M04) and associated bay is currently in a failed state and Planning have confirmed there is no enduring need for this Capacitor Bank.

The objective of this project is to replace selected 132kV primary plant and secondary systems and decommission the 132kV Capacitor Bank and associated bay at Chalumbin substation by October 2028 for Option 1 and October 2032 for Option 2. This project will be executed in conjunction with CP.02948 Chalumbin 275kV Substation Reinvestment project.

This project will follow the two (2) stage approval process and is subject to a RIT-T.

## 2. Project Drawing

[redacted]

*Figure 1: Chalumbin 275kV and 132kV Operating Diagram*

[redacted]

Primary Plant to be replaced under this project (CP.03144)

Plant to be decommissioned under this project (CP.03144)

*Figure 2: Chalumbin 132kV Line Diagram*

*Figure 3: Chalumbin Substation Aerial View*

[redacted]

*Figure 4: Proposed new arrangement under Option 3*

[redacted]

*Figure 5: Proposed new arrangement under Option 4*

## 3. Deliverables

The following deliverables are to be provided in response to this Project Scope Report. The requirement dates for these deliverables will be communicated separately.

This project will follow the two stage approval process. The following deliverables are to be provided for the purposes of options analysis as required under the RIT-T:

1. Preliminary feasibility assessment for each option, including inputs from design, construction and commissioning.

2. A report (e.g. Concept Estimate Report) detailing the works to be delivered, high level staging, resource requirements and availability, and outage requirements and constraints for each option. This report should include the findings and recommendations from the preliminary feasibility assessment.

3. A class 5 estimate (minimum) for each option with consideration of the following:

   - Enduring need for the 132kV feeders to Turkinje is uncertain. Works at Chalumbin to replace equipment in bays D7.1 and D8.2 and works at Turkinje substation are to be estimated as a separable portion.

   - Works associated with the decommissioning of 132kV Capacitor Bank M4 are to be estimated as a separable portion.

4. A basis of estimate document and risk table, detailing the key estimating assumptions and delivery risks for each option.

5. Outline staging and outage plans for each option.

6. Provide a high level project schedule for each option and identify any requirements for early funding to meet the commissioning date (e.g. procurement of long lead time equipment).

## 4. Project Scope

The following scope presents a functional overview of the desired outcomes of the project. The proposed solution presented in the estimate must be developed with reference to the remaining sections of this Project Scope Report, in particular *Section 7 Special Considerations*.

Briefly, the project consists of replacing selected 132kV primary plant and secondary systems and decommissioning the 132kV Capacitor Bank and associated bay at Chalumbin substation. This project will be executed in conjunction with CP.02948 Chalumbin 275kV Substation Reinvestment project.

Four credible options have been identified to replace selected equipment at Chalumbin substation, as presented in Table 1 below. These options will be presented in the RIT-T public consultation (a combined RIT-T will be undertaken for CP.02948 and CP.03144). Concept estimates are required for each option to inform feasibility and cost assessments.

Table 1 - Options summary

| Option | Stage | Works | Comm. Date |
|---|---|---|---|
| **1** | 1 | Replace selected 132kV primary plant in-situ and decommission the 132kV Capacitor Bank and associated bay.<br><br>Replace selected secondary systems equipment within the existing +4 building. Assessment to be undertaken by the project team to confirm whether installation of new panels in the existing buildings or in-situ replacement of devices within existing panels is the preferred approach. | Dec 2031 |
| **2** | 1 | Replace selected 132kV primary plant in-situ and decommission the 132kV Capacitor Bank and associated bay. | Dec 2031 |
| | 2 | Replace selected secondary systems equipment within the existing +4 building. Assessment to be undertaken by the project team to confirm whether installation of new panels in the existing buildings or in-situ replacement of devices within existing panels is the preferred approach. | Nov 2033 |

| | | | |
|---|---|---|---|
| **3** | 1 | Replace selected 132kV primary plant by installing new bays in adjacent spare bay locations and replace equipment in existing locations as per Figure 4 to minimise outage impacts, and decommission the 132kV Capacitor Bank and associated bay.<br><br>Replace selected secondary systems equipment within the existing +4 building (new panels to be installed within existing building). | Dec 2030 |
| **4** | 1 | Replace selected 132kV primary plant by installing two new bays in adjacent spare bay locations and replace equipment in existing locations as per Figure 5 to minimise outage impacts, and decommission the 132kV Capacitor Bank and associated bay.<br><br>Replace selected secondary systems equipment within the existing +4 building (new panels to be installed within existing building). | Nov 2030 |

## 4.1. Option 1 – Replace Primary Plant In-Situ and Secondary Systems in 2028

### 4.1.1. Transmission Line Works

Not applicable.

### 4.1.2. H032 Chalumbin Substation Works

Primary Works

Design, procure, construct and commission the in-situ replacement of the selected 132kV primary plant listed in Attachment 1, with consideration of the following:

- For bays requiring both CB and CT replacement, consideration should be given to utilising dead tank circuit breakers; and
- The ABB A phase CT being replaced in bay D06 (H032-D06-7192-7192CTA) is to be returned to stores as a spare.

Decommission and remove obsolete 132kV primary plant listed in Attachment 2 with consideration of the following:

- The 132kV Capacitor Bank PASS M0 module is currently in a failed state and is to be assessed by the manufacturer to confirm whether it is repairable and able to be retained as a spare. Assessment should be done on site by ABB and economic analysis done to decide if it is worth repairing. If it is deemed to be not economically viable the bushings, mechanism and LCC should be returned to stores for spares; and
- Test and return 3 x capacitor cans, balance CT and CVT to the warehouse for use as spare stock.

Secondary Works:

Design, procure, construct and commission new 132kV secondary systems within the existing control buildings for the following plant:

- 132kV 1 and 2 Bus;
- 132kV bus coupler (D03);

- 132kV feeder 7165 (D8.2);
- 132kV feeder 7166 (D7.1);
- 132kV feeder 7191 (D5.2);
- 132kV feeder 7192 (D6.1);
- OpsWAN and SCADA to provide for control and monitoring requirements including OpsWAN equipment (except the camera) and relocate devices (except the camera) from the OpsWAN camera housing at the top of the pole to the camera patch box at the base of the pole;
- Replace 125V and 50V DC charges and monitoring systems (battery banks were replaced in 2023 under CP.02786);
- Modify AC and DC distribution as required to facilitate the replacement works; and
- Modify and upgrade telecommunications equipment as required to support the new secondary systems;

Decommission and recover all redundant equipment, and update drawing records, SAP records, config files, etc. accordingly.

#### 4.1.3. Remote End Substation Works

Modify protection, control, automation and communications systems as required at all impacted remote end substations.

#### 4.1.4. Telecoms Works

Telecoms works included under Substation Works.

Telecommunications works are to be coordinated with CP.02811 Telecommunication Network Consolidation RAN 2 and CP.02513 OpsWAN and MPLS Replacement RAN 2. It is expected that works under CP.02811 and CP.02513 will be completed at Chalumbin prior to commencing the secondary systems cutovers, however, this needs to be confirmed with the project team.

#### 4.1.5. Easement/Land Acquisition & Permits Works

Not applicable

### 4.2. Option 2 – Replace Primary Plant In-Situ by 2028 and Secondary Systems by 2032

As per the scope of Option 1, except that Primary Plant works are to be completed by 2028 and Secondary Works are to be completed by 2032.

### 4.3. Option 3 – Replace Primary Plant and Secondary Systems by utilising spare bay locations as per Figure 4 by 2028

#### 4.3.1. Transmission Line Works

Design, procure, construct and commission new line entries to facilitate rebuild of primary plant in adjacent spare bay locations as shown in Figure 4.

#### 4.3.2. H032 Chalumbin Substation Works

As per the scope of Option 1, except that primary plant is to be replaced by installing new equipment in adjacent spare bay locations as shown in Figure 4.

#### 4.3.3. Remote End Substation Works

As per the scope of Option 1.

#### 4.3.4. Telecoms Works

As per the scope of Option 1, with additional OPGW/fibre works to accommodate new landing spans and bay locations.

#### 4.3.5. Easement/Land Acquisition & Permits Works

Not applicable

### 4.4. Option 4 – Replace Primary Plant and Secondary Systems by utilising spare bay locations as per Figure 5 by 2028

#### 4.4.1. Transmission Line Works

Design, procure, construct and commission new line entries to facilitate rebuild of primary plant in adjacent spare bay locations as shown in Figure 5.

#### 4.4.2. H032 Chalumbin Substation Works

As per the scope of Option 1, except that primary plant is to be replaced by installing new equipment in adjacent spare bay locations as shown in Figure 5.

#### 4.4.3. Remote End Substation Works

As per the scope of Option 1.

#### 4.4.4. Telecoms Works

As per the scope of Option 1, with additional OPGW/fibre works to accommodate new landing spans and bay locations.

#### 4.4.5. Easement/Land Acquisition & Permits Works

Not applicable

### 4.5. Key Scope Assumptions

The following assumptions should be included in the estimating of this scope:

- This project will be executed in conjunction with CP.02948 Chalumbin 275kV Substation Reinvestment; and

- Telecommunications works under CP.02811 Telecommunication Network Consolidation RAN 2 and CP.02513 OpsWAN and MPLS Replacement RAN 2 will be completed at Chalumbin prior to commencing the secondary systems cutovers.

### 4.6. Variations to Scope (post project approval)

Not applicable

## 5. Key Asset Risks

Asset risk management shall be in accordance with the Asset Risk Management Process Guideline (A4870713).

## 6. Project Timing

### 6.1. Stage 1 Approval Date

The anticipated date by which the project will be Stage 1 approved is November 2025.

### 6.2. Site Access Date

This is an operational substation, therefore, site access is available.

### 6.3. Commissioning Date

The latest date for the commissioning of the new assets included in this scope and the decommissioning and removal of redundant assets, is 31st October 2028 for Option 1 and 31st October 2032 for Option 2.

The asset need date for the primary plant is June 2028. The project team is to assess the earliest possible delivery date for these works (as close as possible to the asset need date) as part of the Concept Estimate and provide a schedule of key milestones and funding requirements to meet this date. The project team are to advise the Sponsor as soon as possible if preapproval funding is required to procure long lead time equipment before completion of the estimate to meet the proposed commissioning date.

## 7. Special Considerations

- Structural assessment of the 132kV towers and gantry is required for options 3 and 4 to confirm landing span changes are feasible.

- Removal of obsolete bus isolator in bay D9.2 is required under options 1, 2 and 4 to improve access to bay D8.2

- Cables, marshalling kiosks and panels are in good condition and do not require replacement. Design to undertake site assessment and determine most appropriate replacement methodology utilising the existing buildings i.e. new panels in the existing buildings or in-situ device replacement within the existing panels. Assessment, including reasons for recommended approach to be provided as part of the Concept Estimate.

## 8. Asset Management Requirements

Equipment shall be in accordance with Powerlink equipment strategies.

Unless otherwise advised [redacted] will be the Project Sponsor for this project. The Project Sponsor must be included in any discussions with any other areas of Network and Business Development including Asset Strategies & Planning.

## 9. Asset Ownership

The works detailed in this project will be Powerlink Queensland assets.

## 10. System Operation Issues

Operational issues that should be considered as part of the scope and estimate include:

- interaction of project outage plan with other outage requirements;
- likely impact of project outages upon grid support arrangements; and
- likely impact of project outages upon the optical fibre network.

[redacted]

## 11. Options

As per section 4

## 12. Division of Responsibilities

Not applicable

## 13. Related Projects

| Project No. | Project Description | Planned Comm Date | Comment |
|---|---|---|---|
| Pre-requisite Projects | | | |
| CP.02786 | Chalumbin Secondary Systems Replacement Stage 1 | Dec 2025 | In execution |
| CP.03104 | Replace 275kV ABB IMB300 CT's - Northern | 2029 | Definition |
| Co-requisite Projects | | | |
| CP.02948 | Chalumbin 275kV Substation Reinvestment | 2028 | Definition |
| CP.02811 | Telecommunication Network Consolidation RAN 2 | Dec 2027 | Definition |
| CP.02513 | CP.02513 OpsWAN and MPLS Replacement RAN 2 | Aug 2027 | Definition |
| Other Related Projects | | | |
| CP.02750 | BS1220 Ross to Chalumbin Life Extension | 2029 | Definition |

## Attachment 1: Primary Plant to be replaced under CP.03144

| Functional Location | Equipment Id | Manufacturer | Model | Tech Type |
|---|---|---|---|---|
| H032-D04-441--1SAA | 20005296 | ASEA | XAR145A2/120 | SUBS0031 |
| H032-D04-441--1SAB | 20005297 | ASEA | XAR145A2/120 | SUBS0031 |
| H032-D04-441--1SAC | 20005298 | ASEA | XAR145A2/120 | SUBS0031 |
| H032-D04-441--1TRFCTA | 20005263 | TYREE | 06/145/50 | SUBS0015 |
| H032-D04-441--1TRFCTB | 20005262 | TYREE | 06/145/50 | SUBS0015 |
| H032-D04-441--1TRFCTC | 20005261 | TYREE | 06/145/50 | SUBS0015 |
| H032-D04-441--4412 | 20005253 | ASEA | HLR145/2501E | SUBS0010 |
| H032-D06-7192-71922 | 20005255 | ASEA | HLR145/2501E | SUBS0010 |
| H032-D06-7192-7192CTA (Return CT to warehouse as spare stock) | 20048922 | ABB AUSTRALIA | IMBM145C5T5 | SUBS0015 |
| H032-D06-7192-7192CTB | 20005269 | TYREE | 06/145/56 | SUBS0015 |
| H032-D06-7192-7192CTC | 20005265 | TYREE | 06/145/56 | SUBS0015 |
| H032-D06-7192-7192SAA | 20005318 | ASEA | XAR145A2/120 | SUBS0031 |
| H032-D06-7192-7192SAB | 20005299 | ASEA | XAR145A2/120 | SUBS0031 |
| H032-D06-7192-7192SAC | 20005317 | ASEA | XAR145A2/120 | SUBS0031 |
| H032-D07-7166-4VTA | 20071500 | TRENCH LIMITED | TEMP138HC | SUBS0009 |
| H032-D07-7166-4VTB | 20071499 | TRENCH LIMITED | TEMP138HC | SUBS0009 |
| H032-D07-7166-4VTC | 20072434 | TRENCH LIMITED | TEMP138HC | SUBS0009 |
| H032-D07-7166-71662 | 20005254 | ASEA | HLR145/2501E | SUBS0010 |
| H032-D07-7166-7166CTA | 20005268 | TYREE | 06/145/56 | SUBS0015 |
| H032-D07-7166-7166CTB | 20005267 | TYREE | 06/145/56 | SUBS0015 |
| H032-D07-7166-7166CTC | 20005264 | TYREE | 06/145/56 | SUBS0015 |
| H032-D07-7166-7166SAA | 20005314 | ASEA | XAR145A2/120 | SUBS0031 |
| H032-D07-7166-7166SAB | 20005316 | ASEA | XAR145A2/120 | SUBS0031 |
| H032-D07-7166-7166SAC | 20005315 | ASEA | XAR145A2/120 | SUBS0031 |
| H032-D08-7165-71652 | 20012130 | AEG | S1-145F1 3PAR P | SUBS0015 |
| H032-D05-7191-71912 | 20012131 | AEG | S1-145F1 3PAR P | SUBS0015 |
| H032-D03-411--4112 | 20012132 | AEG | S1-145F1 3PAR P | SUBS0015 |
| H032-D06-442--4422 | 20014006 | AEG | S1-145F1 3PAR P | SUBS0015 |
| H032-D08-7165-7165CTA | 20012144 | ABB | 169869 | SUBS0015 |
| H032-D08-7165-7165CTB | 20012142 | ABB | 169869 | SUBS0015 |
| H032-D08-7165-7165CTC | 20012134 | ABB | 169869 | SUBS0015 |
| H032-D08-7165-7165SAA | 20012163 | ABB POWER TRANSMISSION | EXLIM R120-AM145M | SUBS0031 |
| H032-D08-7165-7165SAB | 20012161 | ABB POWER TRANSMISSION | EXLIM R120-AM145M | SUBS0031 |
| H032-D08-7165-7165SAC | 20012164 | ABB POWER TRANSMISSION | EXLIM R120-AM145M | SUBS0031 |
| H032-D05-7191-7191CTA | 20012143 | ABB | 169869 | SUBS0015 |
| H032-D05-7191-7191CTB | 20012136 | ABB | 169869 | SUBS0015 |
| H032-D05-7191-7191CTC | 20012138 | ABB | 169869 | SUBS0015 |

| | | | | |
|---|---|---|---|---|
| H032-D03-411--1BUSCTA | 20012141 | ABB | 169869 | SUBS0015 |
| H032-D03-411--1BUSCTB | 20012133 | ABB | 169869 | SUBS0015 |
| H032-D03-411--1BUSCTC | 20012135 | ABB | 169869 | SUBS0015 |
| H032-D03-411--2BUSCTA | 20012137 | ABB | 169869 | SUBS0015 |
| H032-D03-411--2BUSCTB | 20012139 | ABB | 169869 | SUBS0015 |
| H032-D03-411--2BUSCTC | 20012140 | ABB | 169869 | SUBS0015 |
| H032-D06-442--2TRFCTA | 20013855 | ABB | 169869 | SUBS0015 |
| H032-D06-442--2TRFCTB | 20013856 | ABB | 169869 | SUBS0015 |
| H032-D06-442--2TRFCTC | 20013857 | ABB | 169869 | SUBS0015 |

## Attachment 2: Primary Plant to be decommissioned under CP.03144

| Functional Location | Equipment Id | Manufacturer | Model | Tech Type |
|---|---|---|---|---|
| H032-D09-481—12VT (Return CVT to warehouse as spare stock) | 20054801 | ABB SWITCHGEAR | CPA 145 | SUBS0009 |
| H032-D09-481—4812HM (If the HM is repairable, return to warehouse as spare stock) | 20054799 | ABB ADDA | PASS M0 RELOCATABLE | SUBS0037 |
| H032-M04-1CAP (Test and return 3 x capacitor cans to warehouse for use as spare stock along with resin cap balance CT) | | | | Capacitor Bank |

# CP.03144 H032 Chalumbin 132kV Substation Reinvestment

# Concept Estimate

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# 1. Executive Summary

The purpose of this report is to provide a high-level options analysis for the replacement of selected 132kV Primary Plant and Secondary Systems equipment at H032 Chalumbin Substation.

This project will follow the two (2) stage approval process.

This concept report explores the four options detailed in the project scope report:

- **Option 1:** Replace both selected 132kV Primary Plant and Secondary Systems concurrently in situ. The new secondary systems panels have been allowed to be installed in the existing control building.

- **Option 2:** A two staged approach replacing selected 132kV Primary Plant in stage one and the replacement of the entire Secondary Systems in stage two. The new secondary systems panels have been allowed to be installed in the existing control building.

- **Option 3:** Replace the entire Primary Plant and Secondary Systems concurrently by Installing 7 New Bays in the adjacent spare bays. The new secondary systems panels have been allowed to be installed in the existing control building.

- **Option 4:** Replace both selected 132kV Primary Plant and Secondary Systems concurrently by first Installing 2 new Bays in the adjacent spare bays and then utilising bays swaps to rebuild in situ the remaining 5 bays. The new secondary systems panels have been allowed to be installed in the existing control building.

The assessment from the project team has determined that the project can be delivered by **December 2031** for **Option 1, November 2033** for **Option 2, December 2030** for **Option 3,** and **November 2030** for **Option 4.**

## 2. Project Information

Chalumbin Substation (H032) is located in Far North Queensland (FNQ) and has 275kV and 132kV operating voltages in one yard. Chalumbin Substation is connected via four 275kV feeders and is the major substation in the 275kV power transfer corridor between Central Queensland and FNQ. There are two 275/132kV transformers located in Chalumbin enabling power transfer into the local 132kV network in the Cairns region via four 132kV feeders.

Chalumbin Substation was established in 1988. The majority of the Primary equipment was part of the original installation and is now around 37 years old. A condition assessment was carried out in 2020 and identified issues related to selected primary plant with replacement recommended in the next 5 to 10 years.

The substation has undergone feeder and bay extensions and modifications since its original construction, that has resulted in the staged installation of secondary systems from 2004 to 2014. A condition assessment conducted in 2019 has identified that the 132kV secondary systems installed in demountable building +4 in 2012 is due for replacement under this project CP.03144 by 2032. In addition to the 132kV secondary systems, selected 275kV secondary systems also require replacement by this time (Planned under CP.02786 and CP.02948).

The 132kV Capacitor Bank (M04) and associated bay is currently in a failed state and Planning have confirmed there is no enduring need for this Capacitor Bank.

This project consists of replacing selected 132kV primary plant, secondary systems and removal of the failed 132kV Capacitor Bank (M04).

This project will be executed in conjunction with CP.02948 Chalumbin 275kV Substation Reinvestment project.

This project will follow the two (2) stage approval process and is subject to a RIT-T noting that a combined RIT-T will be undertaken for both CP.02948 and CP.03144.

### 2.1 Option Comparison Table

| | Option 1 | Option 2 | Option 3 | Option 4 |
|---|---|---|---|---|
| **Cost (total escalated including contingency)** | • Total Requested Approved Budget - $48,452,901 | • Total Requested Approved Budget - $60,764,893 | • Total Requested Approved Budget - $64,775,793 | • Total Requested Approved Budget - $55,514,960 |
| **Commissioning Date** | • **December 2031** | • **November 2033** | • **December 2030** | • **November 2030** |
| **Deliverable with current Net Ops restrictions** | • No | • No | • Yes | • Yes |
| **Stages Requiring HV Outages** | • 8 (100 weeks) | • 15 (149 weeks) | • 7 (7 weeks) | • 8 (8 weeks) |
| **Execution Strategy Advantages** | • Primary plant and secondary systems to be replaced together, reducing demobilisation / remobilisation, labour and escalation costs (due to project prolongation). | • Extends the operational life of the secondary systems equipment. | • Outage durations limited to cutting over of new bays only.<br>• Extends the design life of the entire 132kV yard's primary plant.<br>• Meets Net Ops 12 Hour RTS requirement. | • Outage durations limited to cutting over of new bays only.<br>• Only 2 new bays to be built vs 7 in option 3 lowering the overall cost by $10m.<br>• Meets Net Ops 12 Hour RTS requirement. |
| **Execution Strategy Disadvantages** | • Replacing primary plant and secondary systems at the same time increases the technical complexity of the scope and introduces additional risk. | • Additional demobilisation / remobilisation, labour and project escalation costs (due to project prolongation).<br>• Higher impact from seasonal weather events | • High capital cost due to constructing 7 new bays.<br>• Involvement of additional design and construction disciplines due to bay swaps.<br>• Replacing primary plant and secondary systems | • Involvement of additional design and construction disciplines due to bay swaps.<br>• Replacing primary plant and secondary systems at the same time increases the technical |

| | | | | |
|---|---|---|---|---|
| | • Does not meet Net Ops 12 Hour RTS requirement. | and Network Operations outage restrictions.<br>• Possibility of new secondary systems standards being developed over the extended project delivery timeline.<br>• Does not meet Net Ops 12 Hour RTS requirement. | at the same time increases the technical complexity of the scope and introduces additional risk. | complexity of the scope and introduces additional risk. |
| **Wet Weather Delay Periods** | • 4 (78 weeks) | • 4 (78 weeks) | • 3 (62 weeks) | • 3 (55 weeks) |
| **Site Mobilisation events required** | • 5 | • 5 | • 4 | • 4 |
| **Site Demobilisation events required** | • 5 | • 5 | • 4 | • 4 |

## 2.2 Dependencies & Interactions

This project is dependent on the following projects:

| Project No. | Project Description | Planned Comm Date | Comment |
|---|---|---|---|
| Co-requisite Projects | | | |
| CP.02786 | Chalumbin Secondary Systems Replacement Stage 1 | July 2027 | This project is the first stage of the 275kV Secondary Systems replacement. Resources will be retained to start CP.02948/CP.03144 immediately upon project completion. |
| CP.03104 | Replace 275kV ABB IMB300 CT's - Northern | 2026 | T1 CT's to be replaced prior to site mobilisation, clearing the RAZ zone. |
| CP.02948 | H032 Chalumbin 275kV Substation Reinvestment | TBC | CP.02948 is planned to be delivered in conjunction with CP.03144 to optimise resource utilisation on site. |
| CP.02811 | Telecommunication Network Consolidation RAN 2 | Dec 2027 | Project is expected to be completed prior to mobilisation, project teams to monitor. |
| CP.02513 | CP.02513 OpsWAN and MPLS Replacement RAN 2 | Aug 2027 | Project is expected to be completed prior to mobilisation, project teams to monitor. |
| Other Related Projects | | | |
| CP.02750 | BS1220 Ross to Chalumbin Life Extension | TBC | Project on the 132kV transmission feeders may be planned around the same time period, coordination is required between project teams. |
| OR.02411 | T055 Turkinje Tfmr 1 & 2 Primary & Sec Sys Mods | TBC | Project currently in execution with potential delays, coordination is required between project teams. |

## 2.3 Site Specific Issues


*Figure 1: H032 Chalumbin Substation*

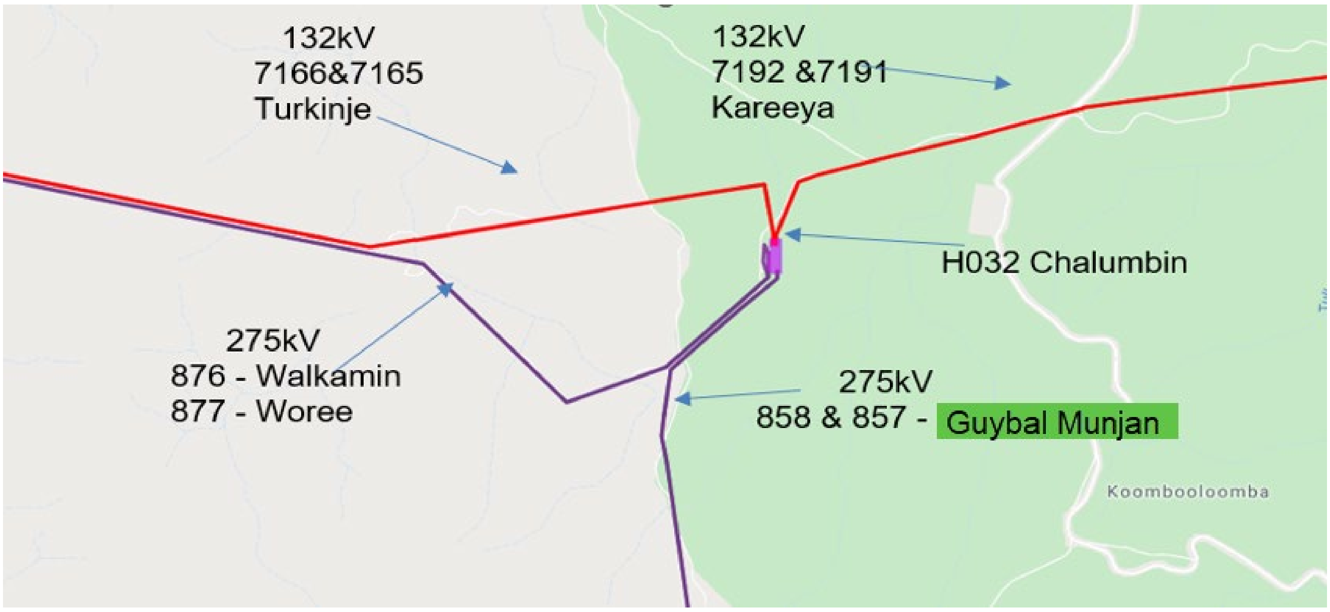


*Figure 2: Overview of HV Supply Network*

Issues specific to the project are as follows:

- The work site is located in the Einasleigh Uplands region on the western edge of Tully Falls National Park and adjacent to Koombooloomba Dam which is 2h 40m and 172km from Cairns Airport.
    - Teams should avoid the Gillies Range route for deliveries from the Cairns region due to accessibility limitations.
    - There is limited accommodation in the area with teams needing to stay in Ravenshoe, approximately 40-50km and 30 minutes from site.
    - The closest concrete batching plant is also in Ravenshoe.
    - Mobile phone reception can be limited.
- H032 has 4 x 132kV and 4 x 275kV Feeders
    - 2 x 132kV Feeders to Turkinje.
    - 2 x 132kV Feeders to Kareeya.
    - 2 x 275kV Feeders to Guybal Munjan.
    - 1 x 275kV Feeder to Walkamin.
    - 1 x 275kV Feeder to Woree.
- Chalumbin substation experiences a humid, high-rainfall climate and is located in the Wet Tropics zone, characterized by a summer monsoon (wet season) and a milder dry season. Below is a summary of average monthly rainfall based on long-term BOM records from the nearby Koombooloomba Dam gauge (which is representative of the substation's location):

| Statistics | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Temperature | | | | | | | | | | | | | |
| Mean maximum temperature (°C) | 27.9 | 27.0 | 25.9 | 23.5 | 21.5 | 20.1 | 19.6 | 20.8 | 23.5 | 25.5 | 27.9 | 28.4 | 24.3 |
| Mean minimum temperature (°C) | 19.1 | 19.3 | 18.5 | 17.1 | 15.1 | 11.5 | 11.1 | 11.7 | 13.3 | 15.5 | 17.3 | 18.5 | 15.7 |
| Rainfall | | | | | | | | | | | | | |
| Mean rainfall (mm) | 343.6 | 468.8 | 480.2 | 359.0 | 238.0 | 150.5 | 124.6 | 100.4 | 82.6 | 94.7 | 120.3 | 188.7 | 2753.9 |
| Decile 5 (median) rainfall (mm) | 277.6 | 413.0 | 396.6 | 323.0 | 241.3 | 128.9 | 111.9 | 58.8 | 40.1 | 68.2 | 110.6 | 159.1 | |
| Mean number of days of rain ≥ 1 mm | 14.5 | 15.6 | 16.6 | 16.0 | 14.2 | 10.0 | 9.5 | 8.4 | 6.2 | 6.8 | 8.1 | 10.4 | 136.3 |

*Figure 3: Climate Statistics for Koombooloomba Dam*

- Due to the high rainfall in the wet season (01/01 – 30/04), any stages requiring civil works to be carried out have been scheduled to avoid this period for all 4 options.

## 2.4 Project Milestones

| Milestones | High Level Timing (Milestone Completion Date) |
| --- | --- |
| Request for Class 3 Estimate | November 2025 |
| Class 3 Project Proposal | June 2026 |
| *Stage 1 Approval (PAN1)* incl funds for design, procurement & ITT preparation | July 2026 |
| RIT-T Issued | July 2026 |
| Project Development Phase 1 & Phase 2 | December 2026 |
| Endorsement for "Going to Tender" from Network & Alternate Solutions | December 2026 |
| RIT-T Approval (assumed 26 weeks) | February 2027 |
| ITT Submission (6 weeks) | February 2027 |

| | |
|---|---|
| Evaluate Tender, Reconcile Estimate and Update PMP for Stage 2 Approval | March 2027 |
| *Stage 2 Approval (PAN2)* | May 2027 |
| Execute Delivery (including award of SPA contract) | June 2027 |

# 3. Option 1 – Replace both selected 132kV Primary Plant and Secondary Systems concurrently in Situ.

## 3.1 Option Definition

### 3.1.1 Option High-Level Scope

**Replacement of the below Primary Plant (see '*Figure 4: 132kV Line Diagram – Option 1'* below for reference).**

- Replace all 132kV Circuit Breakers with Dead Tank Circuit Breaker's (x7).
- Replace Capacitor Voltage Transformer (x3).
- Replace Surge Arrester (x12) – noting that the additional set is shown on the secondary of the 275/132kV Tx diagram and not below.
- Removal of obsolete bus isolator in bay D9.2 to improve access to bay D8.2.
- The ABB A phase CT being replaced in bay D06 (H032-D06-7192-7192CTA) is to be returned to stores as a spare.
- The 132kV Capacitor Bank PASS M0 module is currently in a failed state
    - Equipment is to be assessed by the manufacturer to confirm whether it is repairable and able to be retained as a spare. Assessment should be done on site by ABB and economic analysis done to decide if it is worth repairing. If it is deemed to be not economically viable the bushings, mechanism and LCC should be returned to stores for spares.
    - Test and return 3 x capacitor cans, balance CT and CVT to the warehouse for use as spare stock.

**Replacement of the below secondary systems utilising 8 new panels in the existing building.**

- 132kV 1 and 2 Bus.
- 132kV bus coupler (D3).
- 132kV feeder 7165 (D8.2).
- 132kV feeder 7166 (D7.1).
- 132kV feeder 7191 (D5.2).
- 132kV feeder 7192 (D6.1).
- OpsWAN and SCADA to provide control and monitoring requirements including OpsWAN equipment (except the camera) and relocate devices (except the camera) from the OpsWAN camera housing at the top of the pole to the camera patch box at the base of the pole.
- Replace 125V and 50V DC chargers and monitoring systems (battery banks were replaced in 2023 under CP.02786).
- Modify AC and DC distribution as required to facilitate the replacement works.
- Modify and upgrade telecommunications equipment as required to support the new secondary systems.

**Remote End Substation Works**

Modify the protection, control, automation and communications systems as required at

- 2 x 132kV Feeders to Turkinje.
- 2 x 132kV Feeders to Kareeya.

**Telecommunications Works**

Telecommunications works are to be coordinated with CP.02811 Telecommunication Network Consolidation RAN 2 and CP.02513 OpsWAN and MPLS Replacement RAN 2. It is expected that works under CP.02811 and CP.02513 will be completed at Chalumbin prior to commencing the secondary systems cutovers.

[redacted]

*Figure 4: 132kV Line Diagram – Option 1*

### 3.1.2 Scope Assumptions

- The slab and foundations associated with the failed Capacitor Bank will be removed.
- Allowance has been made to replace the primary equipment foundations and structures.
- Dead tank circuit breakers are to be used.
- New panels will be installed into the existing building.
- Cables between termination racks and marshalling kiosks are in good condition and do not require replacement.
- Marshalling kiosks are in good condition and do not require replacement.
- This project will be executed in conjunction with CP.02948 Chalumbin 275kV Substation Reinvestment.
- Telecommunications works under CP.02811 Telecommunication Network Consolidation RAN 2 and CP.02513 OpsWAN and MPLS Replacement RAN 2 will be completed at Chalumbin prior to commencing the secondary systems cutovers.
- Project Milestone dates are met as outlined in 2.4.
- Outages will be available and any Return to Service (RTS) requirements will be agreed in a timely manner.
- MSP resourcing is available when required to meet the approved commissioning date.
- SPA contractor is available when required to meet the approved commissioning date.
- PLQ Design resources are available when required to meet the approved commissioning date.
- PLQ project and support resources are available to align with the project timing to support meeting the approved commissioning date.
- Access to site is available.
- All required scope items have been included in Revision 3 of the CP.03144 Project Scope Report issued on 04/09/2025.
- Funds will be released to purchase long lead items, undertake design and ITT (Stage 1 Approval).
- Soil conditions are generally suitable for bored, reinforced concrete structures.
- Primary Plant Materials and Secondary Systems Equipment and Materials are available and delivered on time for the construction phase.
- The following lead times have been considered in this estimate:

| Equipment | Lead Time |
|---|---|
| 145kV Dead Tank Circuit Breaker | 78 weeks |
| CVT | 78 weeks |
| Station Post Insulator | 52 weeks |
| Surge Arrestors | 100 weeks (investigating acceleration) |
| Disconnectors | 60 weeks |
| Control Building Panels | 12 weeks |

### 3.1.3 Scope Exclusions

- Easement acquisition works, including permits, approvals, development applications etc. All works are within Powerlink owned land.

- Any outage contingency plans required by Network Operations.
- Any works on the EQL network.
- No allowance has been made for Live Substations work.
- No allowance has been made for External Design resources.
- Additional foundation work associated with high water table.
- Inclement weather in excess of what could reasonably be expected.
- Excavation in hard ground i.e. rock is excluded from this estimate.
- Any work outside of normal working hours.

## 3.2 Project Execution

### 3.2.1 Project Schedule

| Activity | Date |
|---|---|
| Early Works (by SPA) | October 2027 |
| FAT Stage 1 (by MSP) | November – December 2027 |
| *Wet Season Demobilisation* | *January – May 2028* |
| FAT Stage 2 (by MSP) | May – June 2028 |
| 275/132kV T1 | June - September 2028 |
| 275/132kV T2 | September – December 2028 |
| *Wet Season Demobilisation* | *January – May 2029* |
| 132kV Feeder 7166 | May – August 2029 |
| 132kV Feeder 7165 | August – November 2029 |
| *Wet Season Demobilisation* | *January – May 2030* |
| 132kV Feeder 7191 | May – August 2030 |
| 132kV Feeder 7192 | August – November 2030 |
| *Wet Season Demobilisation* | *January – May 2031* |
| 132kV 1 – 2 Bus Coupler | May – August 2031 |
| 1 Bus Outage to remove Capacitor Bank | August 2031 |
| Remove Redundant Equipment | August - November 2031 |
| Project Commissioned | December 2031 |

Notes:

- The above staging durations are assumptions.

- High-level wet weather constraints have been considered in the above timing, based on BOM data for mean rainfall (refer Section 2.3).

#### 3.2.2 Network Impacts

Network Operations have advised that all outages will require a 12-hour return to service (RTS) or an adequate contingency plan.

Given the extended outages required to facilitate the complex scope of works and a 12-hour contingency plan is not possible, this option is not feasible with the current network access limitations.

#### 3.2.3 Resourcing

The following resource strategy is proposed:

- Design by PLQ.
- SPA.
- MSP (core works).
- SPA contractor may be engaged under a D&C contract if PLQ design constraints risk delaying the approved commissioning date.

### 3.3 Project Estimate

| | | Sub Total $ | Total $ |
|---|---|---|---|
| **Estimate Class** | 5 | | |
| **Estimate accuracy (-% / +%)** | -50% / +100% | | |
| Base Estimate | | $30,767,576 | |
| [redacted] | | [redacted] | |
| [redacted] | | | [redacted] |
| [redacted] | [redacted] | [redacted] | |
| [redacted] | [redacted] | [redacted] | |
| [redacted] | | | [redacted] |
| [redacted] | | | [redacted] |

## 4. Option 2 – A two staged approach replacing selected 132kV Primary Plant in stage one and the replacement of the entire Secondary Systems in stage two.

### 4.1 Option Definition

#### 4.1.1 Option Scope

**Staged replacement of Primary Plant at H032 by November 2031 (see below '*Figure 5: 132kV Line Diagram – Option 2'* below for reference).**

- Replace all 132kV Circuit Breakers with Dead Tank Circuit Breaker's (x7).
- Replace Capacitor Voltage Transformer (x3).
- Replace Surge Arrester (x12) – noting that the additional set is shown on the secondary of the 275/132kV Tx diagram and not below.
- Removal of obsolete bus isolator in bay D9.2 to improve access to bay D8.2.
- The ABB A phase CT being replaced in bay D06 (H032-D06-7192-7192CTA) is to be returned to stores as a spare.
- The 132kV Capacitor Bank PASS M0 module is currently in a failed state.
    - Equipment is to be assessed by the manufacturer to confirm whether it is repairable and able to be retained as a spare. Assessment should be done on site by ABB and economic analysis done to decide if it is worth repairing. If it is deemed to be not economically viable the bushings, mechanism and LCC should be returned to stores for spares.
    - Test and return 3 x capacitor cans, balance CT and CVT to the warehouse for use as spare stock.

**Replacement of the below secondary systems at H032 utilising 8 new panels in the existing building by September 2033.**

- 132kV 1 and 2 Bus.
- 132kV bus coupler (D03).
- 132kV feeder 7165 (D8.2).
- 132kV feeder 7166 (D7.1).
- 132kV feeder 7191 (D5.2).
- 132kV feeder 7192 (D6.1).
- OpsWAN and SCADA to provide for control and monitoring requirements including OpsWAN equipment (except the camera) and relocate devices (except the camera) from the OpsWAN camera housing at the top of the pole to the camera patch box at the base of the pole.
- Replace 125V and 50V DC chargers and monitoring systems (battery banks were replaced in 2023 under CP.02786).
- Modify AC and DC distribution as required to facilitate the replacement works.
- Modify and upgrade telecommunications equipment as required to support the new secondary systems.

**Remote End Substation Works**

Modify the protection, control, automation and communications systems as required at the

- 2 x 132kV Feeders to Turkinje.
- 2 x 132kV Feeders to Kareeya.

**Telecommunications Works**

Telecommunications works are to be coordinated with CP.02811 Telecommunication Network Consolidation RAN 2 and CP.02513 OpsWAN and MPLS Replacement RAN 2. It is expected that works under CP.02811 and CP.02513 will be completed at Chalumbin prior to commencing the secondary systems cutovers.

[redacted]

*Figure 5: 132kV Line Diagram – Option 2*

### 4.1.2 Scope Assumptions

- The slab and foundations associated with the failed Capacitor Bank will be removed.
- Allowance has been made to replace the primary equipment foundations and structures.
- Dead tank circuit breakers are to be used.
- New panels will be installed into the existing building.
- Cables between termination racks and marshalling kiosks are in good condition and do not require replacement.
- Marshalling kiosks are in good condition and do not require replacement.
- This project will be executed in conjunction with CP.02948 Chalumbin 275kV Substation Reinvestment.
- Telecommunications works under CP.02811 Telecommunication Network Consolidation RAN 2 and CP.02513 OpsWAN and MPLS Replacement RAN 2 will be completed at Chalumbin prior to commencing the secondary systems cutovers.
- Project Milestone dates are met as outlined in 2.4.
- Outages will be available and any Return to Service (RTS) requirements will be agreed in a timely manner.

- MSP resourcing is available when required to meet the approved commissioning date.
- SPA contractor is available when required to meet the approved commissioning date.
- PLQ Design resources are available when required to meet the approved commissioning date.
- PLQ project and support resources are available to align with the project timing to support meeting the approved commissioning date.
- Access to site is available.
- All required scope items have been included in Revision 3 of the CP.03144 Project Scope Report issued on 04/09/2025.
- Funds will be released to purchase long lead items, undertake design and ITT (Stage 1 Approval).
- Soil conditions are generally suitable for bored, reinforced concrete structures.
- Primary Plant Materials and Secondary Systems Equipment and Materials are available and delivered on time for the construction phase.
- The following lead times have been considered in this estimate:

| Equipment | Lead Time |
|---|---|
| 145kV Dead Tank Circuit Breaker | 78 weeks |
| CVT | 78 weeks |
| Station Post Insulator | 52 weeks |
| Surge Arrestors | 100 weeks (investigating acceleration) |
| Disconnectors | 60 weeks |
| Control Building Panels | 12 weeks |

#### 4.1.3 Scope Exclusions

- Easement acquisition works, including permits, approvals, development applications etc. All works are within Powerlink owned land.
- Any outage contingency plans required by Network Operations.
- Any works on the EQL network.
- No allowance has been made for Live Substations work.
- No allowance has been made for External Design resources.
- Additional foundation work associated with high water table.
- Inclement weather in excess of what could reasonably be expected.
- Excavation in hard ground i.e. rock is excluded from this estimate.
- Any work outside of normal working hours.

### 4.2 Project Execution

#### 4.2.1 Project Schedule

| | |
|---|---|
| Early Works (by SPA) | October 2027 |
| FAT (by MSP) Stage 1 | November – December 2027 |

| | |
|---|---|
| *Wet Season Demobilisation* | *January – May 2028* |
| FAT (by MSP) Stage 2 | May - June 2028 |
| 275/132kV T1 | June – September 2028 |
| 275/132kV T2 | September – December 2028 |
| *Wet Season Demobilisation* | *January – May 2029* |
| 132kV Feeder 7166 | May – August 2029 |
| 132kV Feeder 7165 | August – November 2029 |
| *Wet Season Demobilisation* | *January – May 2030* |
| 132kV Feeder 7191 | May – August 2030 |
| 132kV Feeder 7192 | August – November 2030 |
| *Wet Season Demobilisation* | *January – May 2031* |
| 132kV 1 – 2 Bus Coupler | May – August 2031 |
| 1 Bus Outage to remove Capacitor Bank | August 2031 |
| Remove Redundant Equipment | August – November 2031 |
| Stage 1 SPA Demobilisation | November - December 2031 |
| *Staging Break* | *December 2031 – May 2032* |
| Stage 2 - Secondary Systems Upgrade (refer to project schedule) | May 2032 – November 2033 |
| Project Commissioned | November 2033 |

### 4.2.2 Network Impacts

Network Operations have advised that all outages will require a 12-hour return to service (RTS) or an adequate contingency plan.

Given the extended outages required to facilitate the complex scope of works and a 12-hour contingency plan is not possible, this option is not feasible with the current network access limitations.

### 4.2.3 Resourcing

The following resource strategy is proposed:

- Design by PLQ.
- SPA.
- MSP (core works).
- SPA contractor may be engaged under a D&C contract if PLQ design constraints risk delaying the approved commissioning date.

## 4.3 Project Estimate

| | | Sub Total $ | Total $ |
|---|---|---|---|
| **Estimate Class** | 5 | | |
| **Estimate accuracy (-% / +%)** | -50% / +100 % | | |
| Base Estimate | | $37,815,672 | |
| [redacted] | | [redacted] | |
| [redacted] | | | [redacted] |
| [redacted] | [redacted] | [redacted] | |
| [redacted] | [redacted] | [redacted] | |
| [redacted] | | | [redacted] |
| [redacted] | | | [redacted] |

# 5. Option 3 – Entire replacement of the Primary Plant and Secondary Systems concurrently by installing 7 New Bays in the adjacent spare bays.

## 5.1 Option Definition

### 5.1.1 Option Scope

**Entire replacement of the Primary Plant and Secondary Systems concurrently by installing 7 New Bays in the adjacent spare bays (see '*Figure 7: 132kV Line Diagram – Option 3'* below for reference).**

- Install new 145kV DTCB (7).
- Install new 145kV Disconnectors (6).
- Install new 145kV Disconnector / Earth Switch (8).
- Install new 145kV CVT (18).
- Install new 120kV Surge Arrester (15) – noting that the additional set is shown on the secondary of the 275/132kV Tx diagram and not below.
- Install new 145kV Station Post Insulator (46).
- The ABB A phase CT being replaced in bay D06 (H032-D06-7192-7192CTA) is to be returned to stores as a spare.
- The 132kV Capacitor Bank PASS M0 module is currently in a failed state.
    - Equipment is to be assessed by the manufacturer to confirm whether it is repairable and able to be retained as a spare. Assessment should be done on site by ABB and economic analysis done to decide if it is worth repairing. If it is deemed to be not economically viable the bushings, mechanism and LCC should be returned to stores for spares.
    - Test and return 3 x capacitor cans, balance CT and CVT to the warehouse for use as spare stock.

**Replacement of the below secondary systems at H032 utilising 8 new panels in the existing building.**

- 132kV 1 and 2 Bus.

- 132kV bus coupler (D03).
- 132kV feeder 7165 (D8.2).
- 132kV feeder 7166 (D7.1).
- 132kV feeder 7191 (D5.2).
- 132kV feeder 7192 (D6.1).
- OpsWAN and SCADA to provide for control and monitoring requirements including OpsWAN equipment (except the camera) and relocate devices (except the camera) from the OpsWAN camera housing at the top of the pole to the camera patch box at the base of the pole.
- Replace 125V and 50V DC chargers and monitoring systems (battery banks were replaced in 2023 under CP.02786).
- Modify AC and DC distribution as required to facilitate the replacement works.
- Modify and upgrade telecommunications equipment as required to support the new secondary systems.

**Transmission Line Works**

Design, procure, construct and commission new line entries to facilitate the rebuild of primary plant in adjacent spare bay locations as shown below in '*Figure 6: 132kV – Proposed Bay Swap'.*

A high-level structural assessment has been undertaken on the 132kV Transmission Structures with the below findings.

*'Based on current observations, there's a strong possibility it can continue to perform reliably for another 20+ years without requiring major structural strengthening or full structure replacement —provided we stick with the existing conductor types and loading conditions.'*

A detailed civil and structural assessment of the 132kV Transmission Structures will be completed if this option is selected.

[redacted]

*Figure 6: 132kV – Proposed Bay Swap*

**Remote End Substation Works**

Modify the protection, control, automation and communications systems as required at

- 2 x 132kV Feeders to Turkinje
- 2 x 132kV Feeders to Kareeya

**Telecommunications Works**

- Telecommunications works are to be coordinated with CP.02811 Telecommunication Network Consolidation RAN 2 and CP.02513 OpsWAN and MPLS Replacement RAN 2. It is expected that works under CP.02811 and CP.02513 will be completed at Chalumbin prior to commencing the secondary systems cutovers.
- OPGW/fibre works as required to accommodate new landing spans and bay locations.

[redacted]

*Figure 7: 132kV Line Diagram – Option 3*

### 5.1.2 Major Scope Assumptions

- The slab and foundations associated with the failed Capacitor Bank will be removed.
- Allowance has been made to replace the primary equipment foundations and structures.
- Dead tank circuit breakers are to be used.
- New panels will be installed into the existing building.
- This project will be executed in conjunction with CP.02948 Chalumbin 275kV Substation Reinvestment.
- Telecommunications works under CP.02811 Telecommunication Network Consolidation RAN 2 and CP.02513 OpsWAN and MPLS Replacement RAN 2 will be completed at Chalumbin prior to commencing the secondary systems cutovers.
- Project Milestone dates are met as outlined in 2.4
- Outages will be available and any Return to Service (RTS) requirements will be agreed in a timely manner.
- MSP resourcing is available when required to meet the approved commissioning date.
- SPA contractor is available when required to meet the approved commissioning date.

- PLQ Design resources are available when required to meet the approved commissioning date.
- PLQ project and support resources are available to align with the project timing to support meeting the approved commissioning date.
- Access to site is available.
- All required scope items have been included in Revision 3 of the CP.03144 Project Scope Report issued on 04/09/2025.
- Funds will be released to purchase long lead items, undertake design and ITT (Stage 1 Approval).
- Soil conditions are generally suitable for bored, reinforced concrete structures.
- Primary Plant Materials and Secondary Systems Equipment and Materials are available and delivered on time for the construction phase.
- The following lead times have been considered in this estimate:

| Equipment | Lead Time |
| --- | --- |
| 145kV Dead Tank Circuit Breaker | 78 weeks |
| CVT | 78 weeks |
| Station Post Insulator | 52 weeks |
| Surge Arrestors | 100 weeks (investigating acceleration) |
| Disconnectors | 60 weeks |
| Control Building Panels | 12 weeks |

### 5.1.3 Scope Exclusions

- Easement acquisition works, including permits, approvals, development applications etc. All works are within Powerlink owned land.
- Any outage contingency plans required by Network Operations.
- Any modifications to existing 132kV Transmission Structures.
- Additional cost involved with stringing over live bus.
- Any works on the EQL network.
- No allowance has been made for Live Substations work.
- No allowance has been made for External Design resources.
- Additional foundation work associated with high water table.
- Inclement weather in excess of what could reasonably be expected.
- Excavation in hard ground i.e. rock is excluded from this estimate.
- Any work outside of normal working hours.

## 5.2 Project Execution

### 5.2.1 Project Schedule

Refer to project schedule in the reference documents for detailed staging descriptions.

| | |
|---|---|
| Early Works (by SPA) | July 2027 |
| FAT (by MSP) | July – October 2027 |
| Stage 1 MSP | July 2027 |
| Stage 1a SPA | July – November 2027 |
| *Wet Season Demobilisation* | *January – May 2028* |
| Stage 1b MSP | May – September 2028 |
| Stage 2 SPA | September – November 2028 |
| *Wet Season Demobilisation* | *January – May 2029* |
| Stage 2a MSP | May – June 2029 |
| Stage 3 SPA | June – August 2029 |
| Stage 3a MSP | August – October 2029 |
| Stage 4 SPA | October – December 2029 |
| *Wet Season Demobilisation* | *January – May 2030* |
| Stage 4a MSP | May – June 2030 |
| Stage 5 SPA | June – August 2030 |
| Stage 5a MSP | August – September 2030 |
| Remove Redundant Equipment | September – December 2030 |
| Project Commissioned | December 2030 |

### 5.2.2 Network Impacts

Network Operations have advised that all outages will require a 12-hour return to service (RTS) or an adequate contingency plan.

Based on the network access restrictions, the project team has proposed option 3. This greenfield construction approach minimises outage durations and complies with the 12-hour return to service requirements by leaving the existing infrastructure unaltered and able to be returned into service if there is a loss of supply.

### 5.2.3 Resourcing

The following resource strategy is proposed:

- Design by PLQ.
- SPA.
- MSP (core works).

- SPA contractor may be engaged under a D&C contract if PLQ design constraints risk delaying the approved commissioning date.

## 5.3 Project Estimate

| | | Sub Total $ | Total $ |
|---|---|---|---|
| **Estimate Class** | 5 | | |
| **Estimate accuracy (+% / -%)** | -50% / +100% | | |
| Base Estimate | | $41,952,932 | |
| [redacted] | | [redacted] | |
| [redacted] | | | [redacted] |
| [redacted] | [redacted] | [redacted] | |
| [redacted] | [redacted] | [redacted] | |
| [redacted] | | | [redacted] |
| [redacted] | | | [redacted] |

# 6. Option 4 – Replace selected 132kV Primary Plant and Secondary Systems concurrently by installing 2 new Bays in D9.1 and D4.2, then utilising bays swaps to rebuild in situ the remaining 5 bays

## 6.1 Option Definition

### 6.1.1 Option Scope

**Replace selected 132kV Primary Plant and Secondary Systems concurrently by installing 2 new Bays in D9.1 and D4.2, then utilise bays swaps to rebuild in situ the remaining 5 bays (see '*Figure 9: 132kV Line Diagram – Option 4'* below for reference).**

- Install new 145kV DTCB (x7).
- Install new 145kV Disconnectors (x1).
- Install new 145kV Disconnector / Earth Switch (x4).
- Install new 145kV CVT (x6).
- Install new 120kV Surge Arrester (x12) – noting that the additional set is shown on the secondary of the 275/132kV Tx diagram and not below.
- Install new 145kV Station Post Insulator (x38).
- Removal of obsolete bus isolator in bay D9.2 to improve access to bay D8.2.
- The ABB A phase CT being replaced in bay D06 (H032-D06-7192-7192CTA) is to be returned to stores as a spare.
- The 132kV Capacitor Bank PASS M0 module is currently in a failed state
    - Equipment is to be assessed by the manufacturer to confirm whether it is repairable and able to be retained as a spare. Assessment should be done on site by ABB and economic

analysis done to decide if it is worth repairing. If it is deemed to be not economically viable the bushings, mechanism and LCC should be returned to stores for spares.

- Test and return 3 x capacitor cans, balance CT and CVT to the warehouse for use as spare stock.

**Replacement of the below secondary systems at H032 utilising 8 new panels in the existing building.**

- 132kV 1 and 2 Bus.
- 132kV bus coupler (D3).
- 132kV feeder 7165 (D8.2).
- 132kV feeder 7166 (D7.1).
- 132kV feeder 7191 (D5.2).
- 132kV feeder 7192 (D6.1).
- OpsWAN and SCADA to provide for control and monitoring requirements including OpsWAN equipment (except the camera) and relocate devices (except the camera) from the OpsWAN camera housing at the top of the pole to the camera patch box at the base of the pole.
- Replace 125V and 50V DC chargers and monitoring systems (battery banks were replaced in 2023 under CP.02786).
- Modify AC and DC distribution as required to facilitate the replacement works.
- Modify and upgrade telecommunications equipment as required to support the new secondary systems.

**Transmission Line Works**

Design, procure, construct and commission new line entries to facilitate the rebuild of primary plant in adjacent spare bay locations as shown below.

A high-level structural assessment has been undertaken on the 132kV Transmission Structures with the below findings.

*‘Based on current observations, there’s a strong possibility it can continue to perform reliably for another 20+ years without requiring major structural strengthening or full structure replacement —provided we stick with the existing conductor types and loading conditions.’*

A detailed civil and structural assessment of the 132kV Transmission Structures will be completed if this option is selected.

[redacted]

*Figure 8: 132kV – Proposed Bay Swap*

**Remote End Substation Works**

Modify the protection, control, automation and communications systems as required at the

- 2 x 132kV Feeders to Turkinje.
- 2 x 132kV Feeders to Kareeya.

**Telecommunications Works**

- Telecommunications works are to be coordinated with CP.02811 Telecommunication Network Consolidation RAN 2 and CP.02513 OpsWAN and MPLS Replacement RAN 2. It is expected that works under CP.02811 and CP.02513 will be completed at Chalumbin prior to commencing the secondary systems cutovers.
- OPGW/fibre works as required to accommodate new landing spans and bay locations.

[redacted]

*Figure 9: 132kV Line Diagram – Option 4*

#### 6.1.2 Major Scope Assumptions

- The slab and foundations associated with the failed Capacitor Bank will be removed.
- Allowance has been made to replace the primary equipment foundations and structures.
- Dead tank circuit breakers are to be used.
- New panels will be installed into the existing building.
- Cables between termination racks and marshalling kiosks are in good condition and do not require replacement.

- Marshalling kiosks are in good condition and do not require replacement.
- This project will be executed in conjunction with CP.02948 Chalumbin 275kV Substation Reinvestment.
- Telecommunications works under CP.02811 Telecommunication Network Consolidation RAN 2 and CP.02513 OpsWAN and MPLS Replacement RAN 2 will be completed at Chalumbin prior to commencing the secondary systems cutovers.
- Project Milestone dates are met as outlined in 2.4.
- Outages will be available and any Return to Service (RTS) requirements will be agreed in a timely manner.
- MSP resourcing is available when required to meet the approved commissioning date.
- SPA contractor is available when required to meet the approved commissioning date.
- PLQ Design resources are available when required to meet the approved commissioning date.
- PLQ project and support resources are available to align with the project timing to support meeting the approved commissioning date.
- Access to site is available.
- All required scope items have been included in Revision 3 of the CP.03144 Project Scope Report issued on 04/09/2025.
- Funds will be released to purchase long lead items, undertake design and ITT (Stage 1 Approval).
- Soil conditions are generally suitable for bored, reinforced concrete structures.
- Primary Plant Materials and Secondary Systems Equipment and Materials are available and delivered on time for the construction phase.
- The following lead times have been considered in this estimate:

| Equipment | Lead Time |
| --- | --- |
| 145kV Dead Tank Circuit Breaker | 78 weeks |
| CVT | 78 weeks |
| Station Post Insulator | 52 weeks |
| Surge Arrestors | 100 weeks (investigating acceleration) |
| Disconnectors | 60 weeks |
| Control Building Panels | 12 weeks |

#### 6.1.3 Scope Exclusions

- Easement acquisition works, including permits, approvals, development applications etc. All works are within Powerlink owned land.
- Any outage contingency plans required by Network Operations.
- Any modifications to existing 132kV Transmission Structures.
- Additional cost involved with stringing over live bus.
- Any works on the EQL network.
- No allowance has been made for Live Substations work.
- No allowance has been made for External Design resources.
- Additional foundation work associated with high water table.

- Inclement weather in excess of what could reasonably be expected.
- Excavation in hard ground i.e. rock is excluded from this estimate.
- Any work outside of normal working hours.

## 6.2 Project Execution

### 6.2.1 Project Schedule

Refer to project schedule in the reference documents for detailed staging descriptions.

| | |
|---|---|
| Early Works (by SPA) | July 2027 |
| FAT (by MSP) | July – October 2027 |
| Stage 1 – Decommission Capacitor Bank | July – August 2027 |
| Stage 2 - Build new bay in D9.1 and D4.2 (Stage 1) | August – December 2027 |
| *Wet Season Demobilisation* | *January – May 2028* |
| Stage 2 - Build new bay in D9.1 and D4.2 (Stage 2) | May 2028 |
| Stage 3 – Transfer Feeder 7166 to D8.2 | May – August 2028 |
| Stage 4 – Transfer Feeder 7192 to D7.1 | August – September 2028 |
| Stage 5 – Transfer 275/132kV T2 to D6.1 | September – December 2028 |
| *Wet Season Demobilisation* | *January – May 2029* |
| Stage 6 - Transfer 275/132kV T1 to D4.2 | May 2029 |
| Stage 7 - Transfer Feeder 7191 to D4.1 | May – August 2029 |
| Stage 8 - Transfer Feeder 7192 to D5.2 | August – November 2029 |
| *Wet Season Demobilisation* | *January – May 2030* |
| Stage 9 – Replace Coupler Bay in D7 | May – August 2030 |
| Remove Redundant Equipment | August – November 2030 |
| Project Commissioned | November 2030 |

### 6.2.2 Network Impacts

Network Operations have advised that all outages will require a 12-hour return to service (RTS) or an adequate contingency plan.

Based on the network access restrictions, the project team has proposed option 4. The hybrid delivery methodology of greenfield and brownfield construction minimises outage durations and complies with the 12-hour return to service requirements by leaving the existing infrastructure unaltered and able to be returned into service if there is a loss of supply.

### 6.2.3 Resourcing

The following resource strategy is proposed:

- Design by PLQ.
- SPA.
- MSP (core works).
- SPA contractor may be engaged under a D&C contract if PLQ design constraints risk delaying the approved commissioning date.

## 6.3 Project Estimate

| | | Sub Total $ | Total $ |
|---|---|---|---|
| **Estimate Class** | 5 | | |
| **Estimate accuracy (+% / -%)** | -50% / +100% | | |
| Base Estimate | | $36,179,113 | |
| [redacted] | | [redacted] | |
| [redacted] | | | [redacted] |
| [redacted] | [redacted] | [redacted] | |
| [redacted] | [redacted] | [redacted] | |
| [redacted] | | | [redacted] |
| [redacted] | | | [redacted] |

## 7. Project Risk

| Risks | Impact | Likelihood | Mitigation Strategy |
|---|---|---|---|
| Availability of Resources:<br>• Contractor<br>• MSP | Major | Moderate | Engage in early and ongoing discussions with Network Operations (Net Ops) and Customers to identify and secure required resources. Establish contingency workforce planning. |
| Change in project delivery strategy due to:<br>• Network Outage Change<br>• Staging Change<br>• Design Change<br>• Latent conditions (e.g. unforeseen site issues) | Major | Possible | Conduct ongoing reviews of the overall delivery strategy, staging plans, outage planning, and design changes. Build flexibility into the project schedule and budget. |
| Outage constraints<br>• Net Ops<br>• Kareeya Power Station | Major | Possible | Coordinate closely with Net Ops for early confirmation of outage timeframes. Develop alternative construction methodologies if timeframes are not met. |
| Procurement Delays / Equipment Availability:<br>Long lead times due to market conditions or supplier issues | Major | Possible | Secure early funding and initiate procurement early to lock in delivery dates. Maintain a list of alternate vendors or substitute equipment if needed. |
| Inclement weather during Construction | Major | Likely | Schedule critical path construction activities outside the wet season (December – March). Build weather contingencies into the timeline and budget. |
| RIT-T process (assumed duration 26 weeks): | Major | Possible | Maintain regular communication with the project Sponsor and regulatory teams. Develop contingency commissioning scenarios if RIT-T is delayed. |

| | | | |
|---|---|---|---|
| Design and Delivery Changes | Major | Possible | Confirm contractual commitments early. Implement scope freeze dates and stage-gate reviews to control change. Engage early with third-party contractors and Subject Matter Experts (SMEs). |
| Safety Incidents / WHS Non-compliance | Major | Unlikely | Implement Safety Management Plans. Conduct regular training, audits, and toolbox talks. Ensure all contractors adhere to company safety procedures and reporting. |
| Cost Overruns due to Market Price Escalation | Moderate | Possible | Include risk allowances and escalation contingencies in the project budget. Monitor market trends and renegotiate supply contracts where feasible. |
| Regulatory or Legislative Change | Moderate | Unlikely | Monitor regulatory environment through legal and compliance teams. Adapt project plans to remain compliant with any new regulations. |

## 8. References

| Document | Version | Date |
|---|---|---|
| Project Scope Report | 3 | 04/09/25 |

# Risk Cost Summary Report

# CP. 03144

# Chalumbin 132kV Selective Plant Replacement

## Document Control

Change Record

| Issue Date | Revision | Prepared by |
|---|---|---|
| 22/12/2025 | 1.0 | Asset Strategies |
| | | |
| | | |

Related Documents

| Issue Date | Responsible Person | Objective Document Name |
|---|---|---|
| | | |
| | | |
| | | |

## Document Purpose

The purpose of this model is to quantify the base case and option risk cost profiles for the 132kV equipment at the Chalumbin Substation which are proposed for reinvestment under CP.03144. These risk cost profiles are then included as part of an overall cost-benefit analysis (CBA) to understand the economic benefit of the proposed upgrades. This process provides a benchmarking and internal gate process to support Powerlink in effectively identifying prioritised infrastructure upgrades.

The CBA was designed to demonstrate and quantify the value to be gained through specific infrastructure investments. To evaluate the CBA, an NPV is derived based on the present values of costs and benefits. The flow chart in Figure 4 below designates the methodology used in designing the CBA process.

Primary plant and Secondary systems have been assessed via independent models; however, their overall risk costs have been summed to produce a single analysis for the project.

## Key Assumptions

In calculating the risk cost arising from a failure of the ageing 132kV equipment at the Chalumbin Substation, the following modelling assumptions have been made:

**Primary Plant**

- The functionality of the equipment is assumed to decay according to decay curves calculated by Powerlink, and associated probability of failure (PoF).
- Where equipment in scope is replaced, its associated Health Index (HI) score is reverted to one. Where refurbishment is undertaken, the health index is adjusted according to the target life extension.
- The likelihood of personnel within the substation in the event of explosive failure of equipment (used to calculate safety risk) is assumed to be 25% (based upon historic site entry averages), with the likelihood of resulting injury or death depending on the explosive radius of the equipment, its housing, and the total substation land area. The modelling also assumes that personnel are equally likely to be anywhere within the substation land area. No escalation to the likelihood has been made during construction as it is assumed appropriate risk assessments and risk mitigation measures are completed by the project team.
- In the event of an $SF_6$ gas leak, it is assumed that the entire quantum of $SF_6$ gas is leaked.
- For the purposes of the cost-benefit analysis, the total useful asset life of 40 years has been applied.
- A site-specific value of customer reliability (VCR) of $25,750 has been applied when calculating network risks.

**Secondary Systems**

- Whilst the re-investment scope of secondary systems contains a range of supporting devices (i.e network switches, firewalls and human machine interfaces), for simplicity of risk cost modelling only main protection relays, bay controllers and RTUs were considered.

- Spares for secondary system equipment have been assumed to be available prior to the point of expected spares depletion, which coincides with the expected technical asset life (20 years). After this point the cost and time to return the secondary system back to service increases significantly.
- When calculating network risk cost, it has been assumed that after 24 hours of any network element being protected by a single protection system (due to failure of the alternate system) the Australian Energy Market Operator (AEMO) will direct Powerlink to de-energise the network element.
- Given secondary systems have a shorter asset life, risk cost benefits have been modelled out to 2045, whereas substations assets have been modelled to 2060. This is providing a conservative view of the secondary systems benefits.

## Base Case Risk Analysis

### Risk Categories

Four main categories of risk are assessed as part of this project as consistent with Powerlink's Asset Risk Management Framework:

- Financial Risk
- Safety Risk
- Network Risk (including market impact if applicable)
- Environmental

*Table 1: Risk categories*

| Risk Category | Failure Types | Equipment in scope |
|---|---|---|
| **Substations Equipment** | | |
| Safety Risk | Explosive failure | All equipment with the potential to fail explosively |
| Financial Risk | Peaceful failure | All equipment |
| | Explosive failure | All equipment with the potential to fail explosively |
| Network Risk | Peaceful failure | All equipment related to network elements identified in the planning statement |
| Environmental Risk | Peaceful failure | Circuit breakers and current transformers containing SF6 |
| **Secondary Systems** | | |
| Financial Risk | Failure of the equipment resulting in emergency onsite replacement | All equipment |
| Network Risk | Failure of equipment resulting in de-energisation of network elements after 24 hours | Main protection relays only |

### Base Case Risk Cost

The modelled and extrapolated total base case risk costs are shown in the figures below.

Risk cost associated with the equipment in scope is expected to increase from around $1.76 million in 2026 to $4.86 million in 2036 and nearly $9.30 million by 2045. Key highlights of the analysis include:

- Financial risk is 62% of the total risk (at 2030), reflecting the cost of replacement of peaceful failures across both the primary and secondary systems assets.
- Network risk accounts for approximately 30% of the total risk cost in 2030. This grows marginally higher to approximately 35% by 2060.
- Safety risk accounts for 8% of the total risk (at 2030), reflecting a conservative assumption that personnel are unlikely to be in proximity of equipment during an explosive failure event.

A dip in risk cost can be observed in 2046 as the benefits associated with secondary systems assets roll off as highlighted in the assumptions listed above.


*Figure 1: Total risk cost*

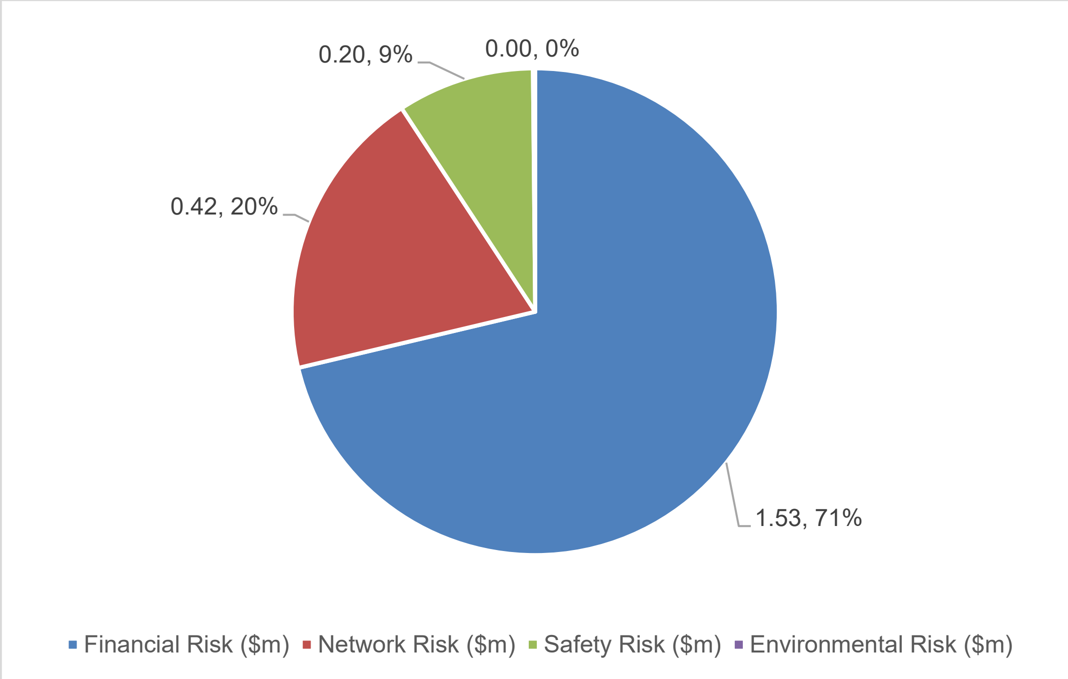


*Figure 2: Base case risk cost by contributions (2030)*

### Option Risk Cost

The figures below set out the total project case risk cost, and associated risk cost savings incremental to the base case.

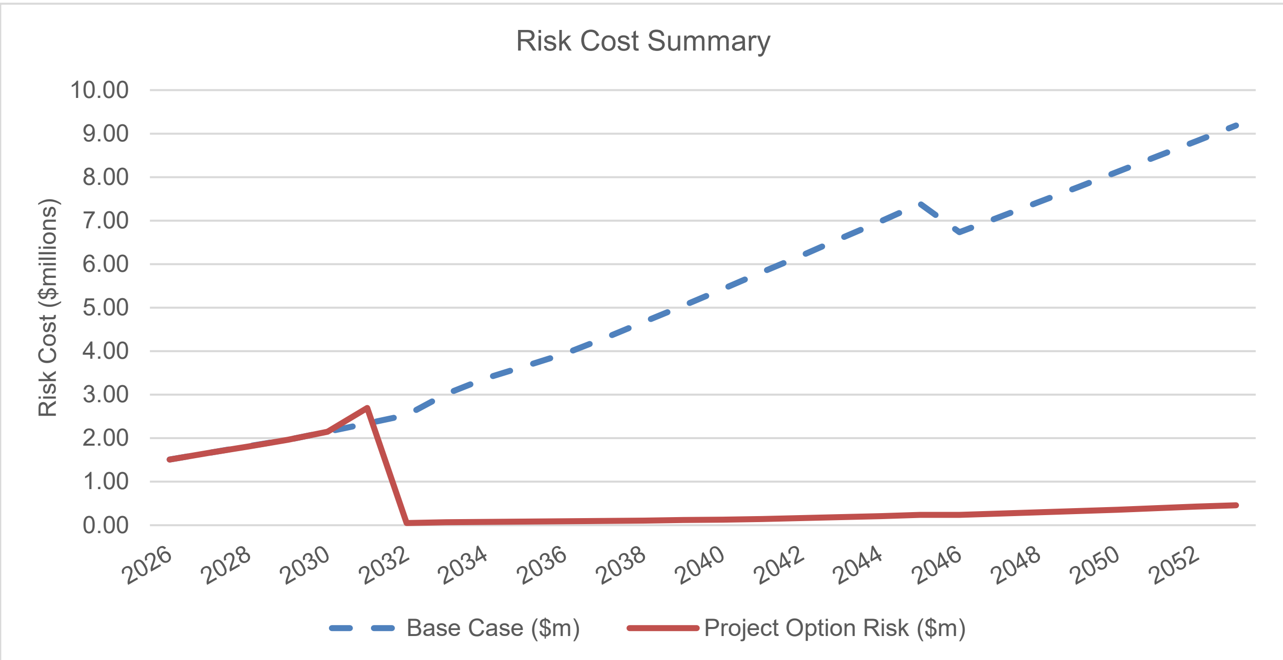


*Figure 3: Project Option Risk Cost (compared to base case)*

Following the year of investment (2031) the risk cost associated with the equipment in scope effectively reduces to approximately $0.05m (some network risk remains). By 2045, the risk cost of the project option is approximately $0.23 million, compared with the base case risk cost of $9.30 million.

## Cost Benefit Analysis

The methodology designed for this regulatory review is set out below.

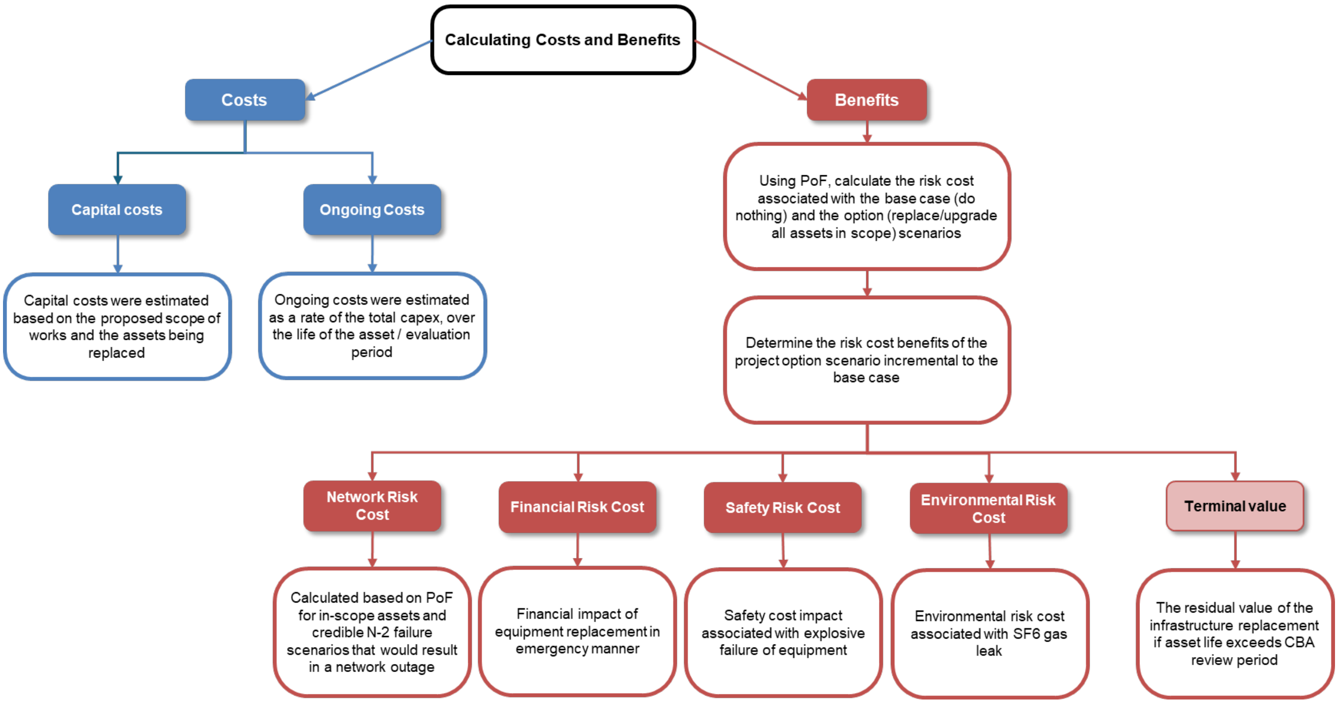


*Figure 4: CBA methodology*

The project is estimated to cost approximately $36.18 million.

Based on a baseline discount factor of 7%, the project has a net present value (NPV) of $26.2 million over a 35-year period, and a benefit-cost ratio (BCR) of 2.08. The project also has a positive NPV and BCR when a discount factor of 10% is applied.

*Table 2: Net Present Value and Benefit-Cost Ratio*

| | | Present Value Table ($m) | | |
|---|---|---|---|---|
| **Discount rate** | % | **3%** | **7%** | **10%** |
| **NPV of Net Gain/Loss** | $m | $84.5 | $26.2 | $8.9 |
| **Benefit-Cost Ratio** | ratio | 3.79 | 2.08 | 1.44 |

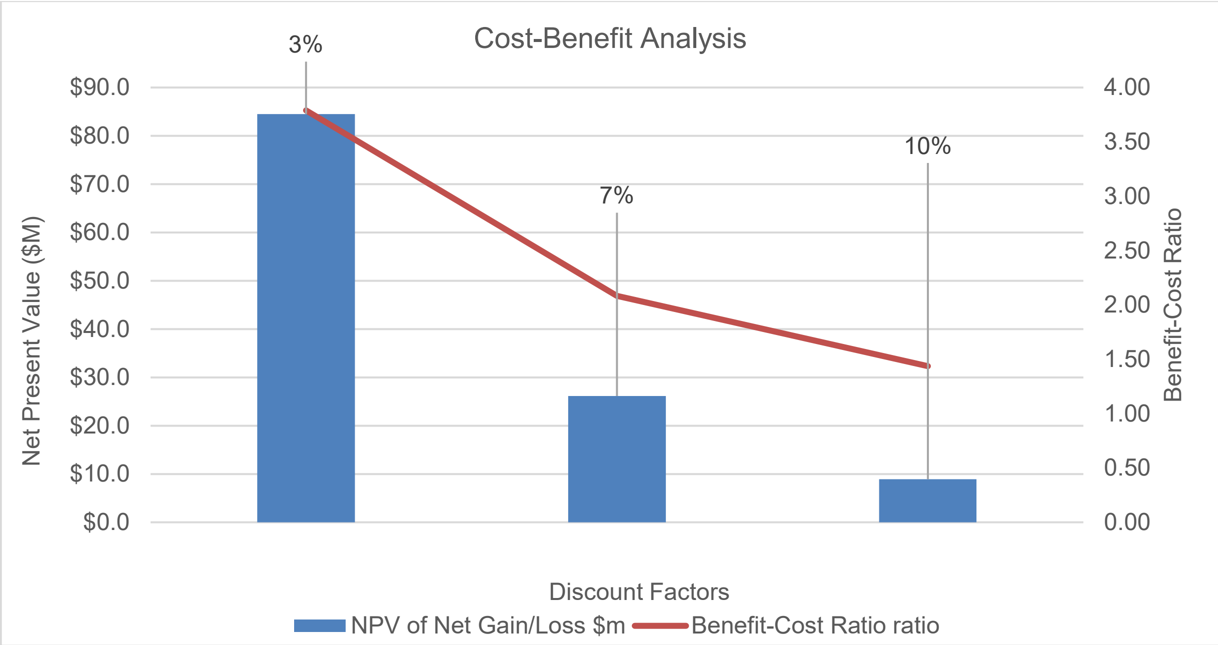


*Figure 5: Cost benefit summary*

## Participation Factors

A sensitivity analysis was undertaken to determine the participation factors for key inputs to the risk cost models (i.e. to identify which inputs are most sensitive to overall risk cost).

The participation factor is defined as the ratio of percentage change in output (i.e. risk cost) to a percentage change in input (e.g. VCR). The participation factors for key model inputs are shown in the table below.

Due to the non-linear nature of the risk cost model (especially network risk costs, which are a function of concurrent failures), the participation factor can change depending on the magnitude of input percentage change.

The model is most sensitive to:

- **changes in value of customer reliability** results in a decrease in risk cost of $0.33 million, or approximately 13.4% of the original base risk.
- **changes in restoration time** results in a decrease in risk cost of $0.23 million.

*Table 3: Participation Factors*

| Input | Baseline value | Sensitivity value (-50%) | Change in risk cost at 2030 ($m) | Participation (%) |
|---|---|---|---|---|
| **Safety** | | | | |
| Likelihood of personnel within substation | 25% | 12.5% | -0.10 | -3.94% |
| Cost consequence of multiple fatality | $11,400,000 | $5,700,000 | -0.03 | -1.14% |
| Cost consequence of single fatality | $5,700,000 | $2,850,000 | -0.07 | -2.80% |
| Cost consequence of multiple serious injury | $4,206,600 | $2,103,300 | -0.02 | -0.90% |
| **Financial** | | | | |
| Emergency premium (peaceful failure) | 20% | 10% | -0.11 | -4.39% |
| Emergency premium (explosive failure) | 300% | 150% | -0.07 | -2.94% |
| Emergency replacement cost without spares – Relay ($m) | 0.02 | 0.01 | 0.00 | 0.0% |
| Emergency replacement cost without spares – Bay Controller ($m) | 0.20 | 0.10 | 0.00 | 0.0% |
| **Network** | | | | |
| VCR ($/MWh) | 25,750 | 12,875 | -0.33 | -13.40% |
| Restoration Time (hrs) | 72-720 (subs)<br>Relay - no spare (10) | 36-360<br>Relay - no spare (5) | -0.23 | -9.29% |