PowerWater

Power and Water Corporation
Preliminary Business Case – Category A

PRD30401
Replace Humpty Doo ZSS

Proposed:

Jim McKay
A/Chief Engineer
Power Networks
Date: 6/2/2018

Approved:

Michael Thomson
Chief Executive & Chair
Investment Review Committee
Date: 23/02/2018

Endorsed:

Djuna Pollard
General Manager
Executive General Manager
Date: 15/2/2018

Refer to email
D2018/72353

Finance Review
Date: 06/02/2018

Refer to email
D2018/62903

PMO QA
Date: 12/02/2018

1 RECOMMENDATION

It is recommended that the Chief Executive approve project PRD30401 – Replace Humpty Doo Zone Substation (ZSS), to replace Humpty Doo zone substation with a single transformer 2.5MVA substation for an estimated capital cost of [redacted] and a corresponding completion date of June, 2023.

Approval is sought for expenditure of up to $0.4M of the total forecast expenditure to undertake the necessary work to proceed to the next approval gateway (Business Case Approval), including:

- Detailed design; and
- Detailed cost estimate, including by seeking a construction price offer from external contractors through a competitive tender.

The project has a 95% likelihood of being delivered at between [redacted]

2 PROJECT SUMMARY

Project Title:	Replace Humpty Doo ZSS		
Project No./Ref No:	PRD30401	**SAP Ref:**	
Anticipated Delivery Start Date:	Jul 2021	**Anticipated Delivery End Date:**	Jun 2023
Business Unit:	Power Networks		
Project Owner (GM):	Djuna Pollard	**Phone No:**	8985 8431
Contact Officer:	Peter Kwong	**Phone No:**	8924 5060
Date of Submission:	23/02/18	**File Ref No:**	D2017/394662
Submission Number:		**Priority Score:**	/100
Primary Driver:	Renewal	**Secondary Driver:**	Service improvement
Project Classification:	Capital Category A		

2.1 Prior Approvals

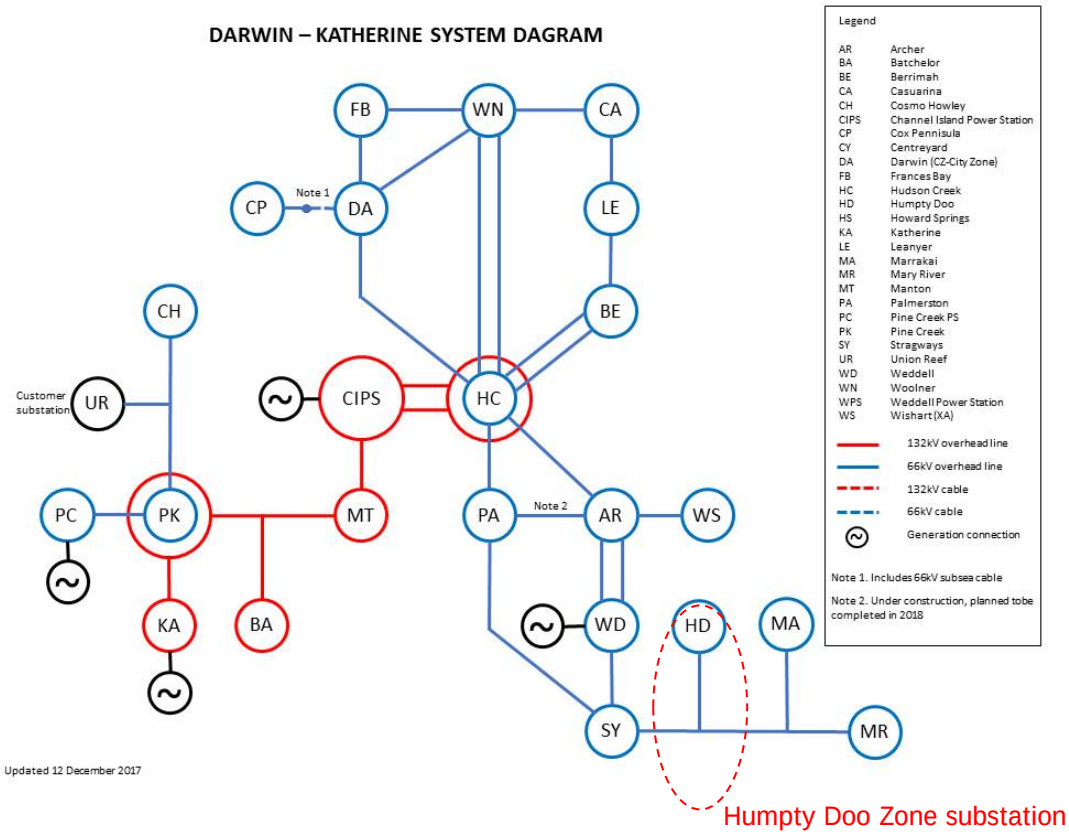
Document Type	Sub Number	Approved By	Date	Capex Value
BNI	10069	Michael Thomson	29/05/2017	[redacted]

3 INVESTMENT NEED

3.1 Background

Humpty Doo Zone Substation is a 66/22kV rural substation located approximately 50km southeast of Darwin. The substation is fed by the tee on the Strangways to Mary River 66kV feeder and it supplies the local rural area at 22kV.

Figure 1: System diagram



The zone substation consists of the two 2.5MVA transformers fed by a single 66kV oil circuit breaker. It originally consisted of three 2.5MVA transformers connected in parallel but one transformer failed in 2012 and was removed from service.

There are two 22kV circuit breakers for the feeders which distribute power to the Lambells Lagoon area.

3.2 Asset details

The majority of assets at Humpty Doo zone substation exceed their design life. For example, a design life of 50 years has been assumed, and both transformers are already 54 years old. The 66kV and 22kV switchgear was manufactured in the early 1980s and will be at least 40 years old by 2024.

Equipment	Year of Manufacture	Age at 2017	Age at 2024
66kV Circuit Breaker	1981	36	43
66/22kV Transformer 1	1963	54	61
66/22kV Transformer 2	1963	54	61
22kV Circuit Breaker 1	1984	33	40
22kV Circuit Breaker 2	1984	33	40

3.3 Management strategy & investigation outcomes

Piecemeal replacement, and replacement on failure, has been undertaken to date as required. The 50VDC battery systems were replaced in 2002 with the installation of sealed lead acid battery and chargers.

Recent inspection reports have identified issues with continued operation of the power transformers at the site due to moisture levels in the paper insulation, significantly elevating the risk of failure. The 66kV switchgear is also assessed as being in poor condition and at high risk of failure and the secondary systems are obsolete, unsupported by the manufacturer, increasingly difficult to maintain, and have an increasing defect rate.

These items are discussed further in the following section.

3.4 Current and emerging issues

3.4.1 Poor condition 66kV Switchgear

The 66kV circuit breaker is an [redacted] minimum oil unit manufactured in 1981 currently 36 years old. At the end of the next RCP, the 66kV CB will be 43 years old. There is a history of operational issues with these breakers, especially failures associated with the operating arm.

Industry experience and the maintenance and test results for the PWC circuit breaker at Humpty Doo indicates that even with regular maintenance the end-of-life for these assets is at about 40 years:

- This type of circuit breaker has a high failure rate within the electricity industry and PWC has previously experienced multiple failures with its other [redacted] circuit breakers;
- The circuit breakers at Humpty Doo ZSS are obsolete models and parts for the remaining units are sourced from old decommissioned circuit breakers. They incur high maintenance costs due to oil leaks – oil must be drained and replaced regularly. The poor condition of this circuit breaker increases the risk of explosive failure, posing the risk of fatal injury to PWC personnel working within the substation.

3.4.2 Poor condition power transformers

The two 66/22kV [redacted] power transformers were manufactured in 1963 are in poor condition with excessive level of moisture in the paper insulation, largely due to significant continuous oil leaks,[1] and indicating that the transformer internal structure has weakened significantly with time, condition and the operating environment.

Both transformers have had numerous oil leaks repaired at various points on the transformer, parts replaced, and water marks and other deposits removed from bushings.

By 2024, the transformers will be 61 years old. Industry experience is that the typical power transformer operating life is 45-50 years, depending on the operational history and other factors, with only a small percentage of transformers operating beyond 60 years.[2]

Since the initial condition assessment, PWC has undertaken a 'dry-out' on Transformer 1. The latest Dirana results conducted in August 2016 on Transformer 1 are 3.1% and indicate a reduction from 'extremely wet' to 'moderately wet' winding. Insulation resistance and polarisation index values at this time were found to be acceptable. The latest Dirana results conducted on Transformer 2 are 4.9% and indicate 'extremely wet' insulation.

In 2015, oil reconditioning was undertaken to remove excessive moisture in transformer No 1. PWC undertook further oil reconditioning to remove moisture in Transformer 1 earlier this year, and has scheduled oil reconditioning for Transformer 2 in 2017/18 to extend the life of these units.

Whilst further maintenance practices will be undertaken to extend the life of these units, the test results for both transformers indicate the insulation is near its end-of-life. Based on common industry benchmarks, the transformers should be replaced within 3-5 years (i.e. by 2023). Due to the low demand at this site and corresponding low criticality of this load the timing of replacement is required by the end of this timeframe.

PWC has observed a strong correlation between the ageing of power transformers and its Degree of Polymerisation (DP). Ageing paper and reducing DP reduces the ability of the transformer to withstand transients and essentially will determine end of life for a transformer. DP values indicate the tensile strength of the paper is severely reduced; it would be prudent to plan for end of life and manage exposure to fault risk.

From the predictive modelling being developed by PWC as part of the power transformer asset (class) management plan, an effective asset age can be developed based on the measured DP values. Transformer 1 has a DP of approximately 297 and Transformer 2 has a DP of approximately 314. These values equate to an effective life for Transformer 1 of 55 years, and for

[1] Humpty Doo Condition Assessment Report

[2] Reference to be provided

Transformer 2 of 54 years. At the end of the next RCP (2024), the effective life is likely to be increased to approximately 62 and 61 years respectively.

3.4.3 Poor condition 22kV circuit breakers

The 22kV circuit breakers are SF6 CBs manufactured by [redacted]. PWC has experienced regular gas leaks due to faulty seals and they require constant maintenance.

3.4.4 Obsolete secondary systems

The existing transformer protection consists of overcurrent and a bias differential protection schemes (electromechanical relays). The 22 kV feeder protection consists of overcurrent protection (static relays). The 22 kV bus is protected by drop-out fuses connected after the transformer LV terminals.

The protection scheme does not comply with PWC's current protection standard that requires all 66/22 kV transformers to be protected by a duplicate protection scheme.

The secondary systems are over 30 years old, considered obsolete and have reached the end of life. Spares are increasingly more difficult to source as manufacturers are ending support for the equipment.

3.4.5 Balance of plant

In addition to the above nominated plant, Humpty Doo Zone Substation consists of the following:

- Three transformer bays equipped with HV and LV surge arrestors and isolator switches
- 22 kV Bus with section isolators
- Two fully equipped 22 kV outdoor feeder bays with one spare 22 kV feeder bay

This equipment was installed when the substation was first constructed. They are similar in age to the other items in the switchyard.

The substation also does not comply with the current PWC standards regarding transformer protection, fire risks and oil containment.

3.5 Peak demand and capacity forecasts

AEMO's demand forecast for Humpty Doo ZSS[3], projects a maximum demand reduction of approximately 1.7% by 2024 to 1.7 MVA [P50], well within the substation firm capacity of 2.5MVA. There are no identified demand-related drivers for this project.

The Network Management Plan (NMP) has confirmed an enduring need for electricity supply to the loads connected to Humpty Doo ZSS.

[3] AERReportForPWC_V3

3.6 Risk analysis

Figure 2 shows the current rating, inherent rating (in 2024, i.e. if no action is taken in the interim), and the residual (post-treatment) risk ratings associated with the condition of assets in the Humpty Doo ZSS.

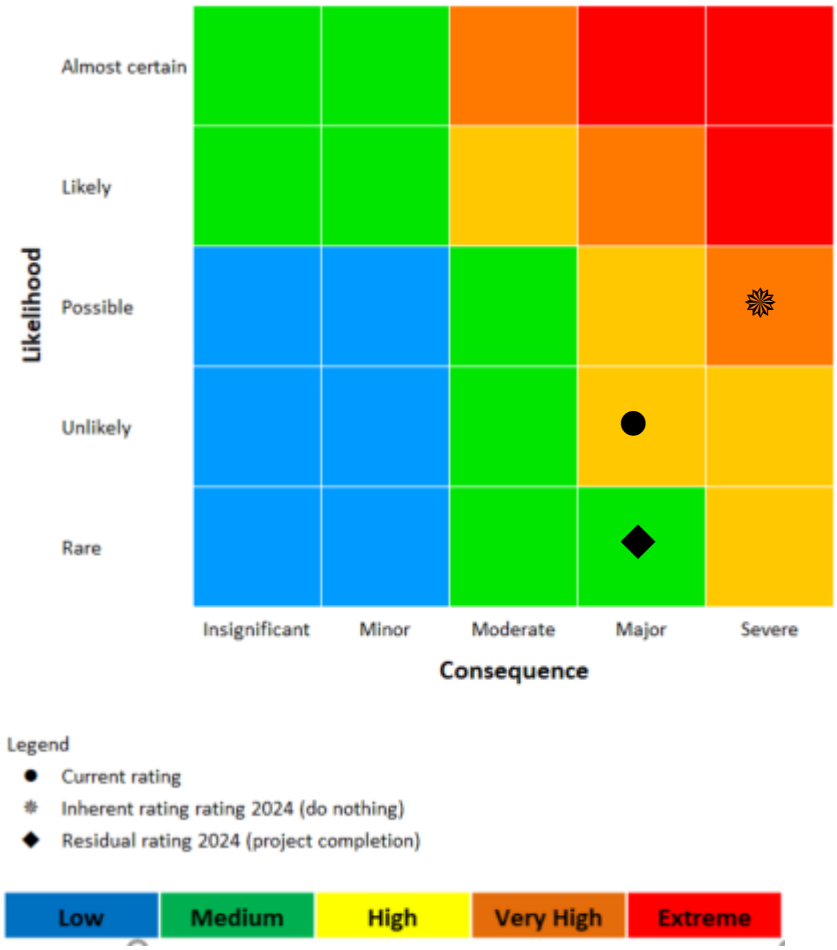
(i) *Current rating:* The Current rating (2017) is assessed to be 'High' due to the aggregate safety risk posed to PWC workers by the poor condition of the primary assets in Humpty Doo ZSS. The probability of explosive failure of primary plant assets is rated as 'unlikely', but should such an event occur, there consequence could be serious injury to PWC operational personnel (or even a fatality).[4] There would also likely be adverse media attention and temporary disruption to electricity supply.

(ii) *Inherent rating:* If the poor condition assets are not replaced by 2024, the likelihood of explosive failure of primary plant is assessed to increase from 'unlikely' to 'possible'. Given the number and frequency of operational personnel that will need to be on site to address the increasing maintenance (inspection and repair) issues of the increasingly poor condition assets, it is more likely that the consequence could be a fatality. There would likely be prolonged adverse media attention and temporary disruption to electricity supply. The inherent risk rating is therefore 'Very High'.

(iii) *Residual rating:* The proposed project will mitigate the poor condition assets through corrective maintenance. Fewer personnel will need to be on site on average over the course of a year because much less maintenance and repair will be required. The likelihood of explosive failure of primary plant will be reduced to 'rare'. The consequence of explosive failure is likely to be severe injury (or, even less likely, fatality). Adverse media attention and temporary disruption to the electricity supply is less likely. The residual rating is therefore 'Medium'.

[4] The 66kV circuit breakers, instrument transformers, and power transformer bushings all contain porcelain components which can explode, sending high velocity porcelain shards and oil into the immediate area around the equipment

Figure 2: Humpty Doo ZSS risk assessment[5]



It is Power and Water's current practice to take action on risks that have an inherent rating of 'HIGH' or above. The PBC summarises the proposed response to this impending risk.

4 STRATEGIC ALIGNMENT

This project aligns with the Corporation's key result areas of operational performance and customer centricity, where the goals are to be an efficient provider of services and delivering on customers' expectations.

This project will allow PWC to safely and reliably meet current and future demand for the Humpty Doo area.

[5] Based on Power Network's Risk Assessment Guide

5 TIMING CONSTRAINTS

The project will need to be completed by June 2023 to minimise the risk of interruptions to the supply to the Humpty Doo area. It is difficult to predict the remaining life of the existing assets, as catastrophic failure can be initiated by a transient external event, such as a through fault. These events are common on overhead networks exposed to the environment, such as trees on lines, lightning, etc.

6 EXPECTED BENEFITS

Driver/Objective	Benefit	Current State	Future State
Safety	Reduced risk of injury (including fatality) from explosive failure of primary plant	Elevated level of personnel safety risk due to poor condition of a high proportion of primary assets	Risk of injury to personnel reduced to acceptable levels
Reliability	Increased reliability and reduced maintenance (inspection and repairs)	Risk of asset failure is very high and increasing maintenance costs	Risk of failure is low for new equipment and reduced maintenance costs

7 REQUIREMENTS

The solution selected must resolve the need to allow PWC to supply power to the Humpty Doo area during credible contingency events and support reliability targets during unplanned events and planned maintenance activity. It is also preferable to minimise the impact on existing operational capabilities at both sites during construction (i.e. maintain system security requirements).

PWC will also require compliance with the following:

- Northern Territory Electricity Reform Act;
- Power and Water's Network Licence as issued by the Utilities Commission, and;
- Network Planning Criteria and Electricity Networks (Third Party Access) Code.

8 OPTIONS

8.1 Options Development

A feasibility options study[6] considered various options for the replacement of

Humpty Doo ZSS including layout drawings and costing information. This study has been drawn upon in the presentation of options below.

8.1.1 Option 1 - Base case (continue to maintain/repair Humpty Doo ZSS)

This option involves no proactive capital expenditure to replace assets assessed as being in poor condition at Humpty Doo ZSS.

The advantage of this approach is deferment of capital expenditure to address risks associated with the poor asset condition at Humpty Doo ZSS.

However, continuing to operate Humpty Doo ZSS beyond 2022/23 is not considered prudent given the risks to personnel safety from explosive failure of the primary plant assets and the increasing risk of disruption to power supplies in case of unavailability of the transformer circuits. This risk will continue to increase with time as the equipment condition continues to deteriorate and the load at risk continues to grow.

The operational costs will also rise over time due to the increasing number of planned and unplanned outages as the equipment reaches the end of operational life.

For the purpose of this assessment, it is likely that the transformers will fail in service and require replacement within a solution similar to Option 2 over the evaluation period. Following failure, the site will have reduced security whilst a transformer is procured. Extended supply outages may occur should both transformers, which are of a similar age and condition fail, as the site is not configured for connection to the Nomad transformer.

Option 1 is not considered to be technically or commercially viable.

8.1.2 Option 2 – Refurbish existing Zone Substation (Preferred option)

This option involves replacing existing equipment in the existing switchyard, by converting Transformer Bay 1 into a dedicated Nomad connection bay and upgrading Transformer Bays 2 and 3 to a single 2.5 MVA transformer bay. In addition, associated HV equipment such as surge arrestors, isolators, instrument transformers and circuit breakers will be replaced, to current Australian and PWC standards. These assets were placed into service when the substation was first commissioned. The proposed scope includes:

- Construct a new Nomad connection bay behind existing Transformer Bay 1. Remove Transformer Bay 1 equipment
- Remove Transformer Bay 2 66 kV equipment and 66 kV bus
- Replacing the existing three (3) transformer bunds with one (1) larger bund to accommodate a 2.5 MVA power transformer
- Upgrade existing Transformer Bay 2 by replacing the existing 66 kV circuit breaker with a new dead tank type circuit breaker and replacing existing isolators and surge arrestors

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[6] Aurecon, November 2017, Options Study – Substation Upgrade at Humpty Doo Zone Substation Ref 500835

- Installation of one (1) new 2.5 MVA, 66/22 kV power transformer
- Replace existing 22 kV circuit breakers, surge arrestors and isolators
- Replace existing oil/water separator with a new SPEL unit
- Install new transformer protection and control panels and control cables to the various equipment
- Remove obsolete 66 kV equipment and foundations

Allowances are made for the replacement of the two 66 kV incoming isolators but this will require planned outages of significant duration on the Strangways-Humpty Doo feeder. Replacement will be scheduled to coincide with other major maintenance tasks at Strangways zone substation or feeder.

The advantage of this option is that it retains the current level of firm capacity, which should be sufficient until 2030 according to the current load forecast.

The disadvantages of this option include:

(i) It assumes access to the Nomad substation;

(ii) It reduces the substation supply to single transformer operation. A transformer failure will result in the transformer being isolated and the Nomad being used. It is expected that the interruption will last at least two days to allow for the initial response to the outage, mobilisation and commissioning of the Nomad. The Nomad may be in service at Humpty Doo zone substation for a period of up to 5 months depending on the severity of the transformer fault;
This may influence the reliability of the PWC network elsewhere, by restricting access to the Nomad substation;

(iii) Brownfields redevelopment requires a lot of construction personnel and operational personnel to be in the close vicinity of live assets that are at risk of explosive failure, increasing the already high safety risk significantly for at least two years;

(iv) The brownfields construction approach will take considerably longer than a greenfields approach (see option 3), prolonging the inherent safety and reliability risks; and

(v) Brownfields redevelopment will require careful outage and commissioning management, and will still result in increased risk of extended supply interruption (i.e. for an unplanned plant/equipment outage whilst the planned outages are in place).

The base cost of this option is estimated at [redacted].

8.1.3 Option 3 – Establish a new AIS single transformer Humpty Doo ZSS adjacent to the existing substation

This option involves construction of a new 66/22 kV Zone Substation adjacent to the existing substation, to replace the existing substation.

The proposed scope includes:

- Construct a new AIS 66/22 kV zone substation consisting of a 66 kV tee-off, transformer bay with a single 2.5 MVA transformer, 66/22 kV Nomad connection bay, 22 kV air insulated metal clad switchboard in a switchroom / control room building, oil water separator and auxiliary transformer
- Convert the existing control building into an amenities building
- Remove all concrete foundations – no other rehabilitation allowed for

Appendix B shows the proposed layout of the new switchyard and building.

The advantage of this option is that it develops a greenfields site, with sufficient firm capacity to meet the long term load forecast, and provide a suite of modern technology.

The primary disadvantage, as with Option 2, this option relies on the design of a single transformer substation and use of the Nomad substation, with the corresponding shift in operational philosophy.

The cost of this option is estimated at [redacted].

8.1.4 Option 4: Establish a new AIS two transformer Humpty Doo ZSS adjacent to the existing substation

The proposed scope includes:

- Construct a new AIS 66/22 kV zone substation consisting of a 66 kV tee-off, two transformer bays with 2x 2.5 MVA transformer, 22 kV air insulated metal clad switchboard in a switchroom / control room building, bunds and oil water separators and auxiliary transformer
- Convert the existing control building into an amenities building
- Remove all concrete foundations – no other rehabilitation is allowed for.

The advantage of this option is that it removes the reliance on the Nomad substation option in the event of transformer failure. However, whilst providing increased supply security to this site commensurate with the current design option, the cost is considered to be prohibitive and was not explored further.

The cost of this option is estimated at [redacted].

8.1.5 Option 5 – Non-network options / Demand Management

The long term Humpty Doo ZSS demand forecast is flat to moderately decreasing at a peak load less than 2MVA.

Based on PWC's research, the most likely source of demand management is via curtailment contracts with large commercial and with industrial customers in the area. PWC does not have access to other forms of demand management such as through ripple control or smart meter activated control of customer loads (such as air conditioners).

Given the stated condition of the substation assets, deferral of this project using demand management is not considered to be prudent.

PWC does not currently have a register of available network support services available in the market, such as local generation, to be provided in proximity of Humpty Doo ZSS, and no such option is currently known to PWC.

The major advantage of Option 5 is that it would delay the need to commit to capital expenditure to maintain supply in the event of a single transformer failure at Humpty Doo ZSS. However, based on the supply arrangements in place at Humpty Doo ZSS, and the low level of demand a network supply connection is likely to be retained and if so, assets at Humpty Doo will be required to be replaced.

The disadvantages of Option 5 are:

(i) PWC has limited experience with securing network support services; and

(ii) The option is unlikely to be technically (or commercially) viable in the medium to long term, as the condition of the substation assets continues to deteriorate.

PWC will continue to explore the technical and commercial viability of this option by engaging with the market to identify providers of network support services prior to submitting the Business Case for Approval.

In the interim, Option 5 is not considered to be technically or commercially viable.

8.2 Comparative cost analysis (including sensitivity analysis)

PWC is currently developing a probabilistic risk-cost methodology which, when completed will be used to compare options and confirm the economically optimum time for investment.

Table 2 summarises the results of a comparative cost analysis, the details of which are included in Appendix A. Of the technically viable options, Option 2 – Replace existing substation has the lowest NPC. Costs shown in the table below are base project costs and do not include the risk-adjusted costs (ie. P_{50}).

Table 2: Summary of comparative capital cost analysis

Option	Capital Base Cost ($M)	Net Present Cost ($M)	Comments
1 – Do nothing	[redacted]	[redacted]	Not technically feasible. NPC does not take into account publicity and outage costs.
2 – Replace existing Humpty Doo ZSS	[redacted]	[redacted]	Lowest NPC out of all the technical feasible options. This would involve using the Nomad to bypass the existing

			substation. (Preferred option)
3 – Construct new Humpty Doo ZSS (1x 2.5/5MVA with Nomad connection)	[redacted]	[redacted]	
4 – Construct new Humpty Doo ZSS (2x 2.5/5MVA)	[redacted]	[redacted]	
5 – Demand management	[redacted]	[redacted]	Not technically feasible

8.3 Non-cost attributes

An analysis of the non-cost attributes for each option has been completed using the multi-criteria analysis method. The attributes are selected considering major risks and priorities to achieve Project Objectives. A weighting is allocated to each, totalling 100%. Each attribute is given a score out of 5 (from 1 – Fails to satisfy, to 5 – exceeds requirements); the score is then multiplied by the relevant weighting to give the weighted score that is summarised in the table below.

8.3.1 Evaluation Summary

	Project Objectives			Technical & System Risk			Stakeholder Risk			Environmental Risk		Commercial
Criteria	**Reduced Risk Asset Failure**	**Maintain System Security**	**40 Year Design Life**	**Standard Assets**	**Constructability**	**Continuity of Supply**	**Safety**	**Community Impact**	**Approvals**	**Oil Contamination**	**Land Clearing**	**NPV/C**
Weighting (%)	10	10	10	5	5	10	10	5	5	5	5	20
Option 1	0.1	0.1	0.1	0.15	0.2	0.1	0.1	0.05	0.2	0.1	0.2	1.0
Option 2	0.4	0.4	0.4	0.15	0.15	0.3	0.3	0.2	0.15	0.2	0.2	0.8
Option 3	0.4	0.4	0.4	0.15	0.2	0.4	0.3	0.2	0.15	0.2	0.15	0.7
Option 4	0.4	0.4	0.4	0.15	0.2	0.4	0.3	0.2	0.15	0.2	0.15	0.6

Weighted Scores:

Option 1: Deferral 2.40

Option 2: Refurbish existing zone substation 3.65

Option 3: New zone substation, 1 x 66/22kV TX 3.65

Option 4: New zone substation, 2 x 66/22kV TX 3.55

8.4 Preferred Option

The preferred option (Option 2) is the brownfields replacement of the existing Humpty Doo ZSS with a single transformer 2.5MVA 66/22kV ZSS with a Nomad connection on the existing substation site.

This option best fulfils the project objectives of safety and reliability at the same time having minimum impact on system security whilst under construction. It also presents an acceptable level of safety risk during construction.

The new Nomad connection will be designed with consideration of the existing switchyard configuration to minimise major alterations to the existing 66kV switchyard.

There is little risk of public opposition to the construction activity associated with this project as it located in a rural area.

The design of the ZSS will be to the existing PWC Substation Standards and will be similar in layout to current zone substations. This will maximise constructability and reduce design cost risk.

There will be minimal clearing of the site as there is no significant native vegetation on the PWC owned land. As with other zone substations, power transformers will be installed with current oil containment systems that will prevent hydrocarbon release.

8.4.1 Other Considerations

As stated above, installation of a single transformer substation changes the design philosophy at this site. In the event of a single transformer failure, it is estimated that at least 2 days will be required for mobilisation and connection of the Nomad substation during which time alternative provisions need to be made for electricity supplies. This is likely to incur a reliability impact for connected customers and performance of the overall PWC network.

It should be noted that Option 1 (deferral) does not include cost of loss load and the monetarisation of risks, including safety and corporate image. It is also likely the average operational cost will increase significantly in the future due to the increased frequency of failures.

9 PROJECT OUTLINE

9.1 Project Description

This project is to replace the existing 66/22kV zone substation at Humpty Doo.

The project will require the use of the Nomad substation to bypass the existing 66/22kV switchyard so the whole site can be decommissioned. Works includes replacing the existing 66kV and 22kV equipment including the

66/22kV power transformer, along with the associated protection and control equipment.

9.1.1 Scope Inclusions

The scope of the project includes:

- Replace the existing 66kV switchyard equipment, including civil works to modify the existing foundations to suit the new equipment;
- Remove the existing 66/22kV transformers and refurbish the pad and oil containment to satisfy the latest standards;
- Convert existing switchyard from a three transformer switchyard to a single transformer with a Nomad connection;
- Refurbish existing control building to allow more efficient use of air conditioners;
- Install new associated protection and control equipment in the control building;
- Replace existing 22kV switchyard with new equipment to allow for two outgoing feeders;
- Minor transmission and distribution line works to turn existing feeders into the new switchyard;
- Minor remote end control and protection equipment upgrades.

9.1.2 Scope Exclusions

- The existing fencing will remain. Any damage found will be repaired as required.

9.1.3 Assumptions

The cost estimate is within ±20% accuracy. The detailed design and costing for the refurbishment has not yet been undertaken.

9.1.4 Dependencies

It is assumed that the Nomad substation will be available for this project. Without the use of the Nomad will increase the cost and complexity of the replacement of substation equipment.

9.1.5 Key Stakeholders

There is little risk of public opposition to the upgrade of Humpty Doo Zone Substation. This project will ensure a safe, reliable and high quality power supply for the area.

Name	Title / Business Unit
Internal – Governance Stakeholders	Chief Executive
	Investment Review Committee

	Executive General Manager Power Networks
	Chief Engineer
	Group Manager Service Delivery
Internal – Design Stakeholders	Senior Manager Networks Development and Planning
	Manager Major Projects
	Senior Manager Network Assets
	Manager Protection
External – Authorities	Environmental Protection Authority
	Aboriginal Areas Protection Authority
External - Other	Cosmo Howley Mine
	Ministers
	Utilities Commission
	Australian Energy Regulator

9.2 Capital Cost

A risk adjusted cost estimate (RACE) was conducted on the preferred option based on latest design, scope and cost information.

Based on the analysis, the project has a 90% likelihood of being delivered between [redacted] The contingency attributable to risk is calculated as P95 – P50 = $0.42M. The calculated P_{50} risk-adjusted cost is the estimated cost of the project.

[redacted]

9.2.1 Base Capital Cost

Item	Estimated Cost $'000 ($P_{50}$)
Design	
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
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[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

Table 1 – Base Capital Cost Estimate

9.2.2 Risk and Contingency

The current estimate has been developed largely based on PWC and consultant estimates considering previous experience with similar works. The contingency amount, calculated as the P95 value minus the expected P50 value, is currently $ 0.42M.

9.3 Estimated Operating Cost Impact

Ongoing costs of the new ZSS are related to operation and maintenance as detailed below. It is expected there will be a saving in operating costs due to lower maintenance costs associated with the new equipment.

Item	Annual Incremental Cost ($)
Planned Maintenance	31,993
Preventative Maintenance	38,259
Unplanned Maintenance	2,253
TOTAL	**72,505**

Table 2 – Estimated Operating Cost Impact

9.4 Project Milestones

Project Phase (end)	Investment Planning	Project Development	Commitment	Implementation	Review
Original Plan (BNI)	07/2017	03/2021	06/2021	06/2023	09/2023
Current Forecast		03/2021	06/2021	06/2023	09/2023
Actual Completion	07/2017				

10 RISK MANAGEMENT AND COMPLIANCE

A preliminary risk register has been established to address project risk. This is included in Appendix C. This register will form the basis of the Project Risk Register into the project delivery phase. The register will be regularly reviewed and updated as required to ensure all identified risks are managed as the project progresses.

10.1 Legal Issues

There are no expected legal issues regarding this project.

10.2 Stakeholder and Approval Issues

There are no expected stakeholder and approval issues regarding this project.

10.3 Environment and Sustainability Issues

All replacement or upgrade work will take place entirely within PWC owned zone substations. Decommissioned assets, such as protection relays, will be disposed of appropriately in accordance with good environmental practice.

10.4 Technical and System Issues

The existing 66kV switchyard will be taken out of service with the use of a Nomad modular substation. However, for all construction work adjacent to energised high voltage equipment, PWC has policies and procedures that must be adhered to, such as the Power and Water Access to Apparatus Rules and Access to High Voltage Apparatus Procedure.

Change over from existing to new 66kV switchyards will involve short term line outages to affect the transfer. These outages will be scheduled away from peak periods and in detail to minimise system security risk in close consultation with System Control.

11 PROJECT IMPLEMENTATION

This project is to be managed by the Power Networks' Major Projects group. It is planned that the project will be delivered using the "Design and Construct" (D&C) methodology through an external contractor.

- This project will follow the requirements of the investment planning framework (gating process);
- This project will follow the requirements of the investment and delivery framework; and
- The project will comply with PWC designs.

Testing and commissioning will be managed by Power Networks' Test and Protection group.

To ensure efficient costs are achieved, the majority of the electrical equipment and construction will be procured through the D&C contract, with detailed specifications prepared by PWC.

11.1 Resourcing Requirements (to next gateway)

Resource Type/Role	How Many?	Internal/ External?	Anticipated Start Date	Duration Required	Allocation (% time or # hrs/days/ wks/mths)
Project Manager	1	Internal	Jan 2018	6 months	10%
Planning Engineer	1	Internal	Jan 2018	6 months	10%
Design Engineer	1	External	Jan 2018	6 months	50%

12 FINANCIAL IMPACT

12.1 Funding Arrangements

This project will be part of the augmentation capital works 2019-24 Network Price Determination to the AER, which is recovered through standard control network tariffs.

Based on the most up to date information, the project cost estimate has been revised to [redacted] This is due to the RACE analysis and considering the associated project risks.

12.2 Capital Expenditure

Year	2019-20 ($'000)	2020-21 ($'000)	2021-22 ($'000)	2022-23 ($'000)	2023-24 ($'000)	Total ($'000)
[redacted]			[redacted]	[redacted]		[redacted]
[redacted]			[redacted]	[redacted]		[redacted]

12.2.1 Variance Coverage

Not applicable

12.3 Incremental Operating Expenditure

Ongoing costs of the new substation are related to operation and maintenance is expected to be $72,505. It is expected there will be a saving of approximately of $120,032 per annum in operating costs due to lower maintenance costs associated with the new equipment.

APPENDIX A

DETAILED FINANCIAL ANALYSIS

Introduction

The purpose of this Appendix is to provide details of the options analysis for the project Replace Humpty Doo ZSS.

Table A1 below outlines the estimated capital expenditure for options 1, 2, 3 and 4. The operational cost of option 4 is higher as there is an extra transformer compared to the other two options. This is reflected in the operational cash flows below.

Commercial analysis of Option 1 (deferral) was not undertaken as it is not considered to be a viable alternative due to the risk of major outages as a result of equipment failure.

Table A1 – Estimated Capital & Operating Expenditure

Option	Capex – Base Costs ($M)	Opex – Base Costs ($000's)
Option 1 – Do nothing	[redacted]	$192 (from 2023/24)
Option 2 – Replace existing Humpty Doo ZSS	[redacted]	$72 (from 2023/24)
Option 3 – Construct new Humpty Doo ZSS (1x 2.5/5MVA with Nomad connection)	[redacted]	$72 (from 2023/24)
Option 4 – Construct new Humpty Doo ZSS (2x 2.5/5MVA)	[redacted]	$102 (from 2023/24)

Assumptions

In modelling the options, technical, economic and cost parameters were included. The technical and cost data was provided by Power Networks and the economic data was sourced from Pricing and Economic Analysis (PEA). Base cost capital expenditure was based on the consultant's feasibility study.

In the assumptions, all costs exclude GST or other government charges.

The common variables employed in the Discounted Cash Flow (DCF) model are presented in Table A2 below. These variables are consistent with the 2019-24 Regulatory Proposal to the AER and are considered appropriate for use in the detailed commercial analysis.

Table A2 – Common Variables

Variables	
Nominal Pre-Tax WACC	6.96%
CPI – 2017/18	2.42%
CPI after 2017/18	2.42%
Time Horizon of Project	40 years

Option 1 - Deferral

The analysis for this option does not require any capital expenditure and it is expected the current average operational cost of $192,537 per annum will continue into the future.

Option 2 – Replace existing Humpty Doo ZSS

The analysis for this option includes capital expenditure of [redacted] is estimated to be the base cost with ongoing operational costs of $72,505 per annum.

Option 3 – Construct new Humpty Doo ZSS (1x 2.5/5MVA with Nomad connection)

The analysis for this option includes capital expenditure of [redacted] is estimated to be the base cost with ongoing operational costs of $72,505 per annum.

Option 4 – Construct new Humpty Doo ZSS (2x 2.5/5MVA)

The analysis for this option includes capital expenditure of [redacted] is estimated to be the base cost with ongoing operational costs of $102,505 per annum.

Least cost analysis

Based on the DCF analysis undertaken, the least cost option is Option 1 (Do Nothing). However, this is not considered to be a viable alternative due to the risk of major outages as a result of equipment failure. The next least cost option is Option 2. This is summarised in Table A3 below.

Table A3 – Net Present Cost of Options

Option	NPC ($M)
Option 1 – Do Nothing	[redacted]
Option 2 – Replace existing Humpty Doo ZSS	[redacted]
Option 3 – Construct new Humpty Doo ZSS (1x 2.5/5MVA with Nomad connection)	[redacted]
Option 4 – Construct new Humpty Doo ZSS (2x 2.5/5MVA)	[redacted]

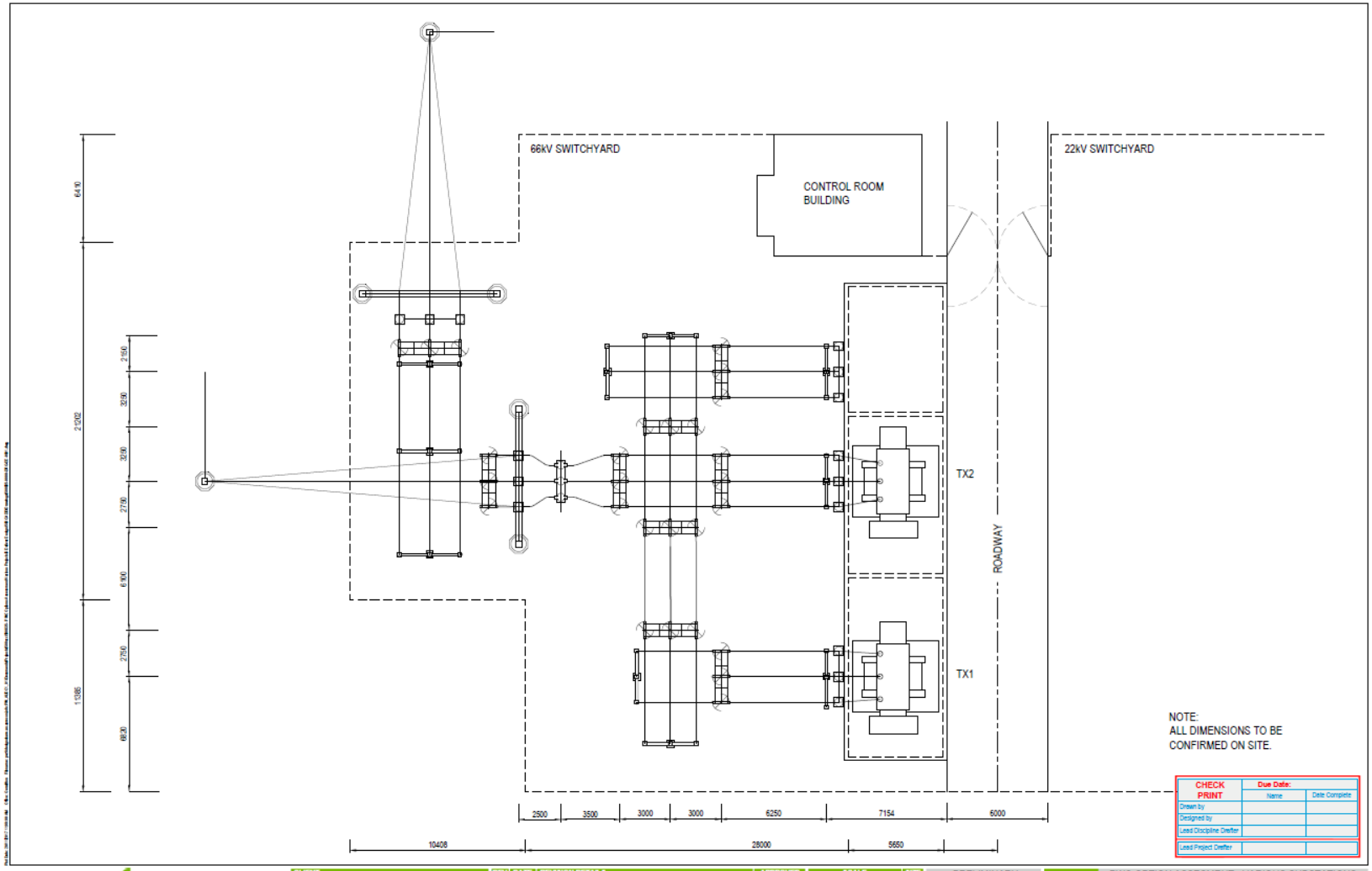
Tariff cover

This project capex (2021/22 and 2022/23 expenditure) will be submitted as part of the 2019 Regulatory Proposal to the AER. The AER's Final Determination will provide the approved level of net capital expenditure for the 2019-24 period. In so far as the Regulated Networks annual capital expenditure program remains at this level (or lower), Networks will earn a guaranteed rate of return through standard control service charges until the commencement of the next regulatory control period in 2024-25.

APPENDIX B

Layout Drawings

Drawing B1: Existing Substation Layout



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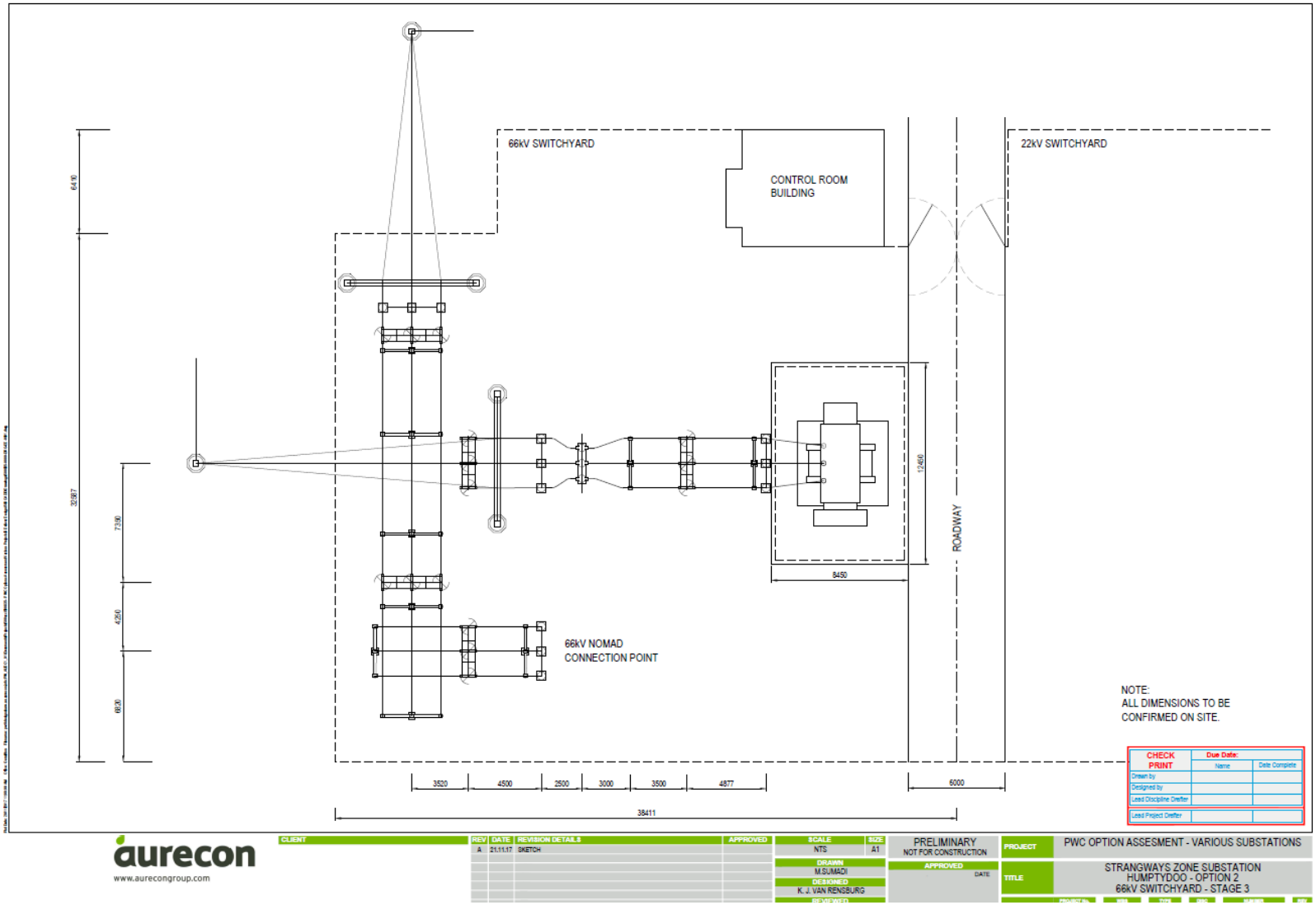
REV	DATE	REVISION DETAILS	APPROVED
A	21.11.17	SKETCH	

SCALE: NTS | SIZE: A1
DRAWN: M.SUMADI
DESIGNED: K. J. VAN RENSBURG
REVIEWED: M. HIBBERT
PRELIMINARY NOT FOR CONSTRUCTION
APPROVED DATE

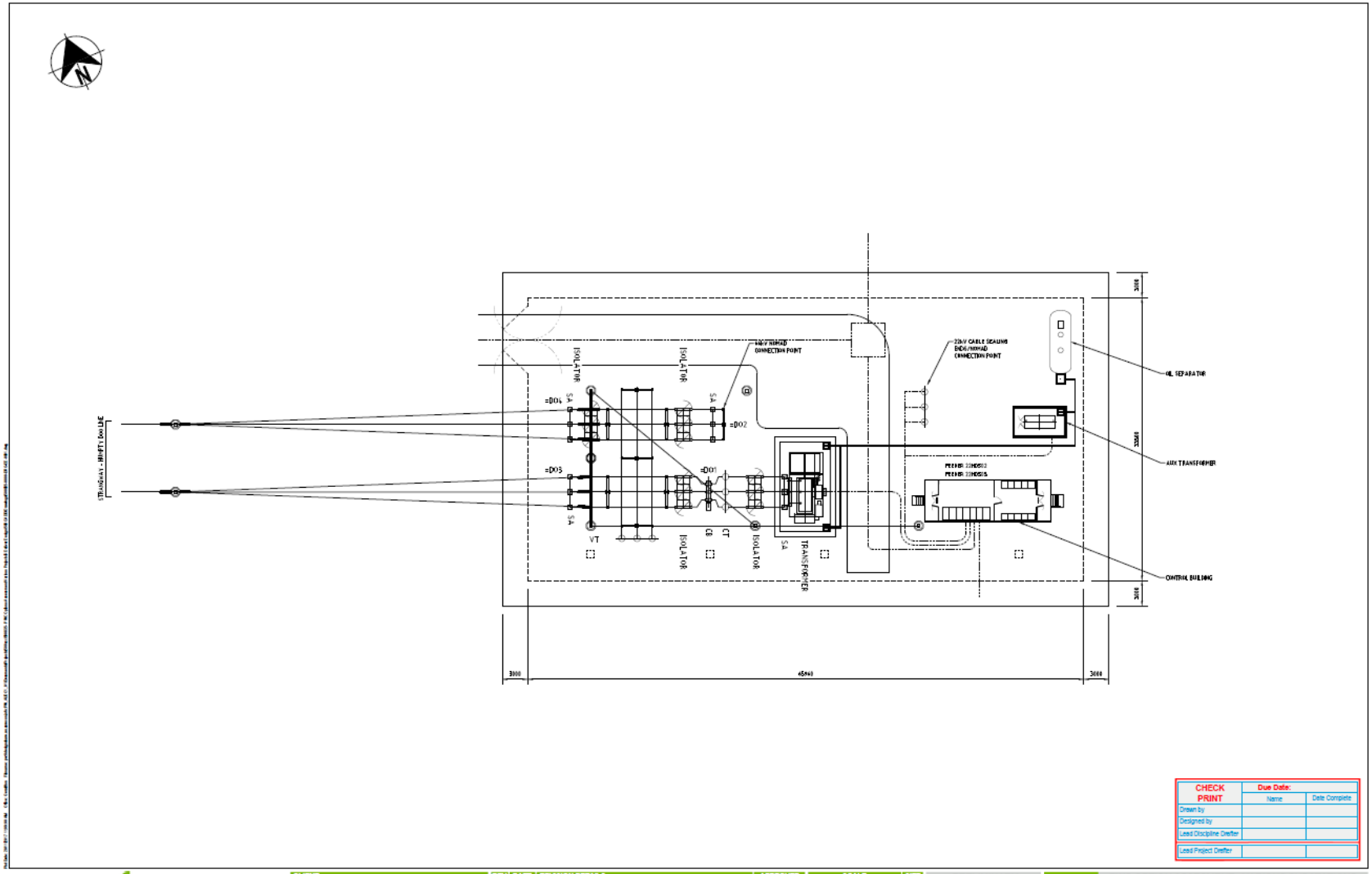
CHECK PRINT	Due Date: Name	Date Complete
Drawn by		
Designed by		
Lead Discipline Drafter		
Lead Project Drafter		

PROJECT: PWC OPTION ASSESMENT - VARIOUS SUBSTATIONS
TITLE: STRANGWAYS ZONE SUBSTATION HUMPTYDOO - OPTION 2 66kV SWITCHYARD - EXISTING
DRAWING No.: 500835 - 0000 - SKT - EE - 0001 - A

Drawing B2: Option 2 (Refurbishment) Substation Layout



Drawing B3: Option 3a (New 1 TX) Substation Layout



CHECK PRINT	Due Date: Name	Date Complete
Drawn by		
Designed by		
Lead Discipline Drafter		
Lead Project Drafter		

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REV	DATE	REVISION DETAILS	APPROVED
A	13.11.17	ISSUE FOR APPROVAL	

SCALE	SIZE
1:500	A1

DRAWN: F BOOTH
DESIGNED: K J VAN RENSBURG
REVIEWED:

PRELIMINARY
NOT FOR CONSTRUCTION
APPROVED
DATE:

PROJECT: PWC OPTION ASSESMENT - VARIOUS SUBSTATIONS
TITLE: STRANGWAYS ZONE SUBSTATION
HUMPTY DOO-OPTION 3
66kV SWITCH YARD PLAN
DRAWING No.: 500835 - 0000 - DRG - EE - 0001 - A

APPENDIX C

DETAILED RISK REGISTER

Refer:

PRD30401 Risk Analysis Humpty Doo Zone Substation

PWC Ref: D2017/485640

APPENDIX D

SUMMARY PROJECT PROGRAM

Task	*Baseline*			*2021*				*2022*				*2023*			
	Plan Start	*Plan Duration*	*Percent Complete*	*Q1*	*Q2*	*Q3*	*Q4*	*Q1*	*Q2*	*Q3*	*Q4*	*Q1*	*Q2*	*Q3*	*Q4*
Options Study	Jul 17	6 wks	100%												
Concept Design	Sep 17	6 wks	100%												
Planning and Permits	Jul 21	12 wks													
Detailed Design	Sep 21	10 wks													
Procurement	Jan 22	16 wks													
Civil Construction	May 22	10 wks													
Primary Installation	Jul 22	16 wks													
Secondary Installation	Sep 21	10 wks													
Commissioning and Energisation	Jan 22	8 wks													
Cutover Existing Services	Apr 22	2 wks													

APPENDIX E

CONDITION ASSESSMENT REPORT

Refer:

Humpty Doo HDZSS Condition Assessment

PWC Ref: D2018/64693