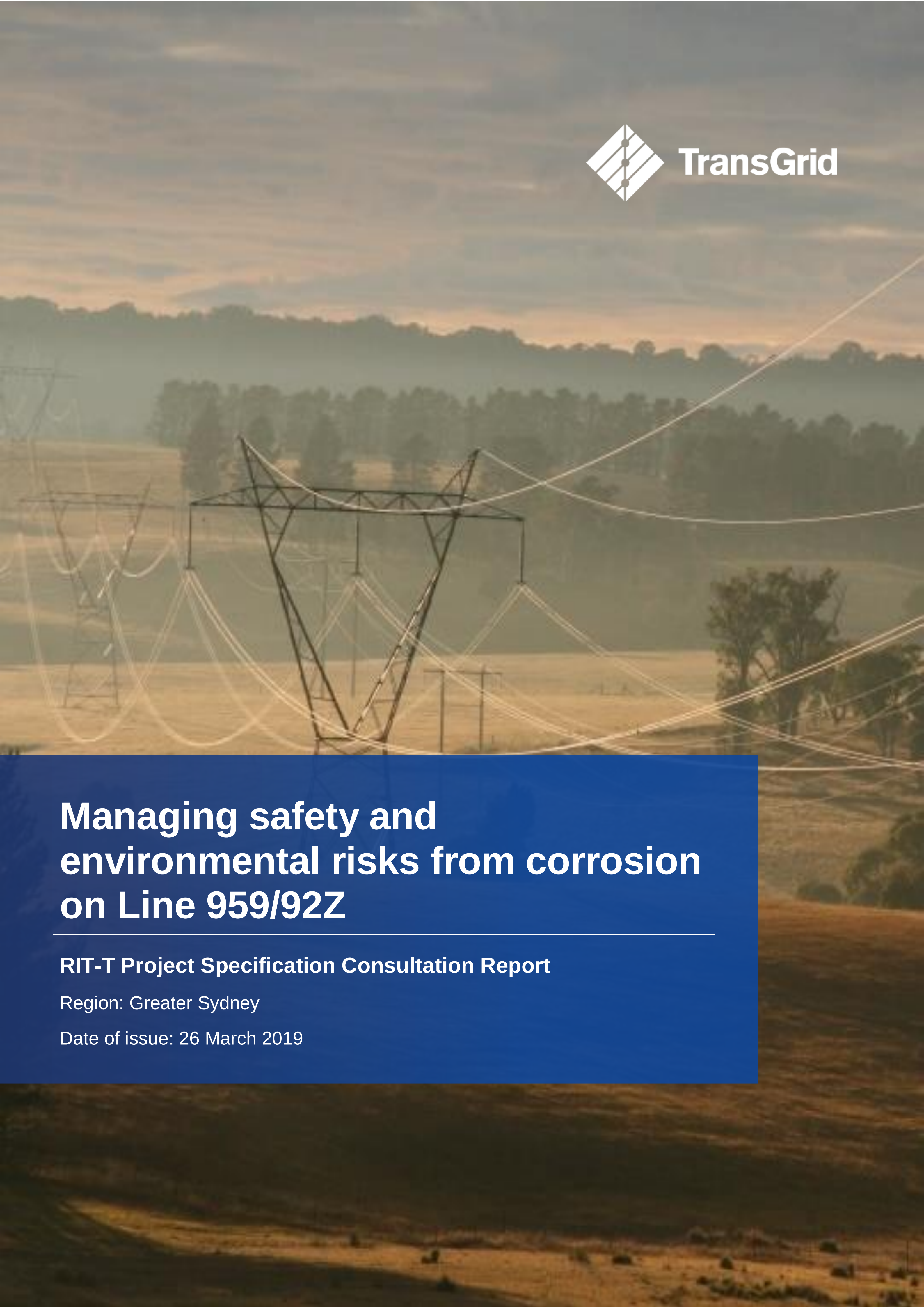

Managing safety and environmental risks from corrosion on Line 959/92Z

RIT-T Project Specification Consultation Report

Region: Greater Sydney

Date of issue: 26 March 2019

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Executive summary

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for mitigating risks caused by corrosion along Line 959/92Z. Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process.

Constructed in 1965, the 23.7 km double circuit 132 kV transmission line is built on 61 steel tower structures between Sydney North and Sydney East 330 kV substations. The majority of the line passes through national parks and certain sections pass through urban areas in Sydney.

The line supplies electricity to the Northern Sydney metropolitan area including North Sydney, Ryde, Macquarie Park, Chatswood, and the suburbs along the Northern Beaches. Line 92Z, which runs on one side of the double circuit transmission line, provides connection to some of Ausgrid's loads through a tee connection at Mt Colah Switching station. Line 959/92Z plays a critical role in providing back-up transmission supply to areas of Sydney which collectively have a 50% Probability of Exceedance[1] (POE50) summer peak load of about 700 MW – almost as large as the biggest smelter in NSW.

Corrosion-related issues that will impact the safe and reliable operation of the network have been found on Line 959/92Z. The condition issues raise a number of risks associated with asset failure, including safety and environmental (bushfire) risks.

Table E-1 – Condition issues along Line 959/92Z and their consequences

Issue	Impact
Corrosion of tower steel members	Steel corrosion, particularly of critical members, can lead to structural failure of tower
Buried concrete foundations	Accelerated corrosion of critical member
Corrosion of earth straps	Earthing safety hazard
Corroded fasteners	Structural failure
Corroded conductor attachment fittings	Conductor drop
Corrosion of earth wire attachment fittings	Conductor drop
Corroded earth wires	Conductor drop
Conductor dampers	Accelerated conductor fatigue due to vibration

Although the structures were designed to the standards at the time of construction, the towers were designed to a lower set of criteria than the more recent design philosophies and standards.

As the asset condition deteriorates over time, the likelihood of failure and subsequent risks may increase should these issues not be addressed.

[1] Probability of Exceedance (POE) demand is a generalised approach to defining the probability of exceedance of electricity demand forecasts. The demand is expressed as the probability the forecast would be met or exceeded, eg a 50% POE demand implies there is a 50% probability of the forecast being met or exceeded. Australian Energy Market Operator, *"Generation and Load,"* accessed 1 February 2019. http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Market-Management-System-MMS/Generation-and-Load

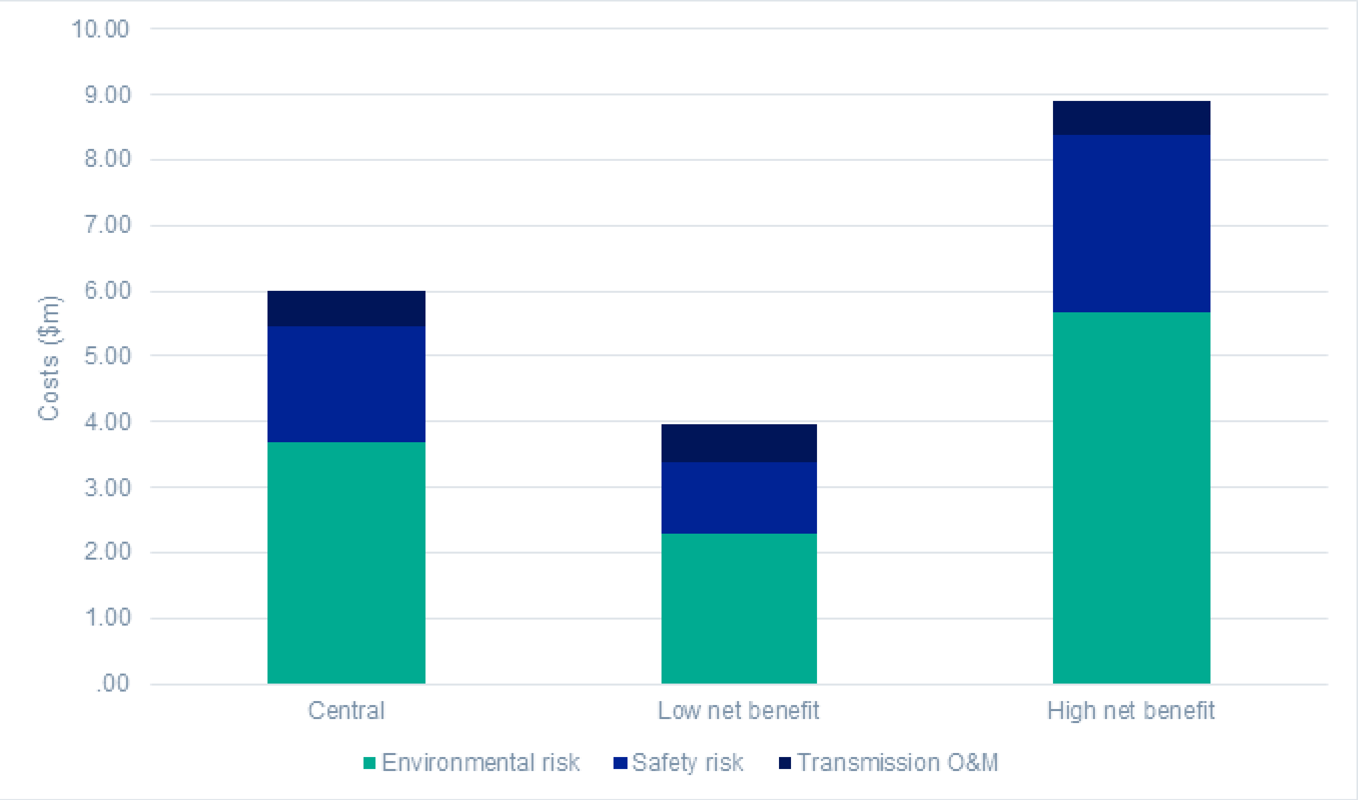
Identified need: managing safety and environmental risks from corrosion on Line 959/92Z

With Line 959/92Z currently in service, TransGrid meets the reliability standard for the Northern Sydney network. This includes the capability to provide back-up supply for areas of Sydney.

Several steel tower structures supporting Line 959/92Z have reached a condition that reflects they are nearing the end of their serviceable lives. The assets affected by corrosion-related issues pose risks to supply, environment, and safety as consequence of potential structural failure, conductor drop, and earthing safety hazards. Further deterioration of the condition of these assets as a result of corrosion increases these risks.

Figure E-1 shows that safety and environmental risks in Sydney are the biggest components that could be mitigated by making investments.

Figure E-1 – Costs forecasts under the base case, present value 2017/18 $m



Line 959/92Z traverses dense bushland and highly populated residential areas. If the corrosion-related condition issues are not addressed by 2020/21, the safety and environment in the surrounding area will be at risk. TransGrid manages and mitigates bushfire and safety risks to ensure they are below tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with TransGrid's obligations under the New South Wales *Electricity Supply (Safety and Network Management) Regulation 2014* and TransGrid's Electricity Network Safety Management System (ENSMS).[2]

Using TransGrid's risk cost framework, the risks on safety and environment are sufficiently large that investments must be taken to mitigate those risks. The safety and environment risk costs from corrosion of steel components, or 'members', of the structures are estimated to be $505,000 per year.[3]

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2 TransGrid ENSMS follows the International Organization for Standardization's ISO31000 risk management framework which requires following hierarchy of hazard mitigation approach.

3 This determination of yearly risk costs is based on TransGrid's Network Asset Risk Assessment Methodology and incorporates variables such as likelihood of failure/exposure, various types of consequence costs and corresponding likelihood of occurrence.

TransGrid's analysis concludes that the costs is less than the benefits from mitigating bushfire and safety risks. Categorised as a reliability corrective action under the RIT-T, the proposed investment will enable TransGrid to continue to manage and operate this part of the network to a safety and risk mitigation level of ALARP.

A reliability corrective action differs from a 'market benefits'-driven RIT-T in that the preferred option is permitted to have negative net economic benefits on account of it being required to meet an externally imposed obligation on the network business.

Credible options considered

In this PSCR, TransGrid has put forward for consideration credible options that would meet the identified need from a technical, commercial, and project delivery perspective.[4]

Table E-2 – Summary of credible options

Option	Description	Capital costs ($m)	Operating costs ($m per year)	Remarks
Option 1	Line Refurbishment	6.93	0.100	Less economical due to higher operating, maintenance and licensing costs
Option 2	Line Refurbishment with Optical Ground Wire (OPGW) Retrofitting	7.13	0.050	Most economical and preferred option
Option 3	New transmission lines from Sydney North to Sydney East	> 75	0.050	Not progressed as uneconomical due to significant costs

Non-network options are not able to assist in this RIT-T

TransGrid does not consider non-network options to be commercially and technically feasible to assist with meeting the identified need for this RIT-T as non-network options will not mitigate safety and environment risk posed as a result of corrosion-related asset deterioration.

Options assessed under three different scenarios

TransGrid has considered three alternative scenarios – a low net economic benefits scenario, a central scenario, and a high net economic benefits scenario – all involve a number of assumptions that results in the lower bound, the expected, and the upper bound estimates for present value of net economic benefits respectively.

4 As per clause 5.15.2(a) of the NER.

Table E-3 – Summary of scenarios

Variable / Scenario	Central	Low net economic benefits	High net economic benefits
Scenario weighting	*50%*	*25%*	*25%*
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Safety and environment risk costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Discount rate	7.04 per cent	9.48 per cent	4.60 per cent

Implementing Option 2 will meet relevant regulatory obligations

Applying the 'As Low As Reasonably Practicable' ('ALARP') principle to manage and mitigate bushfire and safety risks, TransGrid determines that its obligations under the New South Wales *Electricity Supply (Safety and Network Management) Regulation 2014* and TransGrid's Electricity Network Safety Management System (ENSMS) will be met by implementing Option 2 by 2020/21. Under this principle, risks are mitigated unless it is possible to demonstrate that the costs involved in further reducing the risk would be grossly disproportionate to the benefits gained.

Figure E-2 shows that the costs of either option are less than the benefits from mitigating bushfire and safety risks. It also shows that Option 2 is preferred as it provides higher net economic benefits than Option 1. In accordance with the ALARP principle, disproportionality factors have been applied on the risks shown in this figure to just below the level which the community, government and law would consider risk reduction expenditure to be grossly disproportionate.[5]

Figure E-3 shows that taking into account all sensitivities, the optimal timing for the works is before 2020/21.

[5] The values of the disproportionality factors were determined through a review of practises and legal interpretations across multiple industries, with particular reference to the works of the UK Health and Safety Executive. The methodology used to determine the disproportionality factors in this PSCR is in line with the principles and examples presented in the AER Replacement Planning Guidelines and is consistent with TransGrid's Revised Revenue Proposal 2018/19-2022/23.

Figure E-2 – As Low as Reasonably Practicable Test, present value 2017/18 $m

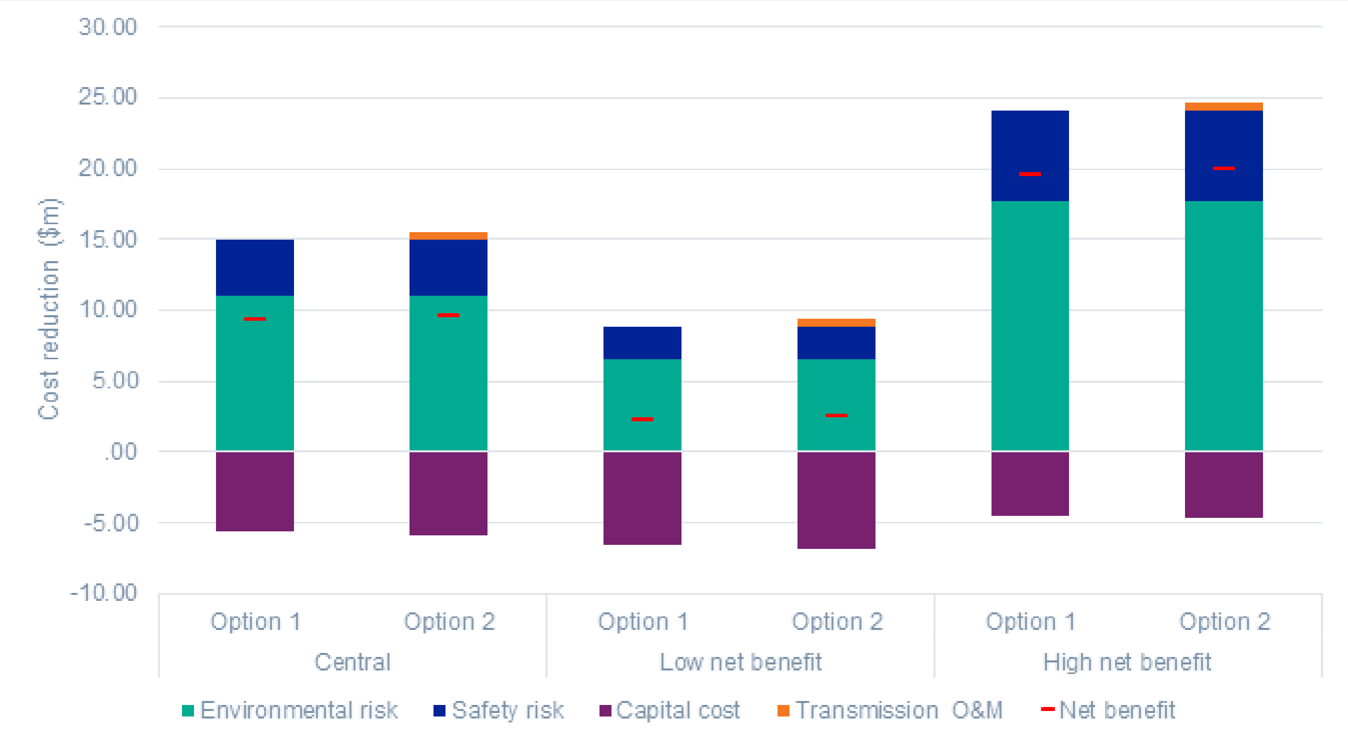
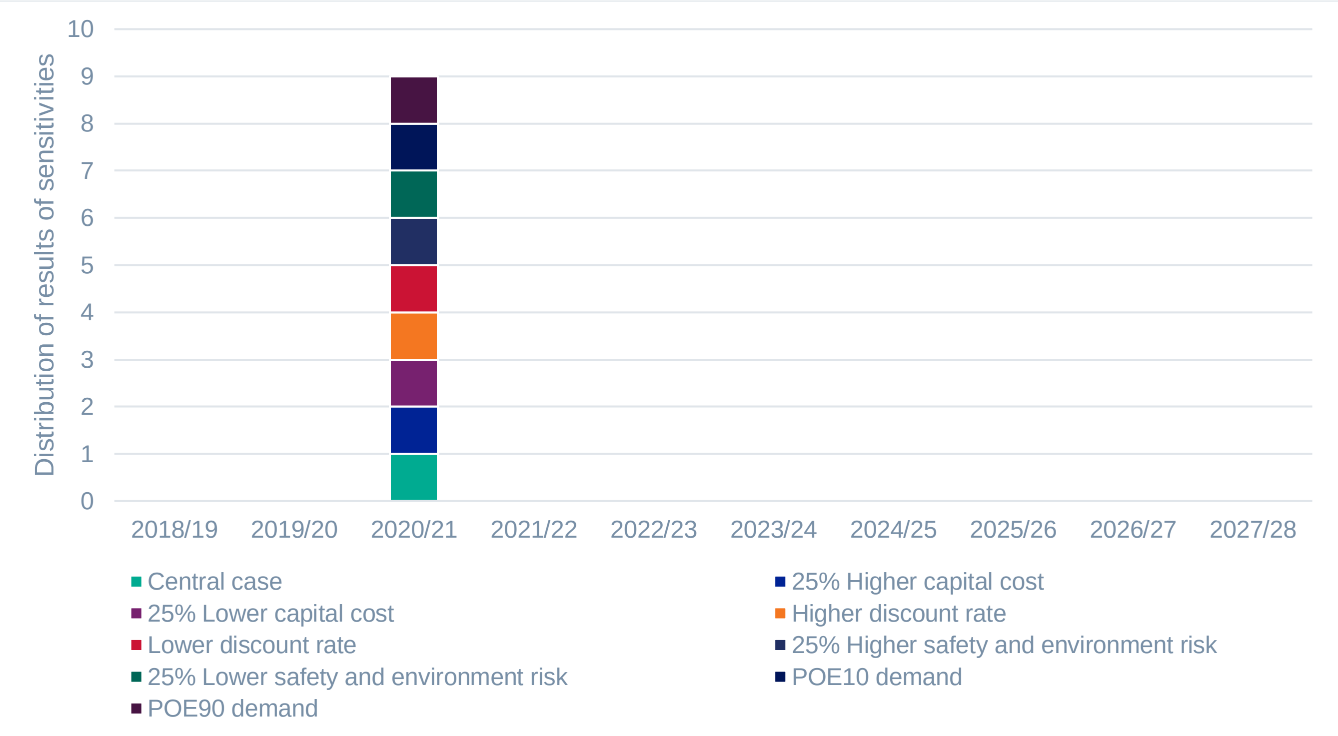


Figure E-3 – Optimal timing of Option 2 to meet safety regulatory obligations



Option 2 reasonably mitigates safety and environmental risks under all sensitivities considered

The figures below illustrate that while the results are most sensitive to the safety and environmental risk costs estimates, it is still reasonable to make investments to mitigate low risk costs estimates.

Figure E-4 – Sensitivities of net present value using the ALARP test

Draft conclusion

Option 2, a scope of works involving refurbishment of the line including OPGW retrofitting, is preferred at this first stage of a formal RIT-T process.

A reasonable reduction in safety and environmental risk costs makes Option 2 preferable over other options at this draft stage. This option passes the ALARP test for mitigating safety and bushfire risks and is consist of works on:

> the substations
> the conductor fittings – suspension, conductor fittings – tension, and conductor vibration damper
> the earth wire fittings – suspension, earth wire fittings – tension, and earth wire replacement
> the replacements of earth straps in line with current standard
> OPGW retrofitting
> site access, and site establishment
> the tower leg earthworks and encasement
> the replacement of tower member and nuts & bolts
> the tower leg painting vs asbestos removal
> the replacement structure ladder
> the insulator fittings install - tension-climbing.

The estimated capital expenditure associated with this option is $7.13 million ± 25%. This option is more expensive than Option 1 by only $200,000 as it employs new technology (OPGW). However, it will also provide additional operating cost savings of $50,000 per year over the life of the asset.

The works will be undertaken between 2018/19 and 2020/21. Planning and procurement (including completion of the RIT-T) will occur between 2018/19 and 2019/20, while project delivery and construction will occur in 2020/21. All works will be completed in accordance with the relevant standards by 2020/21 with minimal modification to the wider transmission assets.

Necessary outages of affected line(s) in service will be planned appropriately in order to complete the works with minimal impact on the network.

Submissions and next steps

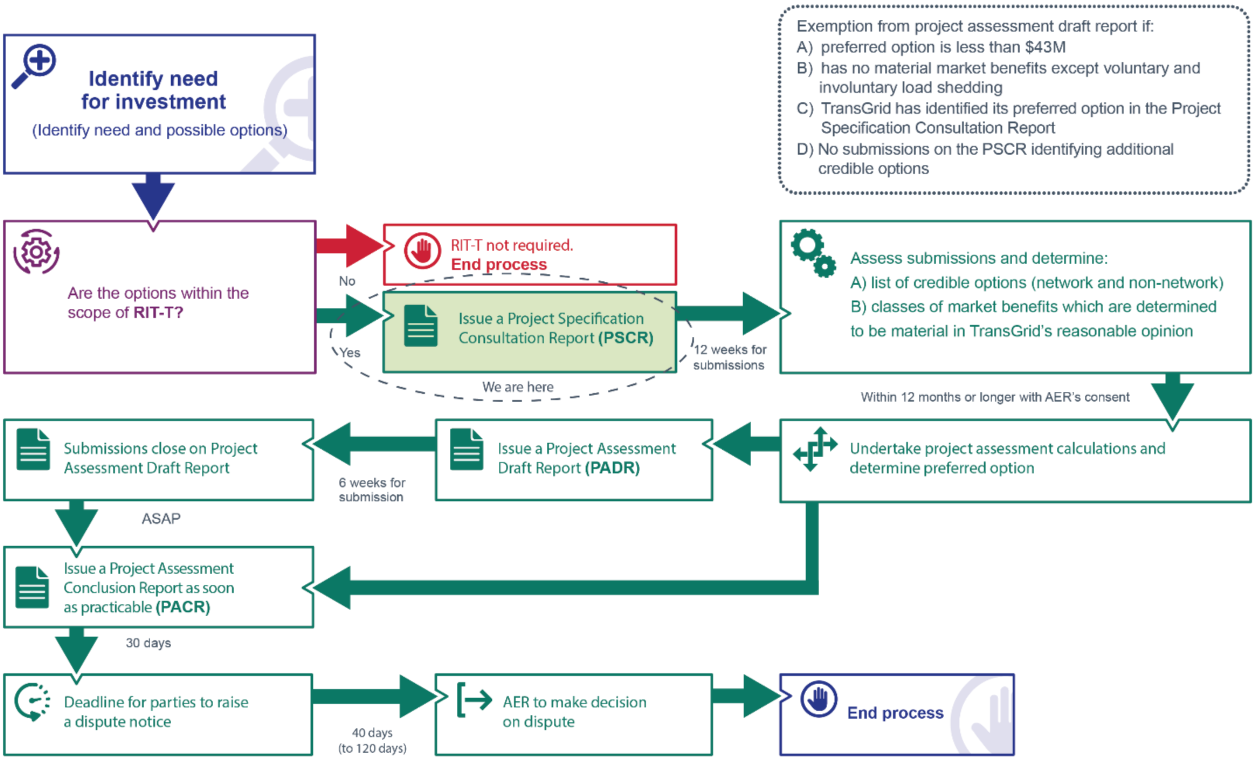
TransGrid welcomes written submissions on material contained in this PSCR. Submissions are due on or before 25 June 2019.

Submissions should be emailed to TransGrid's Prescribed Revenue & Pricing team via RIT-TConsultations@transgrid.com.au.[6] In the subject field, please reference 'Line 959/92Z project.'

Publication of a Project Assessment Draft Report (PADR) is not required for this RIT-T as TransGrid considers its investment in relation to the preferred option to be exempt from that part of the process as per NER clause 5.16.4(z1). Therefore, the next step in this RIT-T, following consideration of submissions received via the 12-week consultation period and any further analysis required, will be publication of a Project Assessment Conclusion Report (PACR). TransGrid anticipates publication of a PACR by 25 July 2019.

In accordance with NER clause 5.16.4(z1)(4), the exemption from producing a PADR will no longer apply if TransGrid considers that an additional credible option that could deliver a material market benefit is identified during the consultation period. Accordingly, if TransGrid considers that any additional credible options are identified, TransGrid will produce a PADR which includes a net present value (NPV) assessment of the net economic benefits of each additional credible option.

Figure E-5 – This PSCR is the first stage of the RIT-T process[7]



[6] TransGrid is bound by the Privacy Act 1988 (Cth). In making submissions in response to this consultation process, TransGrid will collect and hold your personal information such as your name, email address, employer and phone number for the purpose of receiving and following up on your submissions. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement. See section1.2 for more details.

[7] Australian Energy Regulator, *"Final determination on the 2018 cost thresholds review for the regulatory investment tests,"* accessed 15 March 2019. https://www.aer.gov.au/communication/aer-publishes-final-determination-on-the-2018-cost-thresholds-review-for-the-regulatory-investment-tests

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1. Introduction

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for mitigating risks caused by corrosion along Line 959/92Z. Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process.

An assessment of Line 959/92Z performed as part of TransGrid's routine asset monitoring maintenance in 2016 identified condition issues on the line that will impact this part of the network. The condition issues raise several risks including structural failure, conductor drop, safety and environmental risks.

As Line 959/92Z forms part of the network that supplies Sydney, TransGrid considers that this line will continue to play a central role in maintaining reliable supply to the Sydney. TransGrid has, therefore, commenced this RIT-T to examine and consult on options that will enable TransGrid to meet the identified need by 2020/21. As investment is intended to maintain a safe and reliable supply to Northern Sydney, TransGrid considers this to be a 'reliability corrective action'-driven RIT-T.

1.1 Purpose of this report

The purpose of this PSCR is to:

- set out the reasons why TransGrid proposes that action be undertaken (that is, the 'identified need')
- present the options that TransGrid currently considers to address the identified need
- outline the technical characteristics that non-network options would need to provide, whilst outlining how these options are unlikely to be able to contribute to meeting the identified need for this RIT-T
- allow interested parties to make submissions and provide inputs to the RIT-T assessment.

1.2 Submissions and next steps

TransGrid welcomes written submissions on materials contained in this PSCR. Submissions are particularly sought on the credible options presented and from potential proponents of non-network options that could meet the technical requirements set out in this PSCR. Submissions are due on 25 June 2019.

Submissions should be emailed to TransGrid's Prescribed Revenue & Pricing team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'Line 959/92Z project.'

Subject to submissions received on this PSCR, a Project Assessment Conclusions Report (PACR), including full option analysis, is expected to be published by 25 July 2019.

TransGrid is bound by the *Privacy Act 1988 (Cth)*. In making submissions in response to this consultation process, TransGrid will collect and hold your personal information such as your name, email address, employer and phone number for the purpose of receiving and following up on your submissions.

Under the National Electricity Law there are circumstances where TransGrid may be compelled to provide information to the Australian Energy Regulator (AER). TransGrid will advise you should this occur.

At the conclusion of the consultation process, all submissions received will be published on the TransGrid's website. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement.

TransGrid's Privacy Policy sets out the approach to managing your personal information. In particular, it explains how you may seek to access or correct the personal information held about you, how to make a complaint about a breach of our obligations under the Privacy Act, and how TransGrid will deal with complaints. You can access the Privacy Policy here (https://www.transgrid.com.au/Pages/Privacy.aspx).

2. The identified need

2.1 Background

Constructed in 1965, Line 959/92Z, collectively, is a double circuit 132 kV transmission line built on modified single circuit 330 kV steel towers between Sydney North and Sydney East 330 kV substations. The line spans a 23.7 km route supported by 61 structures. The majority of the line passes through national parks and certain sections pass through urban areas in Sydney.

The transmission line was built to supply electricity to the Northern Sydney metropolitan area including North Sydney, Ryde, Macquarie Park, Chatswood, and the suburbs along the Northern Beaches. Line 92Z, which runs on one side of the double circuit transmission line, provides connection to some of Ausgrid's loads through a tee connection at Mt Colah Switching Station. The line plays a critical role in providing back-up transmission supply to areas of Sydney where the POE50[8] summer peak load forecast is about 700 MW – almost as large as the biggest smelter in NSW.

Figure 2-1 depicts the location of Line 959/92Z in TransGrid's network.

Figure 2-1 – TransGrid's Greater Sydney network

A condition assessment performed by TransGrid in January 2016 identified a number of issues with Line 959/92Z. Corrosion-related issues are the biggest factor contributing to deterioration and require rectification

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[8] Probability of Exceedance (POE) demand is a generalised approach to defining the probability of exceedance of electricity demand forecasts. The demand is expressed as the probability the forecast would be met or exceeded, eg a 50% POE demand implies there is a 50% probability of the forecast being met or exceeded. Australian Energy Market Operator, *"Generation and Load,"* accessed 1 February 2019. http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Market-Management-System-MMS/Generation-and-Load

in order for TransGrid to continue to safely and reliably operate the assets. Some of the other issues found were:

- corrosion of tower steel members
- buried concrete foundations
- corroded earth straps
- corroded fasteners
- corroded conductor attachment fittings
- corrosion of earth wire attachment fittings
- corroded earth wires
- conductor dampers.

Figure 2-2 below shows the corroded components supporting Line 959/92Z.

Figure 2-2 – Corroded components of Line 959/92Z

In addition to the issues identified, the modified single circuit 330 kV transmission line structures on Line 959/92Z have deficiencies due to design philosophies used at the time of installation. Although the structures were designed to the standards at that time, investigations following several structure failures during extreme wind events found that the towers were designed to a lower set of criteria than the more recent design philosophies and standards.

2.2 Description of identified need

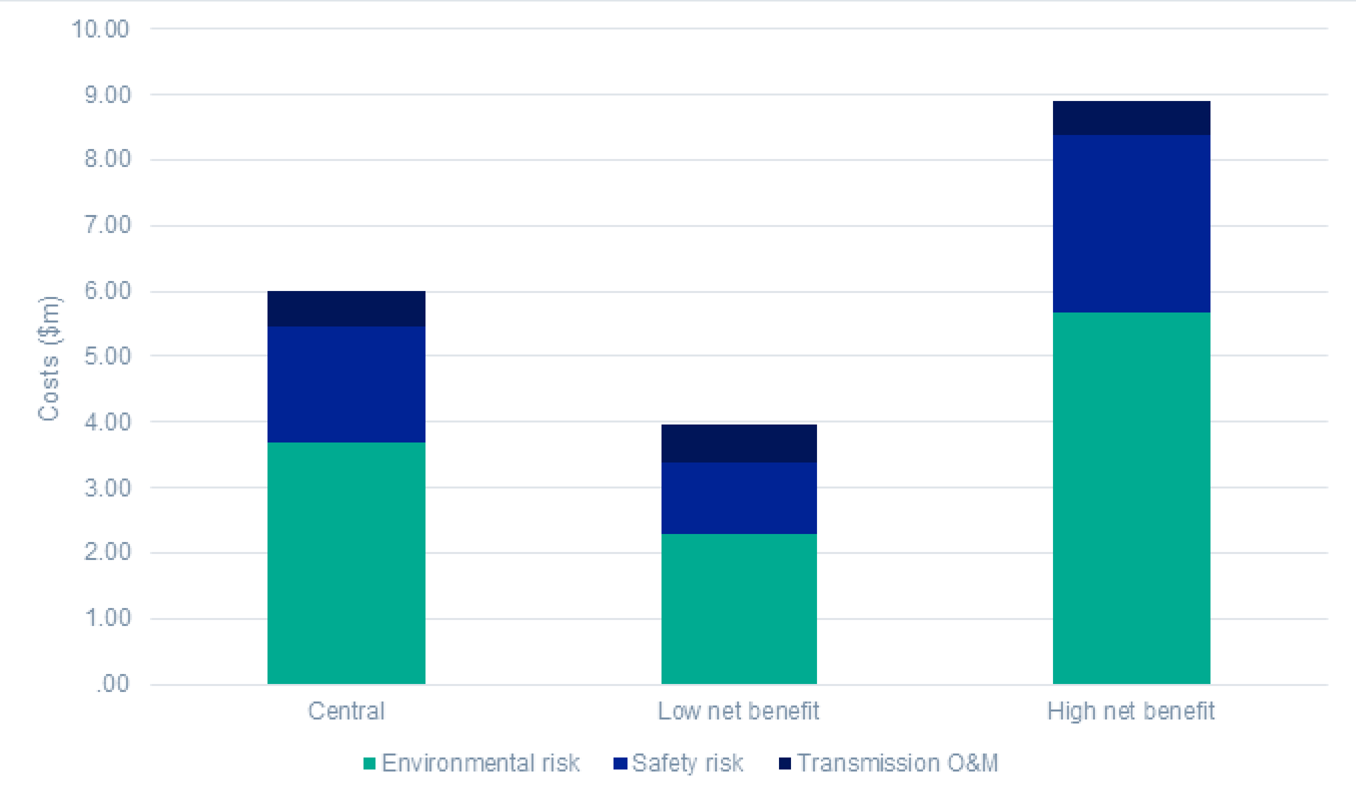
TransGrid calculates that the environmental and safety risks costs are approximately $505,000 per year. This figure will increase as the assets further deteriorate and the structures' failure rates increase.

The corrosion on gantries also presents risk of potential damage to other TransGrid assets which will involve costly corrective maintenance actions.

Figure 2-3 shows that the safety and environment risks in Sydney are the biggest risks from corroded components.

Investments to address the deterioration of the assets along Line 959/92Z due to corrosion are needed to be undertaken to mitigate risks on safety and environment.

Figure 2-3 – Costs forecasts under the base case, present value 2017/18 $m



2.3 Assumptions underpinning the identified need

TransGrid adopts a risk cost framework to quantify and valuate the risks and consequences of increased failure rates. Appendix B provides an overview of the Risk Assessment Methodology adopted by TransGrid.

2.3.1 Deteriorating asset condition

Assessing the condition of the line using TransGrid's Risk Cost Framework revealed that the key asset condition issues, summarised in Table 2-1, suggest accelerated deterioration of the affected assets which will result in increase in line failure rates.

Table 2-1 – Condition issues along Line 959/92Z and their consequences

Issue	Cause	Impact
Corrosion of tower steel members	As the zinc galvanising layer has reached end-of-life, corrosion on the structures, including possible ground line corrosion of tower legs at the footings, is occurring.	Steel corrosion, particularly of critical members, can lead to

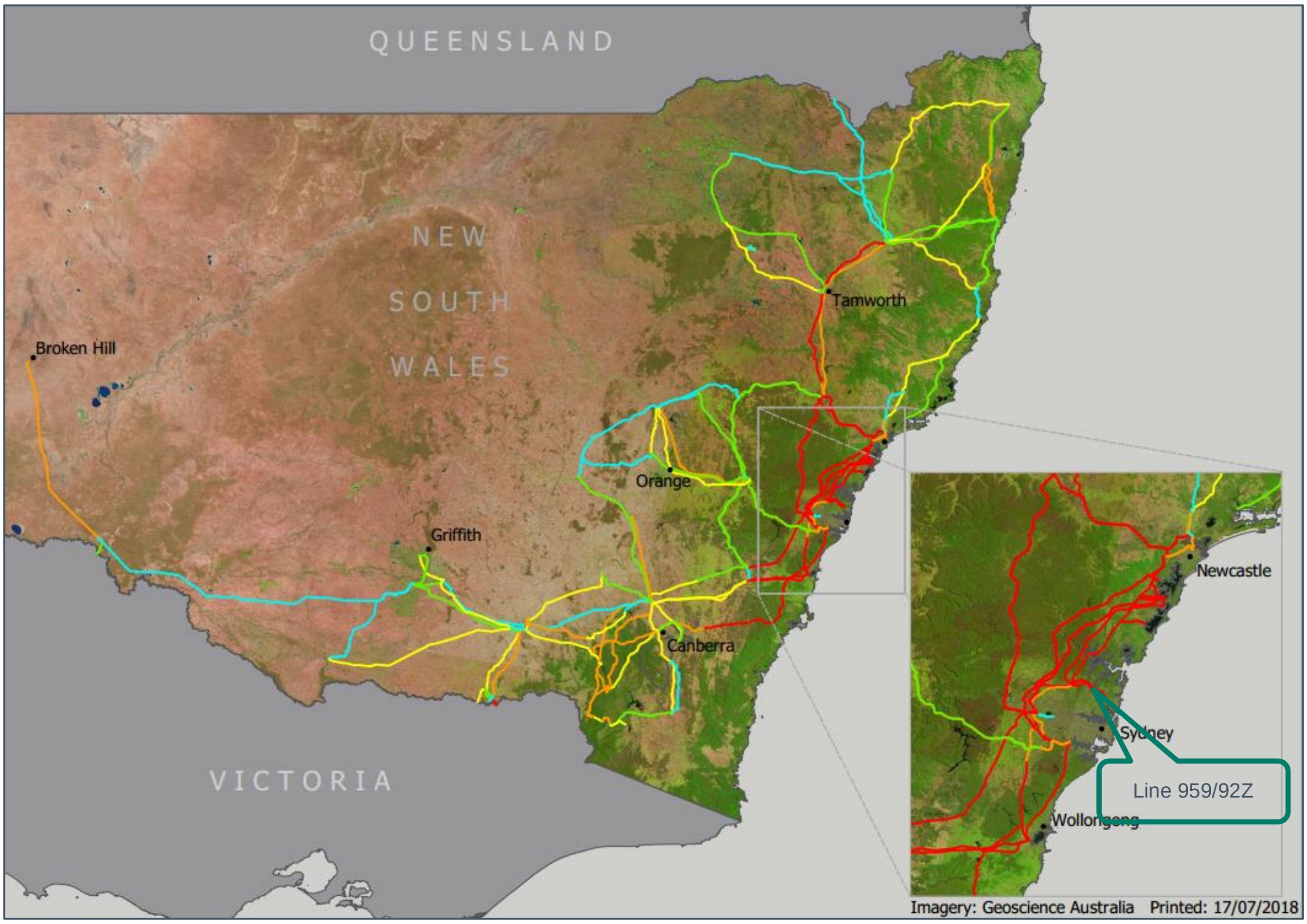
Issue	Cause	Impact
	These critical load bearing members of the tower cannot be easily remediated if the condition passes a stage where rectification works are impossible.	structural failure of tower
Buried concrete foundations	Erosion of soil building up around footings.	Accelerated corrosion of critical member
Corrosion of earth straps	As the towers are situated on predominantly sandstone rock, there is ongoing corrosion of earth straps. The earth straps are typically laid in shallow counterpoise trenches which have eroded away leaving the straps exposed above ground.	Earthing safety hazard
Corroded fasteners	The loss of zinc galvanising layer on the nut thread of the fasteners has led to their poorer condition relative to the main tower steelwork. Nuts & bolts and pins are rusting with some nuts & bolts starting to explode and lose their shape.	Structural failure
Corroded conductor attachment fittings	There is corrosion of fasteners and fittings as the sacrificial zinc galvanising layer has reached end-of-life. These items generally had significantly thinner zinc galvanising layer at the time of manufacturing compared with the steel tower members due to fabrication processes.	Conductor drop
Corrosion of earth wire attachment fittings	Considering the coastal atmospheric conditions and age, there is extensive corrosion of the steel conductor, galvanised zinc (SC/GZ) earth wires. The earth wires have lost zinc galvanising layer and appear red or brown in colour.	Conductor drop
Corroded earth wires	Galvanised zinc end-of-life	Conductor drop
Conductor dampers	Conductor dampers are damaged and weathered. They show various signs of drooping and require replacement to prevent accelerated conductor fatigue.	Accelerated conductor fatigue due to vibration

2.3.2 Safety and environmental risk costs

Figure 2-4 below shows a heat map of transmission line risks. Transmission lines in red have the highest safety and environment risks. This has been developed based on an assessment of risk factors of specific locations.

The figure shows that Line 959/92Z is a high risk line. As Line 959/92Z traverses through bushland and residential area, the environmental and safety risks associated with this line are considered to be amongst the highest in TransGrid's network.

Figure 2-4 –TransGrid's line risks heat map



The safety and environment risk costs from corrosion of steel members of the tower structures are $505,000 per year. This figure will increase over time as the assets continue to deteriorate.

TransGrid's analysis concludes that the costs of mitigating the bushfire and safety risks are less than the benefit of avoiding those risks. Categorised as a reliability corrective action under the RIT-T, the proposed investment will enable TransGrid to continue to manage and operate this part of the network to a safety and risk mitigation level of ALARP.

A reliability corrective action differs from a 'market benefits'-driven RIT-T in that the preferred option is permitted to have negative net economic benefits on account of it being required to meet an externally imposed obligation on the network business.

2.3.2.1 Safety management principles ('ALARP')

TransGrid manages and mitigates bushfire and safety risks to ensure they are below tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with TransGrid's obligations under the New South Wales *Electricity Supply (Safety and Network Management) Regulation 2014* and TransGrid's Electricity Network Safety Management System (ENSMS).[9] In particular, risks are mitigated unless it is possible to

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[9] TransGrid ENSMS follows the International Organization for Standardization's ISO31000 risk management framework which requires following hierarchy of hazard mitigation approach.

demonstrate that the costs involved in further reducing the risks would be grossly disproportionate to the benefits gained.

In the context of investment decisions, ALARP is tested through the use of disproportionality factors which increase the risk costs to just below the level which the community, government and law would consider risk reduction expenditures to be grossly disproportionate.[10]

[10] The values of the disproportionality factors were determined through a review of practises and legal interpretations across multiple industries, with particular reference to the works of the UK Health and Safety Executive. The methodology used to determine the disproportionality factors in this PSCR is in line with the principles and examples presented in the AER Replacement Planning Guidelines and is consistent with TransGrid's Revised Revenue Proposal 2018/19-2022/23.

3. Options that meet the identified need

TransGrid considers credible network options that would meet the identified need from a technical, commercial, and project delivery perspective.[11]

Each option involves refurbishment of the line using different techniques. All works under all options will be completed in accordance with the relevant standards and components shall be replaced to have minimal modification to the wider transmission assets.

In identifying credible options, TransGrid has taken the following factors into account: energy source; technology; ownership; the extent to which the option enables intra-regional or intra-regional trading of electricity; whether it is a network option or a non-network option; whether the credible option is intended to be regulated; whether the credible option has proponent; and any other factor which TransGrid reasonably considered should be taken into account.[12]

3.1 Base case

The costs and benefits of each option in this PSCR are compared against those of a base case. Under this base case, no proactive capital investment is made to remediate the deterioration of Line 959/92Z, and the line will continue to operate and be maintained under the current regime.

The regular maintenance regime will not be able to mitigate the risk of tower collapse which will expose TransGrid and end-customers to approximately $505,000 per year in safety and environmental risk costs.[13]

Table 3-1 summarised the risk costs components under this option.

Table 3-1 – Annual risk costs ($ million) under the base case

Risk category	Annual risk costs ($m per year)
People (Safety)	0.164
Environment	0.341

The large environmental and safety risk costs are mainly due to the significant consequences of a bushfire event resulting from conductor drop and risks associated with compromised earthing. Under the base case, all of these risks will continue to increase.

11 As per clause 5.15.2(a) of the NER.

12 As per clause 5.15.2(b) of the NER.

13 This determination of yearly risk costs is based on TransGrid's Network Asset Risk Assessment Methodology and incorporates variables such as likelihood of failure/exposure, various types of consequence costs and corresponding likelihood of occurrence.

3.2 Option 1 – Line refurbishment

Option 1 involves the refurbishment of Line 959/92Z to prevent further corrosion to tower steelwork. Details of the scope of works under this Option 1 are summarised in Table 3-2.

Table 3-2 – Option 1 scope of works

Issue	Remediation
Buried concrete foundations	On two towers, the following will be implemented: > dig out tower legs > abrasive blast cleaning of steelwork to remove any corrosion product > application of Zinga paint > establish drainage channel where feasible or concrete encase legs to prevent future corrosion. For one tower, in addition to the works mentioned above, concrete scabbling and installation of double plate will also be implemented.
Corrosion of earth straps	Replacement of earth straps in line with current standard.
Corrosion of tower steel members	Replacement of tower members, nuts & bolts and structure ladders; works on tower leg earthworks and encasements; and tower leg painting vs asbestos removal; insulator fittings install - tension-climbing
Corrosion of conductor attachment fittings	Replacement of conductor fittings – suspension, conductor fittings – tension
Corrosion of earth wire attachment fittings	Replacement of earth wire fittings.
Corrosion of earth wires	Replacement of earth wires, earth wire fittings – suspension, and earth wire fittings – tension
Damaged conductor vibration dampers	Replacement of conductor vibration dampers
Site works	Site establishment and access

The works will be undertaken between 2018/19 and 2020/21. Planning and procurement (including completion of the RIT-T) will occur between 2018/19 and 2019/20, while project delivery and construction will occur in 2020/21. All works will be completed by 2020/21 with minimal modification to the wider transmission assets and in accordance with the relevant standards.

Necessary outages of affected line(s) in service will be planned appropriately in order to complete the works with minimal impact on the network.

The estimated capital expenditure associated with this option is $6.93 million ± 25%. The routine operating and maintenance costs are the same as in the base case.

Following the refurbishment under this option, the risk costs associated with the remediated line are shown in Table 3-3.

Table 3-3 – Annual risk costs ($ million) under Option 1

Risk category	Annual risk costs ($m per year)
People (Safety)	0.002
Environment	0.117

The biggest risk reduction comes from environment and safety categories due to reduction in the likelihood of conductor drop and faulty earthing risks.

3.3 Option 2 – Line refurbishment with OPGW retro-fitting

Option 2 involves the refurbishment of Line 959/92Z to prevent further corrosion to tower steelwork. This option includes replacement of one earth wire between Sydney North and Sydney East with OPGW Type A which will improve the communication assets for this section.

Details of the scope of works under this option are summarised in Table 3-4.

Table 3-4 – Option 2 scope of works

Issue	Remediation
Buried concrete foundations	On two towers, the following will be implemented: > dig out tower legs > abrasive blast cleaning of steelwork to remove any corrosion product > application of Zinga paint > establish drainage channel where feasible or concrete encase legs to prevent future corrosion. For one tower, in addition to the works mentioned above, concrete scabbling and installation of double plate will also be implemented.
Corrosion of earth straps	Replacement of earth straps in line with current standard.
Corrosion of tower steel members	Replacement of tower member, nuts & bolts and structure ladder; works on tower leg earthworks and encasement; and tower leg painting vs asbestos removal; insulator fittings install - tension-climbing
Corrosion of conductor attachment fittings	Replacement of conductor fittings – suspension, conductor fittings – tension
Corrosion of earth wire attachment fittings	Replacement of earth wire fittings
Corrosion of earth wires	Replacement of earth wires, earth wire fittings – suspension, and earth wire fittings – tension
Damaged conductor vibration dampers	Replacement of conductor vibration dampers

Issue	Remediation
Sydney North Substation works	This includes: > termination of OPGW into non-metallic conductor at substation gantry > non-metallic conductor run to cable trench system in buried conduit > run in conduit to the communications room to be terminated onto new optical distribution frame.
Sydney East Substation works	This includes: > termination of OPGW into non-metallic conductor at substation gantry > non-metallic conductor run to cable trench system in buried conduit > run in conduit to the communications room to be terminated onto new optical distribution frame.
Site works	Site establishment and access

The works will be undertaken between 2018/19 and 2020/21. Planning and procurement (including completion of the RIT-T) will occur between 2018/19 and 2019/20, while project delivery and construction will occur in 2020/21. All works will be completed by 2020/21 with minimal modification to the wider transmission assets and in accordance with the relevant standards.

Necessary outages of affected line(s) in service will be planned appropriately in order to complete the works with minimal impact on the network.

The estimated capital expenditure associated with this option is $7.13 million ± 25%. This option is more expensive than Option 1 by only $200,000 as it employs new technology (OPGW). However, it will also provide additional benefits from reduced maintenance and licensing costs of $30,000 per year and an additional efficiency savings specific to the Sydney East site of $20,000 per year.

Following the refurbishment under this option, the risk costs associated with the remediated line are shown in Table 3-5.

Table 3-5 – Annual risk costs ($ million) under Option 2

Risk category	Annual risk costs ($m per year)
People (Safety)	0.002
Environment	0.117

The biggest risk reduction comes from environment and safety categories due to reduction in the likelihood of conductor drop and faulty earthing risks.

3.4 Options considered but not progressed

Table 3-6 summarises the reasons the following credible options were not progressed further.

Table 3-6 – Options considered but not progressed

Option	Description	Reason(s) for not progressing
Option 3	New transmission lines from Sydney North to Sydney East	Due to significant costs of option (> than $75 million), a new set of 132 kV transmission lines from Sydney North to Sydney East is not commercially feasible.

3.5 No expected material inter-network impact

TransGrid has considered whether the credible options listed above is expected to have material inter-regional impact.[14] A 'material inter-network impact' is defined in the NER as:

> *"A material impact on another Transmission Network Service Provider's network, which may include (without limitation): (a) the imposition of power transfer constraints within another Transmission Network Service Provider's network; or (b) an adverse impact on the quality of supply in another Transmission Network Service Provider's network."*

AEMO's suggested screening test to indicate that a transmission augmentation has no material inter-network impact is that it satisfies the following:[15]

- a decrease in power transfer capability between transmission networks or in another TNSP's network of no more than the minimum of 3% of the maximum transfer capability and 50 MW
- an increase in power transfer capability between transmission networks or in another TNSP's network of no more than the minimum of 3% of the maximum transfer capability and 50 MW
- an increase in fault level by less than 10 MVA at any substation in another TNSP's network
- the investment does not involve either a series capacitor or modification in the vicinity of an existing series capacitor.

TransGrid notes that each credible option satisfies these conditions as it does not modify any aspect of electrical or transmission assets. By reference to AEMO's screening criteria, there is no material inter-network impacts associated with any of the credible options considered.

[14] As per clause 5.16.4(b)(6)(ii) of the NER.

[15] Inter-Regional Planning Committee. *"Final Determination: Criteria for Assessing Material Inter-Network Impact of Transmission Augmentations."* Melbourne: Australian Energy Market Operator, 2004. Appendix 2 and 3. Accessed 15 March 2019. https://www.aemo.com.au/-/media/Files/PDF/170-0035-pdf.pdf

4. Non-network options

TransGrid does not consider non-network options to be commercially and technically feasible to assist with meeting the identified need for this RIT-T as non-network options will not mitigate safety and environment risks posed as a result of corrosion-related asset deterioration.

Additionally, the maximum deferment benefits for Option 2 is relatively low (approximately $380,000 per year) compared to the safety and risk costs – $505,000 per year. For non-network options to assist, they would need to provide greater net economic benefits than the network option.

5. Materiality of market benefits

5.1 Wholesale electricity market benefits are not material

The AER has recognised that if the credible options considered will not have an impact on the wholesale electricity market, then a number of classes of market benefits will not be material in the RIT-T assessment, and so do not need to be estimated.[16]

TransGrid determines that the credible options considered in this RIT-T will not have an impact on the wholesale electricity market, therefore considers that the following classes of market benefits are not material for this RIT-T assessment:

- changes in fuel consumption arising through different patterns of generation dispatch
- changes in voluntary load curtailment (since there is no impact on pool price)
- changes in costs for parties other than the RIT-T proponent
- changes in ancillary services costs
- changes in network losses
- competition benefits
- Renewable Energy Target (RET) penalties.

5.2 No other categories of market benefits are material

In addition to the classes of market benefits listed above, NER clause 5.16.1(c)(4) requires TransGrid to consider the following classes of market benefits, listed in Table 5-1, arising from each credible option.

The same table sets out the reason TransGrid considers these classes of market benefits to be immaterial.

Table 5-1 – Reasons non-wholesale electricity market benefits are considered immaterial

Market benefits	Reason
Changes in involuntary load curtailment	Since Line 959/92Z forms part of a meshed network (N-1 and N-2 redundant) required to supply Sydney, a failure due to the corroded assets results in extremely low chance of unserved energy.
Differences in the timing of expenditure	Options considered will provide an alternative to meeting reliability requirements but are unlikely to affect decisions to undertake unrelated expenditure in the network. Consequently, material market benefits will neither be gained nor lost due to changes in the timing of expenditure from any of the options considered.
Option value	TransGrid notes the AER's view that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available is likely to change in the future, and the credible options considered by the TNSP are sufficiently flexible to respond to that change.[17] TransGrid also notes the AER's view that appropriate identification of credible options and reasonable scenarios captures any option value, thereby meeting the

16 Australian Energy Market Operator. *"Power System Security Guidelines, 31 December 2018."* Melbourne: Australian Energy Market Operator, 2018. Accessed 20 March 2019. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3715---Power-System-Security-Guidelines.pdf

17 Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018. Accessed 15 March 2019. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

Market benefits	Reason
	NER requirement to consider option value as a class of market benefit under the RIT-T. TransGrid notes that no credible option is sufficiently flexible to respond to change or uncertainty. Additionally, a significant modelling assessment would be required to estimate the option value benefits but it would be disproportionate to potential additional benefits for this RIT-T. Therefore, TransGrid has not estimated additional option value benefit.

6. Overview of the assessment approach

6.1 General overview

As outlined in section 3.1, all costs and benefits considered have been measured against a base case where the existing corrosion along Line 959/92Z are assumed to not be remediated.

The analysis presented in this RIT-T considered a 20-year period, from 2018/19 to 2038/39. TransGrid considers that a 20-year period takes into account the size, complexity and expected lives of the options and provide a reasonable indication of the costs and benefits over a long outlook period. Since the capital components have asset lives greater than 20 years, TransGrid has taken a terminal value approach to ensure that the capital costs of long-lived assets are appropriately captured in the 20-year assessment period.

TransGrid has adopted a central real, pre-tax 'commercial'[18] discount rate of 7.04% as the central assumption for the NPV analysis presented in this report. TransGrid considers that this is a reasonable contemporary approximation of a commercial discount rate, consistent with the RIT-T.

TransGrid has also tested the sensitivity of the results to discount rate assumptions. A lower bound real, pre-tax discount rate of 4.60% equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this PSCR,[19] and an upper bound discount rate of 9.48% (a symmetrical adjustment upwards) are investigated.

6.2 Approach to estimating project costs

TransGrid has estimated the capital costs of the options by using scope from similar works. TransGrid considers the central capital costs estimates to be within ± 25% of the actual costs.

Routine operating and maintenance costs are based on similar to works of similar nature.

Reactive maintenance costs under the base case considers the:

> level of corrective maintenance required to restore assets to working order following a failure
> probability and expected level of network asset faults.

In either credible option, the asset failures are less frequent and restoration costs are reduced.

6.3 Three different scenarios have been modelled to address uncertainty

RIT-T assessments are based on cost-benefit analysis that includes assessment under reasonable scenarios which are designed to test alternate sets of key assumptions and their impact on the ranking and feasibility of options.

TransGrid has considered three alternative scenarios, summarised in Table 6-1, to address uncertainty – namely:

> a 'low net economic benefits' scenario, involving a number of assumptions that gives a lower bound and conservative estimates of net present value of net economic benefits
> a 'central' scenario which consists of assumptions that reflect TransGrid's central set of variable estimates that provides the most likely scenario

[18] The use of a 'commercial' discount rate is consistent with the RIT-T and is distinct from the regulated cost of capital (or 'WACC') that applies to network businesses like TransGrid.

[19] See TransGrid's Post-tax Revenue Model (PTRM) for the 2018-23 period, available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/transgrid-determination-2018-23

> a ‘high net economic benefits’ scenario that reflects a set of assumptions which have been selected to investigate an upper bound of net economic benefits.

Table 6-1 – Summary of scenarios

Variable / Scenario	Central	Low net economic benefits	High net economic benefits
Scenario weighting	*50%*	*25%*	*25%*
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Safety and environment risk costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Discount rate	7.04 per cent	9.48 per cent	4.60 per cent

TransGrid considers that the central scenario is most likely since it is based primarily on a set of expected assumptions. TransGrid has therefore assigned this scenario a weighting of 50%, with the other two scenarios being weighted equally with 25% each.

7. Assessment of credible options

7.1 Estimated gross economic benefits

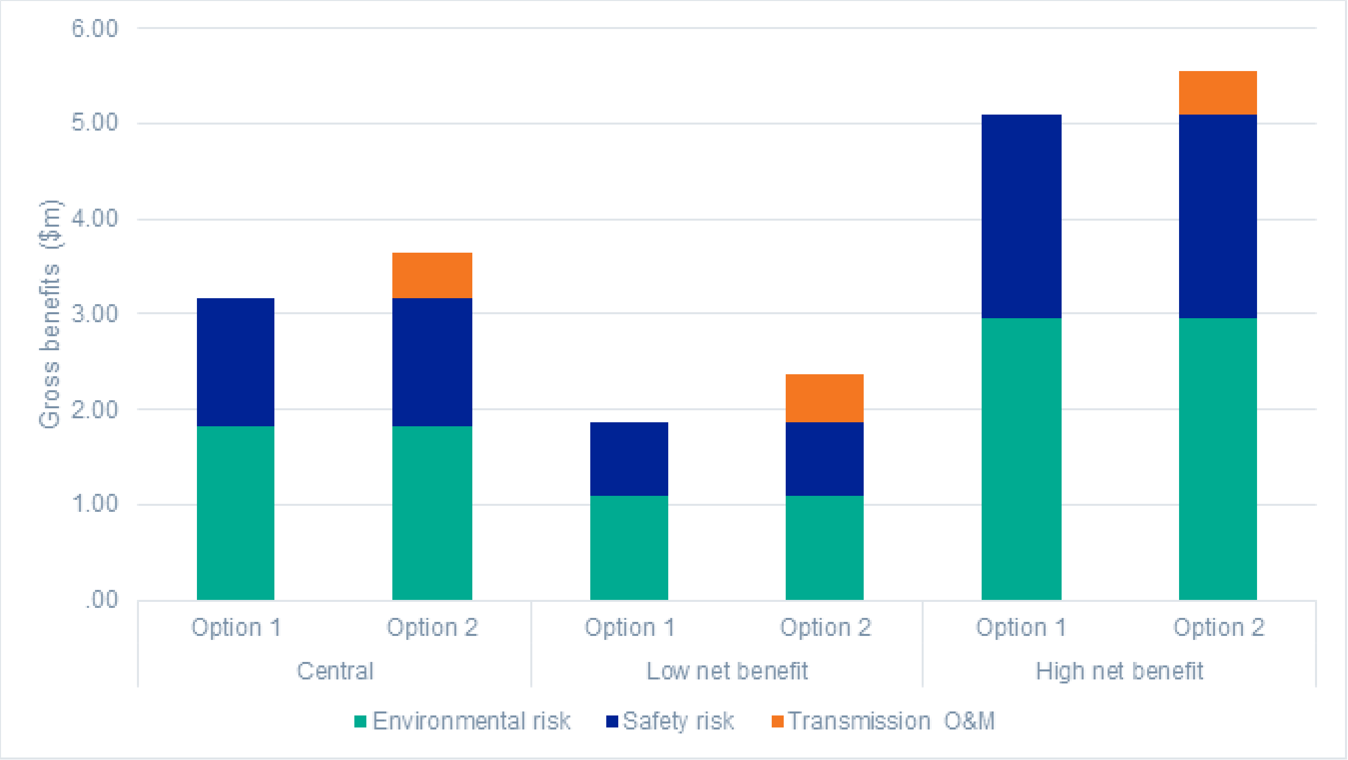
Table 7-1 below summarises the present values of gross economic benefits estimated for each credible option under the three scenarios.

Table 7-1 – Gross economic benefits from credible options relative to the base case, present value 2017/18 $m

Option/scenario	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	3.1	1.8	5.0	3.3
Option 2	3.6	2.3	5.5	3.8

Figure 7-1 provides a breakdown of estimated benefits for each credible option.

Figure 7-1 – Components of gross economic benefits, present value 2017/18 $m



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7.2 Estimated costs

Table 7-2 summarises the present value of costs of the credible options under the three scenarios relative to the base case.

Table 7-2 – Costs of credible options relative to the base case, present value 2017/18 $m

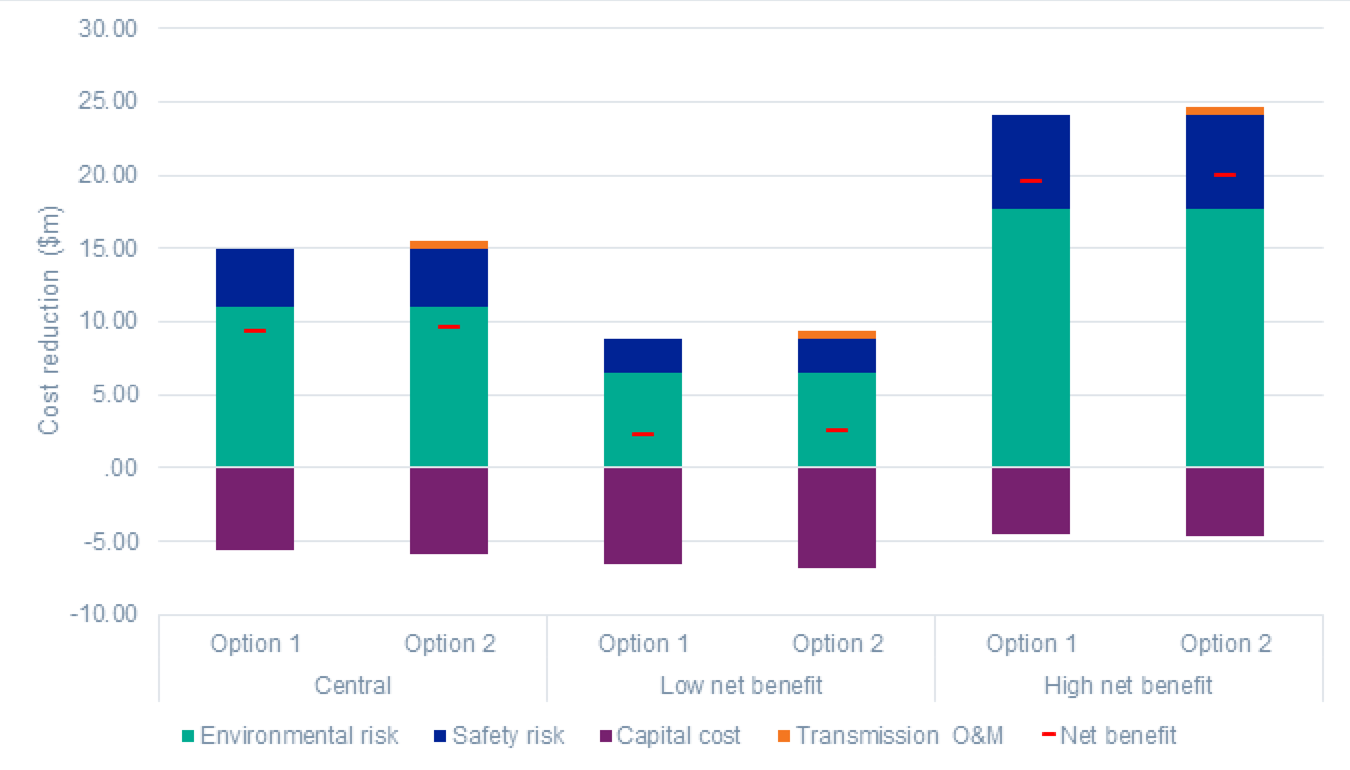
Option/Scenario	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	5.6	6.6	4.5	5.6
Option 2	5.8	6.8	4.6	5.8

7.3 Meeting relevant regulatory obligations

TransGrid determines that its obligations under the New South Wales *Electricity Supply (Safety and Network Management) Regulation 2014* and TransGrid's Electricity Network Safety Management System (ENSMS) will be met by implementing Option 2 as by applying the ALARP principle, the safety and environmental risks will be mitigated reasonably.[20]

Figure 7-2 shows that the costs of either option are less than the benefits of mitigating the bushfire and safety risks. Figure 7-3 shows that the most economical option, Option 2, has to be implemented by 2020/21 to maintain compliance with safety and environmental risk obligations.

Figure 7-2 – As Low as Reasonably Practicable Test, present value 2017/18 $m



20 In accordance with the framework for applying the ALARP principle, a disproportionality factor has been applied to risk cost figures.

7.4 Estimated net economic benefits

Table 7-3 summarises the present value of the net economic benefits for each credible option across the three scenarios and the weighted net economic benefits. These net economic benefits are the differences between the estimated gross economic benefits less the estimated costs.

While the net economic benefits are only positive under the high net economic benefits scenario, Option 2 is still the cheapest options to maintain compliance with TransGrid's safety obligations. TransGrid also notes that the low economic scenario is comprised of extreme combination of low safety and environmental risks estimates and high capital costs.

Though the net economic benefits are negative, the investments are still justified as they are intended to mitigate safety and environmental risks using the ALARP principle.

Table 7-3 – Net economic benefits for each credible option relative to the base case, present value 2017/18 $m

Option	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	-2.5	-4.7	0.5	-2.3
Option 2	-2.1	-4.4	0.8	-1.9

7.5 Sensitivity testing

TransGrid has undertaken thorough sensitivity testing exercise to understand the robustness of the conclusion to underlying assumptions about key variables. These are implemented in stages.

> Step 1 – tests the sensitivity of the optimal timing of the project ('trigger year') to different assumptions on key variables

> Step 2 – once a trigger year is determined, tests the sensitivity of the ALARP test to different assumptions on key variables such as lower or higher bushfire risks.

7.5.1 Step 1 – Sensitivity of optimal timing

The optimal timing for each option is the year in which the safety and environmental risk costs are reasonably mitigated. Shown on Figure 7-3, the optimal timing is 2020/21 and is found to be invariant between the central set of assumptions and a range of alternative assumptions for the following key variables:

> 25% increase/decrease in the assumed network capital costs

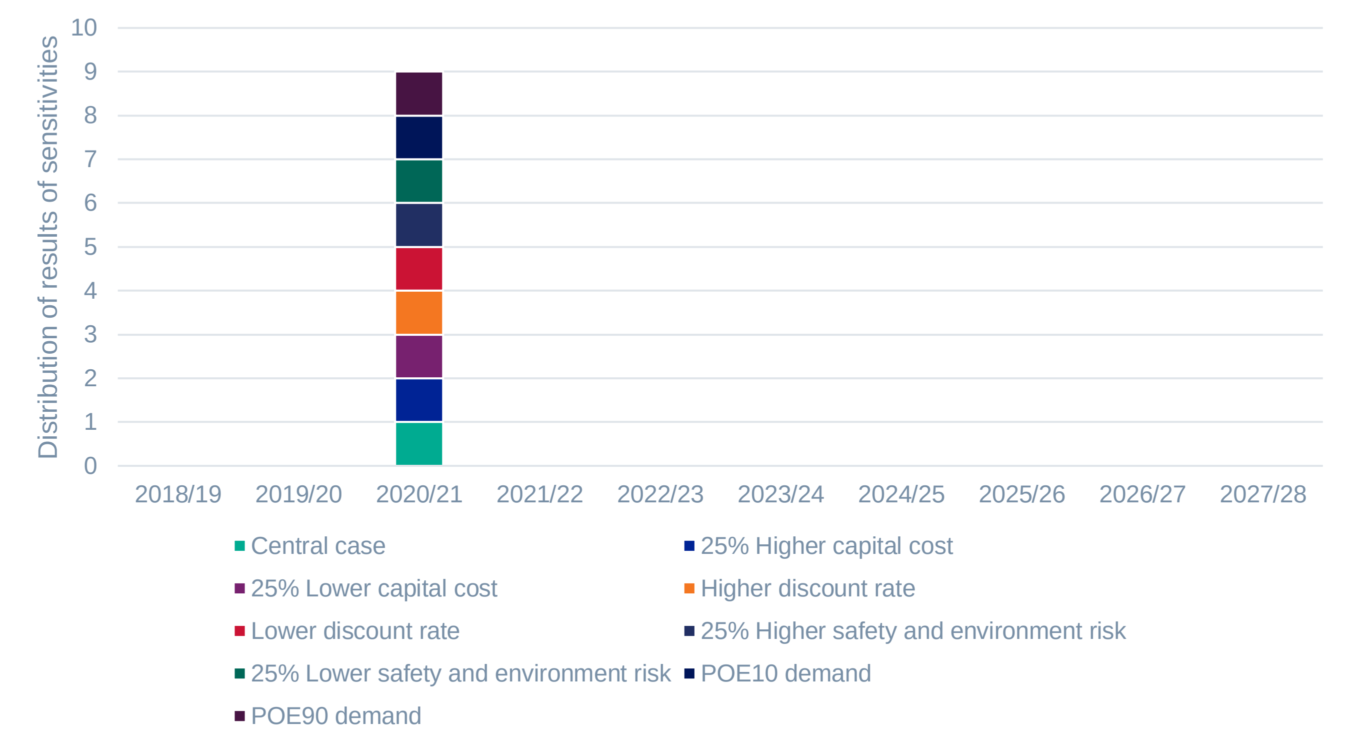
> higher and lower discount rates (9.48% and 4.60%)

> higher and lower assumed safety and environmental risks

> higher and lower demand forecasts (POE10 and POE90).

The figure below illustrates that taking into account all sensitivities, the optimal timing for the works is before 2020/21.

Figure 7-3 – Optimal timing of Option 2 to meet safety regulatory obligations



7.5.2 Step 2 – Sensitivity of the ALARP test

TransGrid has also conducted sensitivity analysis assuming the optimal timing and same sensitivities established in Step 1.

The figures below illustrate that while the results are most sensitive to the safety and environmental risk costs estimates, it is still reasonable to make investments to mitigate low risk costs estimates.

Figure 7-4 – Sensitivities of net present value using the ALARP test

8. Draft conclusion and exemption from preparing a PADR

A reasonable reduction in safety and environmental risk costs makes Option 2 preferable over other options at this draft stage. This option passes the ALARP test for mitigating safety and bushfire risks and is consist of works on:

> the substations
> the conductor fittings – suspension, conductor fittings – tension, and conductor vibration damper
> the earth wire fittings – suspension, earth wire fittings – tension, and earth wire replacement
> the replacements of earth straps in line with current standard
> OPGW retrofitting
> site access, and site establishment
> the tower leg earthworks and encasement
> the replacement of tower member and nuts & bolts
> the tower leg painting vs asbestos removal
> the replacement structure ladder
> the insulator fittings install - tension-climbing.

Furthermore, Option 2 provides additional benefits from reduction in operating, maintenance, and licensing costs.

The estimated capital costs of Option 2 is $7.13 million. Routine and operating maintenance costs will be approximately less than 1% of the estimated capital costs.

The works will be undertaken between 2018/19 and 2020/21. Planning and procurement (including completion of the RIT-T) will occur between 2018/19 and 2019/20, while project delivery and construction will occur in 2020/21. All works will be completed by 2020/21 with minimal modification to the wider transmission assets and in accordance with the relevant standards.

Publication of a Project Assessment Draft Report (PADR) is not required for this RIT-T as TransGrid considers its investment in relation to the preferred option to be exempt from that part of the process as per NER clause 5.16.4(z1). Therefore, the next step in this RIT-T, following consideration of submissions received during the 12-week consultation period and any further analysis required, will be publication of a Project Assessment Conclusions Report (PACR). TransGrid anticipates publication of a PACR by 25 July 2019.

TransGrid welcomes written submissions on material contained in this PSCR. Submissions are due on or before 25 June 2019. Submissions should be emailed to TransGrid's Prescribed Revenue & Pricing team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'Line 959/92Z project.'

NER clause 5.16.4(z1) provides for a TNSP to be exempt from producing a PADR for a particular RIT-T application, in the following circumstances:

(a) if the estimated capital cost of the preferred option is less than $43 million;
(b) if the TNSP identifies in its PSCR its proposed preferred option, together with its reasons for the preferred option and notes that the proposed investment has the benefit of the clause 5.16.4(z1) exemption; and
(c) if the TNSP considers that the proposed preferred option and any other credible options in respect of the identified need will not have a material market benefit for the classes of market benefits specified in clause 5.16.1(c)(4), with the exception of market benefits arising from changes in voluntary and involuntary load shedding.

TransGrid considers that the preferred option is exempt from producing a PADR under NER clause 5.16.4(z1).

In accordance with NER clause 5.16.4(z1)(4), the exemption from producing a PADR will no longer apply if TransGrid considers that an additional credible option that could deliver a material market benefit is identified during the consultation period.

Accordingly, if TransGrid considers that any additional credible options are identified, TransGrid will produce a PADR which includes an NPV assessment of the net economic benefits of each additional credible option.

Should TransGrid consider that no additional credible options were identified during the consultation period, TransGrid intends to produce a PACR that addresses all submissions received including any issues in relation to the proposed preferred option raised during the consultation period.[21]

21 As per clause 5.16.4(z2) of the NER.

Appendix A – Compliance checklist

This appendix sets out a compliance checklist which demonstrates the compliance of this PSCR with the requirements of clause 5.16.4(b) of the Rules version 111.

Rules clause	Summary of requirements	Relevant section(s) in PSCR
5.16.4 (b)	A RIT-T proponent must prepare a report (the project specification consultation report), which must include:	–
	(1) a description of the identified need;	2
	(2) the assumptions used in identifying the identified need (including, in the case of proposed reliability corrective action, why the RIT-T proponent considers reliability corrective action is necessary);	NA
	(3) the technical characteristics of the identified need that a non- network option would be required to deliver, such as: (i) the size of load reduction of additional supply; (ii) location; and (iii) operating profile;	4
	(4) if applicable, reference to any discussion on the description of the identified need or the credible options in respect of that identified need in the most recent National Transmission Network Development Plan;	NA
	(5) a description of all credible options of which the RIT-T proponent is aware that address the identified need, which may include, without limitation, alterative transmission options, interconnectors, generation, demand side management, market network services or other network options;	3
	(6) for each credible option identified in accordance with subparagraph (5), information about: (i) the technical characteristics of the credible option; (ii) whether the credible option is reasonably likely to have a material inter-network impact; (iii) the classes of market benefits that the RIT-T proponent considers are likely not to be material in accordance with clause 5.16.1(c)(6), together with reasons of why the RIT-T proponent considers that these classes of market benefits are not likely to be material; (iv) the estimated construction timetable and commissioning date; and (v) to the extent practicable, the total indicative capital and operating and maintenance costs.	3 & 5

Rules clause	Summary of requirements	Relevant section(s) in PSCR
5.16.4(z1)	A RIT-T proponent is exempt from paragraphs (j) to (s) if: 1. the estimated capital cost of the proposed preferred option is less than $35 million (as varied in accordance with a cost threshold determination); 2. the relevant Network Service Provider has identified in its project specification consultation report: (i) its proposed preferred option; (ii) its reasons for the proposed preferred option; and (iii) that its RIT-T project has the benefit of this exemption; 3. the RIT-T proponent considers, in accordance with clause 5.16.1(c)(6), that the proposed preferred option and any other credible option in respect of the identified need will not have a material market benefit for the classes of market benefits specified in clause 5.16.1(c)(4) except those classes specified in clauses 5.16.1(c)(4)(ii) and (iii), and has stated this in its project specification consultation report; and 4. the RIT-T proponent forms the view that no submissions were received on the project specification consultation report which identified additional credible options that could deliver a material market benefit.	8

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Appendix B – Risk cost framework

This appendix summarises the key assumptions and data from the risk assessment methodology that underpin the identified need for this RIT-T and the assessment undertaken for the Revenue Proposal.[22]

As part of preparing its Revenue Proposal for the current regulatory control period, TransGrid developed the Network Asset Risk Assessment Methodology to quantify risk for replacement and refurbishment projects. The risk assessment methodology:

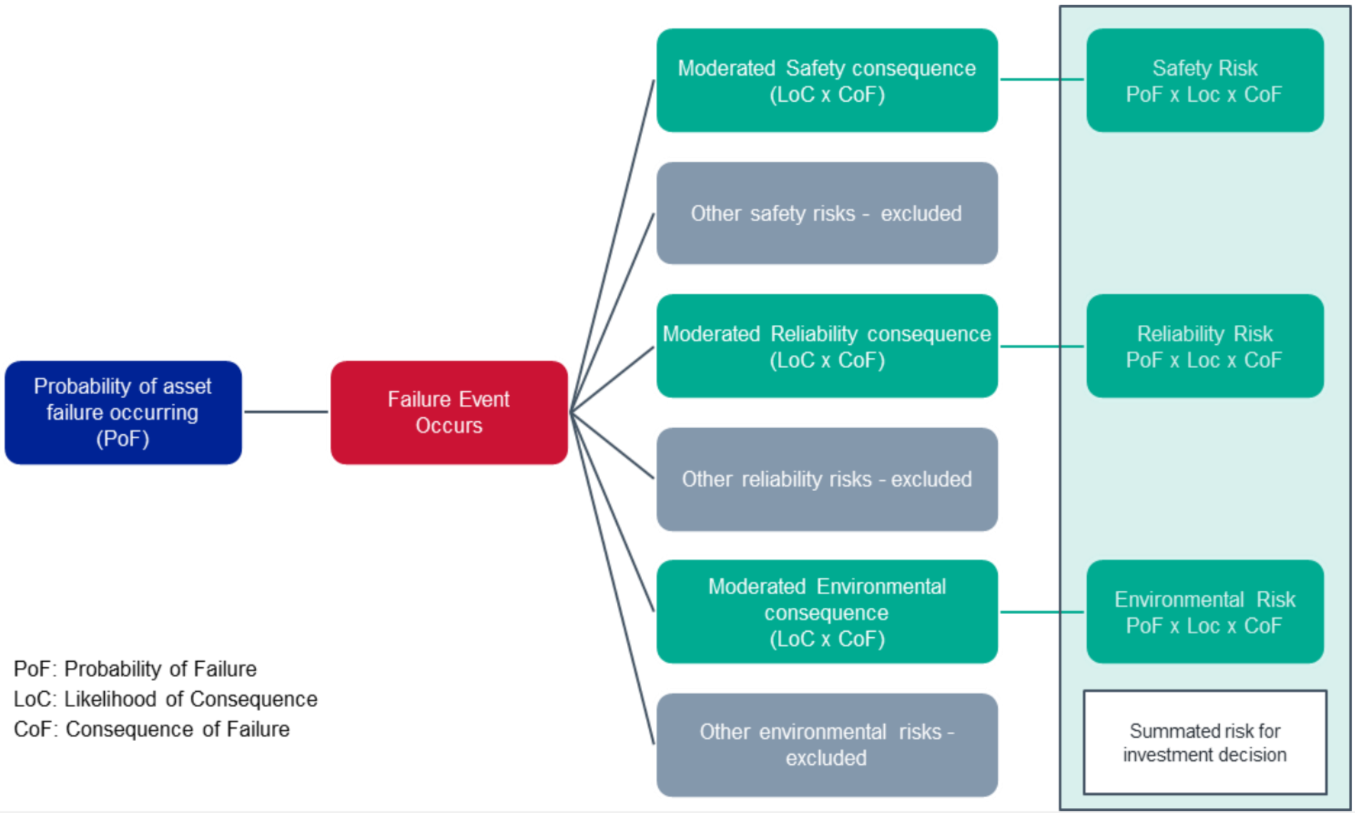
- uses externally verifiable parameters to calculate asset health and failure consequences
- assesses and analyses asset condition to determine remaining life and probability of failure
- applies a worst-case asset failure consequence and significantly moderates this down to reflect the likely consequence in a particular circumstance
- identifies safety and compliance obligations with a linkage to key enterprise risks.

B.1 Overview of risks assessment methodology

A fundamental part of the risk assessment methodology is calculating the 'risk costs' or the monetised impacts of the reliability, safety, environmental and other risks.

Figure below summarises the framework for calculating the risk costs, which has been applied on TransGrid's asset portfolio considered to need replacement or refurbishment.

Figure B-1 – Overview of TransGrid's 'risk cost' framework



[22] TransGrid. *"Revised Regulatory Proposal 2018/19-2022/23."* Melbourne: Australian Energy Regulator, 2017. 63-69. Accessed 15 March 2019. https://www.aer.gov.au/system/files/TransGrid%20-%20Revised%20Revenue%20Proposal%20-%201%20December%202017.pdf

The 'risk costs' are calculated based on the Probability of Failure (PoF), the Consequence of Failure (CoF), and the corresponding Likelihood of Consequence (LoC).

In calculating the PoF, each failure mode that could result in significant impact is considered. For replacement planning, only life-ending failures are used to calculate the risk costs. PoF is calculated for each failure mode base on 'conditional age' (health-adjusted chronological age), failure and defect history, and benchmarking studies. For 'wear out' failures, a Weibull curve may be fitted; while for random failures, a static failure rate may be used.

In calculating the CoF, LoC and risks, TransGrid uses a moderated 'worst case' consequence. This is an accepted approach in risk management and ensures that high impact, low probability (HILP) events are not discounted. But it excludes the risk costs of low impact, high probability (LIHP) which would results in lower calculated risk.