PowerWater

Power and Water Corporation

Preliminary Business Case – Category B

PRD33005

Darwin Transmission Line Uprating

Proposed:

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Power Networks
Date: 6/2/2018

Approved:

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

Endorsed:

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Date: 5/2/2018

Refer to email
D2018/72353

Finance Review
Date: 06/02/2018

Refer to email
D2018/65142

PMO QA
Date: 12/02/2018

1 RECOMMENDATION

It is recommended that the Chief Executive approve project PRD33005 - Darwin - Transmission Line Uprating, to treat nine lines from low clearance for an estimated capital cost of [redacted] and a corresponding completion date of June 2024.

Approval is sought for expenditure of up to $0.5M 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.

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

2 PROJECT SUMMARY

Project Title:	Darwin - Transmission Line Uprating		
Project No./Ref No:	PRD33005	**SAP Ref:**	
Anticipated Delivery Start Date:	Jul 2019	**Anticipated Delivery End Date:**	Jun 2024
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:**	D2017/394338
Submission Number:		**Priority Score:**	
Primary Driver:	Compliance	**Secondary Driver:**	Service Improvement
Project Classification:	Capital Category B		

2.1 Prior Approvals

Document Type	Sub Number	Approved By	Date	Capex Value
BNI	10083	Michael Thomson	24/07/2017	[redacted]

3 INVESTMENT NEED

3.1 Background

There are 132kV and 66kV transmission lines in the Darwin system to transmit electricity from power stations to zone substations in the distribution network. This transmission network was largely designed and built in the late 1970s to early 1980s.

Each transmission line has a specified nominal rating, used in normal operating conditions and a contingency rating, which applies when there is a circuit out of service due to planned or unplanned outages.

The rating of a transmission line is usually determined by two factors, the conductor temperature and the safety clearance of the line conductors from public assets. The conductors on the transmission line are required to operate below a certain temperature that is specified according to the materials and construction. Operating above this temperature results in irreversible conductor annealing, deformation and damage.

Increasing the power flowing through a transmission line will cause the conductor temperature to rise, and will result in the expansion of the conductor. The outcome is greater sagging of the line, reducing safety ground clearance. Power and Water Corporation (PWC) is responsible for managing this sag in accordance with Australian Standard (AS7000) which specifies the minimum clearances from public assets such as roads and bike paths for safety.

Up until now, the contingency rating has been calculated but has not been confirmed via onsite surveys. Hence, these ratings are only used by exception due to the increased risk of clearance breaches or conductor damage.

In addition, the conditions have changed significantly around the Darwin area since the construction of many of the transmission lines, with new residential, commercial and industrial developments along with the associated roads, parks and other public infrastructure. During these development activities, Power Networks have become aware that some lines may no longer meet safety clearances and some remedial activities have been completed. In addition, it has been prudent to review all as-built current conditions, normal ratings and contingency ratings.

3.2 Line survey results

PWC commissioned Connell Wagner to survey[1] and model the Darwin and rural area 66kV transmission network in 2007. The network was determined to be capable of the designed 64MVA rating but increasing the rating up to and beyond 80MVA would require upgrade works on several lines. Since then the Darwin system has expanded with additional generation at Channel Island

[1] Using ground-based survey techniques

Power Station and a new power station built at Weddell, expanded and new industrial areas, and more roads and infrastructure. Due to various developments since the Connell Wagner report, multiple projects have been completed to increase ground clearances, such as at the Tiger Brennan Drive extension, Palmerston Hospital intake road and Hidden Valley Motorsport Complex.

More recently, aerial LiDAR survey of each transmission line (66kV and 132kV) and as-installed conditions have been undertaken. The information has been incorporated into a capacity model using PLS CADD to identify clearance issues and calculate nominal and contingency line ratings.

By simulating a range of system and weather conditions, sections of transmission lines that have infringed on the required AS7000 safety clearances due to excessive sag have been identified. These 'low spans' represent a safety hazard. Upgrading the non-compliant spans to meet minimum required safety clearances may also increase line transfer capacity and may provide opportunities to defer capital expenditure that would otherwise be required to overcome capacity constraints.

A high priority violation is one which:

- Has clearance less than the AS7000 required 6.7m and is exposed to vehicular and general public access.
- Have clearance violations of less than 6.7m over paved or dirt roadways that are reasonably expected to be accessed.

A low priority violation is one which:

- Exceeds the AS7000 required 6.7m over roads but not the PWC specified 8m or 10m construction requirements.

Has a clearance between 5.5m and 6.7m over a dirt track that would not be reasonably accessed by the general public, such as PWC maintenance access tracks, or tracks that could be classed as inaccessible to tall vehicles

Table 1. Line spans with clearance violations

Line	Current design rating	Number of high/low risk clearance violations	Contingency rating	Number of High/low priority Clearance Violations
Hudson Creek – Palmerston (66kV)	64MVA/75°C	2/6	80MVA/90°C	4/12
Hudson Creek – Archer (66kV)	64MVA/75°C	0/3	80MVA/90°C	1/7
Palmerston – Strangways (66kV)	64MVA/75°C	1/10	80MVA/90°C	4/12
Strangways –	64MVA/75°C	5/11	80MVA/90°C	7/13

Weddell (66kV)				
Hudson Creek – Archer (66kV)	64MVA/75°C	0/3	80MVA/90°C	1/7
Hudson Creek – Woolner 1 and 2 (66kV)	64MVA/75°C	2/9	80MVA/90°C	3/11
Berrimah – Leanyer (66kV)	64MVA/75°C	4/6	80MVA/90°C	9/10
Leanyer – Casuarina (66kV)	64MVA/75°C	2/1	80MVA/90°C	4/1
Casuarina – Woolner (66kV)	65MVA/120°C	0/2	80MVA/159°C	0/2
Hudson Creek – Darwin Zone (66kV)	61MVA/73 and 120°C	TBC	80MVA/90 and 159°C	TBC
Hudson Creek – Berrimah 1 and 2 (66kV)	64MVA/75°C	TBC	80MVA/90°C	TBC

3.3 Prioritisation

The prioritisation criteria used to rank the line sections for remedial action is as follows:

- Safety - Line sections in proximity of people (pedestrians etc.) typically pose a greater safety risk than rural line sections with low clearance, however vehicular traffic (e.g. high loads, including farm equipment) can also pose significant safety hazards depending on the frequency with which vehicles etc. come close to/traverse the line section
- Extent of non-compliance, including factors such as the length of offending spans, the difference between the design rating and the contingency rating and also the anticipated duration of the non-compliance. (i.e. meters vs centimetres; incidence, i.e. minutes / hours / days)
- Criticality (e.g. constraining-off generation; loss of customer risk)
- Improved maintenance access, assisting to reduce the loss of customer risk.
- Whether or not other projects (including, for example, customer driven line relocations) will provide an opportunity to rectify clearance issues.

The risk reduction can then be balanced against the cost and complexity of the work to determine the order of rectification.

3.4 Risk analysis

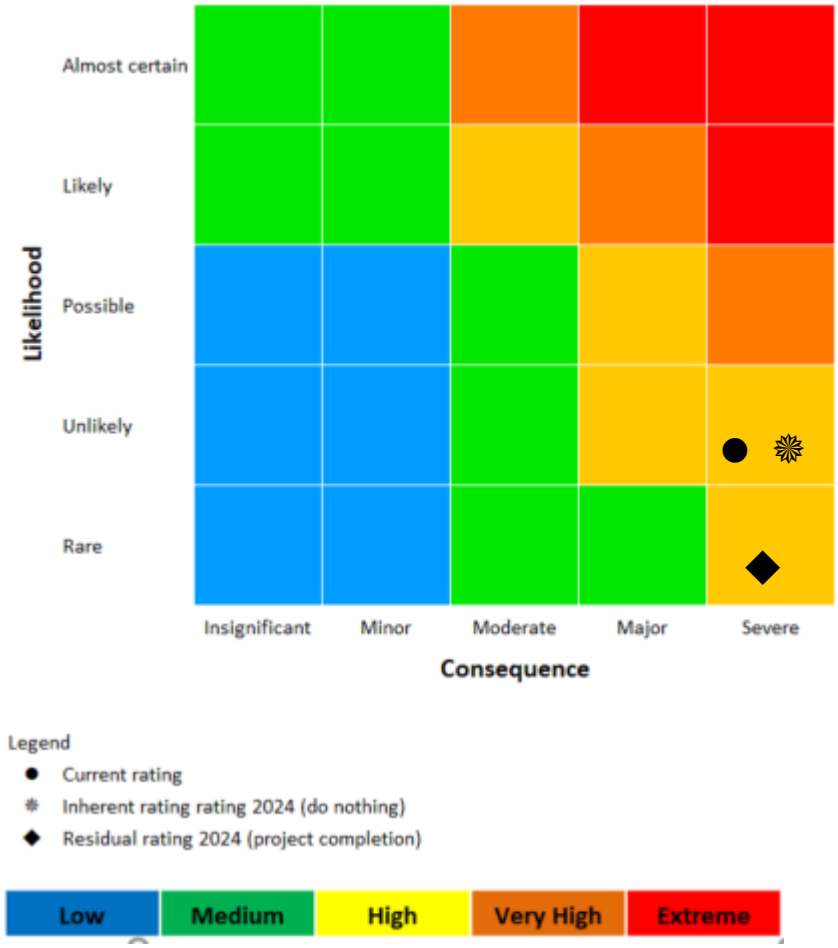
Figure 6 shows the current rating, inherent rating (in 2024, i.e. if no action is taken in the interim), and the residual (post-treatment) risk ratings associated with the line section non-compliances.

(i) *Current rating:* The Current rating (2017) is assessed to be 'High' because the likelihood of someone being fatally injured is rated as 'Unlikely' but the consequence could be 'Severe'.

(ii) *Inherent rating:* The risk posed by the non-compliant line sections is unlikely to increase materially through to 2024. The risk rating therefore remains 'High'.

(iii) *Residual rating:* The proposed project will progressively reduce the risk of fatalities, starting with the highest risk line sections. The likelihood will be reduced to rare; however, the consequence (fatality) remains 'Severe'. Therefore, the residual risk rating remains "High".

Figure 6: Line span non-compliance risk assessment[2]



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

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 Corporations' 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 assist PWC to meet current and future safety and capacity requirements on the transmission and sub-transmission system.

5 TIMING CONSTRAINTS

The project will be ongoing until all lines with clearance violations are rectified. The highest priority violations identified on transmission lines will need to be completed by June 2024 to reduce the safety risk to acceptable levels, allow the most efficient use of the transmission system and to reduce the likelihood of customer interruptions from planned and unplanned outages.

The transmission line study has identified nine lines, all of which contain safety clearance violations that are classed as high risk and priority. Due to the annual load profile, work on the PWC transmission network is limited to Northern Australia's "Dry" season (May-September).

6 EXPECTED BENEFITS

Driver/Objective	Benefit	Current State	Future State
Safety / Compliance	Progressively reduce the risk of a fatality through contact with non-compliant power lines	Low line clearance to ground present a safety hazard to the public and are non-compliant with AS7000 and PWC Standards	No high risk non-complant line sections in the Darwin-Katherine or Alice Springs Network

7 REQUIREMENTS

The solution selected must progressively resolve the clearance violations on the transmission network identified in the line survey to minimise the risk of injury to the public and PWC staff under normal and contingency scenarios.

PWC will also require compliance with the following:

- Northern Territory Electricity Reform Act
- Power and Water' Network Licence as issued by the Utilities Commission
- Network Technical Code and Network Planning Criteria

- Relevant Australian and PWC Standards.

8 OPTIONS

8.1 Options Development

8.1.1 Option 1 – Do nothing (defer expenditure)

This involves deferring any work to address the non-compliant line spans until 2025 (i.e. in the subsequent regulatory period). This is not a technically acceptable option as PWC is required to take reasonable and prudent action to ensure compliance with safety standards, including complying with the specified minimum clearances in AS7000.

8.1.2 Option 2 – Rectify all non-compliant line sections by June 2024

This option would be the prudent approach if:

(a) All the non-compliant spans were rated as high risk; and/or

(b) The safety/technical regulator has issued an Order on PWC to rectify by a certain date; and

(c) There are sufficient resources to undertake the work, cognisant of the portfolio of work planned by Power Networks in the next RCP

The advantage of this option is that all non-compliant spans would be eliminated by 2024.

The disadvantage of this option is that it relatively expensive at a base cost of [redacted].

8.1.3 Option 3 – Rectify all high priority non-compliant line sections by June 2024 (Preferred Option)

This is essentially a staged approach, with:

- High priority line violations at the current design rating rectified in the current RCP with works rolling into the 2019-2024 RCP;
- Highest priority line violations at the extended contingency rating rectified in the 2019-2024 RCP if the capacity exists.
- The remainder of lines with clearance violations to be addressed in the 2024-2029 RCP.

This staggered approach allows for the greatest level of flexibility to address the greatest risks as they are identified due shifting loads and demand patterns. Due to a number of potential renewable energy generation facilities being discussed, there is a significant possibility that the contingency load profiles will change in the future. A flexible approach to managing transmission line violations will ensure that efficient generation is kept on-line without increasing the risks to public safety.

Any work identified as being done as part of other projects would be identified as such and costed and approved separately, but good governance

is required to ensure the work gets done as planned or it has to come back into this program.

The disadvantage of this option is that the lower risk non-compliant line spans are not addressed until the next regulatory period.

The estimated base cost of this option (nine high risk lines at the current rating) is [redacted].

8.2 Comparative cost analysis

Table 2 summarises the results of a comparative cost analysis, the details of which are included in Appendix D. Of the technically viable options, Option 3 – Rectify high priority violations – has the lowest NPC.

Table 2: Summary of comparative capital cost analysis

Option	Capital cost ($M)	Net Present Cost ($M)	Comments
1 – Deferral	[redacted]	[redacted]	Not technically viable. Non compliance.
2 – Rectify all non-compliant line sections by 2024	[redacted]	[redacted]	High cost
3 – Rectify high priority line sections by 2024	[redacted]	[redacted]	Lowest NPC option

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.

Project Objectives	Technical & System Risk	Stakeholder Risk	Env. Risk	Commercial

Criteria	Clearance Requirements	Maintain System Security	Line Capacity	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	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.25	1.0
Option 2	0.4	0.4	0.4	0.2	0.1	0.3	0.4	0.2	0.2	0.2	0.15	0.6
Option 3	0.3	0.3	0.3	0.2	0.15	0.4	0.3	0.2	0.2	0.2	0.20	0.8

8.3.1 Evaluation Summary

Weighted Scores:

Option 1: Deferral	2.65
Option 2: Rectify all non-compliant violations	3.55
Option 3: Rectify high priority violations	3.55

8.4 Preferred Option

The preferred option (Option 3) is the staged approach of rectifying the high priority line violations in the 2019-24 RCP. Only the nine violations at the current design rating are budgeted for rectification.

This option best fulfils the project objectives of resolving the highest priority clearance violations at a prudent and efficient cost. It will address the highest safety risks to the public and will also allow the network to operate in normal and contingency scenarios.

There is little risk of public opposition to the rectification works as it will occur within existing line easements. Works near public roads will be carefully managed with the used of traffic control around the work site.

The design of the rectification works will be to the existing PWC Standards. This will maximise constructability and reduce design cost risk.

There will be minimal clearing of the site as there is no significant native vegetation in existing PWC easements

9 PROJECT OUTLINE

9.1 Project Description

9.1.1 Scope Inclusions

This project will survey, analyse and construct the required upgrading options, if needed, for all 66kV transmission lines in the Darwin and rural area and the 132kV transmission line between Channel Island Power Station and Hudson Creek. The project will take the transmission line spans that have been identified as having a clearance violation, prioritise these spans with a high importance placed on the spans that could expose the general public to a safety hazard, and undertake structural rectification works to eliminate those hazards while maintaining or improving the structural strength of the transmission line to that required in AS7000.

The survey data will also include vegetation clearance reports that the Power and Water, Power Networks, Asset Management branch can use in their vegetation clearing strategy.

9.1.2 Scope Exclusions

This project will not survey or investigate the upgrading requirements of the 132KV Darwin – Katherine Transmission Line, the 66kV Cosmo – Howley line or the 66kV Owen Springs – Lovegrove (Alice Springs) line.

9.1.3 Assumptions

While the quality and accuracy of the data collected by Aerial LiDAR Surveying is now very good, the same can not be said about the knowledge of all of the transmission line towers and poles structural capacities. While compiling the costings for upgrade options, it has been assumed that the structures are capable of withstanding the loads that would be applied to them after rectification works and comply with the requirements of AS7000. The true state of the structural capacities of the poles and towers in question will only be realised when detailed engineering studies are undertaken. There is a possibility that some structures may not be capable of being modified and comply with the requirements of AS7000 resulting in a more expensive upgrade option being selected, which may impact on the number of spans rectified or the projects budget.

9.1.4 Dependencies

Any rectification construction work has to take place during the northern “Dry” season as this is the only time when the electrical demand is low enough to have transmission lines de-energized, when temperature and humidity levels are low enough to allow live line work to be undertaken, the lack of thunderstorms allow for pole and tower access and also this time allows for the workforce to be on task for longer without increased risk of heat stroke. During the northern “Wet” season Power and Water field crews often have to repair storm damage and access to some areas is limited due to flooding and soft ground.

9.1.5 Key Stakeholders

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
	Local Council
External - Other	Local Residents
	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] with a most likely project cost of $4.0M (P50). The contingency attributable to risk is calculated as P95 – P50 = $0.7M.

9.2.1 Base Capital Cost

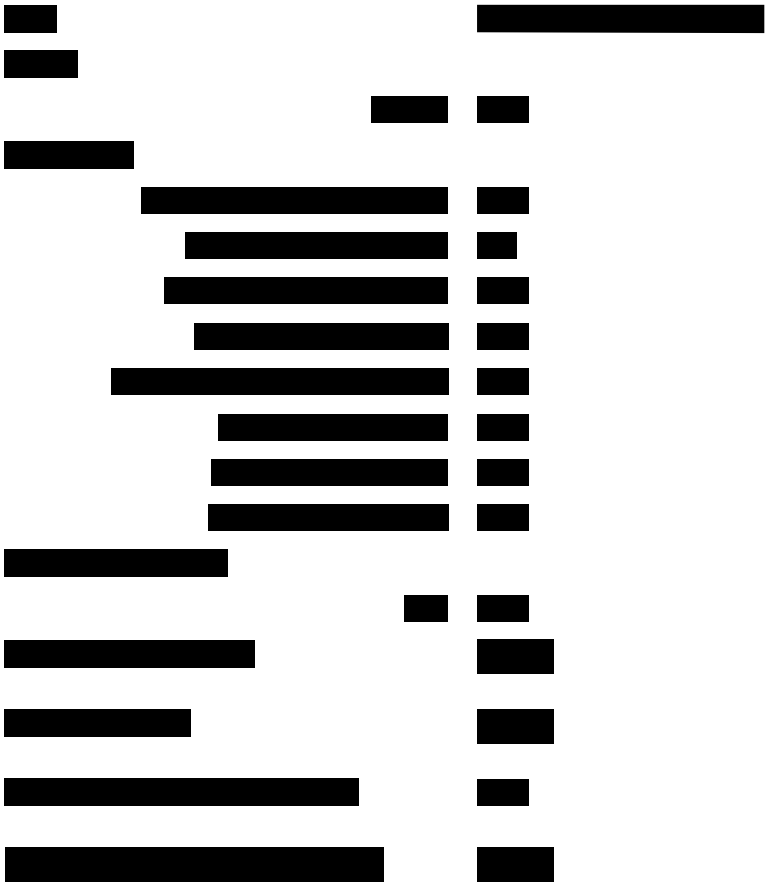


Table 1 – Base Capital Cost Estimate

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. In addition, the RACE process integrates risk into cost estimates based on a monte-carlo simulation of expected pricing and risk realisation.

The contingency amount, calculated as the P95 value minus the expected P50 value, is currently $ 0.7M.

9.3 Estimated Operating Cost Impact

There is not expected to be a net change to the operating costs associated with this project. While there will be upgrades to the existing transmission lines, the overall number of poles and total line length will not significantly change.

9.4 Project Milestones

Project Phase	Investment	Project	Commitment	Implementation	Review

(end)	Planning	Development			
Original Plan (BNI)	08/2017	01/2019	06/2019	06/2021	09/2021
Current Forecast	08/2017	01/2019	07/2019	06/2024	09/2024
Actual Completion					

10 RISK MANAGEMENT AND COMPLIANCE

A preliminary risk register has been established to address project risk. This is included in Appendix B. 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 Technical and System Issues

As the upgrades on existing transmission lines will require outages, close consultation with System Control regarding system security will need to be scheduled prior to the planned works.

During the works, Power and Water AAR (Access to Apparatus Rules) will need to be adhered to. Also, special attention will need to be place on traffic control and managing public access as the majority of the work will occur in road reserves and in unrestricted areas.

11 PROJECT IMPLEMENTATION

This project is to be managed by the Power Networks' Project Management group. At this stage 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 Power and Water investment planning framework (gating process);
- This project will follow the requirements of the Power Networks delivery framework; and
- The project will comply with Power and Water 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 Power and Water.

11.1.1 Resourcing Requirements (to next gateway)

The estimated resource requirements to finalise the Business Case for final gate approval is shown in the table below.

Resource Type/Role	How Many?	Internal/ External?	Anticipated Start Date	Duration Required	Allocation (% time or # hrs/days/ wks/mths)
Project Manager	1	Internal	Jan 2019	6 months	20%
Planning Engineer	1	Internal	Jan 2019	6 months	10%
Design Engineer	1	External	Jan 2019	6 months	20%

12 FINANCIAL IMPACT

12.1 Funding Arrangements

The capital expenditure for this project will need to be approved by the AER's 2019-24 Network Price Determination, 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] The revised cost is based on the estimated costs provided in the line study and additional estimates for internal Power and Water expenditure.

12.2 Capital Expenditure

The capex in the table below is in $2017-18, and is excluding capitalised overheads and cost escalation.

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]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

12.3 Incremental Operating Expenditure

There is not expected to be a net change to the operating costs associated with this project. While there will be upgrades to the existing transmission lines, the overall number of poles and total length will not significantly change.

APPENDIX A

DETAILED FINANCIAL ANALYSIS

Introduction

The purpose of this Appendix is to provide details of the options analysis for Transmission Line Uprating project.

Table A1 below outlines the estimated capital expenditure for each option. 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 safety risk to the public from inadvertent contact with the high voltage conductors.

Table A1 – Estimated Capital & Operating Expenditure

Option	Capex – Base Costs ($M)	Opex – Base Costs ($000's)
Option 2 – Rectify all non-compliant line sections by 2024	[redacted]	$0
Option 3 – Rectify high priority line sections by 2024	[redacted]	$0

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 sourced from 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

Commercial analysis of Option 1 (deferral) was not undertaken as it is not considered to be a viable alternative due to the safety risk to the public from inadvertent contact with the high voltage conductors.

Option 2 — Rectify all non-compliant line sections by 2024

The analysis for this option includes capital expenditure of [redacted] is estimated to be the base cost with no ongoing operational costs as there will not be a net increase in assets.

Option 3 – Rectify high priority line sections by 2024

The analysis for this option includes capital expenditure of [redacted] is estimated to be the base cost with no ongoing operational costs as there will not be a net increase in assets.

Least cost analysis

Based on the DCF analysis undertaken, the least cost option is Option 3. This option is $4.1 million less in Net Present Cost (NPC) terms than Option 2. This is summarised in Table A3 below.

Table A3 – Net Present Cost of Options

Option	NPC ($M)
Option 2 – Rectify all non-compliant line sections by 2024	[redacted]
Option 3 – Rectify high priority line sections by 2024	[redacted]

Tariff cover

A portion of this project capex (2021/22, 2022/23, and 2023/24 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

DETAILED RISK REGISTER

Refer:

PRD33005 Risk Analysis Transmission Line Uprating

Power and Water Ref: D2018/57375

APPENDIX C

PLANNING REPORT

Refer:

Uprating of Darwin Transmission System

PWC Ref: D2017/317660

PowerWater

Report No:	NPR1609	**File No:**	F2005/13996
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Date:	13th February 2018		
Author:	Craig Owens		
Approved by:	Tat Au-Yeung – Senior Manager Network Development and Planning		
Title:	Uprating of Darwin Transmission System		

Report Circulation:

The following staff members are on the circulation list for this report:

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1. Executive Summary

The 132 kV and 66 kV transmission lines in the Darwin area supply electricity to Zone Substations in the distribution network. The rating that can be assigned to these lines is calculated taking into account the allowable operating temperature of the line, and the allowable minimum clearance to ground and nearby structures.

These ratings are assigned as normal and contingency ratings. Contingency ratings apply for a short period of time and provide for higher line loading when an adjacent circuit is out of service.

Existing line ratings in the Darwin area are based on standard calculations which have not yet been confirmed by detailed line surveys.

It is expected that a detailed line survey will allow higher conductor temperatures to be used while maintaining required clearances. Higher allowable line temperatures would provide for higher allowable line loading. These higher ratings would be expected to delay or avoid the need for major upgrade works in the transmission network.

It is recommended that a project be commenced to;

1. Survey the existing 132 kV and 66 kV transmission lines in the Darwin area.
2. Determine the existing 132 kV and 66 kV transmission lines minimum clearances to ground and confirm that requirements of the relevant Australian standards are met.
3. Identify and correct any locations where clearances do not meet the relevant Australian standards requirements.
4. Determine appropriate conductor ratings for normal and contingency conditions that will allow all clearance and other requirements to be met.

2. Network Technical Code & Planning Criteria

The relevant clauses in the Power Networks Network Technical Code and Network Planning Criteria, December 2013 that apply to this study are:

Part A – Legislative Requirements

Part B – Network Technical Code

The purpose of Network Technical Code is it sets out technical requirements that are designed to ensure the network and customer installations will be operated and maintained in a reliable and secure manner.

1.7 Obligations

2.3 Power frequency voltage levels

4.2 Power system security principles

4.3 Power system security obligations and responsibilities

4.5 Control of network voltages

8 Disconnection and reconnection of plant and equipment

Part C – Network Planning Criteria

The purpose of Network Planning Criteria is to strike a balance between each User's need for a safe, secure, reliable, high quality electricity supply and the desire for this service to be provided at minimal cost. At the same time, environmental and social considerations shall be taken into account.

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5. Introduction

5.1. Background

Safety and reliability are the two primary drivers for this project. The safety issue is to confirm that transmission line clearances meet the relevant Australian Standards. Reliability requirements are defined in the Network Technical Code and Network Planning Criteria.

5.2. Safety

Power and Water's Safety Management Corporate Policy[3] states that:

> *The Corporation is committed to complying with relevant WHS legislation and other requirements placed on the Corporation by other bodies, including the Utilities Commission by being:*
> *(i) consistent with the intent of relevant Australian and international Standards on safety management*

The key Australian Standard that applies to overhead transmission lines is AS/NZS 7000:2016 Overhead Line Design. This standard sets out the required safety clearance distance of overhead power lines of various voltages to ground, buildings and other circuits.

Power and Water is not currently able to state definitively that all transmission lines in the Darwin area meet the required clearances for all loading and weather conditions. In order to accurately determine existing clearances, a detailed survey as proposed in this document, is required.

5.3. Supply Contingencies Criteria

6. First Supply Contingency

The Network Technical Code and Network Planning Criteria document defines the contingencies that must be considered when planning the network. In the case of CBD and Urban areas load of greater than 50 MVA, Class of Supply D

[3] D2013/672684 Safety Management Corporate Policy v1 - 30 April 2014 - page 2.

applies[4]. The requirement for a first supply contingency is that area demand is restored immediately. This implies that all lines should be loaded within the rating following a single transmission line outage.

Table 1 below shows the line outages which are expected to lead to overloads in adjacent circuits at peak load during 2017/2018. The loadings used to calculate the utilisation in Table 1 are taken from the most recent Network Management Plan[5][6]. For this analysis, the normal line ratings have been used.

Table 1 - Critical single contingency outages in 2017/2018

	Outage Circuit	**Critical Circuit**	**Maximum Utilisation during outage (based on normal line ratings)**
1	Hudson Creek - Palmerston	Weddell – Strangways	127%
2	Hudson Creek - Archer	Weddell – Strangways	107%
3	Weddell – Strangways	Hudson Creek - Palmerston	119%
4	Hudson Creek – Woolner 1	Hudson Creek – Woolner 2	100%
5	Hudson Creek – Woolner 2	Hudson Creek – Woolner 1	100%

Note that the installation of the Archer – Palmerston line in 2017/2018 is expected to relieve the overload for the outages in rows 1 to 3 of Table 1.

[4] D2013/653383 Network Technical Code and Network Planning Criteria v3.1, December 2013. Table 13, page 126.

[5] D2017/58809 Internal Version Network Management Plan 2013 14 to 2018 19 - January 2017 Information Update. Appendix 2B.

[6] D2017/363285 COwens Transmission Utilisation and Contingency Analysis from 2016 to 2026 (Normal Line Ratings Calculation)

7. Second Supply Contingency

The Network Technical Code and Network Planning Criteria document defines the requirements for a second supply contingency. This is only considered in the case of CBD and Urban load of greater than 50 MVA, designated as Class of Supply D[7]. The relevant criterion states that area demand must be restored within 5 hours.

There are many second contingency outages which would result in customer interruptions at peak load and at lighter loads on the network. No detailed analysis has been done for this project to determine which outages would be critical. In many second contingency cases, the outage would extend until repairs were complete. Since transmission line repairs would often be expected to take longer than 5 hours, it means that the requirements of the Network Planning Criteria are not met in this aspect.

In order to minimise customer outages in such cases, and minimise the likelihood of the Network Planning Criteria being violated, it is necessary to have robustly determined normal and contingency line ratings.

It is a key aim of this project to allow the calculation of these ratings.

8. Scope of study

The scope of study is to survey and determine conductor ratings and ground clearances for all 132 kV and 66 kV transmission lines in the Darwin area. This includes the 132 kV lines from Channel Island to Hudson Creek, and all the 66 kV lines supplied from Hudson Creek. This network supplies Darwin region and the surrounding rural area.

The Channel Island to Katherine 132 kV line and networks supplied from it are excluded from the scope of this project.

9. Risks

Power and Water's Engineering team judgement is that there are few parts of the Darwin transmission system which do not meet Australian Standards clearance requirements. It is expected that this project will identify

[7] D2013/653383 Network Technical Code and Network Planning Criteria v3.1, December 2013. Table 13, page 126.

possibilities to increase line ratings; however there is a risk that the project will identify many locations where clearances are inadequate. If this is the case the project may only correct these non-compliances, and not be able to derive higher line ratings.

10. Options considered

10.1. Do nothing

This option is not considered reasonable since the present lack of definitive information on transmission line clearance is not considered good electricity industry practice.

10.2. Transmission Lines Survey and Corrective works

The project is required to:

Gather data on the existing line clearances
Design and construct any necessary line clearance improvements required to meet clearance standards with existing ratings
Allow higher conductor temperatures to be used, and therefore higher line ratings could be applied

11. Conclusions and recommendations

A business case should be prepared to allow for a detailed survey of transmission lines in the Darwin area.

The business case should allow for:

1. The delivery of the detailed transmission lines survey
2. Analysis to determine any non-compliances regarding ground clearances with relevant Australian standards
3. Allocation of funds to allow for correction of any non-compliances
4. Updated calculation of 132kV and 66kV transmission line ratings under normal and contingency conditions