Planning Proposal

Grid Planning & Optimisation

WR1236790 Hermit Park Substation Refurbishment
Ergon Energy
2020-25

January 2019

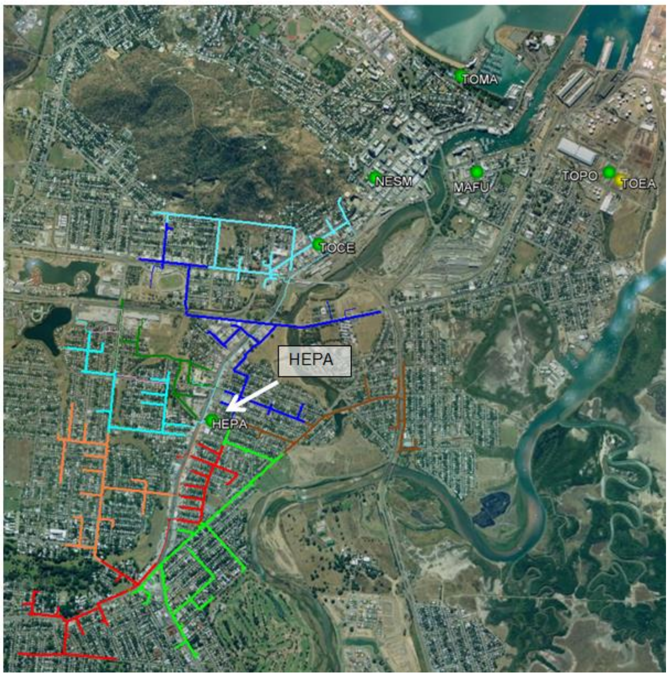
Part of the Energy Queensland Group

EXECUTIVE SUMMARY

Background

Hermit Park Zone Substation (HEPA) is an Ergon Energy zone substation located in Townsville. HEPA was established in the late 1970s with the majority of the primary plant assets manufactured between 1978 and 1979. The substation distributes electricity to 7,200 customers including major retail centres and private hospitals and supplies 28MVA to numerous inner suburbs of Townsville via nine outgoing 11kV circuits.

The HEPA electrical distribution network is shown in the diagram below.



Initiated by a range of end of life assets at HEPA, the purpose of this planning proposal is to outline the risk currently associated with the age and condition of those primary and secondary plant items and to present a recommendation that will cost-effectively and safely remediate that risk to a tolerable level.

Summary of Need for Investment

The HEPA substation was built in the late 1970s and a significant portion of the primary plant is now at or approaching the assessed end of life based on age and condition. HEPA consists of 2 x 66 kV feeder bays, 2 x 66 kV/11 kV 25MVA power transformers and respective 66 kV transformer bays, and an indoor 11 kV Hawker Siddeley switchboard.

Asset Lifecycle data indicates the condition of the two power transformers are poor and have ongoing operational issues and costs. T1 has unacceptable furan, acidity and DPP levels but the condition of T2 is considerably better. As such the replacement of T1 is considered a high priority and the replacement of T2 a lower priority, with a tolerable risk level over the next 5-7 years and suitable for deferral.

The Leads & Northrup (L&N) C2025 model Remote Terminal Unit (RTU) was manufactured in 1985 and due to age and obsolescence, spares and the lack of software support a high risk of failure. Failure of the RTU adversely impacts the remote operational control and supervision of the substation and can result in a loss of automatic control of the 11kV busbar voltages.

HEPA distributes electrical supply via nine 11kV circuits. Of these, three are capacity constrained by the thermal limitations of the aged PLY underground (UG) cables that exit the substation. These constraints can lead to feeder overloads, suboptimal distribution of load and customers across the HV feeders and ultimately limits the utilisation of the substation.

Summary of Feasible Options

Three options have been analysed in this report:

- Base Case Option (Do Nothing): Continue refurbishment and maintenance on a business as usual basis.
- Option A - Replace T1, T1 66 kV CB and CT, 66 kV bus zone and T1 back up protection and constrained 11 kV feeder exit cables, deferring T2 works to 2025/26 or later as required under CBRM.
- Option B - Replace T1 & T2, T1 & T2 66 kV CB and CT, 66 kV bus zone and T1/T2 back up protection and constrained 11 kV feeder exit cables.

Recommendation

Based on analysis contained, this planning proposal recommends Option A, which replaces the aged and poor condition Transformer 1 (T1), associated protection and constrained 11 kV feeder exit cables. The recommended option proposes to defer T2 and associated bay equipment replacement works to 2025/26 or later as required under condition based risk management (CBRM). The required by date (RBD) for this project is February 2023.

The total estimated DCV cost (2018/19) for the recommended works is $2,689,287

Project Information

Work Request Description	Hermit Park 66/11kV Substation Refurbishment.		
Work Request Number	1236790	**Target Capacity Available Date:**	28/02/2023
Initiating Work Group	Planning Northern	**RWR/Scope Approver/Contact**	
Business Owner			
Project Funding Source (A7 J1 code):	D-Asset Replacement - Sub Transmission	**Ellipse Estimate No/s**	
Strategic No:		**Direct Cost Value:**	$2,689,287
Forecast Version:		**RIT-D Required:**	*No*

Document Tracking Details

Network and Non-Network Document Hierarchy Reference Number	**Regulatory Proposal Chapter Reference**	**Document**	**File Name**
NET AUG - 013	7.083	Planning Proposal - Hermit Park Substation	EGX ERG 7.083 Planning Proposal - Hermit Park JAN19 PUBLIC

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

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BACKGROUND

Existing Network, Customer Summary

Hermit Park Zone Substation (HEPA ZS) was built in the late 1970s. Most of the assets in the ZS were manufactured between the years 1978 – 1979. The ZS consists of 2 x 66 kV feeder bays, a 66 kV busbar, 2 x 66 kV/11 kV 15/20/25 MVA (ONAN/ONAF/OFDAF) power transformers and an indoor 11 kV switchboard with 9 x 11 kV feeders (HP-02, HP-03, HP-04, HP-05, HP-06, HP-07, HP-08, HP-10 and HP-11). This means that it may result in significant civil works for any underground access. These feeders supply areas containing residential, commercial and small industrial businesses, which totals to approximately 7,000 customers.

The two power transformers that are situated in HEPA ZS are 25 MVA General Electric Company (GEC) that were manufactured in 1979. The ZS is enclosed by Hughes Street, Marks Street, Roberts Street and Charters Towers Road; a six-lane road that is governed by the Department of Main Roads. The feeder exits are split into two main banks; one group that runs under the heavy vehicle access road (Charters Towers Road) and the other that runs under a concrete drain culvert to Marks St, a residential street (as shown in Figure 1: 66 kV (Orange) and 11 kV Feeders (Blue)).

The zone substation is connected to Garbutt ZS and Oonoonba ZS on the 66 kV sub transmission network (refer to Figure 1: 66 kV (Orange) and 11 kV Feeders (Blue)). In the Safety Net document for Hermit Park, it outlines that there is 3.5 MVA capacity of load transfer via the distribution network in a N – 1 Scheme. This would need to be reviewed in the next Safety Net revision. The maximum load recorded in 2017 is 28.3 MVA and the forecast load for medium growth in 2026 is estimated to be 26 MVA.

Figure 1: 66 kV (Orange) and 11 kV Feeders (Blue)

Hermit Park is a suburb that is located approximately 4 km from Townsville City. This suburb contains the Mater Women's and Children's Hospital, a large shopping centre (Castletown Shopping world) and seven schools; Hermit Park State School, Townsville State High School, Townsville West State School, Mundingburra State School, Saint Joseph's Catholic School, Saint Mary's Primary School and Saint Margaret Mary's College. Furthermore, there is a possibility that a new hospital in West End is proposed to be supplied off HP – 06, which has an expected load of 2 MVA (refer to Appendix F).

This planning report is a compilation of five smaller projects, some of which were previously raised by the Asset Lifecycle Management (ALM) team regarding the replacement of a number of Hermit Park Zone Substation's assets. These work requests discuss the replacement of the two power transformers, feeder exit cables and differential relays. The five smaller projects that were bundled together for this project are: WR1167593 (T1 Replacement), WR1167662 (T2 Replacement), WR1178522 (Feeder exits to Marks St), WR1175063 (Feeder exits to Charters Towers Rd) and WR1182264 (66 kV Differential Relays).

Primary Project Driver

The driver for this project is Repex. A condition assessment conducted on HEPA highlighted a number of aged and poor condition assets. These present significant safety, environmental, customer and business risks. These assets include the power transformers, the C2025 RTU and the PLY underground (UG) feeder exit cables.

Asset Lifecycle data indicates the condition of the two power transformers at HEPA are poor and have ongoing operational issues and costs. T1 has unacceptable furan, acidity and DPP levels with a Health Index (HI) Y0 and HI Y10 of 8.4 and 13 (i.e. both with a HI > 7.5 and above the replacement threshold level) and considered a priority replacement whilst T2 replacement can be deferred as HI Y0 and HI Y10 are 5.3 and 8.0 respectively.

The L&N C2025 RTU at HEPA has been identified as a priority replacement based on age (ie YoM of 1985), obsolescence, spares and supported software.

Hermit Park Substation has a number of aged PLY underground (UG) feeder exit cables. Three of these feeders are currently constrained. The replacement of the HP03, and HP04 feeder exit cables and load transfers will resolve load encroachment, LV supply closing circuit availability and exceedance issues on the feeder ratings and improve the transfer capability for HEPA ZS, especially under contingency arrangements.

Secondary Project Driver

The backup 66/11kV transformer protection schemes at Hermit Park Substation are currently non-compliant with the standard for substation protection (STNW1002).

Applied Service Standards

Tables 1 – 8 outline the Minimum Service Standard (MSS) values for Hermit Park feeders; HP-02, HP-03, HP-04, HP-05, HP-06, HP-07, HP-08 and HP-10. A table for HP-11 has not been included as the data from Distribution Feeder Database (DFD) has not been consistent as figures from some previous years are unattainable.

***Note: Tables 1 – 8 are all YTD Figures**

Table 1: HP-02 Feeder - 5 year MSS performance

MSS Type	2013-14	2014-15	2015-16	2016-17	2017-18*	Average
SAIDI	14.92	64.69	105.01	43.41	76.75	60.96
SAIFI	2.06	0.51	0.57	0.30	1.00	0.88

Table 2: HP-03 Feeder - 5 year MSS performance

MSS Type	2013-14	2014-15	2015-16	2016-17	2017-18*	Average
SAIDI	20.64	135.83	99.00	95.28	239.20	117.99
SAIFI	2.26	0.58	0.45	0.48	2.00	1.15

Table 3: HP-04 Feeder - 5 year MSS performance

MSS Type	2013-14	2014-15	2015-16	2016-17	2017-18*	Average
SAIDI	60.82	167.84	105.58	7.70	79.39	84.27
SAIFI	2.36	1.70	0.52	0.08	1.07	1.15

Table 4: HP-05 Feeder - 5 year MSS performance

MSS Type	2013-14	2014-15	2015-16	2016-17	2017-18*	Average
SAIDI	12.05	10.41	179.39	15.71	70.40	57.59
SAIFI	2.20	0.15	1.38	0.17	0.99	0.98

Table 5: HP-06 Feeder - 5 year MSS performance

MSS Type	2013-14	2014-15	2015-16	2016-17	2017-18*	Average
SAIDI	18.99	345.68	103.35	123.04	77.15	133.64
SAIFI	1.05	1.43	0.55	1.50	1.02	1.11

Table 6: HP-07 Feeder - 5 year MSS performance

MSS Type	2013-14	2014-15	2015-16	2016-17	2017-18*	Average
SAIDI	72.09	61.14	135.62	4.922	73.32	69.42
SAIFI	1.28	0.35	1.33	0.13	0.99	0.82

Table 7: HP-08 Feeder - 5 year MSS performance

MSS Type	2013-14	2014-15	2015-16	2016-17	2017-18*	Average
SAIDI	108.66	24.00	32.64	95.94	89.75	70.20
SAIFI	2.20	0.40	0.38	0.77	1.06	0.962

Table 8: HP-10 Feeder - 5 year MSS performance

MSS Type	2013-14	2014-15	2015-16	2016-17	2017-18*	Average
SAIDI	126.15	204.03	267.69	70.42	75.30	148.72
SAIFI	1.99	2.46	1.58	1.00	1.01	1.61

The average SAIDI values for the tables 1 – 8 above satisfy the reliability limit since they are below 149. Additionally, the average SAIFI values from the tables 1 – 8 are below 1.98, which satisfies the reliability limits outlined by the **Ergon Energy Distribution Authority**.

PROJECT DEPENDENCIES

Project	Project Description	Required by Date
WR1182250	E152 & B152 Feeders – Garbutt	December 2019

PRIOR PROJECTS

Project	Project Description	Required by Date
WR1225288	RTS 2 EIB CBS B152	August 2017
WR1072752	Replace 3 CTs B196	November 2017

LIMITATIONS ON THE EXISTING NETWORK

Sub Transmission Network Limitation

Table 9: 66 kV feeders (SFD Aug 2017 Version 0.4)

Feeder Name	Conductor Type	Design Temp (°C)	Length (m)	Min Limit Rating (Amps)	Min Limit Rating (MVA)
Garbutt – Hermit Park	135 Historic O/H Conductor, Dog 6/1/.186+7/.062 ACSR/GZ (QESI 135)	75	1141	320	36.6
	PLU Conductor, Pluto 19/3.75 AAC	75	1688	524	59.9
Hermit Park - Oonoonba	CHE Conductor, Cherry 6/4.75-7/1.60ACSR/GZ	75	1973	322	36.8
	110 Historic O/H Conductor, 19/.083 HDBC(QESI 110)	75	2966	312	35.7
	NEO Conductor, Neon 19/3.75 AAAC 1120	75	510	521	59.6

Table 9 outlines the specifications of the 66 kV feeders that are connected to Hermit Park ZS. The ZS is connected to Garbutt (GARB) and Oonoonba (OONN). The Garbutt and Oonoonba feeders are not overloaded.

Substation Limitations

Further information to the subsequent sections can be found on Ergon Energy's asset condition assessment process in the Asset Management Plan.

Primary Plant

Asset Lifecycle reporting has transformer one with a priority ranking of three, though at that stage the furan levels were forecast at 5.99ppm. The level of Furan is an indicator of the decomposing insulator and having the furan level at 5 ppm or above requires attention for replacement. Furthermore, the degree of polymerisation (DP) above a level of 200 is considered the end of life of an asset.

Similarly, acidity assists to form sludge, decays the paper insulation and reduces its strength. Effectively, this accelerates cellulose DP reduction and the cooling becomes less efficient. When the acidity level exceeds 0.15, the insulating oil is either reclaimed or replaced.

Table 10 outlines the result of insulation age, wetness in paper or acidity in oil.

Table 10: Insulation Age and Wetness in Paper definitions

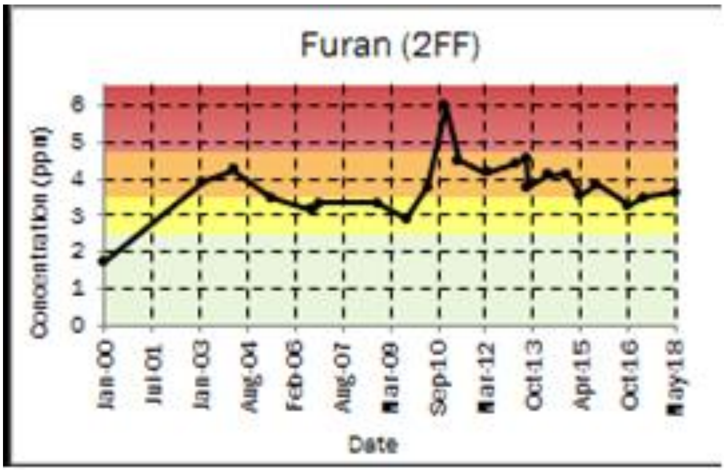
Symptoms	Possible consequences
High insulation age **i.e.** low degree of polymerisation	In the event of a through fault, paper insulation may not have adequate mechanical strength to support the power transformer's winding. This can cause winding failure and may result in catastrophic failure of the power transformer. As per IEEE Std. C57.91; the end of a reliable insulation life is defined as a DP value of 200 or 75% loss of tensile strength.
Very wet paper	In the event of a high load or an overload; bubbles can be formed which can cause internal flashover.
Very high acidity	This decays the paper and accelerates cellulose DP reduction. High levels of acidity contribution to the formation of sludge. Hence, cooling will be less effective and the insulation strength of the oil will reduce. As per IEC 60422; starting from an acidity level of 0.15, a decision may be made to reclaim the oil or, alternatively, if it is more economical, oil replacement may occur if other tests indicate severe ageing.

T1 test results:

Transformer one has a Furan level that is considered to be in the upper moderate levels and the acidity is unacceptable, as it is constantly greater than 0.15. Furthermore, the degree of polymerisation is constantly above 200.

000139176 A31K3039-1 AMB NC

000124384 A31K3039 1 AMB NC

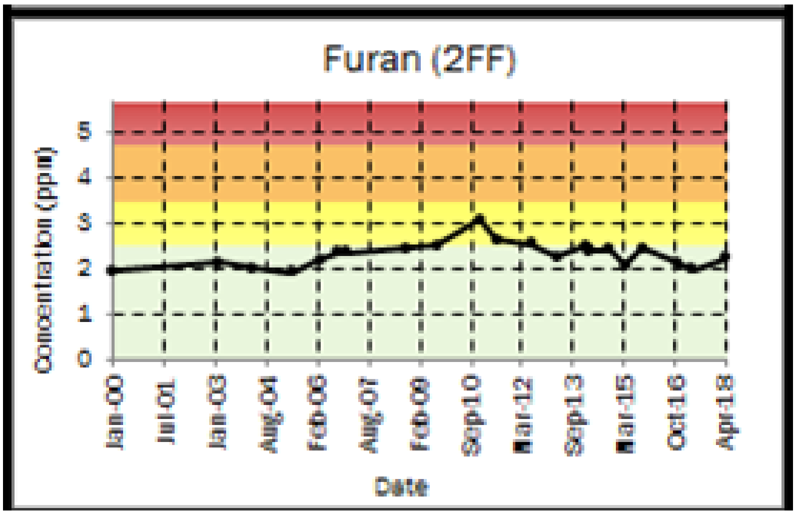


Graph 1: Transformer 1's Furan Levels

T2 test results:

Transformer two shares the same age as transformer one; however, the Furan level is considered to be in the lower moderate threshold and the acidity levels are acceptable even though the Degree of Polymerisation is constantly greater than 200.

000138338 A31K3039-2 YEL NQ I
000124382 A31K3039 2 YEL NQ I



Graph 2: Transformer 2's Furan Levels

It is worth noting that both HEPA T1 and T2 have tripped on Buchholz protection but each was successfully re-energised after this event. Both transformers have had oil leaks leading to possible moisture ingress which may also explain the reason for accelerated ageing and poor oil condition.

The following significant events and repair works over the last few years support the recommendations of this business case.

- Bad oil leak repairs (both T1 & T2)
- Oil top up (T1)
- Fixed oil pump (T1)
- Changed oil pump (T1)
- Replaced cooling fans (T2)
- Dry outs/Hyran (both T1 & T2)
- Replace bushings (T2)
- Tap changer repairs (T1)
- Buchholz protection trip incident (T1)
- Differential protection trip incident (T2)
- AC supply failure (T2)
- Main fans stuck on (T1)
- Sheer clutch failure (T2)
- WTI/OTI out of spec (T2)
- Buchholz protection trip incident (T2)

As can be seen from Table 11, an increasing maintenance annual cost is occurring where approx. 30 - 35% of costs during 2016/17 and 2017/18 have been transformer related.

Table 11: HEPA Operational Costs

Sum of Actual Total Costs		Fin year									
Work Order Type Code	Maintenance Type	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	Grand Total
⊟OP	DE								$1,954.01		$1,954.01
	MC	$71,814.51	$39,240.98	$101,903.23	$12,562.31	$19,496.43	$46,320.08	$14,504.61	$38,329.68	$28,695.75	$372,867.58
	MF	$20,321.13	$29,005.30	$10,040.30	$41,019.75	$17,218.66	$13,012.63	$75,506.20	$118,876.91		$325,000.88
	MP	$13,315.19	$22,365.36	$57,772.47	$60,056.92	$31,025.54	$17,956.02	$32,419.98	$42,445.83	$1,393.43	$278,750.74
	NC							$2,422.64			$2,422.64
OP Total		**$105,450.83**	**$90,611.64**	**$169,716.00**	**$113,638.98**	**$67,740.63**	**$77,288.73**	**$124,853.43**	**$201,606.43**	**$30,089.18**	**$980,995.85**

WO Type = OP (OPEX) MP/MC/MF – Maintenance Preventative, Maintenance Corrective, Maintenance Forced.

Table 11 shows the rating of the power transformers during the summer and winter periods. The table shows that the transformer is able to carry more load than the nameplate rating of 25 MVA. The transformer's cyclic loading capacity in the year 2017 is 28 MVA for normal condition (NC) and 32.5 MVA for Long Term Emergency Cyclic (LTEC) as outlined in Table 12. These ratings are for transformers that are Oil Forced Direct, Air Forced (OFDAF).

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Table 11 – Substation Transformer Ratings (VERSION 0.6 – 2017 TX CYCLIC RATINGS)

Substation	Element	Nameplate Rating	Cooling	Nominal NC		Nominal LTEC		Operational NC		Operational LTEC	
			Cooling	Summer (MVA)	Winter (MVA)	Summer (MVA)	Winter (MVA)	Summer (MVA)	Winter (MVA)	Summer (MVA)	Winter (MVA)
HEPA Hermit Park	Transformer 1 TX No. 1 (66/11kV)	25 MVA	ODAF	28.29	29.30	31.50	32.55	28.29	29.30	31.50	32.55
HEPA Hermit Park	Transformer 2 TX No. 2 (66/11kV)	25 MVA	OFDAF	28.28	29.29	31.50	32.55	28.28	29.29	31.50	32.55

Table 12, 13 and 14 outline Hermit Park's low, medium and high growth scenario forecasts respectively. These forecasts are essentially economic growth forecasts that take into consideration the sales of air conditioners, the industry growth and the mining growth. Table 13 outlines the forecast for a low growth situation and states that the forecast for 2027 is 21.34 MVA; this is below the power transformer's rating of 25 MVA. In contrast, Table 13 and 14 outline that 2027's maximum demand is 26 MVA and 27 MVA respectively which is above the nameplate rating of the transformers.

Table 12: Substation Forecast (SIFT VERSION 27 2017 POST SUMMER POWERLINK LG)

Year	Summer Day				Summer Night				Winter Day				Winter Night				Peak
	MVA	MW	MVAR	Comp	MVA	MW	MVAR	Comp	MVA	MW	MVAR	Comp	MVA	MW	MVAR	Comp	
2017	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.70	19.48	6.99	0.00	20.70	19.48	6.99	0.00	WD
2018	26.61	25.02	9.06	0.00	26.61	25.02	9.06	0.00	20.33	19.13	6.86	0.00	20.33	19.13	6.86	0.00	SD
2019	25.86	24.32	8.81	0.00	25.86	24.32	8.81	0.00	19.71	18.55	6.65	0.00	19.71	18.55	6.65	0.00	SD
2020	25.56	24.03	8.70	0.00	25.56	24.03	8.70	0.00	19.52	18.37	6.59	0.00	19.52	18.37	6.59	0.00	SD
2021	24.86	23.37	8.47	0.00	24.86	23.37	8.47	0.00	19.04	17.92	6.43	0.00	19.04	17.92	6.43	0.00	SD
2022	24.48	23.01	8.34	0.00	24.48	23.01	8.34	0.00	18.77	17.66	6.33	0.00	18.77	17.66	6.33	0.00	SD
2023	24.27	22.82	8.27	0.00	24.27	22.82	8.27	0.00	18.70	17.60	6.31	0.00	18.70	17.60	6.31	0.00	SD
2024	23.39	21.99	7.97	0.00	23.39	21.99	7.97	0.00	18.03	16.97	6.08	0.00	18.03	16.97	6.08	0.00	SD
2025	22.33	20.99	7.61	0.00	22.33	20.99	7.61	0.00	17.26	16.24	5.82	0.00	17.26	16.24	5.82	0.00	SD
2026	21.83	20.52	7.43	0.00	21.83	20.52	7.43	0.00	16.91	15.92	5.71	0.00	16.91	15.92	5.71	0.00	SD
2027	21.34	20.06	7.27	0.00	21.34	20.06	7.27	0.00	16.55	15.58	5.59	0.00	16.55	15.58	5.59	0.00	SD

Table 13: Substation Forecast (SIFT VERSION 24 2017 POST SUMMER POWERLINK ML)

Year	Summer Day				Summer Night				Winter Day				Winter Night				Peak
	MVA	MW	MVAR	Comp	MVA	MW	MVAR	Comp	MVA	MW	MVAR	Comp	MVA	MW	MVAR	Comp	
2017	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.56	19.36	6.94	0.00	20.56	19.36	6.94	0.00	WD
2018	26.91	25.30	9.17	0.00	26.91	25.30	9.17	0.00	20.56	19.35	6.94	0.00	20.56	19.35	6.94	0.00	SD
2019	26.68	25.09	9.09	0.00	26.68	25.09	9.09	0.00	20.41	19.21	6.89	0.00	20.41	19.21	6.89	0.00	SD
2020	26.36	24.79	8.98	0.00	26.36	24.79	8.98	0.00	20.13	18.95	6.80	0.00	20.13	18.95	6.80	0.00	SD
2021	26.46	24.87	9.01	0.00	26.46	24.87	9.01	0.00	20.24	19.05	6.83	0.00	20.24	19.05	6.83	0.00	SD
2022	26.46	24.88	9.01	0.00	26.46	24.88	9.01	0.00	20.26	19.07	6.84	0.00	20.26	19.07	6.84	0.00	SD
2023	26.62	25.03	9.07	0.00	26.62	25.03	9.07	0.00	20.49	19.29	6.92	0.00	20.49	19.29	6.92	0.00	SD
2024	26.08	24.52	8.88	0.00	26.08	24.52	8.88	0.00	20.10	18.92	6.79	0.00	20.10	18.92	6.79	0.00	SD
2025	25.89	24.34	8.82	0.00	25.89	24.34	8.82	0.00	19.96	18.79	6.74	0.00	19.96	18.79	6.74	0.00	SD
2026	26.06	24.50	8.88	0.00	26.06	24.50	8.88	0.00	20.19	19.00	6.81	0.00	20.19	19.00	6.81	0.00	SD
2027	26.22	24.65	8.93	0.00	26.22	24.65	8.93	0.00	20.32	19.13	6.86	0.00	20.32	19.13	6.86	0.00	SD

Table 14: Substation Forecast (SIFT version 25 2017 Post Summer Powerlink HG)

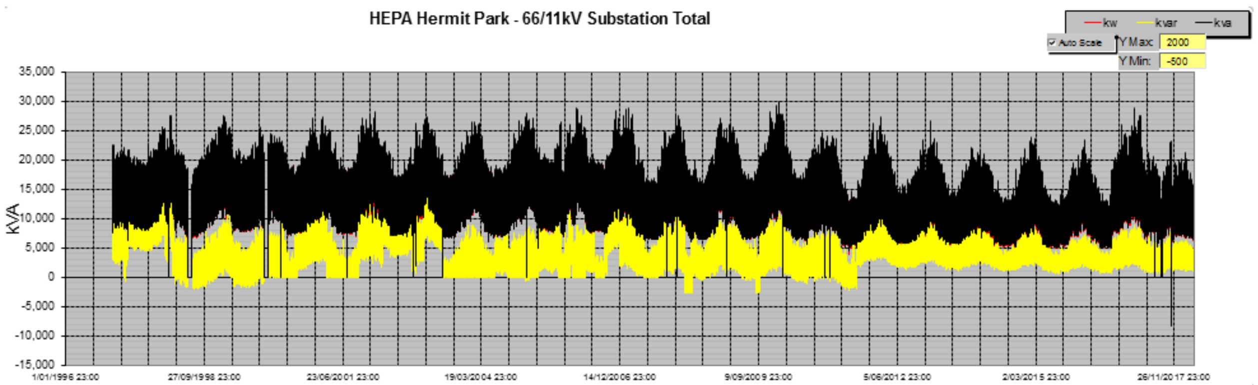
Year	Summer Day				Summer Night				Winter Day				Winter Night				Peak
	MVA	MW	MVAR	Comp	MVA	MW	MVAR	Comp	MVA	MW	MVAR	Comp	MVA	MW	MVAR	Comp	
2017	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.00	20.52	19.32	6.93	0.00	20.52	19.32	6.93	0.00	WD
2018	24.11	22.65	8.27	0.00	24.11	22.65	8.27	0.00	21.93	20.64	7.40	0.00	21.93	20.64	7.40	0.00	SD
2019	25.66	24.10	8.80	0.00	25.66	24.10	8.80	0.00	22.43	21.12	7.57	0.00	22.43	21.12	7.57	0.00	SD
2020	24.71	23.21	8.47	0.00	24.71	23.21	8.47	0.00	21.70	20.43	7.33	0.00	21.70	20.43	7.33	0.00	SD
2021	25.62	24.06	8.79	0.00	25.62	24.06	8.79	0.00	22.45	21.13	7.58	0.00	22.45	21.13	7.58	0.00	SD
2022	25.74	24.18	8.83	0.00	25.74	24.18	8.83	0.00	22.60	21.27	7.63	0.00	22.60	21.27	7.63	0.00	SD
2023	26.54	24.93	9.10	0.00	26.54	24.93	9.10	0.00	23.38	22.01	7.89	0.00	23.38	22.01	7.89	0.00	SD
2024	26.52	24.91	9.10	0.00	26.52	24.91	9.10	0.00	23.39	22.02	7.90	0.00	23.39	22.02	7.90	0.00	SD
2025	26.66	25.05	9.15	0.00	26.66	25.05	9.15	0.00	23.52	22.14	7.94	0.00	23.52	22.14	7.94	0.00	SD
2026	26.96	25.32	9.25	0.00	26.96	25.32	9.25	0.00	23.89	22.49	8.07	0.00	23.89	22.49	8.07	0.00	SD
2027	27.28	25.63	9.36	0.00	27.28	25.63	9.36	0.00	24.19	22.77	8.16	0.00	24.19	22.77	8.16	0.00	SD

Table 15 outlines the assets in HEPA ZS that were manufactured between the years 1978 – 1980. One of the Garbutt 66kV Bay Oil Current Transformer (CT) (Phase A) has been flagged in the rollup tool, to be in poor condition as it is currently overheating. However, Asset Lifecycle data has confirmed that its condition will allow replacement to be pushed out until the next AER period (2025 – 2030). The other assets which share a similar vintage have been assigned by ALM to have an average condition.

Table 15: Zone Substation Assets (Rollup Model Version 30)

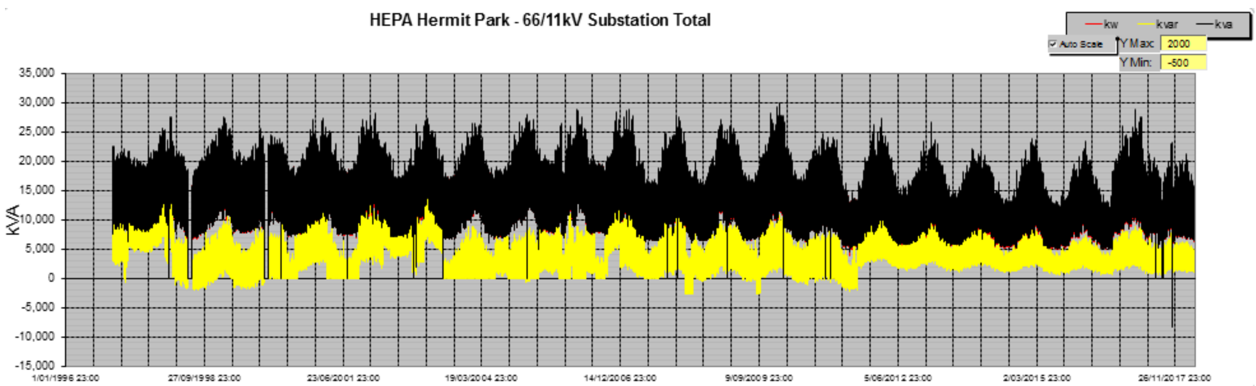
Asset	Model	Year Of Manufacture (YOM)	Quantity
GARBUTT 66 kV Oil CT A196	597E/6/A	1980	3
Transformer 1 66 kV Oil CT A496 (replaced with C/B dead tank proposal)	597E/6/A	1980	3
Transformer 2 66 kV Oil CT B496 (replaced with C/B dead tank proposal)	597E/6/A	1980	3
HEPASS Bus 66 kV Oil VT A797	EMFC70	1978	3

T1 current transformers are to be replaced as part of the 66 kV circuit breaker dead tank works in order to provide sufficient space for bunding and firewall installs including sufficient access for replacement of T2 in future.



Graph 3: Hermit Park ZS loading 01/01/1996 - 19/04/2018 (Version 4.3 of SMDB Profiler)

T1 current transformers are to be replaced as part of the 66 kV circuit breaker dead tank works in order to provide sufficient space for bunding and firewall installs including sufficient access for replacement of T2 in future.



Graph 3 outlines the load demands for HEPA ZS. The Statistical Metering Data Base (SMDB) profile graph for Hermit Park's substation shows a cyclic pattern in load demand. However, the graph shows that the peak of each cycle is lower than the cycles in the years prior to 2009. The graph shows that the maximum peak in 2017# is similar to the peaks that were recorded in the years previous to 2009.

#**Note:** The maximum peak load in 2017 was 29 MVA but this is still below the LTEC loading of 31.5 MVA.

11 kV Capacitor Banks

Two Brown Boveri 11 kV capacitor banks sit in Hermit Park's substation (CP93213238 & CP93213383). These capacitor banks have failed in service prior to 2014 and it was decided that these capacitor banks would not be replaced as the cost to replace these capacitors are estimated to be $847,349. It was determined that with the N – 1 scheme, the transformer capacity for power transformer two is 31.5 MVA (Operation LTEC), which means that a replacement project does not have any capacity or security drivers. It has not been confirmed whether these capacitor banks failures are repairable or require a full replacement. This is to be confirmed and could be removed with the replacement of transformer 2.

It should be noted that the capacitor banks are connected via the 11 kV feeder exit cables by special three way 11 kV tee joints. The removal of the capacitor banks and tee cable will need to consider this special connection method.

FW NQ Cap Bank - WR 682291.msg

11 kV Condition Assessment Switchboard

The condition assessment for the 11 kV switchboard in Hermit Park is currently being conducted. The report is due for release in September and will be attached to this proposal.

Present CBRM assessments indicate a HI YO of 4. Whilst the switchgear is minimum oil and a 1978 YoM, condition assessment will assist with forecast replacement expectations.

Of importance is that the average feeder SAIFI is typical of an inner urban meshed substation and relatively low.

Secondary Systems and Protection

The protection schemes of the substation are now obliged to follow the present standard for substation protection (**STNW1002**). This standard in section 1.2 outlines that when the secondary equipment has reached its end of life, the new equipment must adhere to the standard STNW1002. Table 16 outlines the protection relays that are required to be installed at Hermit Park to satisfy the current protection standard.

Table 16: Hermit Park Protection Relay requiring upgrade

Description	Old Technology	New Technology	YOM	Equipment Number
Transformer 1 back up protection relay	SEL 351A	GE T60 (upgrade with T1 replacement)	2016	605623
Transformer 2 back up protection relay	SEL 351A	GE T60 (upgrade with T2 replacement)	2016	605861
Install back up protection to 66 kV bus	Does not presently exist	P746	N/A	N/A
GARB – HEPA *	Pilot wire scheme	GE L90 via fibre infrastructure	N/A	N/A

***Note:** The differential relay at Hermit Park – Garbutt (pilot wire communication scheme) will not be replaced in this project as another work request has been raised to do this project (WR1182250). This decision has been made as it will be done after the substation at Garbutt has been rebuilt.

Table 18 below outlines the present protection relays that are situated at HEPA ZS but with a criticality index of > 60% and criticality threshold replacement level of 85%.

Table 17: HEPA ZS Protection Devices (Rollup Tool April 2018)

#	#	SPN	Ellipse #	Substation	Protection Scheme Slot	Concat Name	HI YR 2018	HI YR of proposed install Yr	HI YR 2028	Estimated Retirement Year	Proposed Project Year	Age (yrs) as of 2018	Criticality (PWI)	Comment
		Substation:		*HEPA*										
		Target Installation Year:		*-*										
		rd Leadup Period to EOL (yrs):		*5*										
		Minimum HI for Replacement:		*8.0*										
		um Criticality for Replacement:		*85%*										
	1	SPN	Ellipse	Z:	PR Schem	Concat Name	HI 2	HI YR o pro	HI Y 2	Estimat ed Retir	Propo se Pro	Age (y as	Critic ali (PV	Comment
5	5	PR93210504	00000071771	HEPA	HEPA-EA06-J01	NQ HEPA - PR93210504 1999 - ALSTOM GEC > TRANSLAY SDPS101 - EA06 - 66kV Feeder (Main X: PW LDIFF)	8.8	9.4	10	2005	2020	19	92%	EA06 66KV GARBUTT FDR > Recommend removing item with a possible replacement - L90 relay Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age Diff (Age & Ideal Model Age) 4) Age
7	7	PR93212946	00000071771	HEPA	HEPA-EA06-J02	NQ HEPA - PR93212946 1980 - ALSTOM EE GEC > CDD21 - EA06 - 66kV Feeder (Main Y: DOC)	9.5		10	2025		38	78%	EA06 66KV GARBUTT FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
8	8	PR93212452	00000071772	HEPA	HEPA-EA06-J02	NQ HEPA - PR93212452 1980 - ALSTOM EE GEC > CDD21 - EA06 - 66kV Feeder (Main Y: DEF)	9.5		10	2025		38	78%	EA06 66KV GARBUTT FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
9	9	PR93222693	0000007153	HEPA	HEPA-FB02-J01	NQ HEPA - PR93222693 1980 - AREVA ALSTOM GEC > CDG61 - FB02 - 11kV Feeder (OC, EF)	9.5		10	2025		38	77%	FB02 11KV HP02 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
10	10	PR93217591	0000007153	HEPA	HEPA-FB02-J01	NQ HEPA - PR93217591 1999 - ALSTOM EE GEC > CMUR21 - FB02 - 11kV Feeder (SEF)	8.8		10	2024		19	61%	FB02 11KV HP02 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Age
12	12	PR93223886	0000007154	HEPA	HEPA-FB03-J01	NQ HEPA - PR93223886 1980 - AREVA ALSTOM GEC > CDG61 - FB03 - 11kV Feeder (OC, EF)	9.5		10	2025		38	77%	FB03 11KV HP03 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
13	13	PR93223467	0000007154	HEPA	HEPA-FB03-J01	NQ HEPA - PR93223467 1999 - ALSTOM EE GEC > CMUR21 - FB03 - 11kV Feeder (SEF)	8.8		10	2024		19	61%	FB03 11KV HP03 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Age
15	15	PR93231885	0000007166	HEPA	HEPA-FB04-J01	NQ HEPA - PR93231885 1980 - AREVA ALSTOM GEC > CDG61 - FB04 - 11kV Feeder (OC, EF)	9.5		10	2025		38	77%	FB04 11KV HP04 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
16	16	PR93226187	0000007166	HEPA	HEPA-FB04-J01	NQ HEPA - PR93226187 1999 - ALSTOM EE GEC > CMUR21 - FB04 - 11kV Feeder (SEF)	8.8		10	2024		19	61%	FB04 11KV HP04 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Age

16	16	PR93226187	0000007166	HEPA	HEPA-FB04-J01	NQ HEPA - PR93226187 1999 - ALSTOM EE GEC > CMUR21 - FB04 - 11kV Feeder (SEF)	8.8		10	2024		19	61%	FB04 11KV HP04 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Age
18	18	PR93231796	0000007166	HEPA	HEPA-FB05-J01	NQ HEPA - PR93231796 1980 - AREVA ALSTOM GEC > CDG61 - FB05 - 11kV Feeder (OC, EF)	9.5		10	2025		38	77%	FB05 11KV HP05 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
19	19	PR93231888	0000007166	HEPA	HEPA-FB05-J01	NQ HEPA - PR93231888 1999 - ALSTOM EE GEC > CMUR21 - FB05 - 11kV Feeder (SEF)	8.8		10	2024		19	61%	FB05 11KV HP05 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Age
21	21	PR93207211	0000007187(	HEPA	HEPA-FB07-J01	NQ HEPA - PR93207211 1980 - AREVA ALSTOM GEC > CDG11 - FB07 - 11kV Bus (Backup: EF)	9.5		10	2025		38	78%	FB07 11KV BUS > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
22	22	PR93232393	0000007166	HEPA	HEPA-FB07-J01	NQ HEPA - PR93232393 1980 - AREVA ALSTOM GEC > CDG61 - FB07 - 11kV Bus (Backup: OC)	9.5		10	2025		38	77%	FB07 11KV BUS > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
25	25	PR93231778	0000007166	HEPA	HEPA-FB07-J02	NQ HEPA - PR93231778 1980 - ALSTOM EE GEC > CAG12 - FB07 - 11kV Bus (EF CHK)	9.5		10	2025		38	78%	FB07 11KV BUS > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
26	26	PR93231282	0000007166	HEPA	HEPA-FB07-J02	NQ HEPA - PR93231282 1980 - ALSTOM EE GEC > CAG12 - FB07 - 11kV Bus (EF)	9.5		10	2025		38	78%	FB07 11KV BUS > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
33	33	PR93226138	0000007166	HEPA	HEPA-FB09-J01	NQ HEPA - PR93226138 1980 - AREVA ALSTOM GEC > CDG61 - FB09 - 11kV Feeder (OC, EF)	9.5		10	2025		38	77%	FB09 11KV HP06 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
34	34	PR93231776	0000007166	HEPA	HEPA-FB09-J01	NQ HEPA - PR93231776 1999 - ALSTOM EE GEC > CMUR21 - FB09 - 11kV Feeder (SEF)	8.8		10	2024		19	61%	FB09 11KV HP06 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Age
37	37	PR93231345	0000007166	HEPA	HEPA-FB10-J01	NQ HEPA - PR93231345 1980 - AREVA ALSTOM GEC > CDG61 - FB10 - 11kV Feeder (OC, EF)	9.5		10	2025		38	77%	FB10 11KV HP07 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
41	41	PR93226161	0000007166	HEPA	HEPA-FB12-J01	NQ HEPA - PR93226161 1980 - AREVA ALSTOM GEC > CDG61 - FB12 - 11kV Feeder (OC, EF)	9.5		10	2025		38	77%	FB12 11KV HP10 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age

41	41	PR93226161	0000007166	HEPA	HEPA-FB12-J01	NQ HEPA - PR93226161 1980 - AREVA ALSTOM GEC > CDG61 - FB12 - 11kV Feeder (OC, EF)	9.5		10	2025		38	77%	FB12 11KV HP10 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
42	42	PR93231750	0000007166	HEPA	HEPA-FB12-J01	NQ HEPA - PR93231750 1999 - ALSTOM EE GEC > CMUR21 - FB12 - 11kV Feeder (SEF)	8.8		10	2024		19	61%	FB12 11KV HP10 FDR > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Age
46	46	PR?HEPALXC		HEPA	HEPA-LX01-J01	NQ HEPA - PR???????? 1980 - ALSTOM EE GEC > CAG - LX01 - 11kV Bus (FL CHK)	9.5		10	2025		38	78%	- > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
47	47	PR?HEPALXC		HEPA	HEPA-LX01-J01	NQ HEPA - PR???????? 1980 - AREVA ALSTOM GEC > CDG - LX01 - 11kV Bus (NEF)	9.5		10	2025		38	78%	- > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age
50	50	PR93231701	0000007166	HEPA	HEPA-MX02-J01	NQ HEPA - PR93231701 1994 - ALSTOM ASEA > RK411-101-DA - MX02 - 11kV Capacitor Bank (EF, UB)	9.8		10	2019		24	79%	MX02 11KV CAP 2 > Consider retaining item Prioritised Limitations of Relays: 1) Technological Age Limitation 2) Problematic Relay 3) Age

20180808 ALM PR Replacements - HEPA

The estimated retirement age of the 11 kV protection relays is considered around 2025 when the Hawker Siddeley switchboard has a YoM of 1978 and would be 47 years of age. Partial Discharge testing of the 11 kV switchboard is also in progress. It would be prudent to consider replacement of the 11 kV switchboard and associated protection relays at or about the same time. The capacitor banks are de-energised and out of service and therefore any protection relay replacement associated with the capacitor banks would not be undertaken.

Replacement of remaining Foxboro C2025 RTU

The remaining L&N C2025 RTU at HEPA has been identified as a priority replacement based on age (ie YoM of 1985), obsolescence, spares and supported software.

FW RTU
replacements- budg

There are approximately 10 analogues, 37 digitals and 6 controls. From a hardware perspective, there are enough spare slots in the existing C52 RTUs to host these points, additional cards can be procured. Approximate requirements are 3 x ADI cards ($1517 each) and 2 x 8DO cards ($1321 each).

RE RTU
replacements- budg

Distribution Network Limitation

This project is to facilitate the aged asset replacement of the existing PLY underground (UG) feeder exits at Hermit Park with 400 Al Triplex UG cable or 240Cu. 3 Core cables with a proposed rating of 300 A. This will depend on the conduit size availability.

The project will also resolve load encroachment, LV supply closing circuit availability and exceedance issues on the feeder ratings and improve the transfer capability for HEPA ZS, especially under contingency arrangements. This will optimise the benefit that HEPA ZS is able to provide to the supply area into the future. Hermit Park is a central and strategically interconnected substation in the Townsville supply network.

Table 19 - Distribution Capacity (VERSION 1.1 OF CSA 2016– 2017)

Feeder	Existing UG Cable Description	Maximum Demand (Amps)	UG Cyclic rating and [revised] (Amps)	Utilisation	Planning Level (Amps)
HP-02	240mm^2 Al. 3C XLPE/NY/HDPE Bus 1; Marks St	162	250 [250]	64.8%	187.5
HP-03	300mm^2 Al. 3C PLY/SWS/Belted Bus 1; Marks St	186	167 [170]	**111.4% [109%]**	125.3
HP-04	766 Historic 11kV U/G Cable, 300mm^2 3C Al. PLY/SWS SCREENED Bus 1; Marks St, Capacitor C1	178	140 [165]	**127.1% [108]**	105
HP-05	766 Historic 11kV U/G Cable, 300mm^2 3C Al. PLY/SWS SCREENED Bus 1; Charters Towers Rd LS Transformer (11/0.433 kV)	174	233 [239]	74.7% [73%]	174.8
HP-06	765 Historic 11kV U/G Cable, 300mm^2 Al. 3C PLY/SWS BELTED Bus 2; Charters Towers Rd	191	129 [153]	**148.1% [125%]**	96.75
HP-07	766 Historic 11kV U/G Cable, 300mm2 3C Al. PLY/SWS SCREENED Bus 2; Marks St, Capacitor C2	65	192 [199]	33.9% [33%]	144
HP-08	766 Historic 11kV U/G Cable, 300mm^2 3C Al. PLY/SWS SCREENED Bus 2; Charters Towers Rd	153	210 [250]	72.9% [61%]	157.5
HP-10	766 Historic 11kV U/G Cable, 300mm^2 3C Al. PLY/SWS SCREENED Bus 2; Charters Towers Rd	121	181 [187]	66.9% [65%]	135.8
HP-11	1718 Historic 11kV U/G Cable, 240 mm2 Triplex XLPE/SCR13/PVC/DBT/IP/HDPE Bus 2; Charters Towers Rd LS (11/0.433 kV)	112	250 [250]	44.8%	187.5
Lose Bus 1	Bus 1 feeders: HP- 02, 03, 04 and 05	Bus 1 load =700 A	Bus 2 rating = (1039A)		
Lose Bus 2	Bus 2 feeders: HP- 06, 07, 08, 10 and 11	Bus 2 load = 642A	Bus 1 rating = (824A)		

Total	27.0 MVA - 2018	1420 A	Total ZS load		

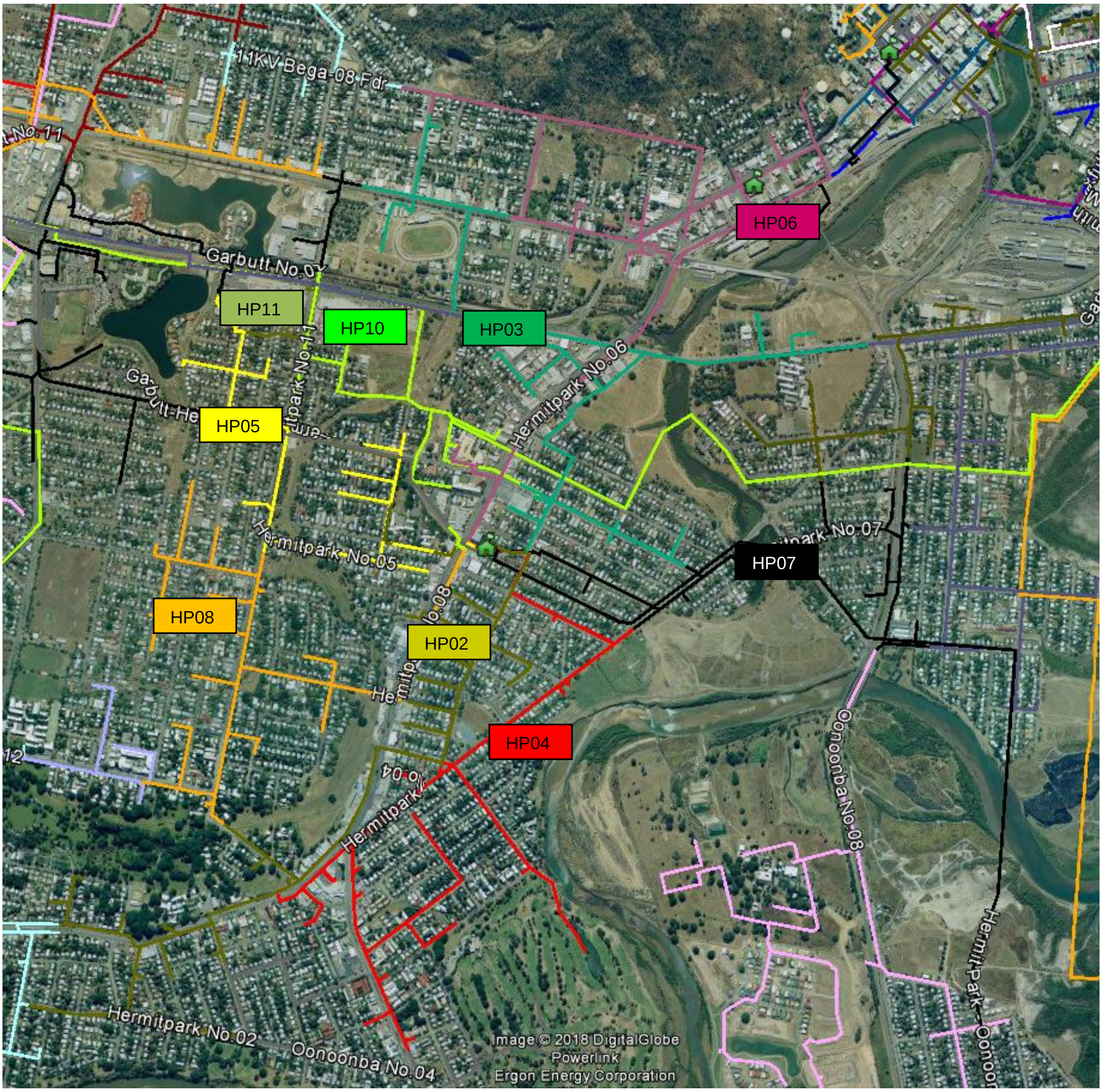


Figure 2: HEPA 11 kV distribution network (CURRENT STATE)

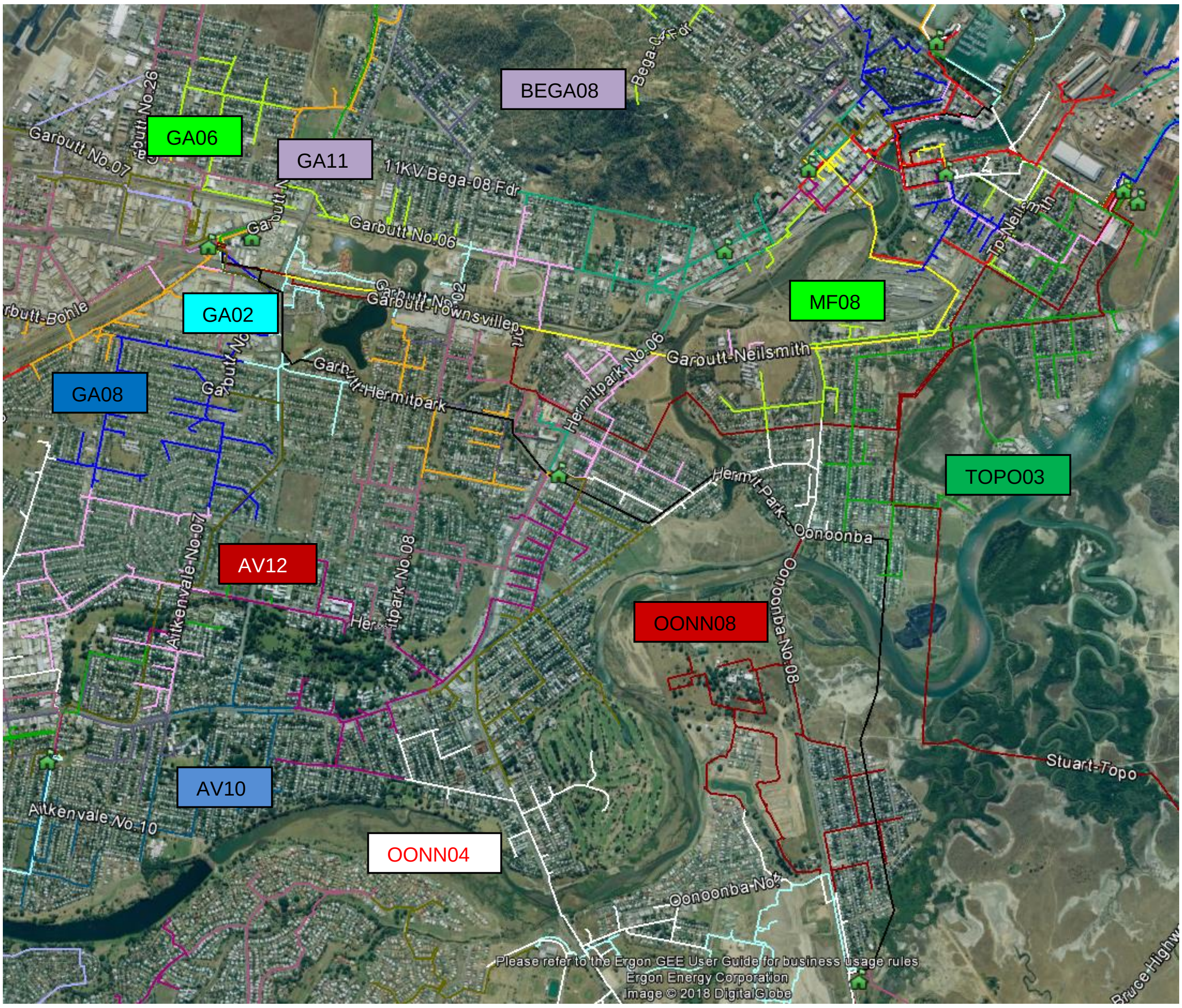


Figure 2: HEPA 11 kV Distribution Network Key Transfer Feeders (Current State)

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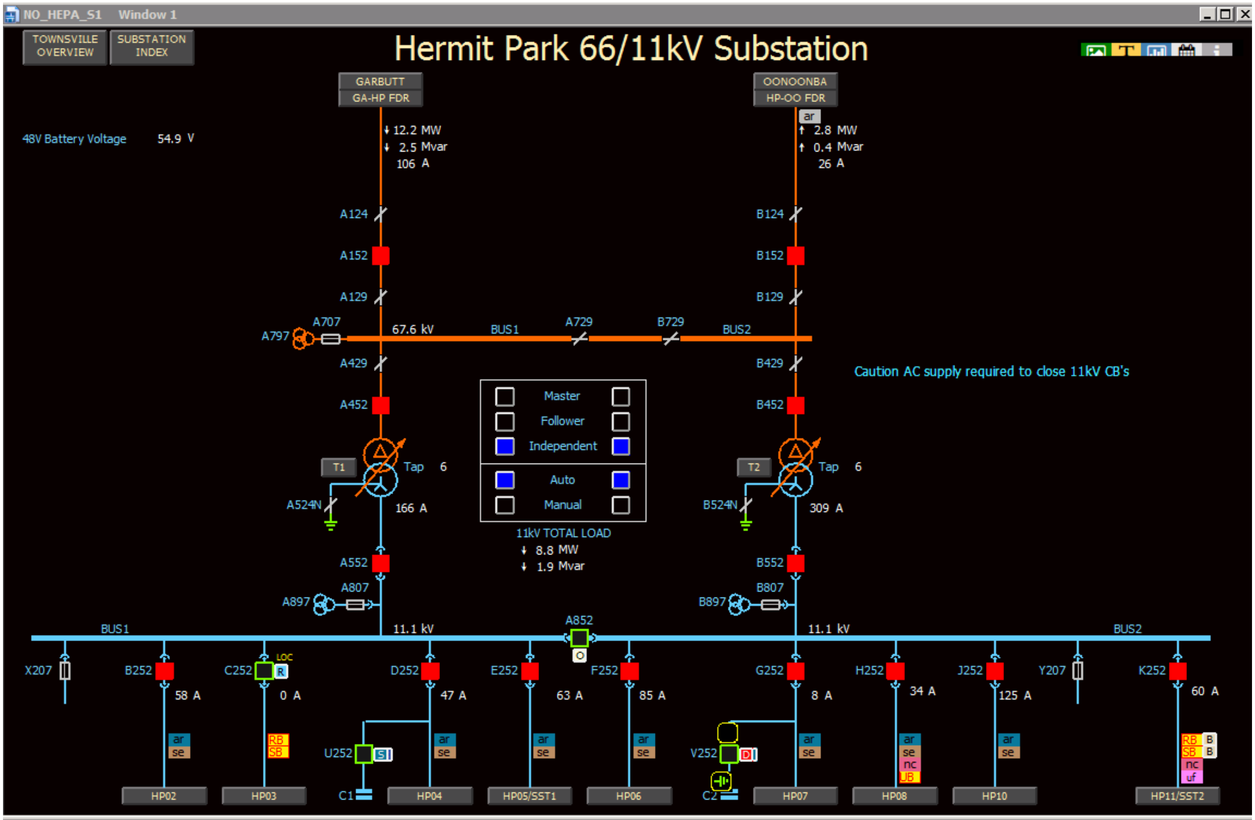


Figure 3: HEPA 11 kV Zone Substation Configuration (Current State)

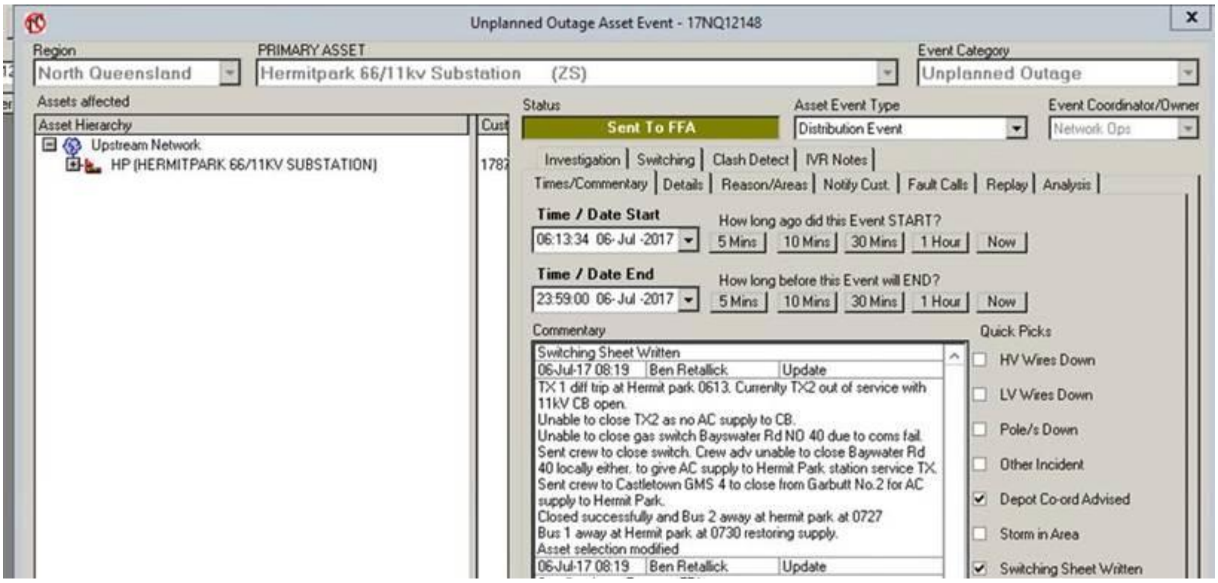


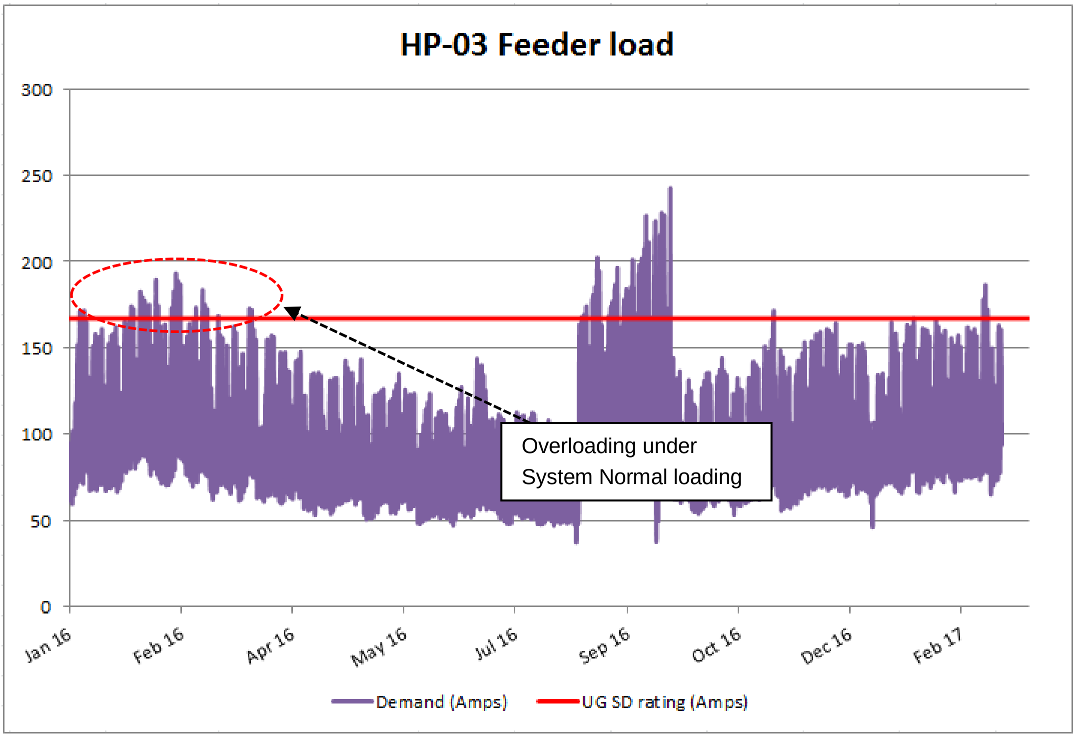
Figure 4: HEPA 11 kV Switchboard LV Closing Coil Constraint Impact (Current State)

NQ-904915-01-0F.pdf

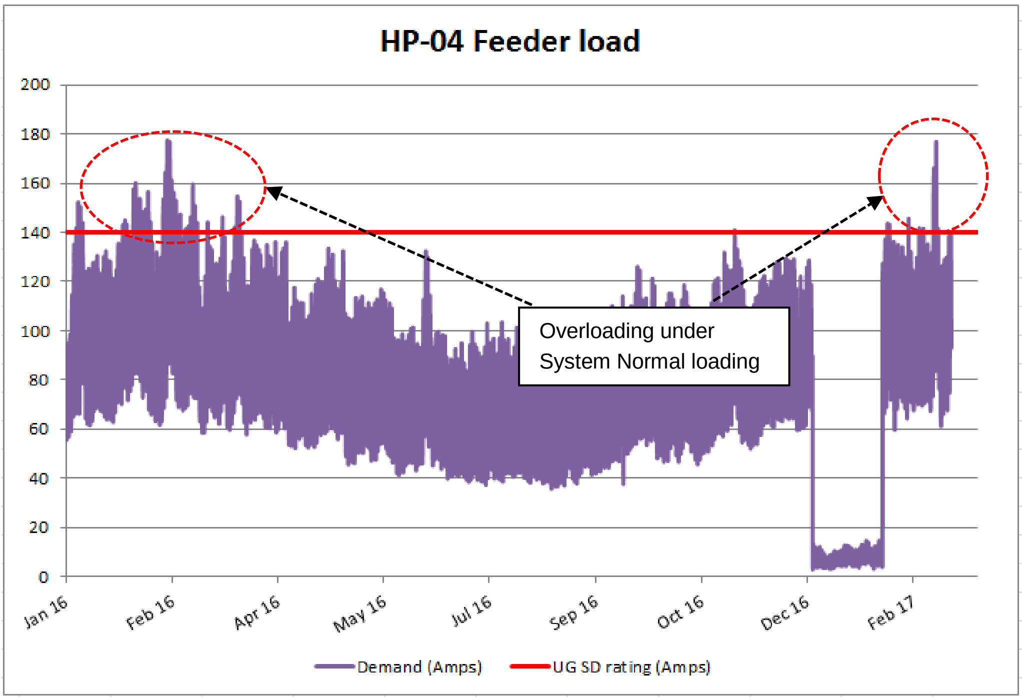
Considering the existing state of loading history it can be seen that;

- Hermit Park No.3 Feeder (HP-03) is currently overloaded (111%) [109%] under system normal conditions.
- Hermit Park No.4 Feeder (HP-04) is currently overloaded (127%) [108%] under system normal conditions.
- Hermit Park No.6 Feeder (HP-06) is currently overloaded (148%) [125%] under system normal conditions.

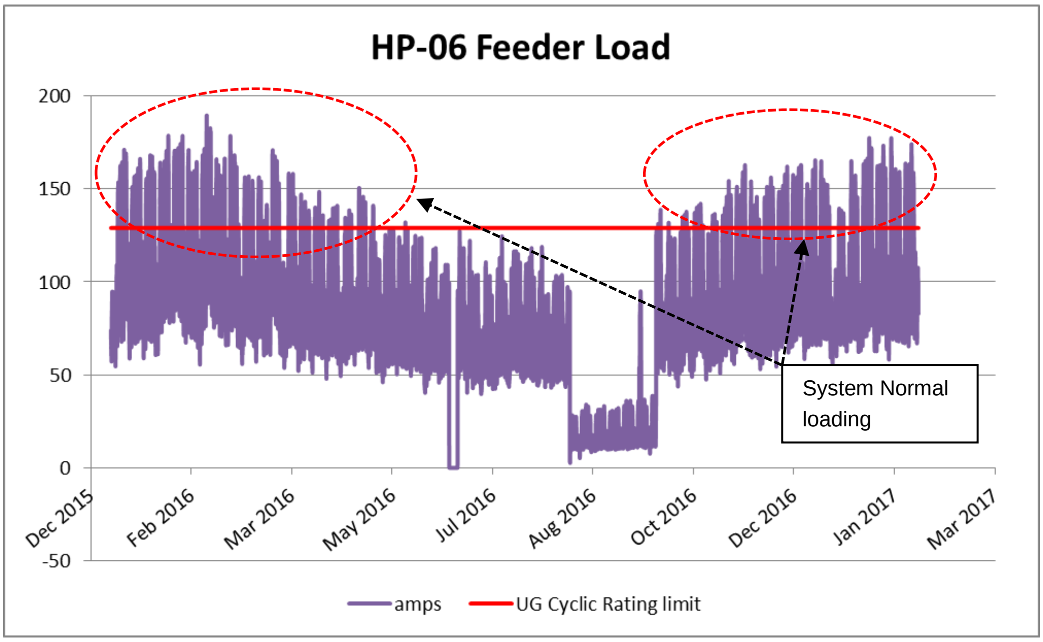
Graph 4 to 6 as shown below outlines the loading on the feeders described above.



Graph 4: HP - 03 Feeder Load (VERSION 4.3 OF SMDB PROFILER)



Graph 5: HP - 04 Feeder Load (VERSION 4.3 OF SMDB PROFILER)



Graph 6: HP - 06 Feeder Load (VERSION 4.3 OF SMDB PROFILER)

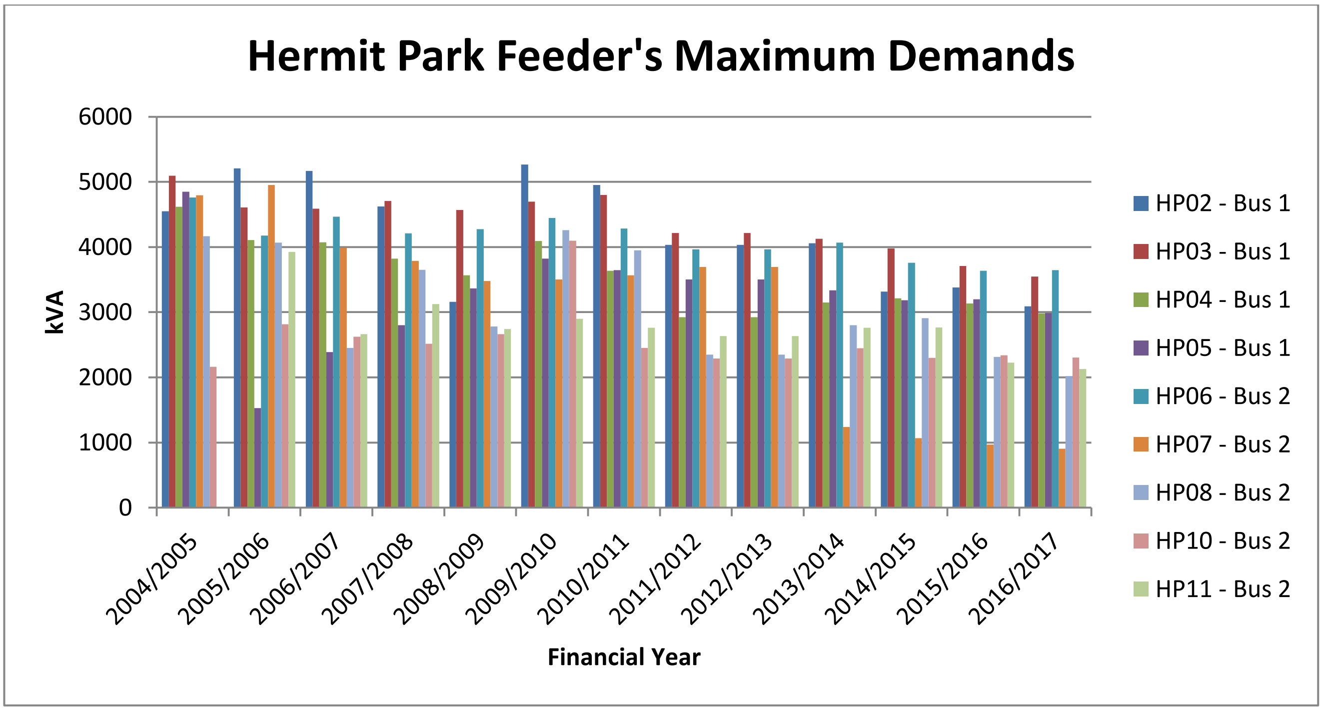
As it can be seen from a loading perspective, the thermal ratings on the HP-03, HP-04 and HP-06 would need to be increased or the feeder unloaded to alleviate the constraint.

Although the analysis above shows issues on two of the feeder exits to Marks St. (i.e. HP-03, HP-04) and one along Charters Towers Rd (ie HP-06), the civil works can be minimised by transferring load from HP-06 to BEGA-08 and utilising the spare conduit and reconfiguring the Marks St. conduit bank feeders.

Whilst an overload of 125% on HP-06 may indicate imminent failure of the Charters Towers Rd bank feeder exit cable, it can be seen from the average weekday and weekend load profiles and feeder cable distribution capacity that diversity and low adjacent feeder cable utilisation in the bank have enabled extra capacity to be made available in the HP-06 cable.

Whilst customer project WR1278179 has lapsed, West State Hospital was to be connected (i.e. 2 x 1000 kVA padmounts or approx. 1.2 MVA of demand) to HP06. As part of the works Kensington Apartments (TVS2767, 1000 kVA connected capacity or 0.4 MVA of diversified demand) was to be transferred to NS-01 and the HP-06 overhead network section will be transferred to BEGA-08. This amounts to approx. 2.06 MVA (recorded in 2016/2017) of transferred load based on 40% utilisation of the total connected capacity.

The net effect of the new connection and the 11 kV network reconfiguration will result in a reduction of load on HEPA ZS especially HP-06 (i.e. by a nett 1.26 MVA). This will reduce the HP06 demand from 191 A down to 125 A or alternatively, reduce the loading of the feeder from 125% to 82%. Should the West State Hospital not proceed as anticipated, the utilisation would drop further with a full transfer of 2.46 MVA (i.e. 130A). BEGA ZS has sufficient spare capacity.



Graph 7: Hermit Park Feeders' Maximum Demand (DFD)

Graph 5 shows the maximum demand for Hermit Park's feeders from the financial years of 2004/05 to 2016/17. The graph also shows that the maximum demands of these feeders have decreased since 2011/12. There was a load transfer that was done in 2013 from Railway Ave No. 2 switch (HP-07 to Oonoonba Feeder No. 08 or OONN-08). It can be seen that HP-02, HP-03 and HP-06 typically have a higher demand in comparison to the other feeders.

Furthermore, the load demand on Bus 1 seems to be relatively higher than Bus 2. Due to the number of schools, hospitals and the showground, this may contribute to the load demand. In addition, Bus 1 and 2 feeders are not evenly balanced across the Marks St. and Charters Towers Rd conduit banks. If one 11 kV bus is out of service, either bank that is carrying the remaining bulk of load may reduce the feeder's rating.

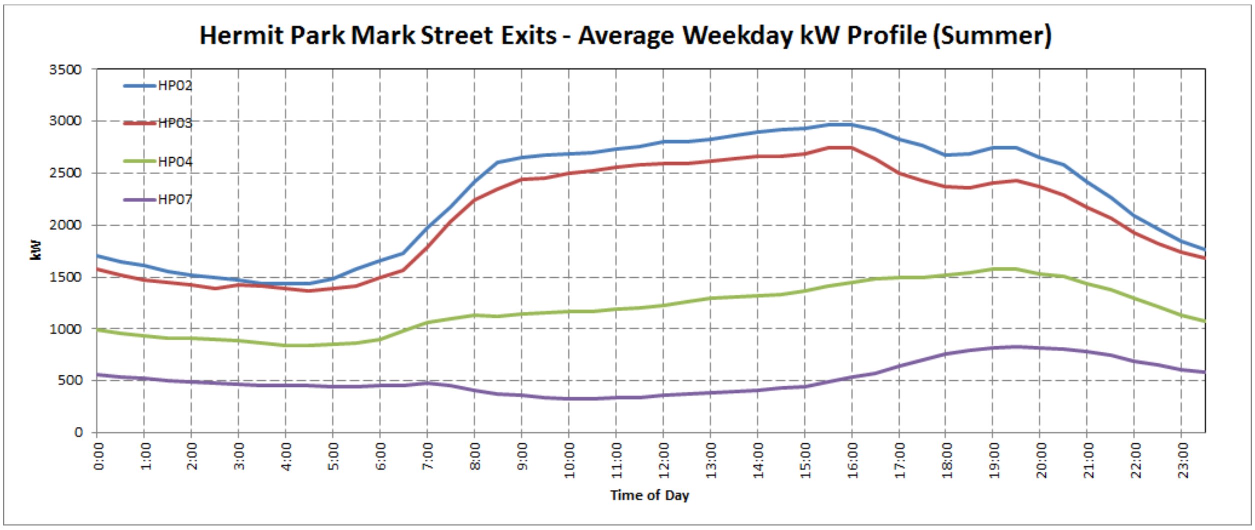
HP-04 has a high potential for growth due to past proposals of unit development surrounding the golf course. This would be a suitable candidate for upgrade as there is a spare conduit in the Marks St. feeder exit conduit bank. It is likely that the conduits have a diameter of 100mm and therefore, would only cater for 3 core 240Cu. XLPE cables and not 400Al. triplex XLPE cables as they require a conduit with a diameter of 125mm for installation purposes.

Similarly, due to the constrained HP-03 feeder, it is recommended 300Al. 3C PLYSWS be drawn out from the existing 100mm conduits and replaced with a 3C 240Cu. XLPE cable. This feeder exit can also potentially provide an alternate high-reliability supply to HP-06.

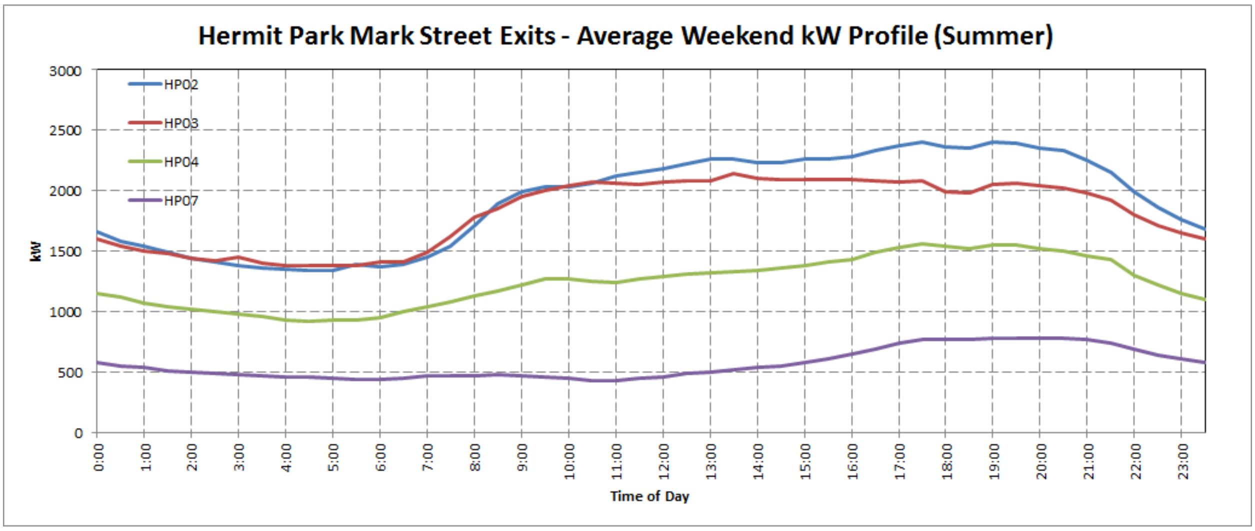
The 11 kV switchboard is 40 years old (YOM: 1978) and it is unlikely to be replaced within 10 years. This means that upgrading all the feeder exit cables will likely require future joints between the feeder exit cables and the switchboard to be replaced.

There are potential risks of losing 11 kV circuit break LV closing coil supply to both bus sections whilst either T1 or T2 is out of service (e.g. replacement of T1 or T2). Whilst this risk is small, the occurrence has occurred on occasions (refer Figure 5), particularly for long-duration plant outages.

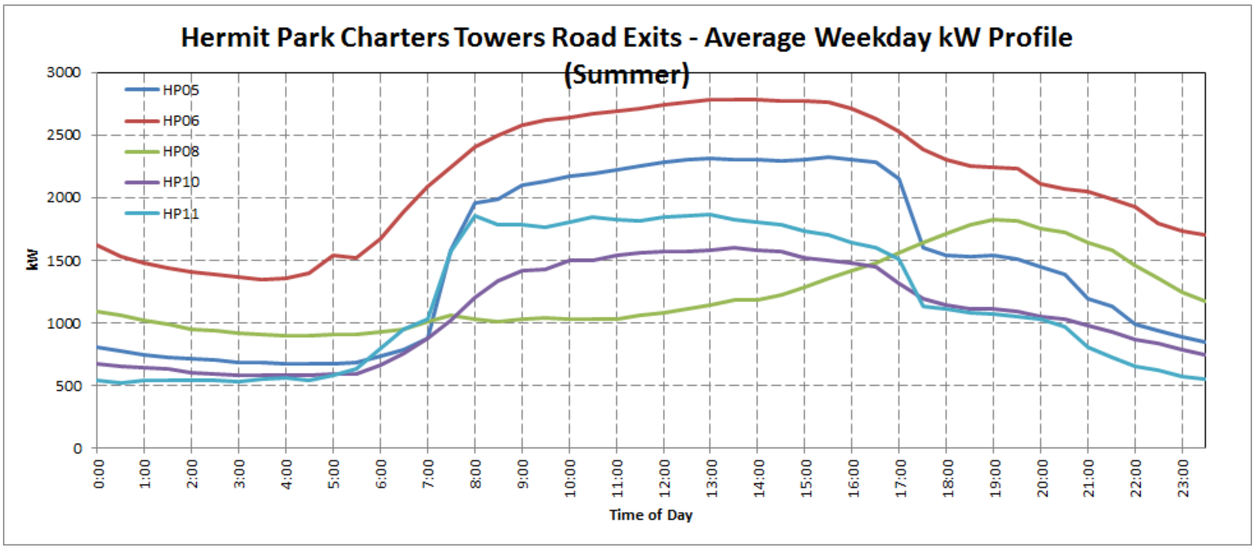
Therefore, it is prudent to upgrade and reconfigure some of the feeder exits (i.e. HP03, HP04 and HP06) that can be reasonably managed considering the loading risk, area growth, balance of feeder loads in the conduit banks, LV closing supply risks and sequencing with future switchboard replacement considerations. This is best achieved by installing a remotely control gas switch in place of the HP-05 No. 1 links.



Graph 8: Hermit Park Feeder Average load profiles (Summer Weekday) - Mark St. exits



Graph 9: Hermit Park Feeder Average load profiles (Summer Weekend) - Mark St. exits



Graph 10: Hermit Park Feeder Average load profiles (Summer Weekday) - Charters Towers Road exits

Real Time Thermal Sensing

Real Time Thermal Sensing has been investigated to understand whether the use of these devices will assist in extending the life expectancy of a cable. In a planning application guideline that is due for release by the Asset Capability and Utilisation Ratings team in December 2018, it suggests these sensors should be installed with cables that regularly have a load demand of 4 – 5 MVA. Furthermore, the estimated cost to install thermal sensors on seven of the feeders is approximately $100k. As shown in graph five, it can be seen that these feeders do not regularly supply 4 – 5 MVA.

Safety Net Compliance

Hermit Park as seen in the following attached document satisfies Safety Net. Due to the N – 1 configuration, the second transformer cannot be retired.

Safety Net
Contingency Manage

Fault Level Limitation

The fault level as shown below in Table 20 is when the network is experiencing maximum fault levels. The bus tie configuration is Normally Open (N.O.).

The impedance of the 15/20/25 MVA (ONAN/ONAF/OFDAF) transformer is 18.23% (and R = 0.78%) at the neutral tap (tap 6).

Table 20: Maximum Symmetrical Fault Levels for Transformer 25 MVA OFDAF (Annual Fault Study Summaries – Subtransient)

	VOLTAGE	FAULT TYPE	FAULT LEVEL (KA)
June 2018 Maximum Fault Level	66 kV	L – G	11.27
	11 kV		14.02 (N.C bus)
			7.4 (N.O bus)
	66 kV	L – L –L – G	13.37
	11 kV		13.27

Note: 18.4 kA rating for Hawker Siddeley 11 kV Switchboard (Symmetrical)

Table 18: Maximum Asymmetrical Fault Levels for Transformer 25 MVA OFDAF, 11 kV Bus (DINIS Simulated)

FAULT TYPE	FAULT LEVEL (KA)
L – G	35.2 (N.C bus)
	19.1 (N.O bus)
	N/O: 82.6% Asymmetrical rating
L – L –L – G	33.3 (N.C bus)
	18.6 (N.O bus)
	N/O: 80.9% Asymmetrical rating

Note: 23 kA rating for Hawker Siddeley 11 kV Switchboard (Asymmetrical)

The allocated 20/25 MVA system spare is:
Plant number: TR94027559
Serial number: P0708A
YOM: 2008
Vector group: Dyn1 66/11 kV OLTC
Cooling: ONAN/ONAF

CatId27666_system spare 20_25.pdf

The impedance of the allocated spare 20/25 MVA transformer is 10% (and R=0.49%) at 20 MVA, neutral tap (tap 5). The existing T1/T2 OLTC impedance is 10.97% (and R= 0.42%) but at 15 MVA and neutral tap (tap 6). This transformer specification is used for the following fault level calculations.

Table 19: Maximum Asymmetrical Fault Levels for spare TR94027559, 11 kV Bus (DINIS Simulated)- TAP 5

FAULT TYPE	FAULT LEVEL (KA)
L – G	47.6 (N.C bus)
	26.6 (N.O bus)
	N/O: 115.7% asym. Rating
L – L –L – G	44.1 (N.C bus)
	25.5 (N.O bus)
	N/O: 110.9% asym. rating

Note: 23 kA rating for Hawker Siddeley 11 kV Switchboard (Asymmetrical)

The allocated 32 MVA system spare is:
Plant number: TR94521257
Serial number: P1110C
YOM: 2011
Vector group: Dyn1 66/11 kV OLTC
Cooling: ONAN/ONAF

The above transformer specification is used for the following fault level calculations.

The impedance of this spare 32 MVA transformer is:

- 19.57% (and R= 0.63%) at neutral tap (tap 5);
- 18.03% (and R= 0.58%) at 32 MVA, max. boost tap 21.

The Belgian Gardens units have an impedance of 19.89% (and R= 0.63%) at 32 MVA, neutral tap 5.

Table 20: Maximum Asymmetrical Fault Levels for a similar 32 MVA spare 11kV Bus (DINIS Simulated) - TAP 5

FAULT TYPE	FAULT LEVEL (KA)
L – G	40.7 (N.C bus)
	22.4(N.O bus)
	N/O: 97.4% asym. rating
L – L –L – G	38.2 (N.C bus)
	21.7 (N.O bus)
	N/O: 94.3% asym. rating

Note: 23 kA rating for Hawker Siddeley 11 kV Switchboard (Asymmetrical)

Table 21: Maximum Asymmetrical Fault Levels for a similar 32 MVA spare at 11 kV Bus (DINIS Simulated) - TAP 21

FAULT TYPE	FAULT LEVEL (KA)
L – G	44.1 (N.C bus)
	24.5(N.O bus)
	N/O: 106.5% asym. rating
L – L –L – G	41.2 (N.C bus)
	23.6 (N.O bus)
	N/O: 102.6% asym. rating

Note: 23 kA rating for Hawker Siddeley 11 kV Switchboard (Asymmetrical)

The existing 15/20/25 MVA HEPA transformers T1 and T2 under a N/O 11 kV bus asymmetrical fault do not exceed 83% of the Hawker Siddeley 11 kV switchboard asymmetrical fault rating. The spare 20/25 MVA (ONAN/ONAF) power transformer is not suitable for HEPA as it exceeds the N/O 11 kV bus asymmetrical fault level. Under normally closed conditions, safety management switching operations will be conducted remotely by SCADA.

In using standard 32 MVA transformer impedances, the margins of error indicate that at typical boost taps, it is likely that the L-G fault level will exceed asymmetrical fault ratings of the Hawker Siddeley 11 kV switchboard.

Whilst it may be argued that Transmission Network Service Provider (TNSP) fault levels will fall as synchronous generation is displaced with renewable generation despatch, the network impedance impacts are dominated by the specification of 132/66 kV and 66/11 kV transformer impedances. Marginal fault level increases can also be experienced by call on demand low voltage diesel generators that operate in the distribution network.

Thus, it is also not recommended that a 32 MVA on load tap changer (OLTC) or the low impedance 20/25 MVA system spare transformer be installed where the asymmetrical fault level operates at the margin of the 11 kV Hawker Siddeley switchgear rating.

Consideration shall be given to:

- transfer the Black River 20/25 MVA power transformer to Hermit Park; and
- install a 32 MVA power transformer at Black River (BLRI).

The BLRI OLTC unit (P1118A) has an impedance of 15.0 % (at 20 MVA) and LTEC of 29.9 MVA, which is similar to the HEPA units. The cost to install a 32 MVA power transformer and associated bund work at BLRI ZS, 11 kV switchboard design and the relocation of P1118A to HEPA ZS may not be economical when compared to a direct purchase and direct install of a similar impedance 20/25 MVA at HEPA.

Table 22: Limitation on Hermit Park's Feeders (June 2013 Zone Substation Rating Report)

HEPA Feeder Cable	Plant and Rating Detail	Fault Rating (kA / 1 sec)
HP – 02	240mm^2 Al 3 core XLPE/NY/HDPE	10.2
HP – 03	300mm^2 Al 3 core PLY/SWS/Belted	23.5
HP – 04	300mm^2 Al 3 core PLY/SWS/Screened	23.7
HP – 05	300mm^2 Al 3 core PLY/SWS/Screened	23.7
HP – 06	300mm^2 Al 3 core PLY/SWS/Belted	23.5
HP – 07	300mm^2 Al 3 core PLY/SWS/Screened	23.7

HP – 08	300mm^2 Al 3 core PLY/SWS/Screened	23.7
HP – 10	300mm^2 Al 3 core PLY/SWS/Screened	23.7
HP – 11	240mm^2 Cu Triplex XLPE/CWS/PVC/CTS/HDPE	10.5

Table 23: Limitation on Hermit Park's 11 kV Transformer Bay 1 and Bay 2 (June 2013 Zone Substation Rating Report)

Plant Item	Plant and Rating Detail	Rating (A/MVA)	Fault Rating (kA)
11 kV Bus	Hawker Siddeley Switchboard 11 kV YOM: 1978	2000/38.1	18.4 (Symmetrical, 1 sec.) 23 (Asymmetrical)
Transformer 1 Cable Ratings Single bonded	Summer 37°C Winter 25°C	1646/31.4 1984/37.4	96.9 (Symmetrical, 1 sec.)
Circuit Breaker **(CB A552 & B552)**	Hawker Siddeley Switchgear YOM: 1978	2000/38.1	18.4 (Symmetrical, 1 sec.) 23 (Asymmetrical)

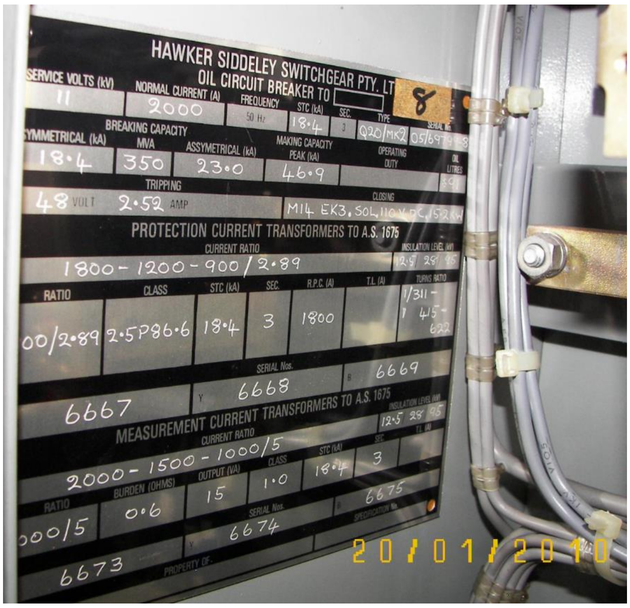


Figure 5: HEPA 11 kV T2 Nameplate Rating (Asymmetrical Rating is the same 23.0 kA for the Feeder Circuit Breakers')

Asset Life Cycle Summary

Remaining Primary Plant

Concat Name	Replacement Year	Condition
NQ HEPA B196 A Ph - CT92682153 1980 66 kV Modern Products > 597E/6/A (M1143)	2030	Bad
NQ HEPA B196 B Ph - CT93055311 1980 66 kV Modern Products > 597E/6/A (M1144)	2030	Bad
NQ HEPA B196 C Ph - CT92629878 1980 66 kV Modern Products > 597E/6/A (M1145)	2030	Bad
[1]NQ HEPA A152 - CB91625127 1979 66kV - SPRECHER AND SHUH > HPFA 409G (8891/30)	2018	[2]HPF
[1]NQ HEPA B152 - CB91636159 1979 66kV - EIB > HPFA 409G (8891/30)	2018	[2]HPF

[1]Note: Projects have been raised regarding the replacement of the Circuit Breakers (CB91625127 & CB94766944). This asset is out of service and has a status of “disposed” (Ergon Ellipse Prod).

[2]Note: HPF: High Potential Failure

It should be noted that A152 and B152 have been replaced under a priority C/B replacement program. Whilst it is not preferred to replace recently installed assets, the dead tank circuit breaker replacement of both the C/B and C/T is based upon access, bunding and firewall necessities.

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)1 under section 6.4 on Network Planning Criteria and can be found under the following links.

The Value of Customer Reliability (VCR) is $27/kWh for Hermit Park. The calculation for this figure can be found in (Appendix B). VCR values have not been included in the financial analysis as the base case is not considered as an acceptable option, and there is no significant customer reliability difference between options.

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

RISK ASSESSMENT

Risk Category	Equipment	Risk Scenario	Inherent / Untreated Risk			Residual Risk (Preferred Option)	
			C	L	Risk Score	L	Risk Score
Safety	Transformer	Catastrophic failure of the transformer causing tank rupture and collapse of windings leading to a transformer fire which results in serious injuries to multiple members of staff or the public.	4	3	12 (Moderate)	1	4 (Very Low) ALARP
			C	L	Risk Score	L	Risk Score
Environment	Transformer	Catastrophic failure of a transformer resulting in loss of oil into the containment system which requires clean up and rectification.	3	4	12 (Moderate)	1	3 (Very Low) ALARP
			C	L	Risk Score	L	Risk Score
Customer	Transformer	Transformer failure results in interruption to 7000 customers or > 1 day to restore.	4	2	8 (Moderate)	1	4 (Very Low) ALARP
			C	L	Risk Score	L	Risk Score
Business	Transformer	Failure of aged transformer (high impedance) without strategic spares results in significant impact on restoration or planned works with a cost premium > $1 million.	4	4	16 (Moderate)	1	4 (Very Low) ALARP
			C	L	Risk Score	L	Risk Score
Business	RTU	Failure of an RTU results in loss of control of network or leads to abnormal network configuration	3	3	9 (Low)	1	3 (Very Low) ALARP

Table 24 Risk Assessment

Network Risk Evaluation Matrices:

Network Risk Sub-Scales.pdf

Risk Assessment Outcome:

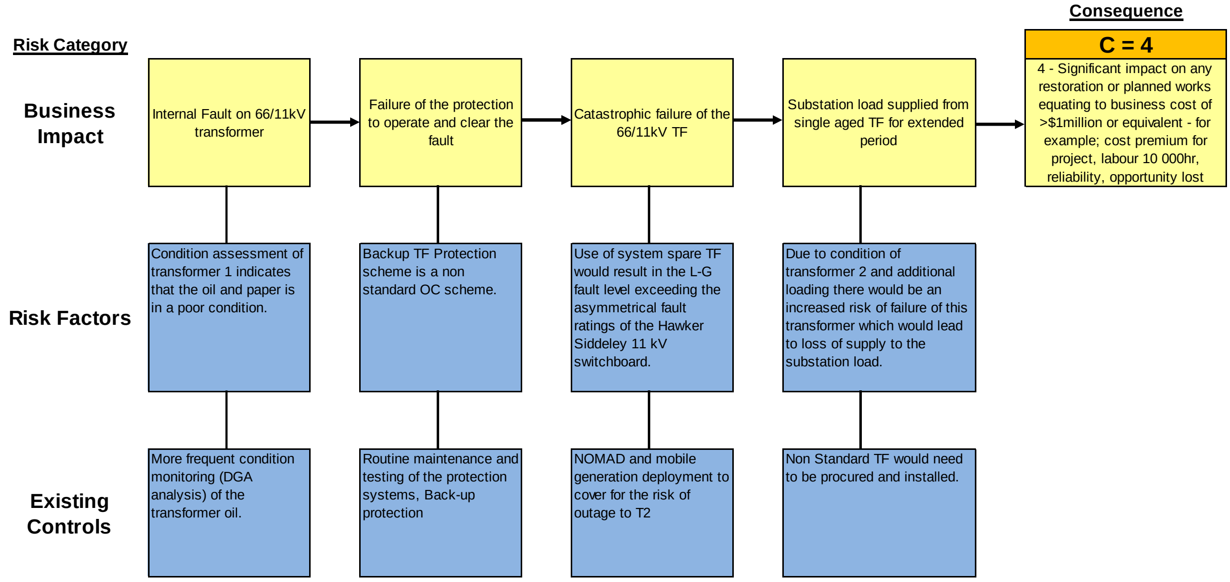
The network (business) risks the organisation would be exposed to if the project was not undertaken (Inherent Risk) are **not** deemed to be as low as reasonably practicable (ALARP). Addressing the risks, as detailed above, through implementation of the preferred option (Option A) will reduce Energy 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 (Hermit Park) is shown below.

Risk Scenario

Failure of aged transformer (high impedance) without strategic spares results in significant impact on restoration or planned works with a cost premium > $1 million.



Relevant Risk Factors, causes and comments

66/11kV Transformer No.1 at Hermit Park Substation has reached retirement age.

Spare transformer has lower impedance than the existing transformer. Use of the spare would result in fault levels higher than 11kV SB rating.

Assessed Likelihood of this scenario

L = 4	4 - Verbal Descriptors - Likely to occur

Risk Score	Risk Descriptor
30 to 36	Intolerable
25 to 29	Very High Risk
18 to 24	High Risk
11 to 17	Moderate Risk
6 to 10	Low Risk
1 to 5	Very Low Risk

Assessed risk of this scenario: R = C x L

R = 16 (Moderate Risk)

Inherent/Untreated Risk

OPTIONS ANALYSIS

Base Case (Do Nothing)

This not considered an acceptable solution.

Condition assessment of T1 and T2 indicates that T1 is a high-risk replacement asset which has an ongoing history of repairs, maintenance and monitoring.

Similarly, the Mark St. 11 kV feeder exits are constrained and aged PLYSWS assets. Whilst HP-06 is constrained and an aged PLYSWS cable, load transfers will mitigate the overload risk.

Outcome

If no action is taken:

- Catastrophic failure: power transformers, current transformers and/or voltage transformer fails and may lead to a loss of supply
- The feeder exit cables will continue to be over utilised – this will shorten the lifespan of the cables and lead to cable failures
- Safety risk: if any assets experience a rupture failure, this may injure nearby staff or members of the public
- An event occurs where protection is needed to operate but fails to do so leading to a dangerous electrical event or at worst a fatality

Scope

Business as Usual

Key Assumptions

- The load that the zone substation currently supplies does not drastically change based on the forecast (SIFT VERSION 27 2017 POST SUMMER POWERLINK LG)
- The assets will run as usual, maintenance tasks will continue and access will eventually be restricted and this will result in significant failure i.e. NARs

Risks

- The fault level that is limited by the 11 kV feeder exit cables: fault rating constraint
- If protection fails to operate: may cause damage to the equipment or cause unnecessary outages, which may affect the power quality in the area
- NARs restrict access

Option A: Replace Transformer 1 (recommended)

Replace T1, T1 66 kV CB/CT with a dead tank CB, 66 kV T1 back-up protection, 66 kV bus zone back-up protection, C2025 RTU and select 11 kV feeder exit upgrades. Defer T2 replacement to 2025/26 or later as required under CBRM.

The total estimated DCV cost (2018/19) of the scope of works covered by Option A is $2.69M.

Scope

- Replace power transformer one (TR93026860) with a new 20/25 MVA ONAF OLTC transformer with specified impedances and tap range of at least 5% buck and 20% boost; however, a 32 MVA is possible as long as the impedances match the impedances of the present power transformer one;
- Upgrade the 11 kV exit feeder cables from PLYSWS to 240mm^2 Cu. 3 core or Triplex 400mm^2 Al Triplex:
  - HP–03 and HP-04 (Marks Street);
- Reconfigure HP-06 (unload to BEGA-08);
- Capacitor Bank removal; however the footprint of the capacitor bank may be retained for future installation;
- Replace transformer backup protection relay to GE T60 on HEPA 66/11kV T1;
- Install EQL Standard P746 protection relay to provide back-up protection to the existing 66kV bus protection scheme;
- Build new bunding and firewalls to satisfy the standard and that will contain the new transformer and allow suitable future access to T2;
- Replace the circuit breaker and current transformers (CB93712976, CT93014664, CT821510444 & CT91663295) in the 66 kV bay to be dead tank circuit breaker to allow space for future replacement of T2 (i.e. space for cranes);
- Upgrade the substation fence to comply against the new standard;
- Replace the existing C2025 (ie RTU) under this scope and work request.

Key Assumptions

- Power transformer two has a low likelihood of failure until after the year 2025
- It is possible to remove the second transformer after transformer one is replaced
- The removal and installing of transformer one, to facilitate future replacement of transformer two is possible
- Not enough information on the capacitor bank failure; these capacitors will be removed when transformer 2 is to be replaced
- Earth Mat investigations are completed every 10 years. If the new transformers are to have the same impedance as the current transformers then there are no risks surrounding the earth mat.

Risks

- Power transformer two could fail during the project which losses supply to Hermit Park
- The initial plan to remove transformer two was deemed possible but when the contract transformer was purchased it was too large to install
  - A possible solution to alleviate this risk is to conduct a design service task and consult contractors
- The standard for the transformer bunding changes, making transformer 2 bunding more difficult to design given its location
- As civil works will be required, there is a risk of increased cost due to unforeseen issues

Option B: Replace Transformer 1 and 2

Replace T1 & T2, T1 & T2 66 kV CB/CT, 66 kV T1 & T2 back-up protection, 66 kV bus zone back-up protection, C2025 RTU and select 11 kV feeder exit cables by 2023.

The total estimated DCV cost (2018/19) of the scope of works covered by Option B is $3.69M.

Scope

- Replace power transformers one and two (TR93026860 and TR92617192) with 20/25 MVA ONAF power transformers with specified impedances to ensure they satisfy the fault rating; however, a 32 MVA is possible as long as the impedances match the impedances of the present power transformer one
- Upgrade the 11 kV exit feeder cables from PLYSWS to 240mm^2 Cu. 3 core or Triplex 400mm^2 Al Triplex:
  - HP–03 and HP-04 (Marks Street);
- Reconfigure HP-06 (unload to BEGA-08);
- Capacitor Bank removal; however the footprint of the capacitor bank may be retained for future installation;
- Replace transformer backup protection relay to GE T60 on HEPA 66/11kV T1 & T2;
- Install EQL Standard P746 protection relay to provide back-up protection to the existing 66kV bus protection scheme;
- Build new T1 & T2 bunding and firewalls to satisfy the standard and allow suitable future access to T2;
- Replace the circuit breaker and current transformers (CB93712976, CT93014664, CT821510444 & CT91663295) in the 66 kV bay to be dead tank circuit breaker to allow space for the replacement of T2 (i.e. space for cranes)
- Upgrade the substation fence to comply against the new standard
- Replace the existing C2025 (i.e. RTU) under this scope and work request.

Key Assumptions

- Replacing both transformers are logistically possible given their location
- Earth Mat investigations are completed every 10 years. If the new transformers are to have the same impedance as the current transformers then there are no risks surrounding the earth mat.

Risks

- As civil works will be required, there is a risk of increased cost due to unforeseen issues
- The positioning of both transformers is not possible, this means that the substation could only allow room for one power transformer
  - A possible solution to alleviate this risk is to conduct a design service task and consult contractors
- The standard for the transformer bunding changes, making transformer bunding more difficult to design given its location

Non-Network Alternatives

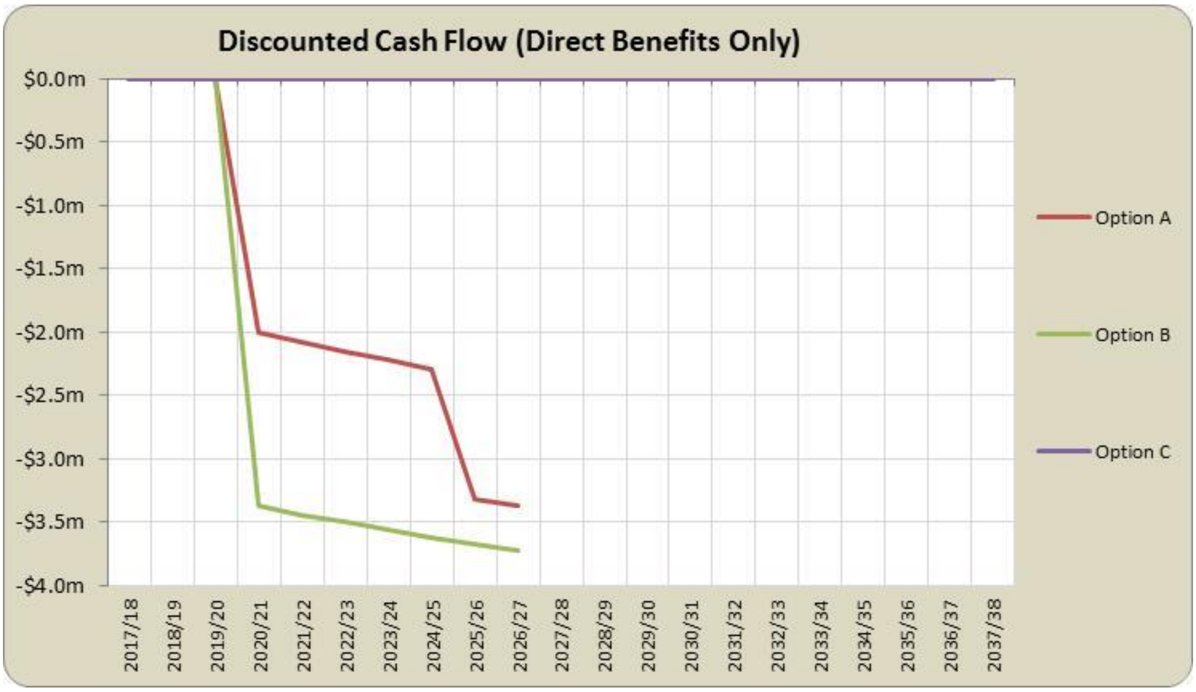
Energy Queensland is committed to the implementation of Non-Network Solutions to reduce the scope or need for traditional network investments. Our approach to Demand Management is listed in Chapter 7 of our Distribution Annual Planning Report but involves early market engagement around emerging constraints 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 Repex, addressing both asset safety and performance risks. A successful Non-Network Solution may be able to assist in reducing the scope required for the replacement project but will not be able to impact the project timing due to the aged equipment risk. The scope of the recommended network option has proposed retaining the existing configuration and capability and it is considered that total removal of the asset would be uneconomic or represents an increase in reliability performance risk that is not acceptable.
The customer base in the study area is predominantly established residential and commercial and has a medium opportunity to reduce demand or provide economic non-network solutions.

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.

FINANCIAL ANALYSIS SUMMARY

$ Millions	Option A	Option B	Option C
Capex	(2.20)	(2.69)	0.00
Opex	(0.96)	(0.91)	0.00
Direct Benefits	0.00	0.00	0.00
Commercial NPV	**(3.15)**	**(3.60)**	**N/A**
Ranking	*1*	*2*	*N/A*
Indirect/Risk	0.00	0.00	0.00
Commercial + Risk	**(3.15)**	**(3.60)**	**N/A**
Ranking	*1*	*2*	*N/A*



Option A	Replace - T1, T1 66 kV CB/CT with a dead tank CB, 66 kV T1 back-up protection, 66 kV bus zone back-up protection, C2025 RTU and select 11 kV feeder exits by 2023. Defer T2 replacement to 2025 or later.
Option B	Replace - T1 & T2, T1 & T2 66 kV CB/CT, 66 kV T1 & T2 back-up protection, 66 kV bus zone back-up protection, C2025 RTU and select 11 kV feeder exits by 2023.

	Base Case		Option A		Option B	
	Advantage	Disadvantage	Advantage	Disadvantage	Advantage	Disadvantage
Safety		Safety risk for the public and this could result in fatality or serious injuries.	Addresses safety issues associated with assets that have been deemed to reach end of life.		Addresses safety issues associated with assets that have been deemed to reach end of life.	
Fault Levels						
Economics	Defer project costs	Cost more in the long term if a catastrophic failure occurs. The project cost to resolve this issue	Facilitates a staged approach			Cost more upfront
Resources	Use normal resources for routine maintenance	Demand and resource for emergency restoration	Relieves the PoW resource requirements by deferring installation of the 2nd 66/11kV TF for five years.	Demand and resource for emergency restoration in the event of a failure		High resource demand – longer project duration
Utilisation		Presently exceeding utilisation on feeder cables max demand	Optimally utilises existing network assets		Optimally utilises existing network assets	
Other			Recover assets that have been deemed to reach end of life		Recover assets that have been deemed to reach end of life	

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

SUPPORTING INFORMATION

CBRM information as required.

CONCLUSION

To address the condition of the power transformer in Hermit Park ZS, this report recommends the replacement of T1, T1 66 kV CB/CT with a dead tank CB, 66 kV T1 back-up protection, 66 kV bus zone back-up protection, C2025 RTU replacement and select 11 kV feeder exit upgrades. It is recommended that T2 replacement be deferred to at least 2025 or later pending condition monitoring.

The total estimated DCV cost (2018/19) for the recommended works is $2,689,287.

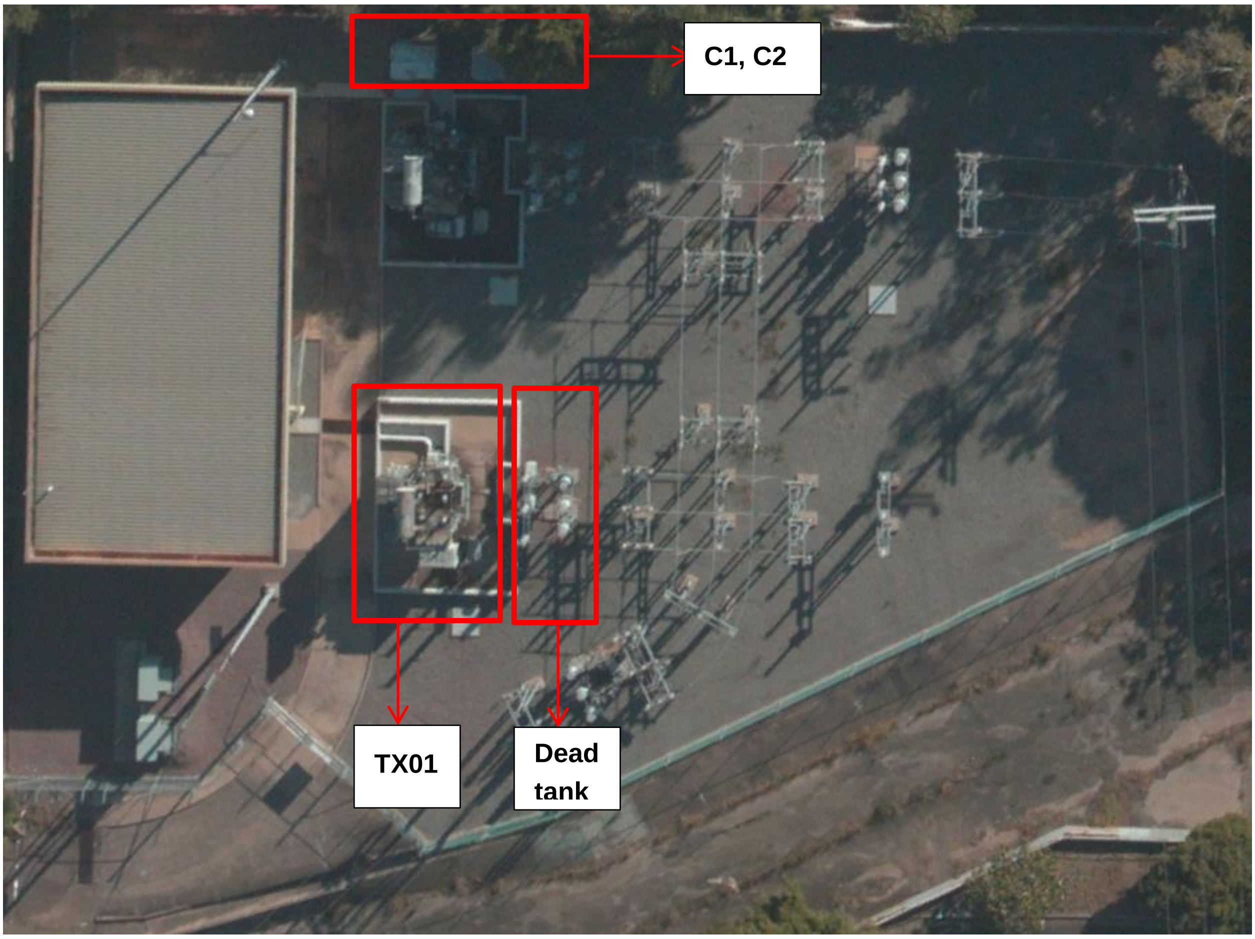
APPENDIX A

Supporting Pictures:

http://corp/erg/EEPZ/Standards/STNW1002.pdf - Standard for the protection relay

HEPA Protection Works.msg

Google Earth Screenshot of Hermit Park's Substation



APPENDIX B

VCR Value Analysis

Table 25: Number of Customers Breakdown (NETDASH)

Feeder	Domestic	Industrial	Total Customers
HP-02	904	148	1052
HP-03	883	182	1065
HP-04	1261	125	1386
HP-05	739	54	793
HP-06	629	137	766
HP-07	613	26	639
HP-08	1282	94	1376
HP-10	216	56	272
HP-11	0	10	10
TOTAL	6527	832	7359

Table 26: AEMO VCR Values (**AEMO VCR FACT SHEET 2016**)

Sector	$/kWh	VCR ($/MWh)
Domestic	$25	$25,420
Commercial	$45	$44,720
Industrial	$44	$44,060
Rural	$48	$47,670

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

$$VCR = \$27.15/kWh \approx \$27/kWh$$

$$VCR = \frac{(832\ x\ 44) + (6527\ x\ 25)}{7359}$$

$$VCR = \$27.15/kWh \approx \$27/kWh$$

APPENDIX C

Financial Analysis

HEPA NPV v0.4.xlsm

APPENDIX D

Feeder Exit Information

Hermit Park 11kV
Exits CB-2013 rev2.x

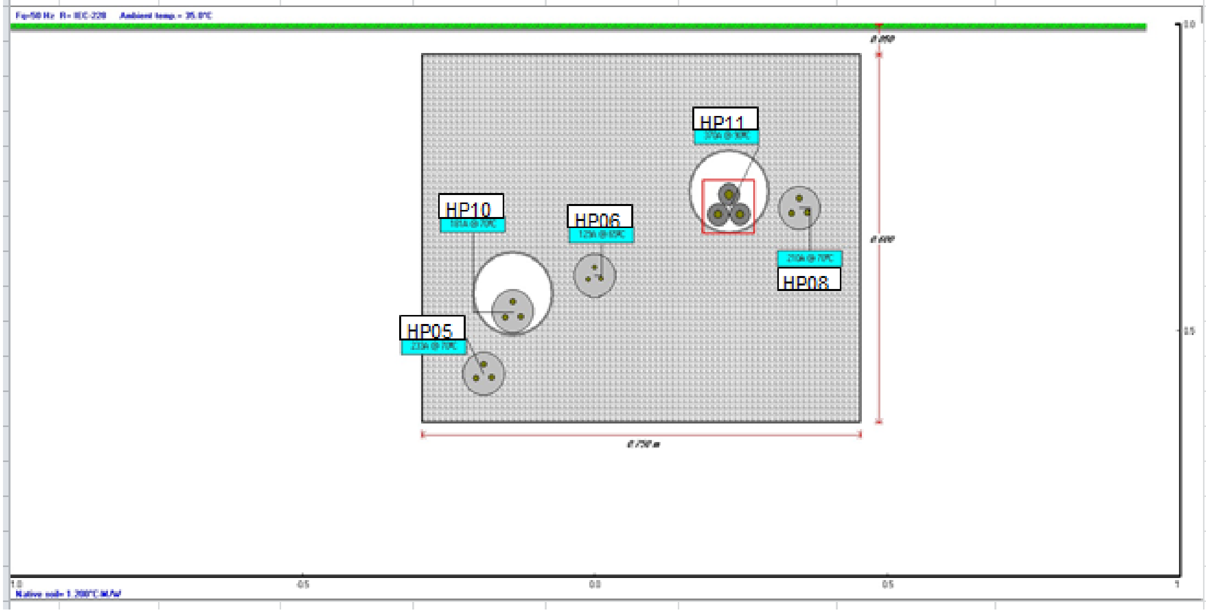
Summary Results

CYMCAP 6.0 rev. 5

Study: HEPA-ChartersTowers RD feeder exits
Execution: HP 6/10/5/8/11 - TR3.0/35deg/LFset/WP6R_trenchsect1
Date: 9/04/2013
Frequency: 50 Hz
Conductor Resistance: IEC-228

Fraction of conductor current returning through sheath for single phase cables: 0

Installation Type: Multiple Duct Banks Backfills							
Parameter						Unit	Value
Ambient Soil Temperature at Installation Depth						°C	35
Thermal Resistivity of Native Soil						°C.m/W	1.2
Layers		Dimensions [m]				Type	Thermal Resistivity [°C.m/W]
No.	Name	X Center	Y Center	Width	Height		
1	NSTD DB1	0.08	0.35	0.75	0.6	Non-Standard ductbank	3



Summary Results

CYMCAP 6.0 rev. 5

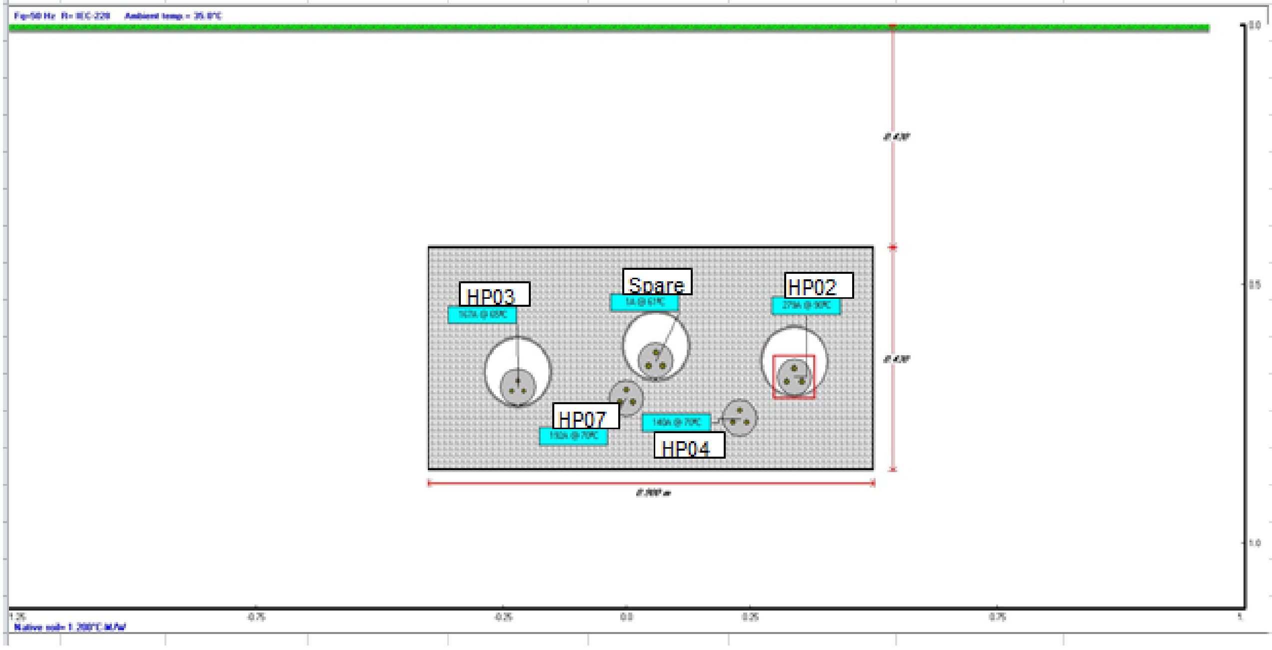
Study: HEPA-Mark St feeder exits temp solution
Execution: HP3/4/7/2 - TR3.0/35deg/LFset/WP51R_trenchsect1spare
Date: 10/04/2013
Frequency: 50 Hz
Conductor Resistances: IEC-228

Fraction of conductor current returning through sheath for single phase cables: 0

Installation Type: Multiple Duct Banks Backfills

Parameter	Unit	Value
Ambient Soil Temperature at Installation Depth	°C	35
Thermal Resistivity of Native Soil	°C.m/W	1.2

Layers		Dimensions [m]				Type	Thermal Resistivity [°C.m/W]
No.	Name	X Center	Y Center	Width	Height		
1	NSTD DB1	0.05	0.645	0.9	0.43	Non-Standard ductbank	3



Summary Results

CYMCAP 6.0 rev. 5

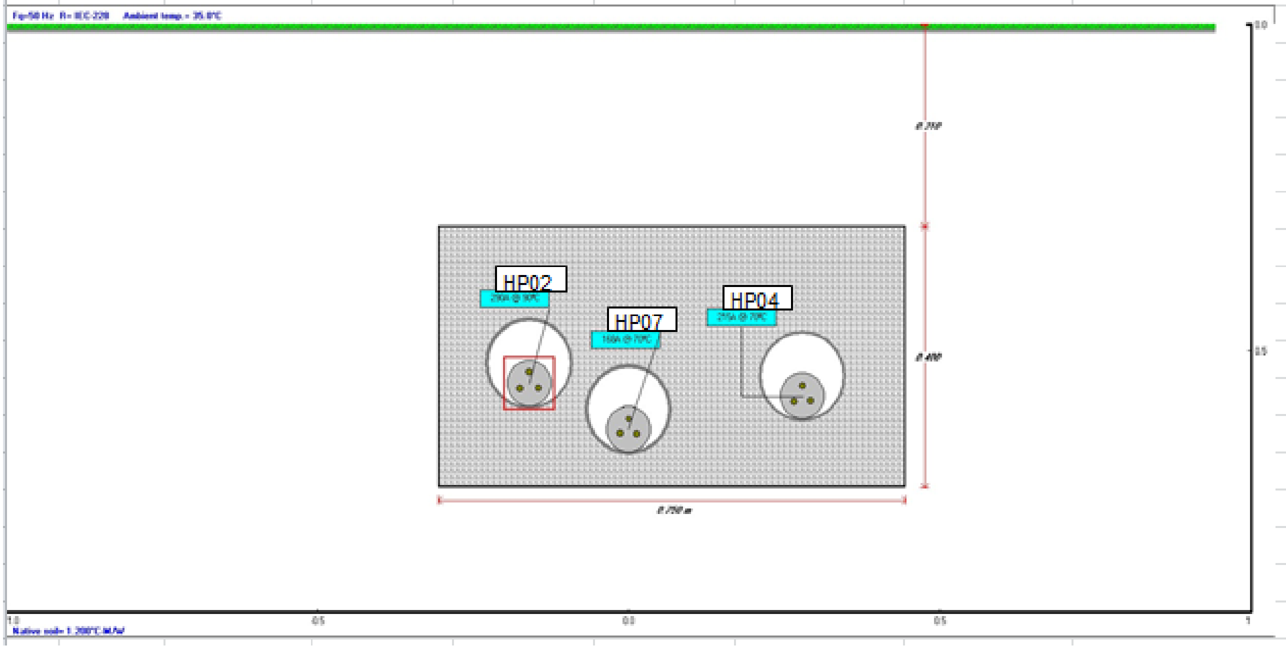
Study: HEPA-Mark St feeder exits temp solution
Execution: HP4/7/2 - TR3.0/35deg/LFset/MID Rd Mark ST-R_trench1
Date: 12/04/2013
Frequency: 50 Hz
Conductor Resistances: IEC-228

Fraction of conductor current returning through sheath for single phase cables: 0

Installation Type: Multiple Duct Banks Backfills

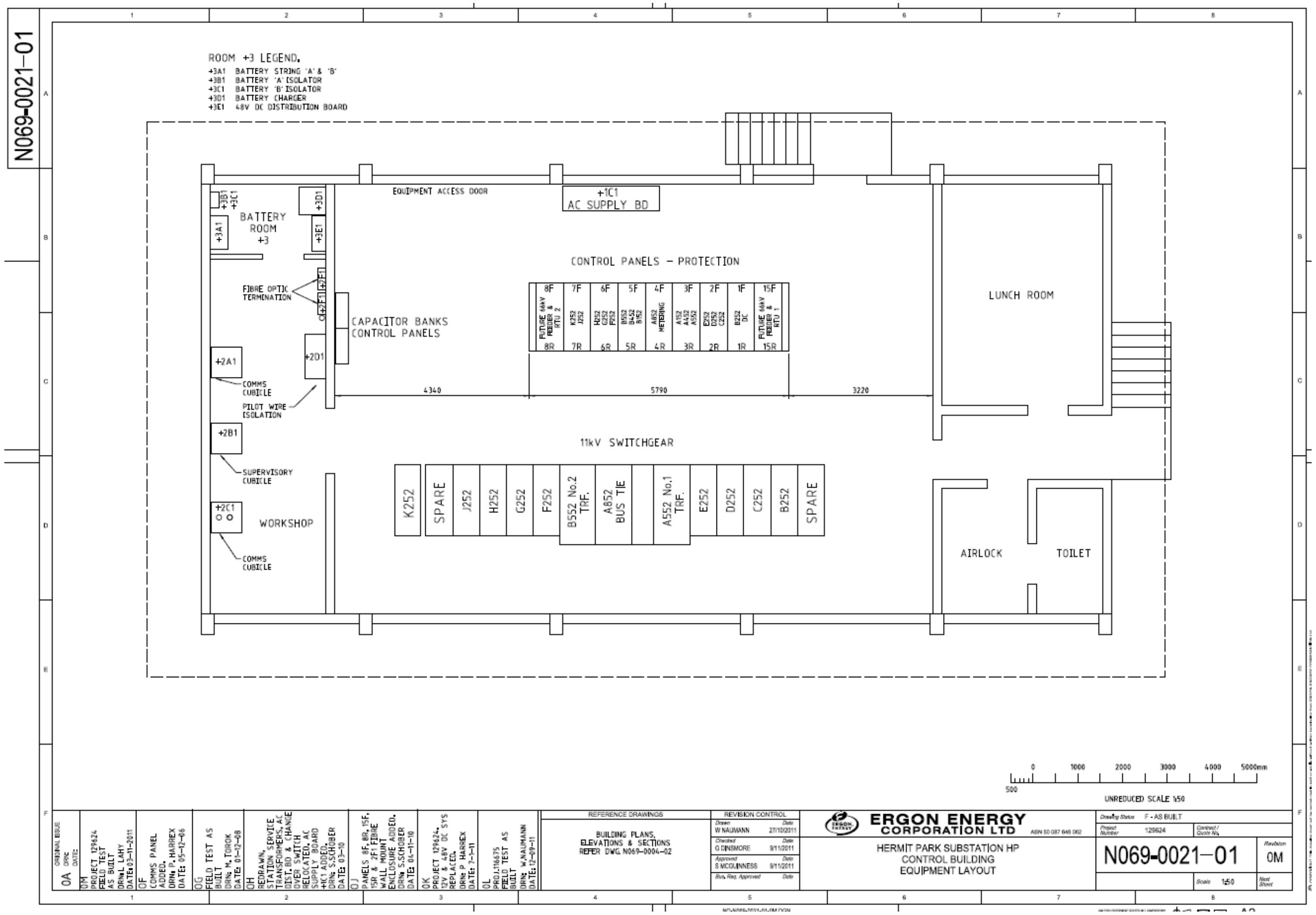
Parameter	Unit	Value
Ambient Soil Temperature at Installation Depth	°C	35
Thermal Resistivity of Native Soil	°C.m/W	1.2

Layers		Dimensions [m]				Type	Thermal Resistivity [°C.m/W]
No.	Name	X Center	Y Center	Width	Height		
1	NSTD DB1	0.07	0.51	0.75	0.4	Non-Standard ductbank	3



Cable Rating Report for Hermit Park U/G cables													
		The cable ratings have been optimised by setting HP11 and HP2 at a peak current of 250A, this will increase the ratings of the Paper lead cables.											
		Note: Diagram 4,5 and 6 are the same trench sections as 1,2 and 3 respectively with the new calculations applied.											
Trench Section													
									General Input Data				
	Cyclic rating DLF 2012-2013	**Summer Wet**	Optimised	HP11 set @ 250A peak					Thermal	Thermal	Amb. Soil	Duct	Bonding
WP 6	**Refer Diagram 4**								Resist.	Resist.	Temp.	Bank	Point
Charters To	Feeder Name	**HP 6**	**HP 5**	**HP10**	**HP 8**	**HP11**			(Native)	(Backfill)	(deg.C)	Size (m)	
Road Exits	Type of Cable	300Al. PLYSWS Belt	300Al. PLYSWS	300Al. PLYSWS	300Al. PLYSWS	240Cu. XLPE				(Bedding)			
	Load Factor	0.77	0.69	0.64	0.7	0.65			1.2	3	35	0.75 x 0.65	Double
	Rated Amps	**153**	**239**	**187**	**250**	**250**							
	Cable load	197	171	122	152	136							
	Rated Cable Temperature	65	70	70	70	90							
	Cyclic rating DLF 2012-2013	**Summer Wet**	Optimised	HP2 set @ 250A peak									
WP51	**Refer Diagram 5**												
Mark St	Feeder Name	**HP 3**	**HP 4**	**HP 7**	**HP 2**								
Exits	Type of Cable	300Al. PLYSWS Belt	300Al. PLYSWS	300Al. PLYSWS	240Al XLPE								
	Load Factor	0.76	0.8	0.72	0.76				1.2	3	35	0.9 x 0.86	Double
	Rated Amps	**170**	**165**	**199**	**250**								
	Cable load	202	173	54	212								
	Rated Cable Temperature	65	70	70	90								
	Cyclic rating DLF 2012-2013	**Summer Wet**	Optimised	HP2 set @ 250A peak									
Mark St	**Refer Diagram 6**												
Road Cross	Feeder Name	**HP2**	**HP4**	**HP7**									
	Type of Cable	240Al XLPE	300Al. PLYSWS	300Al. PLYSWS									
	Load Factor	0.76	0.8	0.72					1.2	3	35	0.75 x 0.4	Double
	Rated Amps	**250**	**222**	**191**									
	Cable load	212	173	54									
	Rated Cable Temperature	90	70	70									

Planning Proposal



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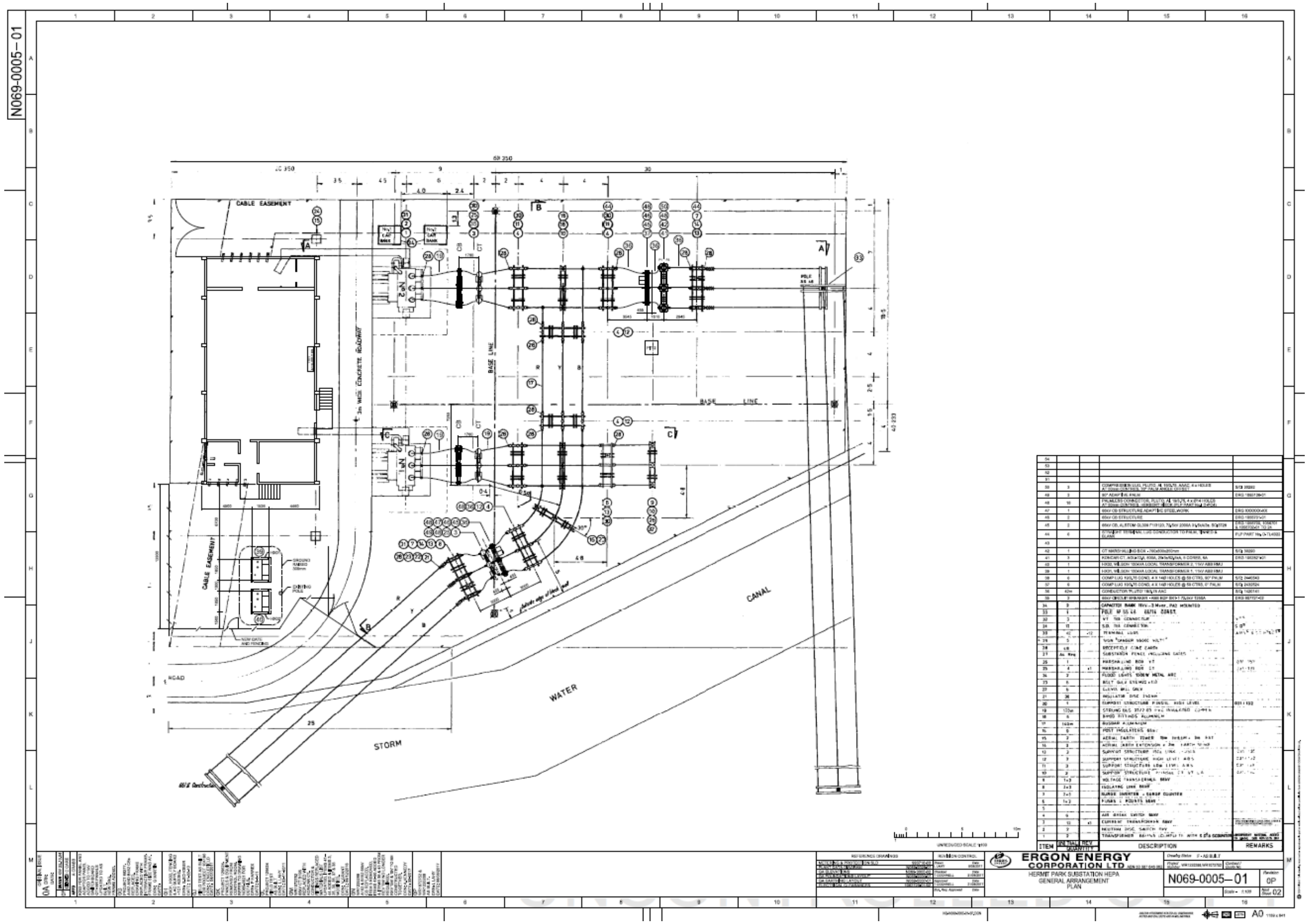

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APPENDIX E: 11 KV FEEDER SCOPE OF WORKS

Feeder Bay: F252 (HP06)

- Unload HP06 to BEGA08 and NS01;
- HP06 net reduction of 1.26 MVA (after reconfiguration to NS01/BEGA08) including West State Hospital load - HP06 demand reduction from 191 A down to 125 A or 82% of feeder rating. Further reduction is anticipated if West State Hospital does not proceed as expected (ie 2.42 MVA or 130 A).

Feeder Bay: E252 (HP-05)

- Install
  - Remote control gas 11 kV switch (mid or pole top mount) in place of HP-05 No. 1 links, pole 5132182 (this will assist with the local LV supply issue should a low probability fault occur whilst T1 or T2 are OOS during the project

Feeder Bay: D252 (HP-04)

- Install
  - 400Al. triplex or 240Cu.3C XLPE cable from D252 to existing term. pole ecorp ID 81444586
  - Pending size of spare conduit in Marks St., install either 400Al. triplex or 240Cu 3C

Feeder Bay: C252 (HP-03)

- Option 1 (recommended): Re-use existing HP-03 conduit (ie withdraw existing PLYSWS if possible)

Install
  - 400Al. triplex or 240Cu.3C XLPE cable from C252 to existing Marks St GMS 2
  - Withdraw existing 300Al. PLYSWS from 100mm conduit to make available for the new XLPE cable
  - Pending size of spare conduit in Marks St., install either 400Al. triplex or 240Cu 3C
  - extend new conduit to Marks St. GMS

- Option 2: GMS option and re-use existing PLYSWS cables pending conduit availability

Install
  - 400Al. triplex XLPE cable from C252 to new 3S1F GMS
  - 3S1F GMS adjacent capacitor bank 1
  - Re-terminate HP03 300Al. 3C PLYSWS belted cable into new GMS c/w fault indicator
  - Re-terminate ex-HP04 300Al. 3C PLYSWS into new GMS c/w fault indicator
  - Re-terminate ex-HP04 to new O/H termination pole (ecorp ID stay pole 82627508)
  - Extend O/H PLUTO from pole 82627508 to 81463556 (HP03 No. 1 link pole)
  - N/O at Marks St. GMS 2 on cable 291943

HEPA 66_11kv ZS area -doc_no-os-102

HEPA 66_11kv ZS area -doc_no-os-102

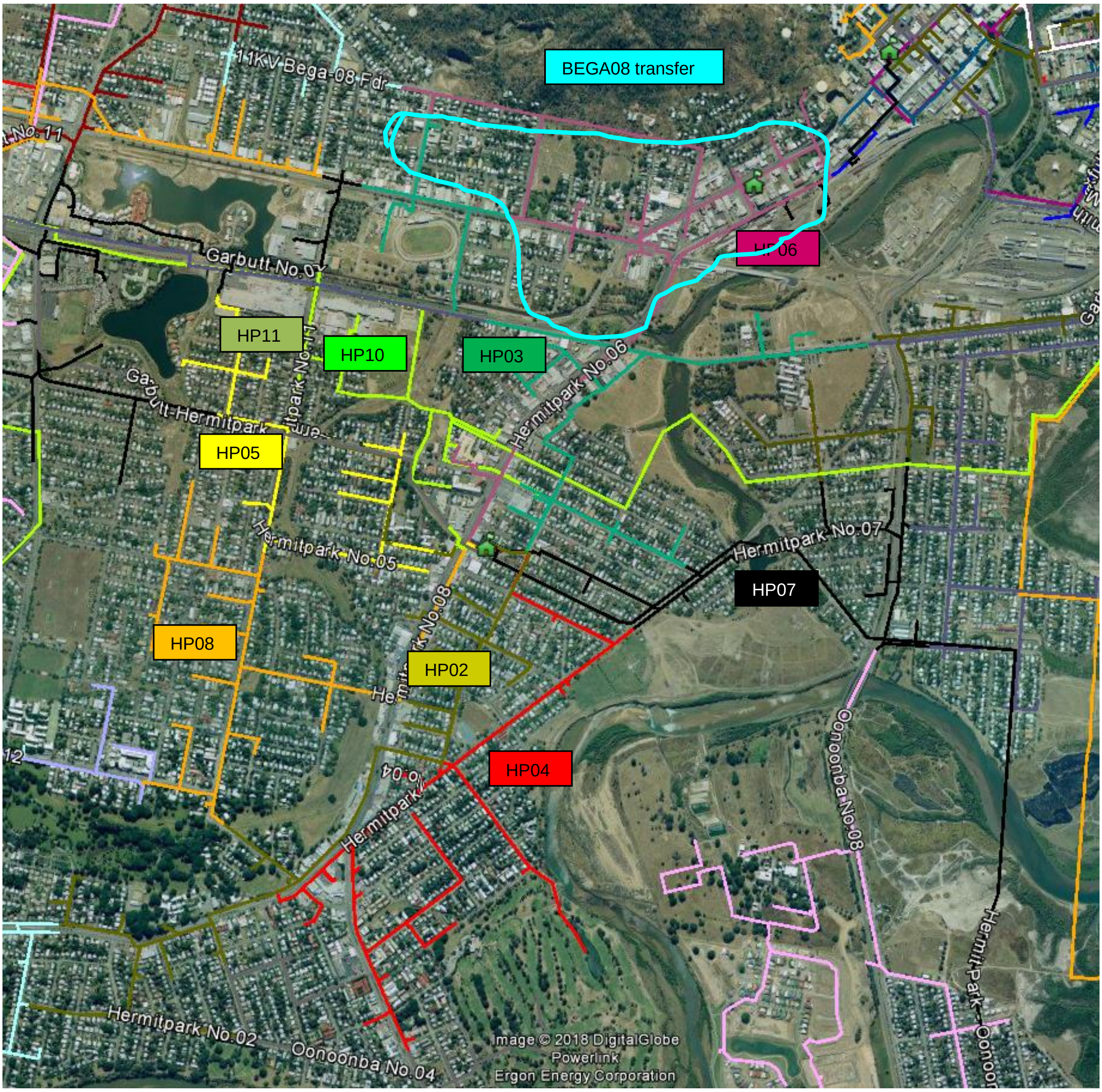

Figure 8: HEPA 11 kV network configuration (PROPOSED STATE)

Planning Proposal

Upgrade stay /streetlight ecorp ID pole 82627508 to 11 kV term. pole- term. Ex-HP04 cable

Extend 11 kV O/H from HV/LV pole ecorp ID pole 81463556 (HP-03 No. 1 link pole) to pole 82627508 (open S at Marks St. GMS 2 on cable 291943)

(Refer Drawing N010-0567-01)

Install new 240Cu. 3C XLPE or 400 Al. triplex to HP04 term. pole ecorp ID 81444586

(Refer Drawing N010-0567-01)

WR1278179: West State Hospital Connection (2018) proposed configuration changes- This offer has lapsed and works did NOT proceed.

Single Line Diagram