Planning Proposal

Grid Planning & Optimisation

WR1274424

Cannonvale and Jubilee Pocket 66 kV Reinforcement Ergon Energy 2020-25

January 2019

Part of the Energy Queensland Group

1. EXECUTIVE SUMMARY

1.1. Background

The Airlie Beach region is a nationally and internationally renowned tourism hub in North Queensland, located approximately 100 km north of Mackay. Airlie Beach, in addition to being a holiday destination in its own right, is the major tourism gateway to the Whitsunday Islands. The 17/18 financial year saw the region attract 795,000 visitors, generate almost $773M of tourist revenue and commence a number of major redevelopment projects ($183M).

The region is supplied by four key substations, with Cannonvale (CANN) and Jubilee Pocket (JUPO) being the main substations supplying the mainland. The 66 kV network in the area comes west from Proserpine and supplies approximately 7,200 premises throughout the region, with major customers including Proserpine Sugar Mill, Hamilton Island, Hayman Island, South Molle Island, Daydream Island and numerous hotels and marinas. The supply area is shown in the diagram below.

This project is driven by the need to maintain security to customers in the Jubilee Pocket and Whitsunday island areas, as the load has increased and existing assets have aged, both posing a risk to reliable supply.

1.2. Summary of Need for Investment

From the Cannonvale substation (CANN) which is the main substation in the area, the radial 66kV network supplying the other three substations has a load of approximately 17MVA. A credible fault on this network would mean that load cannot be restored within the requirements of the Safety Net security criteria, with this situation worsening as load increases.

In addition, the current 66kV supply contains sections of aged 1981 vintage XLPE cable, with similar batches known to have recently failed and with any restoration of such a failure likely to result in extended outage durations to customers and island resorts. The current 66kV switching arrangement at CANN is limited without a proper switched 66kV bus arrangement and with a number of aged 66kV circuit breakers at end of life and proposed for retirement over the next 5 years. The Cannonvale exit cables also require replacement due to degradation of the existing XLPE and in-service failures.

The combination of both 66kV switching arrangement and radial supply to customers beyond CANN results in frequent outages. This has contributed to over half of the urban and short rural feeders supplied from this network experiencing 'Amber' or 'Red' class reliability in three of the last four years. There are also regular supply interruptions to the island resorts.

The combination of these drivers has prompted a coordinated plan to review and reinforce the 66kV supply arrangement, to meet security criteria obligations, address aged asset issues, improve supply reliability to customers and provide capacity for future growth and development.

1.3. Summary of Feasible Options

Four options have been identified in this report:

- Base Case (BAU) – Replace CANN 66 kV cables, duplicate radial 66 kV sections at Airlie Lagoon, Mandalay and the airport and staged development of the 2nd feeder from CANN-JUPO.
- Option A – Install a 7-breaker 66 kV GIS at CANN, replace CANN 66 kV cables, duplicate radial 66 kV sections at Airlie Lagoon, Mandalay and the airport and staged development of the 2nd feeder from CANN-JUPO.
- Option B – Construct dedicated 66 kV feeder from Proserpine (PROS) 132/66/11 kV substation to Proserpine Mill (PRMI) 66/11 kV substation, replace CANN 66 kV cables, duplicate radial 66 kV sections at Airlie Lagoon, Mandalay and the airport and staged development of the 2nd feeder from CANN-JUPO.
- Option C – Construct 66 kV switching station at future Riordanvale site, replace CANN 66 kV cables, duplicate radial 66 kV sections at Airlie Lagoon, Mandalay and the airport and staged development of the 2nd feeder from CANN-JUPO.

1.4. Recommendation

This Planning Proposal recommends the following works (Option A) to address safety net, asset replacement and reliability obligations to customers:

- Upgrade the Cannonvale (CANN) 66/11 kV substation to a fully switched 66 kV yard which includes replacement of the 66 kV cables around CANN;
- Duplication and management of the radial 66 kV cables to Shute Harbour;
- Establishing a 2nd 66 kV feeder between CANN and Jubilee Pocket (JUPO) 66/11 kV substations;

The total estimated DCV cost (2018/19) for the recommended works is $16.68M.

The primary investment driver for this project is Augex, supporting customer growth and network security. A successful Non-Network Solution may be able to assist in reducing the scope or timing for this project, with a number of active demand management programs already underway in the area. As the cost of options considered as part of this report is greater than $6M this investment will be subject to RiT-D as a mechanism for customer and market engagement on solutions to explore further opportunities.

1.5. Project Information

Work Request Description	CANN & JUPO 66kV Reinforcement		
Work Request Number	WR1274424	**Target Capacity Available Date:**	06/09/2023
Initiating Work Group	Planning Northern	**RWR/Scope Approver/Contact**	
Business Owner			
Project Funding Source (A7 J1 code):	*D-Augmentation – Sub Transmission & 11 kV*	**Ellipse Estimate No/s**	
Strategic No:		**Direct Cost Value:**	*$16.68M*
Forecast Version:		**RIT-D Required:**	*Yes*

1.7. Document Tracking Details

Network and Non- Network Document Hierarchy Reference Number	Regulatory Proposal Chapter Reference	Document	File Name
NET AUG - 010	7.084	Planning Proposal - Cannonvale and Jubilee Pocket	EGX ERG 7.084 Planning Proposal - Cannonvale and Jubilee Pocket JAN19 PUBLIC

CONTENTS

2. BACKGROUND

2.1. Existing Network, Customer Summary

The Airlie Beach region is a nationally and internationally renowned tourism hub in North Queensland located approximately 100 km north of Mackay. In addition to being a holiday destination in its own right, Airlie Beach is the major tourism gateway to the Whitsunday Islands. Ergon Energy's sub-transmission and distribution network supplies approximately 7,198 premises in the area, with major customers including Proserpine Sugar Mill, Hamilton Island, Hayman Island, South Molle Island, Daydream Island and numerous hotels and marinas. The total number of people residing in the suburbs of Airlie Beach (1,211), Cannonvale (5,717), Jubilee Pocket (1,819), Riordanvale (313) and Shute Harbour (119) recorded in the 2016 Census was 9,179.

As at June 2018, 551,000 domestic and 244,000 international visitors totalling 795,000 visitors spent a collective $554.6M and $218.1M in the Whitsundays over the year. Considering the impacts of Cyclone Debbie (March 2017), subsequent tourist visitation recovery and refurbishment investment to be completed in the 1st half of 2019 at Hayman Island (approx. $100M) and Daydream Island (approx. $86M) and post-cyclone recovery works yet to proceed at South Molle Island, the GRP will translate into a more buoyant local economy and growth.

The Cannonvale-Airlie-Shute Harbour area is supplied from Cannonvale (CANN) 66/11 kV, Jubilee Pocket (JUPO) 66/11 kV, Mt Rooper (MORO) 66/11 kV and Shutehaven (SHUT) 66/22 kV zone substations. The geographical locations of these substations and major customers are shown in Figure 1.

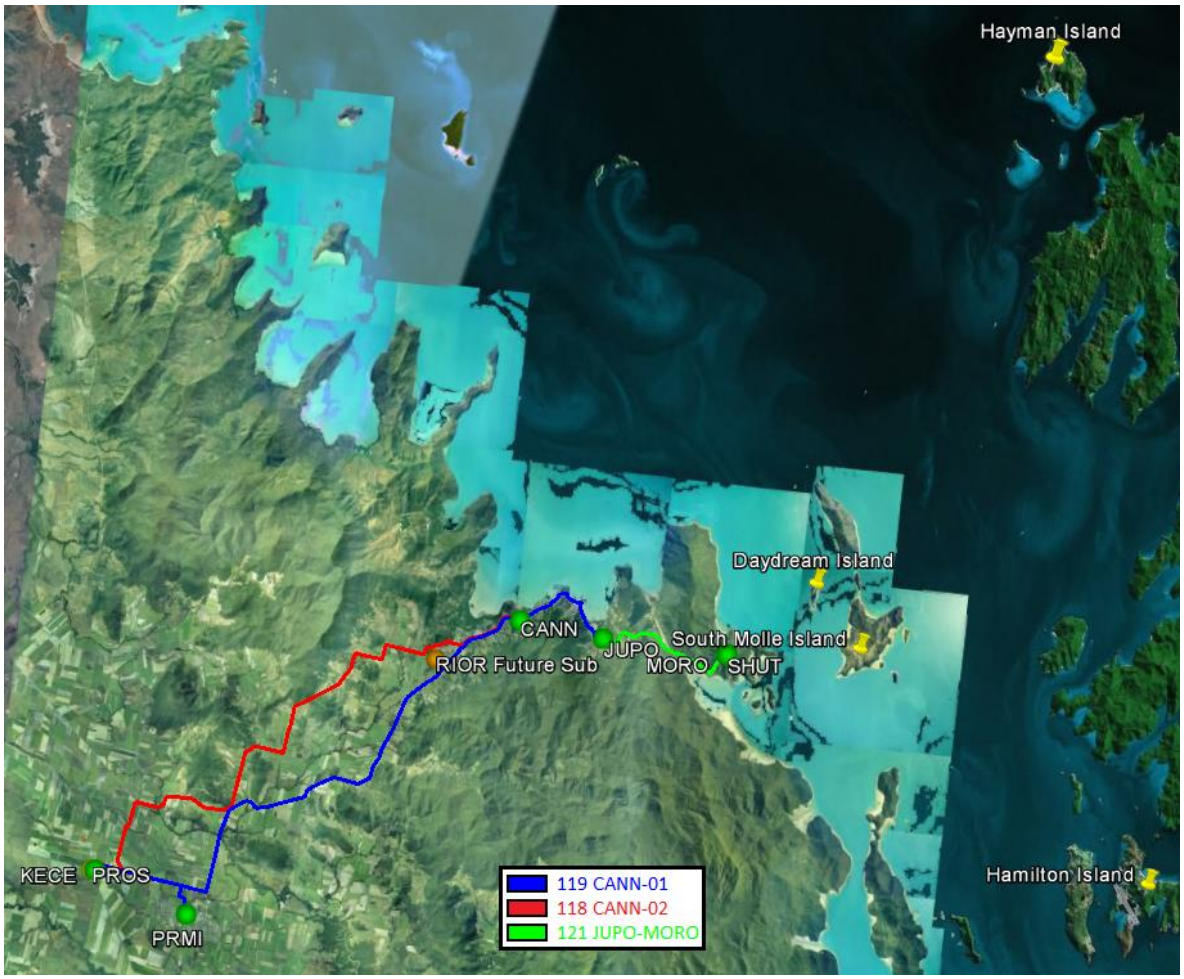

Figure 1 Geographical Locations of Substations and Sub-Transmission Network in the Whitsunday Regional Council Area

2.1.1. Substation Supply Attributes:

CANN substation presently supplies 5,442 customers and has two 15 MVA 66/11 kV transformers which have an N-1 transformer cyclic and long term emergency cyclic rating of 18.9 MVA and 20.0 MVA respectively. Two 4.8 MVAr 11 kV capacitor banks can minimise the transformer load and improve the substation power factor however their primary function is to provide voltage support during 66 kV feeder outages and network re-configuration.

JUPO substation currently supplies 1,674 customers via one 32 MVA 66/11 kV OLTC transformer, three 11 kV feeders and a 4.8 MVAr 11 kV capacitor bank which also provides 66 kV network support under contingency conditions. JUPO was constructed with a fully switched 66 kV bus and outgoing 66 kV feeder to Mt Rooper. A spare 66 kV feeder bay will accommodate a future second feeder from CANN. The cold standby 32 MVA 66/11 kV OLTC transformer is retained as an in-situ spare.

MORO substation currently supplies 80 customers including the major 11 kV customer Daydream Island/South Molle Island via privately owned submarine cables and an 11 kV mainland connection point and recloser. The substation has a single 5 MVA 66/ 11 kV fixed tap transformer that supplies unregulated 11 kV to the islands, however a set of 100 A voltage regulators supplies the 11 kV Shute Harbour feeder and approx. 79 customers. There is a N/O 11 kV feeder tie to the Mandalay feeder from JUPO.

SHUT substation currently supplies two customers including the major 22 kV customer Long Island/Hamilton Island via privately owned 22 kV submarine cables and a 22 kV mainland connection point and recloser. The 22 kV submarine cable to Hayman Island is owned by Ergon Energy. On the island, a fixed tap 5 MVA 22/11 kV transformer supplies the resort via an 11 kV connection point. SHUT has one 25 MVA 66/22 kV OLTC transformer.

Proserpine Mill (PRMI) substation has a single 10/12 MVA 66/11 kV OLTC transformer that currently supplies the township of Proserpine (i.e. 80 customers) and the embedded generator Proserpine Sugar Mill. The Authorised Demand of PRMI is 10 MVA (10 MW) export and 4 MVA (3.6 MW) import.

2.1.2. 66 kV Transmission Line Attributes:

The Cannonvale-Airlie-Shute Harbour area zone substations are supplied via two radial 66 kV feeders (i.e. 119 Cannonvale No. 1 and 118 Cannonvale No. 2 feeders) out of T39 Proserpine (PROS) 132/66 kV substation. Cannonvale No. 2 (CANN-02) supplies CANN substation while Cannonvale No. 1 (CANN-01) bypasses CANN to supply JUPO, SHUT and MORO substations.

The 66 kV feeders between PROS and CANN are predominantly timber pole, timber crossarm construction but no overhead earthwire. One line is constructed in 1984 and the other in 2000. The summer day (SD) overhead line ratings of CANN-01 and CANN-02 are 43.0 MVA and 45.6 MVA respectively. The backbone circuit distance from PROS to CANN is approx. 24.9 km (CANN-01) and 27 km (CANN-02).

CANN-01 has a hard tee (of approx. 1.0 km O/H and 0.37 km U/G) to Proserpine Mill (PRMI) 66/11 kV substation, 4.0 km from PROS.

The existing 66 kV network arrangement is shown schematically in the attachment and Figure 2 below.

MK-OS-10067-01-0F.pdf

The 6.5 km 66 kV section from JUPO to Shute Harbour is predominantly SCCP JASPER with OHEW (approx. 5.9 km) & sections of U/G cable (approx. 0.57 km).The 5.4 km section from CANN to JUPO is a combination of U/G cable (approx. 1.41 km), O/H timber and concrete pole line with OHEW.

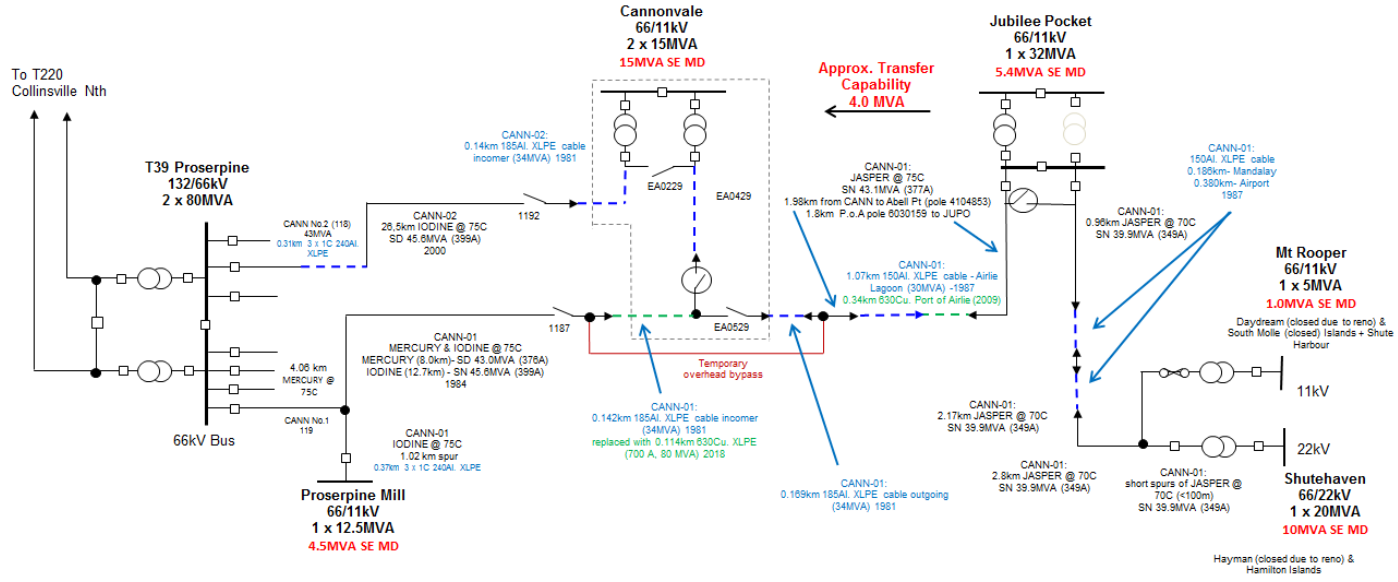

Figure 2 Existing 66 kV Sub-Transmission Network

2.1.3. CANN Substation 66 kV Configuration and Land Purchase:

CANN does not have a fully switched 66 kV bus which would provide distribution supply reliability benefits to the networks supplied from CANN, JUPO, SHUT and MORO and to a lesser degree PRMI. CANN-01 also has a hard tee off to CANN via a normally open 66 kV isolator which is manually closed during contingency failure of CANN-02. Time-consuming manually operated 66 kV switches at CANN are operated to rearrange the 66 kV network and restore supply via CANN-01 or CANN-02 under forced or planned outage conditions.

As the 66 kV transfer between CANN-01 to CANN-02 occurs in the CANN substation on the quasi 66 kV bus and involves staff standing under the 66 kV isolator and in close proximity to the porcelain cable termination (refer to Appendix A), field crews recommend load transfers via the 11 kV or from a de-energised 66 kV due to safety concerns. It should be noted that over the last 8 years, a downstream 66 kV cable terminations and lightning arrestor has failed with the later explosively whilst energising the 66 kV ABS two poles away. All the 66 kV lightning arrestors have since been replaced, particularly as PD testing of CANN-02 cable identified discharges on the L/As.

A temporary overhead bypass has been constructed after the CANN-01 66 kV XLPE cable (circa 1981) to the 66 kV bus, failed in March 2017. The bypass arrangement is temporary and has not undergone the relevant planning applications with Main Roads and Council to remain an approved and permanent installation. The substation arrangement and adjacent land purchase can be seen in Figure 3.

Ergon Energy owns an additional parcel of land behind the CANN substation that was strategically purchased to enable redevelopment of the site into a fully switched 66 kV bus.

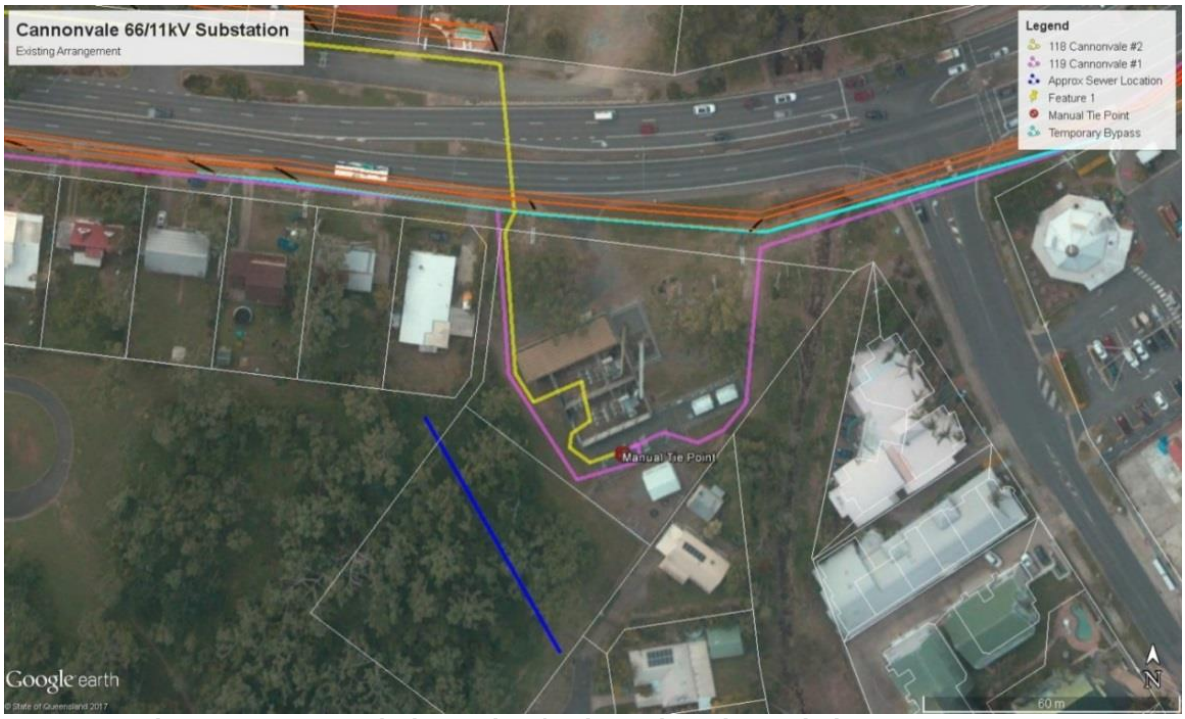

Figure 3 Cannonvale (CANN) 66/11 kV Substation Existing Arrangement

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Energy Queensland Limited ABN 96 612 535 583
Energex Limited ABN 40 078 849 055

2.1.4. 66 kV Cable Failure Results and Priority Cables

Of significant concern are the sections of 66 kV cable at CANN and the radial sections between CANN-JUPO and JUPO-Shute Harbour. Laboratory analysis by The University of Queensland examined XLPE samples from the faulted CANN-01 phase and healthy phase cables for evidence of water trees and electrical trees. Water trees are caused by a combination of voltage stress and moisture present in crosslinked polyethylene (XLPE) and typically initiate as a microscopic defect.

Laboratory test result diagnoses of the samples comprising one slice each from the healthy phases adjacent to the fault and four slices from the faulted phase (one each side of the fault and one at each end of the cable run) exhibit significant degradation of the XLPE insulation. Whilst examination indicated that the faulted phase had the longest bow-tie (non-vented) trees and quantity of advanced length bow-tie trees, all three cores showed advanced length vented trees.

Water trees can be divided into two main types:

- Bow-tie trees: normally the most common type. These form in the bulk of the insulation.
- Vented trees: these form from the interface between the insulation and screen. Their growth is accelerated by the presence of free air.

Small bow-tie trees are of no great concern individually, but when either numbers or sizes become large, they may lead to eventual cable failure if they initiate an electrical tree. Vented trees are the more concerning of the water trees as they protrude into the XLPE from the screen. These often lead to cable failure.

Electrical trees were not observed which is normal as electrical tree formation usually indicates that an electrical failure is imminent. High voltage electrical failures also usually eliminate evidence of electrical trees in any case.

The cross section of the cable can be seen in Figure 4, while images from the testing carried out by UQ highlight vented and bow-tie trees which can be seen in Figure 5 and Figure 6 respectively.

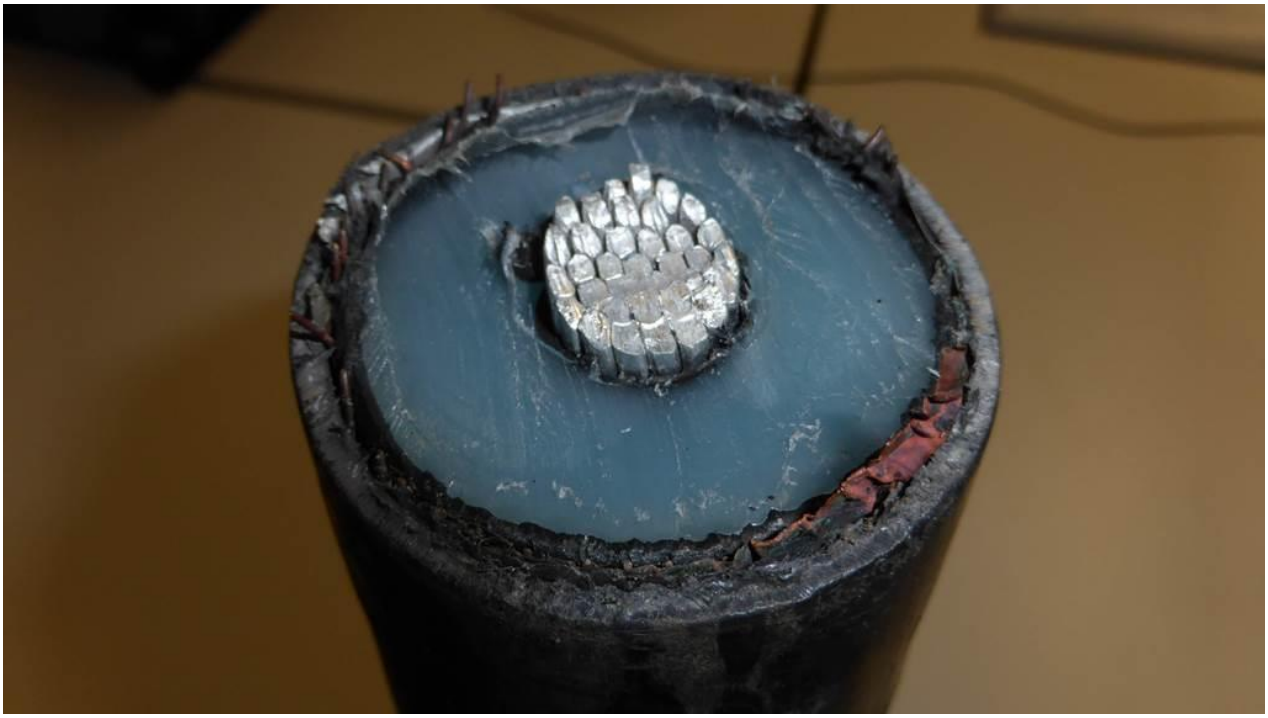

Figure 4 Cross-Section of the Faulted CANN-01 XLPE Cable

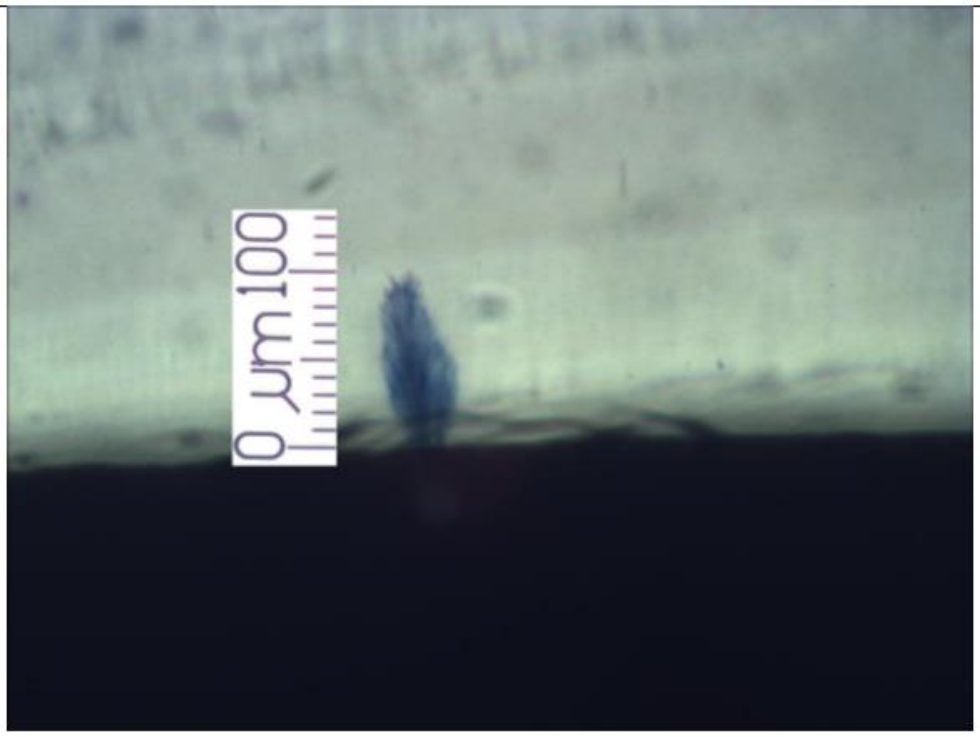

Figure A-1. Cable F3. Vented tree, conductor side of XLPE.

Figure 5 Vented Tree Found During Testing of CANN-01

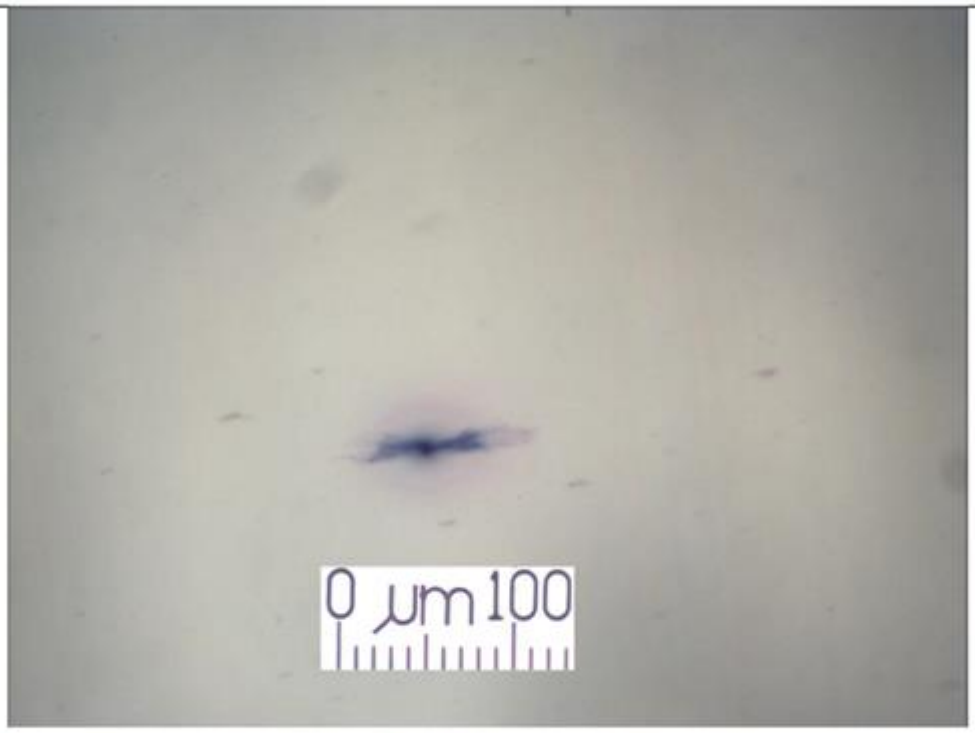

Figure A-3. Cable F3. Bow-tie tree. Note that there appears to be many small bow-tie trees nearby but in a different focal plane.

Figure 6 Bow-Tie Tree Found During Testing of CANN-01

CANN-01 66 kV cable from the termination pole to the CANN 66 kV bus failed in March 2017 and has just been replaced under WR1254348 at a DCV cost of approx. $900k. Actual costs are tracking within 13% below the DCV cost however final costs have not been reconciled.

The cable involved in the fault at Cannonvale was reportedly installed in the early 1980's and is of ASEA manufacture - markings on the cable jacket showed the words ASEA KABELDON 72/40kV. A search of historical records did not identify the cable installation date or year of manufacture or any references to a procurement contract. The installation date is based on dates for the substation construction obtained from local staff in Mackay.

As the 66 kV cables were installed at CANN around the same time (circa 1981), investigation of the CANN-02 cable to 1T 66 kV transformer bay was initiated.

CANN-02 feeder was taken out of service (19th Feb. 2018) and subsequent testing (On-line Partial Discharge (PD) monitoring, Insulation Resistance (IR), PD and Tan Delta test methods) of the 66 kV cable identified high levels of PD.

- IR testing indicated the cable was in reasonable overall condition;
- On-line PD monitoring attributed significant portions of PD to the upstream network and the surge arrestors were replaced; and
- Off-line PD measurements by Energex indicated the A phase PD at 12m, 44m and 66 m from the CANN substation end. No significant PD was identified on B phase and C phase did not show any high levels of PD. The Ergon VLF PD testing also highlighted areas of suspect PD on A phase but at 45m, 60m and 70m from the CANN end and B phase had limited tests with unconfirmed PD locations observed at 60 and 64m from the CANN substation end. Poor weather prevented further testing to fully collaborate and confirm locations of PD using the two test sets.

As a result of the already failed CANN-01 cable and UQ water tree analysis results and various test results of the CANN-02 cable to 1T transformer bay, further scoping work has been initiated to replace this cable.

The remaining untested cables (i.e. CANN-01 cable towards JUPO and CANN 66 kV bus to 2T transformer bay) are of the same vintage (circa 1981) as the failed and recently tested cable. It is quite possible that these radial cable sections will also require replacement.

Approx. 6 years later but further downstream of CANN, 66 kV cables were installed in the radial network to Shute Harbour:

- CANN to JUPO 1.41 km Abell Point to Port of Airlie 66 kV cable (circa 1987);
- JUPO to SHUT/MORO 0.186 km Mandalay hill slope 66 kV cable (circa 1987); and
- JUPO to SHUT/MORO 0.38 km airport crossing 66 kV cable (circa 1987).

The 1st generation XLPE cables (circa 1980) used different manufacturing processes which resulted in typically more inclusions in the primary insulation than would be the case nowadays.

Anecdotal evidence indicates the 1987 cables were manufactured under the same contractual specification, however, further investigations are in progress. These radial cables are on the priority testing list.

Notwithstanding the water tree performance of the CANN cables, the radial nature of these three additional 66 kV underground circuits and:

- significant sections of direct buried trench sections;
- constrained geographic location to install an emergency 66 kV overhead bypass (i.e. Airlie Lagoon route, airport flight path restrictions and to a lesser degree the Mandalay hill slope); and

- cable replacement logistics including cable manufacture lead times, cost, installation approvals and construction timelines escalate this risk.

These cable sections represent a Safety Net risk, high probability VCR cost and reputational risk exposure to both Ergon Energy and the Whitsunday tourism industry.

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2.1.5. VCR and Distribution Supply MSS Reliability

Supply reliability and high VCR of the distribution network is a reflection of the poor performance of the 66 kV sub-transmission network. Table 1 shows that in the last 8 years, 76 % of the known sub-transmission fault locations were identified on the 66 kV supply side of CANN. From this, it is clear that the most degradation is seen by distribution feeders supplied by JUPO, MORO and SHUT.

Table 1 Sub-Transmission Fault Locations (Known) Since 2010

Fault Location	Fault Location	66kV Feeder	% of Known Fault Locations
Beyond CANN	CANN-JUPO	CANN-01	14.29%
	JUPO-SHUT	CANN-01	9.52%
Beyond CANN Total			**23.81%**
Before CANN	PROS BUS 2	CANN-02	4.76%
	PROS-CANN	CANN-02	14.29%
		CANN-01	57.14%
Before CANN Total			**76.19%**
Grand Total			**100.00%**

VCR is an economic value applied to customers' unserved energy for any particular year and can be used to validate a proposed investment option. The net reduction in VCR calculated under each option (post-implementation) is classified as an annual indirect benefit for that option in the NPV cash tool. Failure to use VCR in the cost analysis to inform economic efficiency of investments could impair the prudency and efficiency of those investments.

Applicable outage events, unserved energy and VCR were analysed over 8 years of outage data which showed an average annual unserved energy cost of $2.117M including the 9-hour long term CANN-01 cable outage. The worst 12 months was in the year 2017/18 which saw unserved energy of 200 MWh valued at $5.6M (not including Cyclone Debbie). This was largely due to the CANN-01 66 kV cable fault on one of the incoming feeders into CANN which took 9 hours to locate and isolate while JUPO, MORO and SHUT remained offline.

The 9-hour outage was excluded for the purpose of NPV VCR assessments and an annual indirect benefit figure of $1.765M has been used for options analysis.

The public reputation risk due to both duration and frequency of interruptions is significant. The Airlie Beach area is an internationally renowned tourism hub and the gateway to the Whitsunday Island communities and resorts including Hamilton Island, Hayman Island, South Mole Island, Port of Airlie and Shute Harbour.

Figure 7 shows that a large percentage of events have spanned the evening peak period meaning maximum disruption to the hospitality industry and the general population. Short term disruptions that successfully reclose are not captured in this analysis.

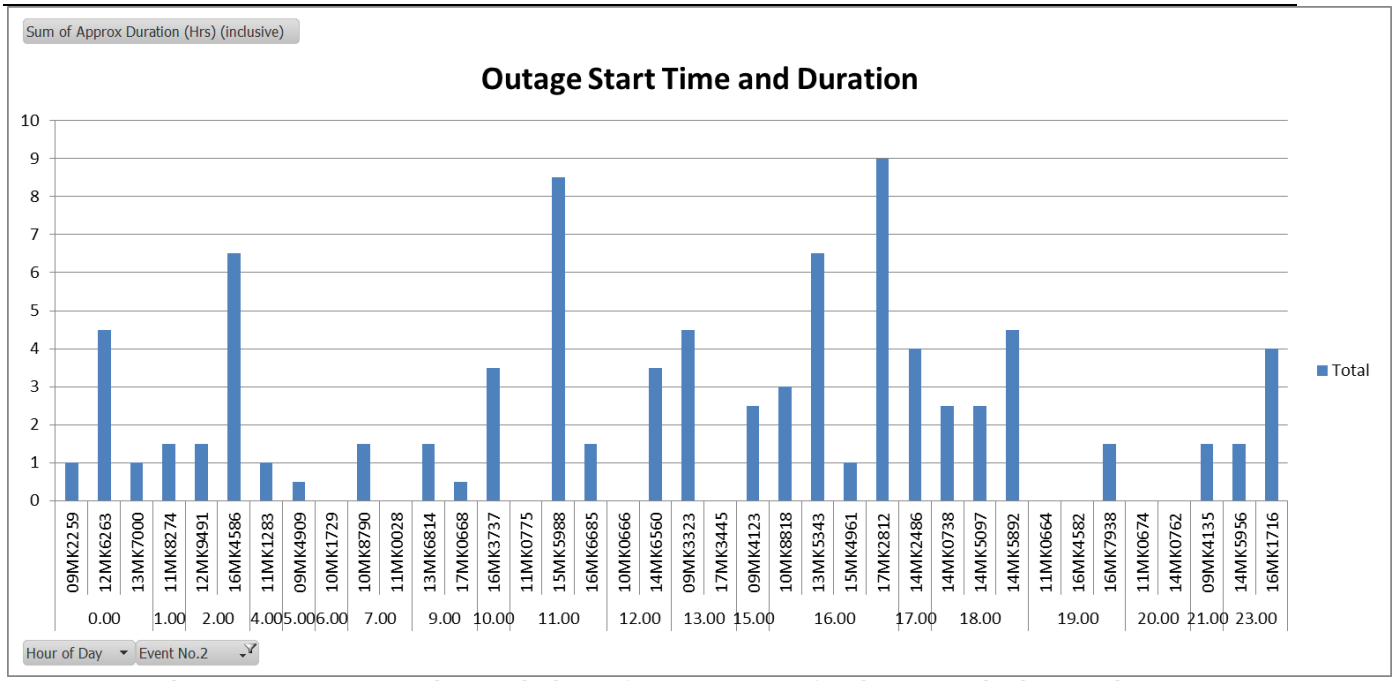

Figure 7 Outage Duration and Time of Occurrence of Sub-Transmission Faults

Customers supplied from JUPO and MORO have experienced MSS 'RED' feeder reliability status over an extended period of time (i.e. over the last 3-5 years).

There is currently no merit in transferring 11 kV feeder loads from CANN to an under-utilised JUPO asset as these customers will then be subject to 'RED' feeder reliability performance.

There is no reliability measure for the major island customer connections (i.e. Hamilton, Hayman, Daydream, South Molle and Long Island) however iconic exclusive resorts and tourist destination experiences reflect poorly on the EECL brand and risks reputational damage.

A notable example of reputation risk exposure was when power was interrupted to Hamilton Island during a performance by an internationally acclaimed popular artist[1]. The venue lights and sound were out for more than half an hour while the island's generation was brought online.

Whilst the upstream CANN 66 kV has notable exposure to faults, it is also recognised that the 66 kV section from CANN to SHUT/MORO represents 24 % of the number of faults and subsequent reliability exposure.

[1] Taylor Swift Event 15MK7358 on 02/12/2015

2.1.6. Long Term Cable Failure Outage Cost

The long term cost due to a sustained cable failure (e.g. 1.41 km Airlie Lagoon cable) from water treeing has been considered in the context of a similar privately owned submarine cable failure to the islands.

Considering manufacturing and sea freight lead times for 66 kV cables of 16 weeks, this would be considered a catastrophic outage scenario. The islands are presently exposed to similar risk during a privately owned submarine cable failure and should have standby operating protocols to manage fuel supply and storage for an outage of a similar long term duration outage.

If the estimated cost of a 4-6 month outage (i.e. $8M-$12M) is borne entirely by the island resort operators, Ergon will bear significant political pressure and brand damage.

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2.2. Applied Service Standards

Applied Service Standards are as per the jurisdictional obligations within Energy Queensland's Distribution Authority (Ergon Energy). The legislated SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) limits are detailed in Table 2.

Table 2 SAIDI (minutes per customer) and SAIFI (interruptions per customer) limits

Feeder Category	SAIDI MSS Limits	SAIFI MSS Limits
Urban	149	1.98
Short Rural	424	3.95
Long Rural	964	7.40

The feeder performance categorisation is based on SAIDI indices against the MSS for a given financial year for each feeder category. The feeder status bands are as follows:

- Green Feeders have a SAIDI <= MSS (Minimum Service Standard) targets
- Yellow Feeders have a SAIDI > MSS < 150 % MSS
- Amber Feeders have a SAIDI > 150 % MSS < 200 % MSS
- Red Feeders have a SAIDI > 200 % MSS

The Safety Net Targets from Ergon Energy's Distribution Authority are provided in Table 3. CANN and JUPO substations are considered as 'Regional Centres' while SHUT and MORO are both considered as 'Rural Areas'.

Table 3 Ergon Energy Service Safety Net Targets

Area	**Targets (for restoration of supply following an N-1 Event)**
Regional Centre	Following an N-1 event, load not supplied must be: ○ Less than 20 MVA after 1 hour; ○ Less than 15 MVA after 6 hours; ○ Less than 5 MVA after 12 hours; and ○ Fully restored within 24 hours.
Rural Areas	Following an N-1 event, load not supplied must be: ○ Less than 20 MVA after 1 hour; ○ Less than 15 MVA after 8 hours; ○ Less than 5 MVA after 18 hours; and ○ Fully restored within 48 hours.
Note: All modelling and analysis will be benchmarked against 50 POE loads and based on credible contingencies. 'Regional Centre' relates to larger centres with predominantly urban feeders. 'Rural Areas' relates to areas that are not Regional Centres.	

2.3. Demographic Development – Mainland

The Cannonvale and Airlie Beach townships form a linear strip of land between the Whitsunday National Park and the sea. The physical geography consists of a series of small valleys and basins separated by steep coastal bluffs. The economy is primarily a sea change/tourist destination supported by ports and marinas at Shute Harbour and Abell Point for people visiting the Whitsunday islands.

The area of supply studied includes the following localities:

- Cannonvale/Airlie Beach; and
- Jubilee Pocket/Shute Harbour.

A number of studies have been used by the Whitsunday Regional Council to make informed decisions about the Planning Scheme including the:

- 2013 Norling Population and Growth Study; and
- 2014 Urban Growth Study.

2.3.1. Residential/Floor Space Forecasts & Tourist Visitation

The Norling Population and Growth study predicts that the combined locations of Cannonvale/Airlie Beach and Jubilee Pocket/Shute Harbour can expect a 100-130 % increase in population to the year 2036.

Table 4 2013 – 2036 Population and Employment Projections

Table 31: 2013 – 2036 Population and Employment Projections – Modest and All Potential Growth Scenarios (Norling Consultancy, 2013).

Location	2013 Population	2013 Jobs	2036 Population	2036 Jobs	2013-2036 Population Difference	2013-2036 Job Difference
Modest Growth Scenario						
Cannonvale – Airlie Beach	6,800	3,400	12,700	7,300	+5,900	+3,900
Jubilee Pocket – Shute Harbour	2,300	900	5,500	1,200	+3,200	+300
TOTAL	9,100	4,300	18,300	8,500	+9,100	+4,200
All Potential Growth Scenario						
Cannonvale – Airlie Beach	6,800	3,400	14,400	8,500	+7,600	+5,100
Jubilee Pocket – Shute Harbour	2,300	900	6,600	1,400	+4,300	+500
TOTAL	9,100	4,300	21,000	9,900	+11,900	+5,600

Extracts from the Norling report also indicate that tourism growth in Airlie Beach will be the main source of direct and indirect employment growth in the area. The same study found that the Whitsunday region was the most tourism-dependent regional economy in Queensland in terms of the contribution to the Gross Regional Product (i.e. GRP).

The Cannonvale – Airlie Beach area is likely to experience the strongest growth due to its capacity for housing, proximity to employment-generating tourism, business and retail areas.

Jubilee Pocket – Shute Harbour will be a dormitory suburb with the majority of persons employed within the Cannonvale – Airlie Beach business and service area.

The latest LGIP V1.6 residential population projections correlate with the Norling report 'Moderate Growth Rate' scenario when extrapolated to 2036.

Table 5 Local Government Infrastructure Plan (LGIP) Mapping and Tables - Residential

SC3.1 Planning assumption tables

Table SC 3.1.1 Existing and projected population

Column 1 Projection area	Column 2 LGIP development type	Column 3 Existing and projected population				
		2016	2021	2026	2031	Ultimate development
Abbot Point	Single dwellings	1,491	801	801	801	809
	Multiple dwellings	92	50	50	50	51
	Other dwellings	277	149	149	149	157
	Total	1,860	1,000	1,000	1,000	1,017
Bowen North	Single dwellings	6,113	6,109	6,152	6,171	6,617
	Multiple dwellings	2,136	2,254	2,395	2,531	2,762
	Other dwellings	21	27	33	38	45
	Total	8,270	8,390	8,580	8,740	9,425
Bowen South	Single dwellings	828	1,124	1,452	1,769	7,211
	Multiple dwellings	287	399	526	654	770
	Other dwellings	5	8	12	17	110
	Total	1,120	1,530	1,990	2,440	8,091
Collinsville	Single dwellings	1,345	1,324	1,352	1,362	2,914
	Multiple dwellings	816	820	854	878	901
	Other dwellings	799	796	824	841	858
	Total	2,960	2,940	3,030	3,080	4,673
Balance former Bowen Shire	Single dwellings	1,021	1,020	1,004	1,003	994
	Multiple dwellings	194	196	194	196	196
	Other dwellings	214	214	211	211	210
	Total	1,430	1,430	1,410	1,410	1,400
Whitsunday Islands	Single dwellings	127	128	129	130	132
	Multiple dwellings	622	612	603	593	586
	Other dwellings	1,091	1,109	1,128	1,147	1,172
	Total	1,840	1,850	1,860	1,870	1,890
Jubilee Pocket / Shute Harbour	Single dwellings	1,817	2,219	2,639	3,116	4,792
	Multiple dwellings	785	1,002	1,246	1,537	1,843
	Other dwellings	8	19	35	57	100
	Total	2,610	3,240	3,920	4,710	6,735
Cannonvale / Airlie Beach	Single dwellings	4,384	5,161	6,024	6,859	15,059
	Multiple dwellings	2,869	3,365	3,913	4,438	7,102
	Other dwellings	27	34	43	53	81
	Total	7,280	8,560	9,980	11,350	22,242

Table 6 Local Government Infrastructure Plan (LGIP) Mapping and Tables – Non-Residential

Table SC 3.1.5 Existing and projected non-residential floor space

Column 1 Projection area	Column 2 LGIP development type	Column 3 Existing and projected non-residential floor space (m² GFA)				
		2016	2021	2026	2031	Ultimate development
Abbot Point	Retail	629	659	688	718	747
	Commercial	1,501	1,552	1,602	1,653	1,703
	Industrial	15,779	19,899	24,018	28,137	32,256
	Community	2,671	2,778	2,884	2,991	3,098
	Other	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Total	20,580	24,888	29,192	33,499	37,804
Bowen North	Retail	19,963	20,275	20,586	20,898	21,210
	Commercial	20,592	21,493	22,394	23,294	24,195
	Industrial	95,724	97,884	100,044	102,204	104,364
	Community	37,057	39,378	41,699	44,019	46,340
	Other	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Total	173,337	179,030	184,723	190,416	196,109
Bowen South	Retail	1,441	1,593	1,745	1,896	2,048
	Commercial	1,749	1,810	1,871	1,931	1,992
	Industrial	7,319	7,517	7,715	7,914	8,112
	Community	2,890	3,157	3,424	3,691	3,959
	Other	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Total	13,400	14,078	14,755	15,433	16,111
Collinsville	Retail	3,231	3,303	3,375	3,448	3,520
	Commercial	3,889	3,965	4,042	4,118	4,195
	Industrial	15,008	18,381	21,754	25,127	28,500
	Community	8,575	8,680	8,785	8,890	8,995
	Other	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Total	30,702	34,329	37,956	41,583	45,210
Balance former Bowen Shire	Retail	1,836	1,855	1,875	1,894	1,914
	Commercial	1,858	1,844	1,830	1,817	1,803
	Industrial	4,408	3,834	3,260	2,686	2,112
	Community	2,709	2,574	2,439	2,305	2,170
	Other	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Total	10,810	10,107	9,404	8,701	7,999
Whitsunday Islands	Retail	5,310	5,556	5,803	6,049	6,296
	Commercial	14,020	14,792	15,564	16,335	17,107
	Industrial	1,100	1,113	1,126	1,139	1,152
	Community	2,196	2,351	2,505	2,660	2,814
	Other	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Total	22,626	23,811	24,997	26,183	27,369
Jubilee Pocket / Shute Harbour	Retail	7,531	7,906	8,280	8,655	9,030
	Commercial	7,551	8,011	8,471	8,931	9,391
	Industrial	13,907	14,105	14,303	14,502	14,700

Whitsunday Regional Council Planning Scheme – Schedule 3 (LGIP V1.6) SC3:9

Column 1 Projection area	Column 2 LGIP development type	Column 3 Existing and projected non-residential floor space (m² GFA)				
		2016	2021	2026	2031	Ultimate development
	Community	5,417	6,338	7,259	8,179	9,100
	Other	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Total	34,406	36,360	38,314	40,268	42,221
Cannonvale / Airlie Beach	Retail	25,126	28,993	32,859	36,726	40,592
	Commercial	31,294	38,482	45,669	52,857	60,044
	Industrial	68,970	82,181	95,391	108,602	121,812
	Community	40,571	47,173	53,775	60,377	66,980
	Other	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Total	165,962	196,829	227,695	258,561	289,428

The non-residential forecast represents an increase of 58 % from the 2016 base across retail, industrial, commercial and other.

Visitor numbers peaked in 2006/07 at approx. 800,000 international and domestic overnight stays.

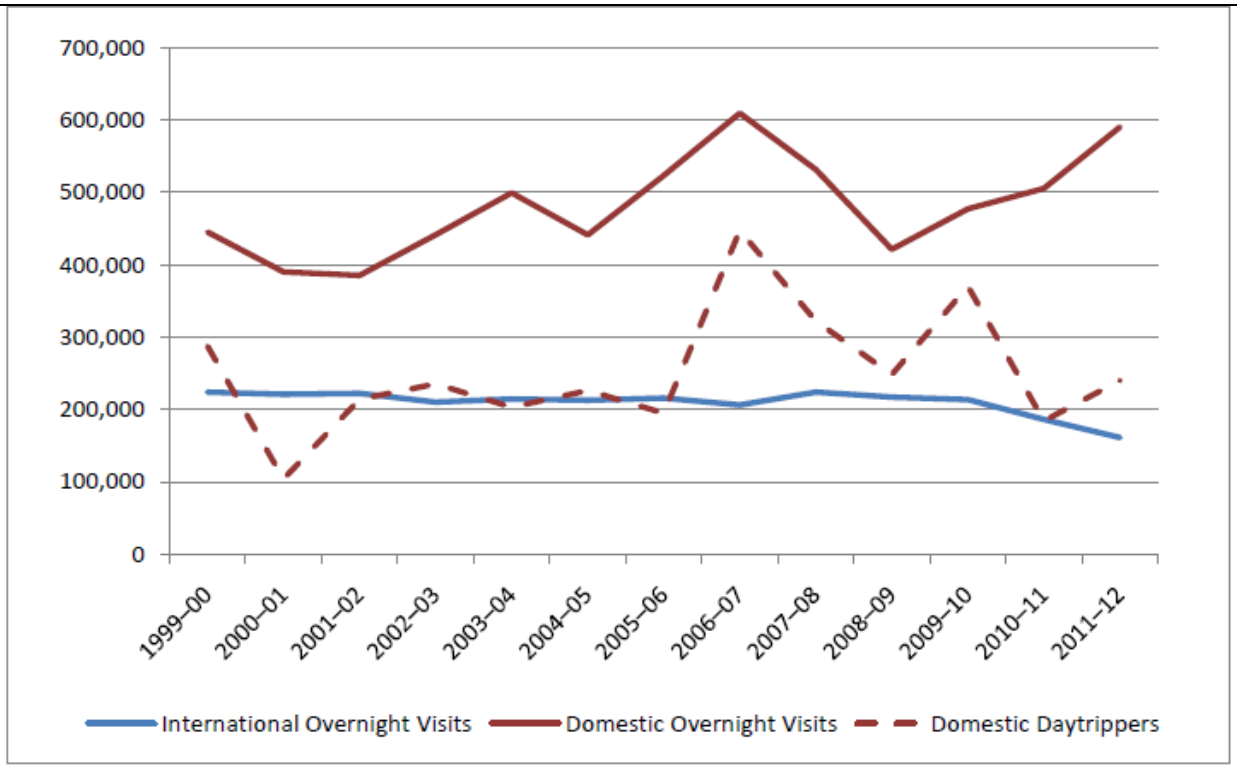

Figure 8 Visitors to the Whitsundays (including Proserpine to Bowen, east to Airlie Beach and the Whitsunday Islands, west to Collinsville)

As an example of the dependency upon tourism, in March 2013, there were 35 tourism accommodation establishments (hotels, motels and serviced apartments) offering some 10,400 bed spaces, representing a decline from the 51 establishments reported in 2010[2].

At that time of writing the Norling report, some 30 cruise ships dock at Airlie Beach per year, carrying 1,800 to 2,400 passengers.

As at June 2018, 551,000 domestic and 244,000 international visitors totalling 795,000 visitors were hosted in this region over the previous year. Considering the impacts of Cyclone Debbie (March 2017), subsequent tourist visitation recovery and refurbishment investment at Hayman Island (approx. $100M), Daydream Island ($86M) and likely works to proceed at South Molle Island, the GRP will trickle down into the local economy and growth.

Whitsundays-Regional-Snapshot-YE-Dec-2

6.-Domestic-Tourism-YE-June-2018.pdf

8.-International-Tourism-YE-Jun-2018.pdf

[2] 2013 Norling Whitsunday Regional Economic and Pop Study4

2.3.2. Zoning Densities

The zoning plans, potential development densities and 2004 demographic load forecasts around Airlie Beach precinct along with the adjacent residential nodes (i.e. Jubilee Pocket and Cannonvale localities) demonstrate the need for CANN and JUPO substations and the benefit of their locations to supply the area.

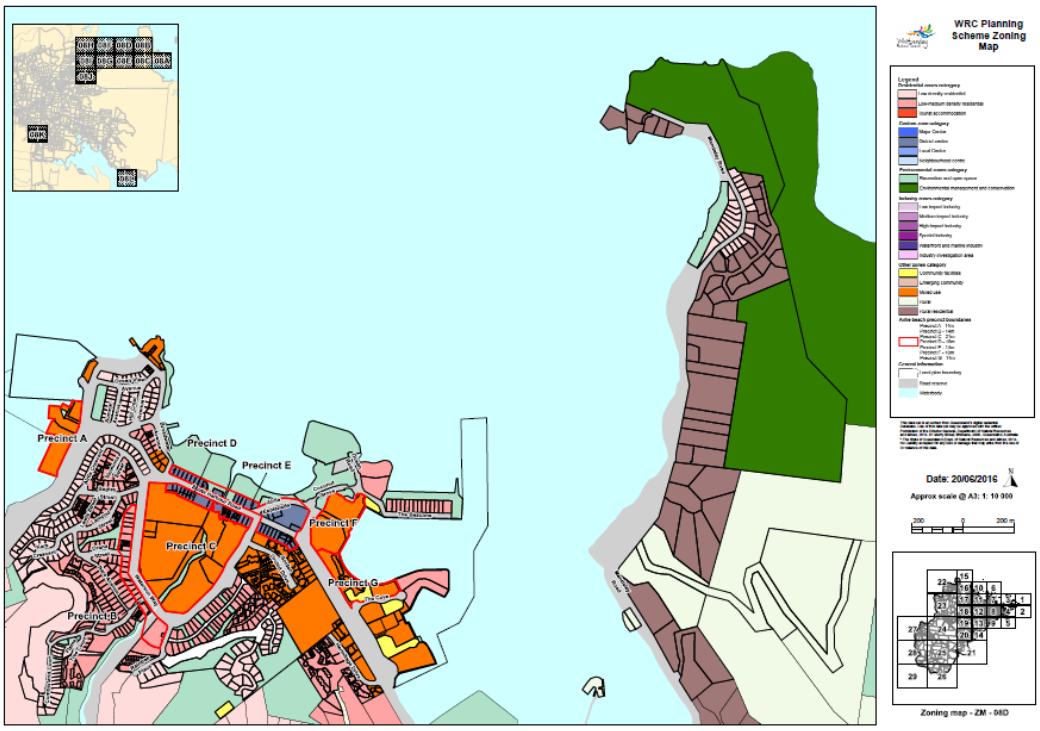

Figure 9 Whitsunday Regional Council Zoning Map (2018)

Figure 10 Potential Building Heights Plan (Airlie Beach Structure Plan Report 2014)

2.3.3. Demographic Load Forecasts (circa 2004)

Demographic load studies undertaken in 2004 (refer to **Figure** 11) provide a guide for the potential load centres to be supplied from the MORO, JUPO and CANN substations. The strategic purchase of the Riordanvale (i.e. RIOR) site enables initial 66/11 kV zone substation development and longer-term 132/66 kV transformation pending the realisation of development, load densities and an ultimate end state load of 150 MVA excluding the island loads.

Load catchment supply areas and plant capacity to supply these areas are anticipated to be designed within the principal design criteria of:

- 66 /11 kV substation 46 MVA ultimate capacity:
  - Z6-32 design 32 MVA 66/11 kV OLTC (say 40.0 MVA operational LTEC rating);
  - 11 kV s/b (12 feeders, 2 capacitors, 3 bus sections, 2500 A rated);
  - 4 into 3, 11 kV urban design criteria with 10% diversity of feeder peak demands; and
  - Allow 4-6 MVA of 11 kV load transfer to an adjacent substation;

- JUPO 66 /11 kV substation:
  - Demographic load (46.0 MVA or 2414 A):
    - Towards Shute Harbour (i.e. 18.0 MVA, 4-5 x 11 kV 6.0 MVA feeders):
      - F.T.C.M. – 4.0 MVA; and
      - J.P. – 14.0 MVA;
    - Towards CANN (i.e. 28.0 MVA, 7 x 11 kV 6.0 MVA feeders):
      - P.O.A. – 7.0 MVA;
      - A.T.C. – 27.0 MVA (say 14.0 MVA from JUPO); and
      - A.R. – 7.0 MVA

- CANN 66 /11 kV substation (46 MVA ultimately):
  - Demographic load (45.7 MVA or 2398 A):
    - Towards JUPO (i.e. 14.0 MVA, 3 - 4 x 11 kV 6.0 MVA feeders):
      - A.T.C. – 27.0 MVA (say 14.0 MVA from JUPO);
    - Surrounding CANN (i.e. 14.0 MVA, 3 - 4 x 11 kV 6.0 MVA feeders):
      - C.E. – 14.0 MVA; and
    - Towards RIOR (i.e. 17.7 MVA, 4-5 x 11 kV 6.0 MVA feeders):
      - C.W. – 17.7 MVA;

- RIOR 66 /11 kV substation (46 MVA ultimately):
  - Demographic load (46.0 MVA or 2414 A):
    - Towards CANN (i.e. 19.0 MVA, 4 - 5 x 11 kV 6.0 MVA feeders):
      - P.C. – 11.0 MVA (it is likely part will be supplied from CANN and part of C.W. from RIOR via A.Rd. per 3 feeders that would be required into A.Rd.);
      - A.Rd. – 8.0 MVA;
    - Around RIOR (i.e. 27.0 MVA, 6 - 7 x 11 kV 6.0 MVA feeders):
      - R.S. – 5.0 MVA;
      - P.W. – 11.0 MVA; and
      - R.E. – 11 MVA of the forecast 25.0 MVA (i.e. ultimate end state).

Initially, RIOR will be developed as a T3-10 or a skid 66/11 kV substation to manage sequencing costs. 66 kV network development is required to manage 3-way differential/distance 66 kV protection schemes.

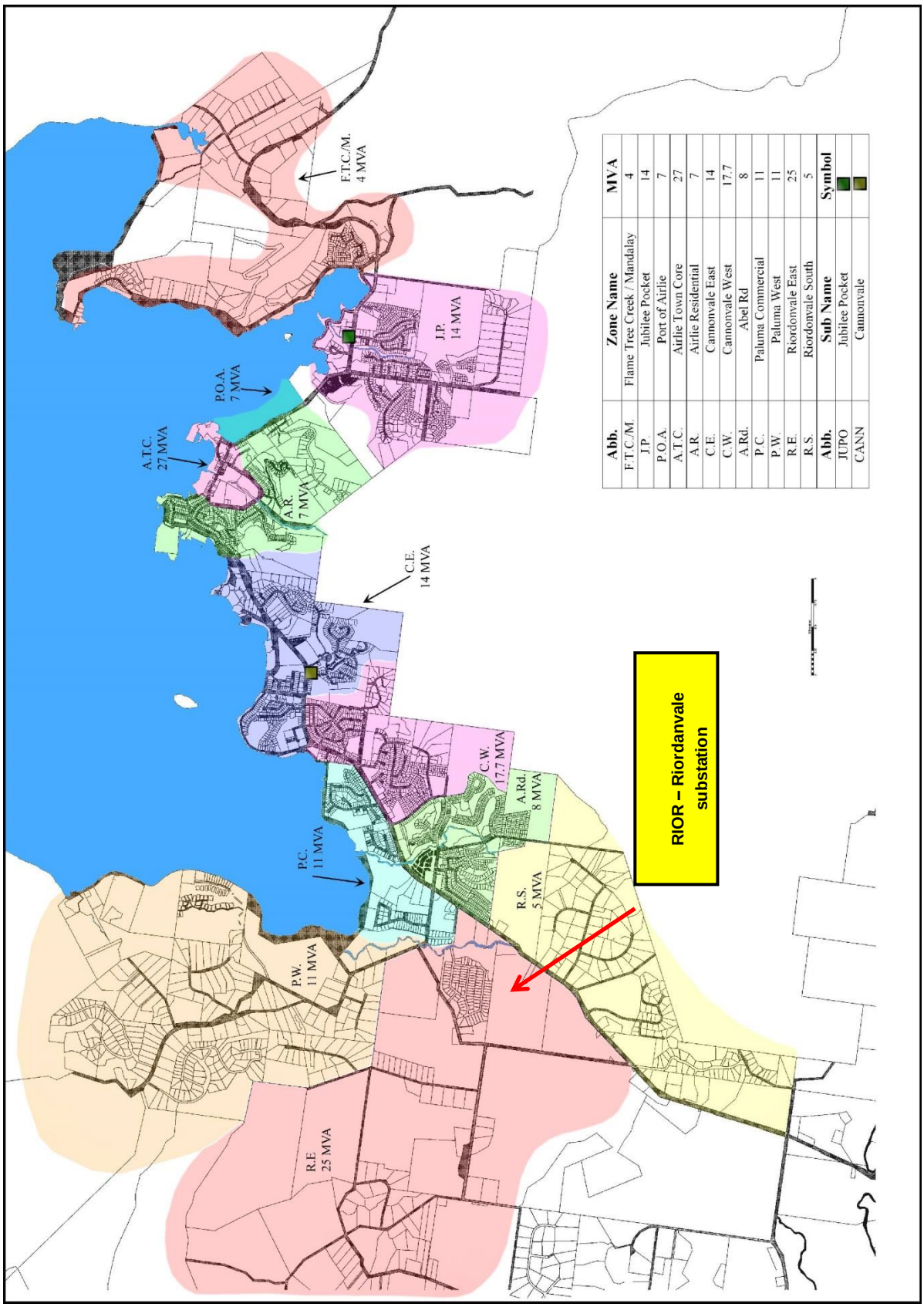

Figure 11 2004 Demographic Analysis

2.4. Primary Project Driver

The primary driver for this project is Augex. The existing sub-transmission network configuration has all customers downstream of JUPO reliant on the CANN-01 66 kV line between CANN and JUPO. Currently, a fault on this section of line will result in an outage for all JUPO, MORO and SHUT customers which combine for a peak load at risk of approximately 16.4 MVA. The section at highest risk of causing an extended outage is the 1.41 km underground cable passing through the main tourist centre of Airlie Beach. Safety net non-compliance is, therefore, the primary project driver.

2.5. Secondary Project Driver

Aged substation equipment and underground cables at Cannonvale substation require replacement and the aging XLPE cables poses an increasing risk.

Customer impact of the Cannonvale/Airlie Beach sub-transmission network configuration has increased substantially in the last four years. This is reflected in the Value of Customer Reliability (VCR) values based on analysis of historical outages over the past eight years. A significant contributor to this is the existing sub-transmission network switching arrangement.

3. LOAD FORECASTS

The recent load forecast does not align with the population growth projections and is likely to be at subdued levels due to the recent impacts from Cyclone Debbie and the uptake of MEGU (i.e. micro-embedded generating units) which is transforming the summer load from a day to night time peak demand characteristic at the major load centre of CANN.

It should also be recognised that as tourism visitations increase and the economy becomes more buoyant, investment in motels, unit accommodation and integrated developments will result in step load increases.

During the high growth period (i.e. 2004 to 2009) around the time of the GFC, the 1-5 and 6-10 year growth rates for CANN in 2007 were being projected at approx. 5 % and 8 % respectively. As recent as 2014, the annual growth rates were forecast at 1.5 % – 2.0 %.

Whilst the present growth rates are indicating nil growth, it is very difficult to predict visitor growth in the coming years due to the vagaries of the tourism industry and fluctuating markets due to unforeseen events such as the Australian dollar, weather events (e.g. 2017 Cyclone Debbie) and epidemics.

As such, it is not unreasonable to undertake sensitivity analysis to growth in the order of 2 % and as high as 4 % to strategically and prudently develop the network whilst being cognisant of electricity infrastructure timelines in these geographically constrained corridors.

In terms of potential future projects, the prospect of developments at Shute Harbour (i.e. integrated marina, resort hotel and residential community) or Airlie, refurbishment investment at Hayman and Daydream Islands subsequently supported by residential and service centre growth in the adjacent Cannonvale and Jubilee Pocket residential areas underpin WRC population growth forecasts to 2036.

3.1. CANN 66/11 kV Substation

The historical load of CANN for the summer day (SD), summer night (SN), winter day (WD) and winter night (WN) periods since 2004 is shown in Figure 12. The sudden drop in load seen between 2010 and 2011 is a result of JUPO substation being energised and taking some of the load from CANN. Taking into account historical feeder growth and the forecast population growth a load growth of 2 % is expected. The peak load by 2030 will then be 19.15 MVA. Under an extreme load growth of 4 %, the load would increase to 24.18 MVA.

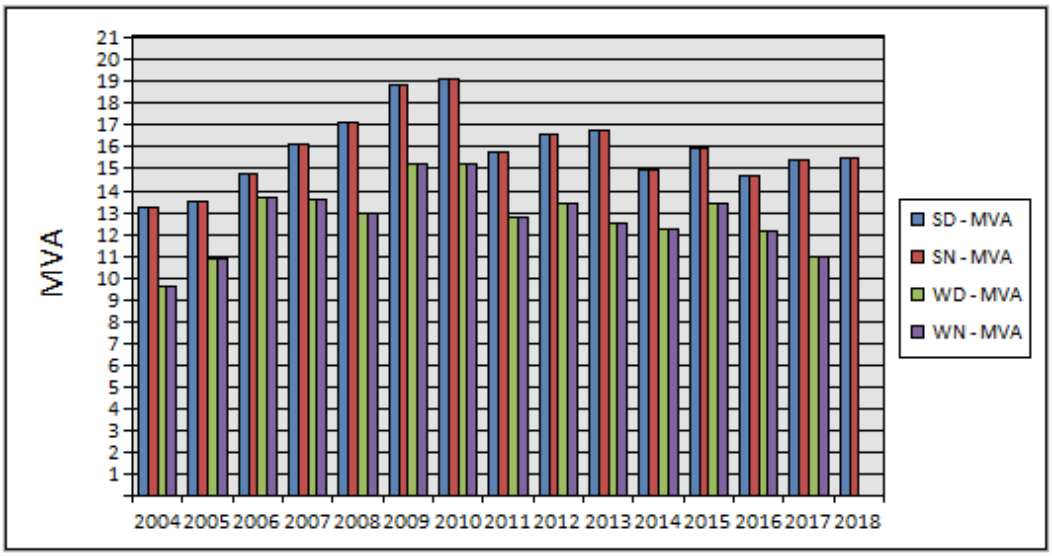

Figure 12 Historical Load of CANN Since 2004

It should be noted that the CANN substation summer peaks were being experienced between 1.30 pm to 4.00 pm in the afternoon, however in recent years (i.e. 2015 to 2018 inclusive), the summer peak is now being experienced from 4.30 pm to 7.30 pm most likely due to the installation of customer MEGU (refer to Figure 13).

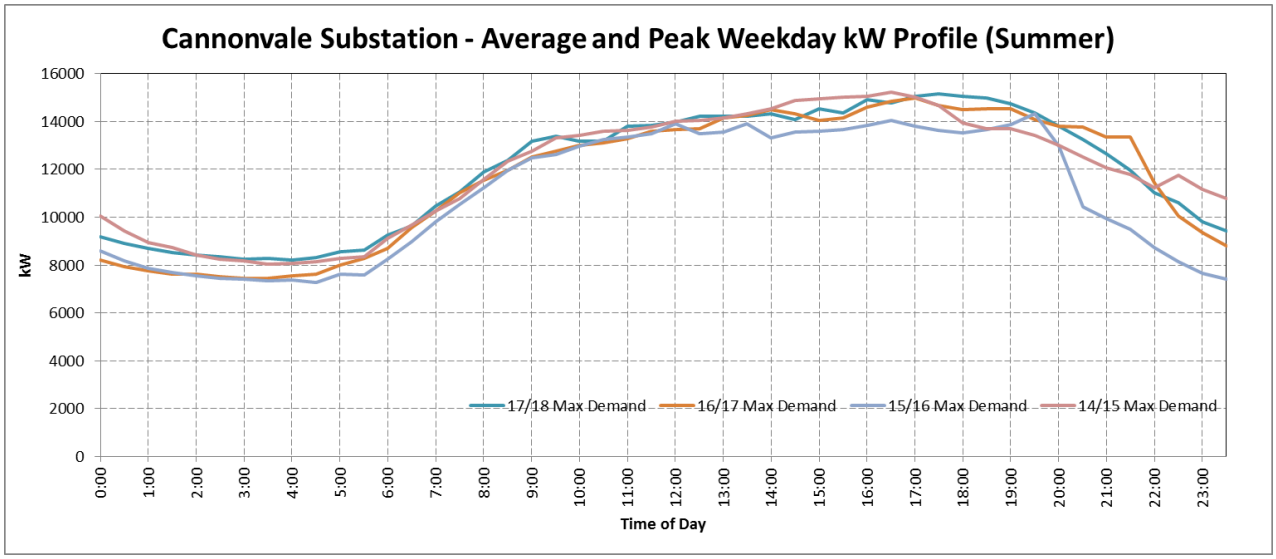

Figure 13 CANN Average and Peak Weekday Load Profile (Summer)

To consider the actual load being experienced (discounting the load supplied via MEGU), the peak load can be supplemented with a typical PV profile based on the amount of installed MEGU (see Figure 14). This graph shows that without the support of customer MEGU generation, the peak demand at the substation would likely remain during the daytime as summarised in Table 7. Table 7 also highlights that the growth experienced by CANN since 2014/15 is approximately 1.5 % if the effects of solar are excluded.

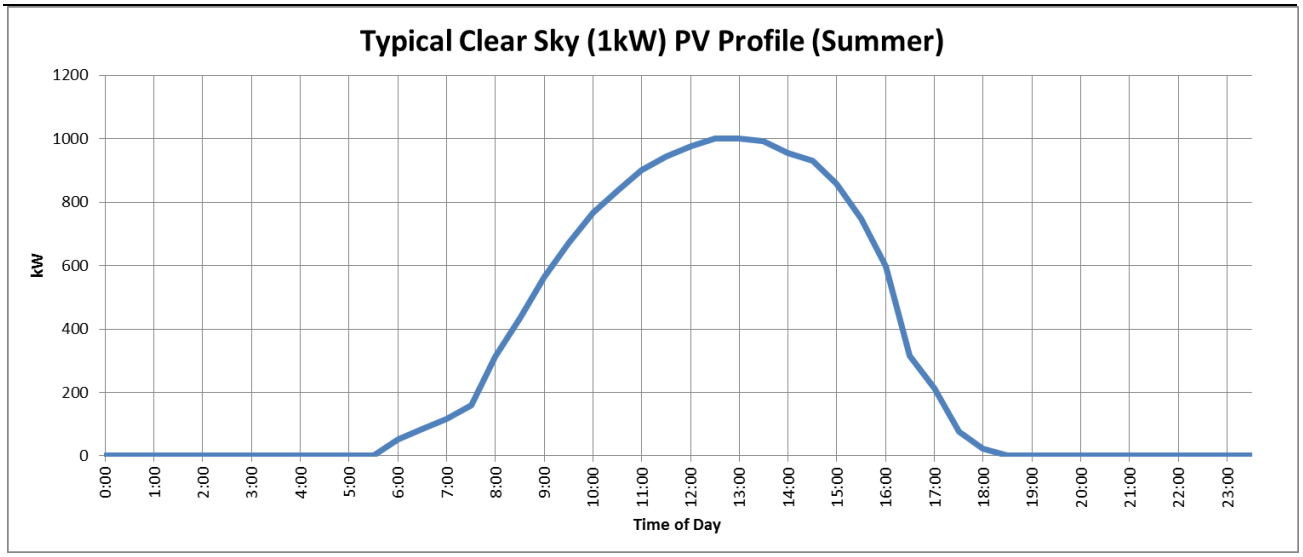

Figure 14 Typical Summer PV Generation Profile

Table 7 Recorded CANN Peak Load and Peak Time and the Estimated Values With Solar Excluded

Year	Recorded Peak (kW)	Recorded peak time of day	Peak with customer PV considered (kW)	Calculated peak time of day
17/18	15,168	18:00	17,487	12:30
16/17	14,988	17:30	17,126	14:00
15/16	14,331	20:00	16,258	13:30
14/15	15,229	17:00	16,752	14:30

Figure 15 shows the forecast solar PV DER capacity growth in the Cannonvale region under low (5 %), moderate (8 %) and high (10 %) growth rates. From this, it is evident that load growth will continue to be somewhat held back by the growth of connected PV in the region.

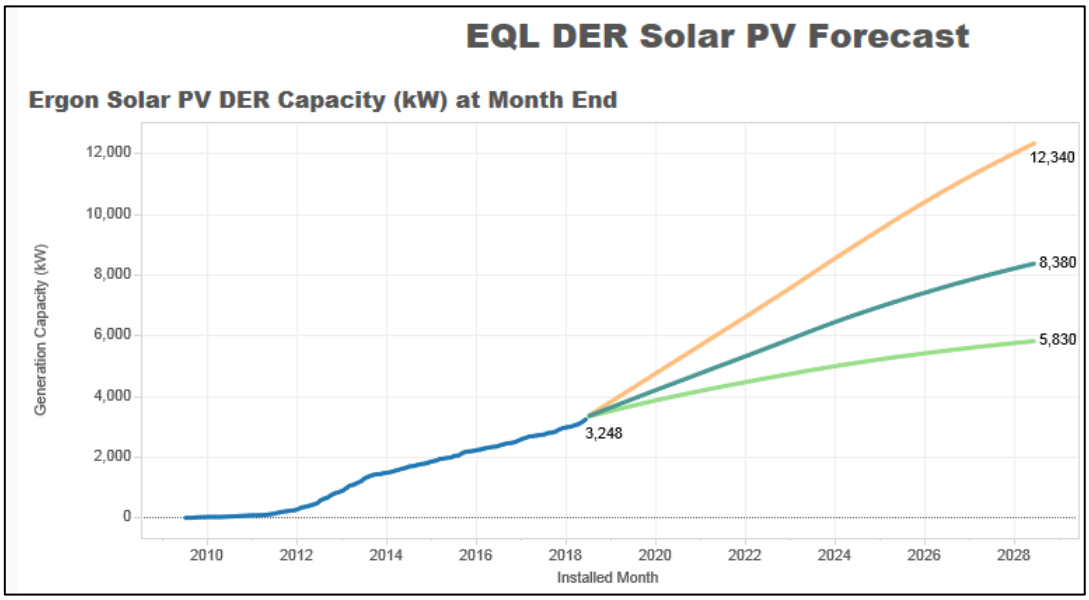

Figure 15 Forecast DER Solar PV Capacity for Cannonvale Substation

3.2. JUPO 66/11 kV Substation

With a 2 % load growth, the load will peak at 6.62 MVA in 2030 which is well below the JUPO transformer nameplate rating of 32 MVA. However, as upstream supply reliability improves it will allow more 11 kV feeder load to be transferred from CANN to JUPO. Point loads like Port of Airlie will likely proceed and be supported by the adjacent residential dormitory locality of Jubilee Pocket. The substation load will increase accordingly. The historical load is shown in Figure 17. The daily load profile is also shown in Figure 16.

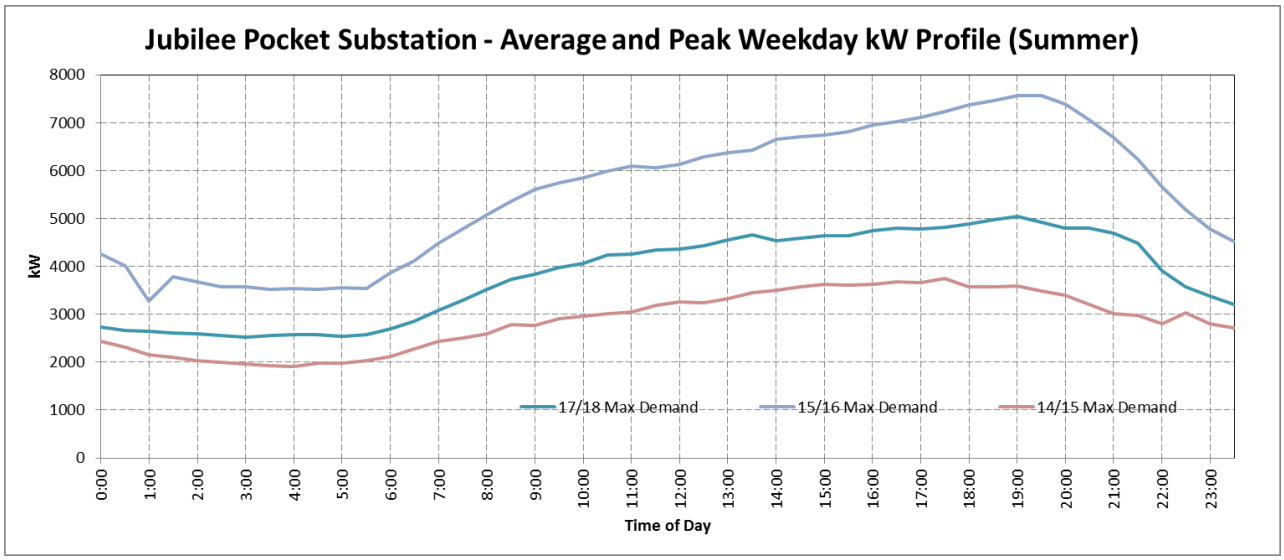

Figure 16 JUPO Average and Peak Weekday Load Profile (Summer)

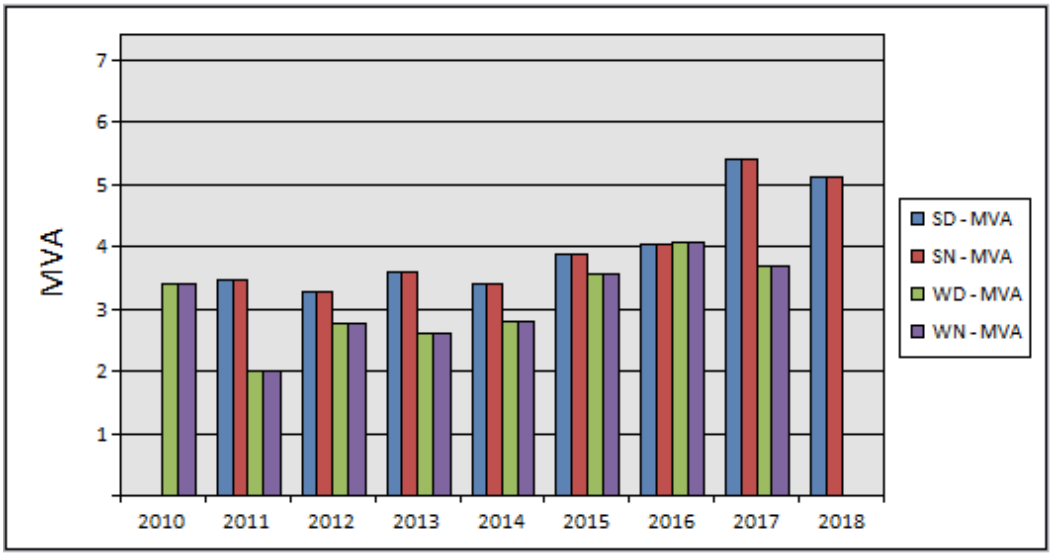

Figure 17 JUPO Historical Load Graph

As detailed with the load at CANN, the peak load and peak load time are dependent on solar. After accounting for the contributions of solar connected to the JUPO feeders the calculated peak load and peak load time are as presented in Table 8.

Table 8 Recorded JUPO Peak Load and Peak Time and the Estimated Values With Solar Excluded

Year	Recorded Peak (kW)	Recorded peak time of day	Peak with customer PV considered (kW)	Calculated peak time of day
17/18	5,039	19:30	5,438	13:30
16/17	5,474	10:00	5,907	10:00
15/16	4,100	19:30	4,425	13:00
14/15	3,744	18:00	4,065	15:00

3.3. MORO 66/11 kV Substation

As the majority of load on this substation will be from the Daydream/South Molle feeder, the forecast growth of this substation will be heavily dependent on the resorts on these islands.

Daydream Island has recently undergone refurbishment and therefore the load is expected to increase as the resort begins taking more tourists. Daydream Island bore the brunt of Category 4 Cyclone Debbie in March 2017 with 260 km/hr wind gusts and a tidal surge that caused significant damage to the iconic island 4.5 star resort.

China Capital Investment Group (i.e. CCIG) has invested $86 M into repair and development works to have the luxury island 277 room resort and associated facilities re-open at the end of the first quarter 2019.

South Molle Island has also been purchased by CCIG, however, redevelopment plans following Cyclone Debbie have not progressed.

Whilst the recent 2016 Deed of Amendment for Daydream Island refers to a revised Authorised Demand (i.e. AD) of 330 kVA, down from the previous AD of 1.2 MVA, the measured demand will be reviewed following the opening of the resort.

The historical load can be seen in Figure 18. This highlights the drop in demand experienced as a result from Cyclone Debbie in 2017. The yearly daily load profile of MORO since 2014/15 is also shown in Figure 19.

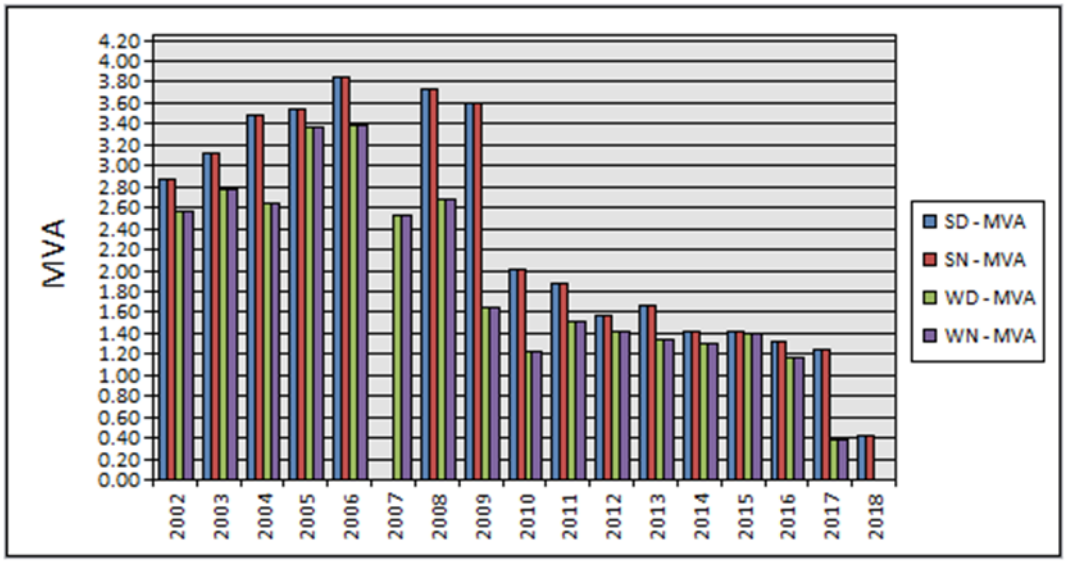

Figure 18 MORO Historical Load Graph

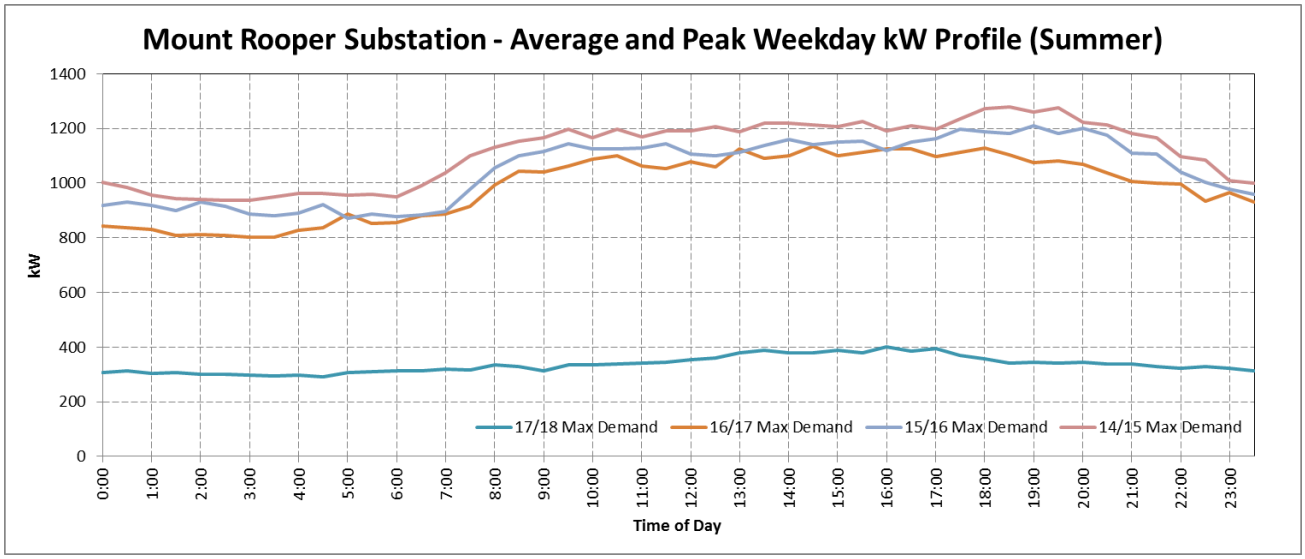

Figure 19 MORO Average and Peak Weekday Load Profile (Summer)

3.4. SHUT 66/22 kV Substation

Similarly to MORO, the load on this substation is dependent on the load of the two connected islands, Hayman and Hamilton.

Before cyclone Debbie damage forced the resorts on the Hayman and Hamilton islands to at least partly close, the ADs were 3.3 MVA and 11.0 MVA respectively. Consequently, it can be expected that the peak load on SHUT can return to previous peak demands of 11.0 MVA and potentially increase to 13.3 MVA being the combined island ADs. This is below the nameplate rating of the 25 MVA SHUT transformer.

InterContinental Hotels Group (IHG) will re-open Hayman Island in the 2nd quarter 2019 following approx. $100 M of refurbishment works.

The historical load on SHUT can be seen in Figure 20 along with the recent daily summer load profiles in Figure 21.

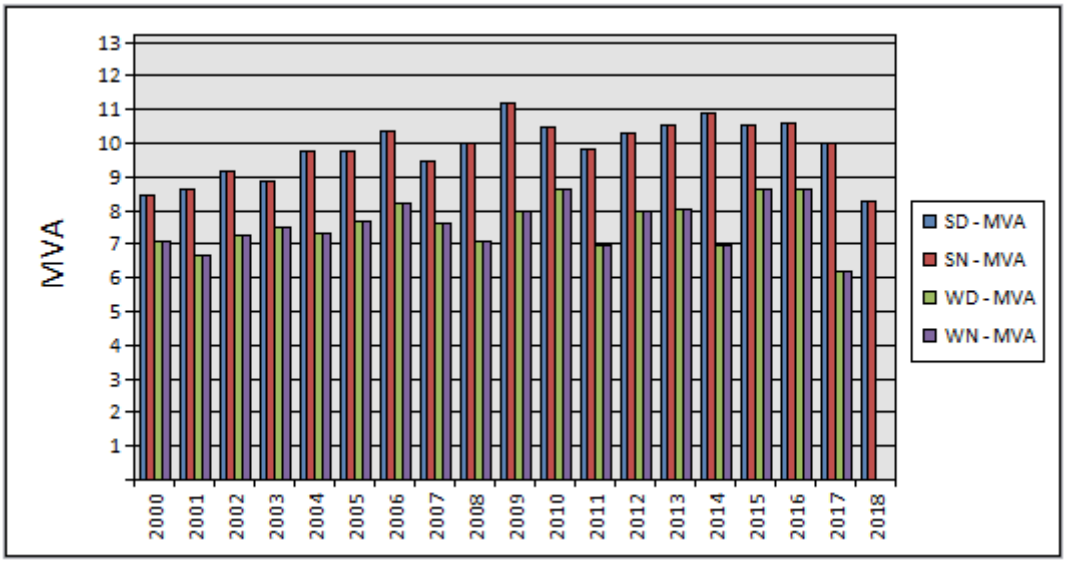

Figure 20 SHUT Historical Load Graph

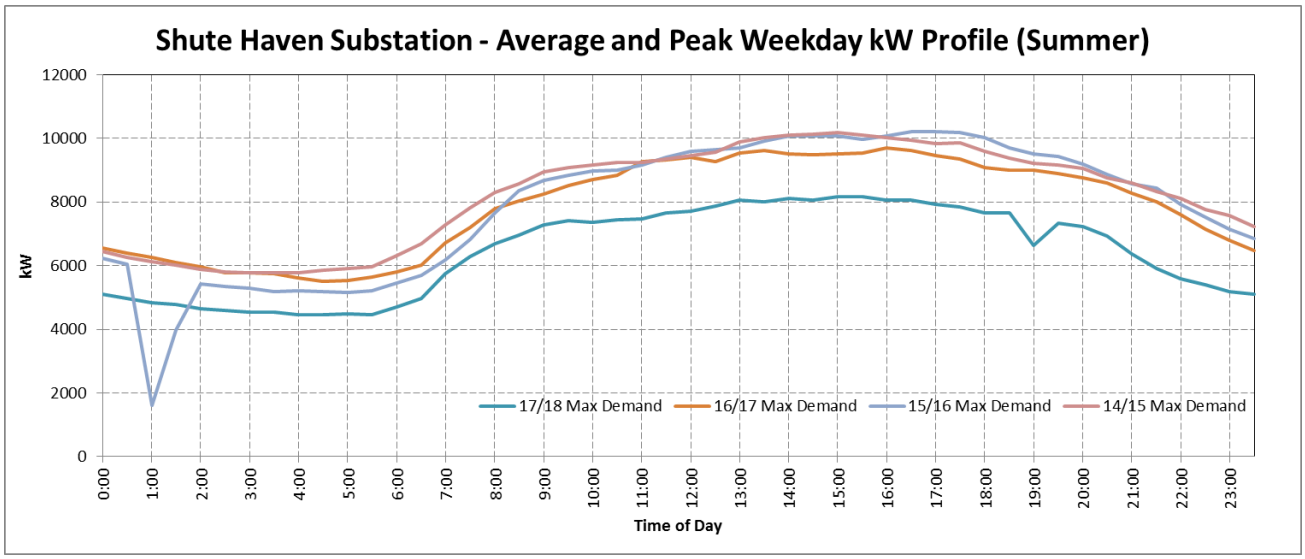

Figure 21 SHUT Average and Peak Weekday Load Profile (Summer)

4. LIMITATIONS ON THE EXISTING NETWORK

4.1. Substation Limitations

Primary Plant:

CANN is equipped with 2 x 66/11 kV 15 MVA (ONAN) OLTC power transformers, Transformer 1 (TR91553056) and Transformer 2 (TR91605815). The cyclic ratings of these two transformers, along with the ratings of all downstream transformers at JUPO, MORO and SHUT, are shown in Table 9.

Table 9 Transformer Ratings (as per Version 0.6 - 2017 Tx Cyclic Ratings)

Substation	Element	Nameplate Rating (MVA)	Cooling	Nominal NC		Nominal LTEC		Operational NC		Operational LTEC	
				Summer (MVA)	Winter (MVA)	Summer (MVA)	Winter (MVA)	Summer (MVA)	Winter (MVA)	Summer (MVA)	Winter (MVA)
CANN	TX No. 1 (66/11 kV)	15	ONAN	17.45	18.88	20.01	21.85	17.45	18.88	20.01	21.85
	TX No. 2 (66/11 kV)	15	ONAN	17.46	18.89	20.01	21.85	17.46	18.89	20.01	21.85
JUPO	TX No. 1 (66/11 kV)	32	ODAF	39.58	43.44	42.85	45.91	39.58	43.44	42.85	45.91
MORO	TX No. 1 (66/11 kV)	5	ONAN	5.80	6.37	7.00	7.46	5.80	6.37	7.00	7.46
SHUT	TX No. 1 (66/22 kV)	25	ODAF	30.44	33.18	34.28	36.56	30.44	33.18	34.28	36.56

The Cannonvale zone substation comprises:

- two transformers, 66/11 kV Dyn1 15 MVA (ONAN) OLTC units (YOM 1981);
- indoor 1600 A 11 kV switchboard c/w:
  - 6 x 11 kV feeders;
  - 2 x 4.8 MVAr capacitor banks; and
  - two transformers and a bus section circuit breakers;
- 66 kV 25 mm OD 1.25 mm thick Cu. busbar rating limited to 60 MVA by the 120 mm^2 stranded bridging conductors;

The transformer technical characteristics are:

- 5.0 % buck, 15.0 % boost, 1.25 % tap step;
- Iron losses of 26.4 kW and 25.7 kW; and
- Impedance of 10.2 % and 10.14 % respectively on a 20 MVA base.

There is insufficient space in the 11 kV switch room to cater for a future Z6-32 substation 11 kV switchboard which typically comprises 12 feeders, 2 transformers, 3 bus sections and 2 capacitor feeders. Given the ultimate end load of 45.7 MVA, strategic provision should be considered in the options analysis.

JUPO is currently equipped with 1 x 66/11 kV 32 MVA (ODAF) OLTC power transformer, Transformer 1 (TR93766468). There is also currently a second 66/11 kV 32 MVA (ODAF) OLTC power transformer at JUPO however this is currently not commissioned but is in place as a system contingency spare and to manage future point load growth (e.g. Port of Airlie) in the Airlie Beach region.

Jubilee Pocket substation comprises:

- one transformer, 66/11 kV Dyn1 32 MVA (ODAF) OLTC units (YOM 2008);
- 3 x 11 kV feeders;
- 2 x 11 kV bus section circuit breakers;
- 1 x 11 kV transformer circuit breaker;
- 1 x 66 kV transformer circuit breaker; and
- 1 x 66 kV bus circuit breaker.

The transformer technical characteristics are:

- 5.0 % buck, 20.0 % boost, 1.25 % tap step; and
- Iron losses of 10.65 kW and copper losses of 71.11 kW.

MORO has 1 x 66/11 kV 5 MVA (ONAN) fixed tap Dyn1 power transformer (TR92282105) with 9 taps of 1.25% step enabling a +/-5% regulation range. MORO substation consists of the following assets:

- one transformer, 66/11 kV Dyn1 5 MVA (ONAN) fixed tap (YOM 1986);
- 2 x 11 kV feeders; and
- 1 x 11 kV line regulator to control voltage for Shute Harbour feeder customers.

The transformer technical characteristics are:

- 5.0 % buck, 5.0 % boost, 1.25 % tap step.

SHUT is equipped with 1 x 66/22 kV 25 MVA (ODAF) OLTC power transformer, Transformer 1 (TR93484638). The assets at SHUT are:

- one transformer, 66/22 kV Dyn1 25 MVA (ODAF) fixed tap (YOM 2007);
- 2 x 22 kV feeders; and
- 1 x 66 kV transformer circuit breaker;

The transformer technical characteristics are:

- 2.5 % buck, 17.5 % boost, 1.25 % tap step; and
- Iron losses of 13.56 kW and copper losses of 49.65 kW.

4.2. Sub-Transmission Network Limitation

The incoming cable from CANN-02 is 185 mm^2 aluminium with a confirmed rating of 34 MVA. This is a constraint at present when CANN-01 is out of service between PROS and PRMI such that PRMI is back-fed from CANN. In the next 5-6 years, assuming around 2 % growth as justified by the forecast load and population growth, the constraint will exist for a single feeder outage without back-feeding PRMI. The incoming cable from CANN-01 was replaced in November 2018 as part of WR1254348 and now has a rating of 80 MVA. As such, this is no longer a constraint however the remaining 66 kV entry/exit cables at CANN still remain.

Table 10 shows a forecast of substation loads and subsequent 66 kV feeder loadings in system normal and contingency arrangements, excluding the temporary bypass arrangement. The existing and emerging cable capacity constraints are visible in red.

Table 10 Forecast Substation and Feeder Loads Including Contingency Arrangements

	Rating (MVA)	Constraint	Forecast	2016/17 (Actuals)	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29
Substation Load Forecasts - Peak Loads (Summer)(MVA)																
CANN Substation				14.1	14.4	14.6	14.9	15.1	15.4	15.7	16.0	16.3	16.6	16.9	17.2	17.5
			Growth %	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%
			Block Increase (MVA)													
JUPO Substation				5.4	5.5	5.7	5.8	6.0	6.1	6.3	6.4	6.6	6.7	6.9	7.1	7.3
			Growth %	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
			Block Increase (MVA)													
MORO Substation				1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6
			Growth %	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
			Block Increase (MVA)													
SHUT Substation				10.5	10.7	10.9	11.1	11.4	11.6	11.8	12.1	12.3	12.5	12.8	13.1	13.3
			Growth %	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
			Block Increase (MVA)													
PRMI Substation				4.5	4.5	4.6	4.6	4.7	4.7	4.8	4.8	4.9	4.9	5.0	5.0	5.1
			Growth %	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
			Block Increase (MVA)													
Coincidence Factor																
119 Cannonvale No1 (JUPO + MORO + SHUT Coincident Peak Load)				15.6	16.0	16.3	16.6	17.0	17.3	17.7	18.1	18.4	18.8	19.2	19.6	20.0
			Coincidence Factor (Calculated)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Feeder Load Forecasts - Coincident Peak Loads (Summer)(MVA)																
118 Cannonvale No2 (PROS - CANN)																
Normal	34	Cable into CANN		14.1	14.4	14.6	14.9	15.1	15.4	15.7	16.0	16.3	16.6	16.9	17.2	17.5
119 (PRMI-CANN) OOS	34	Cable into CANN		29.7	30.3	30.9	31.5	32.1	32.7	33.4	34.0	34.7	35.4	36.1	36.8	37.5
119 (PROS-PRMI) OOS	34	Cable into CANN		34.2	34.9	35.5	36.1	36.8	37.5	38.2	38.9	39.6	40.3	41.0	41.8	42.6
119 Cannonvale No1 (PROS - PRMI Tee)																
Normal	50	OH Line		15.6	16.0	16.3	16.6	17.0	17.3	17.7	18.1	18.4	18.8	19.2	19.6	20.0
118 (PROS-CANN) OOS	50	OH Line		29.7	30.3	30.9	31.5	32.1	32.7	33.4	34.0	34.7	35.4	36.1	36.8	37.5
119 Cannonvale No1 (PRMI Tee - CANN)																
Normal	34	Cable into CANN (FAILED 2017)		15.6	16.0	16.3	16.6	17.0	17.3	17.7	18.1	18.4	18.8	19.2	19.6	20.0
118 (PROS-CANN) OOS	34	Cable into CANN (FAILED 2017)		29.7	30.3	30.9	31.5	32.1	32.7	33.4	34.0	34.7	35.4	36.1	36.8	37.5
119 Cannonvale No1 (CANN - JUPO)																
Normal	30	Cable from CANN		15.6	16.0	16.3	16.6	17.0	17.3	17.7	18.1	18.4	18.8	19.2	19.6	20.0
426 Mt Rooper (JUPO - MORO)																
Normal	47	OH Line		10.7	10.9	11.1	11.3	11.5	11.8	12.0	12.2	12.4	12.7	12.9	13.2	13.4
426 Mt Rooper (MORO - SHUT)																
Normal	47	OH Line		10.5	10.7	10.9	11.1	11.4	11.6	11.8	12.1	12.3	12.5	12.8	13.1	13.3

4.3. Sub-Transmission Network Outages – MSS Reliability Impacts

Table 11 details the significant sub-transmission outages of the last eight years including the fault reason and feeder location. Table 12 then further categorises the fault locations and allows the problem sections to be quantified. These tables indicate that over the last 8 years the sub-transmission fault locations are distributed between sections as follows with approximately:

- 71 % of CANN-01 faults upstream of JUPO;
  - 14 % on the section between CANN and JUPO;
- 19 % of faults are on the CANN-02; and
- 10 % of faults occur on the section from JUPO to Shute Harbour.

Faults before CANN can be resolved via manual switching to transfer JUPO onto CANN-02 or CANN onto CANN-01 resulting in full restore after a 1-4 hr outage.

On the other hand, a cable fault on CANN-01 beyond CANN will result in an extended outage to all major customer island loads including the customer loads at and beyond JUPO including MORO. Supply can only be restored via 11 kV switching which has a transfer limit of 4 MVA.

4.3.1. CANN-02 Outage Rate:

The feeder outage statistics can provide some valuable insights. Including the fault locations that are unknown but do have a feeder circuit outage reference:

- CANN-02 (cct 118) that supplies CANN experienced:
  - 10 momentary outages from 2012-2018 (one of these related to TC Debbie in 2017);
  - 8 outages over 8 years which translates to an overhead outage failure rate (i.e. over 26.5 km O/H) of 3.8 outages/100km-years; and
  - An average overhead outage period of 1.5 hours which is reflective of manual transfer time to CANN-02.

The 11 kV feeder underlying reliability performances are impacted by the 66 kV.

CANN 'Urban' feeders (MSS feeder target of 149 minutes) will have a baseline SAIDI of 90 minutes (or 60 %) of target MSS contributed by the performance of CANN-02.

Feeder performance of CANN-02 operates better than expected for a short overhead timber pole/crossarm line construction. Up to 8 outages per 100km-years could be expected in the terrain the line traverses.[3] Typically high reliability 66 kV line (i.e. SCCP c/w OHEW) outage rates would be in the order of 1.30 to 2.50 outages per 100km-years.

[3] Reliability Planning Guidelines NA000603R100

4.3.2. CANN-01 Outage Rate and Section Performance:

Including the fault locations that are unknown but do have a feeder circuit outage reference:

- CANN-01 (cct 119) feeder between JUPO and Shute Harbour experienced
    - 16 momentary outages from 2012-2018 (two of these related to TC Debbie in 2017);
    - 2 outages in 8 years, not including the U/G, translates to an overhead outage failure rate (i.e. over 6.0 km O/H) of 4.2 outages / 100km-years;
    - An average overhead outage restoration period of 3.5 hours; and
    - Based on the outage rate and period, the outage minutes contributed by the 66 kV will be 52.5 minutes each year;
- CANN-01 (cct 119) feeder between PROS and JUPO that supplies JUPO, SHUT and MORO experienced:
    - 22 momentary outages from 2012-2018;
    - 3 outages (total outage of 12 hours over 8 years, i.e. 90 minutes annually) occurred between CANN and JUPO, 2 of which were U/G related (termination and lightning arrestor);
    - 20 outages over 8 years (3 U/G, 17 O/H) including the CANN – JUPO section which translates to an overhead outage failure rate (i.e. over 29.6 km) of 7.2 outages/100km-years;
    - An average overhead outage restoration period of 2.8 hours (which excluded all the long duration cable related faults); and
    - Based on the outage rate and period, the outage minutes contributed by the 66 kV will be 358 minutes each year.
    - If the failure rate improved to the level experienced by CANN-02 (i.e. 3.8 outages per 100km-years):
        - Excluding the 66 kV U/G outage performance, the outage minutes contributed by the 66 kV would be 189 minutes (i.e. 29.6km x 3.8 outages x 2.8 x 60 min. / 100km) per year or an ‘Amber’ MSS feeder category upon commissioning;
        - Including the 66 kV U/G outage performance adds another 90 minutes – this would result in a combined O/H (189 min.) + U/G (90 min.) SAIDI performance of 279 minutes excluding the 11 kV distribution network contribution; and
        - Adding the Port of Airlie 11 kV full U/G feeder exposure of 3.0km, based on a typical underground outage rate of 3 outages per 100 km-years and a 2 hour sectionalising time given the nearest response crew is at Proserpine depot translates to 10.8 outage minutes per year.

In total, allowing for improved 66 kV O/H performance, the average SAIDI calculated would be 290 min. which is 3 % off ‘RED’ feeder (i.e. 298 min.) status.

Please note that U/G failures (termination, lightning arrestor and cable entry at CANN) resulted in 3 outages with an average outage period of 6.7 hours.

Feeder performance of CANN-01 is better than expected of a short overhead timber pole/crossarm line with no OHEW construction. Up to 8 outages per 100km-years could be expected in the terrain the line traverses.[4]

Based on the combined PROS to JUPO outage rate and restoration period performance of CANN-01, all JUPO feeders (UR or SR) will experience a baseline impact of 448 minutes (i.e. 358 + 90.0 minutes) without even considering the underlying 11 kV performance. Due to the nature of the urban load density of Airlie Beach and short distance from JUPO, all new 11 kV feeders commissioned from JUPO to supply Airlie Beach customers will be categorised 'Urban' (MSS target of 149 minutes) and immediately become 'RED' feeders due to the underlying contributing poor performance of the 66 kV (i.e. CANN-01).

As such, it is not surprising that the JUPO Port of Airlie 'Urban' 11 kV feeder has been a 'RED' feeder since commissioning, however, the latest 2017/18 results appear quite reasonable. Any permanent feeder load transfers from CANN (i.e. Island Drive, Airlie and Shingley) to JUPO will on average immediately experience 'RED' reliability performance and in theory, should not be encouraged.

Similarly, all SR feeders (MSS target of 424 minutes), will commence operation as 'Yellow' (MSS target of 424 minutes) feeder status without considering the underlying performance of the 11 kV network.

In summary, no new 'Urban' MSS categorised feeder can be commissioned from JUPO. Arguably any new 'SR' feeders will also commence operation as a 'Yellow' feeder due to the underlying CANN-02 66 kV performance.

These statistics highlight the impact CANN-01 reliability has on the yearly outage duration and frequency for customers supplied from the JUPO and MORO 11 kV feeders including the major customer island loads.

It should be noted that the outage data used to create Table 11 and Table 12 excludes momentary outages where the feeder experienced a successful auto-reclose.

[4] Reliability Planning Guidelines NA000603R100

4.3.3. Cost of a Long Term 66 kV Cable Outage

The long term cost due to a sustained cable failure (e.g. 1.41 km Airlie Lagoon cable) from water treeing has been considered in the context of a similar submarine cable failure.

Considering manufacturing lead times for 66 kV cables of 6 months, this would be considered a catastrophic outage scenario where:

- The Hamilton, Hayman and Daydream generators would be operating full time for the entire 6 month period:
    - Hamilton Island 9 MVA (6 sets);
    - Hayman Island 5.9 MVA (4 sets);
    - Daydream Island 3 MVA (3 sets); and
    - $40/kVA pa demand charge and $400/MWh running - Total cost of $12.0M comprising:
        - Shute Harbour substation average daily load (i.e. combined Hamilton and Hayman loads which have a combined AD of approx. 12.9 MW):
            - 7.8 MW (i.e. $312,000pa); and
            - 6-month energy charge at an average summer usage of 156 MWh/day (i.e. $62,400/day or $11.4M for 6 months)
        - Daydream Island AD is presently re-negotiated to 330 kVA from 1200 kW:
            - 0.2 MW (i.e. $8,000 pa); and
            - 6-month energy charge at an average summer usage of 4 MWh/day (i.e. $1,600/day or $0.29M for 6 months).
    - The Sept. 2018 EQL Demand Response Opportunities report indicated demand and running cost for Hamilton, Hayman and Daydream Islands would be between $8-$12M (the raw diesel fuel cost with excise discounts would be $34,720 per day or approx. $4.6M for 4 months);
        - Diesel fuel cost is based on the Australian Institute of Petroleum Average Diesel wholesale price (as of 9th December 2018): 126.8 cents per litre, minus the fuel excise of 40 cents per litre, bringing the total to 86.8 cents per litre.
- 4 MVA of JUPO load permanently transferred to CANN; and
- Standby generation deployed at JUPO and MORO to manage the balance.


20181003Whitsunday Generation Report.


CANN JUPO MORO SHHA substation Avg

The islands are presently exposed to similar risk during a privately owned submarine cable failure and should have standby operating protocols to manage fuel supply and storage for an outage of a similar long term duration outage.

A cost of this order (i.e. $8-12M for a 4-6 month restoration) borne entirely by the Island resort operators would result in significant political pressure and brand damage.

4.3.4. Typical 66 kV 'No Fault Found' Scenario

A typical example for a 'no fault found' outage is shown in Figure 22. Some 1400 customers were without power for the first 2 hrs while crew were dispatched to investigate and then manually transfer load from one 66 kV feeder to the other. A subsequent outage was then required to return the network to the normal configuration after no-fault was found.

Event Times	Customers Off
31-DEC-11 00:15:27	1471
31-DEC-11 01:49:00	1353
31-DEC-11 02:25:00	87
31-DEC-11 02:26:00	0
31-DEC-11 04:07:15	118
31-DEC-11 04:09:00	0
31-DEC-11 04:40:00	0

11MK8274		
31/12/2011 **0:18**	New	entered from the SCADA Interface
31/12/2011 0:22	Dispatched	(Crew member) on his way to investigate
31/12/2011 1:25	Work Commenced	Crew confirmed CB tripped on Zone 2 B-C phase fault. **Currently sectionalising**.
31/12/2011 **1:54**	Update	**Opened ABS682 and energised part of feeder**
31/12/2011 2:38	Update	Have isolated fault (exact location still unknown) and placed Jubilee Pocket and islands onto Cannonvale No.2 66kV Fdr.
31/12/2011 2:38	Update	Asset selection modified
31/12/2011 4:05	Update	Need to open CB to close ABS 682
31/12/2011 4:07	Update	Asset selection modified
31/12/2011 4:20	Update	Line energised successfully. Load transfer remaining.
31/12/2011 **4:44**	Restored	**No fault found.** Feeder placed back into normal configuration.
31/12/2011 4:45	Completed	
31/12/2011 11:07	Restored	
31/12/2011 11:09	Completed	Crews patrolled from both Pros end and Cannonvale end during daylight hours Nothing found to indicate cause of last nights fault

Figure 22 Example 'No Fault Found' Disconnected Customer Count and Outage Activity Log

The manual switching arrangement has also exposed customers to extra restoration delays due to operational risks. For example, a Network Access Restriction at the substation extended one outage and a lock and key malfunction on another.

4.3.5. 66 kV Outage Statistics

Table 11 Significant Sub-Transmission Outages on CANN-01 and CANN-02 Since 2010

Year Summer End	Date	Event No.	66kV Feeder	Fault Location	Review Comment	CANN SS Benefit	Customers	Included Duration (Hrs)	Cust. Mins	Unserved Energy (kWh)	STPIS $ Cust. Mins	STPIS $ Cust. Int	STPIS $	VCR @$35/kWh	Number of Events
2010	28/04/2009 0:30	09MK2259	118	UNKNOWN	zone 2 A-C phase distance protection.	FULL	4849	1.00	290,940	7,157	$ 181,739	$ 299,893	$ 481,633	$250,503	1
	15/07/2009 13:00	09MK3323	119	CANN-JUPO	Failed Cable Pothead on pole 6030159 at Airlie Beach, took 3hrs to locate fault	Fault location and switching	727	4.50	196,290	31,696	$ 103,885	$ 42,577	$ 146,463	$1,109,371	1
	2/09/2009 15:00	09MK4123	118	PROS-CANN	B&C Timed Zone 2. Burnt 66kV Crossarm on 66/11kV Common Pole, cnr of Pandanas & Shute Harbour Dr (Before CANN)	FULL	4986	2.50	747,900	33,950	$ 467,185	$ 308,366	$ 775,551	$1,188,233	1
	2/09/2009 21:00	09MK4135	119	PROS-CANN	Burnt 66kV Crossarm near previous fault	FULL	4986	1.50	448,740	14,501	$ 237,493	$ 292,008	$ 529,501	$507,527	1
	17/10/2009 5:00	09MK4909	119	UNKNOWN	Trip and manual reclose	FULL	301	0.50	9,030	5,630	$ 4,779	$ 17,628	$ 22,407	$197,067	1
	31/01/2010 12:30	10MK0666	119	PROS-CANN	JUPO not in service. JUPO would have isolated this fault. Excluded.	FULL	272	0.00						$0	1
2010 Total								1.67	1,692,900	92,934	$ 995,081	$ 960,473	$ 1,955,555	$3,252,701	6
2011	6/12/2010 7:00	10MK8790	118	PROS-CANN	Polymer Insulator replaced SL4111030	FULL	4666	1.50	419,940	8,159	$ 262,321	$ 288,576	$ 550,896	$285,558	1
	26/02/2011 4:30	11MK1283	118	UNKNOWN	Zone 2 trip. Manual reclose successful.	FULL	5872	1.00	352,320	5,694	$ 220,081	$ 363,162	$ 583,243	$199,307	1
2011 Total								1.25	772,260	13,853	$ 482,402	$ 651,738	$ 1,134,139	$484,865	2
2012	31/12/2011 1:00	11MK8274	119	UNKNOWN	Zone 2 trip. Patrols and Manual transfer done. No fault found	FULL	1471	1.50	132,390	13,478	$ 70,067	$ 86,150	$ 156,217	$471,732	1
2012 Total								1.50	132,390	13,478	$ 70,067	$ 86,150	$ 156,217	$471,732	1
2013	26/08/2012 0:30	12MK6263	119	PROS-CANN	Car hit pole near PROS. Manual transfer at CANN hindered by key/lock issue	FULL	1392	4.50	375,840	25,162	$ 198,911	$ 81,523	$ 280,434	$880,656	1
	31/12/2012 2:00	12MK9491	118	UNKNOWN	Patrol done. No fault found. Manual reclose successful	FULL	4818	1.50	433,620	7,104	$ 270,866	$ 297,976	$ 568,842	$248,649	1
2013 Total								3.00	809,460	32,266	$ 469,777	$ 379,499	$ 849,277	$1,129,305	2
2014	8/08/2013 16:30	13MK5343	119	PROS-CANN	Linked to 13MK5345. Forced outage to repair burning pole.	FULL	1507	6.50	587,730	24,748	$ 311,053	$ 88,258	$ 399,311	$866,190	1
	21/10/2013 9:00	13MK6814	118	PROS-CANN	S/L 4047393 pole between PROS and CANN	FULL	4893	1.50	440,370	11,910	$ 275,082	$ 302,615	$ 577,697	$416,862	1
	26/10/2013	13MK7000	119	UNKNOWN	Patrol done. No fault found. Manual reclose successful	FULL	1514	1.00	90,840	7,187	$ 48,077	$ 88,668	$ 136,745	$251,538	1
	30/01/2014 18:00	14MK0738	118	UNKNOWN	Manual reclose would not work. Suspected equipment fault	FULL	4869	2.50	730,350	29,449	$ 456,222	$ 301,130	$ 757,352	$1,030,727	1
2014 Total								2.88	1,849,290	73,295	$ 1,090,434	$ 780,672	$ 1,871,105	$2,565,316	4
2015	17/09/2014 18:30	14MK5097	119	PROS-CANN	pole top fire between PROS and CANN	FULL	1539	2.50	230,850	16,751	$ 122,176	$ 90,132	$ 212,308	$586,293	1
	2/11/2014 18:00	14MK5892	119	PROS-CANN	pole top fire between PROS and CANN	FULL	1546	4.50	417,420	38,061	$ 220,917	$ 90,542	$ 311,459	$1,332,140	1
	3/11/2014 23:00	14MK5956	119	PROS-CANN	pole top fire between PROS and CANN	FULL	1546	1.50	139,140	7,610	$ 73,639	$ 90,542	$ 164,181	$266,361	1
	26/11/2014 12:00	14MK6560	119	PROS-CANN	Fallen Powerlines before CANN	FULL	1547	3.50	324,870	43,739	$ 171,936	$ 90,601	$ 262,537	$1,530,852	1
2015 Total								3.00	1,112,280	106,161	$ 588,668	$ 361,818	$ 950,486	$3,715,646	4
2016	15/08/2015 16:30	15MK4961	119	CANN-JUPO	SL 4104853 between CANN and JUPO.	Fault location and switching	1587	1.00	95,220	7,981	$ 50,395	$ 92,944	$ 143,338	$279,324	1
	8/10/2015 11:00	15MK5988	119	PROS-CANN	4047175 near PROS	FULL	1590	8.50	810,900	37,419	$ 429,164	$ 93,119	$ 522,283	$1,309,650	1
	12/03/2016 23:00	16MK1716	119	UNKNOWN	Patrol Done. No Fault Found. Reclose successful.	FULL	1586	4.00	380,640	27,222	$ 201,452	$ 92,885	$ 294,337	$952,756	1
2016 Total								4.50	1,286,760	72,621	$ 681,010	$ 278,948	$ 959,958	$2,541,729	3
2017	19/06/2016 10:30	16MK3737	119	UNKNOWN	Patrol Done. No Fault Found. Reclose successful.	FULL	1585	3.50	332,850	25,240	$ 176,159	$ 92,826	$ 268,985	$883,408	1
	15/07/2016 2:00	16MK4586	119	CANN-JUPO	Blow LAs on outgoing cable at CANN	Fault location and switching	6766	6.50	2,638,740	43,264	$ 1,396,538	$ 396,255	$ 1,792,793	$1,514,245	1
	16/10/2016 11:30	16MK6685	119	PROS-CANN	Pole 4047206 near PROS	FULL	1604	1.50	144,360	14,658	$ 76,402	$ 93,939	$ 170,341	$513,013	1
	24/11/2016 19:00	16MK7938	119	PROS-CANN	Cane Fire near PROS 4047183	FULL	1585	1.50	142,650	12,122	$ 75,497	$ 92,826	$ 168,323	$424,259	1
	20/01/2017 9:00	17MK0668	118	PROS BUS 2	PROS Bus 2 outage, lost 118. Supply would have been maintained via 119	FULL	10211	0.50	306,330	4,540	$ 191,353	$ 631,514	$ 822,867	$158,892	1
	13/03/2017 16:00	17MK2812	119	PROS-CANN	Cable Fault, incomming 66kV into CANN	FULL	1615	9.00	872,100	100,327	$ 461,554	$ 94,583	$ 556,137	$3,511,437	1
2017 Total								3.75	4,437,030	200,150	$ 2,377,502	$ 1,401,944	$ 3,779,446	$7,005,253	6
Grand Total								2.84	12,092,370	604,758	$ 6,754,941	$ 4,901,242	$ 11,656,183	$21,166,547	28

	Cust. Mins	Unserved Energy (kWh)	STPIS $ Cust. Mins	STPIS $ Cust. Int	STPIS $	VCR @$35/kWh	Number of Events
8 year Average Annual	1,511,546.25	75,594.81	$844,368	$612,655	$ 1,457,023	$ 2,645,818	3.50
3 year Average Annual	2,278,690.00	126,310.74	$1,215,727	$680,903	$ 1,896,630	$ 4,420,876	4.33

Ergon Energy Corporation Limited ABN 50 087 646 062
Energy Queensland Limited ABN 96 612 535 583
Energex Limited ABN 40 078 849 055

Table 12 Sub-Transmission Fault Locations (Known)

Fault Location	Fault Location	66kV Feeder	% of Known Fault Locations
Beyond CANN	CANN-JUPO	CANN-01	14.29%
	JUPO-SHUT	CANN-01	9.52%
Beyond CANN Total			**23.81%**
Before CANN	PROS BUS 2	CANN-02	4.76%
	PROS-CANN	CANN-02	14.29%
		CANN-01	57.14%
Before CANN Total			**76.19%**
Grand Total			**100.00%**

Table 13 Sub-Transmission Momentary Outage Events Since 2012

Event	CANN-01 (PROS-JUPO)	CANN-02 (PROS-CANN)	Mt Rooper 66 kV (JUPO – SHUT+MORO)
Momentary Outage Events	22	10	16

4.4. Distribution Network Limitation

The distribution network feeder limitations for CANN, JUPO, MORO and SHUT are presented in Table 14. It is evident that the distribution feeders in the Airlie Beach region are generally being loaded within the 4 into 3 urban 11 kV feeder utilisation design criteria of 75 % which enables management of contingency condition load transfers. It is possible to switch some loads between feeders if required in order to balance out feeder utilisation using adjacent intra-feeder and/or inter-feeder ties between CANN and JUPO. There are also plans for a future 66/11 kV substation at Riordanvale (RIOR) to further support the distribution network south-east of Cannonvale if required.

Table 14 Distribution Network Feeder Demand, Rating and Utilisation

	Feeder	Existing UG Cable	Existing OH Line	Max Demand (A)	Feeder Rating			Utilisation (%)
					UG (A)	OH (A)	Prot (A)	
PRMI	114 – Main Street	240mm^2 Cu. XLPE (QESI 757)	Neptune 19/3.25 AAC (QESI290)	101	300	343	200	50.5
KECE	101 – Crystalbrook	240mm^2 Cu. Triplex XLPE	Neptune 19/3.25 AAC (QESI290)	154	300	343	250	61.6
KECE	102 - Strathdickie	240mm^2 Cu. Triplex XLPE	Mercury 7/4.50 AAC (QESI288)	123	300	281	250	49.2
KECE	14102 - Foxdale	400mm^2 Al. Triplex XLPE, QESI (1725)	Pluto 19/3.75 AAC	68	310	404	240	28.3
CANN	*105 – Island Drive+*	*3C 240mm^2 Al. PLYSW PVC*	*Neptune 19/3.25 AAC (QESI290)*	*160*	*245*	*220*	*300*	*72.7*
CANN	*106 – Airlie+*	*240mm^2 Cu. Triplex XLPE*	*Neptune 19/3.25 AAC (QESI290)*	*188*	*360*	*289*	*300*	*65.1*
CANN	107 – Cannonvale	3C 240mm^2 Cu. XLPE (QESI 757)	Mercury 7/4.50 AAC (QESI288)	112	300	281	264	42.4
CANN	*127 – Shingley+*	*3C 240mm^2 Al. PLYSW PVC*	*Pluto 19/3.75 AAC*	*108*	*340*	*404*	*300*	*36.0*
CANN	1851 – Able Road	400mm^2 Al. Triplex XLPE, QESI (1726)	Mars 7/3.75 AAC	165	Unk	302	300	55.0
CANN	398 – Paluma Road	240mm^2 Cu. Triplex XLPE	Mercury 7/4.50 AAC (QESI288)	206	300	N/A	300	68.7
JUPO	1882 – Port of Airlie	1C 400mm^2 Cu. XLPE QESI(1724)	N/A	109	400	N/A	300	36.3
JUPO	1885 – Jubilee Pocket Fdr	240mm^2 Cu. Triplex XLPE	Jasper 7/4.75 AAAC 6201(QESI 327)	143	300	183	300	68.3
JUPO	1887 – Mandalay	240mm^2 Cu. Triplex XLPE	Jasper 7/4.75 AAAC 6201(QESI 327)	40	300	280	300	14.3
MORO	108 – Shute Harbour	N/A	Jasper 7/4.75 AAAC 6201(QESI 327)	14	N/A	183	200	7.7
MORO	122 – Daydream/Sth Molle	Private	N/A	60	140	N/A	150	42.9
SHUT	124 – Hamilton	Private	N/A	197	310	N/A	300	65.7
SHUT	125 – Hayman	22 kV Submarine Cable	N/A	73	310	N/A	175	41.7

+ = feeders that supply Airlie Beach

The 2017/18 reliability of the distribution feeders at CANN, JUPO, MORO and SHUT are shown in Table 15. The reliability of the Airlie Beach distribution network since 2013 is presented in Table 16. It is evident that multiple feeders, especially those reliant on CANN-01 (i.e. JUPO and MORO feeders), have consistently shown poor reliability.

Table 15 2017/18 SAIDI and SAIFI Values for all 11 kV Feeders in the Airlie Beach Region

Substation	Feeder	Category	SAIDI	SAIFI	Reliability Status
PRMI	114 – Main Street	Urban	36	0.2	Green
CANN	*105 – Island Drive+*	*Urban*	*20*	*1.0*	*Green*
	106 – Airlie+	*Urban*	*250*	*3.2*	*Amber*
	107 – Cannonvale	Urban	63	1.2	Green
	127 – Shingley+	*Short Rural*	*412*	*4.6*	*Green*
	1851 – Abel Road	Short Rural	24	1.1	Green
	398 – Paluma Road	Short Rural	122	1.4	Green
JUPO	1882 – Port of Airlie	Urban	98	1.1	Green
	1885 – Jubilee Pocket Fdr	Short Rural	177	2.6	Green
	1887 – Mandalay	Short Rural	567	3.2	Yellow
MORO	108 – Shute Harbour	Short Rural	458	3.0	Yellow
	122 – Daydream/South Molle	Short Rural	12877	4.0	Few Cust
SHUT	124 – Hamilton	Short Rural	3515	3.0	Few Cust
	125 – Hayman	Short Rural	42	1.0	Few Cust

Table 16 SAIDI and SAIFI Values Since 2013 for 11 kV Feeders in Airlie Beach Region

Sub.	Feeder	Cat.	2013/14		2014/15		2015/16		2016/17	
			SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI
PRMI	114 – Main Street	UR	207.24	2.15	673.51	4.03	606.98	5.03	619.32	7.33
CANN	105 – Island Drive	UR	81.93	3.05	20.64	0.13	169.49	2.47	250.69	4.53
	106 – Airlie	UR	85.65	1.43	100.24	1.25	500.25	3.31	283.59	5.31
	107 – Cannonvale	UR	208.11	2.94	1179.61	8.48	191.24	2.14	219.62	5.57
	127 – Shingley	SR	247.32	4.05	110.21	2.18	272.16	3.58	306.34	7.61
	1851 – Able Road	SR	N/A	N/A	6.72	0.04	132.38	2.35	199.8	4.46
	398 – Paluma Road	SR	210.54	3.13	258.75	1.51	284.31	2.25	397.64	6.05
JUPO	1882 – Port of Airlie	UR	N/A	N/A	N/A	N/A	763.26	5.1	1015.71	4.76
	1885 – Jubilee Pocket Fdr	SR	269.92	3.24	828.06	5.89	1356.1	7.13	1228.36	6.48
	1887 – Mandalay	SR	499.6	4.16	809.58	5.36	881.63	6.06	1637.01	7.95
MORO	108 – Shute Harbour	SR	621.6	3.42	1383.71	6.15	966.73	7.63	2731.01	8.63

The number of customers and the customer growth on each feeder can be seen in Table 17. Approximately 1,600 customers, in addition to the three major island customers, are subject to the poor reliability of the 66 kV feeder between PROS and CANN.

Table 17 Feeder Customer Numbers since 2013/14

Substation	Feeder	2013/14	2014/15	2015/16	2016/17	2017/18
PRMI	114 – Main Street	Unk	121	120	114	107
CANN	105 – Island Drive	1066	1062	1063	1133	1064
	106 – Airlie	844	803	816	853	780
	107 – Cannonvale	1786	610	620	653	655
	127 – Shingley	691	707	738	783	788
	1851 – Abel Road	0	1226	1276	1373	1422
	398 – Paluma Road	607	637	670	709	733
JUPO	1882 – Port of Airlie	0	79	77	78	73
	1885 – Jubilee Pocket Fdr	1059	1035	1050	1154	1311
	1887 – Mandalay	254	269	264	283	290
MORO	108 – Shute Harbour	86	81	76	78	79
	122 – Daydream/South Molle	1	1	1	1	1
SHUT	124 – Hamilton	1	1	1	1	1
	125 – Hayman	1	1	1	1	1
Total	**All of the Above**	**6396**	**6512**	**6653**	**7100**	**7198**

The premise growth translates to a 2.4 % growth annually since 2013/14. This growth is below the LGIP population forecast, however, the above growth refers to premise growth and the LGIP figures (i.e. 3.2 % pa growth from 2016 to 2021) refers to population growth.

4.5. Requirement for Future Riordanvale Substation

Land has been strategically purchased at Riordanvale, location shown in Figure 1, in preparation for future load growth in the area south-west of Cannonvale. Currently, this area is supplied by the 11 kV feeders Paluma Road, Cannonvale and Abel Road from CANN and from the extremities of Crystalbrook, Strathdickie and Foxdale from Kelsey Creek East (KECE) 66/11 kV substation. The current utilisation of these CANN feeders, as presented in Table 14, indicates that Paluma Road will likely be the first to exceed 75 % utilisation (defined as a 'Red' urban capacity limit) and thus exceed the required 4 into 3 feeder design criteria. A full breakdown of the predicted load for all Airlie Beach region feeders can be found in the following spreadsheet.

CANN_JUPO CSA 2018_v0.3.xlsx

The load growth experienced by the three CANN feeders in recent years is approximately 2.0 %. If this growth rate was to continue, the feeder utilisation of these feeders would look as shown in Table 18. Under the base case scenario, where no efforts were made to reduce the load on any of the feeders, RIOR would be required to support the load growth in 2021. Fortunately, there are existing network ties between the three feeders that would allow feeder reconfiguration and some load redistribution thereby reducing the load on Paluma Road to defer augmentation. The available load transfers would keep the utilisation of Paluma Road below 75 % (defined as 'Yellow' urban capacity feeder) until 2025. The final assessed scenario would require simple network augmentation which would allow approximately 50 A of load to be transferred from Paluma Road to Cannonvale. This would push the required by date of RIOR out until 2032 when all three feeders exceed the design criteria.

Table 18 Feeder Utilisation Under Base Case, Load Transfer and Network Augmentation Scenarios

Year	Paluma Road			Abel Road			Cannonvale		
	Base Case (%)	Load Transfer (%)	Network Aug. (%)	Base Case (%)	Load Transfer (%)	Network Aug. (%)	Base Case (%)	Load Transfer (%)	Network Aug. (%)
2018	70.0	65.0	53.3	56.0	58.7	56.0	37.5	40.2	56.4
2019	71.4	66.3	54.4	57.1	59.8	57.1	38.3	41.0	57.6
2020	72.8	67.6	55.5	58.3	61.0	58.3	39.0	41.8	58.7
2021	74.3	69.0	56.6	59.4	62.3	59.4	39.8	42.6	59.9
2022	75.8	70.4	57.7	60.6	63.5	60.6	40.6	43.5	61.1
2023	77.3	71.8	58.9	61.8	64.8	61.8	41.4	44.3	62.3
2024	78.8	73.2	60.1	63.1	66.1	63.1	42.2	45.2	63.6
2025	80.4	74.7	61.3	64.3	67.4	64.3	43.1	46.1	64.8
2026	82.0	76.2	62.5	65.6	68.7	65.6	43.9	47.0	66.1
2027	83.7	77.7	63.7	66.9	70.1	66.9	44.8	48.0	67.5
2028	85.3	79.2	65.0	68.3	71.5	68.3	45.7	48.9	68.8
2029	87.0	80.8	66.3	69.6	72.9	69.6	46.6	49.9	70.2
2030	88.8	82.4	67.6	71.0	74.4	71.0	47.6	50.9	71.6
2031	90.6	84.1	69.0	72.4	75.9	72.4	48.5	51.9	73.0
2032	92.4	85.8	70.4	73.9	77.4	73.9	49.5	53.0	74.5
2033	94.2	87.5	71.8	75.4	79.0	75.4	50.5	54.0	76.0
2034	96.1	89.2	73.2	76.9	80.5	76.9	51.5	55.1	77.5
2035	98.0	91.0	74.7	78.4	82.1	78.4	52.5	56.2	79.0
2036	100.0	92.8	76.2	80.0	83.8	80.0	53.6	57.3	80.6

4.6. Safety Net Compliance

CANN substation has two 66 kV incoming feeders (CANN-01 and CANN-02) and two 15 MVA transformers that ensure supply can be fully restored to CANN customers within Safety Net requirements. On the other hand, JUPO, MORO and SHUT do not have N-1 security and are reliant on the 66 kV radial feeder between CANN and JUPO. Currently, a fault on this section of line will result in an outage for all JUPO, MORO and SHUT customers which combine for a peak load at risk of approximately 16.4 MVA.

There is load transfer capacity of 4 MVA to transfer JUPO customers to CANN via 11 kV switching. This 11 kV switching combined with mobile generation is sufficient to restore supply to all LV Customers within the Safety Net requirement. The major customers of Hayman, Hamilton, Daydream and South Molle islands would experience an outage for the full duration of the time it takes to locate and restore the fault.

As these are major resorts that play an integral role in the success of the tourism industry in the Airlie Beach region, an extended outage for these customers is undesirable and will likely have a significant business impact.

The section at highest risk of causing an extended outage is the 1.41 km underground cable passing through the main tourist centre of Airlie Beach highlighted in Figure 23 as Section A. Fault finding (i.e. minimum of 1 week unless a notified dig in occurred) and repair (i.e. minimum of 3 days for 2 joints and a new length of cable pending weather and fault location) of this cable would be very time consuming and likely result in an outage that spans days or even weeks instead of hours for the island customers. This section of cable is also the same XLPE type and of similar age to the recently failed 66 kV CANN-01 entry cable and tested CANN-02 entry cable at CANN and has therefore been identified as having a high risk of failure within the next few years.

The concern is that if this particular cable is experiencing water treeing issues, a replacement rather than a repair will be required. The majority of the route from the Airlie Lagoon to Mazlin Street is direct buried, has 2 joint bays and constructing an interim overhead bypass would be highly problematic.

B1100198 Airlie Beach Proposed Unde

B1 100196 66-11kV Extension Airlie Beach

Figure 23 Geographic Overview of the 66 kV Sub-transmission Network Downstream of CANN

A second 66 kV feeder between CANN and JUPO would reduce the likelihood of an extended outage to the island customers. This will also have an additional benefit to the 11 kV customers of JUPO and MORO as this will remove the need of manual switching of the 11 kV network, which typically takes 1-4 hours, to restore supply if a sub-transmission fault occurs. Whilst there is an available 66 kV feeder c/b at JUPO, the cost to duplicate is substantial. A more cost-effective

option would be to duplicate Section A only and progressively build towards a second feeder in co-ordination with TMR.

The strategic need to duplicate this feeder section was also identified around 2005 and steps have been taken to install conduits through Airlie Beach as the opportunities arise. Options analysis has also previously been undertaken regarding selecting and securing a complete feeder route between CANN and JUPO.

Although duplication of the 66 kV Mt Rooper feeder between JUPO and MORO+SHUT would further reduce the likelihood of an extended outage to the island customers, the time to resolve a fault on this line is significantly less than the underground cable of Section A.

The underground cable regions on this feeder, Section B and Section C in Figure 23, are shorter and have better accessibility which results in faster fault location and repair.

The risk of a failure on this cable section will therefore be managed by an appropriate risk management Safety Net plan which may be supported by immediate cable duplication or installation of spare conduits through the direct buried sections and appropriate strategic spares (i.e. 66 kV cable lengths and terminations) of the two underground sections past Mandalay and the airport.

4.7. Asset Life Cycle Summary

The existing CANN substation is of early 1980s vintage and is in reasonable condition. However, CBRM modelling summarised in Table 18, Table 20 and Figure 24 shows that the transformer CTs are due for replacement within the next 10 years, and the transformer 66 kV circuit breakers are ABB HLC type which are planned for replacement in two years as part of a REPEX replacement program. WR1217519 which was raised to replace these 66 kV CBs has been bundled into the WR for this project (WR1274424). The transformers have been recorded as leaking oil via the cable box seal which can be handled under normal maintenance work. The EA01 CTs have already been replaced under WR1107759.

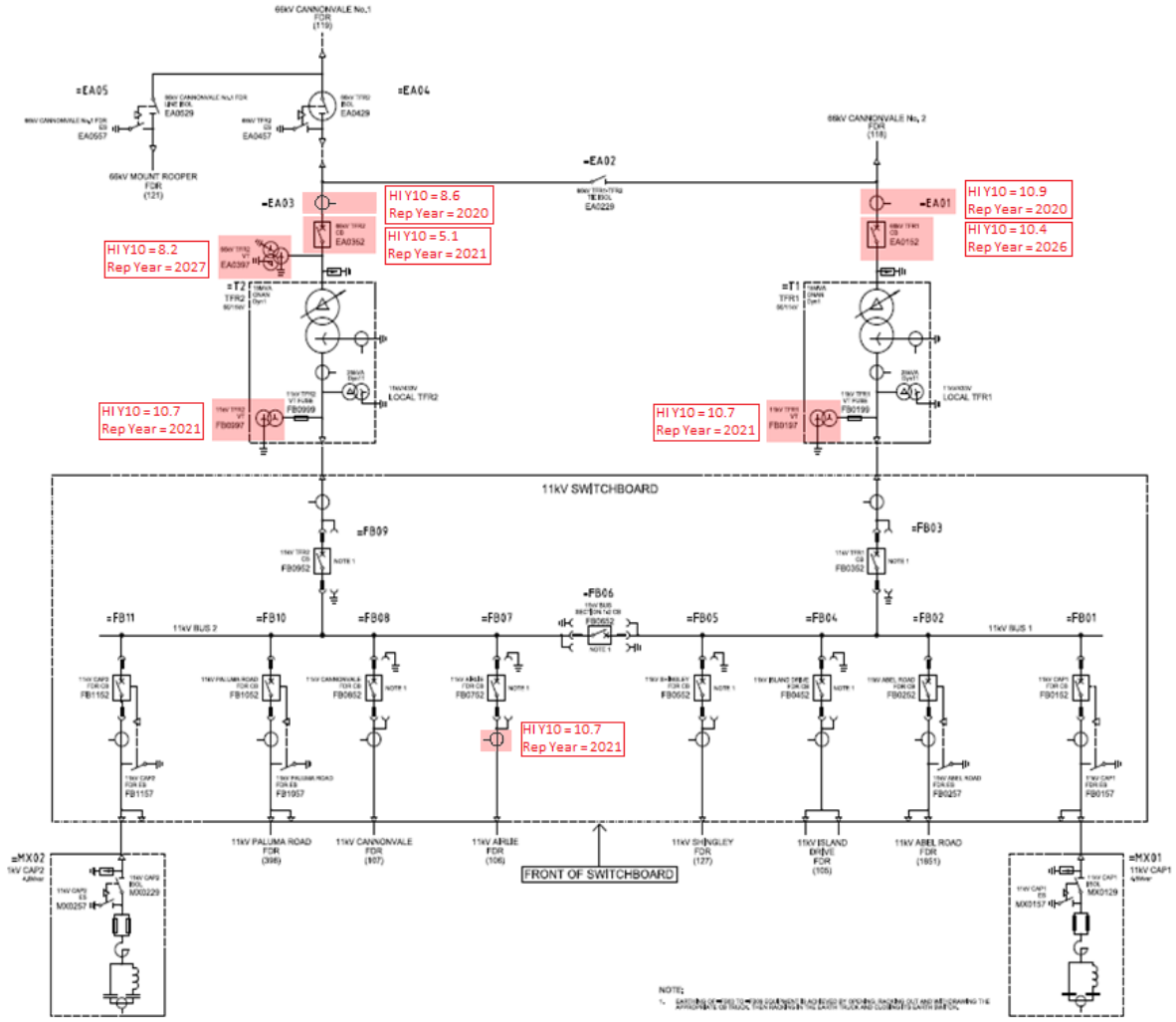

Figure 24 CANN Primary Plant Condition

Table 19 CBRM Results (66 kV)

01-Nov-2017 Asset Description	HI Y0	HI Y10	Age	Estimated Retirement Year	Replacement Reason
MK CANN EA0152 - CB92601516 1981 66kV - ASEA > HLC 72.5-84/1600 (814619105)	5.36	10.36	37	2026	RR3 WR1217519
MK CANN EA0352 - CB92605855 1981 66kV - ASEA > HLC 72.5-84/1600 (814619106)	5.36	10.36	37	2026	RR3 WR1217519
MK CANN EA01T03 A ph - CT93102624 1980 66kV BONNER STANGER > B66990/3 (C0690)	5.67	**10.92**	38	2020	RR2 WR1107759
MK CANN EA01T03 B ph - CT92129842 1980 66kV BONNER STANGER > B66990/3 (C0691)	4.68	**8.55**	38	2020	RR4 WR1107759
MK CANN EA01T03 C ph - CT92561043 1980 66kV BONNER STANGER > B66990/3 (C0692)	5.67	**10.92**	38	2020	RR4 WR1107759
MK CANN EA03T03 A ph - CT93184661 1980 66kV BONNER STANGER > B66990/3 (C0695)	4.68	**8.55**	38	2020	
MK CANN EA03T03 B ph - CT92134493 1980 66kV BONNER STANGER > B66990/3 (C0693)	4.68	**8.55**	38	2020	
MK CANN EA03T03 C ph - CT93048139 1980 66kV BONNER STANGER > B66990/3 (C0694)	4.68	**8.55**	38	2020	
MK CANN EA0397 A ph - VT93209392 1987 66kV ASEA > EMFC72 (7712250)	4.07	**8.20**	31	2027	
MK CANN EA0397 B ph - VT93231196 1987 66kV ASEA > EMFC72 (7712252)	4.07	**8.20**	31	2027	
MK CANN EA0397 C ph - VT93224514 1987 66kV ASEA > EMFC72 (7712251)	4.07	**8.20**	31	2027	

Table 20 CBRM Results (11 kV)

01-Nov-2017 Asset Description	HI Y0	HI Y10	Age	Estimated Retirement Year	Replacement Reason
MK CANN FB07T03 A ph - CT92529529 1981 11kV GEC > ### (564219)	5.50	**10.71**	37	2021	
MK CANN TFR1 3 ph - VT93219427 1981 11kV GEC > ### (1910855)	5.50	**10.71**	37	2021	
MK CANN TFR1 3 ph - VT93225784 1981 11kV GEC > ### (1791415)	5.50	**10.71**	37	2021	

The known issues that currently exist at CANN substation are as follows:

- **Transformer Access** - A large Ubinet antenna pole is in the existing driveway reserve in a location that blocks crane access to the 66/11 kV transformers. This will become more of an issue as CANN 11 kV load grows beyond the N-1 transformer rating. The recommended works should take this into consideration and attempt to improve accessibility.
- **ABB HLC Circuit Breakers** - The two transformer 66 kV circuit breakers are of ABB HLC type. These are part of a REPEX replacement program due to a known potentially explosive failure mode. The CBs are planned for replacement in 2020 under WR217519.

- **Land for 66 kV Switchyard** - The adjoining block of land at the rear of CANN substation has been acquired previously. Development of the block into an outdoor switchyard is complicated by a council-owned sewerage line. Relocation of this sewage line has previously been estimated to be $1M.
- **Failed 66 kV Entry Cable** – CANN-01 feeder cable entering the switchyard at CANN recently failed in January 2017 and, as of November 2018, a temporary overhead bypass arrangement is in place. The cable construction is single core XLPE insulated aluminium conductor with a light duty copper screen and no insect protection. Analysis of the XLPE insulation by The University of Queensland (UQ) on both the faulted phase and a healthy phase cable was conducted. The investigation report stemming from this fault can be found in the INC-1136936 report below along with the testing report from UQ and the scope statement for the cable replacement project. The conclusions from this testing are summarised below:

  "It was postulated that the failure resulted from the flashover of the phase conductor to the screen due to the progressive development into electrical trees of vented trees and/or the cumulative effects of multiple bow-tie trees over time. The true root cause could not be determined without doubt, however, given the age of this cable and the fact significant numbers of water trees were discovered in un-faulted phases, this is the most likely cause in this instance. It is probable that other failures in cables of this same type and age will occur over the next few years."


INC-1136936
Investigation Report


Report C03513
Cannonvale Energex.


WR1254348 MK
CANN Cann No 1 66k

- **Aging 66 kV CANN Cables** – All cables in and out of CANN are of similar type and vintage as the failed CANN-01 entry cable. Additionally, testing of the CANN-02 exit cable was performed as detailed in the below report. On-line Partial Discharge (PD) testing confirmed the presence of PD on this section of cable using two different test sets. The extensive testing performed on the faulted CANN-01 entry cable found the presence of significant water trees and suggested that it is probable that other failures will occur in cables of the same age and type within the next few years.


CANN- 66kV
cannonvale No.2 Fee

- **Aging 66 kV Cable from Abell Point Marina to Airlie Foreshore** – The underground 66 kV cable between Abell Point Marina (pole 4104853) and the Airlie Foreshore (pole 6030159) is also of similar vintage to the failed 66 kV CANN-01 cable. Testing has not been performed on this section of cable as this testing must be performed off-line which would require an outage to the cable. A fault on this approximately 1.41 km section of line would lead to an extended outage to customers downstream of JUPO. Recommended works should therefore also consider the replacement of this aged asset.
- **Cable Constraints –** The 66 kV entry and exit cables at CANN are rated at 34 MVA. The system peak currently exceeds 34 MVA (4.5 MVA from PRMI, 15 MVA from CANN, 5.4 MVA from JUPO, 1 MVA from MORO and 10 MVA from SHUT) when operating under a contingency scenario where CANN-02 has failed. The overhead sections of the 66 kV feeders from PROS are rated above 40 MVA, therefore, the underground cables at CANN are the constraining conductors. Increasing the rating of these cables would alleviate the risk of load exceeding rating during a contingency scenario and thus reduce outage time and improve reliability. The faulted 66 kV CANN-01 entry cable was replaced with a 66 kV cable rated at a cyclic loading of 700 A (80 MVA) as detailed in the below rating report. It is recommended that any additional cable works also achieve this rating.

WR1254348 cable rating report prelim20

4.8. VCR Value

Energy Queensland utilises the AEMO 2014 Value of Customer Reliability (VCR) values as part of its investment and project planning process. VCR is an economic value applied to customers' unserved energy for any particular year and is intended to represent customers' willingness to pay for their reliability of electricity supply. VCR is used to supplement Ergon Energy and Energex's Jurisdictional Security Criteria requirements by helping compare project options in a project business case or RiT-D, where reliability is assessed to have a material impact. VCR analysis can also be used to demonstrate the customer benefits of investment above mandatory requirements, to achieve an improved, efficient customer reliability outcome, but in practice, this application is very rare. Detail about how VCR is applied in investment analysis is included in each DNSP's Distribution Annual Planning Report (DAPR)[5] under Section 6.4 on Network Planning Criteria and can be found under the following links.

Customer impact of the Cannonvale/Airlie Beach sub-transmission network configuration has increased substantially in the last four years. This is reflected in the VCR values based on analysis of historical outages over the past eight years as shown in Figure 25. The calculated VCR value of $28/kWh is justified in Appendix A. The VCR values in Figure 25 are calculated using $28/kWh.

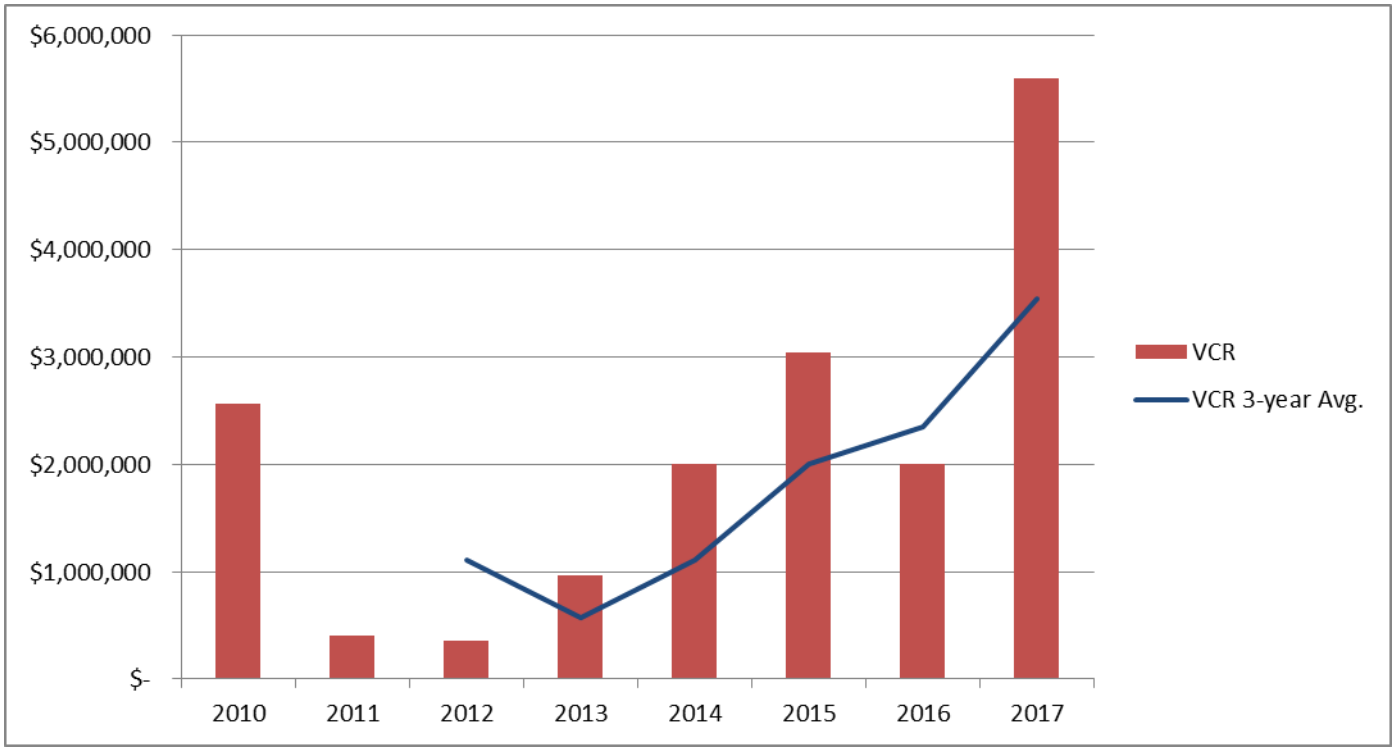

Figure 25 Lost Energy VCR due to Lack of Switchyard at CANN (Actuals)

[5] https://www.ergon.com.au/network/network-management/future-investment/distribution-annual-planning-report

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The proposed BAU VCR to be used in the NPV options will be either based upon:

- The 8 year average of $2.117M pa;
- Escalated to the 3 year average of $3.536M pa if business carries on as usual and aged assets experience long term failures; or
- An 8 year average of $1.765M by excluding the 2017, 9 hour outage that had a VCR cost of $2.8M.

VCR figures used in the NPV options analysis will be applied as an indirect benefit of $1.765M annually.

5. RISK ASSESSMENT

Table 21 Risk Assessment for CANN 66 kV Feeder Duplication and Switchyard Upgrade

Risk Category	Equipment	Risk Scenario	Inherent/Untreated Risks			Target (Residual)	
			C	L	Risk Score	L	Risk Score
Legislative	Cable	Potential Safety Net breach due to fault finding delays and repair for 66 kV cable faults between CANN and JUPO (<6 hours). As concerns about the reliability of this asset have previously been raised an improvement notice may be issued by the regulator.	4	4	16 (Moderate)	1	4 (Very Low) ALARP
			C	L	Risk Score	L	Risk Score
Customer	Cable	Extended outages of >2 days occur due to the repairs required on 66 kV cable faults between CANN and JUPO.	4	4	16 (Moderate)	1	4 (Very Low) ALARP
			C	L	Risk Score	L	Risk Score
Customer		Interruption of 2-6 hours bi-monthly leads to ongoing disruption to 7,198 customers in a tourism-based economy, including major island resorts.	3	5	15 (Moderate)	1	3 (Very Low) ALARP
			C	L	Risk Score	L	Risk Score
Safety		Catastrophic failure of 66 kV plant resulting in a single fatality of staff and/or members of the public.	5	3	15 (Moderate)	1	5 (Very Low) ALARP
			C	L	Risk Score	L	Risk Score
Customer		Adverse regional media attention results in reputation/brand damage due to ongoing outages to internationally renowned tourism resorts and hotels.	3	4	12 (Moderate)	1	3 (Very Low) ALARP

Network Risk Evaluation Matrices:

Network Risk Sub-Scales.pdf

Risk Assessment Outcome:

The network (business) risks the organisation would be exposed to if the project was not undertaken (Inherent Risk) are **not** deemed to be as low as reasonably practicable (ALARP). Addressing the risks, as detailed above, through implementation of the preferred option (Option A) will reduce Energy Queensland's risk exposure (Residual Risk) in the most cost-effective manner.

Risk Assessment Map:

The risk assessment map for the most significant risk present at the study area of this project (Cannonvale and Airlie Beach) is provided in Figure 26.

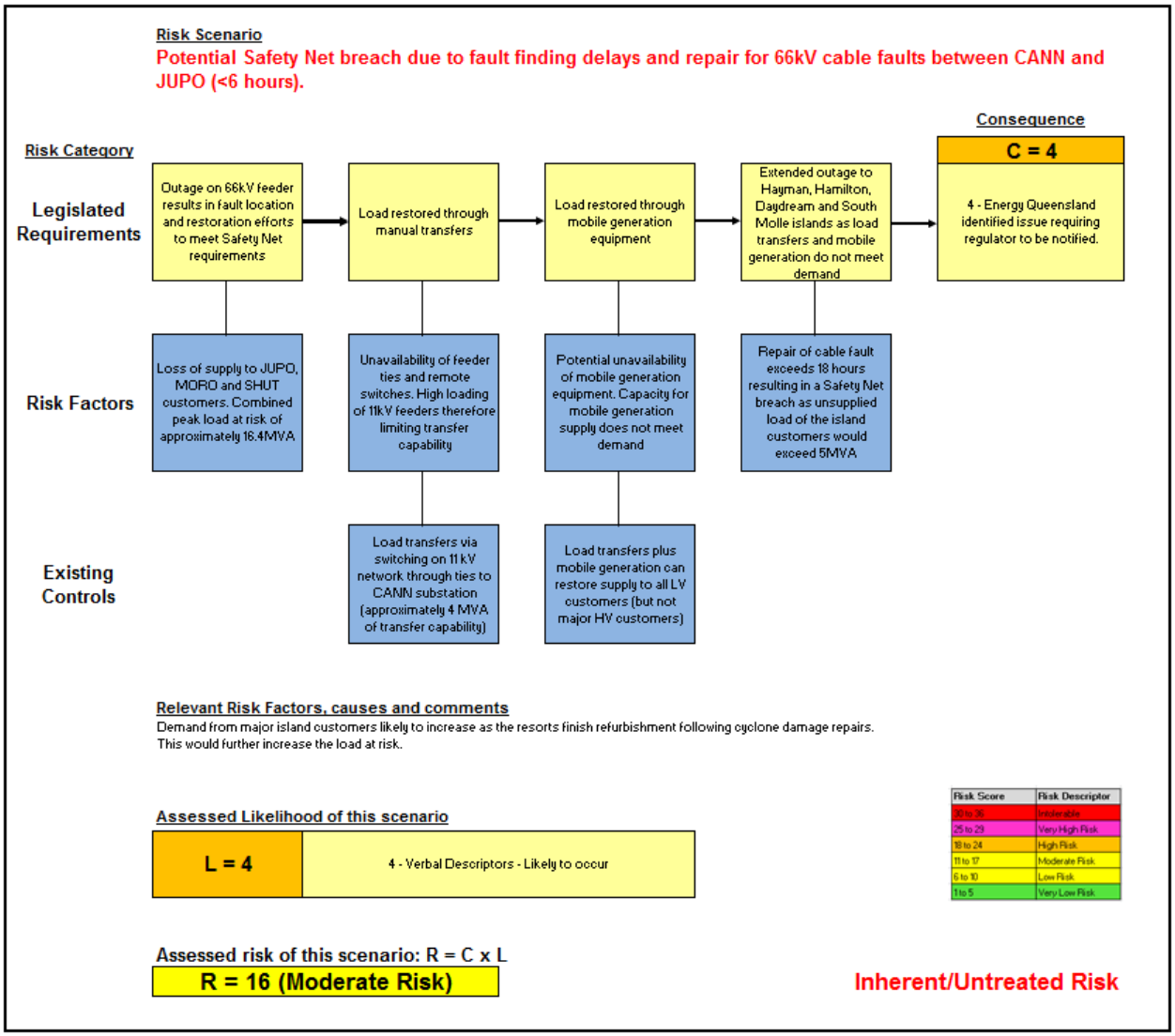

Figure 26 Risk Assessment Map for the Greatest Inherent/Untreated at CANN and the Airlie Beach Sub-Transmission Network

6. PLANNED UPGRADE OF SHUTE HARBOUR ROAD (CANN TO ABELL POINT)

Queensland Department of Transport and Main Roads (TMR) has engaged a consultant (i.e. AECOM) to carry out an options analysis and business case for the upgrade of Proserpine Shute Harbour Road between Island Drive to Waterson Way and Coconut Grove to Hermitage Drive.

This upgrade will have a significant impact on any 66 kV design to duplicate the CANN to JUPO feeder particularly between CANN and Abell Point Marina. This section of feeder will present challenges for both overhead and underground installation as:

- The road corridor is heavily constrained with geographical features (large cut and fill slopes) and significant services present;
- Attempting to erect overhead or install underground along a section of road that is currently undergoing feasibility analysis will be difficult to finalise and obtain TMR design sign off and approval. TMR would prefer a co-ordinated approach given the complexities along this constrained corridor with alignments, shared trench works, potential relocations, asset damage and the subsequent risk of cost escalation upon both parties; and
- The present TMR program of works pending delays due to approval and funding is to complete the:
    - Island Drives to Jones Road by 2022 (approx. 0.9 km); and
    - Jones Road to Waterson Way prior to 2030 (approx. 1.3 km).

Ideally, any 66 kV works in this section will be undertaken at the same time as the TMR road upgrades to minimise costs for both parties however there is currently no approved funding for the road upgrades or the Ergon 66 kV line works.

Considering trenching for 66 kV underground costs is in the order of $2M/km, the potential benefits of a coordinated and aligned approach with TMR could result in significant savings which will be considered in the options analysis of this planning report.

Attached is the proposed TMR line route under investigation.

60558302-SK-OA-03 -combined.pdf

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7. OPTIONS ANALYSIS

7.1. Base Case (BAU) with 66 kV Cable Duplication/Replacement

7.1.1. Outcome

The total estimated DCV cost (2018/19) of the base case is $7.679M.

The BAU option is based upon:

- Replacing/duplicating the deteriorated and long repair time 66 kV cables (circa 1981) at CANN and downstream Airlie Lagoon, Mandalay and airport runway crossing radial cables (circa 1987). Geographic overview of existing and proposed CANN-JUPO cable route can be seen in Appendix G;
- Substation REPEX based replacements as required;
- SCADA improvements to remotely enable 66 kV auto-reclose block at PROS and PRMI to reduce operational resource demand and response times;
- Complete the 11 kV gas switch project that enables remote controlled transfer of Main St. feeder (114) from PROS to KECE; and
- Planned and targeted REPEX defect maintenance of the CANN-01 pole top construction as part of BAU line maintenance work. As the timber crossarms are progressively replaced with vertical standoff post insulators, the historical outage rate of 7.2 outages per 100 km-years should progressively improve to 5.1 outages per 100 km-years which is comparable to the newer CANN-02 feeder that experiences 3.4 outages per 100 km-years. However, this may take some time considering the length of the feeder. Inherent reliability of 3 – 5 outages per 100 km-years will still be commensurate of an aging timber pole, no OHEW line.

Installing standoff insulators in a vertical construction will typically require costly timber pole replacement (i.e. going to a taller 17.0 m pole or inter-poling) to maintain ground and inter-circuit clearances. The longer-term benefit is a 30 % reduction in outage rate with a commensurate operational response benefit.

Notwithstanding the above works recommended under BAU, BAU as described is not recommended as it still exposes the network to poor distribution feeder and customer reliability (i.e. PRMI, JUPO and SHUT/MORO), high ongoing VCR costs, extended outage times to re-configure the network and a high-risk environment operating the CANN 66 kV switches.

The major urban load centres and international/domestic tourist destinations are still being supplied from single radial timber pole lines that have no OHEW and rely on lengthy manual switching to restore supply. Even though MAIFI (i.e. Momentary Average Interruption Frequency Index) is not an MSS measure, it should be noted that supply from a radial 66 kV feeder will be exposed to momentary outages during successful recloses.

If no action is taken:

- Additional capital spend will be deferred;
- A fault on CANN-02 will still require manual switching to restore supply to CANN customers. This will typically take 1-4 hours;
- A fault on CANN-01 will continue to cause an extended outage to JUPO customers and the island customers downstream of MORO and SHUT. 4 MVA of transfer capability is present for JUPO customers to be switched onto CANN via 11 kV switching. This is not sufficient to

meet the current 5.4 MVA peak demand of JUPO customers. The JUPO shortfall would be supplemented with mobile diesel generation;

- Ongoing poor network reliability with significant VCR cost and impacts to business reputation and brand;
- Maintenance of the 66 kV bus tie isolator at CANN will continue to require an outage to the CANN supply area due to insufficient working clearances;
- As the 66 kV manual transfer between CANN-01 to CANN-02 occurs in the CANN substation on the quasi 66 kV bus and involves staff standing under the 66 kV isolator and in close proximity to the porcelain cable termination (refer to Appendix A), field crews recommend load transfers via the 11 kV or from a de-energised 66 kV due to safety concerns. It should be noted that over the last 8 years, a downstream 66 kV cable termination and lightning arrestor has failed with the latter failing explosively whilst energising the 66 kV ABS two poles away. All the 66 kV lightning arrestors have since been replaced, particularly as PD testing of CANN-02 cable identified discharges on the L/As;
- The incoming and outgoing CANN 66 kV feeder cables will still need to be replaced in the future as part of a REPEX project. Testing on the recently faulted CANN-01 entry cable and non-destructive testing of CANN-02 entry cable concluded that the chance of failure of the other cables, which are of the same type and age, over the next few years is very high;
- The underground 66 kV feeder cable between Abell Point Marina (pole 4104853) and the Airlie Foreshore (pole 6030159), Mandalay and airport runway crossing sections will need to be duplicated via a REPEX or AUGEX project. Testing on the recently faulted CANN-01 entry cable, non-destructive testing of CANN-02 entry cable and anecdotal build evidence concluded that the chance of failure of these cables, which are of the same type and similar vintage, over the next few years is high;
- Transformer 66 kV ASEA HLC CBs will still need to be replaced as part of WR1217519; and
- Transformer 66 kV CTs will still need to be replaced within the next eight years as part of a REPEX project.

7.1.2. Scope

- Business as Usual (with 66 kV cable replacement)

7.1.3. Key Assumptions

- Outage frequency will not immediately improve as the REPEX work targets defect remediation which will trigger the pole and pole top configuration replacement.
- Unexpected failure of other devices not mentioned in this scope has not been considered as these have been rated with a ‘good’ condition by Asset Lifecycle Management.
- The load demand of CANN, JUPO, MORO and SHUT does not unexpectedly increase significantly above the forecasted growth.

7.1.4. Estimate Cost

Table 22 Non-Eliminated REPEX and OPEX Estimates

Assumed Costs	Estimated Cost
Replace TX Circuit Breakers (REPEX) (ABB)(Est: 000000172145)	$167k (2019/20)
Replace TX CTs (REPEX)	$300k (2026/27)
Replace Incoming CANN-02 Cable (AUGEX)(Safety Net)(under Rd)	$500k (2020/21)
Replace Outgoing CANN-01 Cable (FIS)(across crk)	$1,000k
OPEX – Ongoing Outage Response and Manual Switching	$12.8k p.a.
Estimated VCR cost	$2.116M p.a. ($1.765M when 66 kV cables replaced)

7.1.5. Risks

Continued operation under a Business as Usual scenario without replacing the high risk 66 kV cable sections pose a number of safety, customer, environment and business risks.

- Public outrage, brand damage and political intervention due to frequent and extended outages (i.e. present outage rate of CANN-01, manual restoration periods and long term cable failure outages) to an international and domestic tourist destination that attracts 795,000 visitors annually;
    - A long term radial cable fault (i.e. up to 4-6 months), could collectively cost between $8–12M in Hamilton, Hayman and Daydream Island generation and plant operating costs.
- Failure to meet MSS (i.e. last 3 of 4 years):
    - PRMI and JUPO ‘Urban’ ‘RED’ feeder status; and
    - MORO ‘Short Rural’ ‘RED’ feeder status due to poor 66 kV performance;
- Potential Safety Net breach due to fault finding, repair or replacement delays for 66 kV cable faults or permanent water tree damaged cable between CANN and Shute Harbour;
    - 66 kV cable is direct buried for the majority of the underground route sections;
    - Extended outage resulting from a cable short term fault (up to 10-14 days for a single point failure of unknown origin) or long term fault (up to 4-6 months for a cable replacement);
- Ongoing CANN-01 poor reliability with the entire community of up to 1,836 customers in a tourism-based economy, including major island resorts, experiencing 2-6 hour outages 2-4 times per year; and
- Failure of 66 kV plant causing a single fatality of staff, contractors and/or the public (i.e. operating plant in the quasi 66 kV bus enclosure).

It should be noted that:

- Major excavations, bores and disruption would be required to install conduits along the 1.07 km Airlie Lagoon foreshore direct buried section potentially during peak season;
- The cable could take 2 weeks to quote/approve purchase; and
- The cable manufacturing/delivery lead time could be in the approx. 16 weeks using standard sea freight.

The replacement could take 4-6 months. Whilst air freight of the cable and other viable alternatives (e.g. overhead bypass, pre-purchase sufficient spare 66 kV 630 Cu. XLPE cable and accessories) would be investigated to minimise restoration, an extended outage is still anticipated. This would form part of an interim management plan.

This option is not considered an acceptable option.

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7.2. Option A: 66 kV Switchyard Upgrade at Cannonvale 66/11 kV Substation and Duplication/Replacement of 66 kV Cables (Recommended)

7.2.1. Outcome

The total estimated DCV cost (2018/19) of the scope of works covered by Option A is $16.68M.

This option installs a seven breaker 66 kV switchyard at CANN, comprised of two feeder breakers in, two feeder breakers out (one spare initially), two transformer breakers and a bus tie breaker.

The 2nd outgoing 66 kV feeder between CANN and JUPO will not be installed for some time particularly when the high-risk Airlie Lagoon 66 kV cable section is duplicated.

TMR are planning to upgrade the section of Shute Harbour road between Island Dr. and Waterson Way over the next 12 years (refer Section 6) which is in direct conflict with the proposed 2nd feeder route. This conflict presents a high risk of costly relocations and delayed approvals.

It is recommended that 66 kV conduits be installed during the proposed TMR roadworks which are expected to occur in two stages over 12 years. The 2nd feeder between CANN and JUPO is a long term network development strategy but not required immediately.

Notwithstanding the risk of a catastrophic water tree failure, this section is a radial cable which is direct buried for the majority of the route. The 1.41 km route would take 4-6 months to replace in an emergency pending council approval for the cable route and trench installation that may be required during the peak holiday tourism season. An overhead bypass is highly unlikely.

Conduits are progressively being installed from JUPO to the Airlie Lagoon, however, the Airlie Lagoon to Abell Point section is still mostly direct buried and has no spare conduits.

Similarly, the Mandalay and airport runway crossing 66 kV cable are mostly direct buried. An airport cable overhead bypass is not possible due to flight path restrictions.

Whilst the islands (i.e. Hamilton, Hayman and Daydream) have standby generation (i.e. 9.0 MVA via 6 sets, 5.9 MVA via 4 sets and 3.0 MVA via 3 sets) to manage submarine cable failures, the cost to run generation based on summer average loads for a 4-6 month period could cost between $8-$12M respectively. This does not include the cost to supply South Molle or the balance of 11 kV load after transfers from JUPO/MORO to CANN.

Based on the CANN 66 kV cable tests (i.e. failed CANN-01 cable tests and non-destructive PD test results of CANN-02), anecdotal cable purchase specification and direct buried install, the Airlie Lagoon, Mandalay and airport 66 kV cables (circa 1987) are considered high-risk assets and should be duplicated immediately.

The fully switched 66 kV bus arrangement at CANN will sectionalise the network and eliminate outages to CANN, JUPO, SHUT and MORO for faults on the 26-27 km upstream sections of CANN-01 and CANN-02 between PROS and CANN.

The subsequent reliability improvement to JUPO and MORO:

- Will allow permanent Airlie Beach load transfers from CANN to JUPO and commissioning of new ‘Urban’ category MSS 11 kV feeders without becoming a ‘RED’ feeder immediately upon commissioning (i.e. as is currently the case with the Port of Airlie 11 kV feeder); and
- Resolve the MORO Shute Harbour (108) 11 kV ‘RED’ SR feeder status.

Reliability of supply to PRMI (i.e. 11 kV Main St. 11 kV 'Urban' MSS 'RED' feeder) which is still exposed to inherent CANN-01 reliability will be managed by:

- Remote control gas switch operational management of the Main St. 11 kV feeder back to Kelsey Ck (i.e. KECE) 11 kV Proserpine feeder (103);
- Upgrade SCADA at PROS and PRMI - allows operations to remotely disable 66 kV auto-reclose and improve response times; and
- Longer term, BAU defects maintenance improvement of the 66 kV line (i.e. vertical standoff insulator construction conversion) which should improve the outage rate from 7.2 to 5.1 outages per 100 km-years.

According to outage analysis these 66 kV feeders experience an outage rate of 3.8 outages per 100km-years (CANN-02) and 7.2 outages per 100km-years (CANN-01) and represent 76 % of known faults (refer also to Table 12). Typical high reliability 66 kV line (i.e. SCCP c/w OHEW) outage rates would be in the order of 1.3 to 2.5 outages per 100km-years but it is not practical or cost effective to build a new 25 km SCCP c/w OHEW (at approximately $1M/km). Planned and targeted REPEX defect maintenance of the CANN-01 pole top construction as part of BAU line maintenance work will improve the outage rate from 7.2 outages per 100km-years to approximately 5.1 outages per 100km-years to be comparable with the outage rate on CANN-02.

The remaining incoming and outgoing 66 kV aged feeder cables at CANN substation will be removed as part of the GIS/AIS build and at risk radial cable sections downstream of CANN (i.e. Airlie Lagoon, Mandalay and airport) are recommended for duplication.

Figure 27 details the network configuration proposed by Option A. Additionally, the proposed CANN substation layout with both GIS and AIS switchyard solutions is shown in Appendix D. The proposed long term strategic 66 kV CANN–JUPO 2nd and existing feeder routes are detailed in Appendix G.

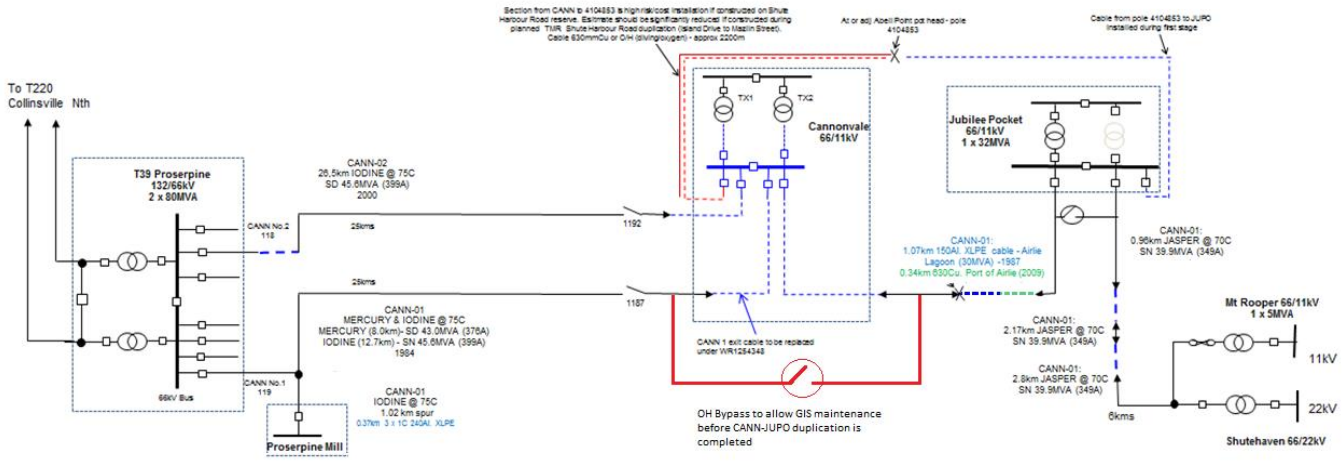

Figure 27 66 kV Network Diagram for Option A

7.2.2. Scope

The full scope of works to be covered by Option A is as follows:

- PROS & PRMI 66 kV remote auto-reclose disable functionality;
- PRMI remote control 11 kV gas switch;
- Continuation of the BAU, REPEX defects replacement of CANN-01 timber crossarm with 17.0 m poles or inter-poling and horizontal standoff post insulator constructions (this is reactive, defect driven improvement);
- CANN Substation:
    - 7 bay switchgear (1 future spare), installed either indoor in the new building (if GIS) or outdoor;
    - Gain approvals for the CANN-01 66 kV bypass to remain permanent and install a N/O bypass to enable maintenance of the CANN to JUPO 66 kV feeder C/B;
    - Separate control-room containing:
        - 66 kV panels;
        - AC changeover;
        - DC batteries, charger and distribution; and
        - Space for future 11kV panels, TX panels & comms;
    - 2 x 315 kVA House TXs;
    - New DC system with dual strings;
    - Decommission and remove redundant transformer HV switchgear;
        - CTs, VTs, Isolators;
    - Decommission and remove redundant HV bus/enclosure with 66 kV ABSs and terminations;
    - Driveway and transformer access set down area to be established around the south-west side of the existing building;
    - 66 kV Cables:
        - CANN-01 exit cable already replaced (as part of WR1254348);
        - Incoming CANN-02 under bore Shute Harbour Rd from existing cable term pole with spare conduits for 11 kV and future 66 kV (possible alternate 2nd JUPO feeder route);
        - Cable to existing Transformer 1;
        - Replace existing outgoing Jubilee Pocket 66 kV exit feeder – open trench, suspended or under-bore across creek and Island Drive.
        - Cable to existing Transformer 2; and
        - Recover old cables as far as practical.
- 66 kV CANN – future strategic JUPO Feeder Duplication (not required initially):
    - Construct an additional 66 kV feeder from CANN – JUPO. Utilise existing conduit from the Abell Point term pole (pole 4104853) through to JUPO and proposed cable duplication as part of the Airlie Lagoon conduit/cable;
    - The overhead section from CANN to Abell Point term pole will be difficult to duplicate due to limited space and the difficult terrain to construct the required poles

on. Works will be reduced in coordination with planned TMR work and timeline to duplicate/widen Shute Harbour Road which shares a path for a large portion of the 2nd 66 kV feeder from CANN to JUPO; and

  - Fibre path provision for signalling along 2nd CANN – JUPO feeder if required.

- Protection/Signalling:
  - PROS to CANN (CANN-01): Differential Scheme – three ended with PRMI - single comms between PROS and CANN, duplicate comms between PROS and PRMI;
  - PROS to CANN (CANN-02): Distance scheme. No comms required;
  - CANN to JUPO (Existing 66 kV Feeder): Distance scheme. No comms required; and
  - CANN to JUPO (New 66 kV Feeder): Distance scheme. No comms required.
- Allows for future RIOR substation to be constructed as a tee-sub from CANN-02.

7.2.3. Key Assumptions

- Requirement for RIOR construction isn't until 2030/31. Significant uncertainty associated with this assumption due to heavy dependence on population (and therefore load) growth in the Cannonvale and Riordanvale regions.
- Unexpected failure of other devices not mentioned in this scope has not been considered as these have been rated with a 'good' condition by Asset Lifecycle Management.
- 2nd feeder from CANN to JUPO will initially be a staged conduit installation in conjunction with the staged TMR works and the actual 66 kV feeder installed as demand at JUPO exceeds Safety Net compliance.

7.2.4. Estimate Cost

Table 23 Non-Eliminated REPEX and OPEX Estimates

Assumed Costs	Estimated Cost
Replace TX Circuit Breakers (REPEX) (ABB)(Est: 000000172145)	$167k (2019/20)
Replace TX CTs (REPEX)	$300k (2026/27)
Replace 66 kV cables	refer to Appendix D
OPEX – Ongoing Outage Response and Manual Switching (loss of CANN-02 or CANN-01 response will be reduced significantly from BAU)	$0k p.a.
Estimated VCR cost	Proposed works result in an expected VCR benefit of $1.319M p.a. The remaining VCR cost is, therefore, $446k p.a.

7.2.5. Risks

- 66 kV cables at CANN fail before they are replaced as part of this project, therefore, escalating costs due to emergency instead of planned replacement;
- RIOR being required earlier than projected due to unexpected load growth. This will decrease the NPV of this option and reduce its desirability amongst other proposed works options;
- There are potential cost savings to be made with the installation of an OH 66 kV line from CANN and Abell Point by undertaking this work when TMR are performing upgrades on Shute Harbour Road; and

- The risk of failure of the UG sections of 66 kV feeder between JUPO and MORO+SHUT (Section B and Section C in Figure 23) will be part of a risk management plan which will likely entail duplication of these sections.

7.2.6. Comparison of GIS vs AIS Switchyard Implementation

Both an outdoor AIS and an indoor GIS solution are technically viable implementations of the proposed 66 kV switchyard. A comparison of these options is therefore presented in Table 24.

Table 24 Comparison of AIS and GIS 66 kV Switchyard Designs

	AIS	GIS
Pros	+ Cheaper material and installation cost (estimated to be $1M)	+ Cleaner looking design with less visual impact in a dense domestic area close to residential homes + Smaller footprint and relocation of underground sewage pipe not required + Allows access to transformers for future replacement due to a smaller footprint
Cons	- Required relocation of underground sewage pipe (estimated cost of $1M) - Larger footprint - Increased fault frequency due to outdoor arrangement - Higher visual impact in a dense domestic area close to residential homes	- Higher material and installation cost (estimated to be $2M)

From a purely NPV perspective, the AIS design is comparable to the 20-year NPV of the GIS design. Therefore due to the advantages identified, a GIS design is recommended.

7.3. Option B: Construction of Dedicated 66 kV Feeder from Proserpine 132/66/11 kV Substation to Proserpine Mill 66/11 kV Substation and Duplication/Replacement of 66 kV Cables

7.3.1. Outcome

The total estimated DCV cost (2018/19) of Option B is $17.61M.

7.3.2. Scope

Option B involves removing PRMI off the CANN-01 feeder and supplying this substation via a new 66 kV overhead feeder from new feeder bay at PROS.

The option assumes reuse of an existing part of the feeder between the tee-off and PRMI. A 2nd 66 kV feeder from CANN to JUPO will be added. The final configuration will have two 66 kV feeders from PROS to JUPO each teed to a transformer at CANN with the 11 kV bus section c/b closed. The existing outdoor switchgear is retained to allow a safe isolation and access to the teed Transformer 2 bay (CANN-01 feeder). To allow for safe isolation and access to Transformer 1 bay either additional outdoor switchgear is required, or a combination of earth switch/isolator/earth switch which replaces the existing cable termination structure inside the bay. The installation of replacement 66 kV cables (i.e. from existing outdoor switchyard to Transformer 2) introduces challenges with respect to adequate clearance for terminations. Planned and targeted REPEX defect maintenance of the CANN-01 pole top construction as part of BAU line maintenance work will improve the outage rate from 7.2 outages per 100km-years to approximately 5.1 outages per 100 km-years to be comparable with the outage rate on CANN-02.

This option requires installation of the 2nd CANN – JUPO 66 kV feeder. This is outlined in the network diagram shown in Figure 28. Appendix G details the proposed 66 kV CANN – JUPO feeder routes. The proposed 66 kV feeder route from PROS – PRMI can be seen in Appendix E.

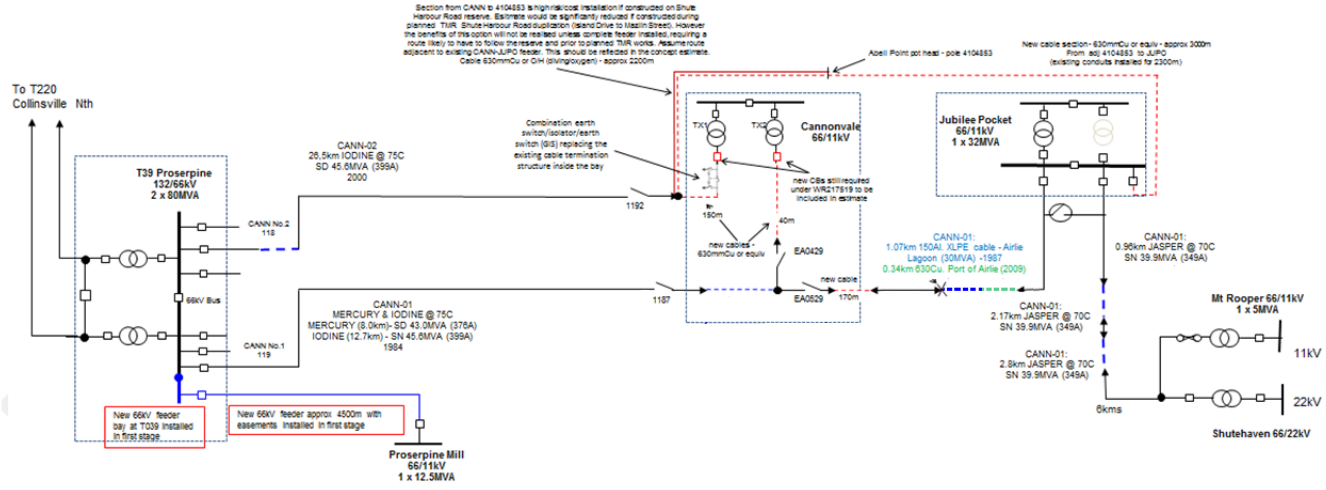

Figure 28 66 kV Network Diagram for Option B

The full scope of works for Option B is as follows:

- PROS & PRMI 66 kV remote auto-reclose disable functionality;
- Ongoing REPEX defects replacement of CANN-01 timber crossarm with 17.0 m poles or inter-poling and horizontal standoff post insulator constructions;
- PROS Substation:
    - New 66 kV feeder bay at PROS with primary plant and secondary systems (including control panels, etc.).

- PRMI Substation:
    - Required protection work due to direct connection to PROS. Will utilise a distance scheme with duplicate comms channels; and
    - PRMI remote control 11 kV gas switch.
- 66 kV PROS – PRMI Feeder Construction:
    - Construct new 66 kV feeder from PROS to existing CANN-01 feeder tee off to PRMI. Reuse existing overhead line from CANN-01 feeder to tee off to PRMI;
    - Acquire easements where required for sections of new feeder and sections of existing tee section where required. Property group have been consulted to provide advice on costs and timing (and associated risk); and
    - Associated protection for new feeder and signalling scheme to include duplicate comms between PROS and PRMI.
- CANN Substation:
    - Switchgear:
        - Replace cable support and terminations in Transformer 1 bay with GIS, containing earth switch/isolator/earth switch. Similar to Toowoomba Central (110 kV) transformer ended feeder arrangement;
        - Existing outdoor switchyard will need to be retained (ISOL EA0529, EA0429 and E/S EA0457, EA0447);
        - Decommission and remove redundant transformer HV switchgear i.e. 66 kV bus tie in transformer compounds; and
        - Replace 2 x 66 kV CBs at CANN (REPEX) as per existing WR1217519.
    - 66 kV Cables:
        - CANN-01 exit cable already replaced (as part of WR1254348);
        - Incoming CANN-02 under bore Shute Harbour Rd from existing cable term pole with spare conduits for 11 kV and future 66 kV (possible alternate 2nd JUPO feeder route);
        - Cable to existing Transformer 1;
        - Replace existing outgoing Jubilee Pocket 66 kV exit feeder – open trench, suspended or under-bore across creek and Island Drive;
        - Cable to existing Transformer 2; and
        - Recover old cables as far as practical.
- 66 kV CANN – JUPO 2nd Feeder:
    - Construct an additional 66 kV feeder from CANN – JUPO. Utilise existing conduit from the Abell Point term pole (pole 4104853) through to JUPO, reducing the risk of exposure to Safety Net requirements;
    - The overhead section from CANN to Abell Point term pole will be difficult to duplicate due to limited space and the difficult terrain to construct the required poles on. This can be reduced if coordinated with planned TMR work to duplicate/widen Shute Harbour Road which shares a path with a large portion of this line;
    - Fibre path provision for signalling along 2nd CANN – JUPO feeder if required; and

  - If required, replace existing cable section (150 mm^2 Al) from pole 4104853 to pole 6030159 (via Airlie Lagoon) utilising spare set of conduits currently existing or added during installation of the 2nd new feeder.

- Protection/Signalling:
  - PROS to CANN to JUPO (CANN-01 + Existing Feeder): Differential Scheme – three ended. Single comms between PROS, CANN and JUPO;
  - PROS to CANN to JUPO (CANN-02 + New Feeder): Differential Scheme – three ended. Single comms between PROS, CANN and JUPO;
  - CANN to JUPO requires single OTP (fibre) installed. Assume for estimation OTP utilising shortest 66kV route - i.e. 50% ADSS (overhead), 50% installed in existing/new comms conduits; and
  - PROS to PRMI (New 66 kV Feeder): Distance Scheme. Duplicate comms channels required.
- Allows for future RIOR substation to be constructed.

7.3.3. Key Assumptions

- Requirement for RIOR construction isn't until 2030/31. Significant uncertainty associated with this assumption due to heavy dependence on population (and therefore load) growth in the Cannonvale and Riordanvale regions;
- Unexpected failure of other devices not mentioned in this scope has not been considered as these have been rated with a 'good' condition by Asset Lifecycle Management;
- The load demand of CANN, JUPO, MORO and SHUT does not unexpectedly increase significantly above the forecasted growth;
- Duplication of 66 kV feeder between CANN substation and Abell Point Marina is possible regardless of the planned TMR road upgrades. The cost of this work may increase as a result of this;
- Required easements can be acquired to allow the construction of the dedicated PROS-PRMI 66 kV feeder; and
- There is sufficient room at PROS to extend the 66 kV bus to allow for the new feeder bay.

7.3.4. Estimate Cost

Table 25 Non-Eliminated REPEX and OPEX Estimates

Assumed Costs	Estimated Cost
Replace TX Circuit Breakers (REPEX) (ABB)(Est: 000000172145)	$167k (2019/20)
Replace TX CTs (REPEX)	$300k (2026/27)
Replace 66 kV cables	refer to Appendix E
OPEX – Ongoing Outage Response and Manual Switching (loss of CANN-02 or CANN-01 response will be reduced significantly from BAU)	$0k p.a.
Estimated VCR cost	Proposed works result in an expected VCR benefit of $1.319M p.a. The remaining VCR cost is, therefore, $446k p.a.

7.3.5. Risks

- 66 kV cables at CANN fail before they are replaced as part of this project, therefore, escalating costs due to emergency instead of planned replacement;
- RIOR being required earlier than projected due to unexpected load growth. This will decrease the NPV of this option and reduce its desirability amongst other proposed works options;
- The section of OH 66 kV line from CANN substation to Abell Point Marina at pole 4104853 is of relatively difficult terrain which may result in an escalated cost compared to that quoted in this estimate;
- There are potential cost savings to be made with the installation of underground conduits between CANN and Abell Point by undertaking this work when TMR are performing upgrades on Shute Harbour Road;
- The risk of failure of the UG sections of 66 kV feeder between JUPO and MORO+SHUT (Section B and Section C in Figure 23) will be as part of a risk management plan which will likely entail duplication of these sections;
- Required easements for PROS-PRMI construction cannot be acquired; and
- A 66 kV feeder bay cannot be constructed at PROS due to insufficient space or the cost of construction is unexpectedly escalated.

7.4. Option C: Construction of 66 kV Switchyard at Future Riordanvale 66/11 kV Substation Site and Duplication/Replacement of 66 kV Cables

7.4.1. Outcome

The total estimated DCV cost (2018/19) of Option C is $22.11M.

7.4.2. Scope

Option C considers a new switching station at existing Riordanvale (RIOR) site. Cable REPEX replacement work at CANN and the duplication of the 66 kV at risk cables between CANN and JUPO will still be undertaken. Existing CANN-01 and CANN-02 feeders are assumed to be split adjacent to the Riordanvale site with exit cables in to and out of the new switching station. The location of the future RIOR substation is shown in Figure 29. Indicated feeder locations are a rough guide only and will be dependent on obtained easements.

Figure 29 Geographic Overview of Future RIOR Substation

This option still proceeds with the installation of the CANN – JUPO 2nd feeder conduits along parts of the Shute Harbour Road reserve (in conjunction with TMR and their timing) between CANN and Abell Point.

The final configuration (RIOR to JUPO) is of two feeders from RIOR, each teed to a transformer at Cannonvale substation. The existing outdoor switchgear at CANN is retained to allow a safe isolation and access to the teed Transformer 2 bay (CANN-01 feeder). Planned and targeted REPEX defect maintenance of the CANN-01 pole top construction as part of BAU line maintenance work will improve the outage rate from 7.2 outages per 100km-years to approximately 5.1 outages per 100km-years to be comparable with the outage rate on CANN-02.

To allow for safe isolation and access to Transformer 1 bay either additional outdoor switchgear is required, or a combination of earth switch/isolator/earth switch which replaces the existing cable termination structure inside the bay. The installation of replacement 66 kV cables i.e. from existing

outdoor switchyard to Transformer 2 introduces challenges with respect to adequate clearance for terminations. The requirement for manual switching of the isolator at EA0429 is still required to restore supply to CANN if a fault occurs on the section of CANN-02 between RIOR and CANN which will result in a longer outage for CANN customers. This will reduce the VCR benefits achieved by this solution, however, this will be resolved as part of the cable replacements.

The requirement for manual switching of the isolator at EA0429 is still required to restore supply to the CANN TX if a fault occurs on the cable section from CANN-01 to the TX which will result in a longer outage restoration for JUPO to Shute Harbour customers. Given this 66 kV cable will be a new 66 kV XLPE cable section, the probability of failure will be low from a VCR perspective and manageable if the external bypass is retained.

This option is outlined in the network diagram shown in Figure 30. Appendix G details the proposed 66 kV CANN – JUPO feeder routes.

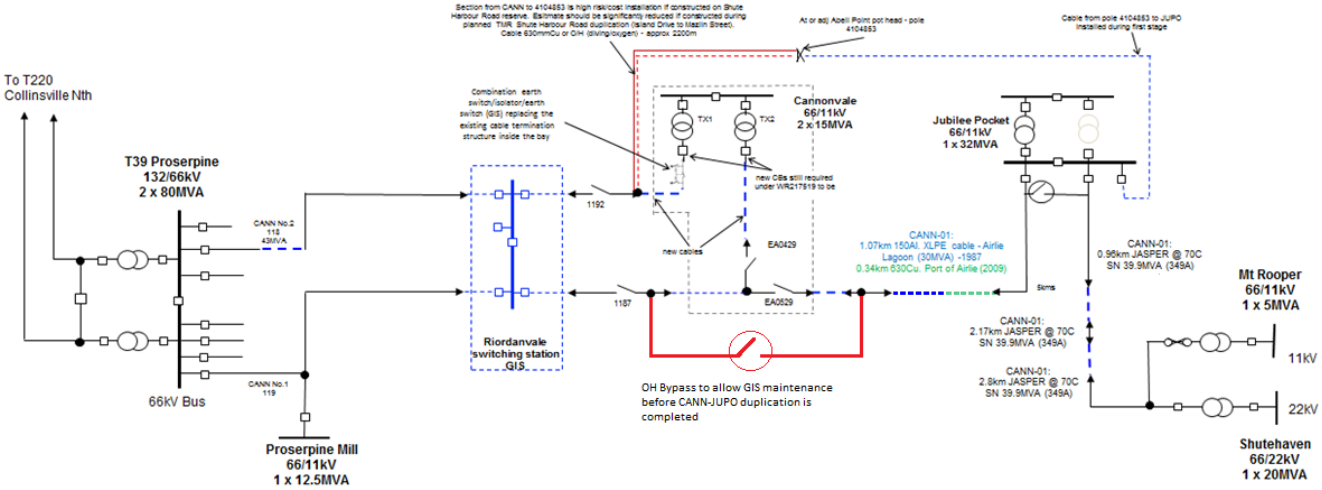

Figure 30 66 kV Network Diagram for Option C

The complete scope of works for Option C is as detailed below:

- PRMI remote control 11 kV gas switch;
- PROS & PRMI 66 kV remote auto-reclose disable functionality;
- Ongoing REPEX defects replacement of CANN-01 timber crossarm with 17.0 m poles or inter-poling and horizontal standoff post insulator constructions;
- PROS Substation:
    - New 66 kV feeder bay at PROS with primary plant and secondary systems (including control panels, etc.).
- RIOR Substation:
    - Construct new 66 kV switching station with in-feeds from CANN-01 and CANN-02 and two out-feeds to CANN:
        - 6 bay switchgear (1 spare for future RIOR T3-10);
        - Separate control room containing:
            - 66 kV panels;
            - AC changeover;
            - DC batteries, charger and distribution; and
            - Comms/control.
        - 2 x 315 kVA House TXs;

        - New DC system with dual strings; and
        - 66 kV cables/overhead/terminations at RIOR.
    - Design with the future intention for RIOR to connect a skid/zone T3-10 substation.
- CANN Substation:
    - Switchgear:
        - Replace cable support and terminations in Transformer 1 bay with GIS, containing earth switch/isolator/earth switch. Similar to Toowoomba Central (110 kV) transformer ended feeder arrangement;
        - Existing outdoor switchyard will need to be retained (ISOL EA0529, EA0429 and E/S EA0457, EA0447);
        - Decommission and remove redundant transformer HV switchgear i.e. 66 kV bus tie in transformer compounds; and
        - Replace 2 x 66 kV CBs at CANN (REPEX) as per existing WR1217519.
    - 66 kV Cables:
        - CANN-01 exit cable already replaced (as part of WR1254348);
        - Incoming CANN-02 under bore Shute Harbour Rd from existing cable term pole with spare conduits for 11 kV and future 66 kV (possible alternate 2nd JUPO feeder route);
        - Cable to existing Transformer 1;
        - Replace existing outgoing Jubilee Pocket 66 kV exit feeder – open trench, suspended or under-bore across creek and Island Drive;
        - Cable to existing Transformer 2; and
        - Recover old cables as far as practical.
- 66 kV CANN – future strategic JUPO Feeder Duplication (not required initially):
    - Construct an additional 66 kV feeder from CANN – JUPO. Utilise existing conduit from the Abell Point term pole (pole 4104853) through to JUPO and proposed cable duplication as part of the Airlie Lagoon conduit/cable;
    - The overhead section from CANN to Abell Point term pole will be difficult to duplicate due to limited space and the difficult terrain to construct the required poles on. Works will be reduced when coordinated with planned TMR work and timeline to duplicate/widen Shute Harbour Road which shares a path for a large portion of the 2nd 66 kV feeder from CANN to JUPO; and
    - Fibre path provision for signalling along 2nd CANN – JUPO feeder if required;
- 66 kV PROS – RIOR and RIOR – CANN Feeder Construction:
    - Construct 66 kV lines to RIOR off from CANN-01 and CANN-02. Will need to acquire the required easements (some sections already acquired).
- Protection/Signalling:
    - PROS to RIOR (CANN-01): Differential Scheme – three ended with PRMI. Single comms channel between PROS and RIOR, however, duplicate comms channel required for PROS – PRMI;
    - PROS to RIOR (CANN-02): Distance Scheme. No comms required;
    - RIOR to CANN to JUPO (CANN-01 + Existing CANN – JUPO Feeder): Distance Scheme. No comms required; and

- RIOR to CANN to JUPO (CANN-02 + New CANN – JUPO Feeder): Distance Scheme. No comms required.

- Allows for future RIOR T3-10 substation to be finished construction at a later date when required. The 66 kV switchyard and feeders will already have been constructed as part of this scope.

7.4.3. Key Assumptions

- Requirement for RIOR construction isn't until 2030/31. Significant uncertainty associated with this assumption due to heavy dependence on population (and therefore load) growth in the Cannonvale and Riordanvale regions;
- Unexpected failure of other devices not mentioned in this scope has not been considered as these have been rated with a 'good' condition by Asset Lifecycle Management;
- The load demand of CANN, JUPO, MORO and SHUT does not unexpectedly increase significantly above the forecasted growth;
- 2nd feeder from CANN to JUPO will initially be a staged conduit installation in conjunction with the staged TMR works and the actual 66 kV feeder installed as demand at JUPO exceeds Safety Net compliance; and
- Easements can be acquired to allow construction of 66 kV incoming and outgoing cables to/from CANN-01 and CANN-02. Easements have already been obtained for some sections of the required routes and discussions are underway with the landowner to obtain remaining easements.

7.4.4. Estimate Cost

Table 26 Non-Eliminated REPEX and OPEX Estimates

Assumed Costs	Estimated Cost
Replace TX Circuit Breakers (REPEX) (ABB)(Est: 000000172145)	$167k (2019/20)
Replace TX CTs (REPEX)	$300k (2026/27)
Replace 66 kV cables	refer to Appendix F
OPEX – Ongoing Outage Response and Manual Switching (loss of CANN-02 or CANN-01 response will be reduced significantly from BAU)	$0k p.a.
Estimated VCR cost	Proposed works result in an expected VCR benefit of $1.319M p.a. The remaining VCR cost is, therefore, $446k p.a.

7.4.5. Risks

- 66 kV cables at CANN fail before they are replaced as part of this project, therefore, escalating costs due to emergency instead of planned replacement;
- RIOR being required earlier than projected due to unexpected load growth. This will decrease the NPV of this option but the decrease will be less than other options due to the 66 kV switching yard having already been constructed;
- There are potential cost savings to be made with the installation of underground conduits between CANN and Abell Point by undertaking this work when TMR are performing upgrades on Shute Harbour Road; and
- The risk of failure of the UG sections of 66 kV feeder between JUPO and MORO+SHUT (Section B and Section C in Figure 23) will be part of a risk management plan which will likely entail duplication of these sections.

7.5. Non-Network Alternatives

Energy Queensland is committed to the implementation of Non-Network Solutions to reduce the scope or need for traditional network investments. Our approach to Demand Management is listed in Chapter 7 of our Distribution Annual Planning Report but involves early market engagement around emerging constraints as well as effective use of existing mechanisms such as the Demand Side Engagement Strategy and Regulatory Investment Test for Distribution (RiT-D). We see that the increasing penetration and improving functionality of customer energy technology, such as embedded generation, Battery Storage Systems and Energy Management Systems, have the potential to present a range of new non-network options into the future.

The primary investment driver for this project is AUGEX, supporting customer growth and network security. A successful Non-Network Solution may be able to assist in reducing the scope or timing for this project. As the cost of options considered as part of this report is greater than $6M this investment will be subject to RiT-D as a mechanism for customer and market engagement on solutions to explore further opportunities.

The customer base in the study area is predominantly residential and tourism and has a medium opportunity to reduce demand or provide economic non-network solutions. There is potential for future load growth resulting from new customer connections in this area if significant economic and/or population growth is experienced.

Non-network alternatives are already in place in the Cannonvale/Airlie Beach region as part of the OIP Cannonvale program. OIP Cannonvale is the delivery of a demand management program during the identified peak load time of 12pm-8pm. The aim of this program is to reduce the load on the Paluma Road, Abel Road and Cannonvale 11 kV feeders from Cannonvale substation and the Foxdale, Strathdickie and Crystal Brook feeders 11 kV from Kelsey Creek substation. This program will allow investment in the new Riordanvale substation to be delayed until a more opportune and economic time.

Expenditure for the proposed project has been modelled as CAPEX and included in the forecast for the current regulatory control period. Funding of any successfully identified NNA solutions will be treated as an efficient OPEX/CAPEX trade-off, consistent with existing regulatory arrangements.

Ergon Energy Corporation Limited ABN 50 087 646 062
Energy Queensland Limited ABN 96 612 535 583
Energex Limited ABN 40 078 849 055

8. PROJECT DEPENDENCIES

WR1217519:

The two existing transformer 66 kV circuit breakers at CANN are ASEA HLC type CBs which have a known explosive failure mode and are part of a network-wide replacement program. These units will no longer need to be replaced as the recommended works will remove this need.

WR1254348:

66 kV Feeder 119 CANN-01 incoming cable at CANN sustained an unassisted failure in March 2017 and a temporary overhead bypass arrangement is currently in place. WR1254348 was completed in November 2018. The recommended works would absorb any future cable replacement projects at CANN with the replacement of all incoming and outgoing 66kV cables, creating corresponding project efficiency gains.

Table 27 Project Dependencies Affecting Future Proposed Work

Project	Project Description	Required by Date
WR1217519	ARP CBRM MK CANN Replace 2 66 kV CBs	Bundled
WR1254348	CANN Cannonvale #1 66 kV Cable Replacement	Completed
WR1363511	MK CANN Cann No 2 66kV Cable Replacement	Pending Scope of Works from WR1274424

9. FINANCIAL ANALYSIS SUMMARY

Table 28 NPV of Options with Forecast VCR ($1.765M Baseline)

$ Millions	Base Case	Option A	Option B	Option C
Capex	(7.75)	(13.45)	(14.18)	(16.25)
Opex	(0.17)	0.00	0.00	0.00
Direct Benefits	0.00	0.00	0.00	0.00
Commercial NPV	**(7.92)**	**(13.45)**	**(14.18)**	**(16.25)**
Ranking	*1*	*2*	*3*	*4*
Indirect/Risk	0.00	14.35	14.35	14.35
Commercial + Risk	**(7.92)**	**0.91**	**0.17**	**(1.90)**
Ranking	*4*	*1*	*2*	*3*

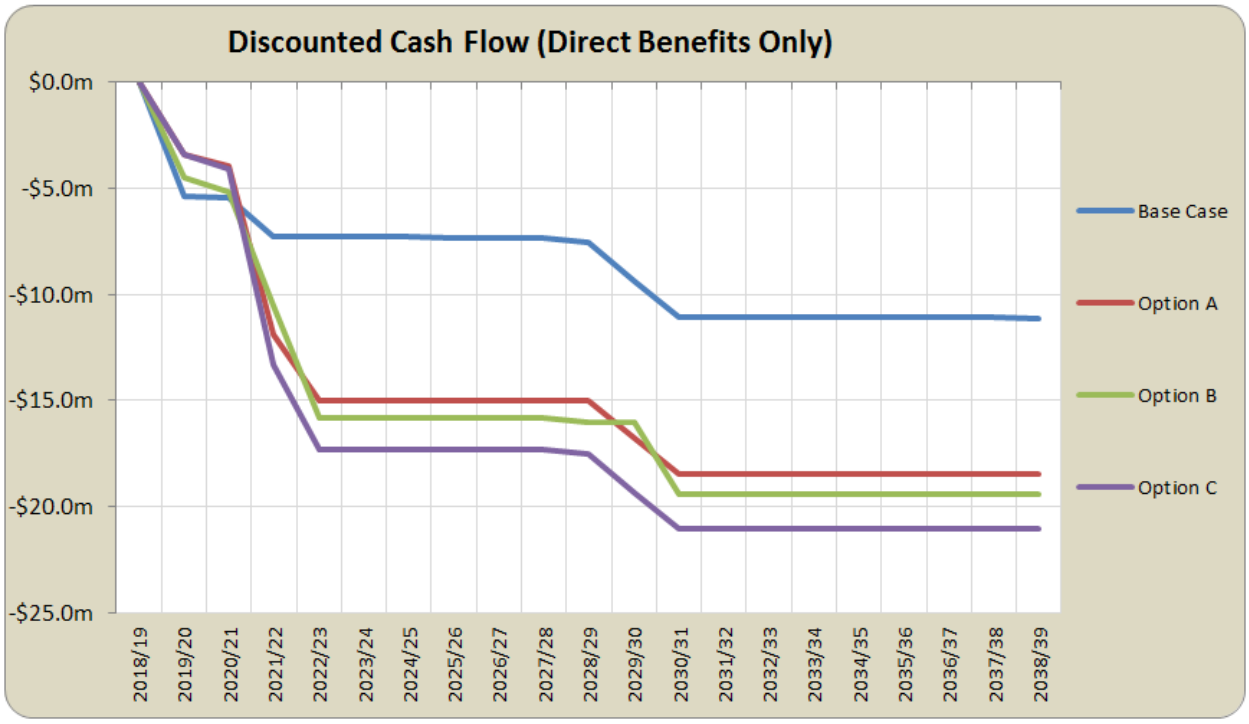

Figure 31 Discounted Cash Flow (Direct Benefits Only) for all Assessed Options (VCR not included)

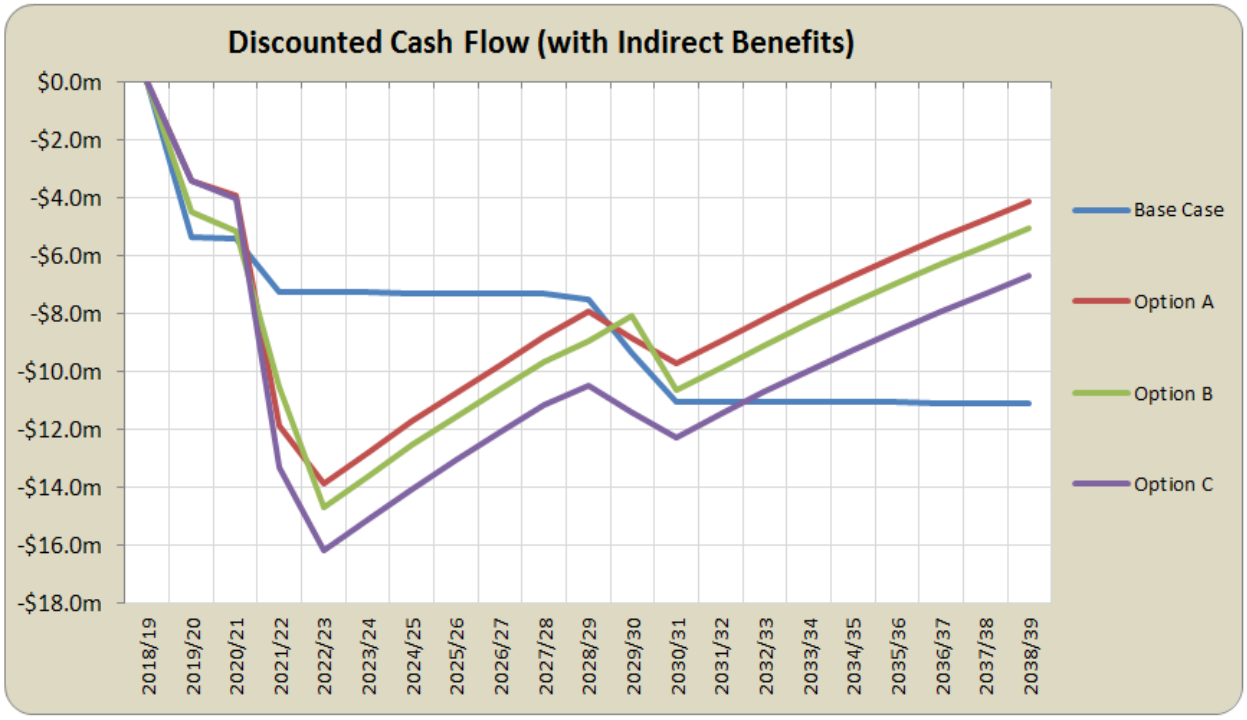

Figure 32 Discounted Cash Flow (with Indirect Benefits) for all Assessed Options (VCR included)

Table 29 NPV of Options with Forecast Low VCR ($1.058M Baseline)

$ Millions	Base Case	Option A	Option B	Option C
Capex	(7.75)	(13.45)	(14.18)	(15.34)
Opex	(0.17)	0.00	0.00	0.00
Direct Benefits	0.00	0.00	0.00	0.00
Commercial NPV	**(7.92)**	**(13.45)**	**(14.18)**	**(15.34)**
Ranking	*1*	*2*	*3*	*4*
Indirect/Risk	0.00	9.09	9.09	9.09
Commercial + Risk	**(7.92)**	**(4.36)**	**(5.09)**	**(6.25)**
Ranking	*4*	*1*	*2*	*3*

A reduced VCR customer economic sensitivity cost analysis was undertaken to review the impact upon options.

Whilst it is anticipated that improvements (i.e. CANN-01 pole top conversion and SCADA automation at PROS/PRMI, 66 kV XLPE cable replacements/duplications, etc.) will improve reliability and VCR, the sensitivity analysis does not change the recommendation.

Option A remains the preferred NPV solution.

A detailed breakdown of the estimate for each option along with the NPV of each option under forecast normal and low VCR scenarios can be found in the following spreadsheets:

CANN BAU_A_B_C_Final_12

WR1274424 Cannonvale 66 kV Pla

WR1274424 Cannonvale 66 kV Pla

10. OPTIONS COMPARISON SUMMARY

Base Case (refer Appendix C)	Business as Usual which includes • Replacement of CANN 66 kV cables; • Duplicated radial 66 kV XLPE cable sections at Airlie Lagoon, Mandalay and the airport; • Ongoing REPEX aligned defects conversion of CANN-01 66 kV pole top to horizontal standoff post insulators; • Staged development (i.e. initially conduits) of the 2nd feeder from CANN to JUPO in co-ordination with TMR timelines; and • RIOR in 2030/31 as simple T3-10 hard 66 kV tee. Not an acceptable solution due to Safety Net concerns, poor reliability and VCR drivers.
Option A (refer Appendix D)	**Recommended:** • Install a 7-Breaker 66 kV GIS at CANN; • Replacement of existing UG sections at CANN as part of 66 kV switchyard works; • Duplicated radial 66 kV XLPE cable sections at Airlie Lagoon, Mandalay and the airport; • Ongoing REPEX aligned defects conversion of CANN-01 66 kV pole top to horizontal standoff post insulators; • Staged development (i.e. initially conduits) of the 2nd feeder from CANN to JUPO in co-ordination with TMR timelines; and • RIOR in 2030/31 as simple T3-10 hard 66 kV tee.
Option B (refer Appendix E)	• Construction of Dedicated 66 kV Feeder from Proserpine 132/66/11 kV Substation to Proserpine Mill 66/11 kV Substation; • Replacement of CANN 66 kV cables; • Duplicated radial 66 kV XLPE cable sections at Airlie Lagoon, Mandalay and the airport; • Ongoing REPEX aligned defects conversion of CANN-01 66 kV pole top to horizontal standoff post insulators; • 2nd 66 kV feeder from CANN to JUPO established by 2022/23; and • RIOR in 2030/31 as switched 66 kV and T3-10 substation.
Option C (refer Appendix F)	• Construct 66 kV switching station at future RIOR site; • Replacement of CANN 66 kV cables; • Duplicated radial 66 kV XLPE cable sections at Airlie Lagoon, Mandalay and the airport; • Ongoing REPEX aligned defects conversion of CANN-01 66 kV pole top to horizontal standoff post insulators; • Staged development (i.e. initially conduits) of the 2nd feeder from CANN to JUPO in co-ordination with TMR timelines; and • RIOR in 2030/31 as simple T3-10 hard 66 kV tee.

	Base Case		Option A		Option B		Option C	
	Advantage	Disadvantage	Advantage	Disadvantage	Advantage	Disadvantage	Advantage	Disadvantage
Safety		CANN: Quasi 66 kV bus switching	Resolves CANN quasi 66 kV bus switching					
Economics	Lowest upfront capital cost Best NPV excl. VCR	Estimated VCR cost of $2.116M/year Significant reputational and brand damage	Best NPV with VCR, 2nd best NPV excl. VCR Allows for staging of the CANN-JUPO 2nd 66 kV feeder - allows co-ordination with TMR project		Reduces VCR impacts in line with Option A	Does not allow staging of CANN-JUPO 2nd 66 kV feeder and will likely incur extra costs due to TMR co-ordination conflicts	Reduces VCR impacts equal with Option A Allows for staging of the CANN-JUPO 2nd 66 kV feeder - allows co-ordination with TMR project	Highest upfront capital cost and worst NPV
Resources	Use normal resources for routine maintenance	Major outage response & restoration impacts	Simplified 66 kV network Reduced 66 kV response & restoration impacts	Major CAPEX resource (design & construction)				Major CAPEX resources (greenfield design and construction)
Utilisation		Does not develop the Airlie Beach region in line with strategic plan JUPO capacity constrained due to 11 kV 'RED' feeders	Brings the Airlie Beach region closer to the future strategic plan			Reduces utilisation of 66 kV network with 3 x 66 kV feeders from PROS	Brings the Airlie Beach region closer to the future strategic plan	Potentially develops assets at RIOR unnecessarily if load growth is not experienced
Other		Significant business impact and cost for island customers due to extended outage Poor MSS 11 kV reliability (i.e. 'RED' status feeders)	Develops access to CANN transformers for future replacement Allows RIOR to be developed as a skid substation with single 66 kV tee (most economic)		Improved reliability for PRMI due to dedicated (shorter) 66 kV feeder	Requires RIOR to be developed as a switched in/out 66 kV tee sub PRMI 66 kV line route approvals	Allows RIOR to be developed as a skid substation with single 66 kV tee (most economic)	

11. CONCLUSION

This Planning Report seeks to present the cost-benefit analysis of feasible options to manage customer reliability, Safety Net and deteriorated/at risk 66 kV XLPE cable assets from CANN to Shute Harbour whilst strategically developing the 66 kV sub-transmission and distribution network in the area.

Option A is the recommended Cannonvale and Jubilee Pocket 66 kV reinforcement solution that will provide the following benefits:

- Manage reliability performance (i.e. MSS 'RED' feeders and VCR); political and public reputation risk and Safety Net compliance of the network;
- Undertake replacement of the deteriorated 66 kV XLPE cables at CANN and duplication/management of the suspect and radial 66 kV XLPE cables (i.e. Airlie Lagoon, Mandalay and airport runway crossing) from CANN to Shute Harbour;
- Stage the installation of conduits for the 2nd 66 kV feeder between CANN and JUPO, closely coordinating with Transport and Main Roads during the Shute Harbour Road development;
- Support ongoing defects remediation under REPEX to convert the lower reliability CANN-01 66 kV timber pole, timber crossarm construction to the higher reliability horizontal standoff or trident urban post insulator construction; and
- Enable future development of RIOR as a single 66 kV T3-10 substation and simple 66 kV tee.

The recommended Option A proposes a fully switched 66 kV yard at CANN including replacement of the 66 kV cables around CANN, duplication and management of the radial 66 kV cables to Shute Harbour (i.e. Airlie Lagoon, Mandalay hill slope and airport runway crossing sections), Shute Harbour Road conduit installation in coordination with TMR for the 2nd 66 kV feeder to JUPO, ongoing defects remediation strategies and strategic development of the future RIOR substation (refer to Appendix D).

The total estimated direct cost for Option A:

- Has a 20-year NPV excluding VCR of $13.45M;
- NPV including VCR: $0.91M (the indirect VCR benefit considered as the nett saving from the baseline); and
- CAPEX to 2024/25 in the 2020-2025 regulatory period: $16.684M including:
    - PROS & PRMI 66 kV remote SCADA auto-reclose disable functionality;
    - PRMI remote control 11 kV Noja recloser and gas switch operation to enable remote PRMI 11 kV transfer of the PRMI Main Street 11 kV feeder to Kelsey Creek substation (i.e. KECE) Proserpine 11 kV feeder;
    - Ongoing REPEX defects replacement of the CANN-01 timber crossarm design with 17.0m poles or inter-poling if required, and horizontal standoff post insulator or in-situ trident urban constructions;
    - CANN Substation:
        - 7 bay switchgear (1 future spare), installed as either GIS or AIS which are cost comparative;
        - Gain permanent approvals for the CANN-01 66 kV bypass and install a N/O bypass to enable maintenance of the CANN to JUPO 66 kV feeder C/B;

        - Separate control-room containing:
            - 66 kV panels and auxiliary equipment; and
            - Space for future 11 kV to enable a full Z6-32, 11 kV switchboard to supplement the existing fully committed 11 kV switch room;
        - Decommission and remove redundant transformer HV switchgear;
        - Decommission and remove redundant HV bus/enclosure with 66 kV ABSs and terminations;
        - Driveway and transformer access set down area to be established around south-west side of the existing building; and
        - Replace deteriorated 66 kV XLPE cables and recover old cables as far as practical.
    - Radial 66 kV XLPE cable duplication of the Airlie Lagoon, Mandalay hill slope and airport runway crossing sections;
    - Future strategic and staged development of the 2nd 66 kV feeder from CANN to JUPO:
        - 66 kV conduit installation works co-ordinated with proposed TMR road widening work (initially between Island Drive to Jones Road – 2022 and Jones Road to Waterson Way by 2031) of Shute Harbour Road; and
        - Fibre path provision for signalling;
    - Protection/Signalling (PROS, PRMI and CANN 3 ended protection scheme); and
    - Consideration for a future RIOR T3-10 66/11 kV substation (i.e. post-2031) via simple 66 kV tee off CANN-02.

11.1. Summary of Need for Investment

There are a number of drivers for the recommended works which are detailed below:

1. The customer base of 7,198 premises including the major international and national holiday destinations of Airlie Beach and Hamilton, Hayman and Daydream Islands are supplied from low-reliability radial 66 kV timber pole (no overhead earthwire) sub-transmission lines that inherently experience regular outages reflective of the 26-27 km line route exposed to cane fires, high rainfall tropical conditions and a salt spray exposed coastal environment;
2. Safety Net obligations to manage supply from the shared asset 66 kV radial cable sections between CANN and Shute Harbour when the suspect XLPE cables are duplicated. Strategically the ultimate fully developed load at JUPO will be in the order of 46 MVA, which under a CANN to JUPO 66 kV cable failure scenario will require restoration of 20 MVA of load within 1 hour and 15 MVA within 6 hours. The time to switch out the faulted cable section to the adjacent duplicate cable installed under this project will not be achieved in 1 hour nor will 20 MVA of load be supplied from the adjacent CANN 11 kV network, as such the justification to strategically develop a 2nd feeder between CANN and JUPO;
3. Over 3 of the last 4 years, over 50 % of the 'Urban' and 'Short Rural' MSS categorised feeders supplied from the 66 kV network have experienced 'Amber' or 'Red' class reliability which has constrained the augmentation of the Airlie Beach 11 kV network;
4. The Value of Customer Reliability (VCR) has been calculated using AEMO fact sheet customer type VCR cost and premise count breakdown at $28/MWh. Over an 8-year long term average assessment (excluding the recent 9 hour outage due to the CANN-01 cable failure and cyclone events), the economic customer cost would be approx. $1.765M annually;
5. As the 66 kV manual transfer between CANN-01 to CANN-02 occurs in the CANN substation and involves staff standing under the 66 kV isolator and in close proximity to the porcelain cable termination (refer to Appendix A), field crews recommend load transfers via the 11 kV or from a de-energised 66 kV due to safety concerns;
6. Laboratory test results of the failed CANN-01 66 kV cable (circa 1981) at CANN exhibit significant XLPE water tree degradation of the XLPE insulation- this cable has been replaced in November 2018 at a DCV cost of $0.9M;
7. Non-destructive tests (Feb. 2018) of the CANN-02 feeder cable (circa 1981) at CANN identified high levels of partial discharge;
8. The remaining three untested, radial and predominantly direct buried 66 kV cables (i.e. Airlie Lagoon, Mandalay hill slope and airport runway crossing) are of the same early vintage (circa 1987) 1st generation XLPE cables that anecdotally used the same build specification and potentially the same manufacturer as the failed and recently tested CANN cables. Whilst these cables are on the priority cable test list, they are planned for duplication;
9. A 66 kV cable failure scenario would take up to 4-6 months to replace due to manufacturing lead times and tourist centre type conduit installation delays. An outage of 4 months would cost approx. $8M including the cost of fuel for diesel generation. Under a short term radial 66 kV cable failure (locate and repair response time of 10-14 days), the cost for generation would be between $0.64-$0.89M for 14 days of operation;
10. CANN-01 is a 66 kV timber pole and crossarm, vertical post insulator no OHEW designed sub-transmission feeder that was constructed in 1984. CANN-02 was constructed in 2000 using timber poles but with horizontal post standoff insulator design. Outage rate statistics and fault type analysis indicates that the timber crossarm

is a major contributor to pole tope fires in both the cane fired and salt spray exposed coastal area. As part of P1/P2/C3 defect remediation cycle, the 1984 constructed CANN-01 design is being progressively converted to the more reliable CANN-02 design. Outage rates are expected to improve from 7.2 outages per 100km-years to 5.1 outages per 100km-years;

11. Co-ordinating the staging of the 2nd 66 kV feeder between CANN to JUPO is necessary to avoid costly future design conflicts and relocations with Transport and Main Roads (TMR) who are proposing a 2022 business case timeline completion (for the Island Drive to Jones Road section) and by 2031 (for the Jones Road to Waterson Way section) along Shute Harbour Road that the proposed 66 kV route shares a common alignment with. Requiring the 2nd 66 kV feeder in an earlier timeline will likely result in TMR design and approval hurdles in addition to lost opportunity cost efficiencies installing the conduits along a jointly agreed alignment; and
12. The cost optimisation and timing of the future RIOR 66/11 kV substation connection requires consideration when developing the overall solution to the issues described.

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11.2. Summary of Feasible Options

Four main options have been explored in the planning report:

- Base Case BAU (refer to Appendix C):
  - Replacement through aged asset replacement and RTS projects;
  - Replace deteriorated CANN (circa 1981) 66 kV XLPE cables;
  - Duplicate at risk Airlie Lagoon, Mandalay and airport runway crossing 66 kV XLPE cables (circa 1987);
  - Continue REPEX pole top conversion strategy;
  - CANN to JUPO 2nd feeder 66 kV conduit installation in conjunction with TMR;
  - Undertake PRMI and PROS SCADA remote control Noja 11 kV Main St. 11 kV feeder transfers and remote 66 kV auto-reclose disablement at PROS; and
  - Continue outage and operational response.

- Option A: CANN 66 KV GIS / AIS SWITCHING STN, (REPLACE AT RISK 66 kV CABLES) (refer to Appendix D):
  - Fully switched 66 kV bus at CANN, replace deteriorated CANN 66 kV XLPE cables (circa 1981);
  - Duplicate at risk Airlie Lagoon, Mandalay and airport runway crossing 66 kV XLPE cables (circa 1987);
  - Continue REPEX pole top conversion strategy;
  - CANN to JUPO 2nd feeder 66 kV conduit installation in conjunction with TMR;
  - Undertake PRMI and PROS SCADA remote control Noja 11 kV Main St. 11 kV feeder transfers and remote 66 kV auto-reclose disablement at PROS; and
  - Strategically enable protection to integrate a T3-10, single 66 kV tee at RIOR.

- Option B: DEDICATED 66 kV PROS to PRMI, (REPLACE AT RISK 66 kV CABLES) (refer to Appendix E):
  - 66 kV feeder bay at PROS;
  - 66 kV feeder from PROS to PRMI;
  - Install CANN to JUPO 2nd feeder 66 kV cable and conduit installation which will not align with TMR works program;
  - Undertake 3-way protection scheme (i.e. PROS, double tee to CANN and JUPO);
  - Replace deteriorated CANN (circa 1981) 66 kV XLPE cables;
  - Duplicate at risk Airlie Lagoon, Mandalay and airport runway crossing 66 kV XLPE cables (circa 1987);
  - Continue REPEX pole top conversion strategy;
  - Undertake PRMI and PROS SCADA remote control Noja 11 kV Main St. 11 kV feeder transfers and remote 66 kV auto-reclose disablement at PROS; and
  - Strategically enable protection to integrate T3-10, switched in/out 66 kV tee at RIOR.

- Option C: RIOR 66 kV SWITCHING STATION (REPLACE AT RISK 66 kV CABLES) (refer to Appendix F):
    - Fully switched 66 kV bus at RIOR;
    - Replace deteriorated CANN 66 kV XLPE cables (circa 1981);
    - Duplicate at risk Airlie Lagoon, Mandalay and airport crossing runway 66 kV XLPE cables (circa 1987);
    - Continue REPEX pole top conversion strategy;
    - CANN to JUPO 2nd feeder 66 kV conduit installation in conjunction with TMR;
    - Undertake PRMI and PROS SCADA remote control Noja 11 kV Main St. 11 kV feeder transfers and remote 66 kV auto-reclose disablement at PROS;
    - Continue existing switching and operation strategy which now applies from RIOR to CANN/JUPO; and
    - Strategically enable protection to integrate T3-10, single 66 kV tee at RIOR.

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APPENDIX A: GENERAL NETWORK INFORMATION

Figure A1: Cannonvale - Front of Substation and Cable-Creek Crossing Location

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Figure A2: 66 kV Bus Tie Isolator ABS Operating Arm on the Other Side of Wall Adjacent that Cable Termination (Working Clearance Issues)

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Figure A3 66 kV Feeder Tie (Failed CANN-01 Cable Out of Service – Droppers Removed)

Figure A4 Transformer No. 2 Oil Leak

Figure A5 Control Room (No Spare Panel Space)

Figure A6 Amenities and Workshop (Some Potential Panel Space)

Figure A7 11 kV Switchboard Transformer 1 Bus

Figure A8 11 kV Switchboard Transformer 2 Bus

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Figure A9 Indoor GIS Berserker Substation

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Figure A10 Outdoor GIS

Figure A11 Outdoor GIS South Toowoomba (Same as ex Moranbah Stock)

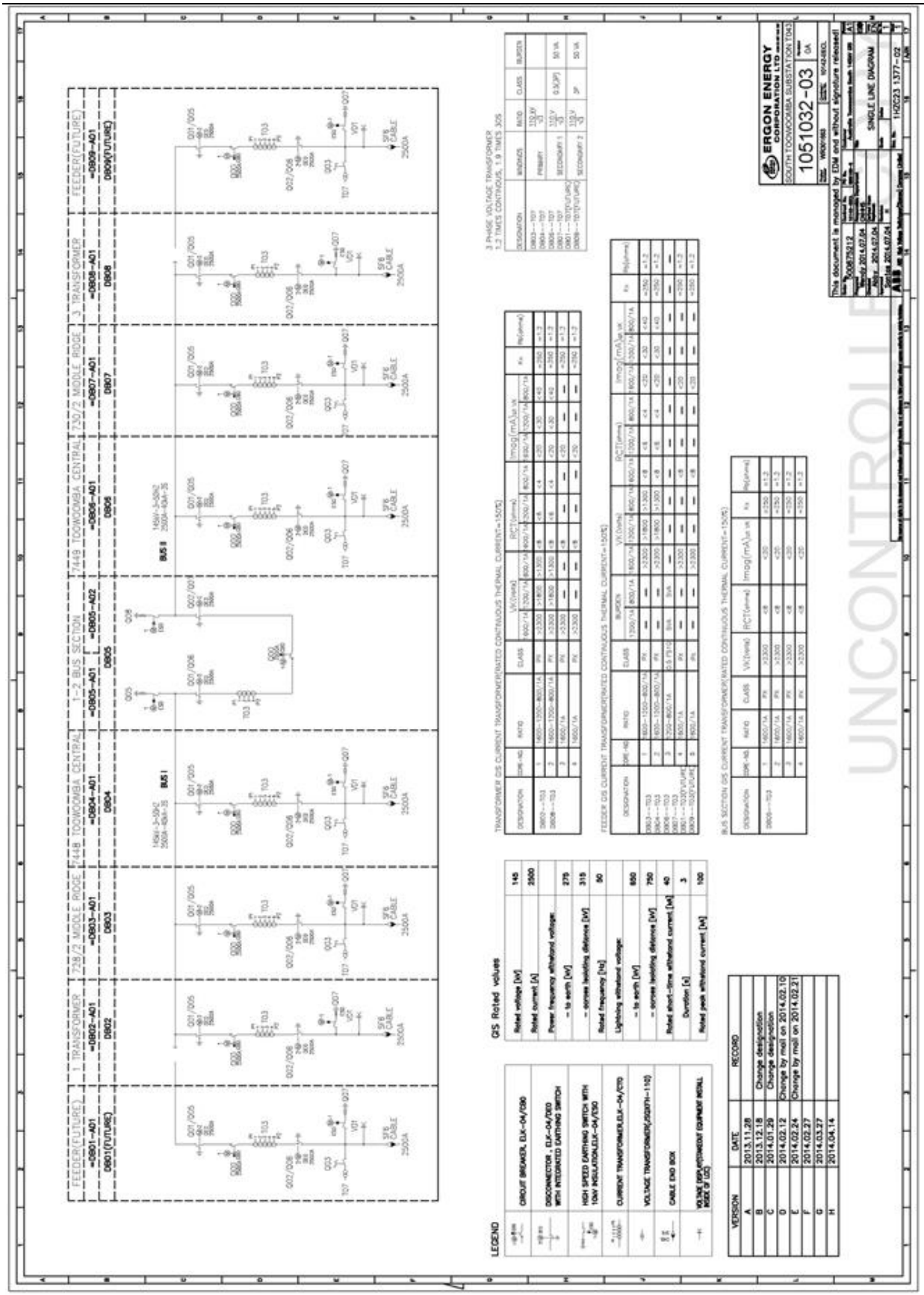

Figure A12 South Toowoomba GIS Schematic

Figure A13 CANN-01 Typical O/H Build – Vertical Post Insulators

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Figure A14 CANN-02 Typical O/H Build – Horizontal Post Stand-Off Insulators

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Figure A15 CANN-01 & CANN-02 Trident Build in Cannonvale

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Figure A16 CANN-01 (JUPO to Shute Harbour) Typical Build

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APPENDIX B: VCR VALUE ANALYSIS

The Value of Customer Reliability calculated for this analysis is $28/kWh. This estimate is based on the customer mix shown in Table B1 and the VCR values for different customer types shown in Table B2 as published by AEMO in the following factsheet.

AEMO_FactSheet_ValueOfCustomerReliabi

Table B1 Airlie Beach Supply Region 2016/17 Customer Breakdown

Substation	Number of Premises	Domestic Premises	Commercial Premises	Industrial Premises
CANN	5,504	4,573	0	930
JUPO	1,515	1,335	0	180
MORO	78	55	0	22
SHUT	0	0	0	0
PRMI	114	42	0	72
Total	**7,211**	**6,005**	**0**	**1,204**

Table B2 AEMO VCR Values for Different Customer Types

Sector	$/kWh	VCR ($/MWh)
Domestic	$25.42	$25,420
Commercial	$44.72	$44,720
Industrial	$44.06	$44,060
Rural	$47.67	$47,670

$$VCR = \frac{(Domestic\ No.of\ Customers\ x\ VCR\ value) + (Industrial\ No.of\ Customers\ x\ VCR\ value)}{Total\ number\ of\ Customers}$$

$$VCR \approx \$28/kWh$$

$$VCR = \frac{(1204 \times 44) + (6005 \times 25)}{7211}$$

Note: the calc. is 2 customers short and immaterial.

CANN-01 & 02 66 kV network: Total Customers of 7211

- 6005 domestic customers;
- 1204 industrial/commercial customers; and
- $28/kWh.

APPENDIX C: BAU – CONTINUE WORK AS REQUIRED (REPLACE AT RISK 66 KV CABLES)

BAU is not the recommended solution as the inherent reliability and VCR cost is not resolved. JUPO 'Urban' feeders will continue as 'RED' feeder status from commissioning thus constraining the use of the JUPO asset to unload CANN. The high risk 66 kV cable sections have been replaced.

BAU:

- CAPEX to the end of the AER period 2024/25: $7.679M (all costs are DCV);
- Replace deteriorated CANN (circa 1981) and duplicate at risk Airlie Lagoon, Mandalay and airport 66 kV cables (circa 1987);
- JUPO 'Urban' feeders inherently are 'RED' MSS feeders upon commissioning;
- Strategically enables RIOR as a T3-10, single transformer tee off the 66 kV.

Base Case Return to Process Page **Non-Escalated DIRECT COSTS (DCV) to be used for all budget inputs**

Description	Assumptions	Asset Life (yrs)	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Capex										
Replace TX Circuit Breakers (REPEX) (ABB)(Est: 000000172145)		50				167,057				
Replace TX CTs (REPEX)		50								
Replace 66 kV cable- CANN-01 to iso. WIP (2018)	WIP (114m)	45								
Replace 66 kV cable - CANN	CANN-01 to JUPO (150m length)	45		900,000						
Replace 66 kV cable - CANN	CANN-02 to CANN 1T (130m length)	45		900,000						
Replace 66 kV cable - CANN	66 kV isolator to 2T (30m)	45		237,000						
Replace 66 kV cable (pole 4104853 to lagoon)	725m conduits, 1070m cable	45		2,076,000						
Riordanvale 66/11 kV Substation Construction		50								
TMR- Shure Harbour conduits	S1- 0.9km 2022, S2- 1.3km 2030	45				1,913,000				
Mandalay & Airport duplication	186m & 380m run	45		1,486,000						
TOTAL IMPLEMENTATION COSTS (real)			0	5,599,000	0	2,080,057	0	0	0	0
TOTAL IMPLEMENTATION COSTS (nominal)			0	5,738,975	0	2,239,994	0	0	0	0
TOTAL IMPLEMENTATION COSTS (discounted)			0	5,386,686	0	1,852,289	0	0	0	0

Opex			2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Extra 66 kV switcing	12,800			12,800	12,800	12,800	12,800	12,800	12,800	12,800

Indirect Benefits			2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
VCR Benefits	Per Analysis		0	0	0	0	0	0	0	0
Existing VCR- 8 year av.: Value $2116000pa but delta	-		0	0	0	0				
VCR- 8 yr av. less REPEX 66 kV cables: base case of $1.765Mpa	-						0	0	0	0

Figure C1 BAU - Direct Cost and Indirect VCR Benefits NPV

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DCV costs

Item	ZS	Description	WR / Estimate No.	Estimate Description	Unit DC Price ($ M)	Quantity	Year of Spend	DC Cost ($ M)	Comments
1	CANN	Replace 66 kV cables- CANN-01 to isolator bus	WR1254348	D-Feeder Cable - Upgrade/Replace	899548	0	2017/18	0.000	WIP- 12/2018 (114m run)
1	CANN	Replace 66 kV cables- outgoing CANN-01 to JUPO	ex-WR1254348	includes terms.	899548	1	2019/20	0.900	169m run to termination pole
2	"	Replace 66 kV cables- incoming CANN-02 to 1T	ex-WR1254348	includes terms.	899548	1	"	0.900	140m run, conduits under highway
3	"	Replace 66 kV cables-isolator to 1T	ex-WR1254348	includes terms.	236723	1	"	0.237	30m run to 1T term. structure
4	Airlie lagoon cable	Duplicate Abell Point to Port of Airlie 66 kV cable (pole 4104853 to 6030159)	Conduit costs ONLY	Historical costs	2125000	0.725	"	1.541	
5	"	Cable install and joint costs		Use Option 1F est.	500000	1.07	"	0.535	630Cu
6	Mandalay	Mandalay conduits only	Conduit costs ONLY	Historical costs	2125000	0.186	"	0.395	
7	"	Cable install and joint costs		Use Option 1F est.	500000	0.186	"	0.093	630Cu
8	Airport	Airport conduits only	Conduit costs ONLY	Historical costs	2125000	0.38	"	0.808	
9	"	Cable install and joint costs		Use Option 1F est.	500000	0.38	"	0.19	630Cu
10	TMR- S1	TMR Section 1- Island Dr. to Jones Rd	Conduit costs ONLY	Historical costs	2125000	0.9	2021/22	1.913	Progressive install with TMR works
11	CANN	66 kV CTs		REPEX	300000	1	2028/29	0.300	CT replace
12	TMR- S2	TMR Section 2- Jones Rd to Mazlin St.	Conduit costs ONLY	Historical costs	2125000	1.3	2029/30	2.763	"
13	RIOR	Single 10 MVA tee substation	WR317031 Gracemere	T3-10	2688267	1	"	2.688	Re-inforce RIOR area
14								0.000	
15								0.000	
16								0.000	
		Projects - detailed estimates							
1	CANN	CANN Cannonvale #1 66 kV Cable Replacement	WR1254348	Replace failed CANN-01 66 kV cable to CANN	899548	1	2017/18		WIP
2	"	ARP CBRM MK CANN Replace 2 66 kV CBs	WR1217519	Replace existing 66 kV Tfer c/bs'	167000	1	2021/22	0.167	
3	"							0.000	
Total		**BAU: Estimated Cost**						**13.427**	

Table C2 CAPEX Estimated Cost of Works (Direct Costs)

APPENDIX D: OPTION A – CANN 66 KV GIS SWITCHING STN (REPLACE AT RISK 66 KV CABLES)

Option A is the recommended solution which is anticipated to provide a strategic network development benefit by allowing the future RIOR 66/11 kV substation to be developed a single T3-10 tee substation.

Option A:

- CAPEX to the end of the AER period 2024/25: $16.684M (all costs are DCV);
- Integrates GIS install with replacement of problematic CANN 66 kV cables (circa 1981);
- Duplicate at risk Airlie Lagoon, Mandalay and airport 66 kV cables (circa 1987);
- Strategically enables RIOR as a T3-10, single transformer tee off the 66 kV; and
- Results in significant reliability and VCR improvement.

Option A Return to Process Page **Non-Escalated DIRECT COSTS (DCV) to be used for all budget inputs**

Option Title:	66 kV Switchyard Upgrade at Cannonvale 66/11 kV Substation
Option Short Description:	CANN GIS + at risk 66 kV cable replacement

*Note: Font in red indicates costs are outside of the evaluation period (From 'Inputs & Assumptions' tab)

Description	Assumptions	Asset Life (yrs)	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Capex										
GIS @ CANN + comms.	building, GIS, cables- ex Opt 1B	50			562,000	7,002,000	3,645,000			
TMR- Shure Harbour conduits	S1- 0.9km 2022, S2- 1.3km 2030	45				1,913,000				
Mandalay & Airport duplication	186m & 380m run	45		1,486,000						
Replace 66 kV cable (pole 4104853 to lagoon)	725m conduits, 1070m cable	45		2,076,000						
RIOR 66/11 kV Subtstation Construction		50								
TOTAL IMPLEMENTATION COSTS (real)			**0**	**3,562,000**	**562,000**	**8,915,000**	**3,645,000**	**0**	**0**	**0**
TOTAL IMPLEMENTATION COSTS (nominal)			**0**	**3,651,050**	**590,451**	**9,600,480**	**4,023,398**	**0**	**0**	**0**
TOTAL IMPLEMENTATION COSTS (discounted)			**0**	**3,426,929**	**520,186**	**7,938,800**	**3,122,786**	**0**	**0**	**0**

Opex			2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26

Indirect Benefits			2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
VCR Benefits	Per Analysis		0	0	0	0	0	0	0	0
Existing VCR- 8 year av.: Base case $2116000pa			0	0	0	0				
VCR- 8 yr av. less REPEX 66 kV cables: Base case less saving		1,319,000					1,319,000	1,319,000	1,319,000	1,319,000

Figure D1 Option A - Direct Cost and Indirect VCR Benefits NPV

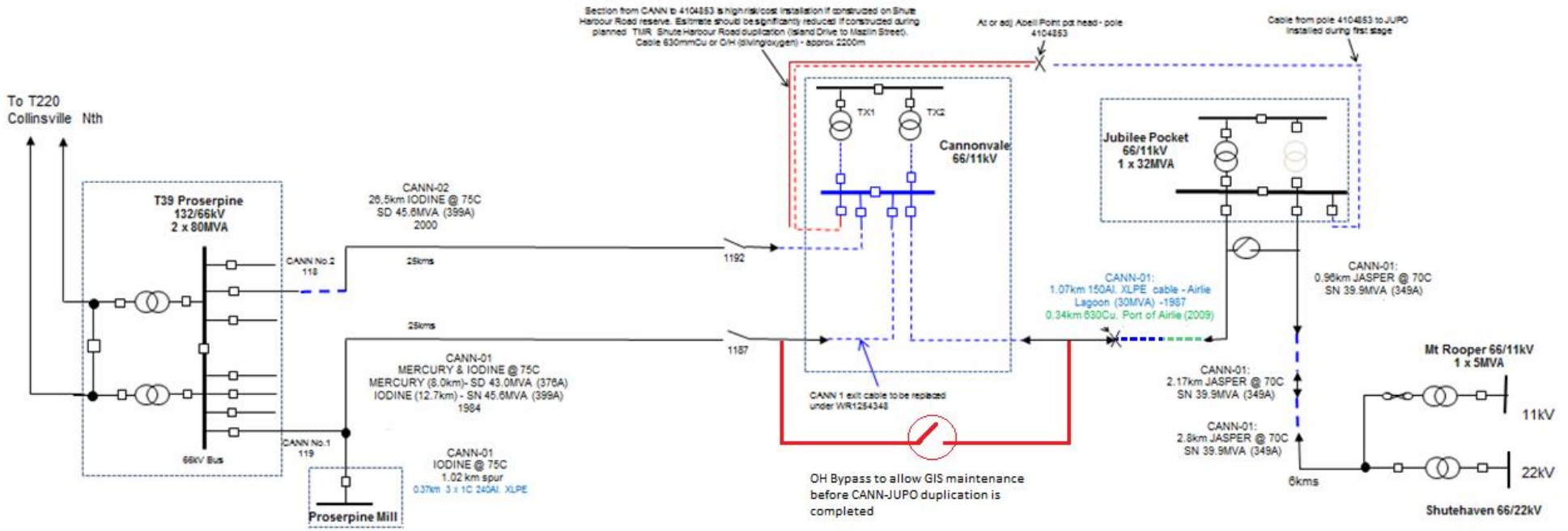

Figure D2 Single Line Diagram of Single 66 kV

Table D3 CAPEX Estimated Cost of Works (Direct Costs)

DCV costs

Item	ZS	Description	WR / Estimate No.	Estimate Description	Unit DC Price ($ M)	Quantity	Year of Spend	DC Cost ($ M)	Comments
1	CANN	Replace 66 kV cables- CANN-01 to isolator bus	WR1254348	D-Feeder Cable - Upgrade/Replace	899548	0	2017/18	0.000	WIP- 12/2018 (114m run)
2	Airlie lagoon cable	Duplicate Abell Point to Port of Airlie 66 kV cable (pole 4104853 to 6030159)	Conduit costs ONLY	Historical costs	2125000	0.725	2019/20	1.541	
3	"	Cable install and joint costs		Use Option 1F est.	500000	1.07	"	0.535	630Cu
4	Mandalay	Mandalay conduits only	Conduit costs ONLY	Historical costs	2125000	0.186	"	0.395	
5	"	Cable install and joint costs		Use Option 1F est.	500000	0.186	"	0.093	630Cu
6	Airport	Airport conduits only	Conduit costs ONLY	Historical costs	2125000	0.38	"	0.808	
7	"	Cable install and joint costs		Use Option 1F est.	500000	0.38	"	0.19	630Cu
8	CANN	CANN GIS	modified estimate 1B	cashflow based on est.	561858	1	2020/21	0.562	
				"	7002615	1	2021/22	7.003	CANN GIS project
				"	3645027	1	2022/23	3.645	
9	TMR- S1	TMR Section 1- Island Dr. to Jones Rd	Conduit/cable costs	Historical costs	2125000	0.9	2021/22	1.913	Progressive install with TMR
10	TMR- S2	TMR Section 2- Jones Rd to Mazlin St.	Conduit/cable costs	Historical costs	2125000	1.3	2029/30	2.763	"
11	RIOR	Single 10 MVA tee substation	WR317031 Gracemere	T3-10	2688267	1	2030/31	2.688	Re-inforce RIOR area
12								0.000	
13								0.000	
		Projects - detailed estimates							
1	CANN	CANN Cannonvale #1 66 kV Cable Replacement	WR1254348	Replace failed CANN-01 66 kV cable to CANN	899548	0	"	0.000	WIP
2	"	ARP CBRM MK CANN Replace 2 66 kV CBs	WR1217513	Replace existing 66 kV Tfer c/bs'	167000	0	2020/21	0.000	
3	"							0.000	
Total		**Option A: Estimated Cost**						**22.134**	

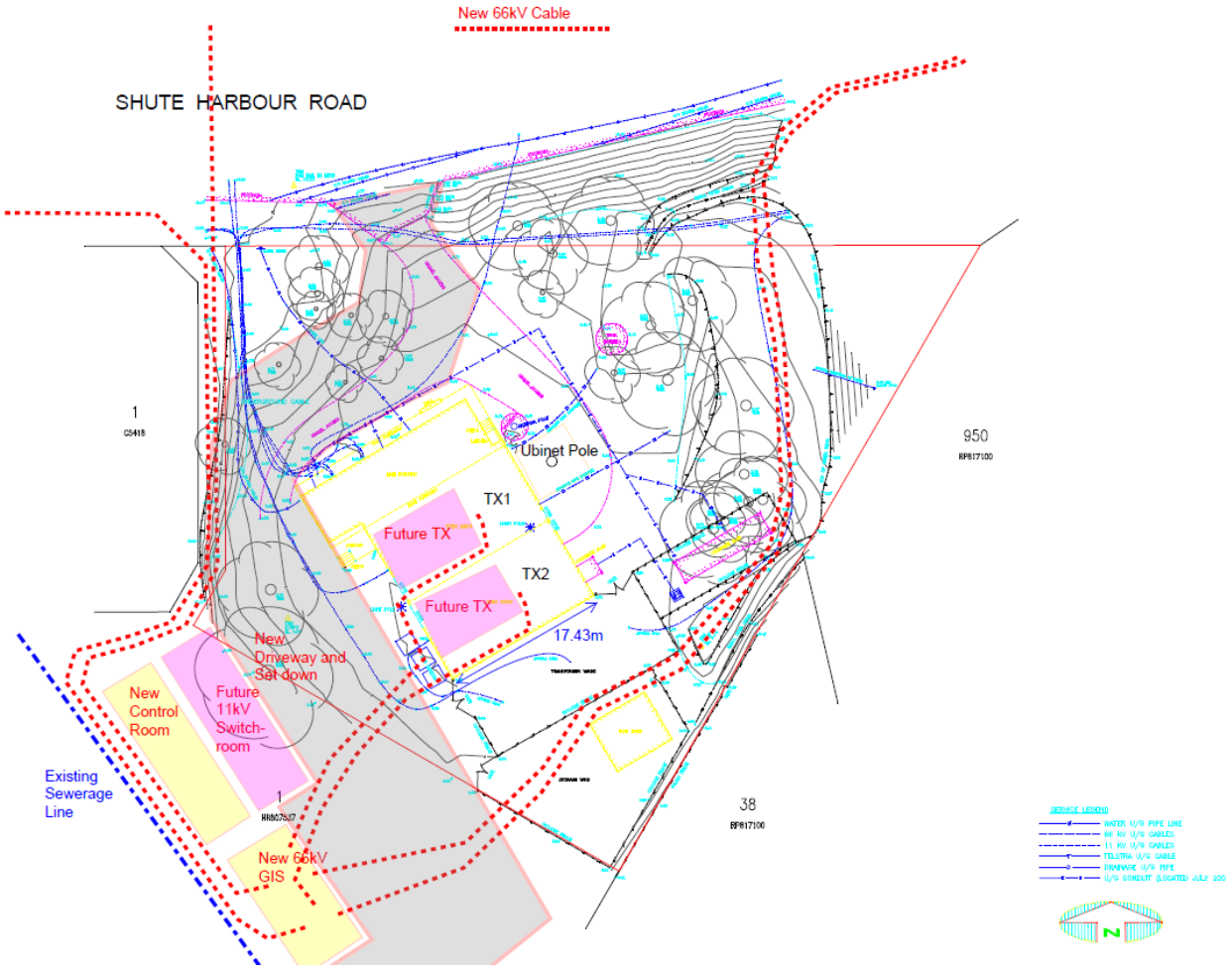

Figure D4 Proposed CANN Substation Layout with a GIS 66 kV Switchyard

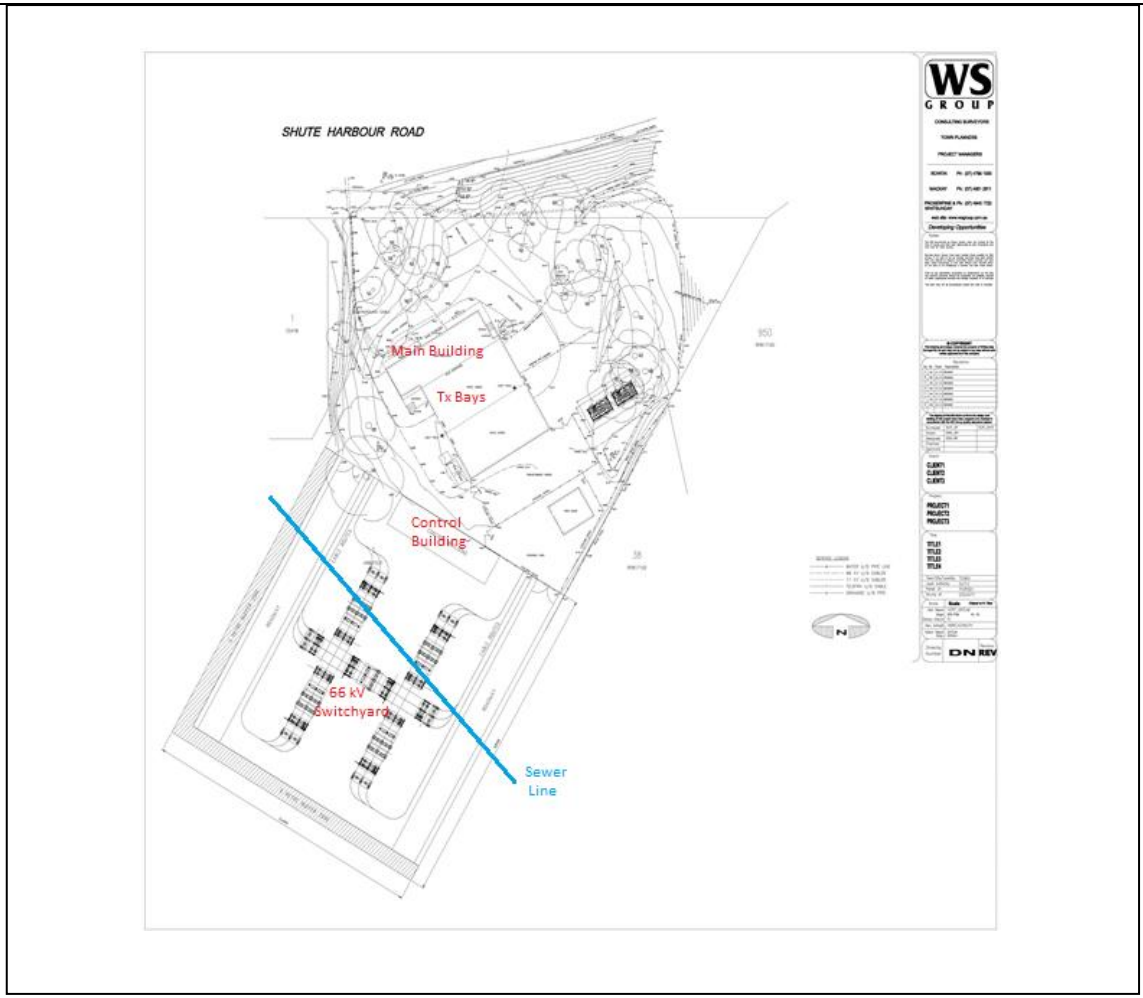

Figure D5 Proposed CANN Substation Layout with an AIS 66 kV Switchyard (not included in this report due to significant cost to relocate sewer line)

APPENDIX E: OPTION B - DEDICATED 66 KV PROS TO PRMI (REPLACE AT RISK 66 KV CABLES)

Option B is not the recommended solution. Whilst it enables CANN to operate as a double tee substation with VCR benefits, the proposed works has a higher upfront CAPEX, increases the complexity of connecting RIOR (i.e. T3-10 substation becomes a more costly switched In/Out 66 kV connection), requires 66 kV route approvals near PRMI and along Shute Harbour Road which are high risk.

Option B:

- CAPEX to the end of the AER period 2024/25: $17.614M (all costs are DCV);
- Removes PRMI from CANN-01 66 kV thus enabling CANN-01 and CANN-02 to supply CANN as a double 66 kV tee;
- Replace deteriorated CANN (circa 1981) and duplicate at risk Airlie Lagoon, Mandalay and airport 66 kV cables (circa 1987);
- Increases future RIOR connection costs as a T3-10 (i.e. switched 66 kV tee); and
- Whilst there are significant reliability and VCR improvement, high-risk approvals for 66 kV route approvals.

Option B Return to Process Page **Non-Escalated DIRECT COSTS (DCV) to be used for all budget inputs**

Option Title:	Construction of Dedicated 66 kV Feeder from Proserpine 132/66/11 kV Substation to Proserpine Mill 66/11 kV Substation
Option Short Description:	

*Note: Font in red indicates costs are outside of the evaluation period (From 'Inputs & Assumptions' tab)

Description	Assumptions	Asset Life (yrs)	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Capex										
66 kV Bay @ PROS + new 66 kV DCCP to PRMI tee	ex Option 3a	50			695,000	3,502,000	1,835,000			
Comms Work @ CANN, PROS, JUPO, PRMI										
TMR- Shure Harbour conduits & cable	S1- 0.9km 2022, S2- 1.3km 2030	45				2,372,000	3,426,000			
Mandalay & Airport duplication, complete lagoon to JUPO	186m & 380m & 1800m run	45		1,486,000			918,000			
Replace 66 kV cable (pole 4104853 to lagoon)	725m conduits, 1070m cable	45		2,076,000						
CANN works + RIOR 66/11 kV Substation Construction	CANN Tfer c/b & CT, RIOR 2030/31	50				167,000				
Replace 66 kV cable - CANN	CANN-02 to CANN 1T (130m length),	45		1,137,000						
TOTAL IMPLEMENTATION COSTS (real)			0	4,699,000	695,000	6,041,000	6,179,000	0	0	0
TOTAL IMPLEMENTATION COSTS (nominal)			0	4,816,475	730,184	6,505,496	6,820,460	0	0	0
TOTAL IMPLEMENTATION COSTS (discounted)			0	4,520,814	643,291	5,379,505	5,293,743	0	0	0

Opex			2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26

Indirect Benefits			2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
VCR Benefits	Per Analysis		-	-	-	-	-	-	-	-
Existing VCR- 8 year av.: Base case $2116000pa	-		0	0	0	0				
VCR- 8 yr av. less REPEX 66 kV cables: Base case less saving	1,319,000						1,319,000	1,319,000	1,319,000	1,319,000

Figure E1 Option B - Direct Cost and Indirect VCR Benefits NPV

Ergon Energy Corporation Limited ABN 50 087 646 062
Energy Queensland Limited ABN 96 612 535 583
Energex Limited ABN 40 078 849 055

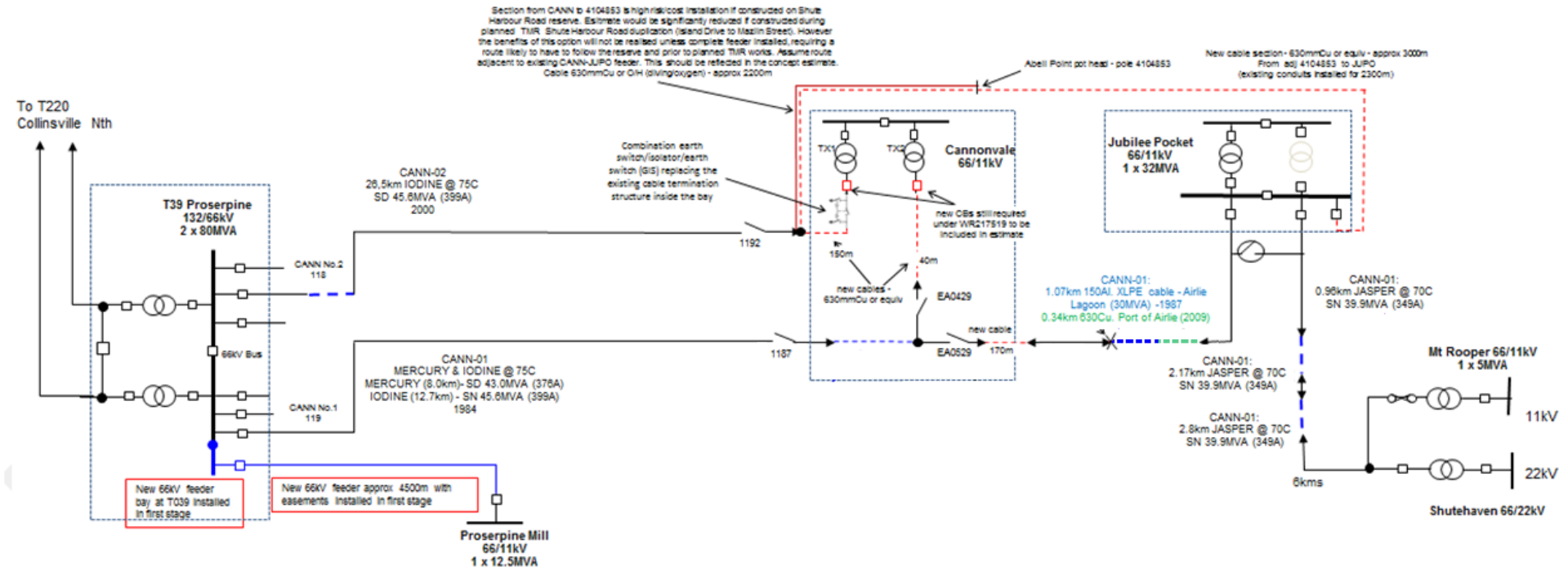

Figure E2 Single Line Diagram of PRMI and Shute Harbour Rd 66 kV

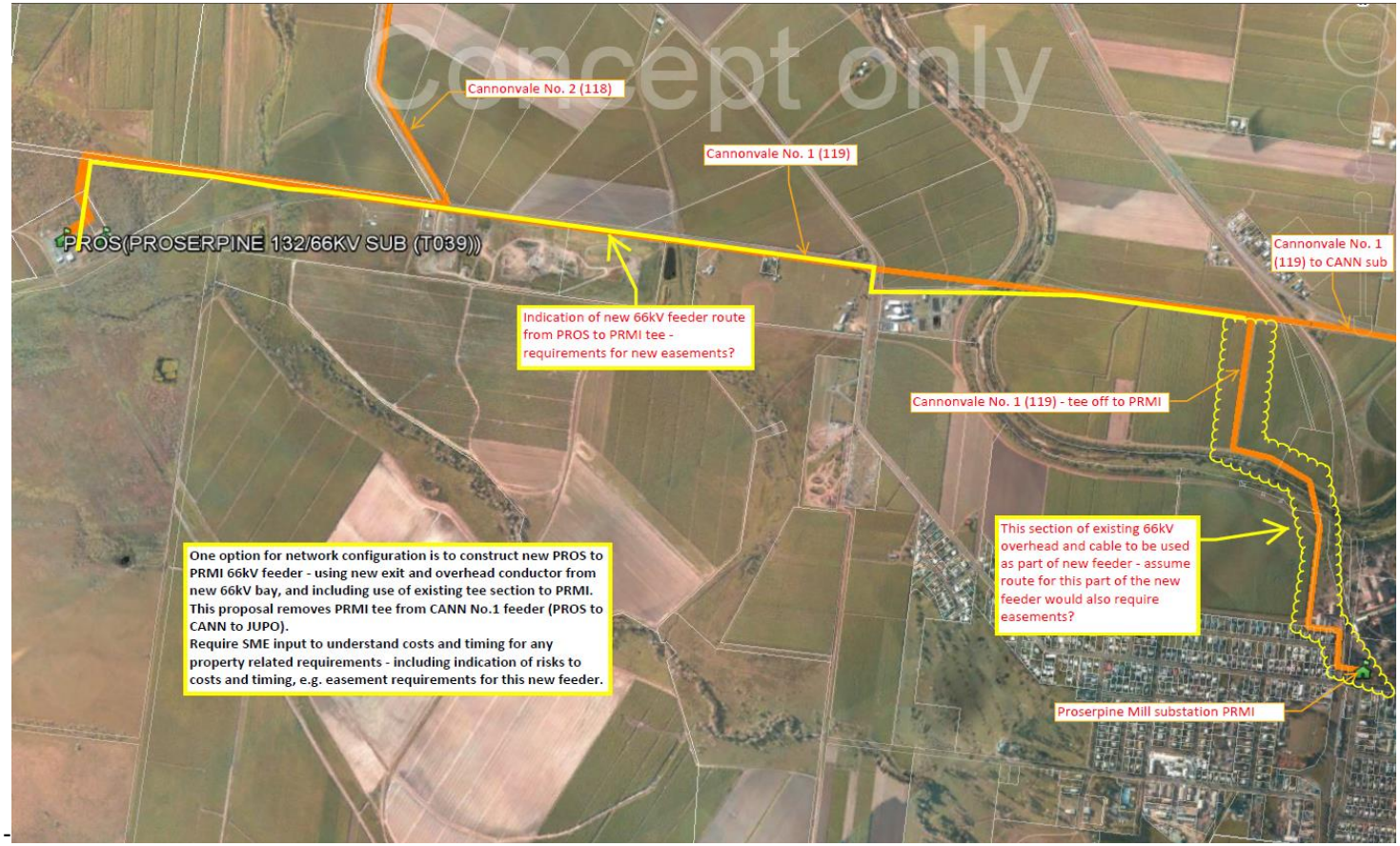

Figure E3 Proposed PRMI Duplicate 66 kV Feeder Route

Table E4 CAPEX Estimated Cost of Works (Direct Costs)

DCV costs

Item	ZS	Description	WR / Estimate No.	Estimate Description	Unit DC Price ($ M)	Quantity	Year of Spend	DC Cost ($ M)	Comments
1	CANN	Replace 66 kV cables- CANN-01 to isolator bus	WR1254348	D-Feeder Cable - Upgrade/Replace	899548	0	2017/18	0.000	WIP- 12/2018 (114m run)
2	Airlie lagoon cable	Duplicate Abell Point to Port of Airlie 66 kV cable (pole 4104853 to 6030159)	Conduit costs ONLY	Historical costs	2125000	0.725	2019/20	1.541	
3	"	Cable install and joint costs	cable costs	Use Option 1F est.	500000	1.07	"	0.535	630Cu
4	Mandalay	Mandalay conduits only	Conduit costs ONLY	Historical costs	2125000	0.186	"	0.395	
5	"	Cable install and joint costs	cable costs	Use Option 1F est.	500000	0.186	"	0.093	630Cu
6	Airport	Airport conduits only	Conduit costs ONLY	Historical costs	2125000	0.38	"	0.808	
7	"	Cable install and joint costs	cable costs	Use Option 1F est.	500000	0.38	"	0.19	630Cu
8	CANN	Replace 66 kV cables- incoming CANN-02 to 1T	ex- WR1254348	includes terms.	899548	1	"	0.900	140m run, conduits under highway
9	"	Replace 66 kV cables-isolator to 1T	ex- WR1254348	includes terms.	236723	1	"	0.237	30m run to 1T term. structure
10	"	PRMI works	modified estimate 3A	cashflow based on est.	694581	1	2020/21	0.695	PRMI dedicated 66 kV
				"	3502194	1	2021/22	3.502	
				"	1834980	1	2022/23	1.835	
11	TMR- S1	TMR Section 1- Island Dr. to Jones Rd	Conduit costs	Historical costs	2125000	0.9	2021/22	1.913	Progressive install with TMR works
12	"	"	cable costs	Historical costs	510000	0.9	"	0.459	"
13	TMR- S2	TMR Section 2- Jones Rd to Mazlin	Conduit costs	Historical costs	2125000	1.3	2022/23	2.763	Progressive install with TMR works
14	"	"	cable costs	Historical costs	510000	1.3	"	0.663	"
15	JUPO	Mazlin St. to JUPO	cable costs	Historical costs	510000	1.8	"	0.918	
16	CANN	66 kV CTs		REPEX	300000	1	2028/29	0.300	CT replace
17	RIOR	Single 10 MVA tee substation	WR317031 Gracemere	T3-10	2688267	1	2030/31	2.688	Re-inforce RIOR area
18	"	Switched 66 kV	S_132FDR_OD	SUB 132kV FDR BAY	1082530	2	"	2.165	To enable 3 ended diff or distance
19	"	Cable in / out of 66 kV	Conduit costs ONLY	Historical costs	2125000	0.2	"	0.425	
20	"		cable costs	Use Option 1F est.	500000	0.2	"	0.100	
21								0.000	
22								0.000	
23								0.000	
		Projects – detailed estimates							
1	CANN	CANN Cannonvale #1 66 kV Cable Replacement	WR1254348	Replace failed CANN-01 66 kV cable to CANN	899548	0	"	0.000	WIP
2	"	ARP CBRM MK CANN Replace 2 66 kV CBs	WR1217519	Replace existing 66 kV Tfer c/bs'	167000	1	2020/21	0.167	
3	"							0.000	
Total		**Option B: Estimated Cost**						**23.290**	

APPENDIX F: OPTION C - RIOR 66 KV SWITCHING STATION (REPLACE AT RISK 66 KV CABLES)

Option C is not the recommended solution. Whilst it enables CANN to operate as a double tee substation with VCR benefits, the proposed works has a higher upfront CAPEX to establish RIOR and has increased exposure to the downstream 66 kV line.

Option C:

- CAPEX to the end of the AER period 2024/25: $21.111M (all costs are DCV);
- Replace deteriorated CANN (circa 1981) and duplicate at risk Airlie Lagoon, Mandalay and airport 66 kV cables (circa 1987);
- Has significant upfront CAPEX; and
- Whilst there are significant reliability and VCR improvement, there is an extra 66 kV exposure to downstream JUPO.

Option C Return to Process Page **Non-Escalated DIRECT COSTS (DCV) to be used for all budget inputs**

Description	Assumptions	Asset Life (yrs)	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Capex										
New RIOR 66 kV switched site	ex Est. 4	50			686,000	8,330,000	4,690,000			
Comms Work @ CANN, PROS, JUPO, PRMI										
TMR- Shure Harbour conduits & cable	S1- 0.9km 2022, S2- 1.3km 2030	45				1,913,000				
Mandalay & Airport duplication, complete lagoon to JUPO	186m & 380m & 1800m run	45		1,486,000						
Replace 66 kV cable (pole 4104853 to lagoon)	725m conduits, 1070m cable	45		2,076,000						
CANN works + RIOR 66/11 kV Subtstation Construction	CANN Tfer c/b & CT, RIOR 2030/31	50				167,000				
TOTAL IMPLEMENTATION COSTS (real)			**0**	**3,562,000**	**686,000**	**10,410,000**	**4,690,000**	**0**	**0**	**0**
TOTAL IMPLEMENTATION COSTS (nominal)			**0**	**3,651,050**	**720,729**	**11,210,431**	**5,176,882**	**0**	**0**	**0**
TOTAL IMPLEMENTATION COSTS (discounted)			**0**	**3,426,929**	**634,960**	**9,270,096**	**4,018,070**	**0**	**0**	**0**

Opex			2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26

Indirect Benefits			2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
VCR Benefits	Per Analysis		-	-	-	-	-	-	-	-
Existing VCR- 8 year av.: Base case $2116000pa	-		0	0	0	0				
VCR- 8 yr av. less REPEX 66 kV cables: Base case less saving	1,319,000						1,319,000	1,319,000	1,319,000	1,319,000

Figure F1 Option C - Direct Cost and Indirect VCR Benefits NPV

Ergon Energy Corporation Limited ABN 50 087 646 062
Energy Queensland Limited ABN 96 612 535 583
Energex Limited ABN 40 078 849 055

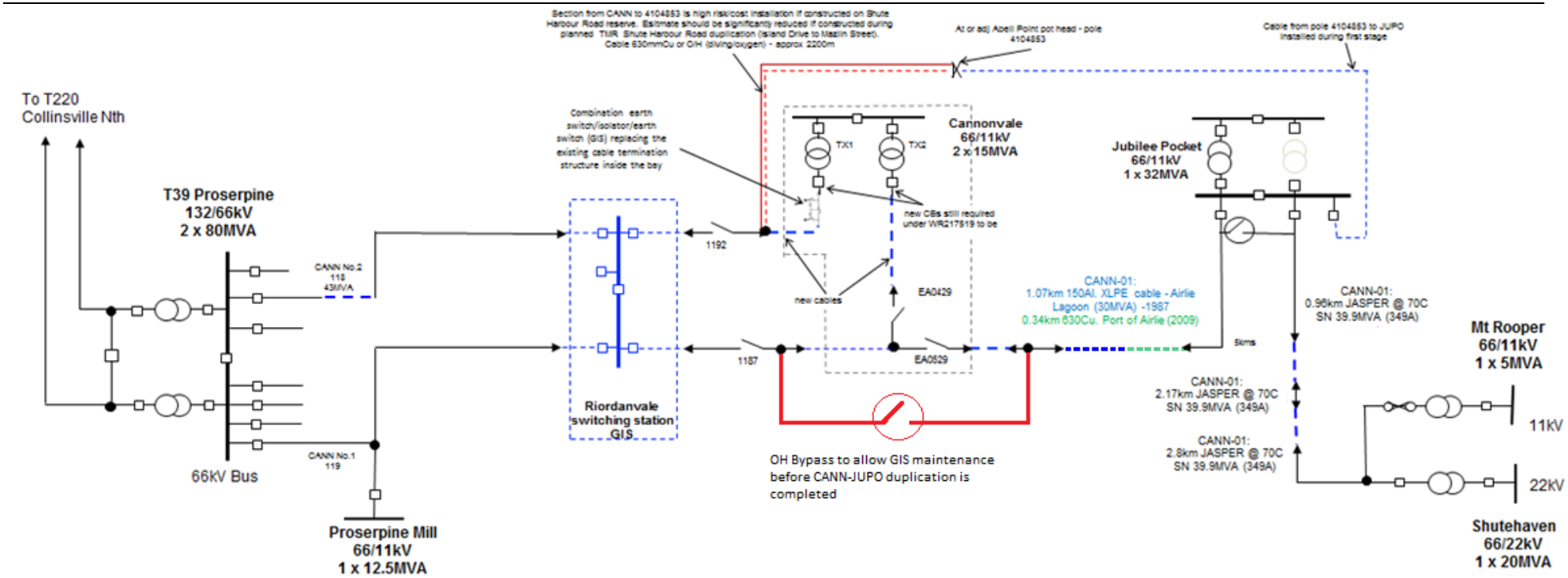

Figure F2 Single Line Diagram of RIOR, CANN and Future Shute Harbour Rd 66 kV

Table F3 CAPEX Estimated Cost of Works (Direct Costs)

Item	ZS	Description	WR / Estimate No.	Estimate Description	Unit DC Price ($ M)	Quantity	Year of Spend	DC Cost ($ M)	Comments
1	CANN	Replace 66 kV cables- CANN-01 to isolator bus	WR1254348	D-Feeder Cable - Upgrade/Replace	899548	0	2017/18	0.000	WIP- 12/2018 (114m run)
2	Airlie lagoon cable	Duplicate Abell Point to Port of Airlie 66 kV cable (pole 4104853 to 6030159)	Conduit costs ONLY	Historical costs	2125000	0.725	2019/20	1.541	
3	"	Cable install and joint costs		Use Option 1F est.	500000	1.07	"	0.535	630Cu
4	Mandalay	Mandalay conduits only	Conduit costs ONLY	Historical costs	2125000	0.186	"	0.395	
5	"	Cable install and joint costs		Use Option 1F est.	500000	0.186	"	0.093	630Cu
6	Airport	Airport conduits only	Conduit costs ONLY	Historical costs	2125000	0.38	"	0.808	
7	"	Cable install and joint costs		Use Option 1F est.	500000	0.38	"	0.19	630Cu
8	"	RIOR works	modified estimate 4	cashflow based on est.	685828	1	2020/21	0.686	RIOR 66 kV fully switched yard
				"	8329500	1	2021/22	8.330	
				"	4690000	1	2022/23	4.690	
9	TMR- S1	TMR Section 1- Island Dr. to Jones Rd	Conduit costs	Historical costs	2125000	0.9	2021/22	1.913	Progressive install with TMR works
10	"	"	cable costs	Historical costs	510000	0	"	0.000	"
11	CANN	66 kV CTs		REPEX	300000	1	2028/29	0.300	CT replace
12	TMR-S2	TMR Section 2- Jones Rd to Mazlin St.	Conduit costs	Historical costs	2125000	1.3	2029/30	2.763	Progressive install with TMR works
13	"	"	cable costs	Historical costs	510000	0	"	0.000	"
14	JUPO	Mazlin St. to JUPO	cable costs	Historical costs	510000	0	"	0.000	
14	RIOR	Single 10 MVA tee substation	WR317031 Gracemere	T3-10	2688267	1	2030/31	2.688	Re-inforce RIOR area
15								0.000	
16								0.000	
17								0.000	
		Projects – detailed estimates							
1	CANN	CANN Cannonvale #1 66 kV Cable Replacement	WR1254348	Replace failed CANN-01 66 kV cable to CANN	899548	0	"	0.000	WIP
2	"	ARP CBRM MK CANN Replace 2 66 kV CBs	WR1217519	Replace existing 66 kV Tfer c/bs'	167000	1	2020/21	0.167	
3	"							0.000	
Total		**Option C: Estimated Cost**						**25.097**	

APPENDIX G: PROPOSED CANN – JUPO 66 KV FEEDER ROUTES

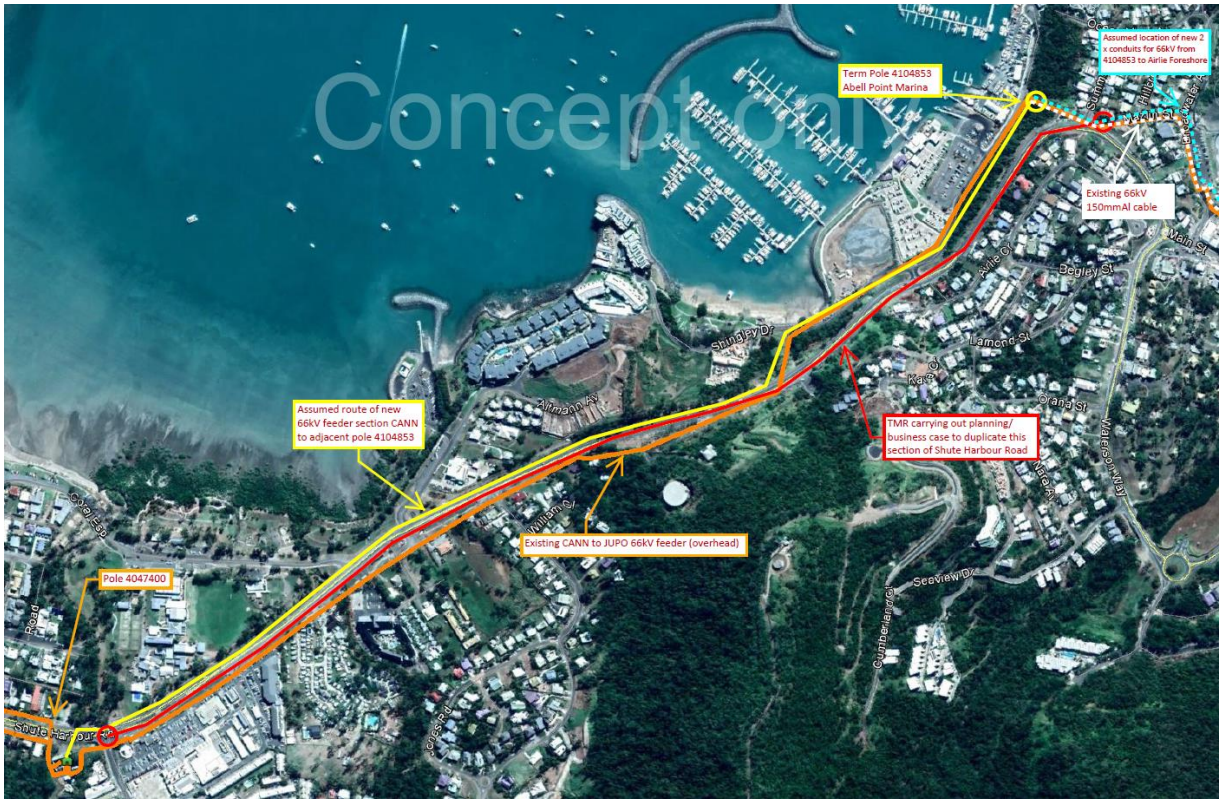

Figure G1 66 kV Feeders from CANN Substation to Term Pole 4104853 Abell Point Marina

Figure G2 66 kV Feeders from Term Pole 4104853 Abell Point Marina to JUPO Substation