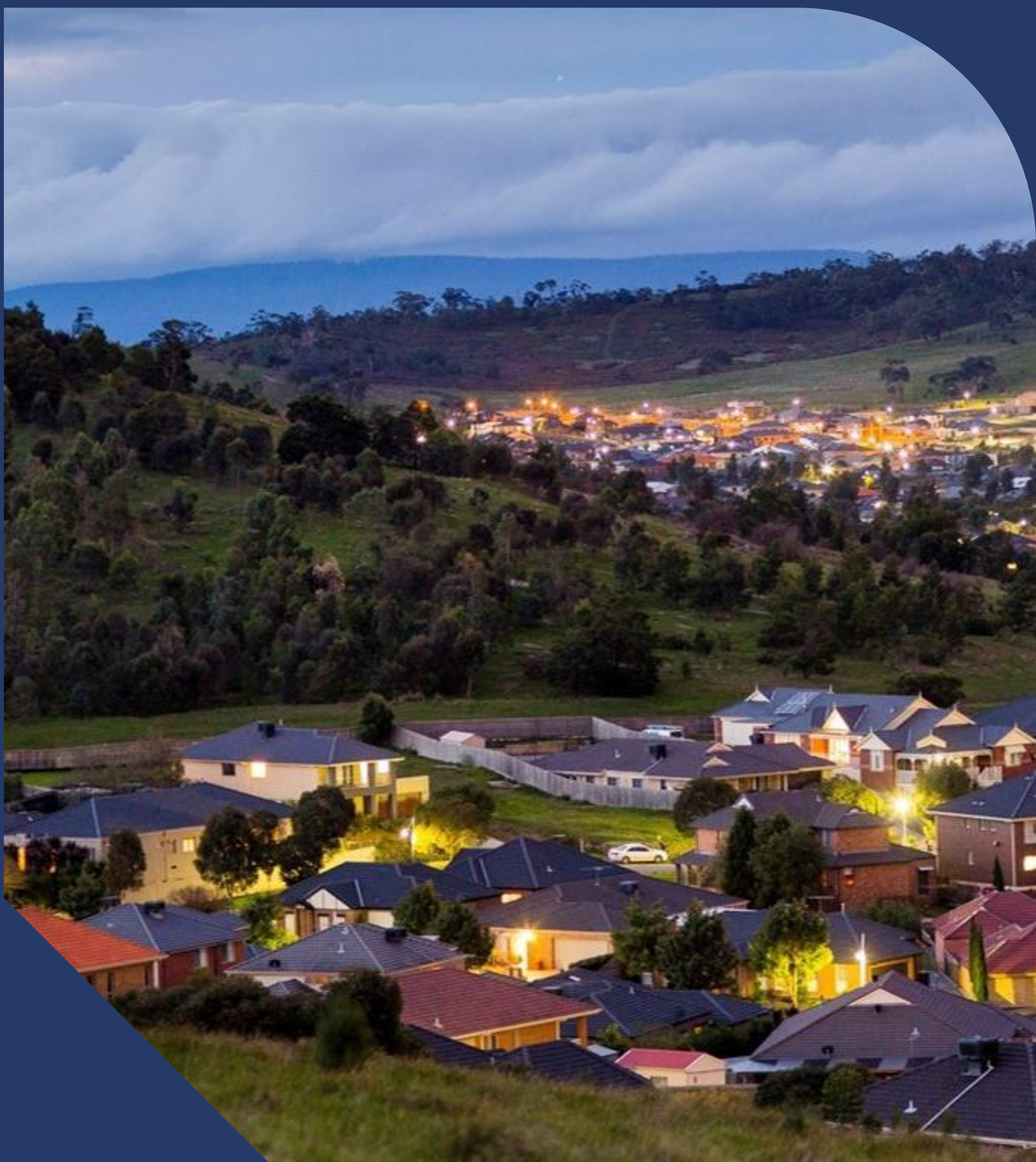
Transmission Line Conductors and Ground Wires

Asset Management Strategy



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AusNet

Table of Contents

Abbreviations and Definitions

TERM	DEFINITION
AAAC	All Aluminium Alloy Conductor
AAC	All Aluminium Conductor
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AIS	Availability Incentive Scheme
AL	Aluminium
ACSR	Aluminium Conductor Steel Reinforced
ALS	Aerial Laser Survey
CA	Condition Score
EHV	Extra High Voltage
FMECA	Failure Mode, Effect and Criticality Analysis
FMI	Field Mobile Inspection
GW	Ground Wire
HV	High Voltage
OPGW	Optical Fibre Ground Wire
RCM	Reliability Centred Maintenance
SAIP	Smart Aerial Image Processing

1. Executive Summary

This document outlines AusNet's asset management strategy for high voltage conductors and ground wires within the regulated electricity transmission network. The strategy addresses the challenges posed by a diverse and ageing fleet of overhead line assets, including 6,600km conductors and 7,400km ground wires across various voltage levels (66kV to 500kV).

A risk based assessment has been conducted, focusing on the consequences of failure, including safety, environmental impact, community disruption, and market reliability. Particular attention is given to ground wires with very poor condition and ground wires potentially underrated for fault currents. A replacement program is proposed to address these condition and rating based risks in the 2027-2032 period. There is no proposed phase conductor replacement in the 2027-32 period.

This strategy also outlines AusNet's approach to managing ground clearance under transmission lines (low spans), guided by the ESMS and Electricity Safety Act 1998. It prioritises proactive monitoring, integrated clearance data, and risk based decisions for compliance and public safety.

AusNet's risk assessment of low transmission spans demonstrates a rigorous, and safety first approach. By combining detailed risk modelling, cost benefit analysis, and proactive engagement with landholders. High risk spans identified for rectification will be included in the TRR (2027–2032) low span program. For lower risk spans monitored and controls will be applied.

Through ongoing maintenance, innovative condition monitoring, ongoing monitoring of ground clearances, landholder engagement and systematic replacement of at risk conductors and ground wires, the plan aims to satisfy stakeholder expectations for safety, reliability, cost effectiveness, and environmental responsibility are consistently met.

1.1. Asset Strategy Summary

AusNet's strategy focuses on proactively managing risk, ensuring safety, and maintaining reliability through a targeted program of replacements, maintenance actions, condition assessments, and monitoring ground clearance across the asset lifecycle stages.

The strategy supports proactive asset management by encouraging the adoption of advanced condition assessment methodologies and applying risk based prioritisation for interventions. It focuses on asset condition, performance, and the likelihood and consequences of failure, enabling more informed and targeted decision making

AusNet is proposing a targeted program for the upcoming regulatory period to manage risk within acceptable levels. This includes replacing corroded steel ground wires, upgrading ground wires to meet fault current capacity requirements, and raising conductor spans that do not comply with clearance standards in AS/NZS 7000. All replacement works will follow AS/NZS 7000 and modern material standards to support long term performance.

Through the implementation of these strategies, AusNet aims to uphold stakeholder expectations for safety, reliability, cost effectiveness, and environmental responsibility.

2. Introduction

2.1. Purpose

The purpose of this document is to outline the inspection, maintenance, replacement and monitoring activities identified for economic life cycle management of transmission line conductors and ground wires installed in AusNet's Victorian electricity transmission network. This document is intended to be used to inform asset management decisions and communicate the basis for activities.

In addition, this document forms part of AusNet' Asset Management System for compliance with relevant standards and regulatory requirements. It is intended to demonstrate responsible asset management practices by outlining economically justified outcomes.

2.2. Scope

This asset management strategy applies to the following regulated assets within the Victorian electricity transmission network operating at voltage of 66 kV and above:

- Bare overhead Transmission lines conductors.
- Bare overhead Transmission line ground wire (including optical fibre ground wire).
- Terminal station ground wires.
- Associated fittings.

Transmission conductors included in the scope are from the start terminal station rack to the end terminal station rack on each circuit.

The strategies in this document are limited to maintaining installed capability in terms of equipment performance and rating. Improvements in quality or capacity of supply are not included in the scope of this document.

2.3. Asset Management Objectives

As stated in REF:AMS 01-05 Strategic Asset Management Plan, asset management objectives and strategic pillars are:

Trusted to bring the energy today and build a cleaner tomorrow							
Strategic Pillars						**Ambition**	
Safely deliver our customer's energy needs today				**Create the energy network of tomorrow**	**Enable the transition to a net zero future**	**Be a leader in asset management practice**	
Asset Management Objectives						**Enabling AMOs**	
Safety: Minimise risk to our people, contractors, customers and communities AFAP across our networks	**Reliability:** Meet the reliability expectations of our customers and communities, and meet our reliability targets	**Resilience:** Improve the resilience of our network to adapt to a changing climate and energy system environment	**Compliance:** Comply with all legislation, regulations, relevant standards and industry codes	**Planning and decision-making:** Deliver valued planning and network outcomes through optimising asset lifecycle management	**Sustainability:** Build stakeholder trust and deliver social value. Reduce our environmental impact. Operate efficiently to sustain financial value creation.	**Competency and capability:** Develop asset management capability and competency in the organisation	**Continuous improvement:** Continually improve asset management maturity for effective delivery of services

3. Asset Description

3.1. Function

3.1.1. Phase Conductor

The primary function of conductors is to safely and efficiently transmit electrical energy between terminal stations. There are two different types of phase conductors in use on the transmission network including aluminium conductor steel reinforced (ACSR) and all aluminium alloy conductor (AAAC).

3.1.2. Ground Wires

A ground wire is a cable installed at the top of transmission towers. It shares a similar construction to a conductor but is typically smaller in diameter. Its primary function is to protect the transmission line from lightning strikes by safely directing electrical surges to the ground, thereby reducing the risk of damage to conductors and associated equipment. Ground wires also contribute to system safety and reliability by helping maintain proper electrical grounding across the network.

There are three different types of ground wires (GW) in use on the transmission network:

- Steel
- ACSR
- Optical fibre ground wire (OPGW)

Traditional ground wires perform two key functions:

- Shielding phase conductors from lightning strike and
- Reducing voltage rise at structures by providing multiple paths for fault currents

OPGW offers additional functionality by providing communication links between terminal stations.

3.2. Population

3.2.1. Conductors

Phase conductors operate at five network voltages including 66kV, 220kV, 275kV, 330kV and 500kV.

A phase conductor arrangement can be a single conductor or a bundle of multiple sub-conductors (double and quad). Phase conductor lengths are reported as circuit route length, which counts all three phases on an individual circuit as one asset.

The total route length of EHV and HV phase conductor on the transmission network exceeds 6,600 km, consisting of over 17,359 circuit spans (as of June 2025).

Conductor sizes vary depending on the electrical and mechanical design requirements for each transmission line. For simplicity of identification most conductors are given code names as defined in AS 1531-1991 and AS 3607-1989". The main transmission network conductors are ACSR types: Paw Paw, Orange, Mango, Lemon and Finch.

Figure 1 displays conductor route length by voltage and type as a percentage of the total conductor population. The 220kV network represents 61% of the total route length and is served by ACSR conductor. The combined route length of Aluminium conductors contributes less than 1% of the total network span length.

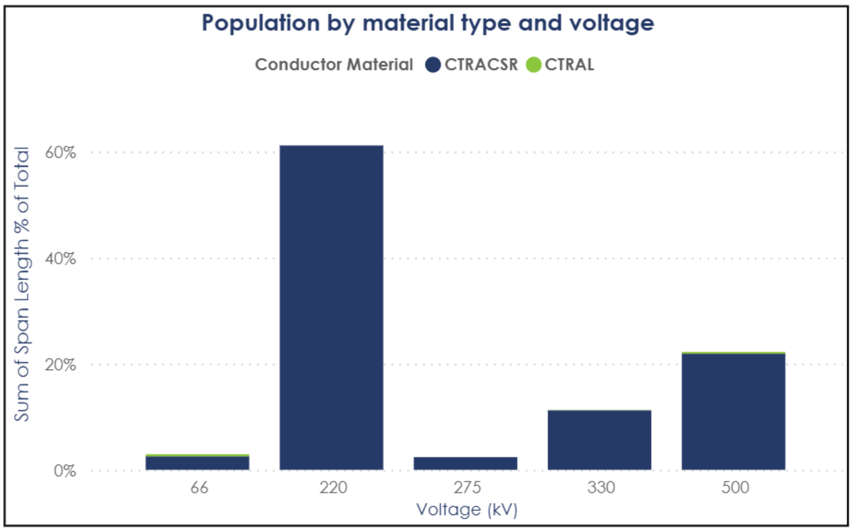


Figure 1: Conductor route length by voltage and material type

Acronyms in the graph above mean CTRACSR as "Conductor Transmission ACSR "and CTRAL "Conductor Transmission Aluminium" Conductor Fittings and Hardware.

Fittings and hardware provide mechanical links between conductors and other transmission line assets. Conductor spacers provide stability to bundled phase conductors and individual conductor separation during normal operation". Thus, avoiding conductors rubbing against each other and prematurely wearing the conductors out.

Conductor fittings and hardware include:

- Vibration dampers
- Conductor spacers
- Line hardware and Fittings

Vibration dampers are fitted to most conductors and some ground wire to minimise the effects of wind induced aeolian vibration.

AusNet network has approximately 180,000 conductor spacers and 85,000 conductor vibration dampers.

3.2.2. Ground Wires

Transmission conductors are shielded from lightning strike by approximately 7,400 km of ground wire and OPGW positioned above phase conductors on the line structures, consisting of over 19,631 circuit spans (as of June 2025).

Additionally, there are small percentage of the wires that make up ground wire spans providing for lightning strike protection in terminal stations.

Each span of ground wire is counted as a separate asset, hence on towers featuring multiple ground wires, each span of ground wire is counted as an individual asset. Ausnet's transmission network has approximately 37% of steel ground wire, 35% OPGW and 28% ACSR ground wire. The following table shows the types and sizes of the ground wire used in Ausnet network.

GROUND WIRE	STRANDING & SIZE
Steel	19/2 SC/GZ
	19/3 SC/GZ
OPGW	OPGW - S
	OPGW - M
	OPGW - L
ACSR	Grape - 30/7/2.50
	Brahma - 16/0.1127, 19/0.0977

Table 1: Ground wire types and size

The ground wire % route length by voltage and type is shown in Figure 2.

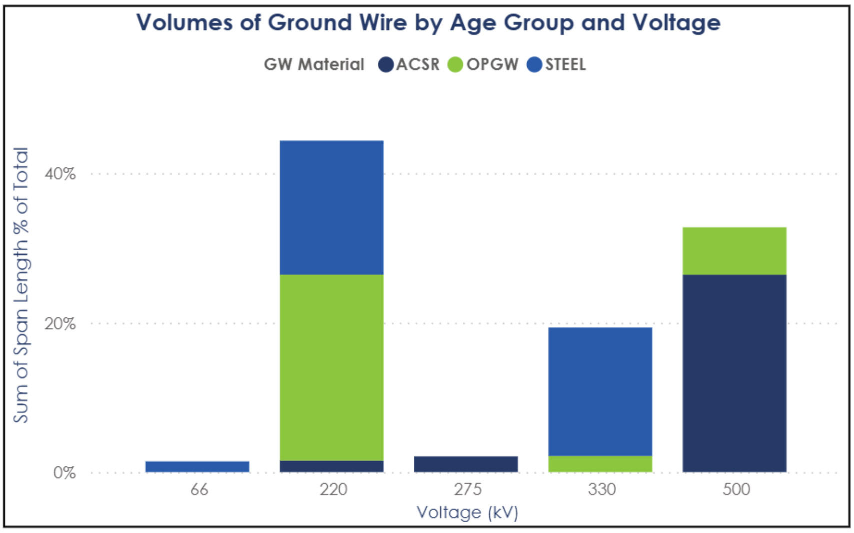


Figure 2: Ground wire sum of length by voltage and material type

The 220 kV network has 44% of the ground wire route length as it contains the highest number of double circuit towers. And 220 kV probably makes up most of the circuit network km too. So it's a combination of most network km and common use of double circuit construction.

3.2.3. Low Spans

AusNet defines a Low Span as a transmission conductor span on that has ground clearances at maximum operating temperature (MOT) below today's AS/NZS 7000 standards. A history of low spans on the Victorian network is presented in Appendix C. To uphold safety compliance and promote ongoing reliability of the network, AusNet has conducted a risk assessment on all Low Spans across our network as outlined in Table 2 below.

VOLTAGE	TOTAL NUMBER OF SPANS	CLEARANCE STANDARD	LOW SPANS ASSESSED
66kV	260	5.5–6.7m	42
220kV	10,380	7.5m	1,413
330kV	2,249	8.0m	262
275kV	779	7.5m	0
500kV	3,633	9.0m	0
Total	**17,301**	**-**	**1,717**

Table 2: Population on conductor spans on AusNet's network

3.3. Age

The Victorian transmission network has evolved over the past century to meet growing electricity demand and support interconnection with neighbouring states. In 1950, construction began on 220 kV lines to connect Melbourne and major regional centres with generators in the Latrobe Valley, forming the backbone of the state's high voltage network. Interconnection with New South Wales was established through 330 kV lines built progressively between the late 1950s and early 1980s.

To support increasing demand and industrial growth, two 500 kV lines were introduced in 1971.72, linking the Latrobe Valley to Melbourne and providing additional transmission capacity. In 1980/81 additional 500kV Lines were constructed to upgrade the connection from the Latrobe Valley to Melbourne and continue through to Heywood and the Portland aluminium smelter in southwest Victoria. In 1988, 275 kV lines were constructed from Heywood to Southeast Substation to enable interconnection with South Australia.

3.3.1. Conductor Age Profile

Figure 3 shows the service age of the transmission line conductor population by operating voltage as a percentage of the total conductor route length of 6,500 km.

Approximately 65% of the conductor fleet has been in service for more than 50 years and is expected that this will increase to 75% by 2032.

Most of the phase conductors used in the transmission fleet is made of ACSR with greased core, which has proven effective in providing a long service life for the network. Only a small percentage of conductor has been replaced based on condition, mainly located in the HYTS-APD line, which is subjected to higher level of corrosivity. There is no proposed phase conductor condition based replacement in the 2027-32 period.

This is further discussed in section 5.1.3 Asset Condition Profile.

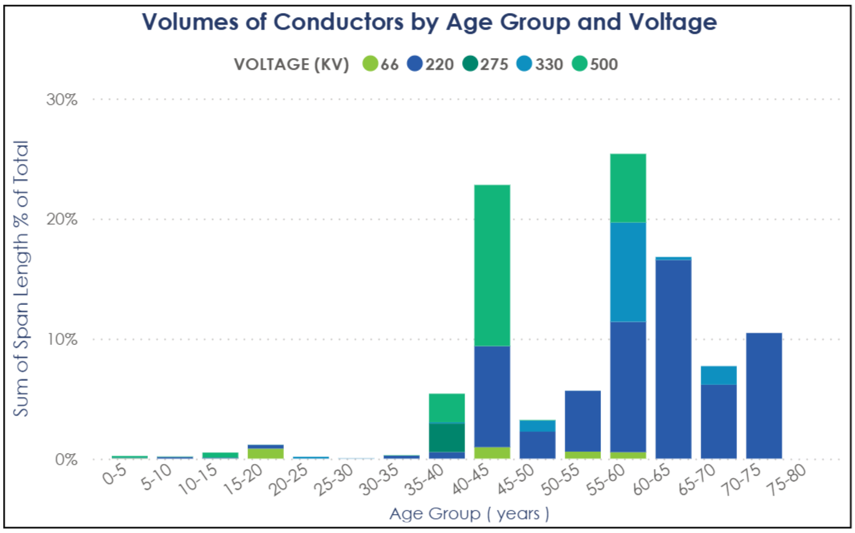


Figure 3: Conductor service age profile by voltage

3.3.2. Ground Wire Age Profile

Figure 4 shows the service age of the transmission line ground wire population by operating voltage as a percentage of the total ground wire route length of 7,400 km.

Approximately 40% of the ground wire fleet has been in service for more than 50 years and is expected that this will increase to approximately 55% by 2032. The average age of ground wire is highest on the 220 kV and 330 kV networks respectively.

Like the conductor fleet, the service life or age of the ground wire fleet does not impact its condition. The majority of ground wire used in the transmission fleet is made of steel conductor with grease, while the 500kV network ground wire uses ACSR with greased core.

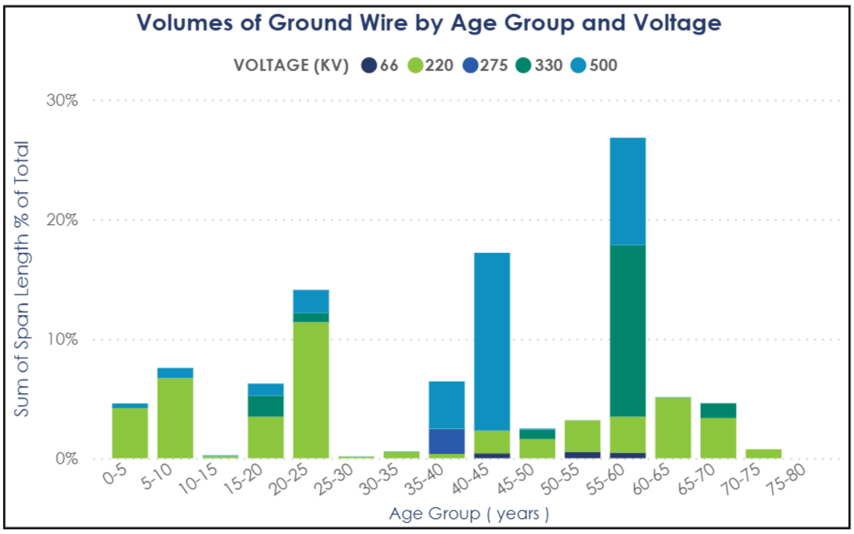


Figure 4: Ground wire service age profile by voltage

AusNet has implemented extensive ground wire replacement programs over the last two decades, primarily driven by the need to upgrade the network's communications systems to meet the performance specifications of the National Electricity Market.

Communication upgrades resulted in the replacement of 30% of ground wire with OPGW. Steel and ACSR ground wire make up the remaining 40% and 30% respectively of the total ground wire route length. Approximately 5% of the network Steel and ACSR ground wire was replaced like for like due to poor condition while the remainder is generally in service since the line was originally built. Condition is further discussed in section 5 Asset Health.

4. Asset Performance

AusNet uses Failure Mode Effect and Criticality Analysis (FMECA) to identify modes and causes of failure for the conductor and ground wire fleet. FMECA is the foundation for the development of effective Reliability Centred Maintenance (RCM) strategies. Performance data provides asset managers with a historical view of the asset's successes and failures. This information ultimately feeds into replacement and maintenance program viability studies.

4.1. Suspended Failures

Suspended failures are defects that are detected and repaired before they cause a functional failure (i.e. outage). The defects are presented as ZA notifications in AusNet's asset management system SAP.

AusNet line inspection program is outlined in LPP 09-01 and LPP 09-06 Condition Assessment of Overhead Lines. The inspection program is aimed at objectively assessing the condition of transmission line components and identifying assets which are not fit to remain in service. Assets deemed not fit for service are repaired or components replaced via ZA work orders raised in Enterprise Asset Management information system.

4.1.1. Phase Conductor and Ground Wire Performance Profile

Figure 5 displays the annual counts of ZA notifications representing defects for conductor and ground wire assets from 2015 to 2025. Within this period the network has experienced 6,850 total defect notifications,

The dominant objects, that are defective, are suspension clamp, followed by conductors, then spacers, bonding lead and damper as shown in the graph below.

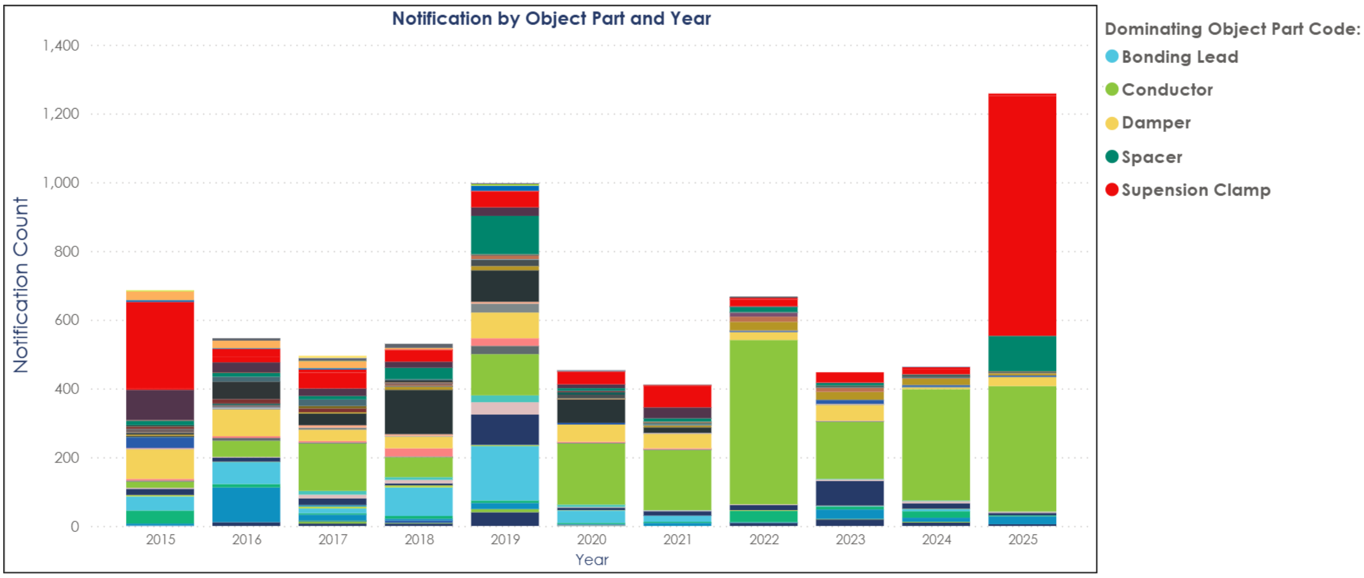


Figure 5: Conductor and ground wire ZA notifications by year

Figure 6 displays the same annual counts of ZA notifications with their associated damage code from 2015 to 2025. Since 2020 there have been a total of 3,653 conductor and ground wire defects notifications. The dominant damage codes are worn ground wire fittings, foreign object, corroded steel ground wire, broken strands and loose strands.

There has been an increase in detected broken strands between 2023 and 2025, driven in part by the Smart Aerial Inspection Process (SAIP) system, which has identified mid-span defects. The SAIP system was introduced as part of the routine inspection regime in 2020.

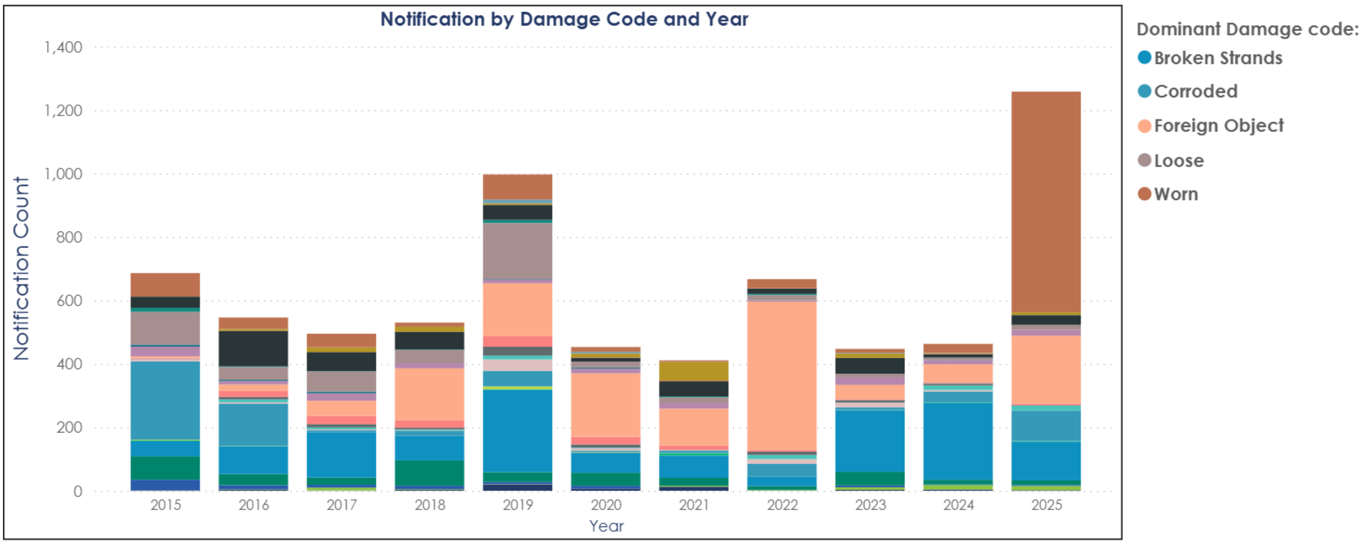


Figure 6: Conductor and ground wire notifications by year

The increase in 2025 is primarily due to corroded and worn ground wire plates and hardware identified on the HYTS–SESS 275kV and HYTS–APD 500kV lines in the Southwest region, which is subject to higher corrosion levels. Replacement of ground wire plates and suspension clamps on the HYTS–SESS line is currently underway and scheduled for completion in 2025/26. Activities on the HYTS–APD line are also in progress and are being integrated with structure refurbishment works, as outlined in AMS 10-77 Transmission Line Structures

4.2. Functional Failures

A conductor functional failure is an incident which prevents the safe flow of electricity. It is defined as loss of either the electrical or mechanical functions of the conductor systems and can be caused by several different failure mechanisms.

A ground wire functional failure is an incident which renders the phase conductors unprotected against an imminent lightning strike and prevents the effective transfer of data in case of an OPGW. Functional failures also constitute incidents which present significant health and safety risks to AusNet workers and contractors and potentially members of the public depending upon location.

The majority of conductor and ground wire functional failures result in loss of mechanical function followed by loss of electrical/communication function i.e. conductor or ground wire falling to ground or onto phase conductors below.

There have been 7 incidents[1] of conductor functional failure due to condition deterioration (unassisted) over a period of 47 years, including 1 in the last decade as per Table 3. The implementation of SAIP, along with improved inspections and effective defect repairs, has contributed to a significant reduction in these incidents recently.

[1] Conductor drop incidents due to tower collapse, installation error or manufacturing defects in conductor hardware and fittings are not included.

YEAR	CIRCUIT NAME	NUMBER OF SPANS AND TYPE OF CONDUCTOR	DAMAGE	CAUSE	ENVIRONMENT
1972	500 kV HWTS-SMTS	1 x ACSR conductor	Broken Strands	Corrosion due to localised Industrial pollution	Paper manufacturing plant in Maryvale
1988	220 kV GTS-PTH	1 x ACSR conductor	Broken Strands	Abrasion due to vibration damper clamp	Rural, medium corrosivity
1998	220 kV RWTS- TTS	1 x ACSR conductor	Broken Strands	Corrosion due to localised Industrial pollution	Metal smelting plant in Dalton Road, Thomastown
2008	500 kV HYTS-APD	2 x ACSR conductor	Broken Strands	Corrosion due to salt deposition	Within 2 km from open ocean shore
2010	500 kV HYTS-APD	1 x ACSR conductor	Broken Strands	Corrosion due to salt deposition	Within 2 km from open ocean shore
2014	500 kV HYTS-APD	1 x ACSR conductor	Broken Strands	Corrosion due to salt deposition	Within 2 km from open ocean shore
2016	500 kV MLTS-HYTS	1 x ACSR conductor	Broken Strands	Abrasion due to defective spacer clamp	Agricultural, low corrosivity

Table 3: Unassisted conductor functional failures

4.3. Vandalism, Foreign Objects and Lightning Strike

In the past five years there have been over 200 incidents which have directly impacted conductor and ground wire systems. Some of these lead to assisted ground wire functional failures as featured in table 4.

These include acts of vandalism, foreign objects and lightning strikes. Most of these incidents can be mitigated through design to a certain extent but not eliminated completely. The implementation of SAIP, along with improved inspections and effective defect repairs, has contributed to reduction in these incidents.

YEAR	CIRCUIT NAME	NUMBER OF SPANS AND TYPE OF CONDUCTOR	DAMAGE	CAUSE	ENVIRONMENT
2002	220kV BATS-BETS	1xOPGW	Broken Strands	Lightning strike	Low corrosivity
2002	220kV BETS-SHTS	1xOPGW	Broken Strands	Lightning strike	Low corrosivity
2004	Eildon River Xing	1xOPGW	Broken Strands	Aeroplane impact	Low corrosivity
2005	220kV BLTS-MLTS	1xOPGW	Broken Strands	Lightning strike	Low corrosivity
2007	220kV MKPS-MBTS	1xOPGW	Broken Strands	Lightning strike	Low corrosivity
2011	220kV BATS-BETS	1xOPGW	Broken Strands	Lightning strike	Low corrosivity

Table 4: Assisted ground wire functional failures

4.4. Fault Current Ratings

The changing network topology and growing number of renewable energy connections is altering fault levels across the network. Connection studies have highlighted a need to review the design of the existing ground wire network and the short circuit rating performance capabilities for existing fault levels.

The fault current rating of an overhead ground wire (also called an earth wire or shield wire) is the maximum return current it can safely carry during a fault (such as a phase-to-ground short circuit) without being damaged. This rating is specified for a short duration (typically 0.5 to 1 second), since faults are cleared quickly by protection systems.

AS/NZS 7000 – specifies all conductors (phase and GW) need to be sized appropriately for currents that may occur without causing permanent damage. Most lines (79%) have 2 ground wires for lightning protection, but the remaining lines have single ground wire lightning protection (14% OPGW and 7% steel)

Common Materials used for the GW conductors are:

- Steel 19/2, 19/3 SC/GZ – used up to 330kV
- Brahma and Grape 30/7/2.50 ASCR - used with 500kV
- OPGW-L, M and S and couple of non-standard sizes – all voltages

COMMON MATERIALS	THERMAL RATING AT MAIN CLEARANCE TIME (KA)	THERMAL RATING AT CBF CLEARANCE TIME (KA)
Steel	11	6
Grape ACSR	40	22.4
OPGW	40	22

Table 5: Typical ground wire ratings at main clearance time and circuit breaker failure CBF time.

4.4.1. Fault level capability Importance of Fault Rating for Ground Wires

The fault rating of ground wires is a critical factor in ensuring the safe and reliable operation of transmission networks. Several considerations highlight its significance:

- Safety: If a ground wire is unable to carry the expected fault current, it may melt, break, or lose structural integrity. This can result in hazardous situations including the loss of shielding, increased risks to the public, Ausnet personnel and potential fire incidents.
- System Protection: Ground wires play a key role in conducting fault currents safely to earth. This function assists protection relays and circuit breakers in operating as intended, ensuring faults are cleared efficiently and effectively.
- Equipment Protection: By providing a low resistance path for fault currents, ground wires help prevent damage to critical infrastructure such as towers, insulators, and other network equipment.
- Asset Condition: Excessive heating of ground wires beyond their design limits can lead to the loss of grease inside the conductor. This accelerates corrosion and can significantly reduce the expected lifespan of the asset.

4.4.2. Desktop Assessment of Ground Wire Performance

To address these concerns, AusNet has undertaken a desktop evaluation of the performance and capacity of ground wires across its network. This assessment involved reviewing existing data to identify any potential vulnerabilities.

Assessment Approach

AusNet's initial evaluation focused on comparing ground wire ratings against the maximum fault levels present at the station busbars, as provided in AEMO's system model. The fault clearing time considered in this assessment was based on the slower back up circuit breaker failure (CB Fail) scenario.

Key Findings

The assessment revealed that the OPGW (Large size) installed over the past two decades, as well as ACSR (Grape) ground wires deployed on the 500kV network, are suitably rated to withstand the expected fault currents under these demanding conditions. However, the study also identified locations where steel ground wires may be underrated and, therefore, at risk during fault events.

Further investigations incorporated detailed fault rating assessments of ground wires, taking into account earth fault current contributions from connecting stations and lines, again focusing on CB Fail scenarios. This included project specific PSS/E earth fault modelling and assumptions regarding ground current sharing. The results indicated that 44 ground wire ends across the network, all original steel ground wires, may be underrated. This represents a small subset of the total network, which comprises more than 360 ground wire ends.

Figure 7 illustrates the percentage utilisation of short circuit thermal ratings for AusNet's fleet of steel ground wires, highlighting 44 ground wire ends potentially exceeding 100% utilisation. These findings suggest potential underrating, warranting further detailed technical assessments, which are currently underway. The steel ground wires identified are particularly vulnerable due to their lower fault current capacity and heightened susceptibility to corrosion.

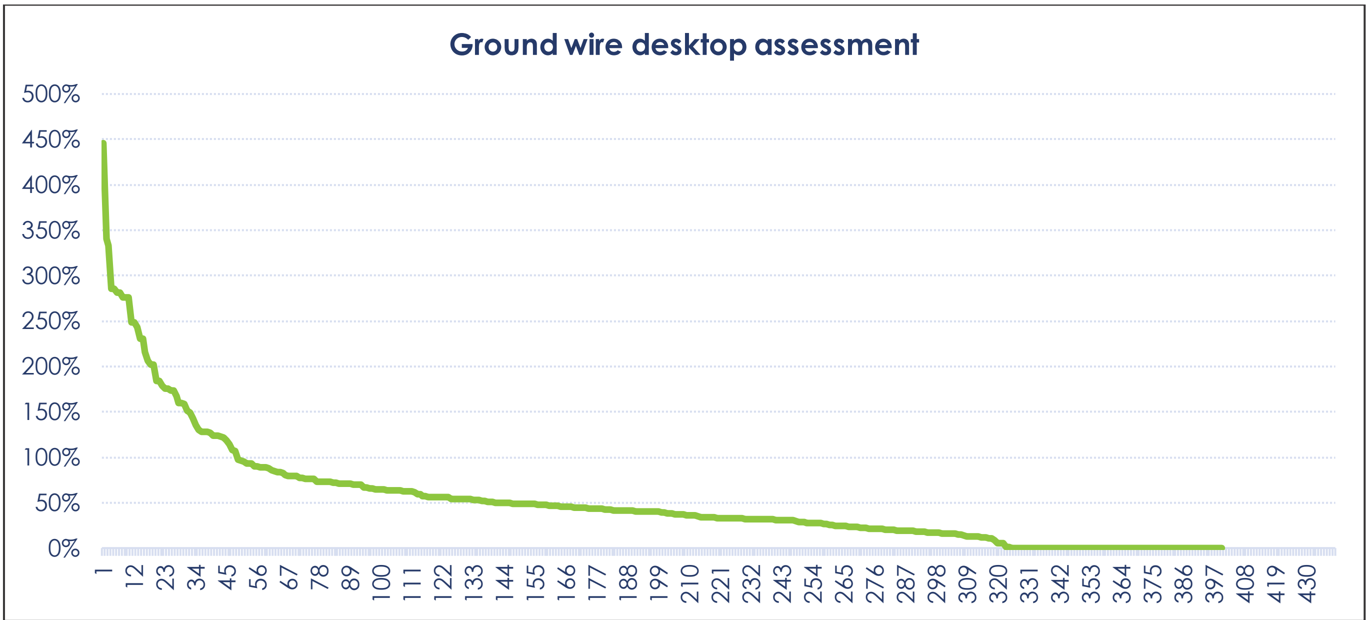


Figure 7: Steel Ground wires, % of short circuit rating utilised

Options for Addressing Underrated Ground Wires

When calculated or expected fault currents exceed the rating of existing ground wires, several mitigation options are available:

- **Increase the Size of the Ground Wire**: Upgrade to a wire with a larger cross sectional area, such as ACSR (Grape) or OPGW (Large), to accommodate higher currents.
- **Use Higher-Strength Materials**: Select materials with superior thermal and mechanical properties, for example, high strength steel or composite wires.
- **Parallel Ground Wires**: Install additional ground wires in parallel to distribute the fault current.
- **Reduce Fault Current**: Employ neutral grounding resistors or reactors to limit the maximum fault current, or enhance system protection to clear faults more rapidly, thereby reducing the duration the wires must carry high current.
- **Regular Inspection and Maintenance**: Implement ongoing inspection and maintenance to enable ground wires remaining free from corrosion and mechanical damage, preserving their effective rating.

Proposed Replacement Program for TRR 2027-32

For the 2027–32 Transmission Revenue Reset (TRR) period, a ratings based ground wire replacement program is proposed. This program will focus on replacing underrated steel ground wires with ACSR conductors to increase fault current capacity, taking care to avoid overlap with existing network plans. Typically, only the first few kilometres of line from each terminal station are critical for fault current rating capacity and are, therefore, included in the scope. Further detailed design modelling, informed by site measurement data, will be undertaken to optimise the replacement scope.

4.5. Transmission Contact Incidents

In consideration of Low Spans on Victoria's transmission network, four accidental contacts between transmission lines and ground vehicles have been recorded over the past 30 years.

- 1998 – Location: Bolte Bridge; During construction, a crane had its arm raised causing a flashover to WMTS-FBTS 220kV line. The crane operator was uninjured, but the crane's electronics were damaged.
- 16/02/2009 – Location: Thomastown; A truck mounted drilling rig was erected in a storage yard when it contacted the RWTS-TTS 220 kV T461 – 462. The operator was taken to hospital.
- 08/12/2011 – Location: West Melbourne; A forklift with its boom extended drove under the KTS-WMTS 220kV T035-036 line resulting in a line contact incident. The driver was not injured but the tyres of the forklift exploded.
- 19/05/2014 – Location: Thompson Road Maude; A tip truck was raised to deliver lime and caused a breach in the clearance under T043 – T044 MLTS – BATS 1 220 kV line which caused the line to trip. The driver was not injured.

Of these incidents only one associated injury was recorded, where the person involved was hospitalised. None of the incidents mention conductor height so it is assumed that the lines provided at least statutory clearance. In all three cases the equipment reported to have contacted the line were capable of exceeding the conductor design height and it is likely that the height of the conductor was not a significant factor in the incidents occurring. Therefore, it is likely that the transmission line incidents could not have been controlled by making minor adjustments to the conductor heights.

A contact frequency was hence calculated as follows:

- 4 incidents / (17,300 transmission spans x 35 years) = 6.6 x 10^{-6} contacts per span-year

Or

- 4 incidents / x 35 years = 0.114 contacts per year for the entire network

None of these incidents were practically preventable by modification of the conductor height so it isn't necessarily appropriate to use these rates to assess the change in risk associated with changes to conductor ground clearance.

4.6. Performance Summary

Despite a wide range in asset age, some exceeding 75 years in service, AusNet's transmission line conductors and ground wires have consistently upheld high performance standards, underscoring the resilience of the network.

To date, only seven major failures in the conductor system have been recorded across the entire fleet, all of which were attributed to corrosion. This singular failure mode highlights the robustness of the asset design and engineering, of these components.

While corrosion remains the dominant failure mode, other factors such as vandalism, foreign object interference, and lightning strikes do occasionally cause strand damage. These events are random in nature and are actively monitored and managed through routine inspection and maintenance programs.

As outlined in Section 5.1.1, AusNet's asset management strategy places strong emphasis on corrosion detection and mitigation. This analysis highlights investment and operational decisions that support our targeted approach replacing only C4 and C5 ground wires, while confirming that our phase conductors do not currently require investment. This facilitates both conductors and ground wires to remain safe, reliable, and their associated programs are tested and viable.

The increasing number of renewable energy connections has highlighted the need to review the short circuit performance capability of existing ground wires under maximum fault level conditions. Desktop analysis has identified a small cohort of steel ground wires that will require upgrading to higher rated ACSR conductors. These upgrades are proposed for inclusion in the 2027–32 Transmission Revenue Reset (TRR) period.

5. Asset Health

The Condition of transmission conductors and ground wires is assessed during regular detailed inspections which are conducted at 3, 6 or 9 yearly intervals, depending on the criticality of the line asset at that location.

Asset links, bolts, joints and terminals are assigned a condition grade from a scale between C1 and C5. Table 6 outlines condition grades for conductor and ground wire equipment including a description against each different grading parameter. More detail is described in LPP 09-06: Condition Assessment of Overhead Lines.

This supplemented with a helicopter-based SAIP (Smart Aerial Image Processing) assessment of transmission conductors and ground wires, undertaken on a 6 year interval.

Condition grades of conductors and ground wires are considered along with other factors such as age, type, corrosivity, effects of functional failures and structure loading design when taking decisions with respect to management of the asset.

CONDITION SCORE	CONDITION DESCRIPTION	CONDITION SCORE CHARACTERISTICS	REMAINING LIFE
C1	Very Good	Conductors are generally new and in very good operating condition with no past history of significant defects or failures.	95%
C2	Good	Conductors are in better than average service condition. They require routine condition monitoring to prevent failures occurring.	85%
C3	Average	Conductors are in average service condition. They require routine maintenance and condition monitoring to prevent failures occurring.	60%
C4	Poor	Conductors are in poor service condition. They require routine maintenance and condition monitoring and may require broken strand repair.	25%
C5	Very Poor	Steel is fully rusted/loss of galvanising with signs of pitting or section loss. OPGW/ACSR - corrosion byproducts/swelling evident, Conductor Broken strands, Bulging etc	15%

Table 6: Condition scoring methodology

5.1.1. Corrosion

All conductor functional failures have been caused by corrosion, primarily in areas of extreme industrial or coastal pollution, where degradation of conductor condition has been accelerated. In high corrosivity environments like Portland Victoria, steel core strands in ACSR conductors and ground wires corrode quickly, leading to reduced tensile strength and failure within 25 years. Corrosion typically starts at the outer strands and progresses inward, causing a reduction in ground wire strength and ultimately strand breakage.

In environments with lower corrosion, ground wires and conductors reach the end of their serviceable life over a longer period, as described in the risk methodology REF: AMS 01-09 Asset Risk Assessment Overview. This failure mode is the main reason for proactive replacement programs.

Figure 8 shows a sample of corroded steel ground wire rated as condition C4.

Figure 8: Corroded Steel Ground Wire rated as condition C4

5.1.2. Environmental factors

Of all environmental considerations, two factors have the most significant impact on corrosivity: salt deposition, particularly prevalent in coastal zones, and airborne pollutants resulting from heavy industrial activity. To facilitate the long term reliability and safety of the network, AusNet has implemented a robust corrosivity classification system for its transmission line assets, allowing for targeted and prudent management of corrosion risks. Appendix A provides a map of these zones

Over the three year duration of the study, AusNet identified three distinct corrosivity zones within its network, in accordance with the AS 4312 "Atmospheric Corrosivity in Australia" standard. These zones are:

- Zone 1: Low Corrosivity – Areas with minimal exposure to corrosive agents, typically inland regions with low salt and pollution levels.
- Zone 2: Medium Corrosivity – Regions with moderate salt or pollution exposure, such as areas adjacent to industrial sites or less exposed coastal zones.
- Zone 3: High Corrosivity – Locations subject to significant salt deposition or industrial pollution, such as coastal corridors and zones near major emission sources.

Each transmission asset is assigned a corrosivity classification based on its location and exposure, enabling AusNet to prioritise inspection, maintenance, and protective measures accordingly. The empirical data from the corrosion coupon study underpins these classifications, ensuring they are evidence based and tailored to the actual environmental conditions experienced by the network.

The annual corrosion rates for each AusNet corrosivity zone, expressed in micrometres (μm) per year, are outlined in Table 7 below. This information is critical for asset management and informs maintenance schedules, material selection, and the design of future infrastructure to withstand varying environmental challenges.

Note: Table 7 provides a direct comparison between AusNet's corrosivity zones, and the corresponding categories defined in the AS 4312 "Atmospheric Corrosivity in Australia" standard, offering a useful reference for benchmarking network conditions against national guidelines.

AusNet Corrosivity Zone	CORROSION RATE, μM / YEAR	AS 4312 Corrosivity Zone
1 (Low)	1.3 to 25	C2
2 (Medium)	26 to 50	C3
3 (High)	51 to 80	C4

Table 7: AusNet Corrosivity Zones

5.1.3. Phase Conductor Condition

The chart shows approximately 75% of conductors fall into Condition C2, indicating a good state of health across the fleet. This is especially true in Zones 2 and 3, suggesting environmental factors are driving asset degradation.

There are very few spans with condition C4 and C5, and these are found in isolated sections. Replacing a single span within a 5–6 span section is generally not cost effective. AusNet continues to monitor these spans through SAIP inspections, and further evaluations of their condition are currently underway via non-invasive CORMON condition assessment methods. Given the limited number of affected spans and pending additional investigation into C4 and C5, a conductor replacement program is not recommended at this time.

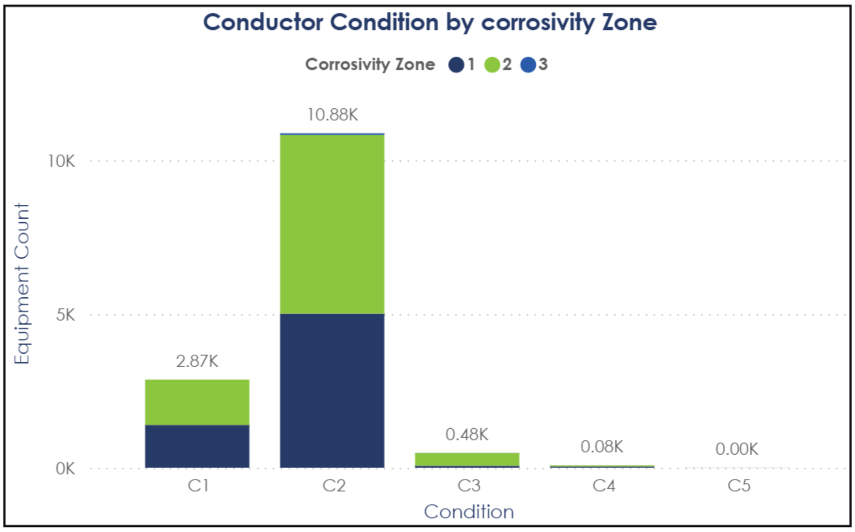


Figure 9: Conductor condition by corrosivity score

5.1.4. Ground Wire Condition

Figure 10 shows that most ground wires fall into Condition C2, with span counts peaking close to 10,000, indicating a moderate health status across the asset class. This suggests that a large portion of ground wires are neither new nor critically degraded but may require monitoring.

Corrosivity Zone 2 dominate the C4 category, highlighting the impact of moderate to high corrosivity environments on asset condition.

The condition based replacement program includes most C4 and all C5 spans located in both Corrosivity Zones 1 and 2. In some cases, these spans are situated within isolated sections, where replacement is proposed based on entire line sections, from tension tower to tension tower, rather than individual spans. As a result, these replacement sections may also include spans classified as C2 /C3. There is a proposed replacement of steel ground within the 2027-32 period addressing all the C5 and most of C4 ground wire.

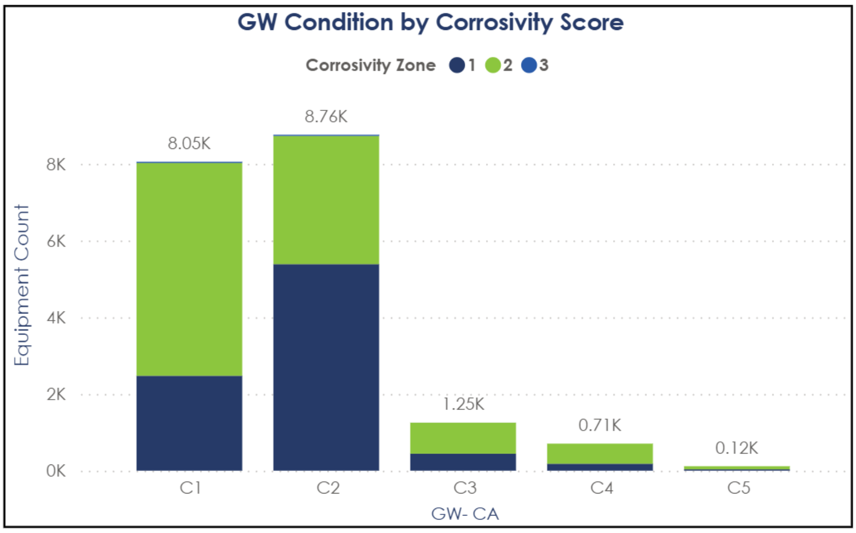


Figure 10: Ground wire condition by corrosivity score

6. Related Matters

6.1. Past Replacements

6.1.1. Conductor Past Replacements

Phase Conductor replacements are driven by poor condition and high criticality. Most of the conductors in service are the original line construction. Other than works for diversion of small sections of lines to accommodate new infrastructure. Table 8 presents the only significant conductor replacements carried out on the network to date.

YEAR	SPAN
1972	500 kV HWTS-SMTS
1988	220 kV GTS-PTH
1997	220 kV YPS – ROTS 5/6
1998	220 kV RWTS- TTS
2008 to 2014	HYTS – APD

Table 8: Condition related conductor replacements

6.1.2. Ground Wire Past Replacements

Ground wire replacements are driven by two main factors:

- Poor condition and high criticality
- Telecommunication network upgrade i.e. upgrades of GW to OPGW.

Most of the ground wire is in service are from the original line construction. Other than works for diversion of small sections of lines to accommodate new infrastructure and OPGW retrofits, the only condition related ground wire replacements carried out to date are presented in Table 9.

YEAR	LINE
2000	YPS switchyard
2002	220 kV MKPS-MBTS
2002	220 kV BATS-BETS
2011	HYTS-APD
2015	HWTS-SMTS No 1
2015	KTS-WMTS
2015	HWTS-SMTS No 1
2016	KTS-GTS 2
2022	TTS-KTS 1 & 2
2022	ROTS-RTS 1&4
2023	ROTS-SVTS 1
2024	RWTS-TTS

2025	TSTS-TTS
2025	HWPS-ROTS 1
2025	KTS-BLTS
2025	SMTS-TTS 2
2025	SMTS-TTS 1
2025	SYTS-MLTS 1 & 2

Table 9: Condition related ground wire replacements

6.2. Low Spans

This section details AusNet's approach to the identification, assessment, and management of risks associated with Low Spans across its transmission Victorian network. The approach is designed to prioritise safety and is economically justified, aligning with industry standards and regulatory requirements.

The process involves systematically identifying spans that fall below the defined ground clearance threshold, assessing the associated risks, and implementing appropriate management strategies. These actions are taken to strive towards a safety focused approach is maintained throughout the network, reflecting best practice and regulatory expectations.

The assessment applied the following principles to all spans with ground clearances below current AS/NZS 7000 standards at Maximum Operating Temperature (MOT):

- Safety Prudence / AFAP: The methodology uses prudent assumptions, strictly follows safety guidelines to facilitate minimised risk as far as practicable.
- Minimising Additional Constraints: The assessment supports that the network can operate at full thermal capacity and includes provisions for ongoing monitoring and review.
- Comprehensiveness: All spans falling below the AS/NZS 7000 standards are included in the assessment, ensuring no at risk spans are overlooked.
- Peer Review: The approach and methodologies used were subject to both internal and independent expert review to enable accuracy and robustness.
- Precision: Each span considered individually, this allows specific risks and conditions to be properly accounted for.

The outcomes of the assessment inform both immediate and long term management actions. Proposed next steps are developed based on these outcomes, ensuring that all remedial actions are justified from both a safety and economic perspective, and are consistent with relevant industry guidelines.

6.2.1. Risk Assessment Methodology

The methodology for assessing risks associated with low transmission line spans is structured around three main steps:

1. Determining the Probability of Flashover: For each individual low span, the probability of a flashover occurring is calculated. This involves a detailed review of the specific characteristics and conditions relevant to each span.
2. Applying the Risk Acceptability Framework: The probability figures determined in the first step are then assessed using a risk acceptability triangle. This framework helps categorise the level of risk associated with each span and guides the prioritisation of remedial actions.
3. Conducting Cost Benefit Analysis and Implementing Controls: Where necessary, a cost benefit analysis is conducted to support controls or mitigation measures introduced are proportionate. Controls are applied following the principle of reducing risk as far as practicable (AFAP).

The assessment process is based on the ENA C(b)1-2006 guidelines, which provide comprehensive instructions for the design and maintenance of overhead distribution and transmission lines, including risk management related to conductor clearance. This standard outlines an equation for calculating the Probability of Flashover (Pf) and introduces a Levels of Risk Acceptability framework. These tools have been systematically applied to the 1,717 identified low clearance spans across various voltage levels on the transmission network, as outlined in Section 6.2.2.

6.2.2. Detailed Risk Assessment Framework

Step 1: Probability of Flashover

AusNet has implemented a systematic and repeatable methodology to calculate the annual probability of flashover (Pof) for low spans, assessing the risk of electrical discharge from a conductor to objects below at maximum operating temperature.

This methodology integrates key variables like actual conductor height, compliance with AS/NZS 7000, voltage, land use, and the frequency and height of objects passing underneath. The calculation draws on established industry standards, such as ENA C(b)1-2006, IEC 60071, and EPRI guidance.

Flashover risk varies, for example:

- Crop farming with frequent high vehicle traversing (Pf = 4.17×10^{-2}, high risk)
- Livestock farming with moderate vehicle activity (Pf = 1.66×10^{-6}, tolerable risk)
- Residential use with low vehicle activity (Pf = 3.05×10^{-7}, trivial risk)

See Appendix C for a detailed description of AusNet's Probability of Flashover equation.

Step 2: Levels of Risk Acceptability

Typically, when considering asset management investment options, AusNet applies a Cost Benefit Analysis to determine whether the benefit outweighs the cost. However, this framework approach from the ENA suggests high level of risk is intolerable and should be actioned irrespective of the cost.

Risks are categorised using a triangle model:

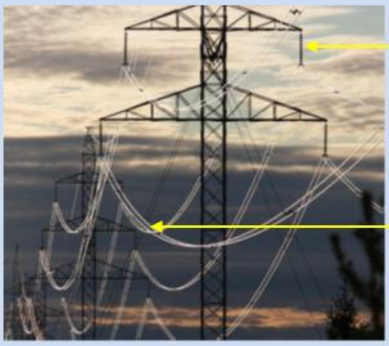
- High Risk: Action required to eliminate risk through increasing clearance
- Tolerable Risk: Cost benefit analysis to determine if engineering solution is proportionate
- Negligible/Trivial Risk: Ongoing monitoring and application of controls

See Appendix C for a detailed description of AusNet's Level of Risk Acceptability.

Step 3: Cost-Benefit Analysis (CBA)

A range of engineering options were identified to reduce the risk level to Negligible or Trivial to meet the Electricity Safety (Network Assets) Regulations 1999 ground clearance requirements. Costs were determined by applying the most cost effective solution, refined to 2 practical solutions replacing vertical suspension insulators with floating strain insulators and re-tensioning conductors, as detailed in Figure 11.

Description of Preferred Solutions



Floating Strain Insulators: involves replacing the vertical suspension insulators with a floating strain solution to raise the suspension points of the conductors to be more inline with the tower arm height.

Re-tensioning of conductors involves 'tightening' conductors usually across multiple towers with the effect of raising the average conductor height, including at the lowest ground clearance point.

Note: A range of other engineering solutions (e.g. tower raising, earthworks, insertion of mid-span pole) were considered in the CBA but these were not found to be practicable insofar as the additional cost was grossly disproportionate to the incremental benefit gained.

Figure 11: Outline of preferred solutions

AusNet applies Cost Benefit Analysis to guide asset investment decisions. Under the ENA risk framework, intolerable risks must be addressed as far as practicable (AFAP), with less emphasis on individual cost benefit outcomes. While some interventions may not be justified in isolation, they can be actioned as a cohort under the AFAP principle, particularly where similar risk profiles exist, ensuring consistent risk reduction across comparable assets

Under the framework Tolerable risk spans were assessed through the CBA, but none passed the CBA. As a result monitoring and controls will be applied as far as practicable (AFAP to Tolerable and Trivial/Negligible risk categories.

Of 1,717 spans assessed:

- 114 are High risk – propose raising these spans
- 461 are Tolerable risk – conducted a Cost Benefit Analysis;
- 1,142 are Trivial/negligible risk – monitor and apply controls AFAP

Within the framework, tolerable risk spans were assessed through the cost benefit analysis (CBA); none fulfilled the criteria. As a result, monitoring and controls will be applied as far as practicable (AFAP) to Tolerable risk and Trivial/Negligible risk categories.

The majority of high risk spans are on 220kV and 330kV lines, and most are traversable. These spans are prioritised based on clearance, risk, and land use.

By adopting this targeted approach, AusNet strives towards investment being directed where it delivers the greatest safety impact, while the program as a whole achieves a balanced and economically sound outcome.

See Appendix C for a detailed description of AusNet's Cost Benefit Analysis.

6.2.3. Prioritisation and Next Steps

Priority 1 Spans

16 spans with very low clearance and high risk land use are being progressed through detailed design, with construction scheduled to begin in 2025. The solutions, typically a combination of re-tensioning and floating strain insulators, including the replacement of one tower with a transmission pole, are designed to bring clearances above the minimum required by AS/NZS 7000 standard.

Note: 6 of the 16 spans were highlighted as a priority to Energy Safe Victoria in April 2025. As these 6 priority spans are situated at different locations along the line, increasing their tension requires adjacent spans connected to them to likewise be re-tensioned – thereby increasing their heights. Adding the 10 spans (which also are high risk spans) made engineering and efficient economic sense.

Priority 2 Spans

The remaining 80[2] high risk spans distributed across the network will be included in the TRR (2027–2032) low span program and considered for action alongside adjacent and nearby spans. The majority of the program is concentrated on seven key transmission lines.

Ongoing Monitoring and Controls

- Annual landholder communications and safety campaigns
- Permit to Work system and on site safety assessments
- Ongoing LiDAR surveys (every three years) to monitor ground clearances
- Regular re-assessment of land use and risk, especially if land use changes to higher risk activities
- Raising adjacent spans where practical, especially during other network upgrades

These controls extend beyond the initial landholder notification letters and are intended to maintain risk at AFAP levels across the network.

Low span Conclusion

AusNet's risk assessment of low transmission spans demonstrates a rigorous, and safety first approach. By combining detailed risk modelling, cost benefit analysis, and proactive engagement with landholders, AusNet aims to facilitate ongoing safety and reliability of its high voltage transmission network.

6.3. Ground Wire Replacements Linked to Renewable Connections

Ground wire replacements are also progressing as part of renewable connection projects, especially in cases where these connections have significantly increased fault levels or require Optical Ground Wire (OPGW) for communications. Where necessary, customers' projects will replace sections of the existing ground wire to meet the higher fault level demands. To avoid duplication, any overlapping spans between condition based replacements, and renewable connection project scopes, have been excluded from the ratings based replacement program proposed for TRR 2027–32.

6.4. Victorian Transmission Planning (VTP) Overlap

Five Victorian Transmission Planning (VTP) projects coincide with ground wire replacement and low span rectification programs.

Ballarat – Moorabool 2020 kV line

The first involves the rebuild of the Ballarat – Moorabool 2020 kV single circuit as a higher capacity double circuit, with completion targeted for 2030. This overlaps with both our proposed replacement of 63 ground wires and rectification of 11 low spans on the same route. In light of VicGrid's scheduled line rebuild during 2027–2032, AusNet has reviewed

[2] There is a total of 114 high-risk spans, of which 16 spans will be addressed as part of the Priority 1 Spans; 18 spans will be addressed by VicGrid's Transmission Plan, leaving 80-high risk spans to be addressed in the coming TRR.

and excluded both the ground wire replacement and low span rectification programs on the BATS–MLTS line from the TRR scope, as these wires will be renewed as part of the VTP project.

Deer Park – Keilor 220 kV lines

The second project relates to the rebuild of all three Deer Park–Keilor 220 kV circuits as new, higher capacity double circuits, planned for service in 2033. This overlaps with 20 spans identified for ground wire replacement in our program. Given the planned VicGrid rebuild is scheduled within a year of our proposed works, AusNet has determined that proceeding with ground wire replacements in the TRR program is not operationally efficient or economically sound. Risk assessments indicate that deferring these replacements until the 2033 line rebuild is acceptable, therefore, these spans have also been removed from the TRR submission.

Mt Beauty – Eildon 220kV Line

The Mt Beauty to Eildon rating increase project directly overlaps with AusNet's planned work to raise three spans on this line. VicGrid acknowledges that increasing the line rating will require rectification of ground clearance issues for these spans. According to the Victorian Transmission Plan (VTP), this work is scheduled for completion by 2029. Therefore, there is a clear overlap in both scope and timing with AusNet's Transmission Revenue Reset (TRR) submission. As a result, AusNet has removed the rectification of the three spans on the MTBS-EPS sections from the TRR submission.

Murra Warra – Horsham – Ballarat 220kV Lines

AusNet initially identified the need to rectify two low spans. One on the ARTS to CWTS line, and the other on the BGTS to HOTS line. However, as VicGrid has outlined plans to rebuild the Ballarat to Murra Warra lines by 2035, undertaking these rectifications ahead of that timeline is not considered efficient or economically prudent. AusNet will deferrer the works until 2035. As such, submission within the next regulatory period is not required.

Kerang – Bendigo 220kV

Lastly, rectification work on two spans of the KGTS–BETS line, coincide with the Victorian Transmission Planning (VTP) projects scheduled for completion by 2035. Given VicGrid's intention to rebuild Kerang to Bendigo with a double circuit line timeframe, undertaking rectification prior to the rebuild is neither operationally efficient nor economically justified. As such, the two rectification projects will not be submitted as part of the 2027-32 TRR.

6.5. Other Considerations

The following are key considerations related to the transmission line conductor and ground wire fleet:

The current condition assessment techniques for ACSR may not accurately assess the true condition of the internal steel strands. More advanced technologies offer more objective alternative such as the application of the SAIP system in conjunction with conductor sampling can improve the accuracy of condition data collected. No ACSR replacements have been proposed for the TRR 2027-32 period.

(1) Accurately assessing the condition of mid span sections of conductor and ground wire during tower climbing inspections is difficult. More advanced technologies such as the application of the SAIP system in conjunction with conductor sampling can improve the accuracy of condition data collected.

(2) Foreign objects due to bird nests need to be proactively addressed by installing premade nests in the tower body to prevent bird built nests on the crossarms in proximity of live conductors.

(3) Since the OPGW and ACSR (Grape) ground wires are relatively newer and in better condition than the steel ground wire, and are adequate for fault current ratings, the replacement program will primarily focus on the steel ground wire.

(4) The replacement of ground wire is most cost effective when the residual strength of the existing conductor is still sufficient to allow its use as a pull wire during installation. However, corrosion in steel strands can lead to a

reduction in diameter and ultimate tensile strength. Additionally, advanced corrosion may cause increased stiffness in the conductor, which can hinder its functionality as a pull wire. These factors must be carefully assessed to support safe and efficient installation of the new conductor.

(5) Several samples of retired ground wire, both steel and ACSR, were collected and subjected to mechanical and chemical testing to assess strength and corrosion levels. The results indicate a noticeable reduction in strand diameter and a corresponding decrease in the overall mechanical strength of the steel conductor. These findings highlight the impact of corrosion on the structural integrity of aged ground wires and reinforce the need for timely replacement strategies.

(6) Ground wire replacement is proposed on a section-by-section basis, typically between strain towers, to avoid mid-span joints and prevent alterations to the existing tower assembly configuration. This method works towards structural consistency and installation efficiency. While this approach may include spans where the ground wire is still in relatively fair condition, the benefits of minimising jointing and preserving tower integrity outweigh the selective retention of individual spans.

7. Proposed Program of Work

7.1. Approach

7.1.1. Risk

AusNet's asset management decisions within the transmission network are guided by a risk based approach, ensuring alignment with our organisational risk appetite. For conductors and ground wires, risk treatment required to achieve this over time involves replacement & maintenance activities. Justification for these projects are developed based on current risk and extrapolated risk.

The risk of each asset is calculated as the product of Probably of Failure (PoF) of the asset and the Consequence of Failure (CoF). This risk is then extrapolated into the future accounting for forecast changes in PoF and CoF.

AusNet's approach to asset risk management is detailed in REF: AMS 01-09 Asset Risk Assessment Overview.

7.1.1.1. Asset Quantification Methods

Probability of Failure

The PoF for Conductors and Ground wires is determined using health score model calculations, incorporating three key factors:

- Corrosion Zone
- Asset physical condition.
- Type of conductor

Asset managers use the health score models to calculate the conditional PoF for the next year. The following years of PoF are calculated using Weibull model. AMS 01-09 provides details to logic and parameters of the Weibull model.

Consequence of Failure

AusNet assigns a monetised value to CoF which provides an economic basis of calculating potential consequence.

The cost of failure is assessed through three key lenses: Safety, Environment, Customer/Market and Financial Impact. These lenses offer a structured analysis of potential impacts in areas related to conductors and ground wires. Table 10 summarises the focus of each lens:

CONSEQUENCE LENSES	DESCRIPTION
Safety	Threat to health and safety of the public and employees
Environment	Bushfire damage
Customer / Market	Loss of supply to customers Impact to on energy market
Financial	Emergency response and repairs Asset replacement costs Collateral damage

Table 10: Consequence lens description

7.2. Economic Viability

7.2.1. Economic Model

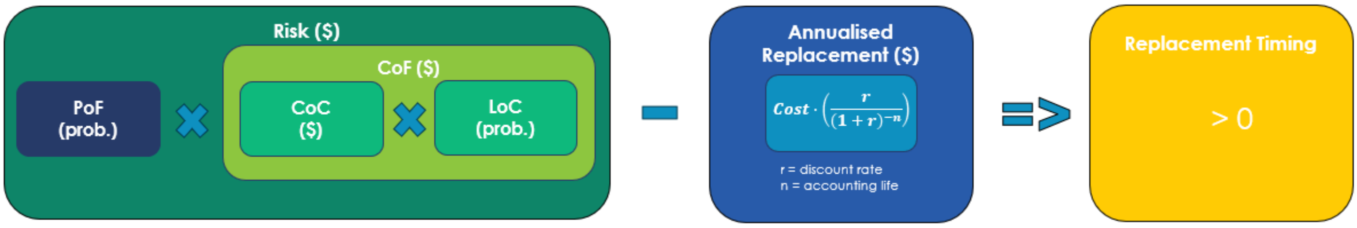
Asset Managers use the calculated risk based on PoF and CoF outputs to identify optimal intervention years, balancing technical feasibility with economic efficiency. These outputs are incorporated into an economic model. The economic model demonstrates the year when the calculated annualised risk is higher than the annualised replacement cost, and as such when the asset becomes economically viable to replace. The concept is illustrated below.

The economic model is producing a structured approach for each asset in the fleet. The economic model for the justified replacement program is available in asset class economic model

REF: *ANT – TRR 2028-32 Asset Replacement Economic Model –Transmission Line- Ground wire condition based replacement– Final*

REF: *ANT – TRR 2028-32 Asset Replacement Economic Model –Transmission Line -Ground wire rating based replacement – Final*

REF: *ANT – TRR 2028-32 Asset Replacement Economic Model –Transmission Line- Ground Clearance – Final*



7.3. Output Validation

Following the generation of asset health models and Weibull forecasts, a structured validation process is undertaken. This step works towards model outputs being interpreted within the broader context of engineering judgement, operational experience, and current asset condition data.

An assessment is made whether the model's recommendations such as, asset replacement, refurbishment or no action are reasonably practicable. This involves verifying condition data, evaluating operational priorities, and considering strategic timing of interventions. Where appropriate alternative actions may be recommended after consideration of asset health and risk of failure.

This validation process complements the use of Weibull based forecasts by integrating predictive outputs with expert knowledge. It supports a balanced and accountable approach to asset management, one that upholds technical integrity while remaining responsive to operational realities.

7.4. Proposed Program

Ground wire

AusNet is proposing a targeted ground wire replacement program for the next regulatory period. Assets selected for this program have been prioritised using a condition based methodology, underpinned by risk assessments and economic evaluations as detailed in Section 7.2. These assets have demonstrated increased risk profiles due to their deteriorating condition, necessitating intervention to prevent potential future failures.

In addition, a ratings based risk assessment has identified assets that are projected to fall short of the Australian Energy Market Operator's (AEMO) short term fault current requirements. These, too, have been substantiated for replacement through a risk and economic analysis.

The resulting scope encompasses the replacement of a specific set of spans, ensuring that all interventions are justified by both risk considerations and compliance with relevant standards.

For the 2027–32 period, our ground wire condition based replacement program will address 138 km in total, 116 km will be replaced on a like-for-like basis, while 22 km will be upgraded to Optical Ground Wire (OPGW) for enhanced communication capability.

Concurrently, the ratings based initiative involves upgrading 149 km of steel ground wires to ACSR conductors. Altogether, this equates to 287 km of replacements during the period, which is a reduction compared to the 326 km delivered in the 2022–27 period. Further details on the allocation of replacements by circuit can be found in Appendix C.

Low Span Rectification

The program of work is driven by the recognition of appropriate ground clearance applicable to low spans, targeting low spans deemed high risk using AusNet's procedure for probability of flashover.

AusNet's assessment and analysis of the probability and consequence of flashover across the transmission network found 80[3] spans requiring targeted engineering solutions and project interventions during the TRR Period 2027-2032.

These actions are necessary for appropriate management of risk to community and landowners, ongoing compliance with standards, policies, and regulatory. Further details on the low span rectification by circuit can be found in Appendix C.

3 VicGrid's VTP identified BATS-MLTS #1 220kV line rebuild removes 18-spans from the Program of Works, decreasing the number of spans from 98 to 80-high risk spans.

8. Asset Strategies

8.1. New Assets

- All newly installed conductors are designed and constructed in accordance with current industry guidelines and standards (AS/NZS 7000).
- Replace steel/ACSR ground wires with OPGW where required for communication purposes.
- Install AAAC in area subjected to extreme corrosivity to strive for maximum life. AAAC is more corrosion resistant than ACSR.
- Install customised support structures to elevate transmission spans to meet clearance standards under AS/NZS 7000.

8.2. Inspection and Monitoring

- Continue improving the SAIP technology to assess the condition of conductor
- Fully establish the routine condition assessment program in terminal stations for overhead assets
- Continue improving the existing transmission line inspection regime as outlined in LPP 09-01 and LPP 09-06.
- Continue forensic analysis of removed defective/poor condition conductor to maximise learnings
- Regularly assess low span risk and update assessments based on operational changes, including:
  - Inspect and monitor identified low spans, through LiDAR assessments every three years,
  - Leveraged land use database to reassess and mitigate risks for spans where higher risk activities occur.

8.3. Maintenance

- Replace or repair defective conductor and ground wire assets as part of corrective maintenance tasks.
- Manage the transmission line ground clearance in line with REF: AMS 10-75-21.

8.4. Replacement

- Replace poor condition steel ground wire covering 138 km on various circuits
- Replace underrated steel ground wire covering 149 km on various circuits
- Retension, install floating strain insulators, or replace existing towers with new structures to bring clearances above the minimum required by AS/NZS 7000 standards on various circuits

9. References

NO.	TITLE
1	LPP 09-06: Condition Assessment of Overhead Lines
2	01-09 Risk Overview
3	LPP 09-01: Condition Assessment of Overhead Lines
4	AMS-10-75-21 Line Clearance
5	REF: *ANT – TRR 2028-32 Asset Replacement Economic Model –Transmission Line- Ground wire condition based replacement– Final*
6	REF: *ANT – TRR 2028-32 Asset Replacement Economic Model –Transmission Line -Ground wire rating based replacement – Final*
7	REF: *ANT – TRR 2028-32 Asset Replacement Economic Model –Transmission Line- Ground Clearance – Final*

10. Schedule of Revisions

ISSUE NUMBER	DATE	DESCRIPTION	AUTHOR	APPROVED BY
0	06/10/2008	First publication	[C.I.C]	[C.I.C]
0.1	04/03/2009	Review and update	[C.I.C]	[C.I.C]
0.2	16/11/2012	Review and update	[C.I.C]	[C.I.C]
1	15/12/2012	Review and update	[C.I.C]	[C.I.C]
2	25/08/2015	Review and update	[C.I.C]	[C.I.C]
3	29/07/2020	Review and update	[C.I.C]	[C.I.C]
4	30/06/2025	Review and update	[C.I.C]	[C.I.C]

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Appendices

Appendix A – Corrosivity Zones on The Victorian Transmission Network

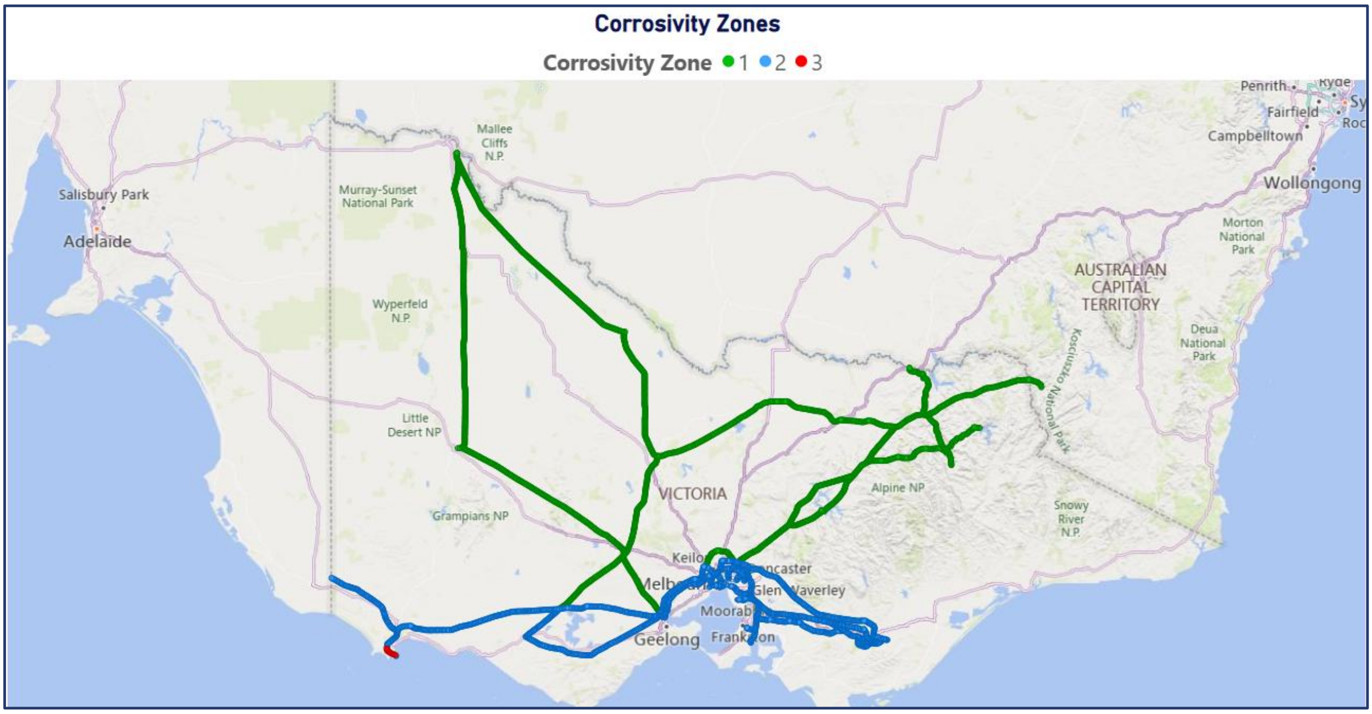


Table 12: Corrosivity Zones

Appendix B – Bushfire Consequences on the Victorian Transmission Network

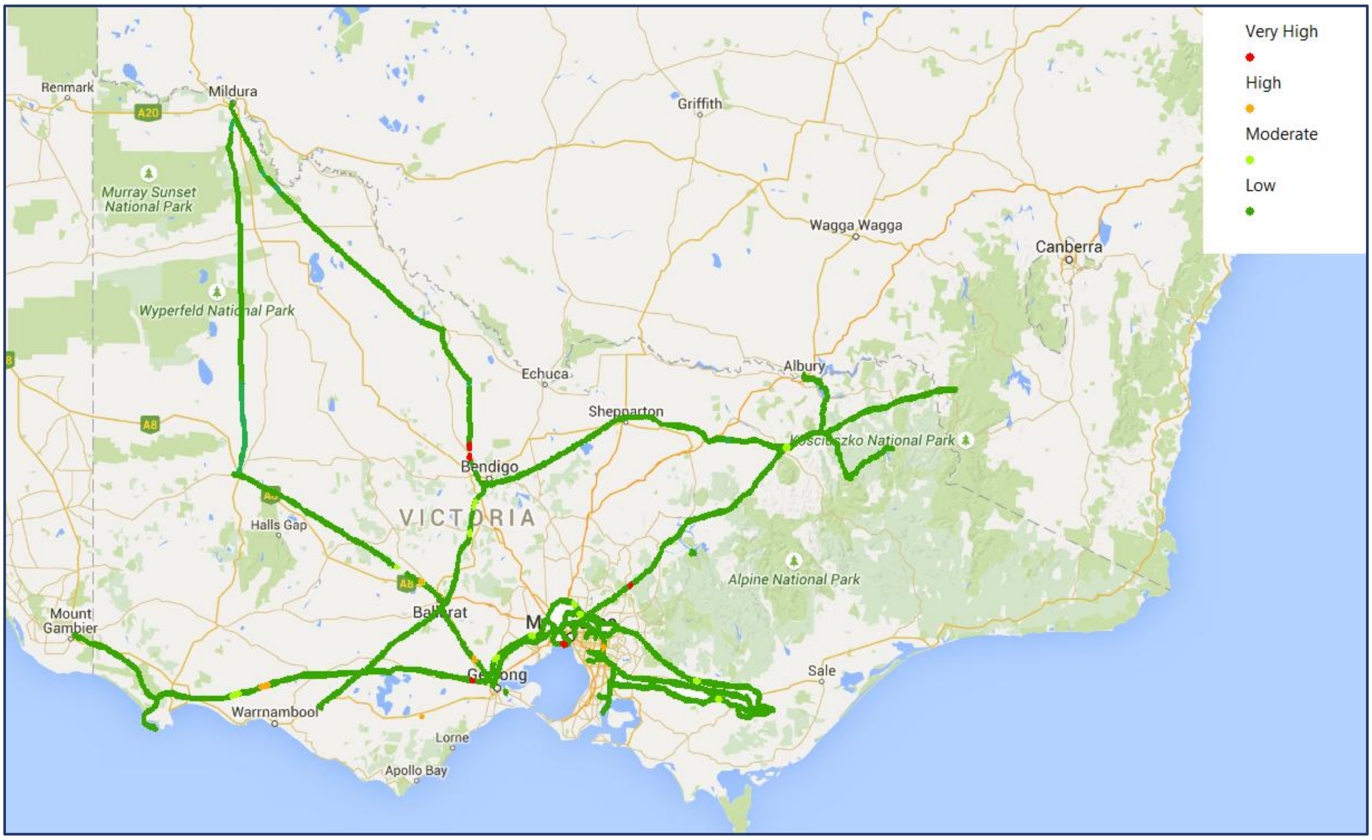


Figure 13: Bushfire Consequences on Victorian transmission network

Appendix C – Ground Clearance (Low Spans)

History

The 1954 version of the Energy Networks Australia (ENA) C(b)1, 'Code of practice for overhead line construction' published by the Electricity Supply Association of Australia (ESAA) specified a ground clearance for 220kV lines of 25 feet or 7.6m. This clearance requirement has remained unchanged in subsequent versions of ENA C(b)1 and matches published SECV and AusNet design guidance. All SECV and AusNet 220kV lines have been installed with a design clearance of 7.6m.

The early lines on AusNet's network were designed for a maximum operating temperature of 49°C (120°F). This was based on contemporary design practice in England. Higher ambient temperatures in Victoria meant that the 49°C conductor temperature limit was reached at lower operating line loads than would be the case in a cooler climate, leaving a gap between the intended and realised capacities for these early lines.

At some stage between the late 1950s and early 1960s this issue was addressed by re-rating the line for operation at 65°C (150°F). This was achieved by permitting reduced ground clearances of 22 feet or 6.7m. These lower limits are reflected in existing Energy Safe Victoria (ESV) statutory clearance limits. At the time almost all lines were uprated to 65°C. The exception is the Kerang to Redcliff's line which presumably already had low clearances and could only be up rated to 55°C.

Prior to the mid-1960s, new lines were constructed with a 7.6m clearance at 65°C. Following this period, 220kV lines were generally built for a 7.6m clearance at 82°C (180°F), and more recently, at 90°C.

As a result, AusNet has a legacy of lines with ground clearances below what could be considered industry practice in other parts of Australia. In December 2010, the ESV clearance regulations (ESV, 2005) were withdrawn, removing the statutory endorsement of these clearances. In 2010 the new Australia and New Zealand overhead line design standard, AS/NZS 7000, was released, establishing 7.5m as the 220kV clearance benchmark.

The electrical safety management scheme (ESMS) which replaces the repealed ESV regulations as the governing compliance regime, will default to reference the Australian and New Zealand standard as the base standard for compliance for new lines.

Probability of Flashover

AusNet has modified a tailored repeatable methodology to calculate the annual probability of flashover (Pof) for any span within its transmission network. This methodology estimates the likelihood of electrical discharge between a bare conductor and a conductive object beneath it, such as a vehicle or structure, under maximum operating temperature (MOT) conditions.

The equation incorporates key variables including actual conductor height at MOT, the applicable clearance standard (AS/NZS 7000), line voltage (with a conservative buffer), land use classification, and the height and frequency of traversing objects.

The procedure involves the calculations from the *Electricity Networks Association, ENA C(b)1 – 2006* found in *Appendix G: Risk Management of Conductor Clearance*.

Figure 14 illustrates the general arrangement and relevant information required for the analysis, where Pof = Pf.

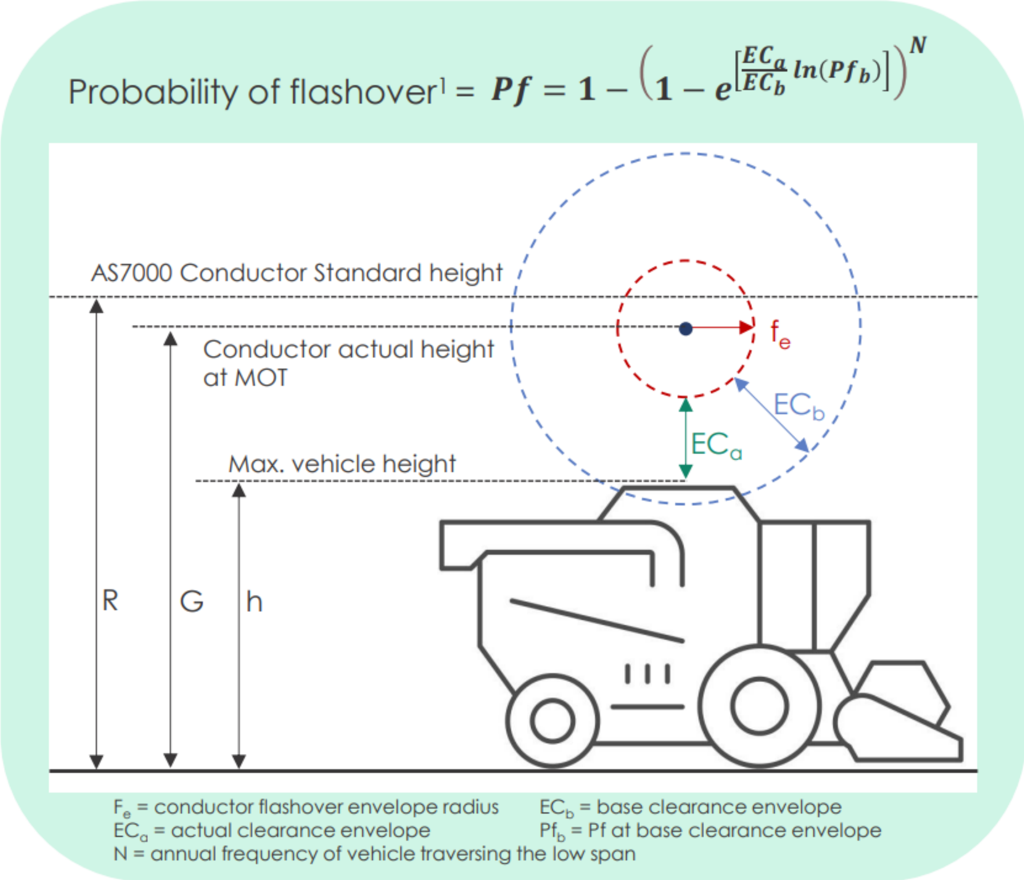


Figure 14: Probability of flashover illustration

By applying this probabilistic model, adapted from the Energy Networks Australia guidelines and validated through peer review, AusNet can objectively determine the level of risk posed by each span. This enables prioritisation of mitigation strategies based on safety impact, cost effectiveness, and regulatory compliance, ensuring that resources are directed where they are most needed.

Derivation of Annualised Probability of Flashover (Pf)

The probability of flashover per crossing event, Pf" is determined as per the formula below:

$$Pf = e^{\left[\frac{EC_a}{EC_b}\ln(Pf_b)\right]}$$ **Formula 1**

and

EC_a = Actual envelope clearance) = G – h –f_e **Formula 2**

EC_b = Base envelope clearance) = R - h – f_e **Formula 3**

Where:

Pf = Probability of flashover, per crossing event

Pf_b = Probability of flashover, at base clearance

G = Actual ground clearance of bare aerial conductor (m)

h = Base height of exposure group, e.g., harvester height, golf cart height, height of a person with arm extended upwards, etc. (m)

f_e = Conductor flashover envelope radius, specific to the line voltage (m)

= this is the distance away from the conductor where a well grounded, sharp, copper object would be expected to flash at around 50% of the occasions at which it was inserted towards the conductor.

R = Road or Ground clearance for bare aerial conductors, i.e., Table 3.5, AS/NZS 7000 (m)

To incorporate the annualised probability of flashover into the above Formula 1, it is modified as below.

$$Pf = 1 - \left(1 - e^{\left[\frac{EC_a}{EC_b}\ln(Pf_b)\right]}\right)^N$$ **Formula 4**

Where:

N = Number trials, i.e., number of times the span is traversed by the critical exposed group (days)

Formula 4 is based on first determining the probability of not having a flashover over 'N' number of days and then subtracting this value from 1 to determine the probability of flashover over the same 'N' number of days.

Identification of required Ground Clearance at MOT

Use Table 3.5 Min Clearance from Ground, Lines other than Insulated Service Lines, *AS/NZS 7000: Overhead line design – Detailed procedures* to identify the required ground clearance of the span at maximum operating temperature (MOT).

Specific reference is to be made to the point where the lowest distance between the ground and conductor exists.

Note: The term 'ground' includes any vegetation, infrastructure, and any temporary structure or stockpile under the span, e.g., haybales, dumping of items, etc.

The required ground clearance is dependent on the nature of the land. Whether it is traversable or not. AusNet included 'accessibility' of the land to vehicles in the analysis as this is a crucial part in the risk assessment.

Note that with the introduction of a land management system that will regularly monitor the land use and landownership, the information of accessibility and vehicle height used in the easement will be used effectively in the risk assessment.

Traversability and Vehicle Height

AS/NZS 7000 infers traversable land is where a vehicle higher than 3m can drive along the land considering its terrain, topography, swampiness and steepness.

The following table summarises the required ground clearance at maximum operating temperature, R, at various voltages, based on the traversability.

TRAVERSABILITY	VOLTAGES		
	66 kV	220 kV	330 kV
Traversable	6.7m	7.5m	8m
Non-Traversable	5.5m	6m	6.7m

Table 11: Ground clearances at maximum operating temperature (R)

The Land Management Team of AusNet has contacted and engaged the landowners identified with low spans on their properties, to understand the land use and vehicle types traversing the easement.

The analysis considers whether the land where the ground clearance infringement occurs provides access to a vehicle higher than 3m, and if the terrain type, vegetation and ground slope makes it possible for such a vehicle to traverse the land. For sites which are traversable by vehicles greater than 3m in height, the actual height of vehicle is used as the base height of critical exposure group.

For sites which are traversable by vehicles up to 3m, the base height of critical exposure group is 3m. For example, sites which are located on Crown land, vehicle heights will be taken as 3m given that anything higher will not be able to access the site which would be unmaintained and uneven.

For non-traversable land, the base height of the critical exposure group will be 2.6m, i.e., this represents a person standing with arms extended up.

Based on discussions with the various landholders, these are the heights used in the analysis:

- Crop Farming – 4.8m[4]
- Industrial – 4.8m
- Carriageway of roads - 4.6m (legal to use in Victorian roads w/out a permit)
- Commercial – 4.3m
- Crown land – 3m
- Mixed Farming / Farming (Cattle, Hobby, Horse) – 3m
- Residential – 3m
- Non-traversable/ not accessible for vehicles – 2.6 m

Understanding Frequency of travel under the span, N

The probability of flashover considers the number trials, i.e., number of times the area is frequented by the critical exposed group (CEG). For the various land uses involved in the cohort, the average number of times these are frequented in a year is given below:

- Carriageway of road – 365 days
- Mixed Farming / Farming (Cattle, Hobby, Horse) – 104 days
- Residential – 104 days
- Non-traversable/ not accessible for vehicles – 28 days
- Industrial – 24 days
- Crop Farming – 20 days
- Commercial – 8 days
- Crown land – 4 days

Where the site specific information in known, this have been used in the analysis.

Identifying the Over-voltage for Analysis

The over voltage dictates the applicable conductor flashover envelope radius, fe, to be used in the context of flashover to the critically exposed groups (CEGs) passing underneath the span for their climatic environment and system environment.

Three over voltage levels can be used in the analysis, in order of increasing levels: 1) maximum voltage level which is usually 10% over nominal voltage of the a.c. voltage level; 2) maximum switching surge voltage; or 3) the lighting surge withstand voltage.

In the context of AusNet's network, it is deemed highly unlikely that members of the CEG will be passing underneath the span during a storm event that could result in a lightning strike along the line.

Likewise, the probability that a member of the CEG will pass under the line during maintenance works is remote, i.e., on average, maintenance works along the transmission network is less than ten times a year, so the outage rate for Planned work is approximately 0.027 (i.e., 10 / 365).

As the analysis will involve the annual probability of a flashover, the appropriate voltage to use is the maximum a.c. system voltage, i.e., 10% over voltage of the nominal line voltage, because this is the most probable fault scenario when a vehicle traverses under the span.

Referring to Table 3.1 of *AS 2067: Substations and high voltage installations exceeding 1 kV a.c.*, the over voltage values to be used for the calculations are:

---

[4] There is one exception to this height along T200-201 BATS-BETS, where the landowner uses an irrigator that is 5.5 metres high.

- For 66kV: 72.5 kV r.m.s.
- For 220kV: 245 kV r.m.s.
- For 330kV: 362 kV r.m.s.

Determine conductor flashover envelope radius, fe

The flashover envelope radius, fe is the region required to provide electrical insulation at a specified voltage level. This region is identified by the distance away from the conductor wherein a well grounded, sharp, copper object would be expected to flashover 50% of the time it was inserted. The value depends on the voltage and lightning strike potentials, including atmospheric conditions.

For the case study in Appendix G of ENA C(b)1 and as appropriate for this analysis using a 10% over voltage, formula G.3 from *IEC 60071-2: Insulation co-ordination Part 2: Application Guide, Section G.2 Insulation response to slow-front over voltages* was used to calculate this distance.

U_{50RP} = 1080 ln (0.46*d +1) ***Formula 5***

In the above formula, substitute the over voltage value (U_{50RP}) from Step 4 for each respective normal operating voltage and then solve for the value "d" which will be in metres. The value of d obtained is the flashover envelope radius (i.e., d = fe).

The values calculated for d = fe, for 66kV, 220kV and 330kV are below:

- fe for 66kV: 0.151m
- fe for 220kV: 0.553m
- fe for 330kV: 0.865m

These values will be used in the succeeding sections to determine the EC_b and then EC_a.

Probability of Flashover at Base Clearance, Pfb and Corresponding Envelope Clearance, Ecb

The probability of flashover for the base clearance envelope is determined as per the methodology proposed in Section G8 of Electricity Networks Association, ENA C(b)1 – 2006 Appendix G.

Pf_b is determined by first assigning an arbitrary probability for the base clearance envelope that gives a trivial risk (3×10^{-7}) at AS/NZS 7000 ground clearances in Step 1 above. It is assumed that the trivial risk is based on vehicles up to 4.6m (maximum legal height for a class O vehicle in Victoria) that will pass underneath the line 365 days a year.

For non-traversable spans, it is assumed that the trivial risk is based on a person standing up with arms extended, 2.6m, walking underneath the line 365 days a year.

Pf_b is determined by solving Formula 4 above with:

- Pf = 3×10^{-7}
- ECa = ECb (i.e. G= R in Formula 2 and 3 above)
- N = 365

$$3 \text{ x } 10^{-7} = 1 - \left(1 - e^{[\ln(Pf_b)]}\right)^{365}$$

This results in a Pf_b of $8.2192e^{-10}$. The corresponding EC_b values are determined by Formula 3 above.

The following table summarises the EC_b values for traversable spans that corresponds to Pf_b of $8.2192e^{-10}$.

	VOLTAGES		
	66 kV	**220 kV**	**330 kV**
Road clearance / Ground clearance – NZS/AS 7000 (R)	6.7m	7.5m	8m
Base height of exposure group (h)	4.6m	4.6m	4.6m
Conductor flashover envelope (Fe)	0.151m	0.553m	0.865m
ECb (R - h – fe)	1.949m	2.347m	2.535m

Table 12: ECb values for traversable where Pfb is 8.2192e-10

Similarly, the following table summarises the EC_b values for non-traversable spans that corresponds to Pf_b of $8.2192e^{-10}$.

	VOLTAGES		
	66 kV	**220 kV**	**330 kV**
Road clearance / Ground clearance - NZS/AS 7000 (R)	5.5m	6.0m	6.7m
Base height of exposure group (h)	2.6m	2.6m	2.6m
Conductor flashover envelope (F_e)	0.151m	0.553m	0.865m
EC_b (R - h - fe)	2.749m	2.847m	3.235m

Table 13: ECb values for non-traversable where Pfb is 8.2192e-10

Calculate the Actual Clearance Envelope Clearance, ECa

Determining the actual envelope clearance, ECa, that corresponds to the actual ground clearance, G, with the Formula 2 above using the vehicle height traversing the site based on land use in *5.1.2 Traversability*, and conductor flashover envelope, f_e, from *5.1.1.5 Conductor flashover envelope radius*, above.

Probability of circuit operating at Maximum Operating temperature

The required data was substituted into **Formula 4** to obtain the probability of flashover, Pf, at the specific ground clearances and number of times the area is frequented by the critical exposed group.

Levels of Risk Acceptability

AusNet adopted the ENA "Levels of Risk Acceptability Framework" to support a structured and intuitive approach to managing low span risks. This framework helps align PoF results with appropriate risk mitigation actions. The diagram below illustrates how PoF outputs correspond to different levels of risk acceptability, guiding decisions on the most suitable methods for reducing risk.

By applying this model, AusNet can meet safety requirements while effectively implementing "As Far As Practical" principles. The visual representation shows how risk levels transition from acceptable (green) to high (red), helping prioritise actions based on risk severity and regulatory obligations.

ENA C(b)1 Levels of Risk Acceptability Triangle		Actions to take	Examples
Risk should be eliminated	**High** >10,000-year event	**ACTION TO REDUCE RISK BY INCREASING GROUND CLEARANCE** Apply the most cost-effective engineering solution[2] that will reduce the risk level to at least Negligible or Trivial	**Example 1: Crop Farming** (T200-201 BATS-BETS 220KV) • Probability of flashover = 4.17×10^{-2} • Therefore, risk level is high • Proposed action – reduce risk to negligible or trivial
Limit for HSE UK, Royal Soc. UK	**1×10^{-4}/yr**		
Risk tolerable if reduction is impractical or cost is grossly disproportionate to the improvement gained (AFAP principle)	**Tolerable** <100,000-year event	**APPLY A COST BENEFIT ANALYSIS TO DETERMINE APPROPRIATE ACTION IN LINE WITH AFAP** • See next slide for more information • Apply controls to AFAP	**Example 2: General Farming** (T012-013 YPS -ROTS 5 220KV) • Probability of flashover = 1.66×10^{-6} • Therefore, risk level is assessed as tolerable • Proposed action – move to step 3 cost benefit analysis and apply controls to AFAP
Objective for NSW DoP, HSE UK, Royal Soc. UK[1]	**1×10^{-6}/yr**		
Broadly acceptable	**Negligible** <1,000,000-year event	**MONITOR AND CONTROL** • Apply controls to AFAP • Monitor ongoing risk and action if situation changes • Incorporate engineering solutions into planned future capex programs where relevant	**Example 3: Residential** (T316-317 DDTS-SHTS 220KV) • Probability of flashover = 3.05×10^{-7} • Therefore, risk level is assessed as trivial • Proposed action – apply controls to AFAP, monitor ongoing risk and action if situation changes
	3×10^{-7}/yr		
Acceptable	**Trivial** <30,000,000-year event		

Table 14: Risk Acceptability Triangle

The risk levels for the 1,717 spans are shown below, with 114 high risk spans requiring immediate mitigation, while 461 spans have been classified as tolerable risk and will be monitored. The remaining spans pose negligible risk and will continue to be managed through routine asset practices. This prioritised approach directs resources where they are most needed, supporting regulatory obligations and public safety.

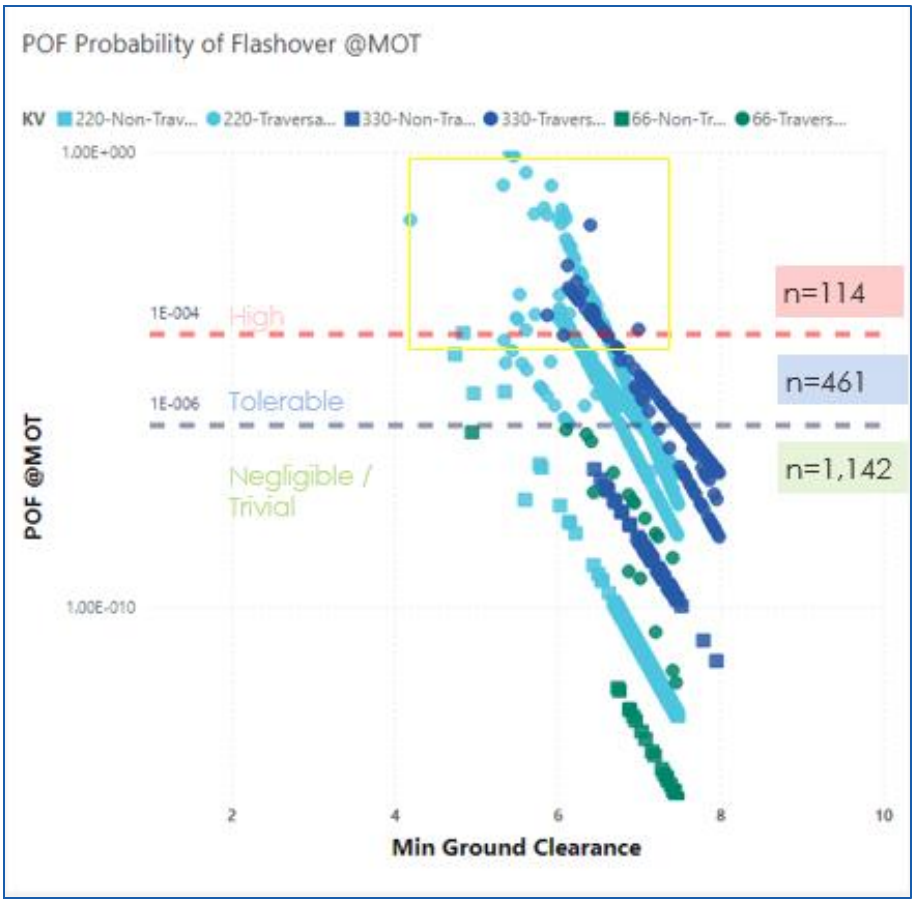


Figure 15: Level of risk acceptability outcome

10.1.3. Acceptable Risk

In the Negligible and Trivial Risk (Green) category, the probability of flashover is extremely low, less than 1 in 1,000,000 per year for Negligible risk, and less than 1 in 30,000,000 per year for Trivial risk. These thresholds align with the objectives set by the HSE UK, Royal Society UK, and the NSW Department of Planning. In this zone, the risk is considered broadly acceptable, and immediate mitigation is not required. However, ongoing monitoring remains important. Controls will still be applied where practical, particularly if they can be integrated into planned Capital Works Programs. The focus is on maintaining awareness of the risk and ensuring that it remains within acceptable limits over time.

10.1.4. Tolerable Risk process

In the Tolerable Risk (Blue) category, the probability of flashover falls below the threshold of 1 in 10,000 per year, which is considered tolerable under certain conditions. In this zone, the risk is not immediately unacceptable, but mitigation is still expected where it is reasonably practical. The guiding principle is that risk should be reduced as far as practical (AFAP), unless the cost of doing so is grossly disproportionate to the benefit gained.

A Cost Benefit Analysis (CBA) is essential in this context to determine whether further mitigation is justified and, if so, what form it should take. For example, in the case of general farming under T012–013 YPS–ROTS S 220kV line, the probability of flashover is approximately 1 in 6,000. This places it within the tolerable range, prompting a BCA to assess and apply appropriate controls in line with AFAP principles.

10.1.5. Unacceptable Risk process

In the High Risk (Red) category, the probability of flashover exceeds the tolerable threshold of 1 in 10,000 per year, as defined by regulatory benchmarks such as those from the HSE UK and the Royal Society UK. In these cases, the risk is deemed unacceptable and must be actively mitigated. A BCA is still required however, its role is not to determine whether mitigation should occur, but rather to identify the most economic and effective strategy for reducing the risk to a Trivial or Negligible level.

In summary, the decision to act is already made, what remains is to determine how best to implement that action.

Project to address Priority Sites: From the 114 high risk spans, 16 spans have been identified as Priority sites because these spans have a ground clearance below 6 metres at MOT and are located at Traversable sites. A project has been created to address these spans starting in 2026.

Cost Benefit Analysis

When evaluating asset management investment options, AusNet conducts a benefit cost analysis to determine whether the expected benefits justify the associated costs. This method is typically applied regardless of the outcome of the initial risk assessment.

Adopting the framework recommended by the ENA, sites whose risks are assessed as intolerable (i.e., those falling within the red zone) must be addressed and prioritised. In such cases, engineering action is required to mitigate the risk. Cost benefit analysis is then applied to identify the most economic risk reduction option or strategy.

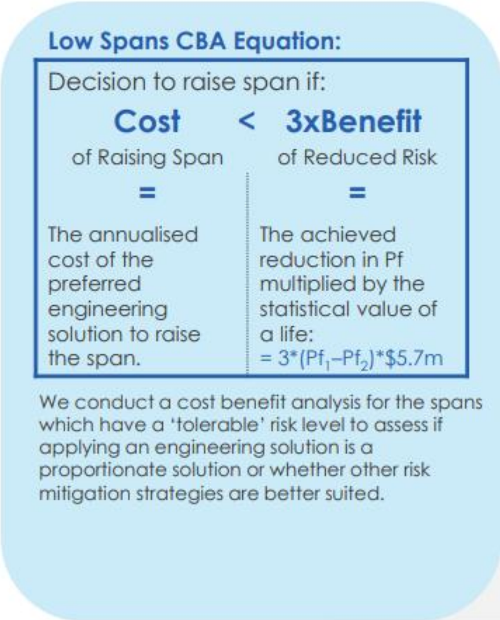
10.1.6. Cost Benefit realisation/extrapolation

Following the classification of risk into High, Tolerable, and Negligible or Trivial categories, AusNet applies a structured cost benefit formula to determine the most appropriate mitigation strategy. This analysis assesses whether span raising is a proportionate response when compared to other available risk reduction measures, such as re-tensioning the span or replacing existing towers with taller structures.

The benefit of mitigation is calculated by subtracting the reduction in the PoF achieved by the assessed mitigation effort (i.e., the difference between the initial and reduced PoF) with the economic consequence of a flashover under a worst case scenario. In line with industry standards, AusNet assumes the worst case consequence to be a human fatality, applying the Australian Government's value of a statistical life, currently set at $5.7 million. To reflect the serious safety implications of such events, a disproportionality factor of 3 is applied, consistent with accepted practice for risks involving potential single fatalities. This consequence based approach aims for grounded decision making in the potential for severe outcomes, using established economic proxies: $5.7 million for a Death or Severe Injury (DSI), and $225,000 for a Lost Time Injury (LTI), both in 2024 dollar terms. $5.7 million for a Death or Severe Injury (DSI), and $225,000 for a Lost Time Injury (LTI), both in 2024 dollar terms.

These figures are sourced from Australian Government and Safe Work Australia guidance[5] and are used to quantify the societal cost of safety incidents. For low spans, where the primary hazard is electrical flashover due to insufficient ground clearance, these values are critical in determining the cost of consequence.

This framework enables mitigation decisions to not only technically sound but also economically justified and socially responsible.



$$\textit{Benefit} = 3 * (Pf_1 – Pf_2) * \$5.7m$$

Appendix D - Proposed Program

Condition Based Replacement

Line Name	Voltage (kV)	Length (km)
BGTS-CWTS	220	2.18
BLTS-KTS 1	220	5.89
CBTS-ERTS-LYD	66	11.30
CBTS-TBTS 1	220	21.60
DC-TSTS	66	1.41
DDTS-SHTS	220	0.95
DDTS-SMTS 1	220	1.08
DDTS-SMTS 2	220	8.04
ERTS-ROTS 1	220	0.50
HWPS-HWTS 2	220	2.80
HWPS-HWTS 3	220	1.72
HWPS-ROTS 1	220	19.49
JLTS-MWTS 1	220	0.09
KMTS-RCTS	220	1.13
MLTS-TGTS	220	1.05
ROTS-YPS 7	220	43.36
RWTS-TTS	220	14.17
YPS-YWPS 1	220	0.20
YPS-YWPS 3	220	0.56
YPS-YWPS 4	220	0.06
Grand Total		**137.58**

Ratings Based replacement:

Line Name	Voltage (kV)	Length (km)
CBTS-FTS 1	66	6.25
DDTS-SHTS	220	6.54
DDTS-SMTS 1	220	12.95
DDTS-SMTS 2	220	12.51
DPTS-GTS 2	220	6.63
EPS-TTS 1	220	4.76
ERTS-ROTS 1	220	3.44
HWPS-HWTS 1	220	0.26
HWPS-HWTS 2	220	7.09
HWPS-HWTS 3	220	5.77
HWPS-JLTS 1	220	0.82
HWPS-ROTS 1	220	12.93
KTS-GTS 1	220	6.40
KTS-WMTS	220	6.30
MSS-DDTS 1	330	9.99
ROTS-MTS 1	220	6.44
ROTS-RTS 1	220	9.77
ROTS-YPS 7	220	11.37
TTS-KTS 1	220	6.37
TTS-KTS 2	220	10.26
YPS-YWPS 1	220	1.75
YPS-YWPS 2	220	0.12
Grand Total		**148.69**

Low Span Rectification

LINE NAME	220KV	330KV	GRAND TOTAL
MSS-DDTS No.1		23	23
MSS-DDTS No.2		9	9
DDTS-SMTS No.1		2	2
KTS-ATS	1		1
DDTS-SHTS	2		2
SVTS-HTS No.2	1		1
WETS-RCTS	1		1
YPS-ROTS No.8	4		4
DPS-MBTS	1		1
KTS-GTS No.3	1		1
DPTS-GTS 2	1		1
BATS-BETS	9		9
RWTS-TTS L	1		1
EPS-TTS R	12		12
SHTS-BETS	3		3
GNTS-SHTS No.1	1		1
TTS-KTS No.1	1		1
HWPS-HWTS No.3	1		1
YPS-ROTS No.6	4		4
HWPS-ROTS No.1	1		1
HWPS-ROTS No.2	1		1
Grand Total	46	34	80

Aerial Map - Location of Low Spans

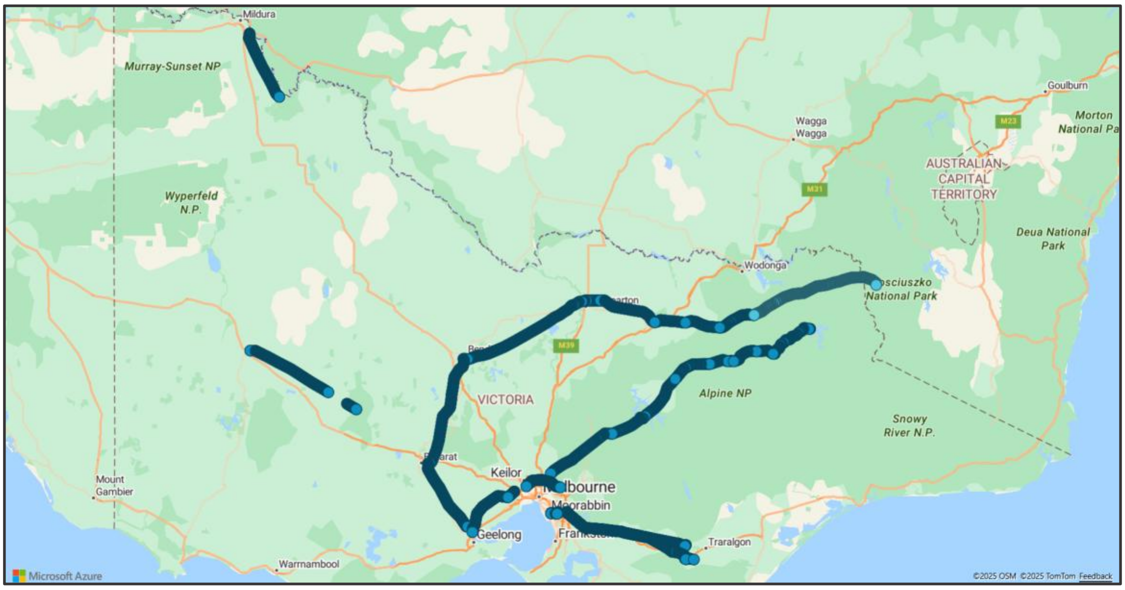


Figure 16: Low span map

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