AER Information Request

2025-30

Part of Energy Queensland

Reference	Root Cause Analysis	**Date**	September 2024
Attachments to response	N/A		

QUESTIONS:

There are two questions relevant to this response:

- Evidence of root cause analysis or working with us to unpack the pole defect data provided to us to identify the underlying concerns driving the investments (that is, poles, ex-ante pole top replacements, reliability driven programs, etc).
- Evidence of defect concerns with the pole population in a specific location such as the Western region which was informally raised with us late in the assessment process (late August)

RESPONSES:

Background

Over many years, Ergon Energy has completed and continues to complete activities that monitor the quality of inspection practices, inspection results and to determine appropriate methods of managing its assets within the different financial and resourcing constraints at different times.

One of the key indicators over time has been the Code of Practice Works requirement to achieve a 3 year moving average of 99.99% reliability for poles. That is, approximately 97 unassisted pole failures per year. The trend of unassisted pole failures is shown in Figure 1.

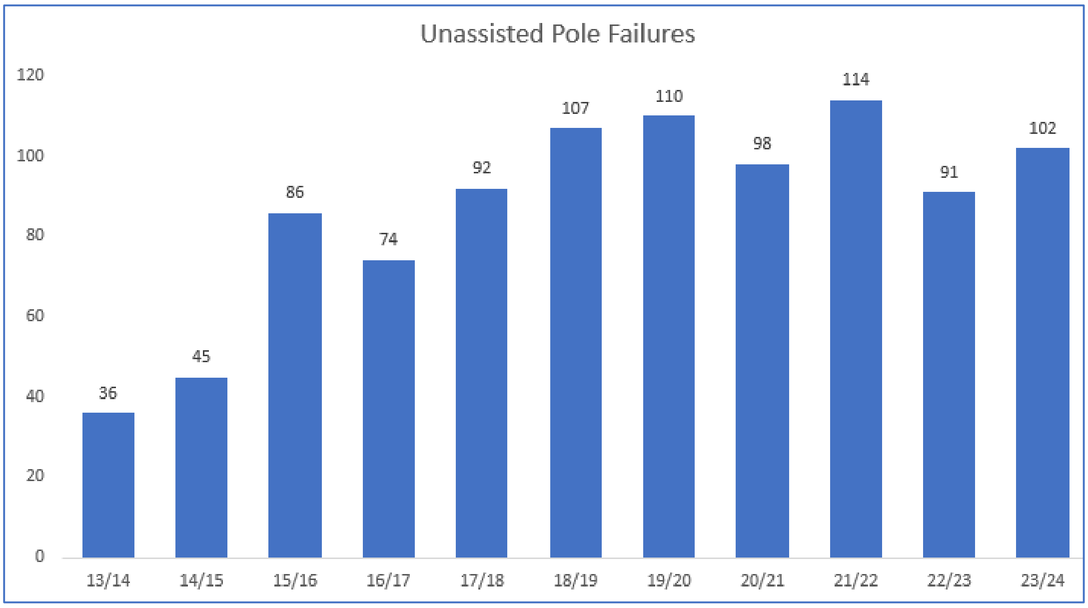


Figure 1 – Unassisted Pole Failures

It can be noted that:

- Reported unassisted pole failures were very low through to 2017/18 and well below Code of Practice requirements.
- Volumes for 15/16, 16/17 and 17/18 have been backcast based on current criteria (i.e. inclusion of storm related failures where significant wind speeds or direct lightning strikes did not occur)
- Unassisted pole failure annual volumes went above the threshold in 2018/19 and has consistently been above the 3 year rolling average since then

As shown in Figure 2, historical pole replacements were very low from the period from 2002/03 through to 2016/17, with an average of about 3,500 poles replaced over this period. When considering the accepted life of a pole of 50 years, let alone 75 year or 100 year lives, this average replacement rate is well below the notional replacement rate required to manage the asset effectively. It is thought that the under expenditure in pole replacements over this period is a likely contributor to the increase in unassisted pole failures and the worsening performance.

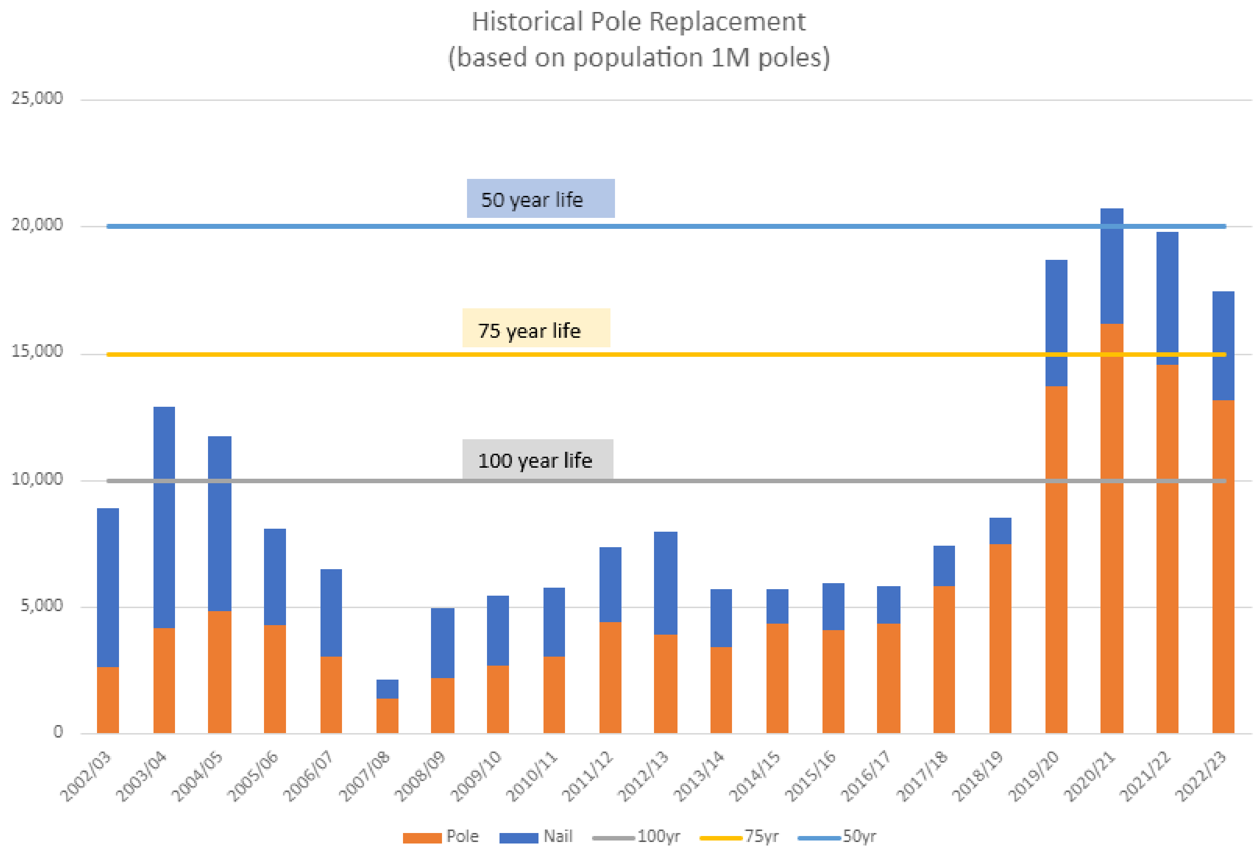


Figure 2 – Pole Replacement and Nailing

In 2017/18, new contracts were established and a focus on training/retraining commenced to ensure the pole inspectors were identifying unserviceable poles correctly. This saw a small increase in the unserviceable poles identified.

Also in 2017/18, changes were made to the pole nailing criteria on the back of safety concerns raised by operational staff and supported by the relevant Unions. This also contributed to the increased ratio of pole replacement to pole nailing from 2017/18 onwards.

In 2018/19, significant analysis, research and risk assessments were completed due to the concerns surrounding field crews working on low strength poles (i.e. ≤5kN) and the increasing failure rate of this size of pole. This led to significant changes being made to the pole serviceability calculations and a range of other components of the asset management approach for low strength wood poles.

After these changes were implemented in April 2019, there have been a number of initiatives and ongoing business as usual activities undertaken to review and monitor the pole serviceability calculation results, ongoing pole replacement and nailing volumes and unassisted pole failure rates to ensure that a prudent solution is in place to manage the aging and deteriorating wood pole population in Ergon Energy. This includes:

- Unserviceable pole audit and process review
- Post implementation review of pole serviceability calculation results and impacts.
- Compliance auditing of pole inspections
- Unassisted pole failure investigations and post mortems
- Trials of non-destructive technologies for pole serviceability assessment
- Field validation of unserviceable poles
- Independent review of pole assessment and classification

The following sections detail the key activities and analysis undertaken prior to the pole serviceability calculation changes in 2018/19 and those that have been undertaken or are ongoing since that time.

Events Prior to 2019/20

Implementation of Variable Cycle Inspections 2013/14

In the AER final determination for the 2010-15 regulatory period, Ergon Energy received funding for an average 4.5 year cycle. Up until that point, Ergon Energy had a 4 year inspection cycle in place.

After analysis of asset populations, asset condition data, geographical influences, asset performance data and detailed risk assessments and consideration Queensland legislative requirements, the decision was made to implement 6 year and 8 year inspection cycles for specific subsets of the pole population. This included:

- Rural wood poles in low risk locations.
- Concrete poles.
- Steel poles that aren't direct buried.
- Steel lattice towers.

These changes effectively moved approximately 110,000 poles to a 6 or 8 year inspection cycle and resulted in an average inspection cycle of 4.5 years. These changes were implemented for the commencement of the 2014/15 financial year.

As a consequence of this decision, it also meant that defective poles and other defects could remain in service for an additional 2 or 4 years than they would have previously, which is somewhat evident in Figure 2. Modelling and risk assessments at the time assessed this to be a low risk given that the pole population was performing relatively well in terms of unassisted failures.

At the time of making this decision, the unassisted pole failure rates were particularly low and there was no evidence that low strength poles were an emerging issue. Unfortunately, many of the poles that were determined to be moved to a 6 year cycle were in lower risk rural locations, generally with low customer numbers and therefore smaller conductors, small tip load requirements and therefore installation of small poles – many of the low strength 3kN poles were therefore moved to an extended 6 year cycle. This decision, in part, has resulted in the increase in unassisted 3kN pole failures.

Pole Nailing Criteria Change

In May 2018, a modification was made to which poles could be nailed following feedback from operational staff and unions on safety concerns with regard to climbing aged poles with a small nominal working strength which had seen an increased number of failures during storm season.

The decision was made to cease nailing poles that met particular criteria about their strength (low), girth (small) and sound wood at ground line and these poles would instead be replaced.

The initial change involved manual process steps to modify the task on the work order from Nail to Replace. This was communicated via Operational Update T-1408 and later formalised and automated in the FMC Upgrade Project implemented in April 2019.

This contributed to the reduction in nailing rate seen in 2018/19 and the ongoing lower replacement to nailing ratio.

Low Strength Pole Analysis

In late 2017, concerns were raised after regular unassisted failures of poles with a nominal strength of less than or equal to 5kN WS. The concerns were driven from two perspectives:

- The safety of Ergon Energy operational staff who were required to perform work on these low strength poles.
- The increase unassisted failure rate and the implications on compliance with the legislative requirements described in the Code of Practice Works 2010.

Figure 3 shows the 3kN pole failures that occurred in each operational area over a 5 year period. This information clearly shows the increase in 3kN pole failures that occurred in 2017/18 which triggered the review of the management of low strength poles.

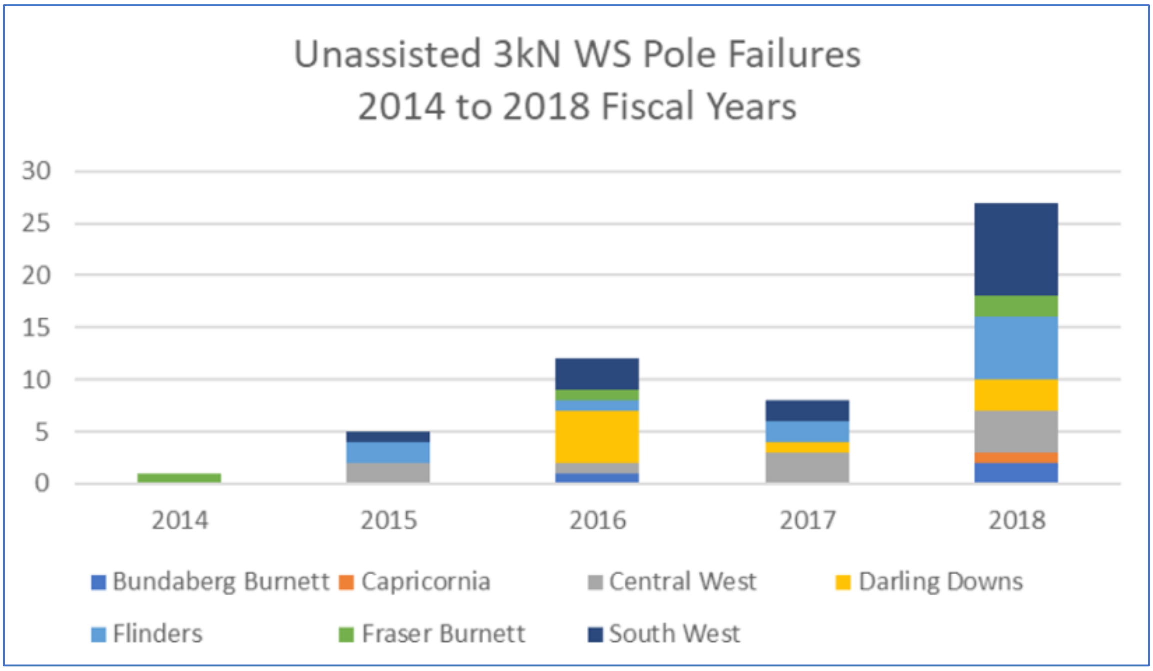


Figure 3 – Unassisted pole failure volumes of 3kN low strength poles 2014-2018

Unassisted 3kN pole failures have unfortunately remained high since this analysis was completed in 2018 as per Figure 4 below. 3kN poles account for approximately 24% of unassisted pole failures in this time which is very high for a population of 3kN poles that account for approximately 10% of the total pole population.

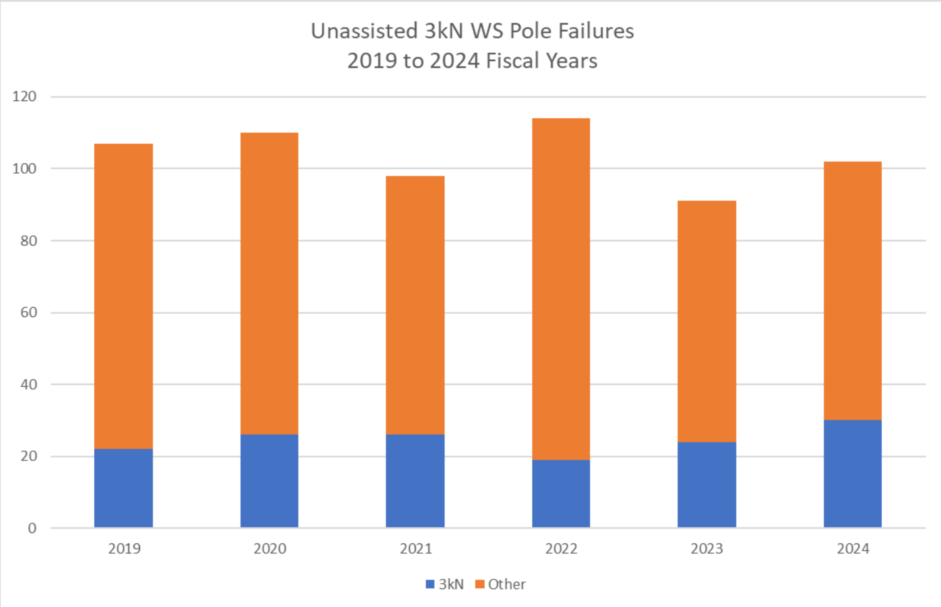


Figure 4 – Unassisted failures of 3kN poles 2019-2024

Figure 5 shows 2 of the 3kN unassisted pole failures that contributed to the review.

Central West: Aramac SWER poles failed during storms January 2018	
Pole 4130560	Pole 4140805
	

Figure 5 – Examples of unassisted 3kN pole failures

At that point in time, Ergon Energy had approximately 450,000 poles with a strength of less than or equal to 5kN. Approximately 115,000 of these were 3kN or less – approximately 12% of the pole population – which were installed over a 60 year period from 1957 to 2017 largely on the SWER network in western areas. 87% of these poles were installed between 1967 and 1987 meaning that the majority of these lower strength poles were aged in excess of 40 years in 2017.

Figure 6 shows the distribution of poles with a nominal 3kN and 5kN Working Stress (WS) strength across the Ergon Energy network in 2017. The greatest population of lower strength poles were located in the western areas of the state in wind region A, particularly in the South West and Central West areas.

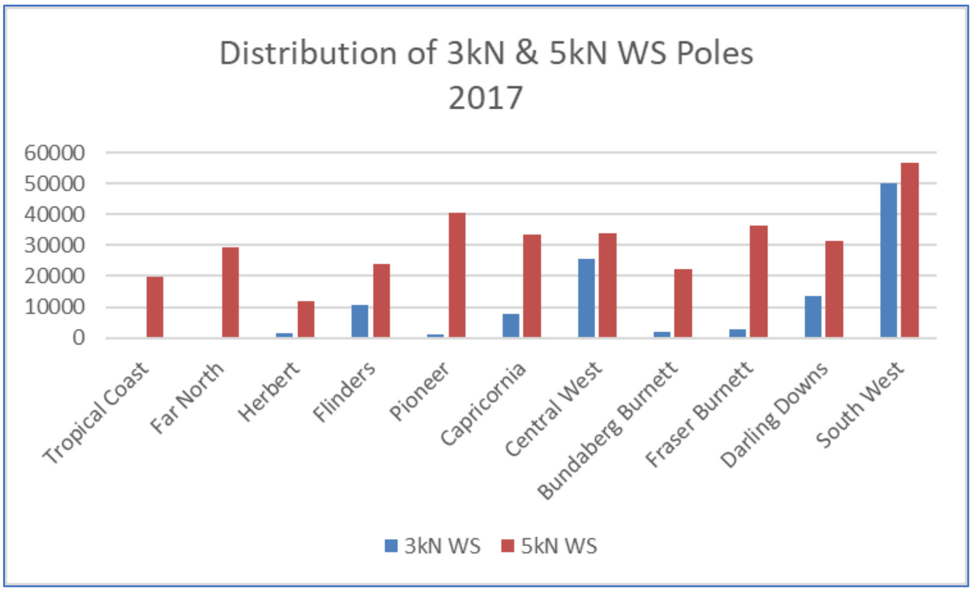


Figure 6 - geographical distribution of 3kN and 5kN poles

Based on analysis and investigation of pole failures, concerns were raised about the durability of these poles in dry areas, ability to withstand lightning strikes and identification of defects outside of the "normal" inspection zone where serviceability assessments are generally undertaken.

A working group was formed to perform a detailed analysis of this problem and to develop appropriate controls. Further detail on the risk assessment and actions taken to address the concerns are in Annex A.

Events Since 2019/20

Unserviceable Pole Audit and Process Review

In September 2019, as a response to an investigation into an unassisted pole failure in 2018 that was not replaced when deemed unserviceable in 2015, Ergon Energy initiated a:

- Reinspection of a random sample of 800 poles that had previously been identified as unserviceable.
- Complete review of unserviceable pole processes.

Due to the higher than expected (1.3%) volume of poles found not to have been replaced from the random sample, the decision was made to audit approximately 23,000 unserviceable poles from the previous 3 years to ensure appropriate actions had been taken and to rectify if they had not.

This process failing initiated internal and independent, external reviews of:

- EQL's systems relating to the management of defects.
- the risk classification and overall identification of US poles across Queensland; and
- recommendations with respect to EQL pole inspection and replacement programs.

Post Implementation Unserviceable Pole Impact Review

Analysis of 168,251 wood poles inspected from April 2019 to February 2020 was completed in 2020. The aim was to understand the predominant failure mode for every pole which failed the calculated serviceability thresholds. Poles were compared by pole structure and nominal working strength from the pole disc.

Figure 7 shows the percentage of the pole sizes inspected and the percentage of unserviceable poles per size. This shows that particularly for 3kN poles and unknown strength poles, the rate of unserviceability is high compared to the volume inspected.

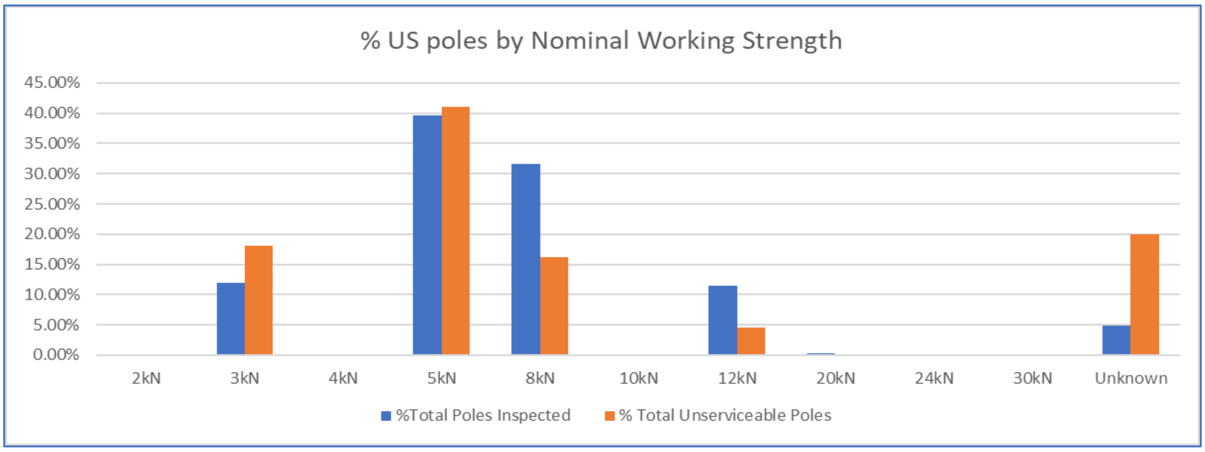


Figure 7 – Percent of US Poles by Strength

Figure 8 shows the numbers of poles which failed one or more of the three calculated serviceability thresholds, grouped by nominal working stress (WS) strength or pole structure:

- Minimum solid wood less than 30mm
- %Strength less than 100%
- Minimum calculated Limit State (LS) strength <5kN

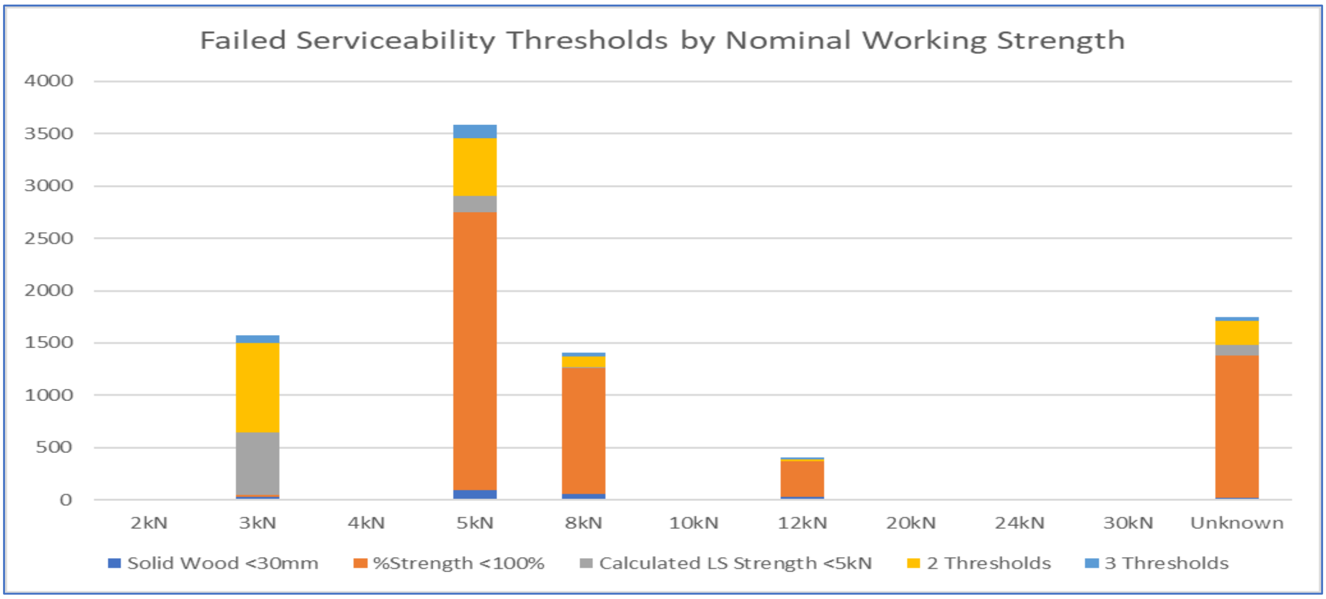


Figure 8 – Breakdown of reasons for failing serviceability

The following actions were completed and deployed in July/August 2020:

- The scenarios for a small number of specific pole structures were revised and recalculated to ensure that the required tip loads were refined and reflected appropriately to ensure that the correct poles were deemed to be unserviceable.
- Three additional structures with lower required loads were created to provide greater granularity:
    - Urban HV intermediate (span 60m)
    - Rural intermediate, span <100m
    - Light service pole (span 30m)
- Changes to the nailing criteria to allow the nailing of poles that failed the minimum strength criteria and had a calculated LS strength between 4.5 to 5.0kN (approximately 35% of unserviceable 3kN poles as shown in Figure 9) to enable increased nailing of 3kN poles.

Additional pole nails suitable for reinforcing the smaller diameter poles were introduced in August 2020.

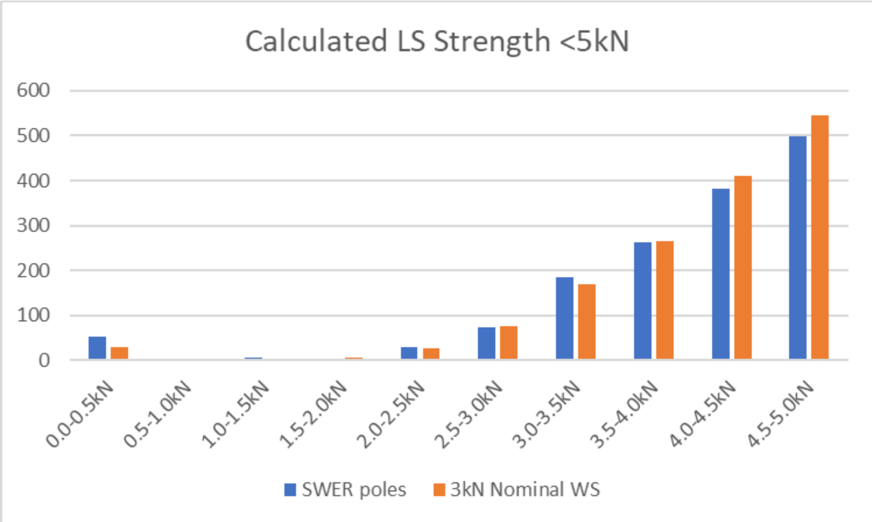


Figure 9 – Volume of SWER poles and 3kN nominal WS with a calculated LS strength <5kN

Inspection Auditing and Compliance

Ergon Energy has had an established auditing process for over 20 years to ensure the quality of pole inspection results and compliance to inspection standards and requirements.

Over the past 3 years, Ergon Energy has completed audits on 14,125 poles following their inspection. From these audits, the following non-conformances have been identified:

- 0.3% of pole inspections audited (40) had a pole attribute non-conformance (e.g. the inspector has recorded incorrect pole height, weakest point, girth measurement, solid wood measurement).
- 0.6% of pole inspections audited (90) had a pole structure non-conformances (i.e. the inspector has recorded the incorrect Pole Structure Type. This is selected using a logical series of questions to present a subset of Pole Structure Types to select from the initial set of 81.
- 0.5% of pole inspections audited (75) had "overcalled" defects (i.e. defects that the inspector raised that the auditor thought shouldn't have been raised OR defect raised at a higher priority than they should have been).
- 2.7% of pole inspections audited (383) had "undercalled" defects (i.e. defects that the inspector didn't identify that the auditor thought should have been raised OR defects that were raised at a lower priority than they should have been).
- 0.2% of pole inspections audited (33) had unserviceable poles that the inspector didn't identify, many of which would be due to incorrect Pole Structure selection or Pole Attributes recorded.

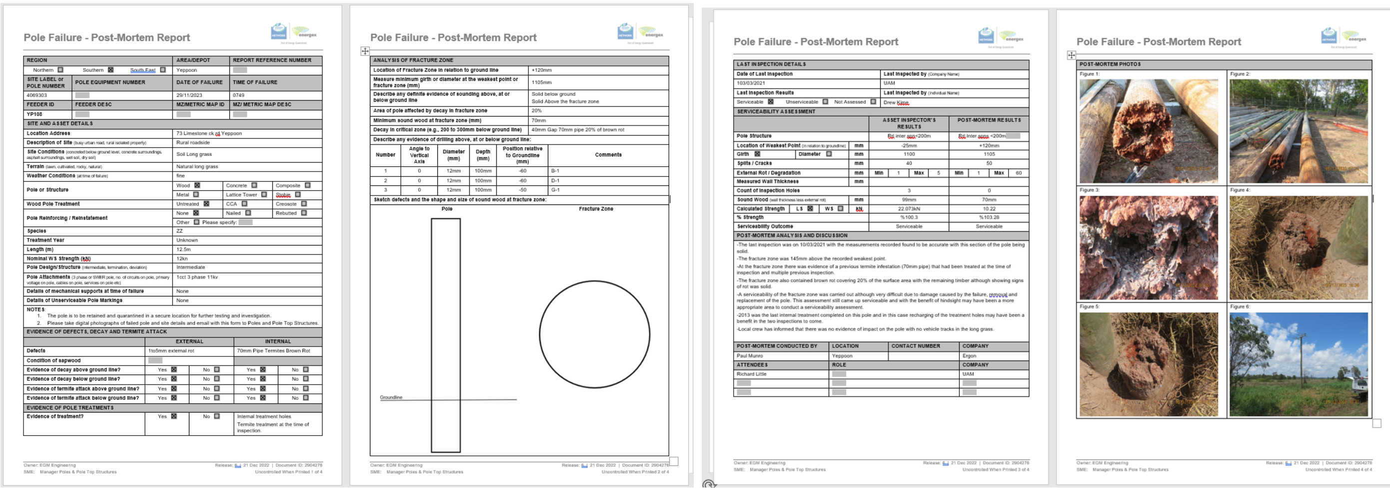
Information from the audits is collated into reports on a monthly basis and fed back to the asset inspection contractors to drive improvements in the inspection process for the companies and individuals. The results are discussed in monthly meetings with the contractors. Where there are major non-conformances, the contractor is expected to provide their own report including details of the corrective actions completed to address the problem.

Pole Failure Investigations and Post Mortems

Ergon Energy undertakes analysis of all unassisted pole failures. For unassisted pole failures where there is a concern about the integrity of the inspection, specific unusual scenarios or where there is a safety/legal driver, a full investigation may be conducted.

These investigations include a full review of the circumstances surrounding the pole failure, the inspection and maintenance history, the condition monitoring results for pole serviceability and any other observations that contribute to understanding of the root cause of the failure. Photographic evidence and commentary from the attending field crew is captured and physical evidence is encouraged to be kept where possible so that a deeper understanding of the failure modes can be developed.

In cases where the pole has been inspected within the 12 months prior to the failure, a formal post mortem is completed, generally by a pole inspection auditor, to compare results from the recent inspection in order to identify any issues with the quality of the inspection, specific inspector training requirements, process or system problems or reporting issues and recommend improvements. An example is shown in Figure 10.


Pole Failure - Post-Mortem Report

Pole Failure - Post-Mortem Report

Pole Failure - Post-Mortem Report

Pole Failure - Post-Mortem Report

Figure 10 – Example of a pole failure post mortem.

This post mortem information is combined with the other investigation information to determine clear conclusions around how and why the unassisted pole failure occurs and any recommendations for improvement actions. An example of an investigation report is shown in Figure 11.

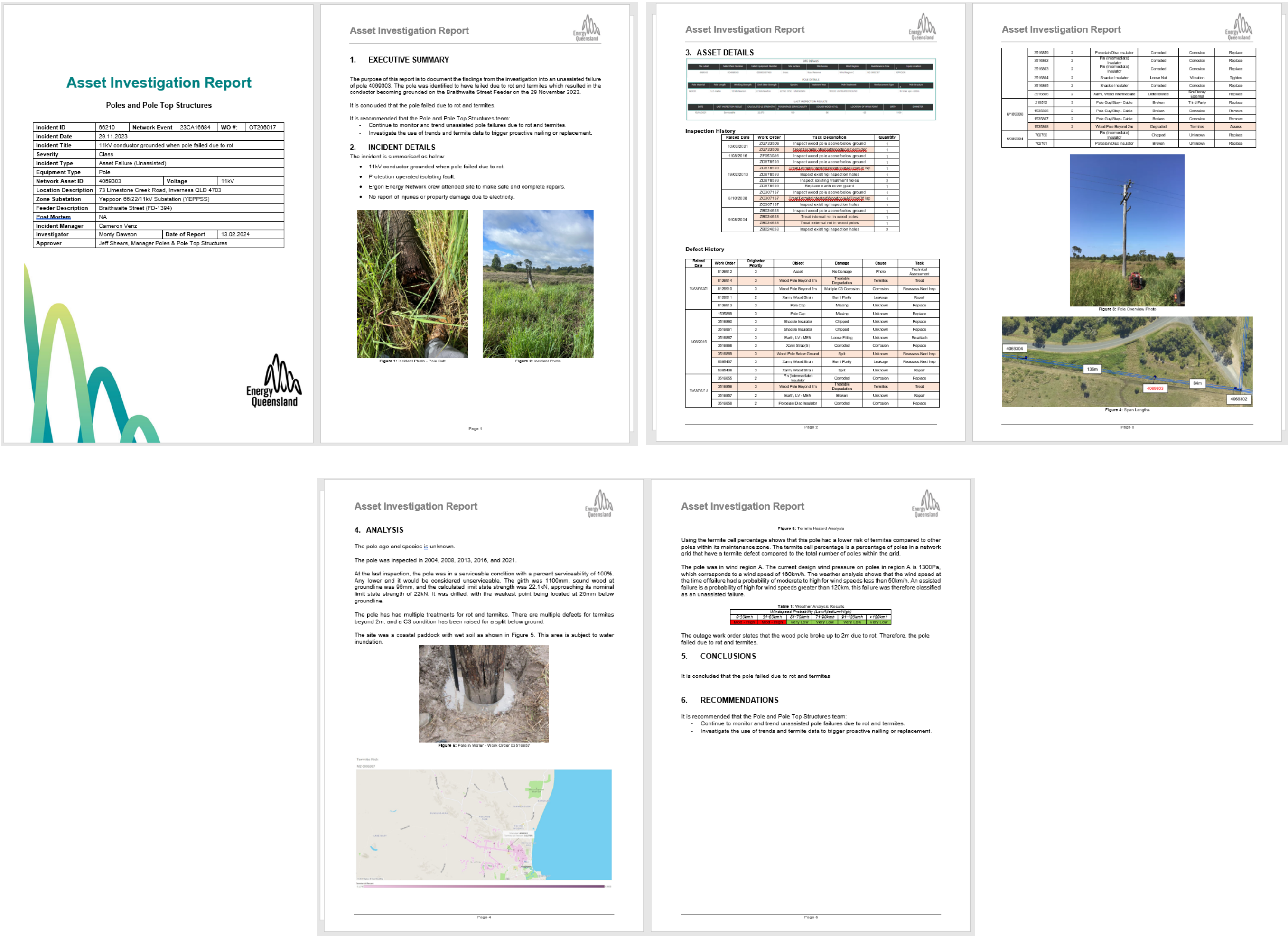


Figure 11 – Example of an unassisted pole failure investigation report

Some example photographs of failed poles are shown in Annex B to provide some information and evidence as to the challenges that are faced in the Ergon Energy network. This shows a subset of failures including poles that have failed due to rot/decay, termites and pole top deterioration and also shows some of the challenging and diverse environments and conditions that the network is constructed in. Of significance, what this does show is that in spite of the efforts to determine pole serviceability effectively, there are still some poles that either aren't identified as being unserviceable at the time of the inspection due to process, inspector or tool issues or poles that deteriorate quicker due to termites or rot than what was expected.

Reporting and monitoring of unassisted pole failures is completed on a monthly basis for Asset Maintenance to understand failure modes and define opportunities for improvements. This information is used for the Executive and Board to understand the volumes of unassisted failures occurring, the causes and the work being undertaken to improve.

Figure 12 and Figure 13 show the 2023/24 financial year failures and the typical failure information that is trended and reviewed including working strength, age, location, voltage and last inspection outcomes.

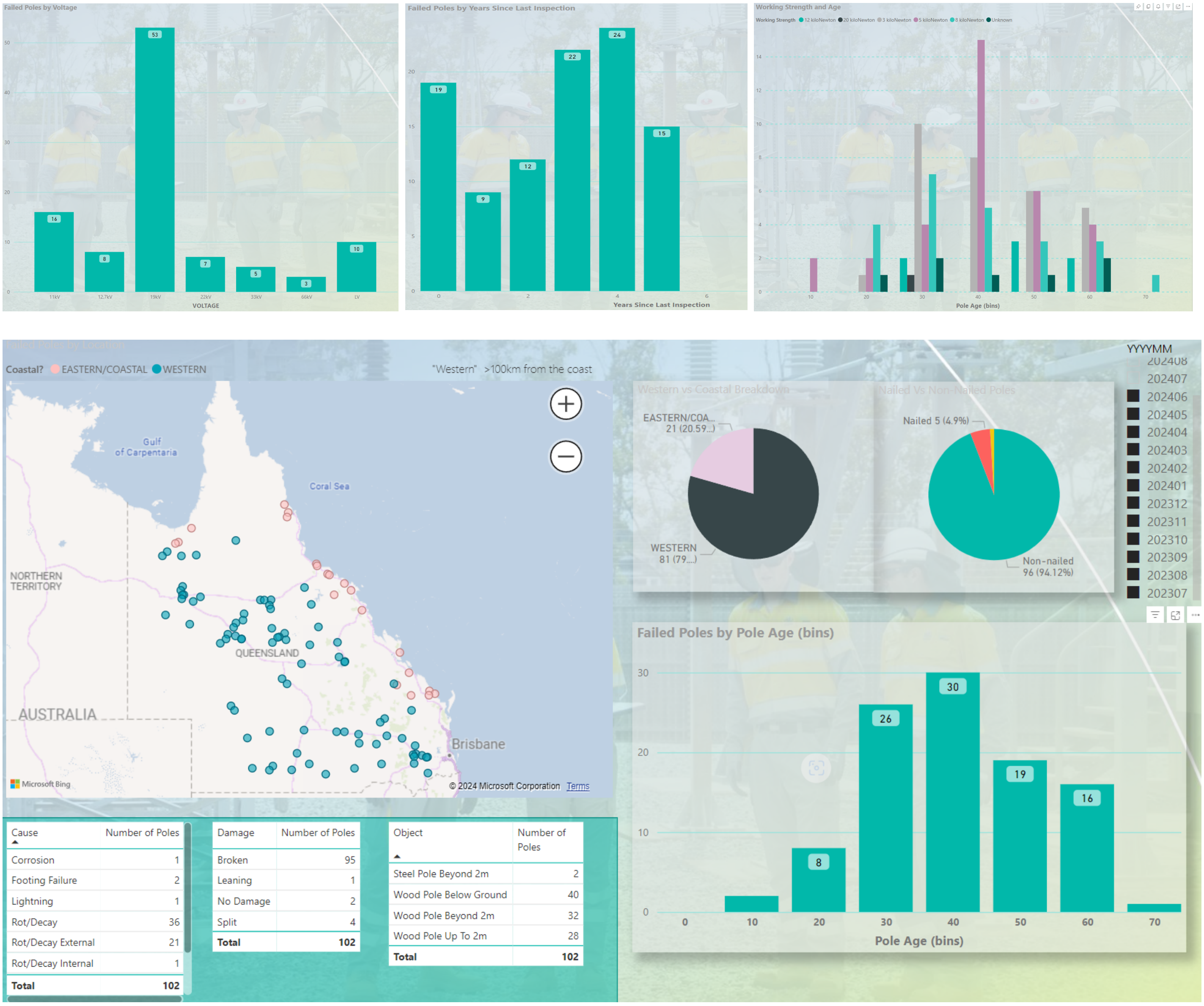


Figure 12 – Unassisted pole failure attribute trends 2023/24

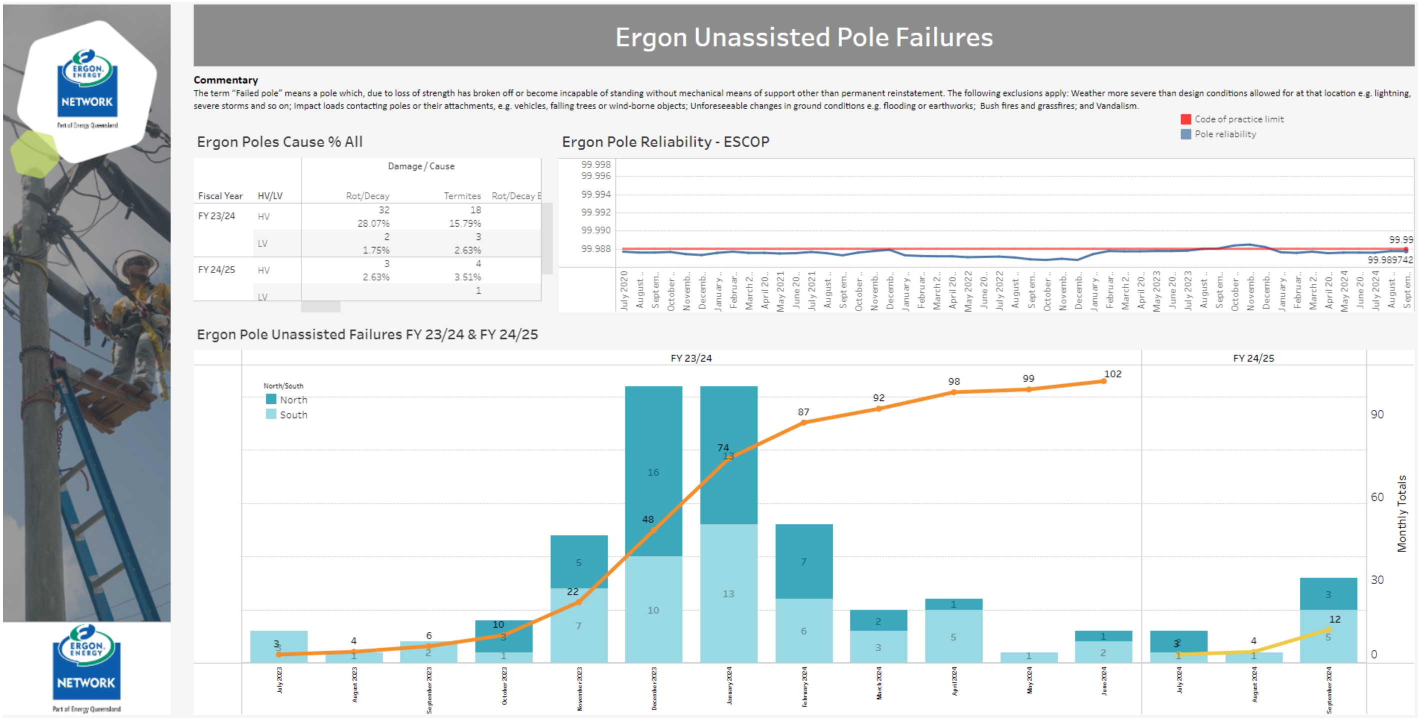


Figure 13 – Ergon Energy Unassisted Pole Failure Dashboard

Defect Data Trend Analysis (incl Eastern / Western Region trends)

Ergon Energy has a significant volume of records to describe defects that have been raised as a result of routine ground line inspection activities (i.e. pole serviceability assessments). The below information and visualisations attempt to explain some of the significant trends that are seen in the data and the pole assets that are deemed to be unserviceable.

All defect trend analysis below is based on the pole defect information provided previously for the period from 2017/18 to 2022/23 with some additional information added to the data to categorise defects into Eastern and Western (>100km from the coastline) areas and to further describe condition monitoring results and the reasons for poles becoming unserviceable.

In terms of the population of poles, approximately 49.2% are found in Western areas and 50.8% are in Eastern areas.

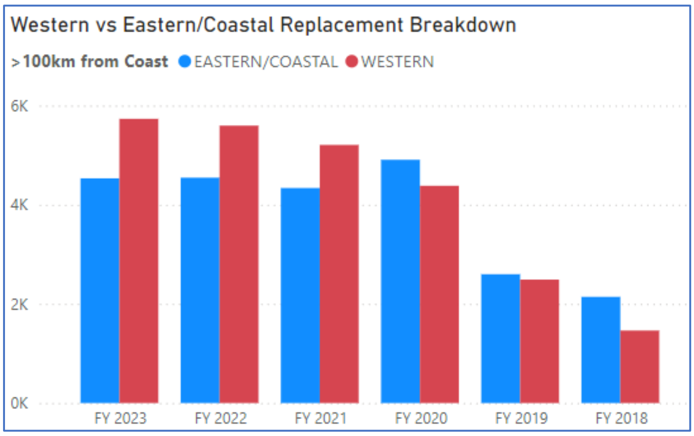
The unserviceable poles are scattered across Queensland as indicate in Figure 14.

Figure 14 – Map of unserviceable poles

Pole Replacement vs Pole Nailing

Pole replacement and pole nailing are the common methods for remediating an unserviceable pole. Ergon Energy has a legislative requirement under the Code of Practice Works 2020 to replace or reinstate (nail) the unserviceable pole within six months.

Figure 15 shows the overall trend in pole replacements. As shown, in FY 2018, FY 2019 and FY 2020, a higher volume of replacements were occurring in the Eastern areas but from FY 2021 onwards and as a result of the pole serviceability calculation improvements implemented in April 2019 and changes to pole nailing suitability criteria, the Western areas account for a higher volume of replacements while the Eastern areas an increase in nailing has occurred.



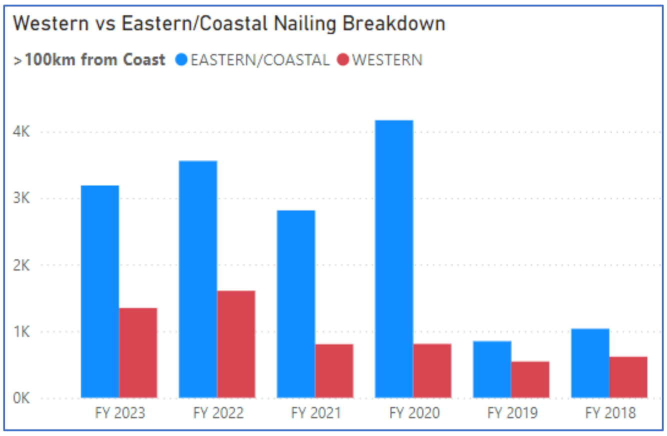


Figure 15 – Pole Replacements (left graph) vs Pole Nailing (right graph)

Figure 16 shows the replacement vs nailing rates over the past 6 years.

Overall, a ratio of about 70:30 is maintained between replacement and nailing.

However, in the Western areas, nailing activities are reduced significantly. There are 2 key reasons for this:

- Previous resourcing arrangements to complete nailing was inefficient in Western areas due to significant travel requirements.
- Many of the smaller 3kN poles are unable to be nailed due to the reduced girth and minimum solid wood measurement meaning that the nail is unable to be secured effectively (relates to the change introduced in 2018 as mentioned in the section titled “Pole Nailing Criteria Change”). The majority of 3kN poles are in Western areas.

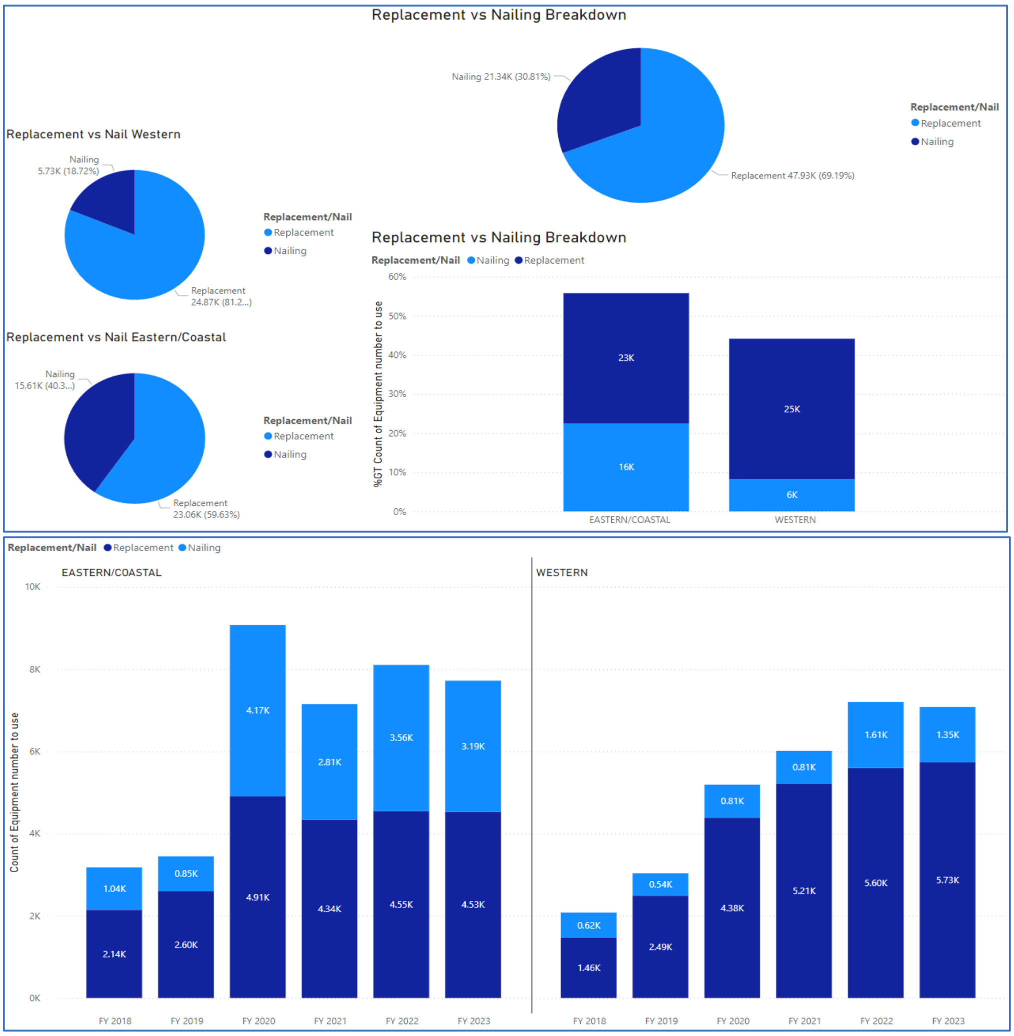


Figure 16 – Pole Replacement versus Nailing

The graph of the Western region replacement versus nailing volumes shows that in 2021/22, an increase is seen in the nailing rates. This is due to a change that was implemented in August 2020 to enable the nailing of poles that had a calculated Limit State Strength between 4.5kN and 5kN.

Defect - Object, Damage and Cause

The Object, Damage and Cause are a coded set of responses that are mandatory to provide when entering a defect into the Ellipse system. These 3 codes, combined with other key asset attributes, provide information on the root cause of defects for a complete library of objects on both line and substation assets. These codes align to the information and photographic examples provided to the pole inspection crews and internal field crews in the Lines Defect Classification Manual. It is expected that the pole inspector/field crew records and classifies defects correctly in accordance with guidance provided in this manual.

Figure 17 shows a split of the top 5 causes of poles becoming unserviceable (x axis) and the location and material of the pole where it is unserviceable. This data clearly shows that the predominant reason for unserviceable poles is rot/decay (primarily external) and termite damage.

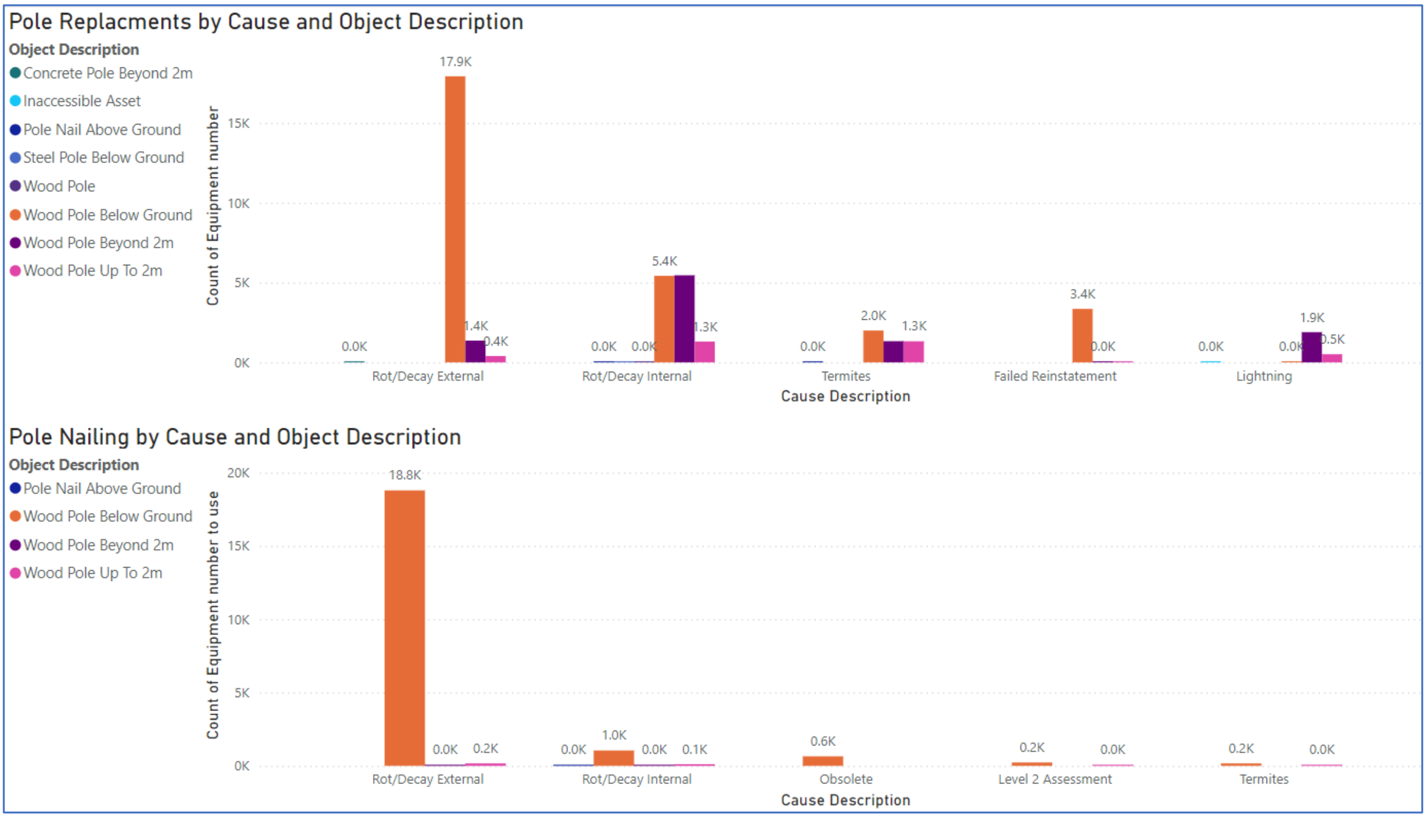


Figure 17 – Unserviceable poles by Object and Cause

Strength and Species

Figure 18 shows the pole strengths that are most prone to becoming unserviceable.

The predominant working strength that fails the serviceability assessment are 5kN and 8kN poles however this is due to the high population of these poles in the network. Of interest is the volumes of 3kN and unknown strength poles that are unserviceable.

There is a population of approximately 94,000 3kN poles remaining in the network. For 3kN poles this translates to an unserviceable rate of approximately 16% (of the 3kN poles inspected). By comparison, for 5kN poles, with a population of approximately 322,000, the unserviceable rate is approximately 6.5%.

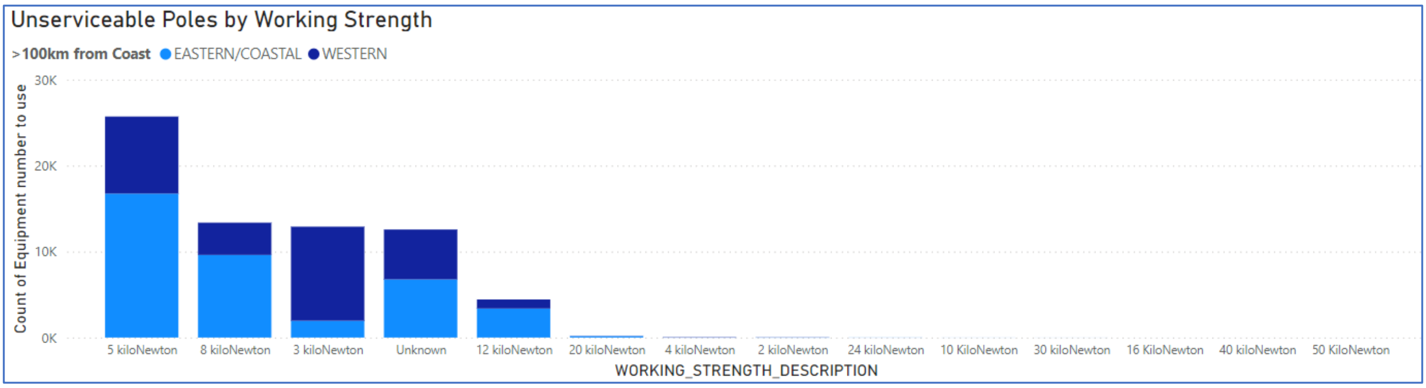
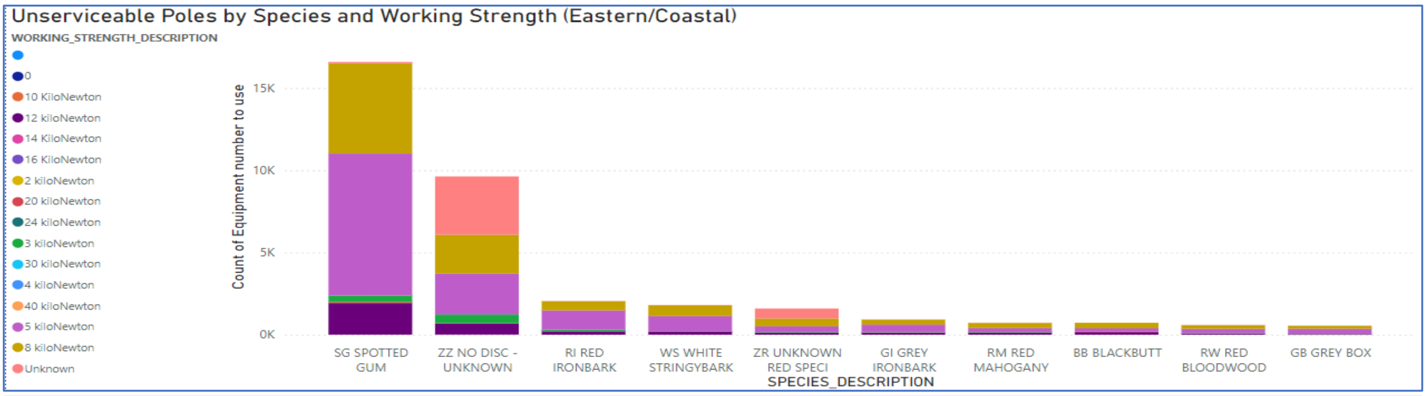


Figure 18 – Unserviceable poles by working strength

As shown in Figure 19, the predominant timber species of Ergon's wood poles is Spotted Gum at around 46% of the total population and therefore it is also the predominant species of pole that is replaced. Poles with an Unknown species make up approximately 15% of the population and have the highest replacement rate based on the population. The majority of Ergon Energy wood poles are Strength Group S2 and Durability Class 2.

Unknown species are either natural (bush) poles which are old and untreated or poles where the manufacturer's disc has fallen out of the pole before the species, length and strength was able to be captured by an inspector.

There are 46 different species of wood poles (including those that are unknown) used in the Ergon Energy network.



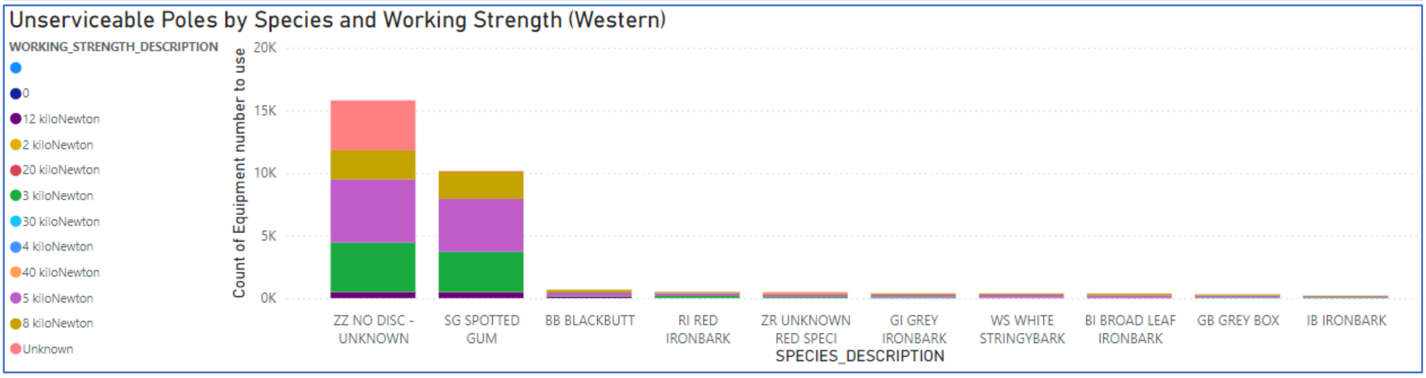


Figure 19 – Unserviceable poles by species

When normalised against the population, for species with a significant population of > 2,000 poles per location, unknown species and red timber species are performing the worst. Red timber species are proactively nailed in high-risk locations due to previous known failures of this species. Although they are not unserviceable due to loss of timber at the weakest point, red timber poles are managed under the same process as unserviceable poles. Spotted Gum has a very low unserviceable rate in comparison as shown in Figure 20.

Worst Species (>10% US rate)	Eastern	Western
ZR UNKNOWN RED SPECI	35.68%	30.14%
ZZ NO DISC - UNKNOWN	23.14%	14.81%
WS WHITE STRINGYBARK	23.26%	17.66%
RW RED BLOODWOOD	15.05%	
RI RED IRONBARK	11.26%	
RM RED MAHOGANY	15.42%	
SG SPOTTED GUM	7.10%	4.52%

Figure 20 – Worst performing species compared to spotted gum

Unserviceable Poles by Working Strength and structure type (Eastern / Western)

Ergon Energy uses Pole Structures as part of the serviceability assessment process to define the pole tip load supported by that pole. The most common structure is SWER intermediate which is a lightly loaded structure with a single, small SWER conductor attached at a higher tension than in urban areas and with an average span length of 200m. As shown in Figure 21, 3kN poles were installed commonly for the SWER intermediate construction and are the most common combination of strength and structure to become unserviceable. Note that this data only shows the top 10 pole structures per volume – there are 81 Pole Structures to select from when completing the serviceability assessment.

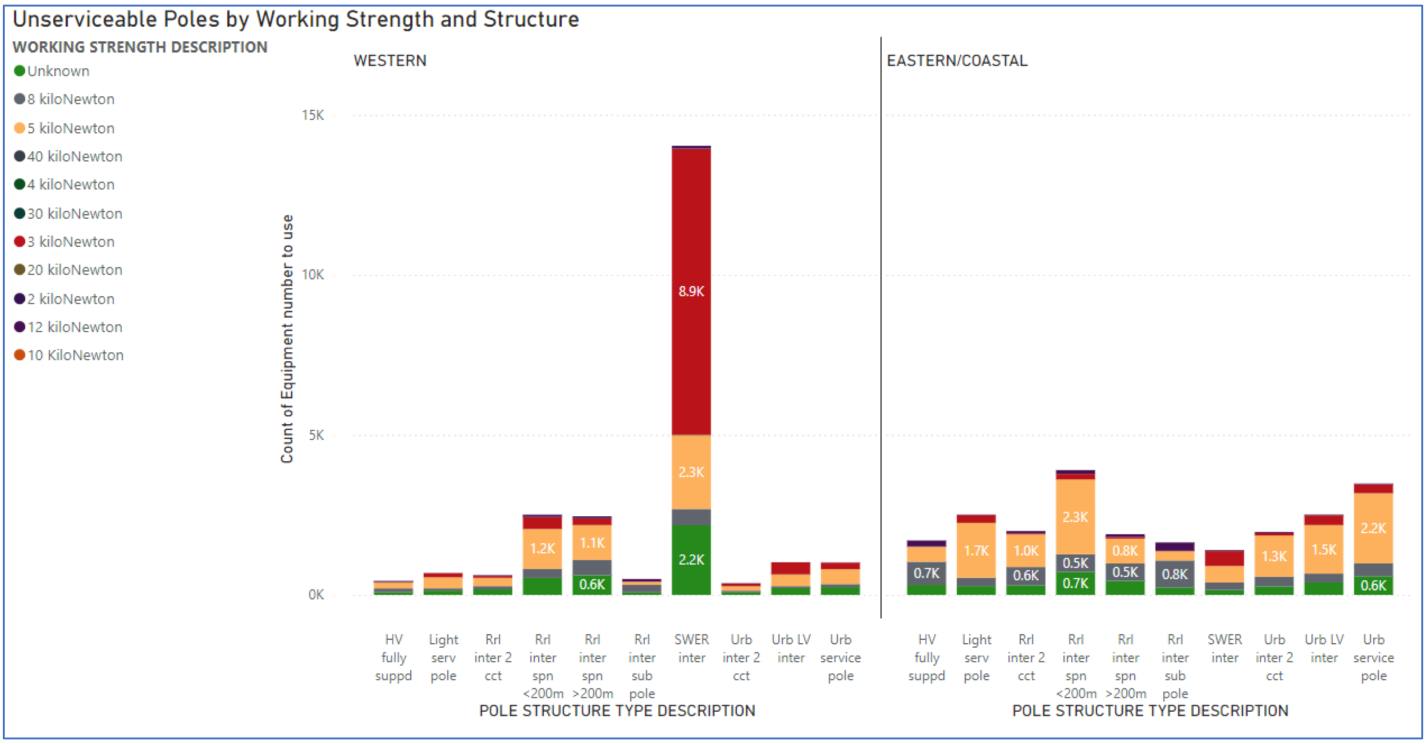


Figure 21 – Unserviceable poles by working strength and pole structure

This graph clearly shows majority of unserviceable 3kN SWER poles in the Western region.

Year of Manufacture

Figure 22 shows information about the year of manufacture of the poles that are made unserviceable and the working strength of these poles. The data shows that the majority of the poles that are unserviceable are aged >40 years old with a high volume of 5kN and 3kN strength ratings. 73% of 3kN poles were installed in Western areas prior to 1990. The volume of 3kN poles failing serviceability assessment significantly reduces as the year of manufacture is greater than 1990, which aligns with the smaller population of 3kN poles of that more recent vintage in service in the network.

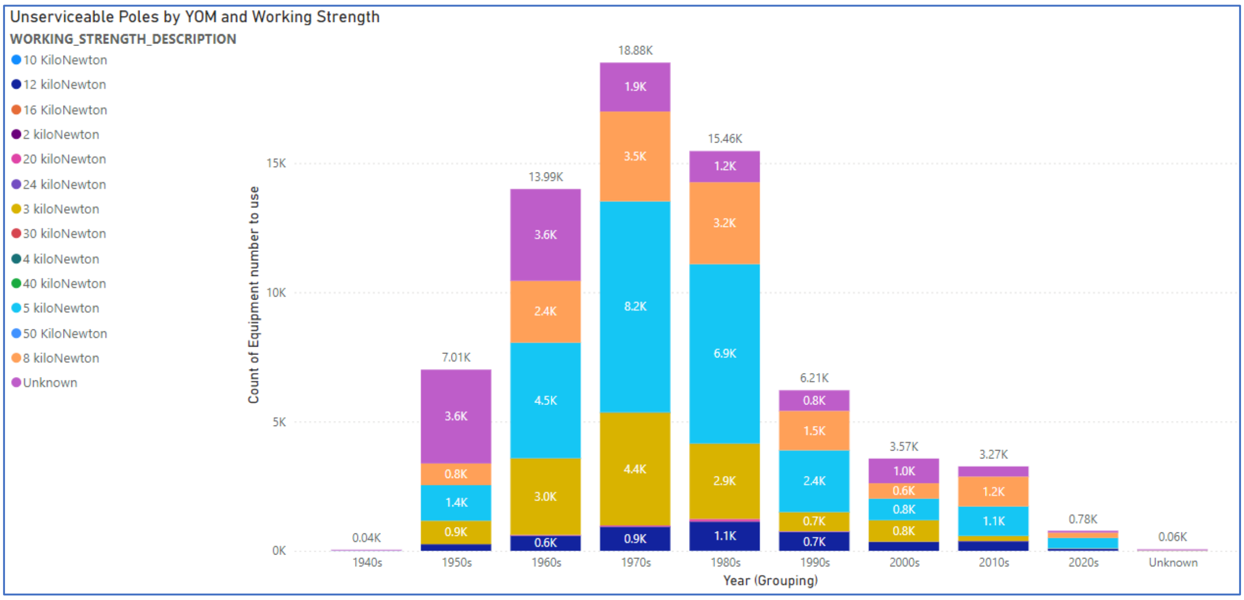


Figure 22 – Unserviceable poles by year of manufacture

Of poles over 40 years old, failed reinstatement is a significant volume which captures nailed poles where the nail is no longer effective in supporting the pole.

Unserviceable Poles by Cause

Figure 23 shows the age of the unserviceable pole against the cause of the pole being unserviceable. The dominant cause of unserviceable poles is rot/decay which may be internal and/or external as indicated by the larger pink and purple sections of the columns.

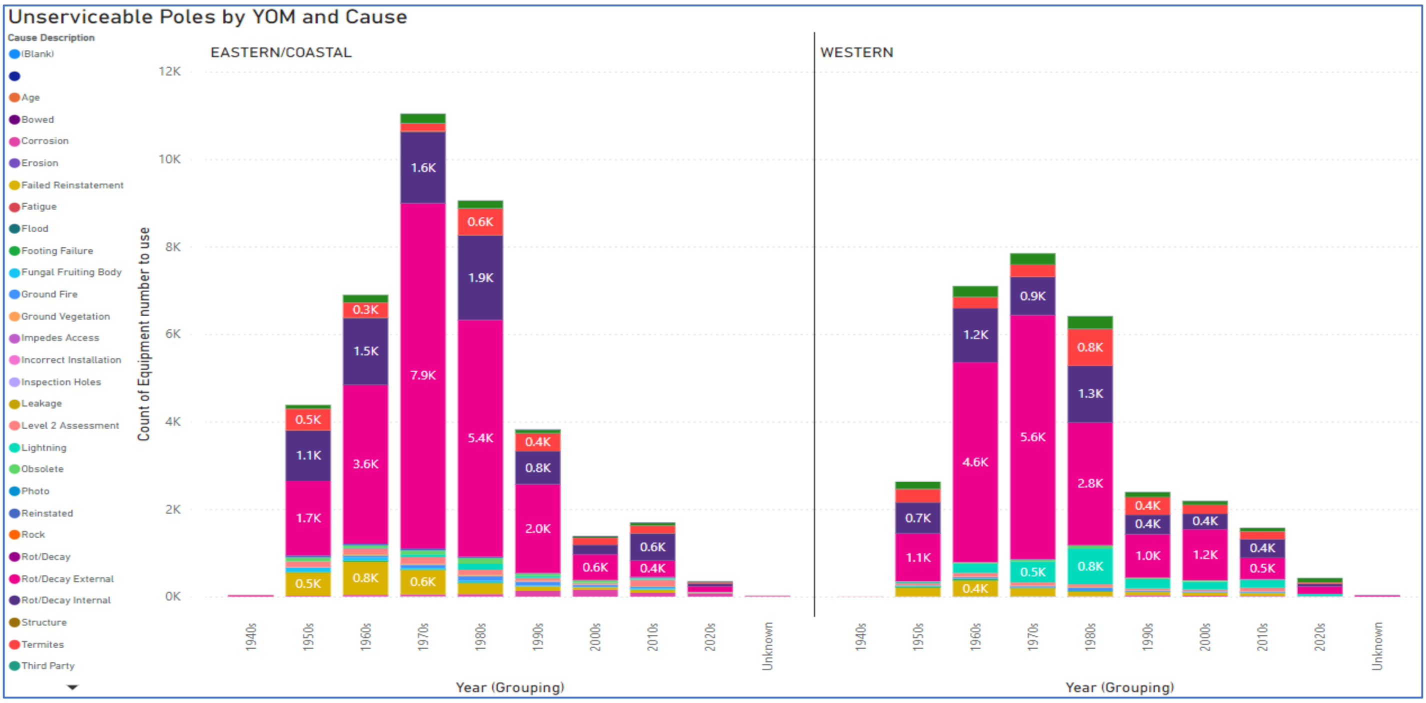


Figure 23 – Unserviceable poles by year of manufacture and cause

In Western areas, lightning is the cause of a number of unserviceable poles across all age ranges as severe storms are prevalent during summer months. Some of these may be lightning strikes that occurred some time ago but the pole has remained in service until the visual inspection of the degradation has deemed it unserviceable.

Termite damage is a significant cause of unserviceable poles in all areas but particularly in Western areas. The 2 most damaging termite species in Australia are prevalent in Western areas, namely Mastotermes, the most destructive species in Australia, and Coptotermes, the species with the most economical impact (*refer to Pests of Timber in Queensland, B.C. Peters, J. King, F.R. Wylie, Queensland Department of Primary Industries, 1996*).

Condition Monitoring Information

When serviceability assessments are completed in the field, the data from the serviceability assessments and the calculated values are returned to the Ellipse system.

Figure 24 highlights that 82.63% of unserviceable poles are purely determined based on the results of the pole serviceability calculations. 17.37% of unserviceable poles are identified based on visual assessment of the condition of the pole.

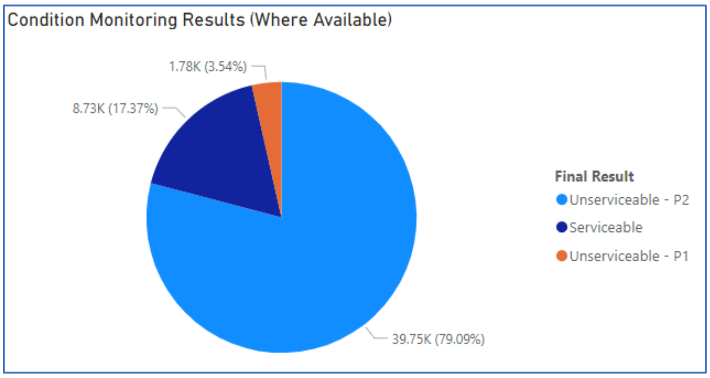


Figure 24 – Determination of pole serviceability

As per Figure 25 below, of those unserviceable poles identified through visual assessment, over 50% are due to deterioration at the top of the pole which isn't subject to the serviceability assessment calculations and measurements. These are generally related to lightning strikes and stays or other fittings that are wrapped around or embedded in the timber causing deterioration and rot/decay to form.

Visual assessment of below ground condition contributes 38%. A small number of visual assessments are due to identified fungal fruiting bodies, or splits or cracks through the pole where substantial loss of cross-sectional area has not yet occurred. The majority are based on the inspector's observation of the deterioration and level of rot/decay or termite damage of nailed poles below ground. Condition monitoring measurements for nailed poles are taken at the top of the nail and below ground degradation is not reflected in the calculated results.

Visual assessment of the pole up to 2 metres from the ground is the other main component and this will generally be caused by deterioration or damage caused by bushfire, third party impacts, rot/decay and termite damage.

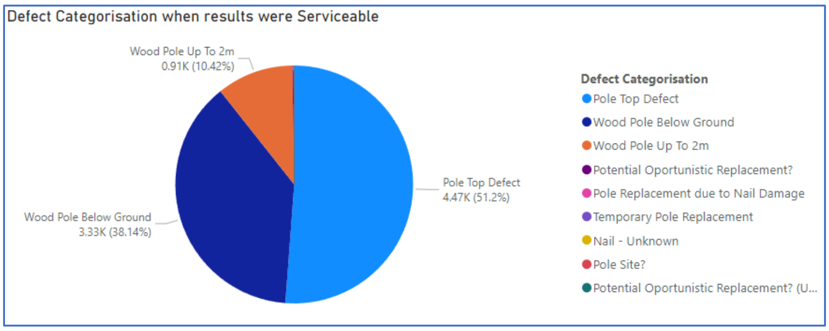


Figure 25 – Location on pole related to unserviceable determination

Impact of Changes to Pole Inspection Cycle Change

In 2020/21, pole inspection volumes were increased due to removing the 6 year and 8 year cycles and moving all of those pole inspections to 5 year cycle. This has contributed to a higher volume of unserviceable poles per year based on the increased inspection volume. Many of the poles that were on a 6 year cycle were rural, lower risk SWER poles which is where the predominant population of 3kN poles are. Due to the multitude of changes that occurred in a similar period it is difficult to isolate exactly the size of the impact due to the inspection cycle change, but it is estimated to have impacted up to 10% of unserviceable pole uplift.

Impact of Changes to Pole Serviceability Calculations on Pole Replacement Volumes

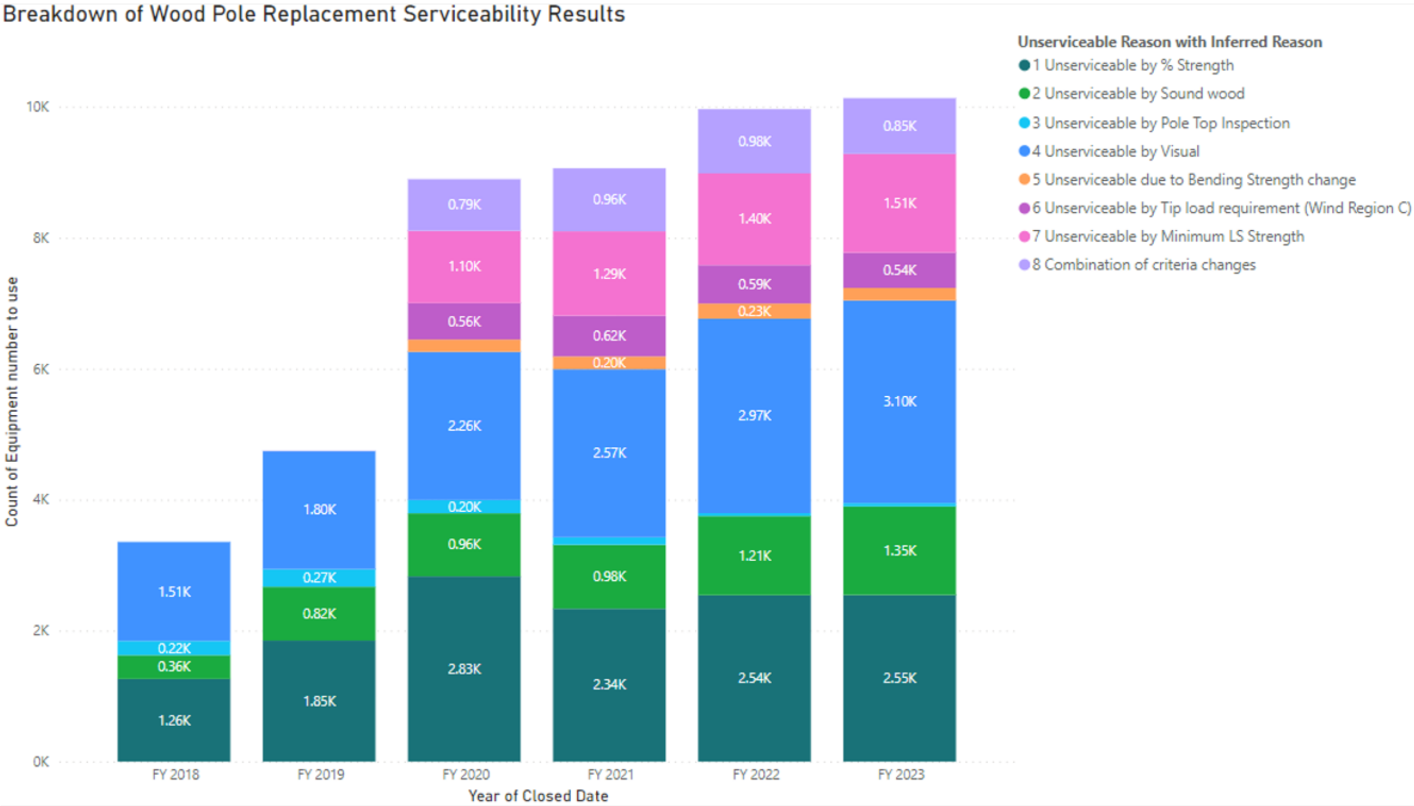


Figure 26 – Impact of changes to pole serviceability calculations on wood pole replacement volumes (all poles)

Figure 26 shows an increase in the number of pole replacements driven from serviceability assessment from FY2020 to FY2023, when compared to those in FY2018 and FY2019. The work order and condition monitoring results have been analysed for all unserviceable poles to identify the numbers which can be attributed to each of the following categories that reflect the modification made to the pole serviceability calculations in April 2019 in addition to categories of unserviceability that were in place prior to these changes:

- Sound wood measurement only
- Pole top inspection by Elevated Work Platform only

- Percentage Strength
- Visual signs that the pole is not fit for purpose in accordance with the Lines Defect Classification Manual
- Reduction in the Characteristic Bending Strength only (to align to AS/NZS 7000) implemented April 2019
- Tip Load changes in wind region C only (to ensure assessment of poles in wind region C in accordance with the design and construction standards that they were installed to) implemented April 2019
- Minimum Calculated LS Strength only (to address safety concerns related to low strength poles) implemented April 2019
- Combination of changed criteria - failed on multiple parts of the serviceability calculation that were changed (i.e. bending strength, tip load changes for wind region C or minimum calculated LS strength) implemented April 2019

Impact of Major Pole Serviceability Calculation Changes

The following sub-sections describe the trends in each category where a major change was implemented to the serviceability calculation across the population.

<u>US pole replacements due to reduction in Characteristic Bending Strength only:</u>
The reduction in Characteristic Bending Strength has been attributed to a small increase of unserviceable pole replacements, averaging approximately 200 each year over the four years since the change was implemented at the end of FY2019.

Note that 87% of unserviceable poles that failed due to a combination of the changes were in part due to the reduction in Characteristic Bending Strength (refer Figure 29).

<u>US due to Tip Load changes in wind region C only:</u>
Wind region C covers a narrow 50km band along the coastline from Bundaberg to Cairns which includes most of the larger regional Queensland cities and therefore the highest pole population. The increase to the required tip loads for poles located in wind region C has resulted in an average of about 200 unserviceable pole replacements per year.

Note that 65% of unserviceable poles that failed due to a combination of the changes were in part due to the Tip Load changes in wind region C (refer Figure 29).

<u>US poles due to Minimum Calculated Limit State strength only:</u>
The implementation of the minimum calculated strength threshold has the greatest impact on unserviceable pole replacement volumes and is particularly evident for lower strength poles (2kN and 3kN) as demonstrated in Figure 27. The majority of low strength poles are located in western Queensland, therefore there are low numbers of unserviceable low strength poles impacted by the tip load change in wind region C.

Note that 47% of unserviceable poles that failed due to a combination of the changes were in part due to the Minimum Calculated Limit State strength (refer Figure 29).

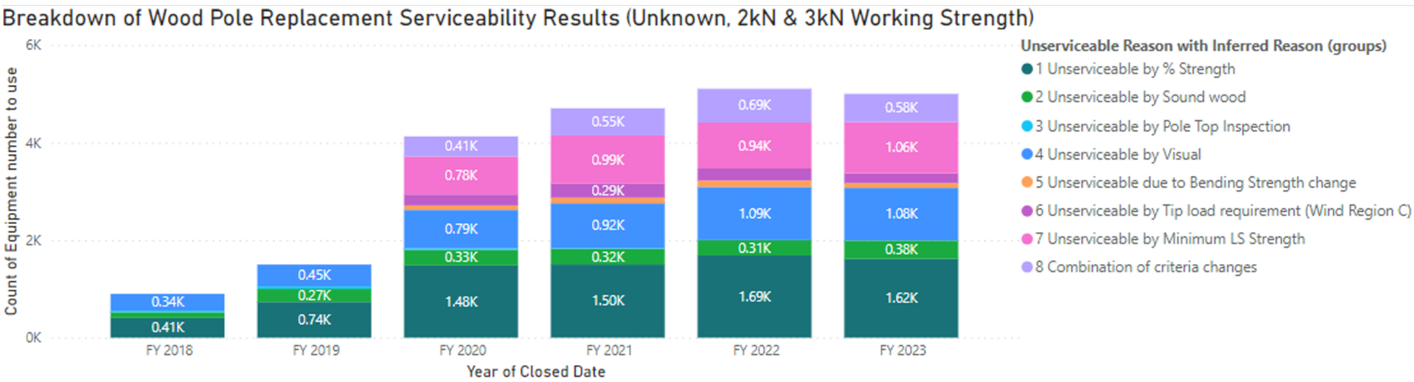


Figure 27 - Impact of changes to pole serviceability calculations on unserviceable pole volumes (low strength poles)

Figure 28 shows the lower impact of the minimum calculated strength threshold for poles with larger nominal working strengths. However, it has had a larger impact on Eastern Wind region C poles.

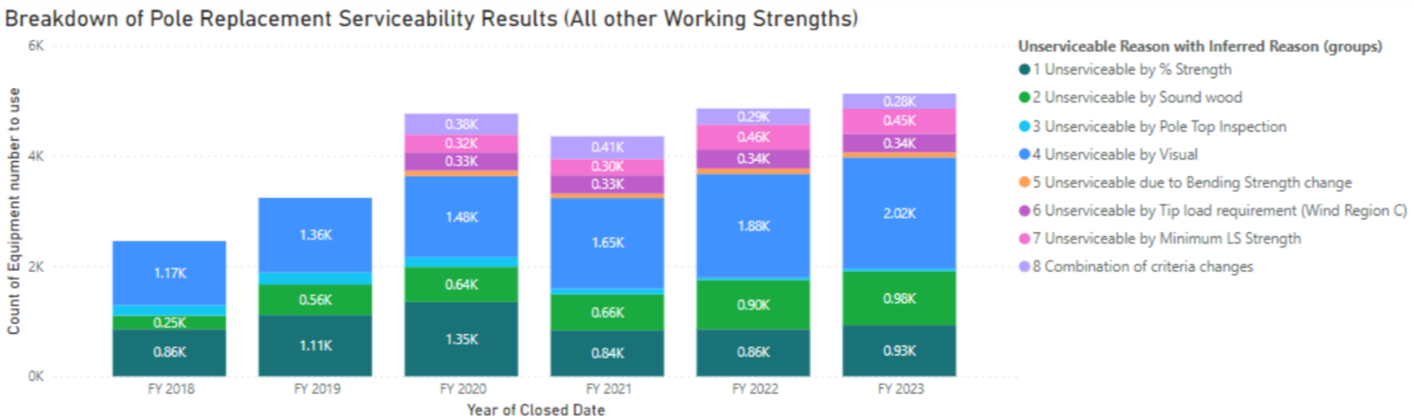


Figure 28 - Impact of changes to pole serviceability calculations on unserviceable pole volumes (higher strength poles)

<u>US Poles due to Combination of Changes:</u>
This category represents those poles that failed serviceability due to a combination of the changes made. As per Figure 29, over 87% of these failed the serviceability assessment due to the bending strength change (as well as either tip load requirements or calculated minimum LS strength).

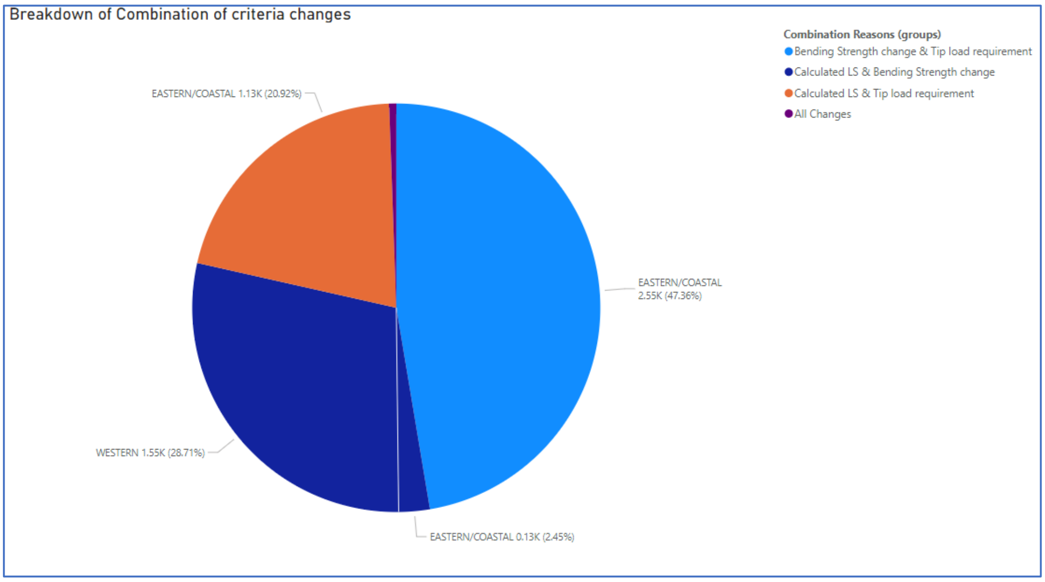


Figure 29 – Breakdown of unserviceable poles that failed due to combination of changes

Figure 30 shows that the poles that have failed only the calculated minimum strength criterion are predominantly from the western area of the network. The majority of these low strength poles are replaced. These poles are typically low strength SWER with long spans over 200m. From August 2020, poles with a calculated strength between 4.5kN and 5kN are nailed provided other nailing assessment criteria are met.

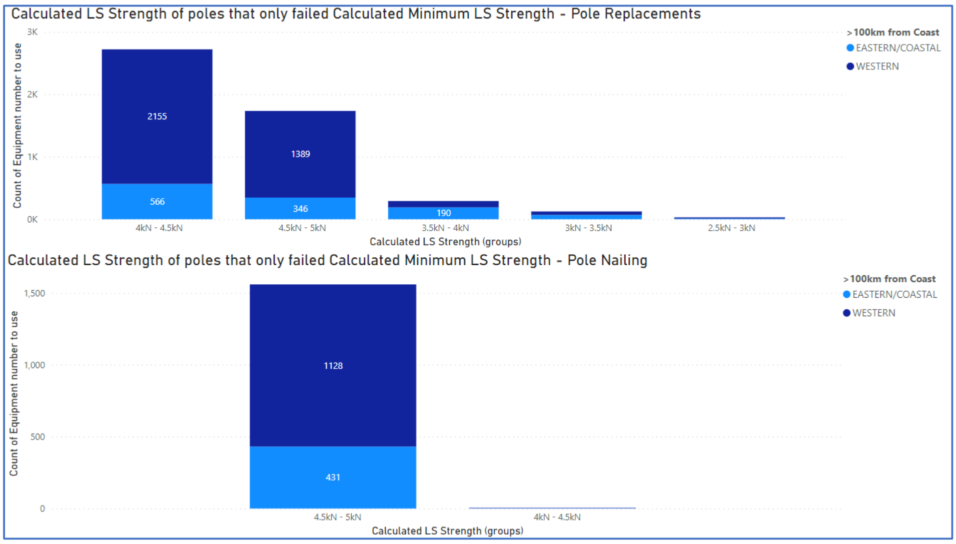


Figure 30 – Location breakdown of unserviceable poles due to the calculated limit state strength

Impacts on Unserviceable Poles not due to Major Changes in Pole Serviceability Calculations
The following sub-sections describe the trends in each category where the unserviceable pole is no attributed to the changes in pole serviceability calculations.

Sound wood measurement and % strength
The measurement of Sound Wood and calculation of reduction in strength have been in place since the initial version of Ergon's serviceability calculations where initiated in 2003.

Despite these parts of the serviceability assessment not fundamentally changing, there has been an upward trend in the volume of unserviceably pole replacements in these categories due to the aging and deteriorating pole population, largely due to the following factors:

- Incremental improvements to the selection of pole structures types and tip load requirements for specific scenarios
- Degradation due to aging poles with low replacement rates over the previous inspection cycles
- Increased degradation due to major flooding event across Queensland in FY2019
- Unseasonal rain across western Queensland since FY2019

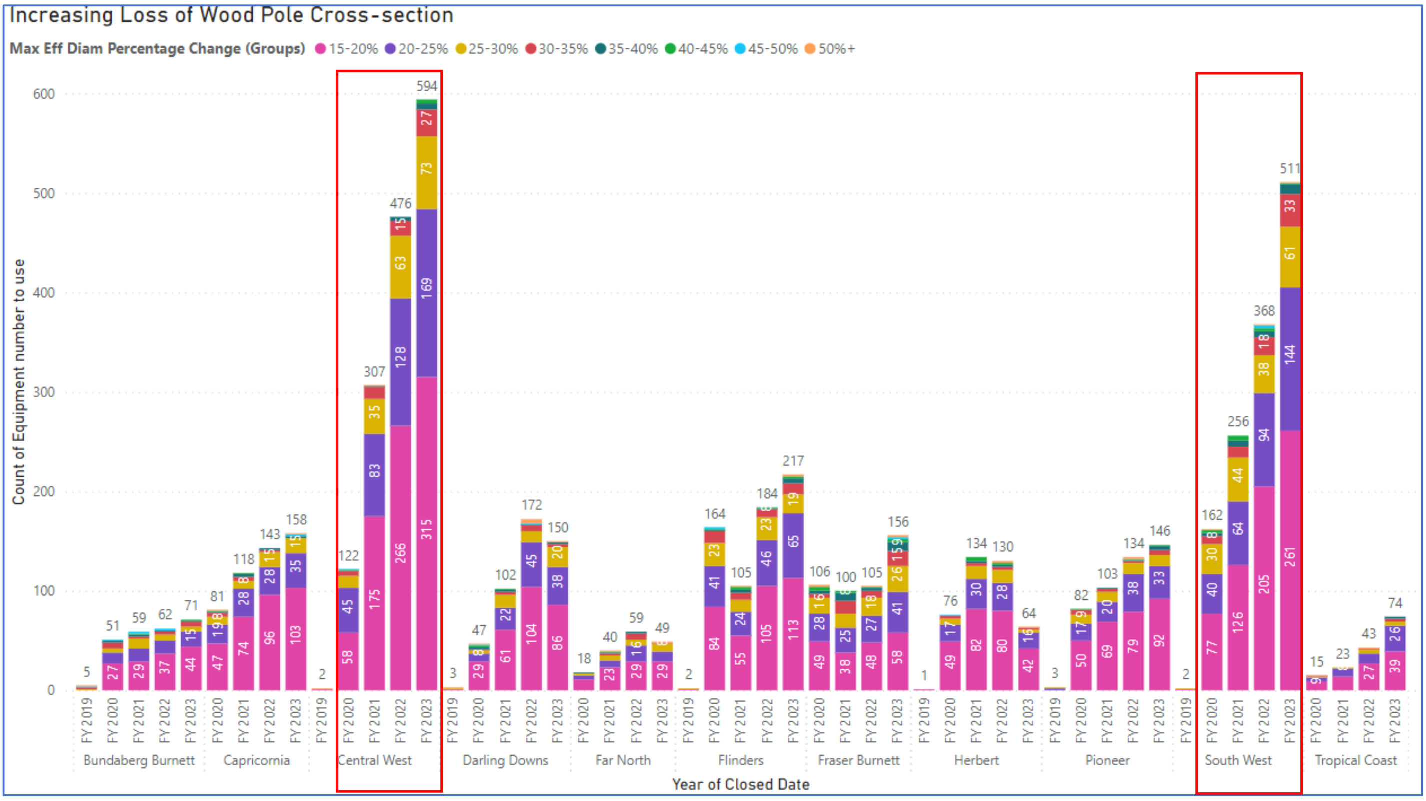


Figure 31 – Increasing loss of cross-section for unserviceable poles from FY2019 onwards

The degradation is evident when comparing the percentage loss of cross-sectional area for all unserviceable poles from FY2019, to that of the previous cyclic inspection. Central West and South West distribution areas were most affected by the flooding and unseasonal rain. They are also the areas with the majority of low strength poles (refer to Figure 31).

<u>Visual assessment</u>

The visual assessment of pole condition has always been a part of the inspection process. The criteria for the visual assessment of pole deterioration is documented in the Lines Defect Classification Manual and accounts for many of the conditions that are not identifiable through pole serviceability/strength calculations.

A small impact occurred in FY2021 when efficiency measures were introduced to reduce the number of site visits required to perform subsequent technical assessments of pole condition, particularly for assessing significant deterioration at the pole top requiring an Elevated Work Platform to complete the assessment.

As is the case for the sound wood and percentage strength categories, some of the volume increase is attributed to:

- Degradation due to aging poles with low replacement rates over the previous inspection cycles
- Increased degradation due to major flooding event across Queensland in FY2019
- Unseasonal rain across western Queensland since FY2019

Pole Top Inspection

Pole top inspections are completed in high rainfall areas of tropical North Queensland and are a very small volume of the unserviceable pole replacements identified each year. These are all based on visual assessment.

Independent review of pole assessment and classification

In July 2021, an independent review was commissioned for a review of the current pole inspection and assessment processes and methodologies to ensure that they align with industry best practice, are accurate and reliable, yield credible results consistent with expectations and accurately model pole serviceability and pole health.

This review concluded, amongst other things, that the "EA Technology has found that Ergon Energy is performing pole inspections diligently. The algorithm used in pole inspections is aligned with industry best practice both in Australia and in other comparable countries. The volumes of poles being condemned are in line with expectations. The number of unassisted pole failures is currently in excess of the ESCOP levels and is expected to fall over the coming years as appropriate volumes of poles are reinforced and replaced. This demonstrates the effectiveness of the response that Ergon has made to its current situation over the past few years.".

Non-Destructive Testing Trials

Ergon Energy has had a watching brief on Non-Destructive Testing (NDT) solutions to assess the serviceability of poles without using the traditional methods of drilling the pole. This includes participation in several former and current industry working groups looking into this and various other topics related to the condition of timber.

After reviewing several solutions and completing a pilot, one of these solutions was trialled in the field in August and September of 2019.

Unfortunately, the trial was unsuccessful in determining a solution that could be embedded into Ergon Energy's work practices as there was little confidence in the results and process.

Ergon Energy is an active participant in the ENA/API research project on NDT technologies. In July 2023, a controlled field trial of eight NDT solutions was conducted on poles of various condition followed by pole breaking tests to validate the effectiveness of each NDT solution.

The project concluded that at this stage it is difficult to recommend any of the devices tested as suitable for pole inspection in their current form / working methods. However several devices have potential in improving some aspects of the inspection process but require further development to obtain the accuracy required.

Ergon Energy has recently completed the field components of a trial using a non-destructive testing tool for pole serviceability. The reason for commencing this work was two-fold:

- To continue the exploration of non-destructive solutions to determine pole serviceability.
- To potentially validate the serviceability assessment on poles recently deemed unserviceable.

The NDT device trialled is a device that penetrates the timber to estimate the remaining strength of the pole and appears to penetrate sufficiently into the timber for condition assessment. It appeared to be detecting internal rot/decay for poles that have not been drilled. Assuming accurate, the device would provide/allow for earlier condition monitoring input.

There are some cases where the NDT device and the traditional method have a slight discrepancy in results for wall thickness and there are some concerns around the impact of moisture to the accuracy of the device. The NDT device in some cases is giving a lower wall thickness than the inspection result and the sample would suggest an increase in unserviceable pole rates if used more holistically.

A third party supplier has completed pole break testing and are currently preparing the results for further analysis and in particular the accuracy in the pole serviceability assessment calculations in determining the remaining strength of the pole. This information is expected to be available within days.

Field Validation

An initiative has been established to collect additional information on unserviceable poles that are removed from service. Operations staff are either taking measurements and photographs of the unserviceable poles to highlight the deterioration and change in cross sectional area or delivering physical samples to selected depots in order for engineers to review the unserviceable poles.

Conclusions

Ergon Energy has performed and continues to perform a number of activities, analysis and investigations to ensure the efficacy and quality of its pole inspection and serviceability assessments processes and standards.

This includes:

- Reactive activities where there has been a need to react to a situation or concern from a safety perspective, reacting to data analysis or reacting to feedback from field staff.
- Proactive activities such as auditing and routine data analysis to give confidence that the systems, standards and processes that have been established are effective and fit for purpose.
- Learning activities such as failed pole post mortems and investigations and field validation of unserviceable poles to ensure that we identify gaps and improvement opportunities
- Research activities to look for improvements to processes and tools for determining pole serviceability

There have been numerous improvements implemented over the years which include initiatives which have increased replacements, increase nailing, shifted volumes from replacement to nailing and looking for better ways to manage the aging and deteriorating population of wood poles in the Ergon Energy network.

In summary,

- There are approximately 94,000 3kN poles remaining in the Ergon Energy network.
- The predominant cause of unserviceable poles is rot/decay identified below ground
- Approximately 16% of 3kN poles inspected are determined to be unserviceable compared to a approximately 6.5% for 5kN poles which account for almost one third of the poles in the network.
- Spotted Gum is the most predominant species in the network and generally performs well compared to poles that have an Unknown species, which are generally old untreated poles
- In the Eastern region:
    - The replacement to nailing ratio is approximately 60:40.
    - 5kN poles are the predominant pole size that becomes unserviceable, many of which are in rural areas
- In the Western region:
    - 73% of 3kN poles in the network were installed in Western areas prior to 1990
    - A large proportion of the Western network is SWER intermediate construction which will often be 3kN poles. 3kN SWER intermediate poles dominate the unserviceable poles in Western areas.
    - The replacement to nailing ratio is approximately 80:20 – this is due to the predominance of 3kN poles in the Western region

  - An increase in nailing occurred in 2021 due to a change to enable nailing of poles with a calculated limit state strength between 4.5kN and 5kN

Changes to calculations for various reasons contributed to the increase in unserviceable poles:

- Change in tip loads mainly attributed to the addition of Wind Region C to align the serviceability assessment to design and construction practices.
- Change to the Characteristic Bending Strength to align to AS/NZS 7000.
- Threshold for the calculated limit state strength to address safety concerns related to low strength poles.
- Increase in inspection volume due to removal of 6 and 8 year cycles.
- Accelerated deterioration and reduction of maximum effective diameter due to flood events.

In terms of unassisted pole failures and unserviceable poles, 3kN poles installed as SWER intermediate poles in Western areas are the primary pole construction that have driven the higher replacement rates. There are still 94,000 3kN poles in the network and it is likely that rate of unassisted pole failures and unserviceable poles will remain at or above current rates for some time into the future. An intervention program option, such as a dedicated program to replace 3kN poles in Western areas might be a prudent approach to see a drop in the unassisted pole failures and annual replacements due to failing the serviceability assessment.

ANNEX A – LOW STRENGTH POLE CONTROLS

The following information contains detailed information of some of the work completed as part of the Low Strength Pole Working Group and subsequent actions to put appropriate controls in place to manage the risks.

A risk assessment was undertaken with 11 subject matter experts from across the business with a range of specialist backgrounds including representative from the Asset Management and Operational parts of the business. The risk scenario considered was:

> *Failure of a low strength pole (≤5kN) in a rural/remote area leads to an energised conductor being low or to ground, resulting in a person contacting the mains and a single fatality.*

The untreated risk score was calculated to be 12 (moderate) and a number of additional controls were identified for consideration. These additional controls implemented are outlined below:

- Update and improve the pole inspection training for Asset Inspectors - completed with a strong focus on understanding pole serviceability calculations and measurements.
- Reinforced the requirements to ensure replacement poles are fit for purpose.
- Ongoing trials and implementation of alternative pole options and preventative treatments such as treated softwood poles, increased use of steel butted poles in Western areas prone to bushfire and termites, trial of fire protection options for poles (e.g. paint, wraps), trials and testing of Composite Fibre poles is continuing, implementation of alternative termite treatment, Altriset.
- Improvements to the mobility software to allow better reporting of failure information, additional rigour in recording photos and retaining evidence of failures in order to complete root cause analysis and investigations and improvements to the reporting and investigation processes.
- Energy Queensland is an active participant in industry groups where there is a focus on improving processes, materials, standards and understanding of wood poles:
    - Lines Industry Working Group.
    - ENA/API research project on NDT technologies – this group is focussed on trialling non-destructive techniques for the assessment of pole serviceability.
    - Utility Pole Research Cooperative in association with the National Centre for Timber Durability and Design Life.
- Implementation of improved work bundling for conductor replacement to ensure that opportunities for prudent and efficient consequential replacements were identified.
- Improvements to internal work practices for working on low strength poles.
- Improvements to the pole serviceability calculations to identify unserviceable poles according to revised pole strength standards. The following changes to the pole serviceability calculations were implemented in April 2019:
    - Moved from a Factor of Safety and working strength calculation to a Limit State calculation in line with overhead design calculations and standards.
    - Implemented changes to the Characteristic Bending Strength values for pole strength groups to align with the requirements of AS/NZS 7000 and overhead design calculations.
    - Added additional Pole Structures to enable a more accurate pole tip load comparison across the population and incorporated changes to account for the requirements of Wind Region C (Wind Region C is defined as “Cyclonic”. Wind speeds of up to 238km/h). A significant

change was the increase to tip load for SWER intermediate poles which would ultimately result in more low strength poles failing serviceability assessment compared to the previous calculation.

- o Introduced a new serviceability threshold of Minimum Calculated Strength. Calculated Limit State strength must be ≥ 5kN Limit State to be serviceable.
- o Changes to pole nailing criteria to cease nailing specific unserviceable poles with <30mm wall thickness, untreated/natural poles and for poles that have <50% remining wood at groundline

Many of these actions triggered further analysis to determine gaps and further improvement opportunities but of particular relevance was the analysis completed for determining the changes to be implemented in the pole serviceability calculations. As part of this there was a significant amount of modelling completed to look at the potential impact of implementing different options and different combinations of options before final decisions were made on the correct criteria and changes to implement.

This analysis is based on detailed modelling for each individual pole using the measurements taken from the previous inspection to predict the serviceability outcome. An example of the modelling at the individual pole level is shown in Figure 32. This spreadsheet contains all of the measured values and calculated results from the previous inspection and the new formulas and variables required in the new calculation.

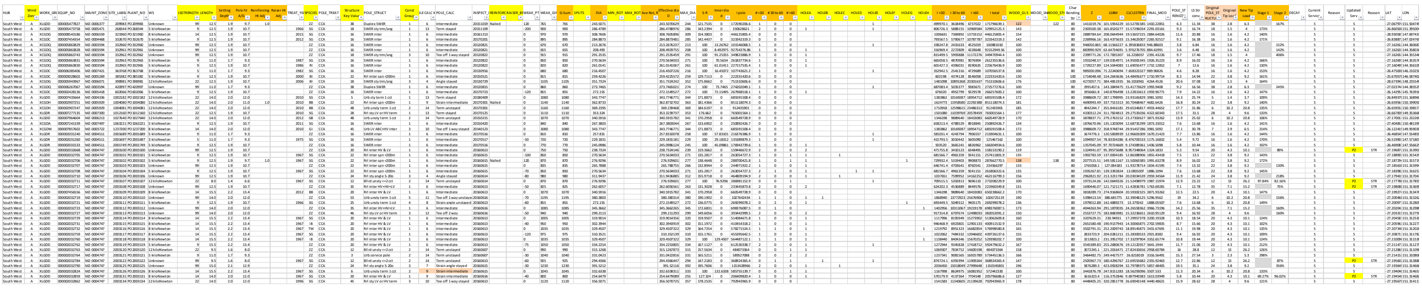


Figure 32 – snapshot of modelling data used impact analysis

A key part of this modelling was the comparison of the old serviceability result to the new serviceability result to understand the impact on the replacement/nailing volumes for different changes to bending strength and the calculated Limit State strength comparison as shown in Figure 33. The green cells represent those poles where the serviceability result remains the same. Red cells represent poles that would be unserviceable under the new calculation but were serviceable previously.

SOUTH WEST

		New Calculation			
	Minimum Char Bending STR and 5kN calculated LS strength				
	Row Labels	P1	P2	S	Grand Total
Old Calculation	P1	54	5		59
	P2	5	408	19	432
	S	5	4537	137301	141843
	Grand Total	64	4950	137320	142334
	Mid Char Bending STR and 5kN calculated LS strength				
	Row Labels	P1	P2	S	Grand Total
	P1	53	6		59
	P2	4	397	31	432
	S	4	3834	138005	141843
	Grand Total	61	4237	138036	142334
	Mid Char Bending STR and 4.5kN calculated LS strength				
	Row Labels	P1	P2	S	Grand Total
	P1	53	6		59
	P2	4	397	31	432
	S	4	2681	139158	141843
	Grand Total	61	3084	139189	142334
	Mid Char Bending STR and 4kN calculated LS strength				
	Row Labels	P1	P2	S	Grand Total
	P1	53	6		59
	P2	4	397	31	432
	S	4	2100	139739	141843
	Grand Total	61	2503	139770	142334
	Maximum Char Bending STR and 4kN calculated LS strength				
	Row Labels	P1	P2	S	Grand Total
	P1	52	5	2	59
	P2	4	383	45	432
	S	4	1630	140209	141843
	Grand Total	60	2018	140256	142334

Figure 33 – Impact modelling of potential serviceability changes (South West area)

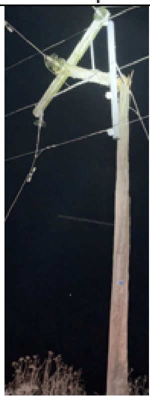
This modelling was completed for all areas and options. A snapshot summary of the analysis is shown in Figure 34 below. This table shows the different options that were considered for implementation and the associated impact on unserviceable poles volumes in each geographical area.

	Unserviceable Pole Options Analysis (P1 and P2)												
	Pioneer	South West	Capricornia	Darling Downs	Herbert	Far North	Tropical Coast	Bundaberg	Flinders	Central West	Fraser Burnett	TOTAL	Per Year
Option 1 - Minimum Char Bending STR and 5kN minimum strength	3,589	5,014	4,079	1,596	4,467	1,308	1,679	1,660	4,253	2,588	903	31,136	7,076
Option 2 - Mid Char Bending STR and 5kN minimum strength	3,111	4,298	3,372	1,225	3,756	1,013	1,325	1,365	3,588	2,142	727	25,922	5,891
Option 3 - Mid Char Bending STR and 4.5kN minimum strength	3,077	3,145	3,267	1,169	3,746	1,013	1,315	1,361	3,509	1,621	699	23,922	5,437
Option 4 - Mid Char Bending STR and 4kN minimum strength	3,061	2,564	3,223	1,149	3,740	1,013	1,311	1,357	3,472	1,364	684	22,938	5,213
Option 5 - Maximum Char Bending STR and 4kN minimum strength	2,662	2,078	2,710	891	3,188	799	1,057	1,128	2,946	1,142	563	19,164	4,355
Population	62,325	142,334	91,685	95,566	43,465	58,357	39,237	66,129	78,189	86,447	79,509	843,243	
Option 1 - % of population	5.76%	3.52%	4.45%	1.67%	10.28%	2.24%	4.28%	2.51%	5.44%	2.99%	1.14%	3.69%	
Option 2 - % of population	4.99%	3.02%	3.68%	1.28%	8.64%	1.74%	3.38%	2.06%	4.59%	2.48%	0.91%	3.07%	
Option 3 - % of population	4.94%	2.21%	3.56%	1.22%	8.62%	1.74%	3.35%	2.06%	4.49%	1.88%	0.88%	2.84%	
Option 4 - % of population	4.91%	1.80%	3.52%	1.20%	8.60%	1.74%	3.34%	2.05%	4.44%	1.58%	0.86%	2.72%	
Option 5 - % of population	4.27%	1.46%	2.96%	0.93%	7.33%	1.37%	2.69%	1.71%	3.77%	1.32%	0.71%	2.27%	

Figure 34 – Summary of pole serviceability calculation change modelling by area

ANNEX B - POLE FAILURE PHOTOS

The following are examples of some of the pole failures that occur within the Ergon Energy network. These are included to show the extent of some of the rot and termite problems as well as to highlight other reasons for pole failures.

	
Site Label: 5071274 Inspection Date: 25th November 2022 Failure Date: 30th September 2024	Site Label: 5022043 Inspection Date: 21st October 2019 Failure Date: 26th October 2023
	
Site Label: 3119279 Inspection Date: 25th March 2020 Failure Date: 20th July 2023	Site Label: 5162317 Inspection Date: 20th February 2020 Failure Date: 16th February 2023
	
Site Label: 3103388 Inspection Date: 23rd January 2020 Failure Date: 5th November 2023	Site Label: 5234433 Inspection Date: 6th September 2023 Failure Date: 17th November 2023

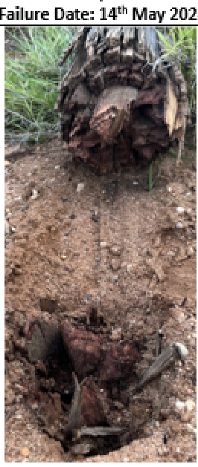
Site Label: 4226153 Inspection Date: 13th April 2021
Failure Date: 7th December 2023

Site Label: 5209341 Inspection Date: 17th August 2018
Failure Date: 20th October 2022

Site Label: 3193847 Inspection Date: 22nd April 2020
Failure Date: 9th December 2023

Site Label: 2074150 Inspection Date: 15th September 2023
Failure Date: 1st January 2024

Site Label: 4225495 Inspection Date: 27 April 2018
Failure Date: 27th January 2023

	
Site Label: 2118219 Inspection Date: 20th September 2022 Failure Date: 8th March 2023	Site Label: 3201281 Inspection Date: 9th March 2021 Failure Date: 6th January 2024
	
Site Label: 2091529 Inspection Date: 13th May 2019 Failure Date: 14th May 2024	Site Label: 3009730 Inspection Date: 8th August 2023 Failure Date: 29th September
	
Site Label: 5022088 Inspection Date: 8th October 2019 Failure Date: 11th January 2024	Site Label: 2074519 Inspection Date: 12th April 2024 Failure Date: 27th September 2024

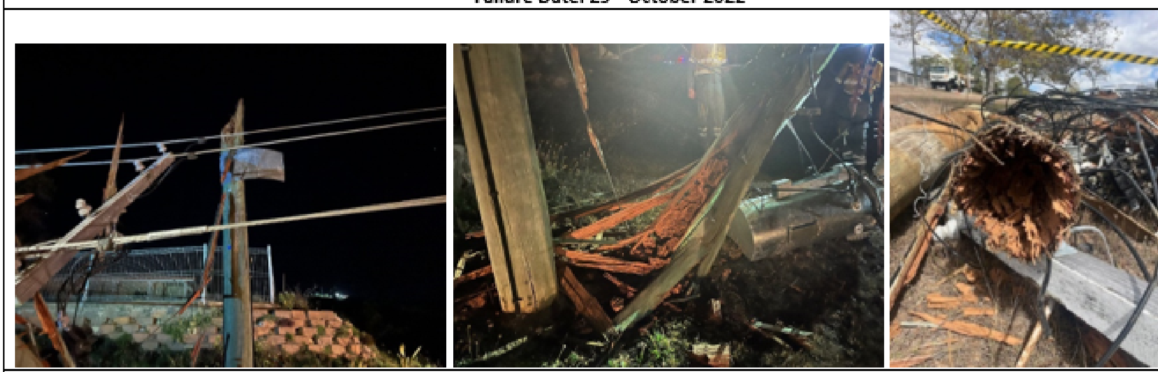
	
Site Label: 2070331 Inspection Date: 12th December 2020 Failure Date: 20th February 2024	Site Label: 5154111 Inspection Date: 26th April 2020 Failure Date: 29th March 2023
	
Site Label: 3120345 Inspection Date: 28th June 2019 Failure Date: 15th March 2023	Site Label: 6030240 Inspection Date: 9th November 2018 Failure Date: 7th April 2023
	
Site Label: 4246758 Inspection Date: 14th June 2021 Failure Date: 2nd July 2024	Site Label: 3097925 Inspection Date: 20th January 2020 Failure Date: 7th April 2023

	
Site Label: 3145248 Inspection Date: 19th January 2024 Failure Date: 7th April 2024	Site Label: 3054189 Inspection Date: 27th September 2022 Failure Date: 2nd February 2023
	
Site Label: 4125050 Inspection Date: 7th September 2021 Failure Date: 13th March 2023	Site Label: 5002190 Inspection Date: 11th December 2020 Failure Date: 9th April 2023
	
Site Label: 5090143 Inspection Date: 8th October 2020 Failure Date: 8th March 2023	Site Label: 3054101 Inspection Date: 4th October 2022 Failure Date: 8th October 2022

Site Label: 4147043 Inspection Date: 15th July 2020
Failure Date: 23rd January 2024

Site Label: 5149534 Inspection Date: 13th November 2018
Failure Date: 29th March 2023

Site Label: 2064757 Inspection Date: 29th April 2019
Failure Date: 29th October 2022



Site Label: 5241595 Inspection Date: 19th May 2022
Failure Date: 10th September 2024