Unplanned Interruptions Report

For the Year End 31 March 2023

Contents

1. Summary 3

2. Reference to reporting compliance requirements. 5

3. Glossary. 5

4. List of tables. 5

5. List of figures. 6

6. Our Network. 7

7. Quality Compliance. 7

8. TLC's quality and asset management performance in RY2023. 8

9. Independent reviews of our network 9

10. Internal Investigations of our non-compliance 12

11. Major Events Analysis 27

12. Analysis of our network condition 29

13. Summary of our asset management improvement. 39

14. Intended reviews, analysis or investigations into RY2023 reliabilty performance. 44

15. Schedule 10: Form of director's certificate for unplanned interruptions reporting. 45

Appendix A: Summaries of Major Event ICAM reports. 46

Appendix B: Detailed Class C Interruptions 54

Appendix C: Analysis conducted. 55

Appendix D: Independent investigations 63

1. Summary

Breach of quality standard for Regulatory Year 2023.

As detailed in section 4 – Quality Standards of our Annual Compliance Statement for the year ended 31 March 2023 (RY2023), The Lines Company (TLC) is non-compliant with our unplanned (class C) SAIDI and SAIFI. As we have exceeded our unplanned limits for the assessment period, we must provide the Commerce Commission with unplanned interruptions reporting and make the report publicly available on our website.

Summary of our assessment.

In Regulatory Year 2023 (RY2023) the TLC network experienced the most extreme weather days since records began in 1940, with almost three times the number of extreme weather days than the previous 20-year average. Although the year was punctuated with Cyclone Gabrielle in February, 92% of the most extreme weather days[1] in RY2023 had occurred before that point.

Our analysis indicates that weather intensity was the key driver behind TLC's outages in RY2023, with 75% of our interruption duration (SAIDI) and 44% of our interruption frequency (SAIFI) resulting from outages occurring around days with extreme weather.

TLC also experienced outages caused by defective equipment; however, it was pleasing to see that despite the significant additional stress on the TLC network, defective equipment faults, and their impact on customers remained generally consistent with the previous five-year average.

Our response to cyclone Gabrielle

Cyclone Gabrielle was an exceptional event that created significant disruption on our network. As with other electricity distributors, field and fault resources were stretched beyond normal operating capacity as we sought to manage the volume of damage to our network. We have undertaken an independent review to identify the key learnings from this event and to understand how we can prepare for similar events in future. This has highlighted some improvements we can make how we develop a greater 'surge' response for extreme events, especially in key areas of our control and field teams. We are working to further develop in this area, giving consideration to efficiencies we can make by implementing supporting systems, and balancing costs to our customers.

[1] 85% of extreme weather days occurred before Cyclone Gabrielle as measured at the 95th percentile, or 92% as measured by the 90th percentile, as defined by NIWA, occurred prior to February 2023.

TLC is continuing to invest in asset management.

TLC is making significant investments in its network and people. We have materially increased our asset renewal and quality of supply expenditure in the last five years and continue to progress our asset management capabilities and supporting systems through an ongoing asset management improvement programme.

We believe our people, processes and systems are working effectively to manage reliabilty to our customers and we are continuing to positively progress our asset management capabilities and network performance.

2. Reference to reporting compliance requirements.

DPP Determination Requirement	Reference section in this report
12.4 (a)	Section 8: TLC's quality and asset management performance in RY2023
12.4 (b)	Appendix B: Detailed Class C Interruptions
12.4 (c)	Section 9: Independent reviews
12.4 (d)	Section 11: Major Events Analysis and Appendix A: Summaries of Major Event ICAM reports
12.4 (e)	Section 10: Internal Investigations of our non-compliance
12.4 (f)	Appendix C: Analysis conducted
12.4 (g)	Section 14 Intended reviews, analysis or investigations into RY2023 reliabilty performance
12.4 (h)	Schedule 10: Form of director's certificate for unplanned interruptions reporting

3. Glossary.

ADMS	Advanced Distribution Management System
DOC	Department of Conservation
GLZ	Growth Limit Zone
LiDAR	Light Detection and Ranging
ME	Major Event
NIWA	National Institute of Water and Atmospheric Research
RY	Regulatory year - commencing 1 April to 31 March.
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index

4. List of tables.

Table 1 Compliance Summary 7

Table 2 Independent review: TLC's response to Cyclone Gabrielle 9

Table 3 Independent review: Failure mode and effects analysis 11

Table 4 Outages that occurred during the bands around 90th percentile extreme weather days. 17

Table 5 Primary drivers of SAIDI and comparative increase from preceding years. 25

Table 6 Primary drivers of SAIFI and comparative increase from preceding years 26

Table 7 Summary of Major Events in RY2023 28

5. List of figures.

Figure 1: RY2023 raw SAIDI compared with the preceding 5-year average 12
Figure 2: RY2023 raw SAIDI compared with February adjusted to the preceding 5-year average. 13
Figure 3: RY2023 raw SAIFI with February 2023 normalised to the preceding 5-year average. 13
Figure 4: RY2023 raw SAIFI with February 2023 adjusted to the preceding 5-year average. 14
Figure 5: RY2023 – count of days when weather intensity exceeded the 95th percentile on the TLC network. 15
Figure 6: RY2023 – correlation of days when weather exceeded the 90th percentile on the TLC network and fault count 16
Figure 7: RY2023 count of outages compared with the preceding 5-year average. 17
Figure 8: Number of days with more than five outages. 18
Figure 9: Vegetation outages in RY2023 18
Figure 10: Example of a line corridor prior to a storm. 19
Figure 11: The same line corridor following a storm. 20
Figure 12: Example of tree damage from a plantation forest. 20
Figure 13: A line originally constructed on a farm that has been converted to a commercial forest... 21
Figure 14: Example of tree at risk of falling onto a line following heavy rainfall. 21
Figure 15: A commercial forest with most trees snapped following Cyclone Gabrielle 22
Figure 16: Defective equipment fault count trends 23
Figure 17: Defective equipment SAIDI trends. 23
Figure 18: Unknown cause fault count trends. 24
Figure 19: Unknown cause SAIDI trends. 24
Figure 20: RY2023 Raw SAIDI within and outside TLC's direct control. 26
Figure 21: Typical asset deterioration over time 30
Figure 22: How the condition of TLC's key asset condition ranks against NZ Electricity Distributors... 30
Figure 23: RY2023 faults on poles across health grades 32
Figure 24: RY2023 faults on crossarms across health grades 33
Figure 25: Asset replacement and renewal expenditure for the preceding ten-year period 33
Figure 26: Asset replacement and renewal expenditure – actual vs forecast 34
Figure 27: Renewal expenditure per customer – industry comparison 36
Figure 28: Quality of supply expenditure for the preceding ten-year period. 37
Figure 29: Operational governance framework for asset management 41
Figure 30: TLC's asset management maturity progress since RY2018. 43

6. Our Network.

The Lines Company Limited (TLC) owns and operates the electricity distribution network in the King Country, Ruapehu and Central Plateau areas. Our network covers an area of 13,700 km^2 and supplies approximately 24,000 connections. Our network has 4,500 km of power lines, 35,000 power poles, 5,000+ transformers, 29 substations and eight points of supply from the national grid.

7. Quality Compliance.

Clause 9.7 of the DPP Determination requires non-exempt Electricity Distribution Businesses (EDBs), in respect of each assessment period, to comply with the annual unplanned reliability assessment specified in clause 9.8 for that assessment period. To comply with the annual unplanned interruptions reliability assessment, non-exempt EDBs must not exceed the unplanned SAIDI limit, or the unplanned SAIFI limit specified in paragraph (1) of Schedule 3.2 of the DPP Determination.

TLC did not comply with its Unplanned SAIDI or SAIFI limits for RY2023 as shown in Table 1:

Table 1 Compliance Summary

Unplanned SAIDI	
Unplanned SAIDI Limit	181.48
Unplanned SAIDI Assessed Values	238.94
Compliance result	**Non-Compliant**
Unplanned SAIFI	
Unplanned SAIFI Limit	3.2715
Unplanned SAIFI Assessed Values	3.4377
Compliance result	**Non-Compliant**

As we did not comply with clause 9.8(a) of the DPP Determination and accordingly, we must:

1. Provide the Commission with the "unplanned interruption reporting" specified in clause 12.4 of the DPP Determination within five months after the end of that assessment period; and
2. Make the "unplanned interruptions reporting" available on our website.

This report is provided to meet the requirements following our non-compliance with Unplanned SAIDI and SAIFI for RY2023.

8. TLC's quality and asset management performance in RY2023.

Section12.4(a) of the DPP Determination 2020 requires us to report on the reasons for not complying with the annual unplanned interruptions reliability assessment specified in clause 9.8 and supporting evidence for those reasons.

Our assessment of the network unplanned outage performance is that:

- **In terms of TLC's breach of SAIDI and SAIFI compliance thresholds:**
  - Adverse weather and out of zone tree fall (which was driven by adverse weather) were the primary drivers of outages during the year.
  - Defective equipment and unknown cause outages were secondary effects driven in part by the adverse weather experienced in RY2023.
  - RY2023 was, by historic measures of weather intensity, an exceptional year.
  - The effects of that weather intensity were seen throughout the year, and not confined to specific months.
- **In terms of TLC's network assets:**
  - The condition of TLC's at-risk (H1 and H2) assets is broadly in line with the industry median.
  - H1 and H2 assets were not disproportionately represented in defective equipment faults.
- **In terms of TLC's asset management practices:**
  - TLC is consistently renewing assets in line with its forecasts and is investing at a rate generally higher than the industry as measured by investment per customer.
  - TLC is making ongoing improvements to its asset management capabilities and systems.

These findings and supporting evidence are outlined in the following sections of this report.

9. Independent reviews of our network

Section12.4(c) of the DPP Determination 2020 requires us to report on any independent reviews on the state of the network or operational practices completed in the assessment period or in any of the three preceding assessment periods.

Two external reviews have been undertaken relating to the relevant assessment periods. They focused on gaining a better understanding of our fault causes and our operational response to managing faults. The reports and their key findings are summarised below and are attached in Appendix C.

A further report by Strata Energy was commissioned by the Commerce Commission to investigate TLC's SAIDI and SAIFI quality compliance in RY's 2018, 2019 and 2020, and was completed in March 2020. The outcome of this investigation is yet to be finalised; however, it is likely that an independent engineering review will be completed as part of the follow up to the quality exceedances.

Responding to Cyclone Gabrielle

This report was commissioned to enable TLC to assess its performance in managing an extreme event, and to gain insights on areas of improvement. The report is summarised in Table 2.

Table 2 Independent review: TLC's response to Cyclone Gabrielle

Title	**Responding to Cyclone Gabrielle: A review of The Lines Company's response to and recovery from Cyclone Gabrielle**
Author	Paul Blackmore, Agila Solutions Limited
Issued	30 June 2023
Purpose	To document the learnings that The Lines Company (TLC) gained from its response to and recovery from the impact of Cyclone Gabrielle and provide TLC with insights and recommendations on how to improve its response to future events.
Summary of Findings	The key findings of the report are summarised as follows: • TLC implemented a Co-ordinated Incident Management System (CIMS) framework during Cyclone Gabrielle, but it was not specifically tailored to damaging windstorms. • The implementation of prepared information gathering tools such as integrated dispatch and incident Response Management spreadsheets could have enabled the CIMs intelligence function to operate more effectively. **TLC notes that:** *These are key learnings for TLC to streamline its CIMs framework, (which was first initiated mid 2022 calendar year) for major events. TLC had planned to run a major incident simulation in March to test the robustness of the CIMS framework under a major event scenario, but this was pre-empted by Cyclone Gabrielle which occurred before the planned simulation.* • The use of visual aids such as maps displaying the location and status of outage areas proved to be highly effective.

	TLC notes that: *The use of visual aids continues to be a significant tool for TLC's control functions, and we are continuing to develop these.* • It could have been helpful to have additional controllers available to alleviate bottlenecks for switching and access permits. **TLC notes that:** *We agree that it could have been helpful to have additional controllers to alleviate bottlenecks, and the issue was exacerbated by the illness of one controller during the Cyclone Gabrielle event. However, we note that the number of controllers is dimensioned to support normal business operations (including being able to support typical major events). In contrast, Cyclone Gabrielle was an extreme event that was unprecedented. There are pragmatic recommendations in the report to relieve constraints on controllers (such as administrative tasks) that we are reviewing. Our Digital Utility Programme, which we are now commencing, is expected to significantly change the controller functions through the implementation of an Advanced Distribution Management System (ADMS) that will alleviate significant overhead from controllers. This is expected to be implemented over the next 24 months.* • Better communication of restoration priorities to controllers and field crews would have improved queuing of field crew access to the controllers. **TLC notes that:** *We agree, and this is a key learning in our response to extreme events.* • Undertaking a significant network event simulation exercise can enhance the response to major weather events. **TLC notes that:** *We agree, and as noted, this was planned for March 2023 but was pre-empted by the occurrence of Cyclone Gabrielle.*

This review has been a valuable in developing our response to managing extreme events. However, we note that had the recommended mitigations been in place, TLC's SAIDI and SAIFI compliance outcomes would not be materially different, as the majority of the SAIDI and SAIFI incurred during the event was "normalised out" of our compliance assessment via the quality normalisation process. As we note later in this report, RY2023 was characterised by an almost threefold increase in extreme weather days, which occurred throughout the year, and this was the primary contributor to SAIDI and SAIFI performance.

Failure Mode and Effects Analysis of pole top assets.

This review was commissioned to gain a deeper understanding of common pole top failures, and the effectiveness of inspection methods to detect them. This work was undertaken to support a business case to commission a full network wide pole top photography programme to update TLC's asset database on the health of TLC's core distribution line assets. The report is summarised in Table 3.

Table 3 Independent review: Failure mode and effects analysis

Title	Review of Failure Mode and Effects Analysis (FMEA)
Author	Paul Blackmore, Agila Solutions Limited
Issued	20 November 2022
Purpose	To assess TLC's defective equipment failure modes and determine how these could be detected by various inspection methods. The report investigated the following issues: • Consequences of failure in relation to safety and service levels. • The level of risk given current failure rates • The most effective inspection task available for the failure cause. • How far in advance can the inspection task detect future failure. • Tasks effectiveness – proportion of future failures it can reliably detect.
Summary of Findings	The key findings of the report are summarised as follows: • Pole top photography is effective for about 64% of failure modes. • Ground inspections will still be required to manage safety related structural failure modes for timber poles, steel poles and stay wires. • There is no effective field inspection method to address joint and conductor failures, but this could be managed by predictive modelling. **TLC notes that:** *This review has supported TLC's decision to commission a full network pole top photography condition assessment which is planned to be completed in RY2024.*

10. Internal Investigations of our non-compliance

Section 12.4(e) of the DPP Determination 2020 requires us to include in our unplanned interruptions report any investigations we have undertaken to understand why we did not comply with our compliance limits.

We have undertaken an internal review of RY2023 performance which is provided in this section.

10.1. Extreme weather and out-of-zone tree interference were the primary drivers of our non-compliance.

The primary drivers of noncompliance in RY2023 were:

- an increase in extreme weather events on our network
- interference from out of zone trees which was driven by adverse weather.

Two other outage categories contributed to our SAIDI and SAIFI performance in RY2023, which we believe are also driven by adverse weather above. They were:

- outages caused by defective equipment.
- outages caused by unknown cause interruptions.

10.2. RY2023 was an extreme year even without Cyclone Gabrielle.

Figure 1 shows the context of our unplanned Raw (non-normalised) SAIDI in RY2023 compared with the preceding five-year average. This includes the impact of Cyclone Gabrielle in February 2023, which was a rare event with a material impact on our total outage performance.

Figure 1: RY2023 raw SAIDI compared with the preceding 5-year average

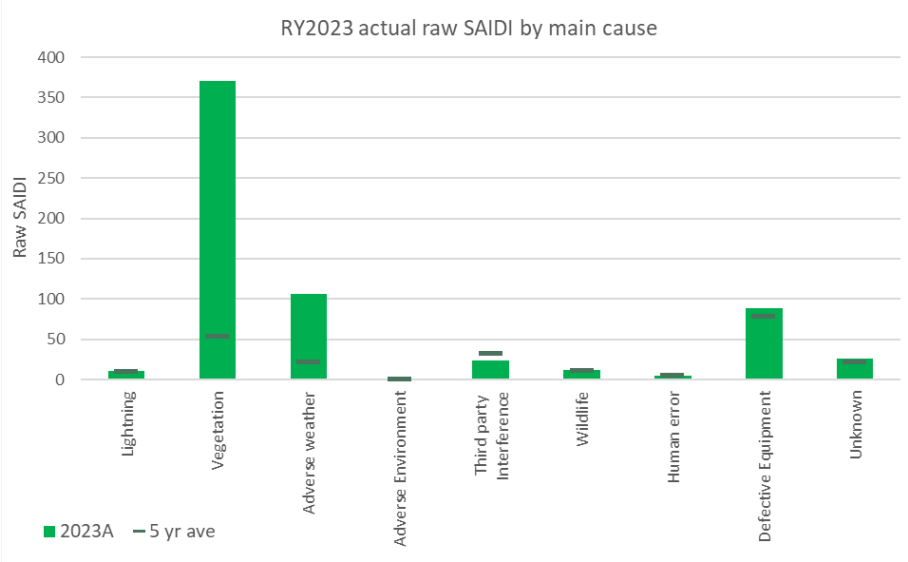


Figure 2 shows the total Raw (non-normalised) SAIDI with the impact of Cyclone Gabrielle removed. In this case we have replaced the February 2023 SAIDI with the preceding 5-year

average SAIDI for February. It shows that even without the impact of Cyclone Gabrielle, RY2023 was an extreme year dominated by vegetation interference and adverse weather conditions.

Figure 2: RY2023 raw SAIDI compared with February adjusted to the preceding 5-year average.

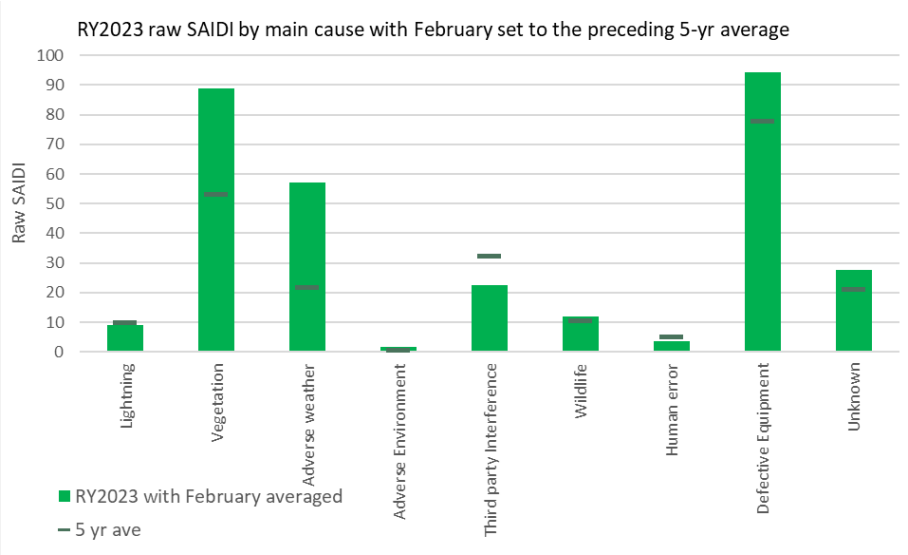


Figure 3 shows the context of our unplanned Raw (non-normalised) SAIFI in RY2023 compared with the preceding five-year average (this includes the impact of Cyclone Gabrielle) and shows that adverse weather and vegetation were the primary drivers for SAIFI increases during the year.

Figure 3: RY2023 raw SAIFI with February 2023 normalised to the preceding 5-year average.

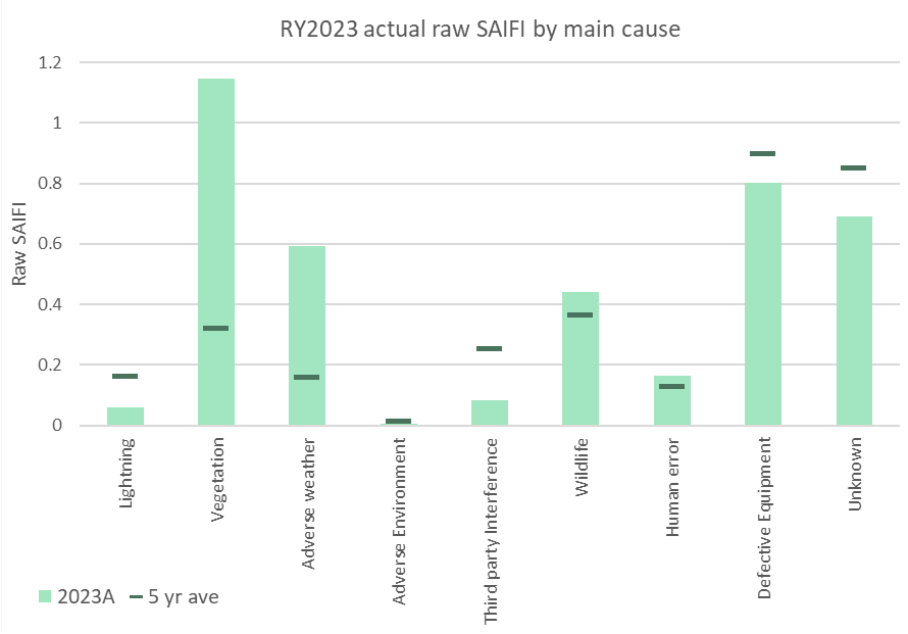
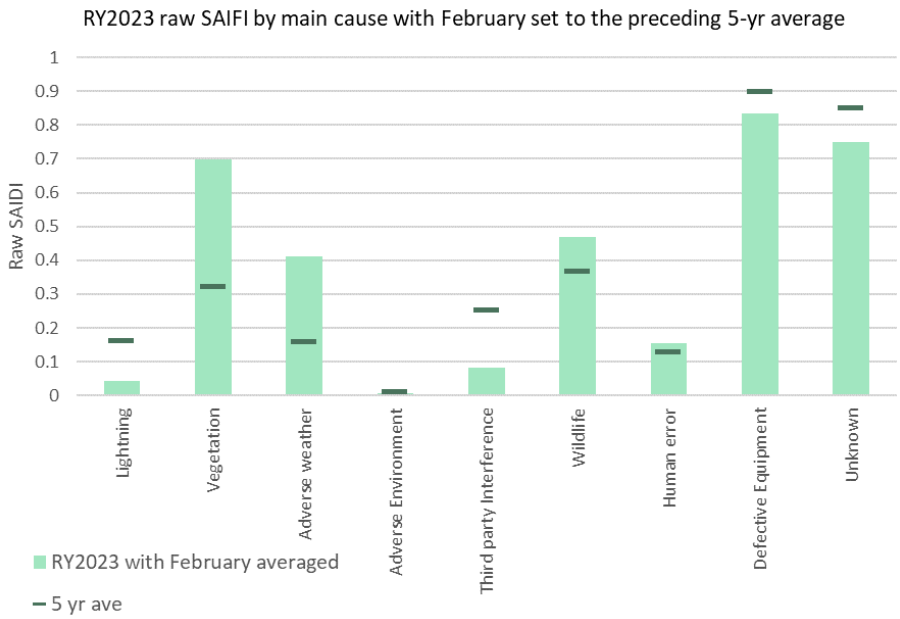


Figure 4 shows the total raw (non-normalised) SAIFI with the impact of Cyclone Gabrielle removed. It highlights that the core drivers of SAIFI during the year were the same and that Defective Equipment and Unknown Cause SAIFI were lower than the 5-year average.

Figure 4: RY2023 raw SAIFI with February 2023 adjusted to the preceding 5-year average.



10.3. Analysis of key driver: Extreme weather.

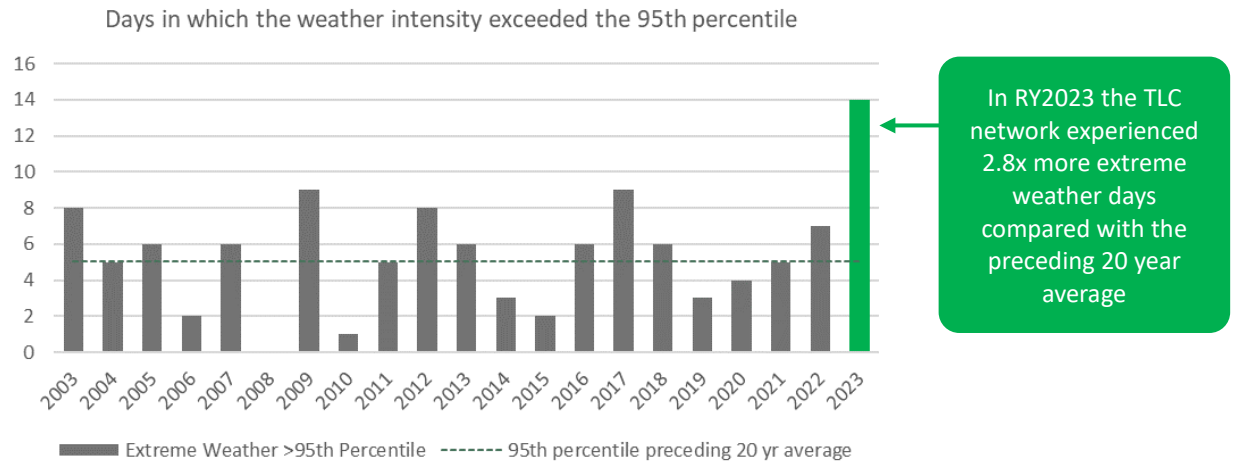
We have assessed RY2023 in several ways to highlight the significant difference in RY2023 compared with prior years.

Extreme weather days comparison.

To assess the impact of weather on TLC's network performance in RY2023, we engaged NIWA to establish a base measurement for extreme weather, which we defined as days where the wind intensity or rain inundation (or both) were above the 95th percentile for the TLC network (refer to Extreme Weather Report prepared by NIWA in Appendix D). We have included rain inundation as a criterion because although wind intensity is typically the primary cause of vegetation or weather related outages, rain inundation weakens the supporting ground strength of trees and pole assets, rendering them more susceptible to failure under lighter wind gusts.

Figure 5 shows the count of days each year when weather intensity exceeded the 95th percentile over the last twenty years. It shows that RY2023 had the most extreme weather days of any year in the last twenty years. The total count of extreme weather days was roughly 2.8x the preceding twenty-year average. NIWA's analysis has also confirmed that in fact RY2023 had the most extreme weather days since records began in 1940 when measured at the 95th percentile.

Figure 5: RY2023 – count of days when weather intensity exceeded the 95th percentile on the TLC network.



Extreme weather correlation with faults

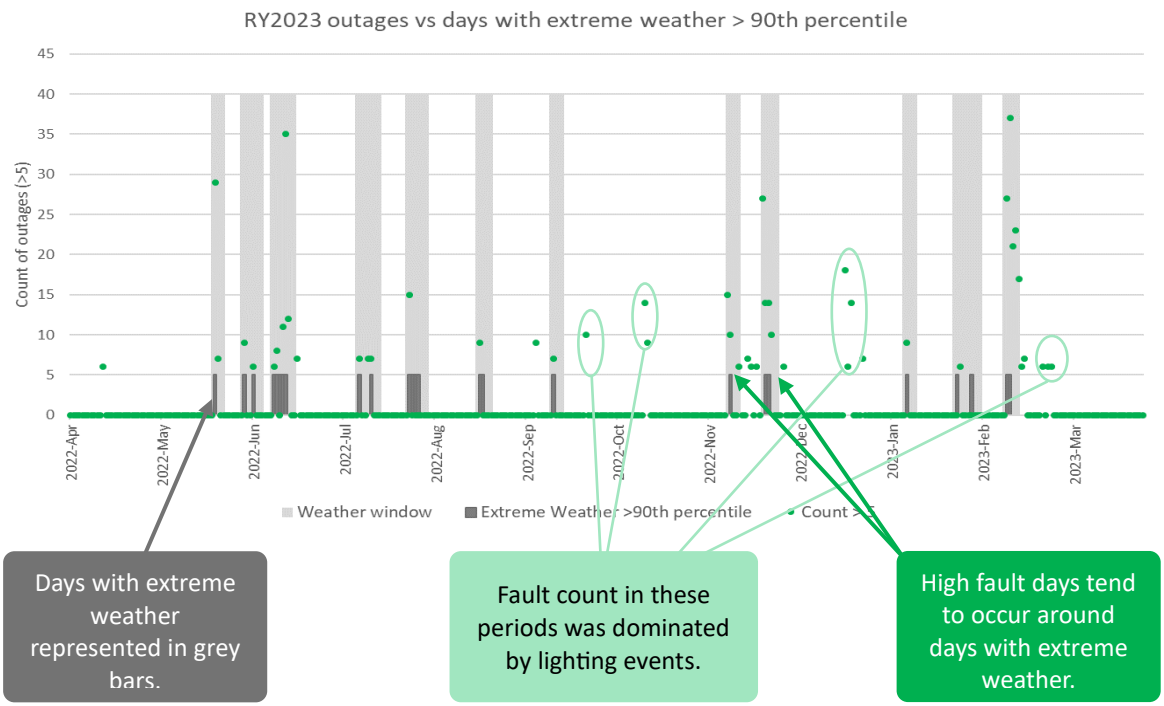
To understand the correlation between extreme weather and fault count we overlaid the extreme weather days against days when TLC's fault count exceeded 5 outages per day[2]. We also extended the NIWA analysis to capture days when the weather intensity exceeded the 90th percentile, to provide a broader data set for weather and fault correlations.

Note that the correlation is imperfect because wind and water inundation are localised and have build-up and run-down periods. Consequently, we expect that faults will build in days just prior to an extreme weather day and continue after as the storm intensity reduces but has left residual damage on the network that is vulnerable to further failure. Our experience is that outages linked to an extreme weather event tend to begin ~24 hours prior as the storm builds up, and continue until ~3 days after, as property owners notice water supply to troughs and other services are not operating. To demonstrate this and the correlation with extreme weather events we have shown the four-day window ('bands') around extreme weather days.

Figure 6 shows that there is a strong correlation between extreme weather days in RY2023 and the number of days with high outages.

[2] The rationale for choosing five outages per day was to eliminate the effect of 'normal 'fault days from the analysis. Typically, TLC experiences less than five outages per day (87% of days in RY2023 had less than five outages).

Figure 6: RY2023 – correlation of days when weather exceeded the 90th percentile on the TLC network and fault count



Not all outages are driven by wind and water inundation. In some cases high fault days occur outside extreme weather days. In most cases during RY2023, high fault occurrences outside extreme weather days were driven by lightning storms that did not breach the 90th percentile intensity threshold but generated significant faults. For example, 14 lightning faults occurred on 13 October and 18 lightning faults occurred on 20 December.

Most extreme weather days occurred prior to cyclone Gabrielle.

Although the year was punctuated by the impact of Cyclone Gabrielle in February 2023, most of the extreme weather days occurred before that point. 85% of extreme weather days if measured by the 95th percentile occurred before February 2023, and 92% if measured by the 90th percentile.

Most of TLC's fault count, SAIDI and SAIFI occurred during the extreme weather windows.

The extreme weather windows, meaning the 24 hours prior to and 3 days following an extreme weather day, totalled 82 days in RY2023, or 22% in terms of time. However, most of the fault count, SAIDI and SAIFI occurred during these extreme weather windows. Table 4 shows that 75% of SAIDI and 44% of SAIFI occurred during the bands around the 90th percentile extreme weather days.

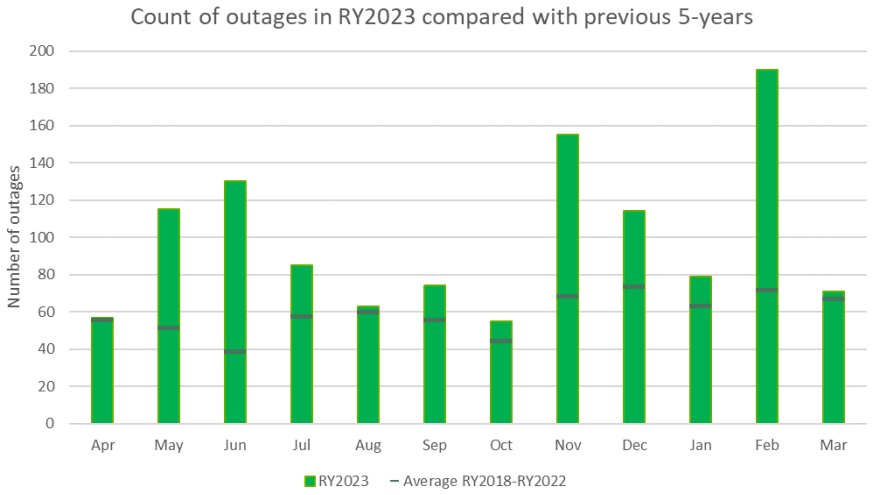
Table 4 Outages that occurred during the bands around 90th percentile extreme weather days.

	Days in the extreme weather bands	Count of faults	SAIDI	SAIFI
Within the extreme weather bands	82	525	491	1.76
Total in all RY2023	365	1,188	656	3.98
Proportion	22%	44%	75%	44%

Count of outages comparison

Figure 7 provides a consolidated comparison of RY2023 compared with TLC's historic performance, showing the count of outages in RY2023 compared with the preceding five-year average. This demonstrates that the fault count was consistently high across the RY2023 year, and not confined to individual months.

Figure 7: RY2023 count of outages compared with the preceding 5-year average.

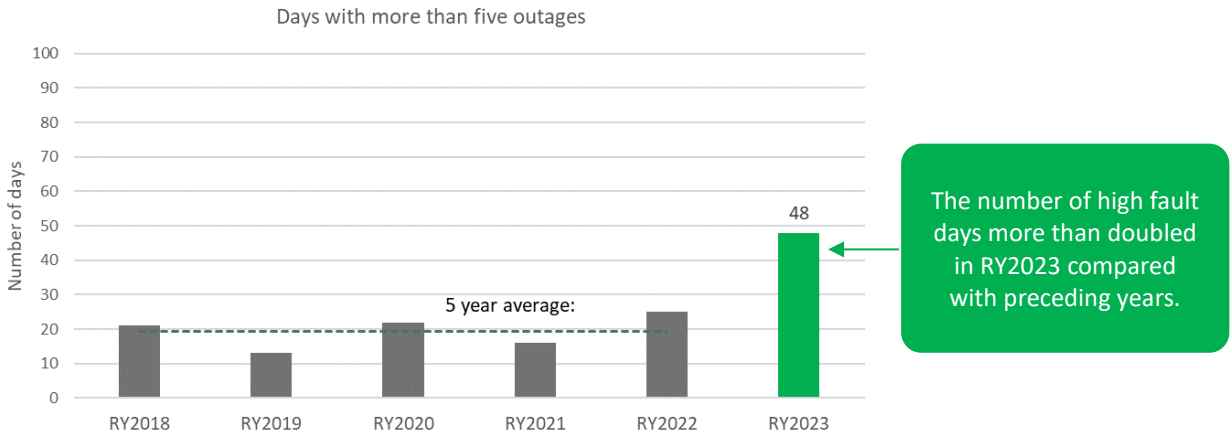


High fault days comparison.

Days with extreme weather generate multiple faults, so we can also get an indicative view of weather impacts by assessing the count of outages per day where the fault count is high. TLC typically experiences around 20 days per year when the fault count exceeds five faults per day. Figure 8 shows that in RY2023 TLC experienced 47 high-fault days. Although this is only an indicative measure of the impact of weather on our network, it demonstrates the significant difference of RY2023 compared with TLC's historic trends.

We note from this analysis that electricity distributors, including TLC, are typically sized to manage an average year of outages. Although there is some ability to stretch capacity for unusual years, the volume of high fault days in RY2023 was beyond expected operating capacity. This impacted TLC's response to faults, especially in regard to managing fatigue. Under these circumstances the average time to restore faults typically increases during high fault days. Figure 8 shows context of high fault days TLC experienced on its network in RY2023. It shows that the number of days with high fault counts more than doubled in RY2023 compared with the preceding five-year average.

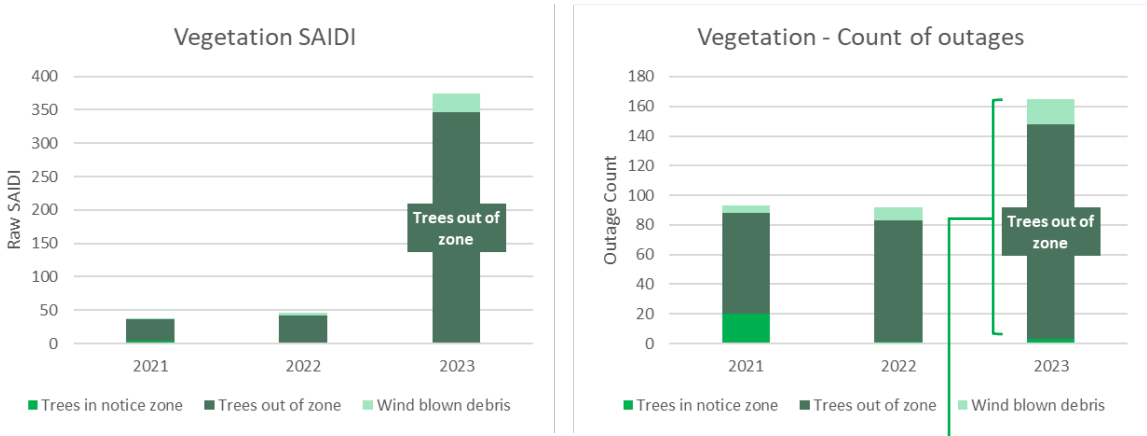
Figure 8: Number of days with more than five outages.



10.4. Analysis of key driver: Out of Growth Limit Zone (GLZ) vegetation interference.

RY2023 also saw an increase in vegetation interference due to out of growth limit zone compared with prior years. In 2021, we extended our fault reporting to capture more detail on vegetation interference, which has shown that more than 90% of our vegetation interference is caused by trees falling onto lines from outside the GLZ notice zone. Figure *9* shows that in RY2023 98% of vegetation outages were caused by out of zone tree fall.

Figure 9: Vegetation outages in RY2023



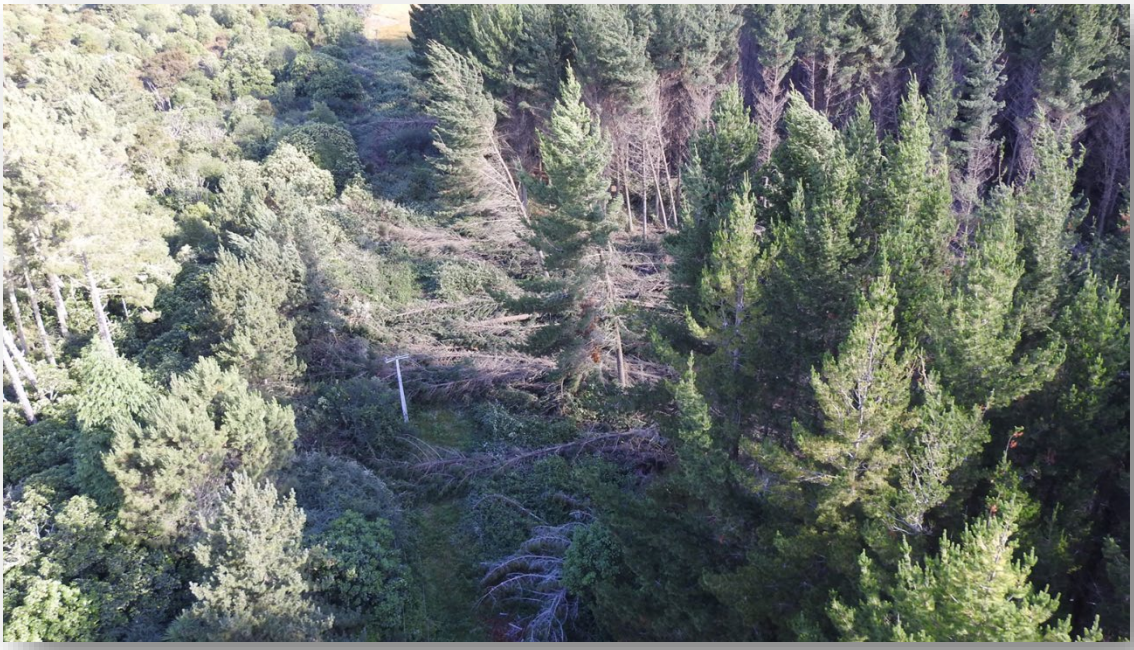
In RY2023, 98% of vegetation outages were caused by trees failing onto our lines from outside the notice zone, or from windblown debris.

We have previously noted in our submissions on tree regulations, that tree fall is an increasing challenge on the TLC network for several reasons:

1. The network is heavily forested with both native national parks and commercial pine forests with 269 km of our overhead lines running through forestry blocks and a further 106 km through dense Department of Conservation (DOC) land. TLC has intensive vegetation clearance programs in place and regularly fly the network by helicopter to identify tree risk areas and do fault finding. Landowners are notified of any vegetation withing the Growth Limit Zone and TLC will work with them to either remove or trim these trees as required. Landowners are however generally less co-operative to remove trees outside the GLZ and it is these trees that causes most of our issues.
2. As well as ongoing the helicopter inspections TLC executed a full LiDAR scan across the network in 2021 and plan do this every four years. This LiDAR scans enables our engineering team to pro-actively identify low hanging lines, lines with potential to clash, the proactive identification vegetation encroaching into the GLZ.
3. Figure *10* shows a line corridor with a national park and commercial forest on either side. Figure 11 shows the same forest following a storm, with severe damage resulting primarily from the commercial forest.

Figure 10: Example of a line corridor prior to a storm.

Figure 11: The same line corridor following a storm.



4. The density of commercial forest plantations means that internal trees have weak root structures and are extremely vulnerable to rain inundation and wind. Figure 12 shows an internal tree that has failed and fallen onto a line.

Figure 12: Example of tree damage from a plantation forest.

5. Vast areas of land are being converted from cleared land traditionally used for dairy or beef farming, to heavily forested areas to support carbon sequestration.

Figure 13: A line originally constructed on a farm that has been converted to a commercial forest.

6. Rain inundation destabilises root systems causing failure even without wind impacts. Figure 14 shows a tree that is at risk of falling onto a line following heavy rainfall.

Figure 14: Example of tree at risk of falling onto a line following heavy rainfall.

7. Forest structures fail completely under severe cyclones. During Cyclone Gabrielle vast areas of commercial forests were devastated, as pine trees snapped in half under heavy winds. TLC's network infrastructure was severely damaged as a result.

Figure 15: A commercial forest with most trees snapped following Cyclone Gabrielle

10.5. Analysis of secondary factor: Defective equipment

We assess that defective equipment was a secondary factor in our SAIDI performance in RY2023. Defective equipment faults were elevated in RY2023 but remained generally consistent with historic performance despite the effects of Cyclone Gabrielle. However, the SAIDI impact from the defective equipment faults was minor in comparison with the primary drivers (weather and vegetation). Figure 16 shows that defective equipment fault count has been trending down over the last decade. Although RY2023 saw an increase in defective equipment outages, the increase was relatively low and proportional to the significant increase in extreme weather experienced on the network.

Figure 16: Defective equipment fault count trends

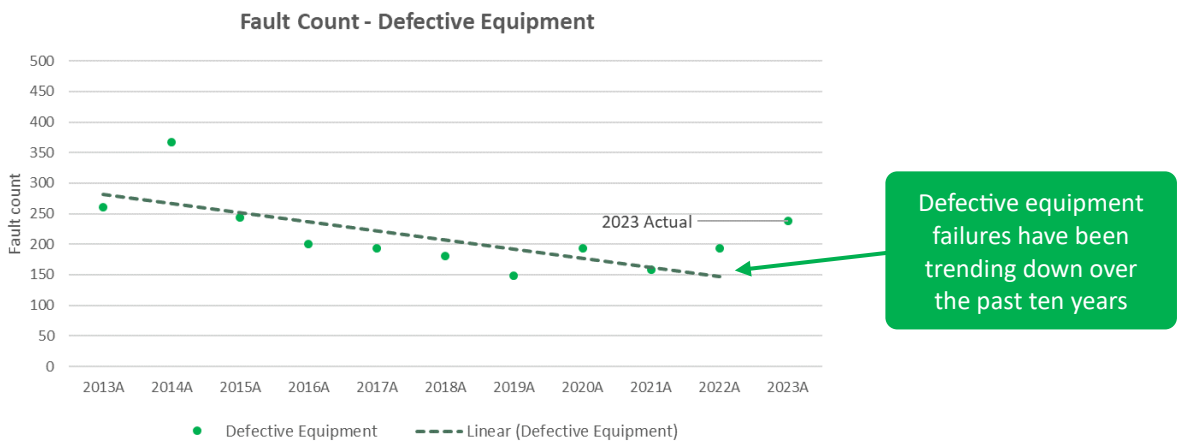
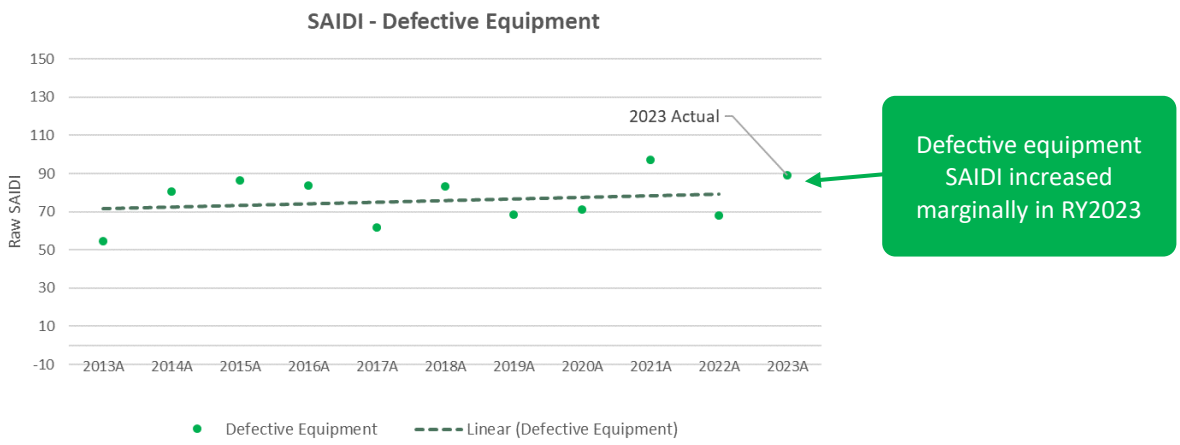


Figure 17 shows that defective equipment SAIDI increased marginally in RY2023.

Figure 17: Defective equipment SAIDI trends.



In general, Defective Equipment outages correlate strongly with weather intensity. For context, typical common failure modes seen on distribution equipment as a result of severe weather are:

- Conductor failures

- Cross-arm failures due to excess strain on cross-arms
- Jumper failures

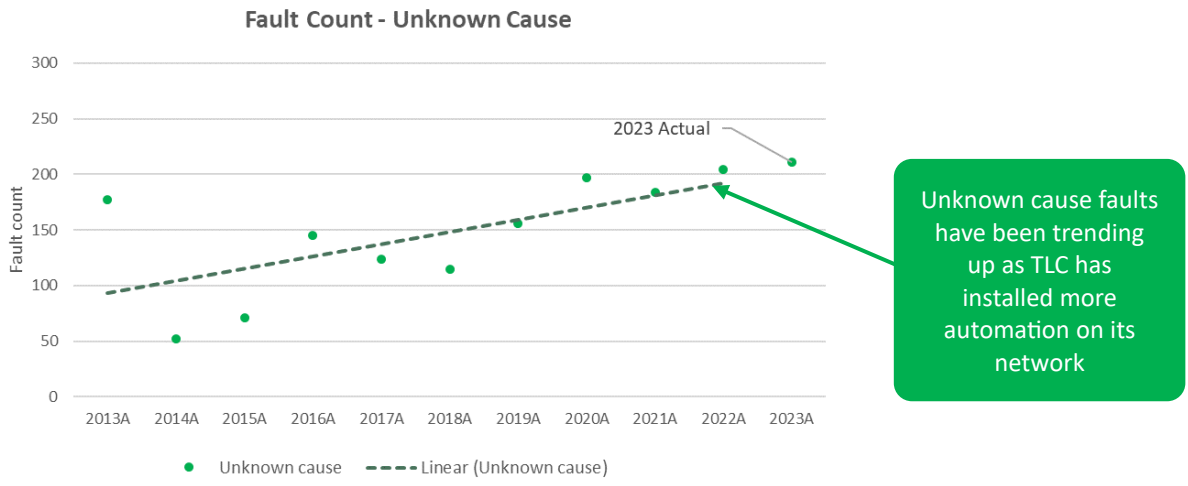
Addressing these common failure modes is part of TLC's ongoing renewal programme discussed later in this report.

10.6. Analysis of secondary factor: Unknown cause interruptions.

Typically, unknown cause outages also correlate with extreme weather. Unknown cause faults can be caused by a range of reasons. Examples include tree branches momentarily contacting lines, wind-blown debris, or lines swinging into nearby trees. Each will cause a fault which is later cleared (the debris or line is blown away) leaving no identifiable evidence of the initiating event. These faults trip protection equipment which is later reclosed remotely or manually by a fault man.

Unknown cause fault count has, in general, been trending up. This is likely, in part, driven by our automation programme, which has seen a significant number of new auto-reclose switches on our network in an attempt to reduce SAIDI and the effect of an extended outage on customers.

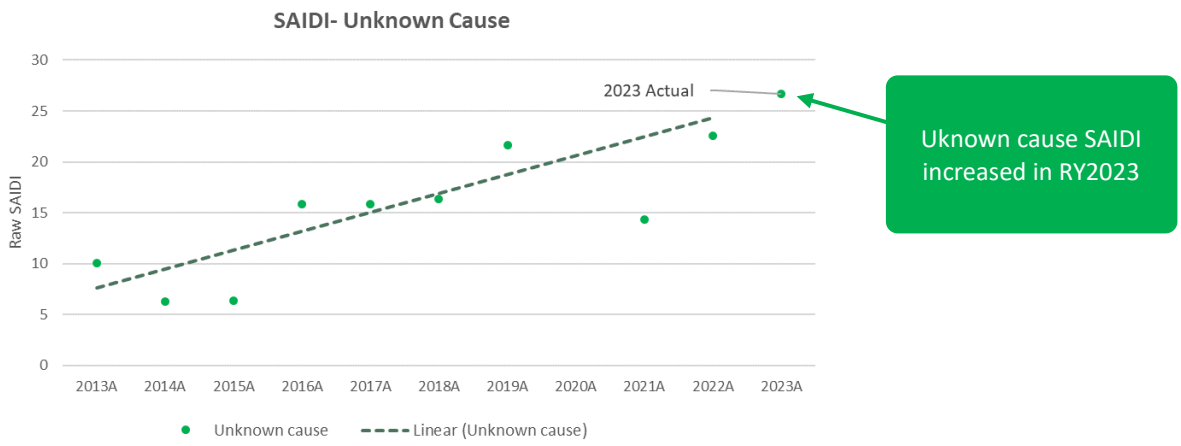
Figure 18: Unknown cause fault count trends.



SAIDI from unknown cause faults has been trending up over the last ten years despite the improvements brought along with the automation programme. We believe that in part this is because we have also introduced new health and safety processes (such as blind closing and fire management policies) that require longer wait times before initiating a reclose. Figure 18 shows that the unknown cause fault count in FY23 was generally consistent with prior years, and

Figure *19* shows that Unknown cause SAIDI was slightly elevated.

Figure 19: Unknown cause SAIDI trends.



Our assessment is that while unknown cause faults were a contributor to the increase in SAIDI in RY2023, they were not a primary driver, and would have been exacerbated by weather and vegetation impacts discussed earlier.

10.7. Our analysis indicates that the primary drivers of outages in FY2023 were not within TLC's direct control.

During RY2023 most interruptions were caused by weather and vegetation (specifically out of zone vegetation), which are factors not within TLC's direct control. Table 5 shows that the materiality of the SAIDI increases resulting from weather and vegetation drivers.

Table 5 Primary drivers of SAIDI and comparative increase from preceding years.

Outage Category	RY2023 Raw SAIDI	%	Preceding 5yr Ave	RY2023 increase
Adverse weather and lightning	120	18%	31	286%
Vegetation interference	375	57%	53	609%
Defective equipment	90	14%	78	16%
Unknown cause	27	4%	21	31%
All other categories	43	7%	48	-9%
Total RY2023, all categories	656	100%	230	

The significant increase in SAIDI in RY2023 was driven by weather and vegetation.

Figure 20 shows this graphically. In total, SAIDI driven by factors outside TLC's control increased by an average of 338% and SAIDI driven by factors inside TLC's control increased by 13% during RY2023.

Figure 20: RY2023 Raw SAIDI within and outside TLC's direct control.

10.8. Our analysis indicates that the primary drivers of SAIFI and SAIDI (extreme weather and out of zone tree fall) were the same.

Table 6 shows that the key drivers of SAIFI in RY2023 were the same as for SAIDI, i.e. the material increases were driven by weather and vegetation interference.

Table 6 Primary drivers of SAIFI and comparative increase from preceding years

Outage Category	RY2023 Raw SAIFI	%	Preceding 5yr Ave	RY2023 increase
Adverse weather and lightning	0.65	16%	0.32	104%
Vegetation interference	1.14	29%	0.32	258%
Defective equipment	0.80	20%	0.90	-10%
Unknown cause	0.69	17%	0.85	-19%
All other categories	0.69	0	0.75	-8%
Total RY2023, all categories	3.98	100%	3.14	

The key drivers of SAIFI in RY2023 were also weather and vegetation.

10.9. Operationally, TLC recognised compliance risks early and took actions to mitigate those risks.

TLC recognised the potential for exceeding its compliance limits relatively early in the year, and made material attempts to mitigate an exceedance outcome.

- At the end of July, following two months of unusually extreme weather, TLC management noted in its August Operations Report to the Board, that it had established a working group to identify ways to reduce SAIDI and SAIFI for future months.
- In the September Chief Executive report to the Board, management noted that mitigating measures had been put in place to support the reduction of SAIDI which was the primary risk factor at that time. The mitigating measures taken included hiring two large generators, implementing a new fault response process to trigger earlier dispatch based on a CIMS model, and placement of spare parts in readily accessible locations[3].
- Management maintained a higher monthly vegetation expenditure run rate to reduce the volume of vegetation faults. As such only $70k of the ~$1.3m budget remained by the end of January 2023, and approval was then given to increase this by a further $87k targeted at high-risk feeders during February and March.

11. Major Events Analysis

Section 12.4(d) of the DPP Determination 2020 requires that (d) where there was a SAIDI major event or SAIFI major event during the assessment period in which the non-exempt EDB first failed to comply with the annual unplanned interruptions reliability assessment specified in clause 9.8, any investigations of that SAIDI major event or SAIFI major event.

TLC experienced six major events during RY2023:

- Mokau feeder (SAIDI major event) caused by adverse weather.
- Multiple feeders weather event 12 June 2022 (SAIDI major event) caused by extreme weather (lightning, wind) and out of zone trees.
- Lake Taupo feeder (SAIDI major event A) caused by defective equipment – pole tops.
- Gadsby/Wairere feeder (SAIDI major event) caused by defective equipment – pole tops.
- Cyclone Gabrielle (SAIDI and SAIFI major event) caused by adverse weather and vegetation.
- Lake Taupo feeder (SAIDI major event B) caused by vegetation – out of zone trees.

[3] In fact the placement of spare parts in readily accessible locations was initially implemented in one location but abandoned shortly after due to complexities of tracking and management of spares outside controlled depot locations.

Table 7 summarises the events that occurred and the key learnings from each which are either implemented already or in the process of being implemented. A detailed summary of each major event is provided in Appendix A.

Table 7 Summary of Major Events in RY2023

Event	Factors that could have prevented or minimised the event if implemented	Recommendations to mitigate a future event
Mokau feeder	Rapid deployment of generators	Analyse LIDAR Data for line clash potential and mitigate high risk spans (included in renewal design) Investigate options for permanent generator or back feed options for Mokau (in progress)
Multiple feeders weather event – 12 June 2022	Forestry owner clearance of out of zone (GLZ) trees	Discussion with forestry owners to clear tees that are out of Growth Limit Zone (GLZ). Noting that TLC does not have legal rights to enforce this. (in progress)
Lake Taupo feeder (A)	Immediate dispatch of fault person Fixing damaged insulator as planned work Double nutting the crossarm kingbolt	Update DS16 with double nutting procedure (complete) Consider retrofitting nuts on high criticality lines (following detailed analysis this won't be progressed) Improve situational awareness when responding to faults (in progress) Dispatch fault person immediately rather than waiting 15 minutes for manual closing attempt (implemented) Consider investigating alternative supply options to Kiko Road substation (project definition scope done and business case under development)
Gadsby/Wairere feeder	Combining UAV and ground-based data for asset inspections in asset management system Remediation tracking of all structural defects identified by aerial inspection	Check all structure defects in Wairere tie line. Develop process to transfer future UAV inspection data to asset management system (tendered) Update contact details of staff involved (completed)

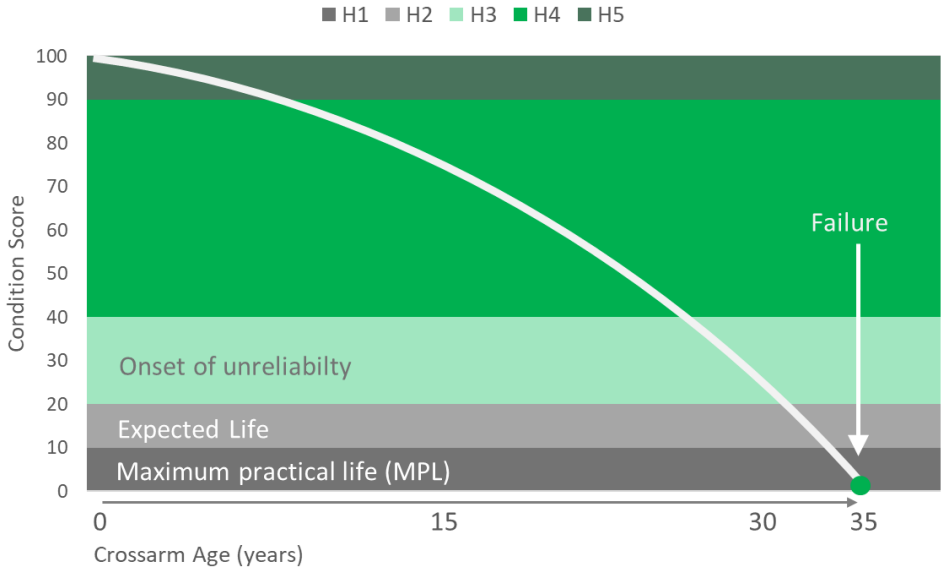
Event	Factors that could have prevented or minimised the event if implemented	Recommendations to mitigate the impact of a future event
Cyclone Gabrielle	Refine the CIM event mangement processes to better support major events. Continued use and extension of visual aids like maps. Improve intelligence and communication of restoration priorities within the response team. Simulation of a significant network event. Increase the number of controllers.	Generic CIMS framework needs to be customised **(completed)** Perform a significant event simulation once process and system changes implemented **(scheduled)** Create and deploy additional visual aids **(in progress)** Implement a suite of process management and information gathering tools (in progress) Improve restoration process **(completed)** Implementing a digital utility programme including ADMS that will reduce the administrative workload on controllers **(in progress)**
Lake Taupo feeder (B)	Clearance of risk vegetation post cyclone	Implement post major event process to prioritise review of affected areas. **(Complete – ICAM process established**)

12. Analysis of our network condition

Our network health is aligned with industry, and we are investing to improve it.

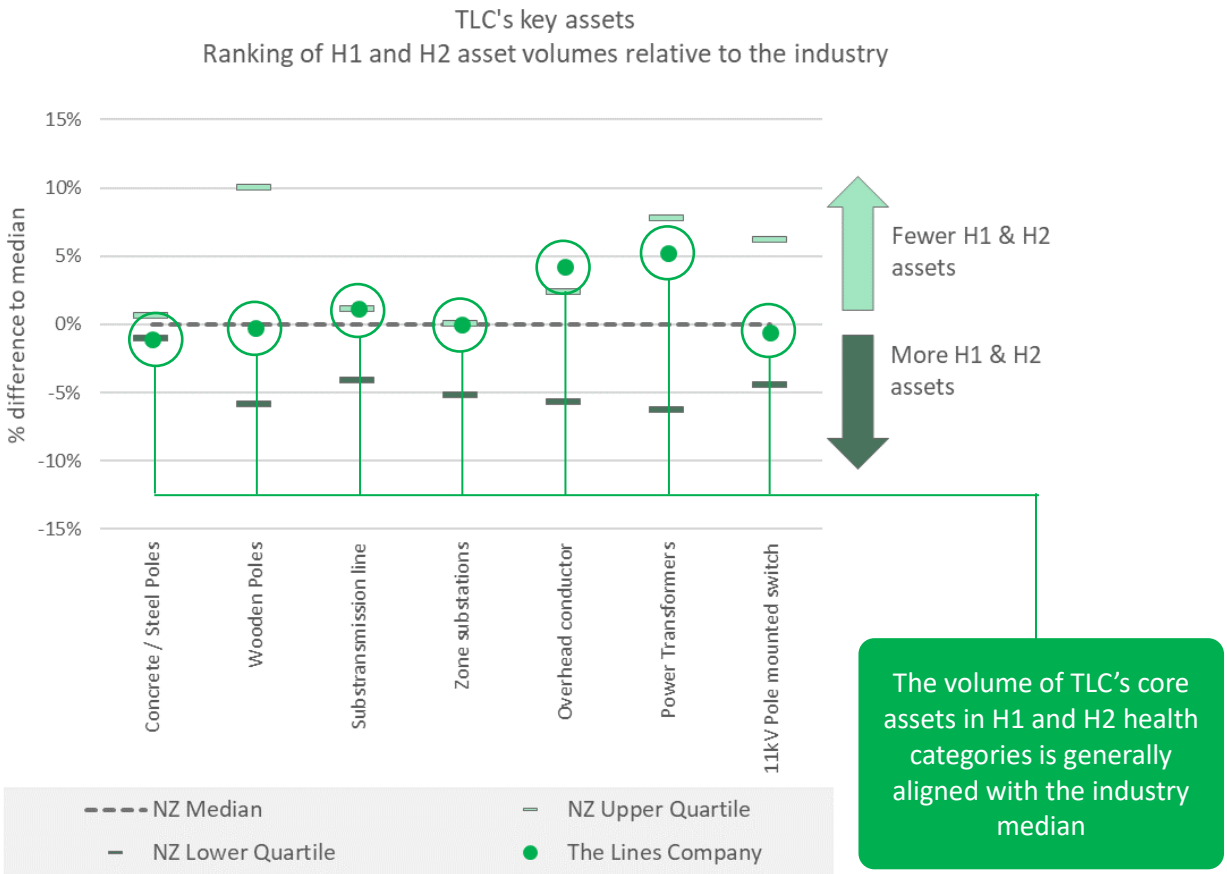
In 2020 we established a condition scoring methodology that is aligned with the DSO common methodology and have further applied this to match asset health indices for reporting. Network health is typically indicated by the volume of assets that are moving from the onset of unreliability (OOU) to their maximum practical life (MPL), i.e. the H1 and H2 bands. We expect assets in these categories carry a higher rate of failure, and our asset management aim is to replace assets prior to failure or sooner depending on their specific risk profile. Figure 21 shows the typical failure of an asset over time, and how we have applied our asset condition scoring system to align with the asset health indices.

Figure 21: Typical asset deterioration over time



We analysed TLC's key assets to determine if TLC's proportion of H1 and H2 assets are aligned with industry. Figure 22 shows that TLC's proportion of H1 and H2 assets within its key asset groups are broadly aligned with the industry median.

Figure 22: How the condition of TLC's key asset condition ranks against NZ Electricity Distributors



Asset condition was not a key driver for our outages.

We analysed the proportion of defective equipment faults that occurred on our key pole and crossarm assets, to determine whether the faults disproportionately occurred on assets with health indices of H1 or H2[4]. Our finding was that the H1 and H2 assets were not disproportionately represented in our defective equipment failures during RY2023. Most defective equipment faults occurred on assets with health indices H3 to H5, further indicating further that the faults are not caused by condition but other external factors including weather.

Figure 23 shows that faults that occurred on TLC's poles during RY2023 were approximately proportional to the pole population across all asset grades. There was no identifiable concentration of faults in H1 and H2 asset groups.

[4] This purpose of this analysis was to understand how our main asset classes (poles and crossarms) were contributing to faults across condition grades. To do this we filtered faults where the fault type was Defective Equipment and the fault cause was related to design, crossarms, insulators, poles, or stay wires. For clarity other fault causes such as DDO, fuse, conductor, switchgear, lightning arrestor and transformer were excluded. Lookups were used to identify the pole number and then the health indices for the pole and crossarm assets. Not all poles were able to be identified from our outage data - we were successful in identifying about 85% of poles within these fault categories with reasonable confidence.

Figure 24 shows the same analysis and outcome for crossarm assets.

Figure 23: RY2023 faults on poles across health grades

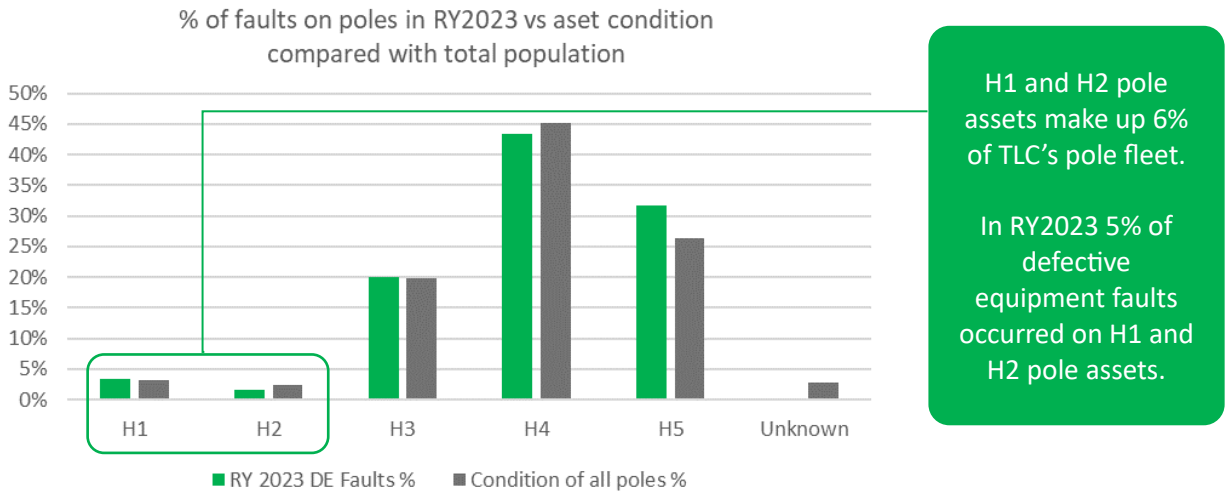
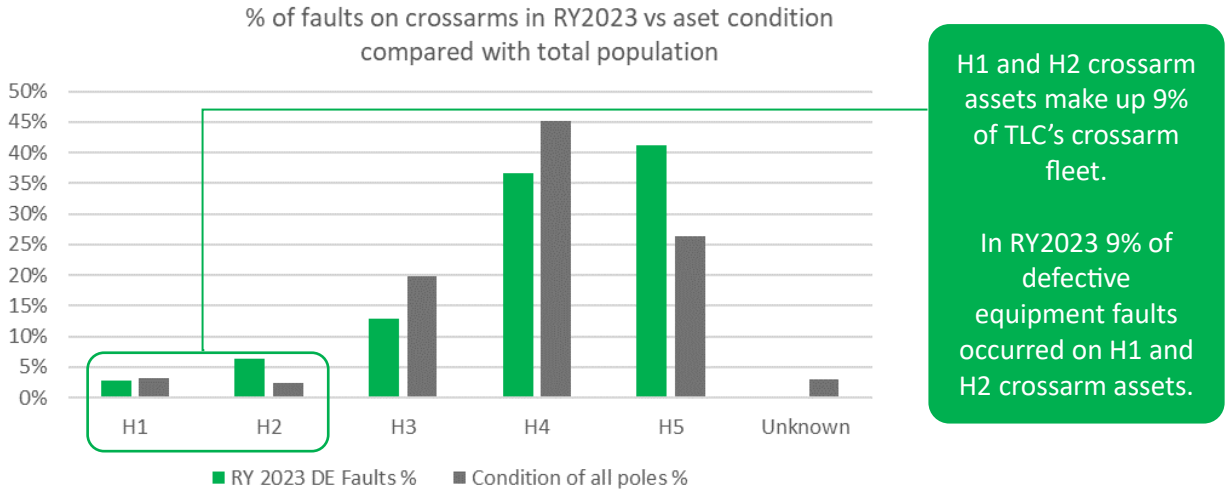


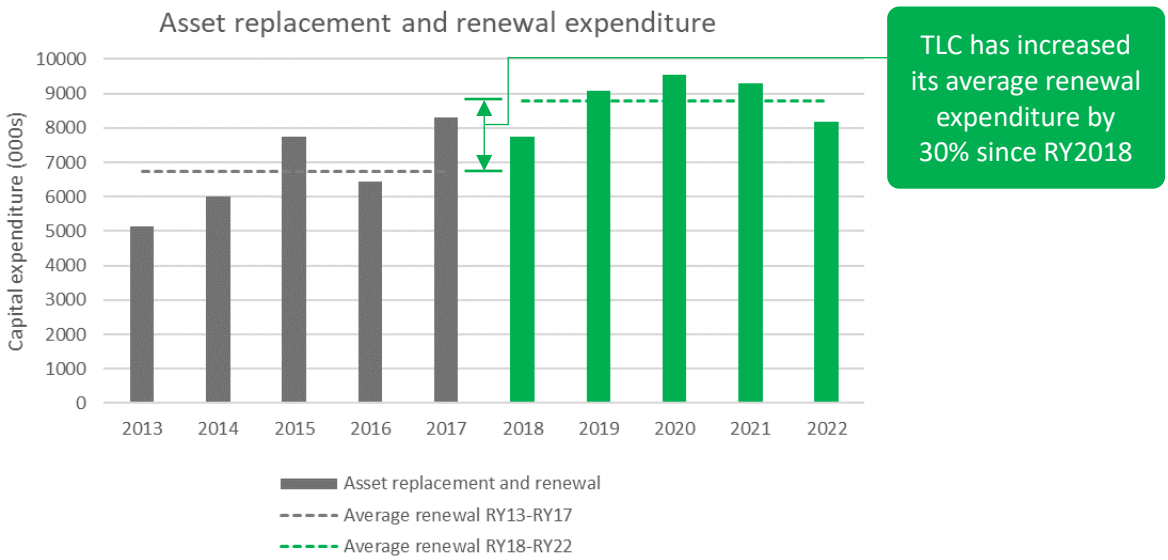
Figure 24: RY2023 faults on crossarms across health grades



Asset renewal has been a focus for TLC over the past five years.

Since 2018 we have accelerated our renewal expenditure. Figure 11 shows that asset renewal expenditure increased by 30% from an average of $6.7m (RY2010 to RY2017) to $8.8m (RY2018 to RY2023).

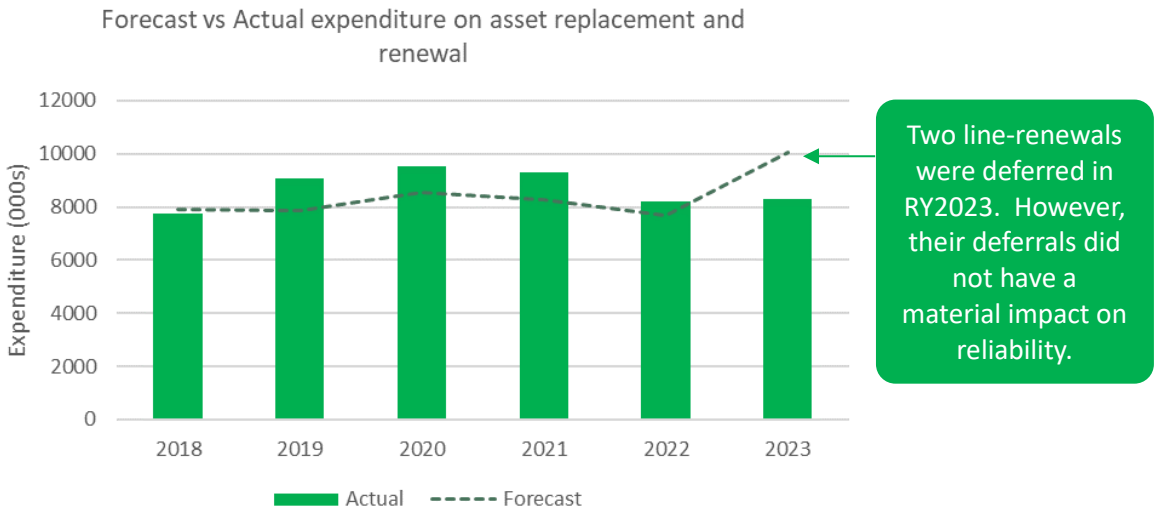
Figure 25: Asset replacement and renewal expenditure for the preceding ten-year period



Our expenditure on asset replacement and renewal generally exceeds our forecast.

Since 2018 we have sought to prioritise renewal of overhead lines and projects to strengthen security of supply. Figure 26 shows that our forecast renewal expenditure is in general, being consistently achieved through delivery[5].

Figure 26: Asset replacement and renewal expenditure – actual vs forecast



In RY2023 TLC did not achieve its full capital expenditure overall, but our analysis indicates that this did not have any material impact on the network performance (refer to Note 2 below). Reasons for the underspend include:

Project Category	Deferred Projects	Reason for Deferral	Capex ($'000)
Customer Projects	Various customer works	Deferred by customer	904
Renewals	Ground mount transformers	Awaiting landowner consent (note 1)	1,978
	Line renewals (2 of 29 deferred)	Resource availability - limited by fault activity (note 2)	860
	Tahāroa switch room renewal	Dependency on customer planning	1,700
	Whakapapa / Tūroa ski field	Access to site and lead time for components	400
Security of Supply	Arohena substation upgrade	Transformer design issue being resolved with manufacturer	500
	Kuratau feeder split	Awaiting landowner consents	930
	Mobile substation	Originally intended to be purchased as part of a customer project	1,500
			8,772

[5] Note that the underspend in RY2023 was primarily driven by a delayed renewal of a 33kV switch room ($1.7m) serving a single industrial customer.

Note 1: The deferral of ground mount transformers is not just an issue of obtaining easements. The current location of these transformers is typically on private property that requires substantial ground works to relocate to roadside, and in some cases crosses areas sensitive to our local Iwi.

Note 2: Two of the 29 line-renewals planned for RY2023 were deferred, but their deferral did not have a material impact on reliability. Three faults[6] occurred on these lines during the RY2023 year accumulating to 0.036 SAIDI and 0.00013 SAIFI.

Our renewal is in line with asset depreciation.

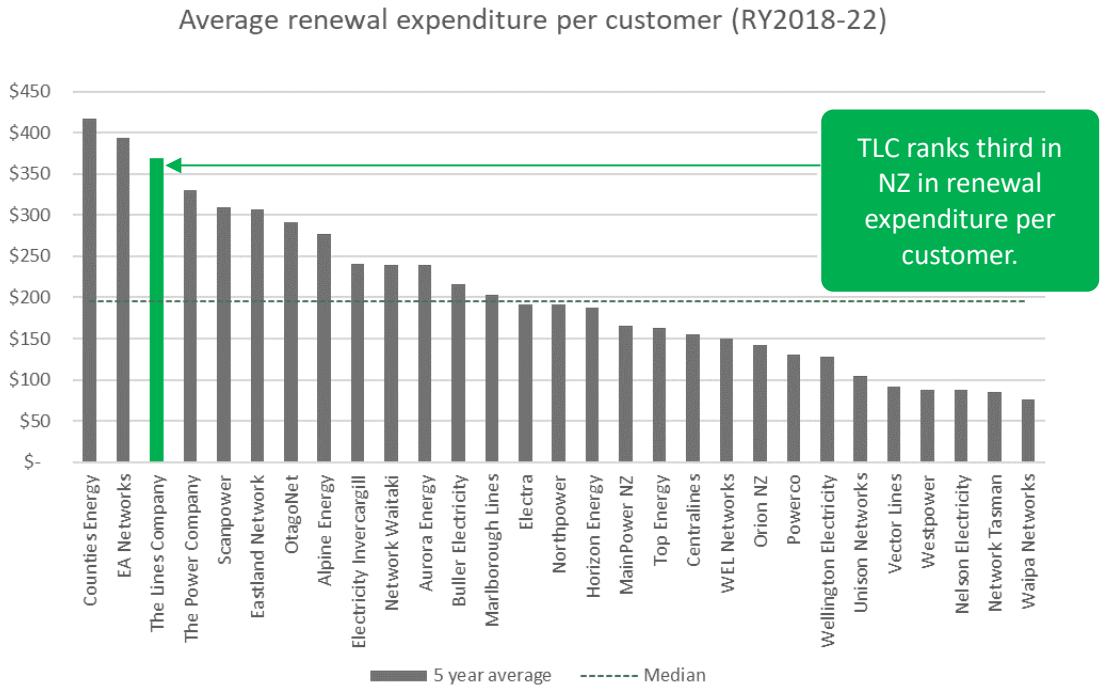
During the last five years TLC has spent over $44 million on asset replacement and renewal, which amounts to 16.7% of the total RAB value for RY2023. Renewal expenditure is also broadly aligned with depreciation (circa $9.4m), noting that assets are also renewed for other reasons relating to safety or reliability and consequently their replacement expenditure falls into these regulatory reporting categories.

Our renewal expenditure per customer is among the highest in the industry.

Although we are becoming more targeted in our renewal planning, our renewal expenditure per customer is among the highest in the industry. We are cognisant of the impact of this cost on our customers, however maintaining a reliable network is expected to provide enduring benefits to the community as a whole. On that basis our 2023 AMP continues a significant renewal programme for the next ten year planning period.

[6] The causes for these three events were Defective Equipment, Lightning and Unknown Cause.

Figure 27: Renewal expenditure per customer – industry comparison



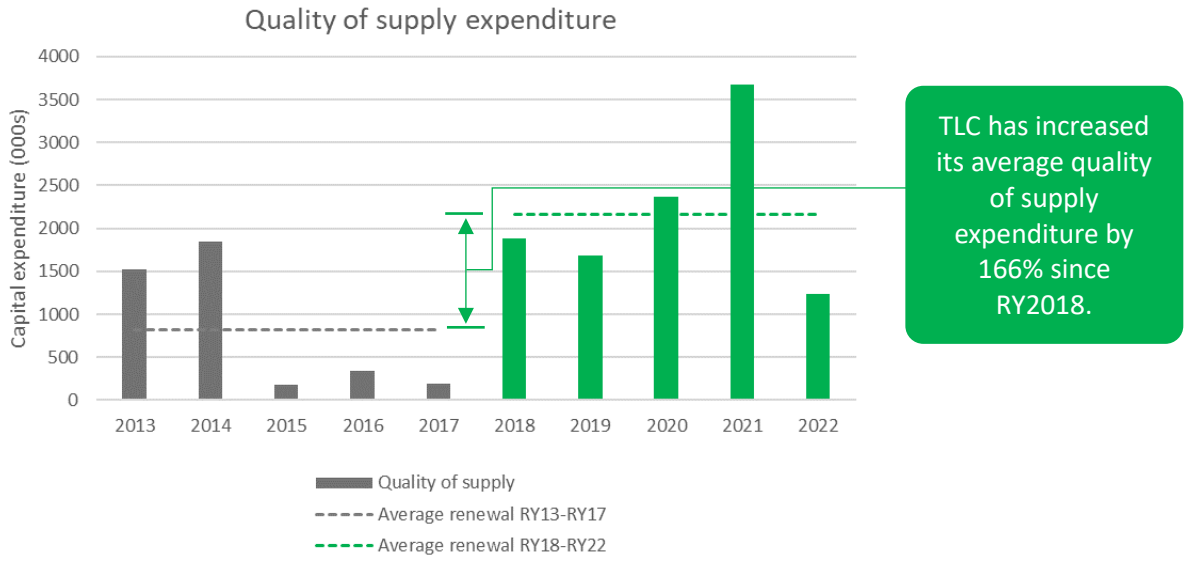
We have been focusing on renewing pole assets.

Most of our faults occur on distribution lines. Therefore, a key focus has been improving the condition of pole and crossarm assets. Since 2018 we have upgraded an average of 932 poles per annum from our ~35,000 pole assets. This may include the replacement of poles or pole top assets (for example, in the case that the pole is of concrete construction with a >80-year life, crossarms may be upgraded or replaced but the pole may remain in-situ). Overall, this puts our pole renewal at a 38-year cycle. This programme is set to continue for the forthcoming ten-year planning period outlined in our 2023 AMP. We are also introducing improved condition monitoring programs with pole top helicopter and drone inspections, reducing the times in between condition assessments on our poles.

12.1. We have been investing in ways to reduce the impact of outages on our network.

Since RY2018 we have also materially increased expenditure on quality of supply. This has included a specific programme to increase the automation and sectionalisation of our network by installing automated switches to isolate faults from higher population centres.

Figure 28: Quality of supply expenditure for the preceding ten-year period.

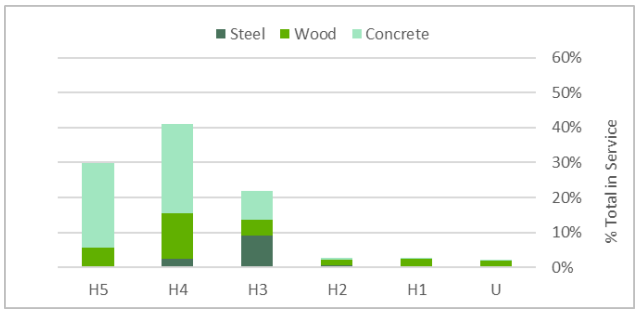


12.2. Condition of Assets.

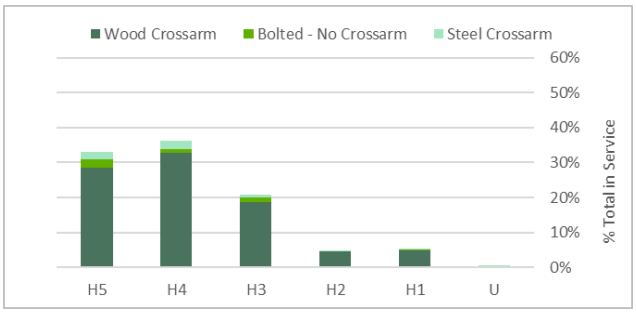
Our current asset condition is summarised below using the following asset health indicators.

U	Asset health unknown
H1	Replacement recommended
H2	High risks
H3	Increasing risk
H4	Assets serviceable
H5	As new condition

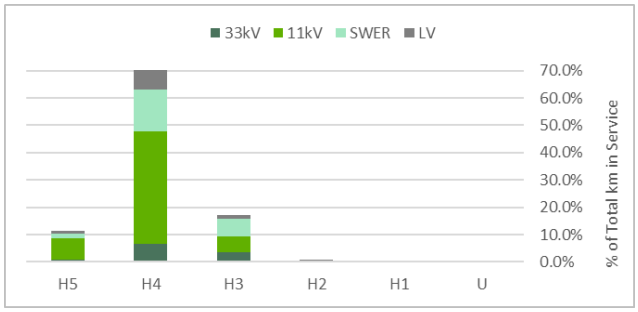
Poles



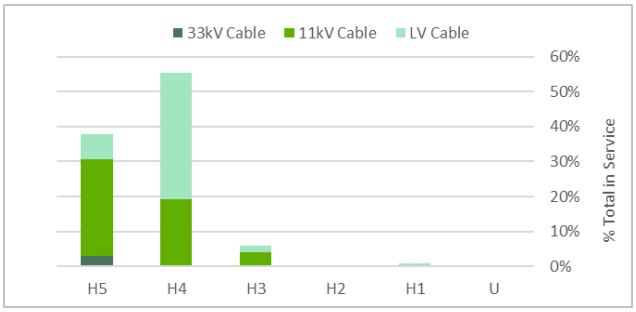
Crossarms



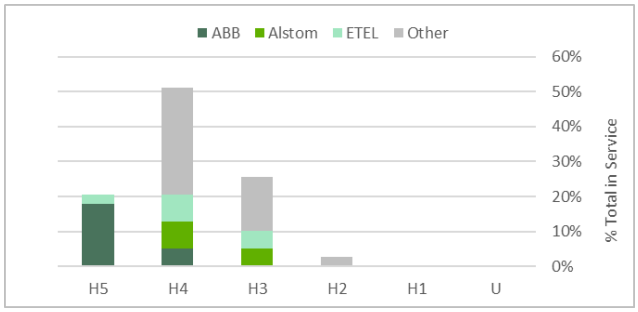
Overhead conductors



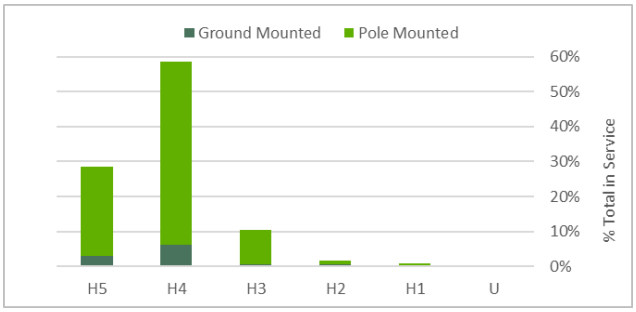
Underground assets



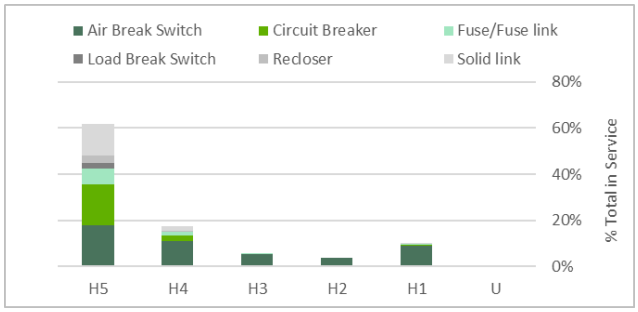
Power transformers



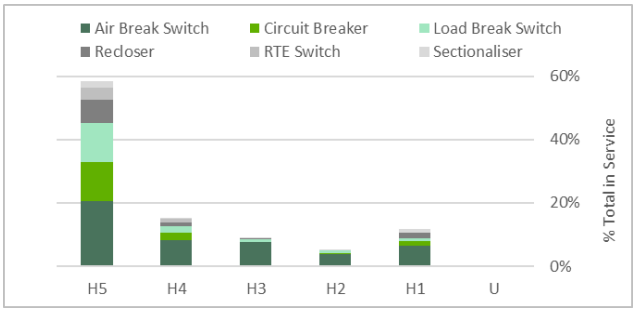
Distribution transformers



Subtransmission switchgear



Distribution switchgear



13. Summary of our asset management improvement.

Since 2018 TLC has implemented material changes to mature its asset management capabilities. These changes are summarised in this section.

We have become more targeted in our renewal using asset data for planning decisions.

Before RY2018 our asset renewal planning was driven primarily by asset age. Since RY2018 we have adopted an asset health assessment methodology aligned with the DNO Methodology, used widely in Great Britain as a robust framework for assessing asset health. Our assessment methodology is systemised using an application tool called Asset Altitude. The Asset Altitude system uses the DNO framework as well as a range of indicators to predict when assets reach the onset of unreliability and maximum practical life. The model drives our decisions in both the prioritisation of current year renewal planning and our forward renewal expenditure forecasting.

We understand the importance of asset data quality and are continuing to make improvements.

We have an ongoing asset data improvement programme. Since RY2018 we have undertaken a range of initiatives to improve our data quality. This has included:

- Reviewing assets with a 'default commissioning date' to estimate the actual age of the assets based on other age indicators (specific asset type, asset stamp information etc)
- Redeveloping our inspection forms to capture a more comprehensive data set for condition analysis, as well as developing a tablet-based inspection tool and automating the upload of data into our asset management database to eliminate human error.
- Surveying the GIS location of our poles using LiDAR correcting our asset records.
- Developing an automated network connectivity checking tool that corrects errors in connectivity as assets are added, modified, or removed from our asset database.
- Developing an electronic asset amendment form to continuously integrate new assets to the system.
- Developing an end-to-end defect detection and work management dashboard to continuously stay aware of the network defects and resolve in due time.

Converting our CAD drawings to GIS data to improve public health and safety factors around underground assets.

We are currently working to significantly change our inspection processes to enhance and standardise our asset condition assessment and increase the frequency of surveys.

This will be achieved by establishing a new helicopter and drone-based line inspection programme that will provide high frequency (5 year) line condition data for all our pole assets. The survey will

become a regular programmed activity and provide a rich data set for condition review further enhanced in conjunction with LiDAR scanning data.
Along with condition information it will also provide a range of other information and fault indicators, such as infrared heat detection, corona discharge indication and a video survey of the line infrastructure for review and reference. We expect to commence the survey in November 2023.

We have improved our understanding of fault drivers.

Over the last three years we have undertaken several initiatives to improve our understanding of the drivers of faults. This has included:

- Establishing an Outage Management Committee (OMC) to review outage events and determine underlying trends.
- Establishing a Vegetation Management Committee (VMC) to review outage events and determine underlying trends and management strategies related to vegetation.
- Developing a more enhanced fault reporting framework.
- Undertaking a detailed Failure Mode and Effects Analysis (FMEA).
- Undertaking quarterly reviews of reliability performance.

We have created an overhead line visual inspection guideline.

Following the FMEA analysis we have developed an Overhead Line Visual Inspection Guide which provides a set of guidelines with pictorial examples of how to assess our pole assets.

We have improved our approach to vegetation management.

Since 2018 we have undertaken several initiatives to improve our vegetation management
This has included:

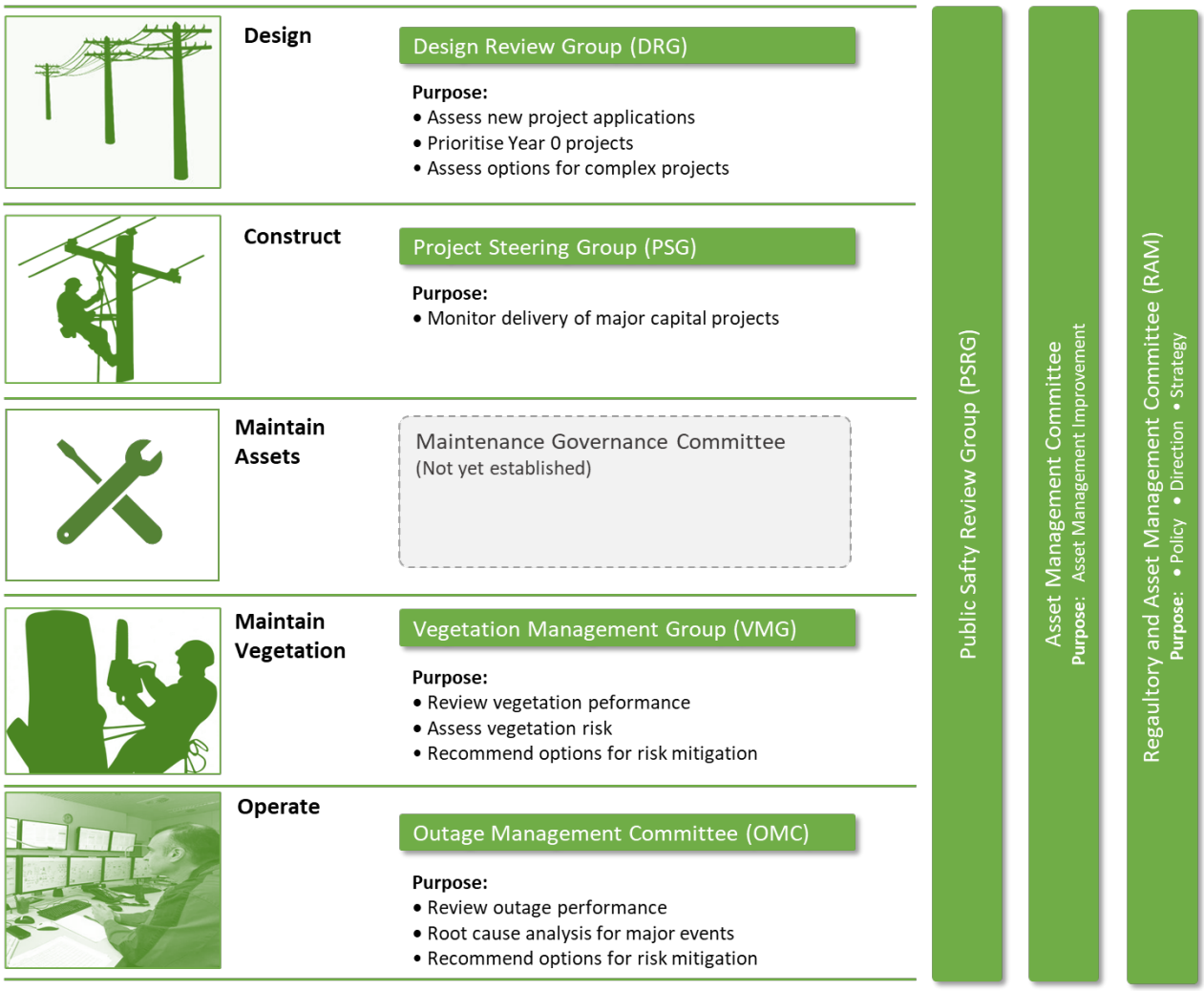
- Materially increasing our vegetation management budget from ~$900k to $1.4m since 2018.
- Expanding our fault reporting framework to increase our understanding of outage drivers for vegetation.
- Completing a LiDAR survey of our vegetation in 2021 and applying the vegetation risks found into our vegetation planning.
- Established a Vegetation Management Committee – an operational group assigned to review and improve our vegetation management and performance.
- Developing a Vegetation Management Strategy.
- Establishing a high-risk tree database.
- Engaging with forestry owners to consider line diversion as a key reliability option.
- Introducing a road reserve vegetation clearance and spraying programme.

- Strengthening our ability to take legal action against landowners not compliant with the Tree Regulations.

We have established new operational governance frameworks.

Since 2018 we have established a new asset management governance framework to provide oversight on our asset management and network performance. The framework consists of five operational management groups to oversee operational performance and drive business change and two committees to provide governance oversight. The framework covers the key areas of asset management including design, construction, maintenance, vegetation, outage performance and public safety. Senior management and Board engagement is enabled through regular Asset Management Committee (AMC) and Regulatory & Asset Management Committee (RAM) meetings respectively, which closely monitors the development and operation of our distribution assets . Figure 29 shows the framework.

Figure 29: Operational governance framework for asset management



We have improved our fault management processes.

In the last 24 months we have put in place several initiatives to improve our fault management for major events. The most significant changes have been:

- A new Coordinated Incident Management System (CIMS) framework for managing severe faults.
- A new NiWA weather forecasting tool that provides a 7 day ahead weather forecast.

We have also made changes to our fault response improvements initiated during the year were:

- All feeder faults/recloser lockouts (except SWER reclosers) are dispatched immediately instead of waiting to see if the control room can restore first (following a mandatory 15 minute stand-down to manage fire risk);
- Priority in fault restoration should be given to the restoration of supply over fault repair;
- Where a fault contains both HV and LV, repair HV first then LV;
- Use of mobile generators for feeder faults. Specific connection points established on critical feeders across the network for such eventuality.

These tools have improved our general management of major outage events, and we believe they have helped mitigate several Major Events from being triggered in FY2023.

We are continuing to develop our fault response processes. In RY2024 we intend to develop a network wide spares management capability that will allow deployment of critical spares at strategic locations around the network to enable fault staff to restock in flight rather than travelling to depots.

We have increased our asset management resources.

In 2022 TLC completed a review of its network and asset management resources, which has resulted in a staff increase of 14% to support these functions. Recruitment of staff is now almost complete and will provide a significant increase in capability to continue to drive improvements.

We are continuing to improve our asset management.

We are continuing to improve our asset management processes and systems. Key initiatives we are planning to put in place over the next twelve months include:

- Helicopter and drone surveillance of our pole top condition.
- Commencing a three-year programme to renew, digitise and integrate our key asset management planning and operational systems including GIS, CRM, ADMS and Finance systems.

- Establishing an integrated risk tool with the assistance of NiWA to overlay detailed 35 day ahead weather forecasts against line segment criticality, asset condition and historic outage performance.
- Purchasing and operationalising a mobile substation to reduce the impact of planned outages on our customers, and to provide emergency backup support in fault events.
- Continuing to progress our security of supply programme and extending this to include a new Security of Supply standard for feeders.

We are investing in further digitisation and automation of our systems and processes.

In our 2023 AMP[7] we have outlined an estimated investment of $6m to upgrade TLC's key asset management and operational systems. This is a business wide business digitisation project that including (at a high level) renewing, commissioning and integrating the following systems:

- **GIS** (Geographic Information System): **Upgrade and integrate**.
- **ADMS** (Advanced Distribution Mangement System): **New**.
- **AMS** (Asset Management System / database): **Upgrade and integrate**.
- **SCADA** (Supervisory Control and Data Acquisition system): **Upgrade.**
- **CRM** (Customer Relationship Management system): **New**.
- **Finance and accounting**: **Integrate**.

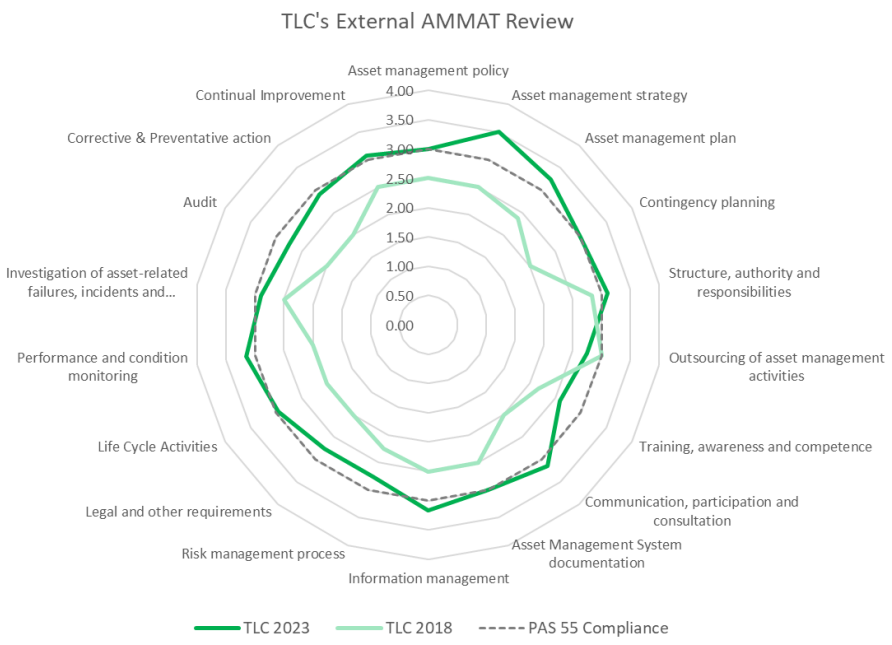
To achieve this, TLC has created a new department focusing on the implementation of these systems and improving operational excellence in TLC's asset management and operational processes.

Since 2018 we have undertaken external AMMAT assessments to monitor our asset management improvement.

Since 2018 we have undertaken external assessments of our asset management improvement (AMMAT) to track our progress. The review indicate that TLC is continuously improving in its asset management capabilities. Figure 30 shows the improvements in key asset management functional areas that TLC has made since RY2018.

Figure 30: TLC's asset management maturity progress since RY2018.

[7] 2023 AMP sections 4.5 page 69 and Section 8.1 page 141



14. Intended reviews, analysis or investigations into RY2023 reliabilty performance.

Section12.4(g) of the DPP Determination 2020 requires us to outline any intended reviews, intended analysis, or investigation that would meet the categories specified in clause 12.4(c)-(f), which is planned, but not yet completed.

Analysis undertaken in this Unplanned Interruptions Report forms the basis of our investigation of RY2023 network performance. Its key finding is that the increase in network outages were driven by an year of extreme weather that triggered increases in adverse weather and out of zone tree faults, and that our assets and vegetation management programmes generally performed as planned.

As noted in this paper TLC has developed a range of asset management processes and operational governance structures over the last five years, which we think appropriately in monitor and manage our network performance, and which we are continuing to develop and improve.

At this stage TLC does not have any further reviews or investigations planned into the RY2023 performance.

15. Schedule 10: Form of director's certificate for unplanned interruptions reporting.

Clause 12.4(h)

I, Bella TAKIARI-BRAME, being a director of The Lines Company certify that, having made all reasonable enquiry, to the best of my knowledge and belief, the attached unplanned interruptions reporting of The Lines Company, and related information, prepared for the purposes of the Electricity Distribution Services Default Price-Quality Path Determination 2020 has been prepared in accordance with all the relevant requirements.

Bella Takiari-Brame

Director

30 August 2023

Note: Section 103(2) of the Commerce Act 1986 provides that no person shall attempt to deceive or knowingly mislead the Commission in relation to any matter before it. It is an offence to contravene section 103(2) and any person who does so is liable on summary conviction to a fine not exceeding $100,000 in the case of an individual or $300,000 in the case of a body corporate.

Appendix A: Summaries of Major Event ICAM reports.

The following summaries provide greater detail on each major event. In each case TLC has completed a more comprehensive ICAM report which contains greater detail.

1. Mokau feeder SAIDI major event

Location	11 kV Mokau feeder	**Main equipment**	Distribution lines
Cause type	Adverse weather	**Cause detail**	Extreme wind

Major contributing interruption:

- 19/05/2022 17:30 to 21/05/2022 16:59
- 35.54 normalised to 2.36 SAIDI minutes

Response to the major event

At 17:24 on 20/05/2023 strong winds brought down a section of overhead conductor on the Mokau 11 kV feeder. Information from the circuit breaker that tripped to lockout indicated that a line clash caused the conductor to fall. The fault occurred near the start of the Mokau feeder, which is a remote rural feeder with no back-feed options. The conductor (a 210m span) had fallen across State Highway 3 and traffic management was required (from Hamilton) to repair. There had already been 34 unplanned outages the day of the major event and therefore staff fatigue was an issue. Given it was also getting dark, a decision to request a generator was made early in the fault response. The generator required needed to come from Auckland and, after a few technical issues, the generator restored supply to most affected customers the following morning. All customers had their supply reinstated by 12:25 on 21/05/2022.

Mitigating factors that may have prevented or minimised the major event

- Rapid deployment of the generator.

Proposed steps to mitigate the risk of future similar major events

- Analyse LIDAR data for line clash potential and mitigate high-risk (high clash potential on high criticality segments) spans.
- Investigate options for a permanent generator or back-feed on the Mokau feeder.

2. Multiple feeders weather event 12 June 2022 SAIDI major event

Location	TLC Network	**Main equipment**	11 kV Distribution Lines
Cause type	Extreme Weather	**Cause detail**	Wind/Lightning

Major contributing interruption:

- 12/06/2022 16:30 to 13/06/2022 22:59
- 12.38 normalised to 3.37 SAIDI minutes

Response to the Major Event

At 02:46 on 12/06/2022, the first fault for this major event occurred. Pomerangai and Taumatamaire weather stations were reporting high winds after 13:00, accompanied by various spur line outages. At 19:46 the Te Mapara feeder tripped and was sectionalised and restored by 20:39 (212 customers, 0.34 SAIDI). At 20:58 a recloser on the Benneydale feeder tripped from tree contact with lines (42 customers 0.481 SAIDI). At 03:14 on 13/06/2022, a tree fell through the northern feeder beyond switch 6151. A recent upgrade in RY2021 of switch 6151 meant that 327, as opposed to 498, customers were affected by this outage (SAIDI 2.55 minutes). This was the most significant outage during the weather event.

A total of 46 class C (unplanned interruptions) outages were recorded over 2 days – outages over 0.50 SAIDI minutes for this major event are detailed below:

date/time off	feeder	customers	SAIDI	classification
12/06/2022 08:25	Mokau	16	1.00	Lightning
13/06/2022 03:14	Northern	327	2.55	Vegetation (Residential out of zone)
13/06/2022 09:22	Ongarue	30	0.62	Extreme Weather (Wind)
13/06/2022 06:53	Te Mapara	55	0.65	Defective Equipment (Faulty Switch)
13/06/2022 08:32	Mokau	48	0.64	Extreme Weather (Wind)
13/06/2022 06:48	Tirohanga	254	0.64	Extreme Weather (Wind)
13/06/2022 15:08	Northern	327	1.79	Vegetation (Residential out of zone)
13/06/2022 16:25	Aria	25	1.20	Lightning
13/06/2022 19:02	Benneydale	14	0.52	Extreme Weather (Wind)

Factors that may have prevented or minimised the major event if implemented

- This event was primarily a weather event however opportunities to improve our response to such events are continuing to be explored.
- A CIMS-type event management system would help the management of resources during extreme weather events to ensure the network activities are prioritised correctly.

Proposed steps to mitigate the risk of future similar major events

- CIMS event management is in the process of being implemented and tested at the time of writing this report.
- Discussion with forestry owners/managers to clear trees that are out of the Growth Limit Zone (GLZ), however, EDBs do not have any legal rights to enforce this.

3. Lake Taupo feeder SAIDI major event A

Location	33 kV Lake Taupo feeder	**Main equipment**	Sub-transmission lines
Cause type	Defective equipment	**Cause detail**	Crossarm - Loose bolts

Major contributing interruption:

- 5/10/2022 12:30 to 7/10/2022 11:59
- 15.83 normalised to 0.60 SAIDI minutes

Response to the Major Event

At 12:29 on 6/10/2022, CB6578 at the start of the Lake Taupo 33 kV feeder tripped to lockout. Customers supplied from Awamate and Waiotaka zone substations were back fed, but an attempt to close the tripped breaker resulted in an additional loss of the Tokaanu/Kuratau 33 kV feeder due to Transpower's CB1102 detecting the fault before CB6578. A faultman and helicopter were dispatched to find the issue. The faultman found a damaged insulator, however, the cause of the fault was identified from the helicopter as a tilted cross-arm that had lost its kingbolt. The fault was isolated, and the repair was carried out. Because the Lake Taupo 33 circuit shares some pole sites with the Rangipo-Hautu 11 kV feeder and the Hirangi SWER, these lines also needed to be isolated to enable the repair. The SWER isolation was initially overlooked which required re-permitting. Both the damaged insulator and cross-arm were repaired and the supply to all customers was reinstated at 19:15.

Factors that may have prevented or minimised the major event if implemented

- Immediate dispatch of the fault person when the initial trip occurred.
- Fixing the damaged insulator later as planned work.
- Double nutting the cross-arm Kingbolt.

Proposed steps to mitigate the risk of future similar major events

- Update DS16 with double nutting procedure.
- Consider retrofitting double nuts on high-risk lines.
- Improve situational awareness of where our field resources are and consider a geospatial system to track vehicle location.
- Reiterate the requirement to dispatch a fault person upon a trip to lockout, rather than waiting 15 minutes for the result of the manual closing attempt.
- Consider investigating alternative supply options for the Kiko Road substation.

4. Gadsby Road / Wairere feeder SAIDI major event

Location	33 kV Gadsby Rd / Wairere feeder	**Main equipment**	Sub-transmission lines
Cause type	Defective equipment	**Cause detail**	Crossarm - Rotten

Major contributing interruption:

- 11/11/2022 11:00 to 13/11/2022 10:29
- 17.41 normalised to 1.20 SAIDI minutes

Response to the Major Event

CB2202 tripped to lock out at 10:51 on 12/11/2022 resulting in the loss of supply to Oparure, Gadsby Rd, Wairere and Mahoenui Substations. A couple of communication issues hampered the initial response, but a helicopter was in the air at 11:34. At 12:05 the fault was found to be caused by an insulator that had come free from a split crossarm at Pole 3070282. The fault was isolated, and repairs were carried out. All customers had their power supply reinstated by 15:25.

The failed cross-arm had been given 4-5 year remaining life when inspected in 2016 and was initially part of a multi-year line renewal project. The first phase of the line renewal was completed but in 2018 an UAV aerial inspection of the Gadsby Rd/Wairere 33 kV feeder was carried out by an external contractor to improve the quality of the data supporting the renewal project. In the inspection report, the cross-arm at pole 3070282 was described as a "Weathered old arm with some splitting" and was given a Low urgency rating by the contractor. Higher urgency-rated assets were prioritised for replacement and there was no follow-up on the cross-arm at pole 3070282.

Factors that may have prevented or minimised the major event if implemented

- Internal review of urgency/intervention ratings for structural defects identified by contractors.
- Combining UAV and ground-based data to provide a single source of asset inspection information (in BASIX).
- Remediation tracking of all structural defects identified by aerial inspection.

Proposed steps to mitigate the risk of future similar major events

- Check that all structure defects in the Wairere Tie line UAV Aerial inspection report (Broadspectrum, 2018) have been addressed.
- Develop processes to transfer future UAV inspection data into BASIX to provide a single source of asset condition information used for line renewals.
- Improve contact details (including backup phone numbers and credentials) for all staff involved in fault responses.

5. Cyclone Gabrielle SAIDI and SAIFI major event

Location	Network-wide faults	**Main equipment**	Overhead lines
Cause type	Adverse weather/vegetation	**Cause detail**	Multiple

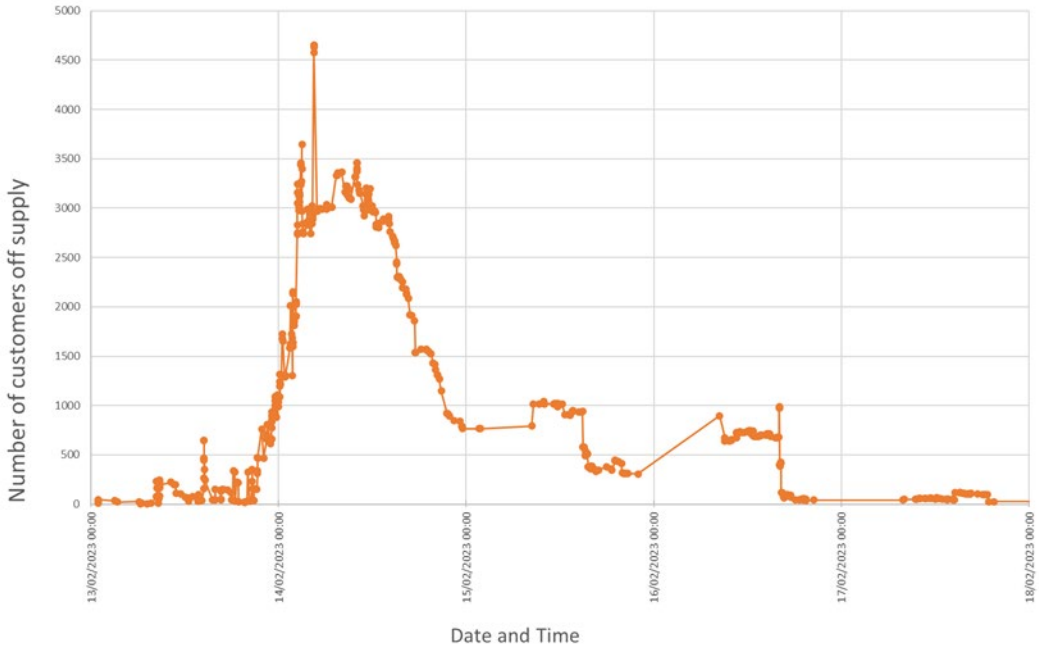
Multiple contributing interruptions:

- 12/02/2023 17:00 to 17/02/2023 07:59
- 338.00 normalised to 11.93 ***SAIDI*** minutes

- 12/02/2023 23:00 to 15/02/2023 02:29
- 0.6362 normalised to 0.0917 ***SAIFI*** minutes

Context and Response to the Major Event

On the evening of February 13, 2023, New Zealand was hit by ex-tropical cyclone Gabrielle, resulting in heavy rainfall, strong winds, and coastal flooding in the North and Eastern regions of the North Island. While less affected than other areas in New Zealand, parts of The Lines Company's network sustained significant damage resulting in 4,650 customers being without power at the peak of the event. Recovery efforts were intensive, lasting several days due to the extensive damage to the network. Despite these challenges, 50% of customers had their power restored within 11 hours and 90% within 35 hours, as shown in Figure 1. This event was unprecedented in The Lines Company's recent history, and the high volume of incidents and extensive network damage placed a significant strain on the people, processes, and systems involved. The damage to the network was primarily caused by out-of-zone fallen trees.



Plot of customers off supply vs time during the Cyclone Gabrielle event and its recovery.

Example photographs of typical network damaged that occurred during Cyclone Gabrielle.

Factors that may have prevented or minimised the major event if implemented

- While CIMS is a versatile incident response framework, it is not prescriptive in its specific procedures. As a result, the existing generic training received by TLC staff on CIMS was not specifically tailored to the systems, processes, and procedures needed to respond effectively to damaging windstorms, which are a common occurrence in a distribution network.
- Although some level of uncertainty is inevitable during the early stages of a significant event, such as Cyclone Gabrielle, the amount and duration of uncertainty could have been significantly reduced with proper preparation. The implementation of pre-prepared information gathering tools, such as integrated dispatch and Incident Response Management spreadsheets, could have enabled the CIMS intelligence function to operate more efficiently, thereby providing more accurate and timely information to the IMT.
- In addition, the use of visual aids such as maps displaying the location and status of outage areas proved to be highly effective in visualizing the incident and planning response at a macro level.
- To alleviate the bottleneck for switching and access permits, it could have been helpful to have additional controllers available. This would have made it possible to divide the network into north and south regions speeding up switching and issue of access permits.
- Communicating restoration priorities clearly to controllers and field crews would have enabled the queuing of field crew access to the controllers to be better optimised, potentially improving the rate of customer restoration.

- The failure to conduct a significant network event simulation resulted in a missed opportunity to identify issues that, if addressed, could have significantly enhanced the response to Cyclone Gabrielle.

Proposed steps to mitigate the risk of future similar major events

- The generic CIMS framework needs to be customized by defining specific roles, responsibilities, tasks, procedures, systems, and checklists for incident participants to effectively deal with common large-scale network events like windstorms and lightning storms.
- Implement a suite of process management and information gathering tools that integrate across the various incident response roles (such as dispatch, control and field operations). This could use spreadsheets and other standard software tools.
- Create and deploy visual aids to assist in managing similar network-wide events. These aids may take the form of GIS maps, or, if deemed more practical, paper or whiteboard tools located in the incident room.
- Conduct a review to determine the ideal number of network controllers to balance cost-effective BAU services and capacity to handle high volume network events, recognizing the tension between these two requirements.
- To improve the restoration process and address the bottleneck caused by limited network controllers, the Incident Response team should create a prioritized list of restoration priorities and communicate them to both control and field supervisors. This will ensure proper sequencing of the restoration effort and minimize the impact of the controller bottleneck.
- After implementing the process and system changes recommended in this report, perform a significant network event simulation to evaluate and further refine TLC's response capability.

6. Lake Taupo feeder SAIDI major event B

Location	33 kV Lake Taupo feeder	**Main equipment**	Sub-transmission lines
Cause type	Vegetation	**Cause detail**	Veg – Plantation trees out of zone

Major contributing interruption:

- 28/03/2023 10:00 to 30/03/2023 09:29
- 17.79 normalised to 0.41 SAIDI minutes

Response to the Major Event

An out-of-zone tree that had been previously damaged by Cyclone Gabrielle brought down the Lake Taupo 33 kV feeder.

Factors that may have prevented or minimised the major event if implemented

- Clearance of at-risk vegetation post-cyclone.

Proposed steps to mitigate the risk of future similar major events

- Implement a post-major event process to prioritise the review of affected areas, identifying remaining hazards and promptly acting to remedy them.

Appendix B: Detailed Class C Interruptions

Section 12.4(b) of the DPP Determination 2020 requires us to provide for each Class C interruption for the assessment period:

(i) the start date (dd/mm/yyyy) of the Class C interruption;

(ii) the start time (hh:mm am/pm) of the Class C interruption;

(iii) the end date (dd/mm/yyyy) of the Class C interruption;

(iv) the end time (hh:mm am/pm) of the Class C interruption;

(v) SAIDI value of the Class C interruption;

(vi) SAIFI value of the Class C interruption;

(vii) the cause;

Please refer to Detailed Class C Interruptions Excel Report.

Appendix C: Analysis conducted.

Section 12.4 (f) of the DPP determination 2020 requires us to provide any analysis, conducted in the assessment period in which the non-exempt EDB failed to comply with the annual unplanned interruptions reliability assessment specified in clause 9.8 or in any of the three preceding assessment periods, of:

(i) trends in asset condition;

(ii) the causes of Class C interruptions;

(iii) asset replacement and renewal; or

(iv) vegetation management;

During the course of RY2023 and the preceding three years, TLC presented 93 papers to the Asset Management Committee (AMC) for review. We have summarised the papers that have information relevant to the four categories listed in 12.4 (f) above in the following table.

Date	Presented to	Title	Purpose	Analysis / information presented
Jun 2019	AMC	2019 Network reliability analysis (unplanned outages)	To provide a summary of the unplanned network outages for the 2019 financial year	Detailed analysis of network reliability performance including: • Comparison to prior years; • Major event days; • Vegetation outages; • Defective equipment outages; • Weather related outages; • Third-party damage outages; • Wildlife outages; • Human error related outages.
Jun 2019	AMC	Vegetation Management Plan	To present the FY20 Vegetation Management Plan for approval	Detailed vegetation management plan including: • Targeted Performance Improvement • Analysis of Vegetation Related Outages • Review of Key Actions Taken to Date • Vegetation Management Strategy and Plans • Considerations and Assessment • Vegetation Management Improvement Plan • Supporting Plans • Targets and Reporting • Feeder Priority Schedule • Feeder Inspection Plan • Feeder Remediation Plan
Nov 2019	AMC	Outage Analysis H1 FY20	To provide an overview of network faults for Q1 and Q2 of FY20. Including additional analysis of all major network faults and a year on year comparison with Q1 and Q2 of FY19	Detailed analysis of network reliability performance including: • Year on year comparison • Analysis of major interruptions
Nov 2019	AMC	Incident Report – Taharoa Village Substation Outage	To provide an ICAM review of the incident.	Detailed review of the outage in ICAM format

Nov 2019		Planned Work to Minimise SAIDI & SAIFI Impact FY20	To outline the changes made to planned work for FY20 in order to keep both SAIFI and SAIDI under maximum limits whilst not affecting FY20 CAPEX.	Outlines TLC's approach to minimising SAIDI and SAIFI impacts while continuing to deliver the planned capex programmes.
Nov 2019	AMC	Outage Management and Analysis	To outline refinements to the month end process for recording and monitoring of outages and their associated costs.	Outlines changes to TLC's processes to monitor, review and record outages, including trigger points for undertaking internal reviews of major outages and ICAM reviews of major event outages.
Nov 2019	AMC	Power Transformer Management	To seek approval for new transformer procurement to support the power transformer replacement programme.	Summarises the results of the recently developed Power Transformer Procurement Case Study and recommends the procurement of three new power transformers to allow commencement of the Power Transformer Replacement Programme. Two additional papers are connected with this cover paper that outline: • the business case for power transformer procurement, • the transformer procurement and relocation programme, • a detailed study of the existing power transformers in TLC's fleet • rationale for renewal and relocation of power transformers
Nov 2019	AMC	Turangi Backup Supply Options Update	Provides an update on identification and implementation of backup supply options for the Turangi Township.	Outlines progress on the stage 1 of the Turangi 11kV cable upgrade.
Nov 2019	AMC	LIDAR Network Survey	Provides and overview of the proposal for LIDAR survey of the TLC Network	Outlines the approximate costs, benefits and risks to undertake a LiDAR survey of the TLC network.
Nov 2019	AMC	AMP Planning Update	To provide an initial overview of the 2020 AMP process, its key objectives and issues, and how TLC is considering forming the balance between risk, service, delivery and cost.	Outlines the objectives of the 2020 AMP and discusses changes in expenditure for key asset classes to support these objectives. The objectives as outlined are: • Alleviating security of supply constraints • Maintaining a sustainable line renewal programme • Managing reliability • Improving Safety
Feb 2020	AMC	Incident Report – Turangi Car vs Pole	To provide an ICAM review of the incident.	Detailed review of the outage in ICAM format
Feb 2020	AMC	Incident Report – Waikawau Outage	To provide an ICAM review of the incident.	Detailed review of the outage in ICAM format

Feb 2020	AMC	Incident Report – Extended Outage – Ohakune	To provide an ICAM review of the incident.	Detailed review of the outage in ICAM format
Feb 2020	AMC	Incident Report – 12296 Switching Process Failure	To provide an ICAM review of the incident.	Detailed review of the outage in ICAM format
Feb 2020	AMC	AMP 2020 Proposed Plan	To renew approval for our Asset Management Policy and Objectives, update the AMC on the revised capital plan and seek approval for the Base Option that is recommended	Outlines key changes to the AMP plan including analysis of capex changes and the expected improvements resulting from those changes. This includes analysis of": • feeder performance, • risk improvement, • SAIDI improvements
Feb 2020	AMC	Quality Measures and Targets	To provide the AMC with an early view of a Network Performance and Customer Experience section that is proposed to be added to the 2020 AMP.	Outlines the quality measures and targets proposed for the 202 AMP. This includes a supporting paper (proposed quality section of the 2020AMP) that covers analysis on: • Network performance: Faults • Major causes of interruptions • Defective equipment • Vegetation interruptions • Third party interference interruptions • Managing unplanned interrutpions • Feeder performance • Customer experience measures
Feb 2020	AMC	Turangi Backup Supply Options Update	To provides an update on identification and implementation of backup supply options for the Turangi Township.	Provides an update of progress of the 11kV backup cable upgrade to Turangi township
Feb 2020	AMC	Changes to TLC's outage management system.	Sets out the planned changes for our outage management system for FY2021	Outlines changes to TLC's outage mangement recording to provide enhanced visibility of fault causes. It covers changes TLC is seeking to make in: • Data capture • Analysing the data • Reporting the data
Feb 2020	AMC	Outage Analysis for the first three quarters of FY20	To provide an overview of network faults for Q1 to Q3 of FY20 and compares them to FY19 for comparison purposes.	Detailed analysis of network reliability performance including: • Year on year comparison • Analysis of major interruptions

Feb 2020	AMC	Overhead line conductors in poor condition	To identify if there are any other locations where the overhead line conductor is in poor condition	Outlines analysis of • Types of conductor on the TLC network • Reasons why conductors can fail • Regional issues • Work required to prepare remedial work plans
Jun 2020	AMC	Reliability Analysis for FY2020	To provide a summary of the TLC's quality performance for the 2020 Financial	Detailed analysis of network reliability performance including: • Year on year comparison of key SAIDI and SAIFI categories • Comparison against historic trends • Comparison across DPP periods • Analysis of major interruptions
Sep 2020	AMC	Network Quality Performance Analysis	To provide an overview of TLC's network outage performance for the first five months of FY21 between 01 April 2020 and 31 August 2020.	Detailed analysis of network reliability performance for key SAIDI and SAIFI categories including: • Year on year comparison • Analysis of major interruptions
Sep 2020	AMC	Vegetation Management Strategy	To outline a strategy that will enable TLC to effectively assess and manage vegetation risk	Provides analysis and strategic framework for improving vegetation management.
Sep 2020	AMC	Vegetation Management Plan FY2021	To seek approval for the FY2021 vegetation management strategy	Provides detailed analysis of vegetation management performance including • Tree maangement performance • Review of FY2020 Vegetation Related SAIDI and SAIFI • Inspection Performance • Analysis of Vegetation Management Practice Outlines a vegetation management plan for FY2021
Dec 2020	AMC	Network Quality Performance Analysis	To provide an overview of TLC's network outage performance for the first eight months of FY2021 between 01 April 2020 and 30 November 2020.	Detailed analysis of network reliability performance including: • Year on year comparison of key SAIDI and SAIFI categories • Comparison against historic trends • Primary causes and trends of interruptions • Analysis of major interruptions
Dec 2020	AMC	Impact of changes to reclosing settings and procedures on SAIDI	To outline the impact on unplanned SAIDI from the introduction of the 15-minute minimum wait time for	Provides analysis of the impact of changing TLC's operating procedures (that were implemented to support public safety) on TLC's SAIDI performance.

		for FY2019 and FY2020	manually closing locked-out auto-reclosers and the disabling of auto-reclosing during periods of high fire risk	
Dec 2020	AMC	Incident Report – Lake Taupo 33 Outage	To provide an ICAM review of the incident.	Detailed review of the outage in ICAM format
Dec 2020	AMC	Incident Report – Gadsby Rd / Wairere 33 outage	To provide an ICAM review of the incident.	Detailed review of the outage in ICAM format
May 2021	AMC	Network Quality Performance Analysis	To provide an overview of TLC's network outage performance for FY2021.	Detailed analysis of network reliability performance including: • Year on year comparison of key SAIDI and SAIFI categories • Comparison against historic trends • Primary causes and trends of interruptions • Analysis of major interruptions
May 2021	AMC	Incident Report – Gadsby Rd / Wairere 33 outage	To provide an ICAM review of the incident.	Detailed review of the outage in ICAM format
May 2021	AMC	Vegetation Management Plan FY 2022	Sets out what TLC will deliver in the short term (next 12 months) based on both progressing the strategy and addressing immediate challenges and performance	Provides: • A review of vegetation management performance • A review of Vegetation SAIDI and SAIFI performance • Outlines an FY2022 improvement plan • Targets • Feeder prioritisation and schedule
Sep 2021	AMC	Network Quality Performance Analysis	To provide an overview of TLC's network outage performance for the first four months of FY22 between 01 April 2021 and 31 July 2021.	Detailed analysis of network reliability performance including: • Year on year comparison of key SAIDI and SAIFI categories • Comparison against historic trends • Primary causes and trends of interruptions • Analysis of major interruptions
Sep 2021	AMC	Update on the LiDAR Project	To update that AMC on our progress with the LiDAR project so far.	Provides an overview of preliminary results from the LiDAR survey relating to vegetaiton and asset clearances.

Nov 2021	AMC	Network Quality Performance Analysis	To provide an overview of TLC's network outage performance for the first seven months of FY2022 between 01 April 2021 and 31 October 2021.	Detailed analysis of network reliability performance including: • Year on year comparison of key SAIDI and SAIFI categories • Comparison against historic trends • Primary causes and trends of interruptions • Analysis of major interruptions
Nov 2021	AMC	Progressing our vegetation management approach	To outline how we intend to progress our vegetation management approach based on insights from the LiDAR survey conducted this year.	Outlines findings from the LiDAR survy related to vegetation risk, and outlines an approach to manage these risks.
May 2022	AMC	Network Quality Performance Analysis	To provide an overview of TLC's network outage performance for FY22 in relation to regulatory quality standards and to historical performance for Class B and Class C outages.	Detailed analysis of network reliability performance including: • Year on year comparison of key SAIDI and SAIFI categories • Comparison against historic trends • Primary causes and trends of interruptions • Analysis of major interruptions
Aug 2022	AMC	Network Quality Performance Analysis	To provide an overview of TLC's network outage performance for the first four months of FY22 between 01 April 2021 and 31 July 2022.	Detailed analysis of network reliability performance including: • Year on year comparison of key SAIDI and SAIFI categories • Comparison against historic trends • Primary causes and trends of interruptions • Analysis of major interruptions
Aug 2022	AMC	Vegetation Management Plan FY 2023	Sets out what TLC will deliver in the short term (next 12 months) based on both progressing the strategy and addressing immediate challenges and performance	Provides: • A review of vegetation management performance • A review of Vegetation SAIDI and SAIFI performance • Outlines an FY2023 improvement plan • Targets • Feeder prioritisation and schedule
Nov 2022	AMC	Network Quality Performance Review	To provide an overview of TLC's network outage performance for Class B (planned) and Class C (unplanned) outages for the first seven months of FY23	Detailed analysis of network reliability performance including: • Year on year comparison of key SAIDI and SAIFI categories • Comparison against historic trends • Primary causes and trends of interruptions • Analysis of major interruptions

			between 01 April 2022 and 31 October 2022.	
Nov 2022	AMC	FMEA analysis and effectiveness of inspection techniques	To review the effectiveness of inspection technicques in detecting major causes of defective equipment faults	Provides a detailed analysis of asset failure types, the consequqnces of failure, SAIDI impact and the effectiveness of know inspection and detection methods.

Appendix D: Independent investigations

Section12.4(c) of the DPP Determination 2020 requires us to report on any independent reviews on the state of the network or operational practices completed in the assessment period or in any of the three preceding assessment periods.

Please refer to the following oi

- **Responding to Cyclone Gabrielle:** A review of The Lines Company's response to and recovery from Cyclone Gabrielle, Paul Blackmore, Agila Solutions Limited
- **Review of failure Mode and Effects Analysis** (FMEA), Paul Blackmore, Agila Solutions Limited
- **Extreme Weather Days,** Ben Noll, NIWA meteorologist

RESPONDING TO CYCLONE GABRIELLE

A review of The Lines Company's response to and recovery from Cyclone Gabrielle, lessons learned and opportunities for improvement.

30 June 2023

Paul Blackmore
Agila Solutions Limited
Paul.blackmore@agila.co.nz

Executive Summary

This report outlines the key learnings from The Lines Company's response to and recovery from Cyclone Gabrielle, with the goal of providing insights to improve responses to future events. The cyclone caused significant damage to parts of TLC's network, leaving thousands without power for several days. Despite the challenges, recovery efforts were successful in restoring power to a large percentage of customers relatively quickly. However, the event highlighted several areas for improvement, including the need for improved systems and processes and better incident coordination.

Top Six Lessons Learned

1. While CIMS is a versatile incident response framework, it is not prescriptive in its specific procedures. As a result, the existing generic training received by TLC staff on CIMS was not specifically tailored to the systems, processes, and procedures needed to respond effectively to damaging windstorms, which are a common occurrence in a distribution network.
2. Although some level of uncertainty is inevitable during the early stages of a significant event, such as Cyclone Gabrielle, the amount and duration of uncertainty could have been significantly reduced with proper preparation. The implementation of pre-prepared information gathering tools, such as integrated dispatch and Incident Response Management spreadsheets, could have enabled the CIMS intelligence function to operate more efficiently, thereby providing more accurate and timely information to the IMT.
3. In addition, the use of visual aids such as maps displaying the location and status of outage areas proved to be highly effective in visualizing the incident and planning response at a macro level.
4. To alleviate the bottleneck for switching and access permits, it could have been helpful to have additional controllers available. This would have made it possible to divide the network into north and south regions speeding up switching and issue of access permits.
5. Communicating restoration priorities clearly to controllers and field crews would have enabled the queuing of field crew access to the controllers to be better optimised, potentially improving the rate of customer restoration.
6. The failure to conduct a significant network event simulation resulted in a missed opportunity to identify issues that, if addressed, could have significantly enhanced the response to Cyclone Gabrielle.

Top Six Recommendations

1. The generic CIMS framework needs to be customized by defining specific roles, responsibilities, tasks, procedures, systems, and checklists for incident participants to effectively deal with common large-scale network events like windstorms and lightning storms.
2. Implement a suite of process management and information gathering tools that integrate across the various incident response roles (such as dispatch, control and field operations). This could use spreadsheets and other standard software tools.
3. Create and deploy visual aids to assist in managing similar network-wide events. These aids may take the form of GIS maps, or, if deemed more practical, paper or whiteboard tools located in the incident room.
4. Conduct a review to determine the ideal number of network controllers to balance cost-effective BAU services and capacity to handle high volume network events, recognizing the tension between these two requirements.
5. To improve the restoration process and address the bottleneck caused by limited network controllers, the Incident Response team should create a prioritized list of restoration priorities and communicate them to both control and field supervisors. This will ensure proper sequencing of the restoration effort and minimize the impact of the controller bottleneck.
6. After implementing the process and system changes recommended in this report, perform a significant network event simulation to evaluate and further refine TLC's response capability.

The following report has been prepared by Agila Solutions based on our professional judgment and analysis of available information provided to us during our review. While we have made every effort to ensure the accuracy of the information contained within this report, we cannot guarantee the completeness, correctness or reliability of the information provided. This report has been prepared in accordance with the short form agreement for consultant engagement, Cyclone Gabrielle Response Review. This report is provided as “Commercial in Confidence” intended to be used, by the named company for the project on the front cover.

Contents

Executive Summary i
Background 1
Purpose 1
Context 1
Scope 3
Approach 3
Detailed Lessons Learned and Recommendations 4
Conclusions and Recommendations 12
Top Six Lessons Learned and Recommendations 13
Appendix A List of Artefacts Reviewed ..... A
Appendix B – People Interviewed ..... B

Background

Purpose

This report documents the learnings that The Lines Company (TLC) gained from its response to and recovery from the impact of Cyclone Gabrielle and provides TLC with insights and recommendations on how to improve its response to future events.

Context

On the evening of February 13, 2023, New Zealand was hit by ex-tropical cyclone Gabrielle, resulting in heavy rainfall, strong winds, and coastal flooding in the North and Eastern regions of the North Island. While less affected than other areas in New Zealand, parts of The Lines Company's network sustained significant damage resulting in 4,650 customers being without power at the peak of the event. Recovery efforts were intensive, lasting several days due to the extensive damage to the network. Despite these challenges, 50% of customers had their power restored within 11 hours and 90% within 35 hours, as shown in Figure 1. This event was unprecedented in The Lines Company's recent history, and the high volume of incidents and extensive network damage placed a significant strain on the people, processes, and systems involved. The damage to the network was primarily caused by fallen trees, as illustrated in Figure 2.

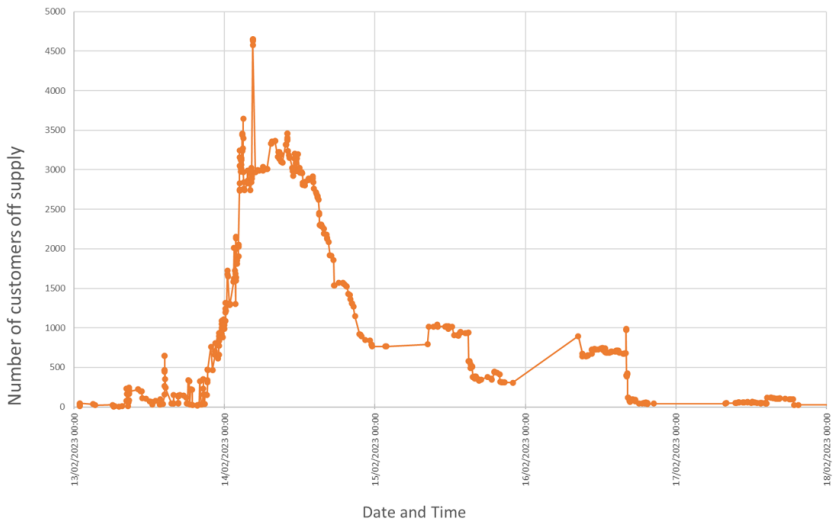


Figure 1 Plot of customers off supply vs time during the Cyclone Gabrielle event and its recovery.

Figure 2. Example photographs of typical network damaged that occurred during Cyclone Gabrielle.

Scope

This review had a specific focus on evaluating the organization of the incident response team and the efficiency of response management, with the ultimate goal of improving response and recovery efforts. However, it was not intended to include an analysis of the technical performance of the network to identify lessons learned and improve the network's ability to cope with future events. Despite having access to relevant data and conducting interviews with staff members, we faced constraints that prevented us from conducting an extensive quantitative analysis or fully validating statements.

Approach

To conduct this review, we utilized the following sources:

1. Documentation pertaining to TLC's incident management systems and processes.
2. Documentation and data generated during the event.
3. Interviews with all staff members who held designated CIMS roles during the event.
4. Interviews with select staff members involved in the response.

By analysing these inputs, we have identified recurring observations that are relevant to the response and recovery. We have documented the lessons learned from these observations and have made recommendations for improvement.

Detailed Lessons Learned and Recommendations

Area	Observations	Lessons Learned	Recommendations
Incident response team organisation	**CIMS is a Generic Framework** Before the incident, TLC had started implementing a new incident management framework based on the New Zealand Coordinated Incident Management System (CIMS). Although many employees had received introductory or intermediate training, this training was not tailored specifically to the procedures and processes needed by TLC.	While CIMS is a versatile incident response framework, it is not prescriptive in its specific procedures. As a result, the existing generic training received by TLC staff on CIMS was not specifically tailored to the systems, processes, and procedures needed to respond effectively to damaging windstorms, which are a common occurrence in a distribution network.	R1. The generic CIMS framework needs to be customized by defining specific roles, responsibilities, tasks, procedures, systems and checklists for incident participants to effectively deal with common large-scale network events like windstorms and lightning storms.
	Staff not Given Prior Notice of Their CIMS Role The staff members who participated in the incident response team were not informed of their roles in the team prior to the event. As a result, they did not receive any briefings or training related to their roles or have any opportunity to prepare for their responsibilities during the response.	Staff members on the incident response team were unprepared for their roles and had to learn on the job. This, combined with the generic nature of the CIMS training and preparation, which was discussed earlier, created a vacuum regarding staff responsibilities and expectations during the response effort.	R2. To improve the effectiveness of the incident response team, it is recommended that a staff roster be developed and regularly updated. The roster should include assignments of specific staff members to appropriate incident response roles. Careful consideration should be given to ensure a suitable match between the role requirements and the skills of the assigned staff. R3. Role specific training tailored for TLC's specific processes should be provided on a regular basis.
	Incident Staff Not trained or experienced in existing incident response procedures and tools. Smaller storms are not uncommon on the TLC network, and as such, systems and processes are already in place to handle these events. However, these existing systems rely heavily on the knowledge, skills, and experience of core Business As Usual (BAU) staff. During the Gabrielle storm, the volume of damage	Spreadsheets are a widely-used and adaptable tool, but they require comprehension of the initiator's intentions and discipline to ensure that those	R4. In conjunction with R3 ensure that specific training in how to use systems such as official spreadsheets. Consider enhancing spreadsheets to include data

Area	Observations	Lessons Learned	Recommendations
	was too much for the BAU staff and systems to handle, leading to the involvement of other staff members who were not familiar with the existing systems. Unfortunately, these staff members either made uncontrolled adaptations and modifications to the systems or failed to keep them up to date.	intentions are accurately carried out. When utilized for mission-critical procedures, significant discipline must be exerted to ensure that information is consistently recorded and effectively managed.	validation and protections to aid with data integrity.
	Simulation training event not conducted Regular incident simulation events should be conducted, at least once a year, to train staff, test systems and processes, and identify areas for improvement. It was found that an event simulation had not taken place in the past 12 months. A simulation exercise was planned for March but was unfortunately was pre-empted by Cyclone Gabrielle Had an event simulation been conducted, involving all individuals expected to participate in a major event, it would likely have identified many of the deficiencies that became evident during Cyclone Gabrielle.	The failure to conduct a significant network event simulation resulted in a missed opportunity to identify issues that, if addressed, could have significantly enhanced the response to Cyclone Gabrielle.	R5. After implementing the process and system changes recommended in this report, perform a significant network event simulation to evaluate and further refine TLC's response capability.
	Incident Response Team Accommodation An incident room at TLC's King Street offices was established in the days leading up to the event. The accommodation provided desks communications and computer facilities for the key CIMS functions. The room however was found to be noisy and was not initially set up with visual aids such as network schematics, geographic maps and whiteboard tools that might have assisted with the response.	Had visual tools such as maps and whiteboards been available and incorporated into the incident response processes and systems from the beginning, the incident response would have benefitted greatly. As the event progressed, the response room evolved to include these tools.	R6. In conjunction with the review of roles, tasks procedures and responsibilities described in R1 establish the required visual aids and tools.
	Team Handover A vs B As the incident continued, it was evident that the Incident Response Team needed assistance. This was achieved by forming a second team, referred to as 'Team B', which assumed complete responsibility for the response. This handover to another team caused some disruption and a shift in the response strategy. Although the changes were generally viewed as positive, some staff from 'Team A' felt excluded from the response and that their contributions were no longer necessary.	A more effective method than a complete shift change would be to allocate backup personnel to each role in the incident response roster as recommended in R2. This would enable staff to rotate in and out of the response team on a flexible and negotiated schedule, taking into account the	R7. Instead of using an A and B team, it is recommended that each incident response role have a designated lead and backup(s) assigned in advance through the roster (see R2). This approach would offer greater flexibility for both incident management and individual circumstances. It would also

Area	Observations	Lessons Learned	Recommendations
		needs of the incident response and the circumstances of the individuals involved.	provide contingency and succession planning in the event that an individual is unavailable.
	Lack of formal fatigue management A formal fatigue management policy and monitoring system was not in place for the office based incident response team, the team instead relying on individuals and the team to self-monitor.	While there were no reported safety or performance issues related to fatigue management, the lack of formal fatigue management process represents a risk to TLC should an fatigue related incident or injury occur.	R8. TLC should implement a formal fatigue management policy monitoring function for office staff involved in major incidents.
Policy and Documentation	**Response did not follow the approved Incident management plan.** TLC currently has an approved incident management plan document, which is in version 2 as of March 2021. Section B9 of the document outlines the specific steps that TLC should follow when responding to major network events. Additionally, Section B9 includes details that are absent from the Generic CIMS framework but are necessary for the management of extensive network events. Opting to align with CIMS during the incident, despite having a formal incident management plan, led to modifications in real-time. This most likely led to initial confusion and inefficiencies in the response. Had the team followed the documented plan, such issues could have been avoided.	A formal incident plan existed which if followed could have resulted in a better initial response.	R9. The incident management plan should be subject to regular reviews and always regarded as the plan to follow in case of an incident.
Incident Intelligence	**IRT initial situational awareness** The IRT's response was hampered in the initial stages of the event due to a lack of situational awareness. A contributing factor was that the CIM's intelligence function was not set up at the start to collect, orient and interpret and then present information from diverse sources to provide the incident controller with an overall 'big picture' view of the event. This	Although some level of uncertainty is inevitable during the early stages of a significant event, such as Cyclone Gabrielle, the amount and duration of uncertainty could have been significantly reduced with proper preparation. The implementation of	R10. Implement a suite of process management and information gathering tools that integrate across the various incident response roles (such as dispatch, control and field operations). This could use

Area	Observations	Lessons Learned	Recommendations
	was rectified as the event progressed with improvement in the spreadsheets being used the development of map products and the implementation of visual tools such as paper maps and whiteboards.	pre-prepared information gathering tools, such as integrated dispatch and Incident Response Management spreadsheets, could have enabled the CIMS intelligence function to operate more efficiently, thereby providing more accurate and timely information to the IMT. In addition, the use of visual aids such as maps displaying the location and status of outage areas proved to be highly effective in visualizing the incident and planning response at a macro level.	spreadsheets and other standard software tools. R11. Create and deploy visual aids to assist in managing similar network-wide events. These aids may take the form of GIS maps, or, if deemed more practical, paper or whiteboard tools located in the incident room.
	Hourly Intelligence and Decision Cycle The IRT operated on an hourly intelligence gathering and decision cycle. This was found to be too frequent as it was a) not necessary in the context of the pace of the event and b) the overhead of the manual data gathering methods diverted key staff from other response activities. Some information that was repeatedly requested verbally was available in documents or systems (for example control system logs) but incident staff were either unaware of its existence or unable to access and interpret it. One responsibility of the CIMS intelligence function is the preparation of situation reports that are disseminated outside of the immediate CIMS team. The hourly issue cycle for situation reports was found to be too frequent and as a consequence caused inefficiency throughout the response.	The cycle time for the intelligence and decision cycle should be flexible and based on the needs of the event and the judgement of the incident controller. Automation of some information gathering through better systems or knowledge could have reduced the information collection overhead.	R12. The incident controller should determine the cadence of the Intelligence and Decision cycle based on the needs of the incident. R13. Effort should be made to streamline processes for collecting routine incident data. This would reduce information gathering overhead and facilitate faster Information cycle cadence.
	Situation Report Format and Information One responsibility of the CIMS intelligence role is to prepare an issue situation reports. These are primarily intended for stakeholders outside of the IRT such as other agencies and when active the regional CIMS controller. Prior to the event there was limited guidance provided to the Intelligence role regarding the information required. This resulted in wasted	Having a pre-defined Sitrep template readily available would have been advantageous. It would have facilitated the intelligence role in preparing situation reports more efficiently.	R14. Define a template for situation reports for future incidents. Ensure that the content of the situation reports meets the needs of the recipients and that where practicable it does not duplicate information readily available from

Area	Observations	Lessons Learned	Recommendations
	effort and repeating of information available through other sources.		other sources such as for example TLC's TVD system. R15. Create a situation report template for future incidents that satisfies the requirements of the recipients and avoids duplicating information that is already accessible through other sources, such as TLC's TVD system, wherever possible.
Aerial Intelligence Gathering	**Helicopter intelligence gathering was a game changer** After the cyclone had passed, a helicopter was dispatched to assess network damage, which proved to be instrumental in providing the IRT with a more comprehensive understanding of the situation, improving the effectiveness of the response effort. However, there were several constraints that affected the use of helicopters. Firstly only a single service provider was available for deployment due to the stand down of one provider pending investigation of an incident. Secondly, while there are four observers current in the mandatory safety training required for TLC staff to perform the reconnaissance function only two were available for deployment. Furthermore, the deployment of the helicopter was not optimally planned and coordinated on the ground, resulting in some inefficiencies. For example, the helicopter was sent to survey a feeder that had already been restored, indicating a lack of coordination and planning in the deployment.	Having only one helicopter provider and two qualified TLC staff available for deployment was a bottleneck which if relieved could have hastened the gathering of information and efficiency of the response. Systems were not in place to perform the ground-based planning and coordination that would have improved the efficiency of the use of the helicopter. Technology to stream video and georeferenced photographs to the IRT would be a powerful value add to the helicopter capability.	R16. Take steps to ensure that multiple helicopters with trained TLC observers are available for future events. R17. Develop procedures, guidelines, and templates to streamline ground-based planning to improve the efficiency of future helicopter reconnaissance. R18. Investigate the availability and feasibility of low-cost technology to stream video and georeferenced photos from the helicopter to the IRT to reduce the cycle time for data collection.
Logistics	**The CIMS Logistics function worked well** The IRT Logistics leads were highly experienced individuals with a robust personal network of contacts and an in-depth understanding of TLC's purchasing and administrative procedures. Thanks to these advantages, the Logistics function was able to effectively locate and contract the necessary	The logistics function performed well during the event, but its success heavily relied on the experience and personal networks of the staff involved. Although this was not an issue, there is potential for improvement by	R19. Develop a directory of vendors over the range of services that TLC might need to procure during an event. Where warranted, this could extend to

Area	Observations	Lessons Learned	Recommendations
	additional resources, including traffic control, vegetation management, and generators. However, like other CIM roles, the Logistics team was not informed in advance of their involvement or the specific resources required, which limited their preparation opportunities.	developing a directory of suppliers for key response services with established relationships with TLC. By doing so, some procurement tasks could be delegated, and less experienced staff without personal networks could step in to assist. Additionally, for certain resources such as generators, helicopters, and vegetation management, it may have been beneficial to initiate the procurement process prior to the event. This could have taken the form of assessing availability and notifying suppliers of the potential need for their services.	negotiating rates or preferential availability. R20. As part of the pre-event response consider making initial enquiries for key resources likely to be required to ascertain and where feasible secure their availability.
Network Controllers	**Network Controllers were a bottleneck in the response** Network controllers play a critical role in incident response as they are responsible for managing switching and access to the network. This means that most repairs cannot start without the authorization and involvement of a network controller. During the event, there were only two available network controllers, with one active at any given time, as the third trainee was absent due to illness. The Incident Manager, also a qualified controller provided support and relief at times. This caused severe bottlenecks as multiple crews tried to obtain authorization for fault finding and repairs at the same time. As a result, crews had to wait inactively to contact controllers before starting their work. Although wait times varied, some crews reported delays of several hours, while others reported 30 minutes to an hour as typical. The bottleneck was made worse by a lack of communication of restoration priorities from the IRT to both the controllers and field crews. In the absence of clear priorities, the controllers worked on a first-in-first-out (FIFO) basis, taking requests from field operators in the order they were received. Field staff did not know where their job was in the queue, so they didn't know whether to stand aside for higher-priority work or push for their	To alleviate the bottleneck for switching and access permits, it could have been helpful to have additional controllers available. This would have made it possible to divide the network into north and south regions speeding up switching and issue of access permits. Communicating restoration priorities clearly to controllers and field crews would have enabled the queuing of field crew access to the controllers to be better optimised, potentially improving the rate of customer restoration. During future incidents it may be possible to relieve controllers of some of their routine tasks such as for example updating of the TVD and other systems.	R21. Conduct a review to determine the ideal number of network controllers to balance cost-effective BAU services and capacity to handle high volume network events, recognizing the tension between these two requirements. R22. To improve the restoration process and address the bottleneck caused by limited network controllers, the Incident Response team should create a prioritized list of restoration priorities and communicate them to both control and field supervisors. This will ensure proper sequencing of the restoration effort and minimize the impact of the controller bottleneck. R23. To improve the performance of network controllers during high volume events, a review should be conducted to determine the feasibility of

Area	Observations	Lessons Learned	Recommendations
	turn to access the controller. This lack of clear priorities and FIFO access resulted in some suboptimal sequencing of work. Due to the safety-critical nature of their work, controllers must work in a methodical, error-free manner and properly record their actions and update systems and logs. They also have responsibilities to update other systems, such as team chat and the TVD outage reporting system. During normal operations with few outages, the volume of information required to be manually recorded and updated is not an issue. However, during the outage, it exacerbated the controller bottleneck. This was partially resolved by assigning the updating of the TVD outage system to another person.		providing additional technical and administrative support. This could include relieving controllers of non-administrative tasks or providing additional competent personnel to assist controllers with technical tasks.
	Coordination between IRT and Network Controllers Could have been improved The IMT identified that access to Network Controllers was a bottleneck in restoration efforts, leading to controllers being considered 'off limits' and unable to be diverted from their immediate tasks. Additionally, communication and coordination with controllers was impacted by their remote work. While remote work reduced distractions and travel, it also resulted in a loss of informal communication and information sharing that could have helped prioritize and sequence restoration efforts. This isolation of the controllers from the incident response decision-making process, while expedient in the short term, ultimately had a negative impact on the response effort.	The controllers' remote location and the IMT's decision to keep them 'off limits' hindered informal communication and information sharing that would have occurred if they were co-located. As a result, controllers were not fully informed of the IMT's priorities and the IMT could not benefit from the controllers' input when setting priorities. There are differing opinions on whether it would have been beneficial for the controllers to be physically located with the IMT and dispatch teams. Some argue that co-location would have allowed for more informal communication, while others believe that formal communication channels could have been improved to achieve the same result.	R24. In future events, it is recommended to establish appropriate channels of communication between the IMT and Network Controllers to facilitate information exchange and ensure that the IMT is fully informed of the Controllers' experience and perspectives. This will help in implementing the incident plan effectively. R25. Consider reviewing the decision to allow Network Controllers to work remotely during significant network events. The decision should integrate with improvements in incident procedures and systems recommended elsewhere in this report.
Public Information	**The information published on the TVD system was not always up to date accurate or in a form readily absorbed by the public**		

Area	Observations	Lessons Learned	Recommendations
	Clear and timely information is crucial for consumers during network outages, as it helps them plan and mitigate the effects of the outage. It also reduces the workload for the response team by allowing consumers to self-service by first checking if an issue is already known before calling. TLC uses the TVD system to communicate outage information to consumers and other stakeholders, which should be accurate, timely, and easy to understand. However, during the initial stage of the event, the Network Controller workload meant that the TVD system was not always kept up to date and lacked context and detail to help consumers understand how the outage would affect them.	The TVD is currently TLC's official outage communication channel and should be the master source of information made available to the public. High quality information is of great value to consumers and effort to provide accurate and timely information adds value by managing expectations, allowing consumers to mitigate the effects of outages, and reducing the workload of incident response staff, particularly telephone operators.	R26. To improve the accuracy and timeliness of outage information provided to consumers through the TVD, a review of procedures should be conducted as recommended in R2. As part of this review, a planned process should be implemented to transfer the management of the TVD from the network controller to a trained TVD operator who is part of the incident response team. The TVD output should be aligned with and driven by real-time incident data managed by the IMT Intelligence role.
	Facebook was an effective channel for communicating with the community. Facebook was effectively used as a communication channel during the incident, with high engagement from the community. The two-way communication enabled the incident response team to manage consumer expectations and gather additional information about network damage. However, the publication of information was hindered by the lack of accurate and timely outage information from the TVD. This made it difficult to rely on TVD data for public communications. Delays in obtaining approvals for release also impacted the effectiveness of communications.	Facebook is an effective bi-directional communication tool with high engagement. This highlights the importance of Facebook and social media in general for future events.	R27. In order to improve the timeliness of communications, it is recommended to review and streamline the approval process cycle times for communications.
Welfare	**Information regarding vulnerable customers was out of date** One of the functions of the welfare role is to address the needs of individuals impacted by the incident, with an emphasis on mitigating its impact on vulnerable consumers. Although a list of vulnerable customers was available, it was outdated, and there was no defined policy outlining the level of support that TLC should provide.	It would be beneficial to have a pre-defined policy regarding the support that TLC should provide to vulnerable customers.	R28. Develop a policy for providing support for vulnerable customers and take steps to ensure that the vulnerable customer database is current.

Area	Observations	Lessons Learned	Recommendations
Staff Compensation	**Clarity of employment conditions** During the event office-based staff were requested to work outside of their normal hours. While all staff responded to the request, their expectations regarding remuneration for additional time worked in some cases varied from their employment conditions.	To avoid any misunderstandings or reluctance to contribute in future incidents, it is important to establish clear expectations, employment conditions, and remuneration for staff who are requested to work outside of their normal hours during incident response.	R29. As a part of the development of a response roster as suggested in R2 TLC should ensure that there is clarity with respect to staff employment conditions so that TLC can be assured that staff will be available when required.

Conclusions and Recommendations

Cyclone Gabrielle was an exceptional event, producing more damage than any other event in recent TLC history. The scale of the event stressed TLC's BAU systems beyond their capacity requiring support from staff not normally involved in managing network outage events. TLC's BAU processes are geared to smaller events relying largely on the experience of core response staff and somewhat informal business systems. The reliance on experience and informal processes and systems made it difficult for the response to scale up to effectively utilize additional staff needed to meet the needs of the response.

A further complication that affected the response was TLC's implementation of the New Zealand CIMS incident framework. At the time of the event, implementation of CIMS within TLC was at an early stage and had not been developed to cover the details of the important operational roles required to deal with a large-scale network event. This gap meant that many staff were not aware of their roles and responsibilities prior to the event, did not have training and did not have prepared systems and processes to support their roles. The key recommendations in this report are associated with developing the capability of people and systems to enable TLC to effectively and as far as practicable pivot from day-to-day operations to incident management operations.

An effective response to large-scale weather events should be considered a fundamental business capability for an overhead distribution network due to the inherent susceptibility to such events. There however exists a commercial tension between response capability and day-to-day operations, as management strives to maintain cost-efficiency while also having the necessary surge capacity to tackle large-scale network events. Establishing surge capacity may necessitate investment in personnel and systems that may be underutilized during normal operations. The challenge is to strike a balance that meets the expectations of consumers.

The dedication and willingness of the TLC team to contribute to the recovery effort was a bright spot in the response. Throughout the investigation, pride in the TLC team's teamwork dedication and capability emerged as a recurring theme. This foundation provides a solid basis to implement the necessary improvements.

Top Six Lessons Learned and Recommendations

Top Six Lessons Learned

1. While CIMS is a versatile incident response framework, it is not prescriptive in its specific procedures. As a result, the existing generic training received by TLC staff on CIMS was not specifically tailored to the systems, processes, and procedures needed to respond effectively to damaging windstorms, which are a common occurrence in a distribution network.
2. Although some level of uncertainty is inevitable during the early stages of a significant event, such as Cyclone Gabrielle, the amount and duration of uncertainty could have been significantly reduced with proper preparation. The implementation of pre-prepared information gathering tools, such as integrated dispatch and Incident Response Management spreadsheets, could have enabled the CIMS intelligence function to operate more efficiently, thereby providing more accurate and timely information to the IMT.
3. In addition, the use of visual aids such as maps displaying the location and status of outage areas proved to be highly effective in visualizing the incident and planning response at a macro level.
4. To alleviate the bottleneck for switching and access permits, it could have been helpful to have additional controllers available. This would have made it possible to divide the network into north and south regions speeding up switching and issue of access permits.
5. Communicating restoration priorities clearly to controllers and field crews would have enabled the queuing of field crew access to the controllers to be better optimised, potentially improving the rate of customer restoration.
6. The failure to conduct a significant network event simulation resulted in a missed opportunity to identify issues that, if addressed, could have significantly enhanced the response to Cyclone Gabrielle.

Top Six Recommendations

1. The generic CIMS framework needs to be customized by defining specific roles, responsibilities, tasks, procedures, systems, and checklists for incident participants to effectively deal with common large-scale network events like windstorms and lightning storms.
2. Implement a suite of process management and information gathering tools that integrate across the various incident response roles (such as dispatch, control and field operations). This could use spreadsheets and other standard software tools.
3. Create and deploy visual aids to assist in managing similar network-wide events. These aids may take the form of GIS maps, or, if deemed more practical, paper or whiteboard tools located in the incident room.
4. Conduct a review to determine the ideal number of network controllers to balance cost-effective BAU services and capacity to handle high volume network events, recognizing the tension between these two requirements.
5. To improve the restoration process and address the bottleneck caused by limited network controllers, the Incident Response team should create a prioritized list of restoration priorities and communicate them to both control and field supervisors. This will ensure proper sequencing of the restoration effort and minimize the impact of the controller bottleneck.
6. After implementing the process and system changes recommended in this report, perform a significant network event simulation to evaluate and further refine TLC's response capability.

Appendix A List of Artefacts Reviewed

1. Cyclone Gabrielle Situation reports from 13.02.2023 1:00om to 16.02.12pm
2. Outage spreadsheet
3. Coordinated Incident Management System 3rd Edition.
4. CIMS Role Cards
5. TLC Outage Data 2022 2023
6. Geographic outage maps (16 Feb Faults.pdf and 1702 faults.pdf)
7. TLC Incident Management Framework.

Appendix B – People Interviewed

Warren Harris (Controller) – Manager Operations

Jason Wano (Logistic) – Customer Projects Manager

Des Claussen (Operations) – Team Leader Electricians North/South

Tony Hollart (Intel) – Manager Asset Strategy

Gavin Sneddon (Pim) – Communications Partner

Anne Terry (Welfare) - Customer & Community Engagement Manager

Amy Bentley (Liaison & After-Hours Dispatcher) – Network Performance Analyst

Saurabh Rajvanshi (Intel)– Manager, Assets and Engineering

Joel Williams (Controller) - Manager Programme Delivery & Key Accounts

Charlotte Porter (Pim) – Communications Manager

Deepak Chand (Logistics) – Project Manager

Carl Botha (Operations) – Network Services Manager

Steve McLennan (Intel) - Asset Engineer

Michelle Goddard (Liaison) – Senior Project Coordinator

Jordan Hughes – Line Foreman/Acting Team Leader Line Mechanics

Andrew Leatuafi – Senior Project Manager

Shogun Haami – Coach Mentor

Tony Gannon – Team Leader Line North/South

Tau Turner – Network Controller

Grant Dellow – Network Controller

Krystal Griffiths – Faults Call Centre/Dispatcher (Network & Faults)

Jacqui Aitkin – Team leader Admin & Faults

From	Paul Blackmore
To	Asset Management Committee
Cc	Craig Hackett Saurabh Rajvanshi
Date	20/11/22
Subject	FMEA analysis and effectiveness of inspection techniques

Summary

TLC currently inspects its pole assets at 15 year intervals and is now exploring whether its asset risk management can be improved by more frequent and more targeted inspection.

TLC's asset management team theorised that regular pole top photography undertaken by helicopter or drone could provide a more effective inspection outcomes with similar cost. However, it was not clear how effective pole top photography could be, and to what extent ground based inspections could be reduced.

Paul Blackmore was engaged to assess TLC's defective equipment failure modes and determine how these could be detected by various inspection methods.

The investigation found that:

- Pole top photography covers about 64% of failure modes quantified by SAIDI with varying effectiveness.
- Ground inspections will still be required to manage safety related structural failure modes for timber poles, steel poles, stay wires and to a lesser extent concrete poles. Further analysis is needed to determine how these should be targeted and the inspection interval required.
- There is currently no effective inspection task proposed to address joint and conductor failures. However, this could be managed by establishing a predictive model that assesses proximity factors that contribute to joint health or deterioration.

The general conclusion is that pole top photography can be an effective monitoring system for a wide range of faults. However, this work has not yet determined what an optimum mix of pole and ground inspection is, and this is reliant on the costs to implement each. Our next steps are therefore to seek market costs for pole top photography to better understand the cost of each option before making a final recommendation.

Background

The Lines Company is exploring changes to its overhead line inspection program to improve service levels and reduce risk while being cost efficient. The concept is to implement a program where frequent technology assisted aerial surveys capture most risk issues and ground-based inspections are applied where necessary to capture those safety related failure modes that can only be reliably detected from the ground.

This memorandum provides a progress update evaluating the likely effectiveness and limitations of the proposed overhead photography-based program to inform development of an RFP and to plan

implementation. Development of the final program would be dependent on the capabilities and pricing that is offered by RFP respondents.

Method

Two years of failure data grouped by failure cause was evaluated by answering the following questions:

- What are the credible consequences of failure in relation to safety and service levels.
- What is the level of risk given current failure rates (intolerable, tolerable, broadly tolerable, and acceptable).
- What is considered the most effective inspection task available for preventive detection of the failure cause.
- What is the lead time to failure – how far in advance can the inspection task detect future failure.
- What is the tasks effectiveness – what proportion of future failures can it reliably detect.

Table 1. Inspection tasks considered

Inspection Task	Description
Detailed poletop imaging	High resolution photographs of the poletop and poletop equipment from multiple angles to allow detailed inspection and identification of potential failures.
Aerial whole of pole photo	An overview photo of the pole showing the whole pole taken while capturing detailed poletop photos. This is considered a separate task as some high-speed image collection methods do not cost effectively capture these images.
General pole ground inspection	General pole ground inspection focussed predominantly on detecting structural failure modes such as below ground decay of timber poles, corrosion of steel poles and stay anchors and cracking and spalling of concrete poles.
Visual inspection not viable	A placeholder to indicate that no visual based inspection method is available to reliably detect this potential failure.

Results Summary

Table 2 below shows the output of this analysis for the top 5 failure causes by risk. Risk was assessed by a combination of service level represented by SAIDI and qualitatively assessed safety risk.

Table 2. Summary of top 10 failure modes by risk

Failure	No. Events	SAIDI	Credible Consequences of failure	Safety risk (now)	Task	Notes
8.3.1 DE - Connection / Joint - Wire break at joint	87	18.4	If the conductor falls away from the source of supply, it can stay energised and present a safety risk. This would occur on average 50% of the time. SWER will likely stay alive in most cases presenting a hazard with potential for stock loss or loss of human life. Risk can be	Intolerable	No viable inspection available	There is no viable visual based inspection available currently. A possibility is to use the number of joints as a proxy for past failures (see later section for discussion)

Failure	No. Events	SAIDI	Credible Consequences of failure	Safety risk (now)	Task	Notes
			increased if the line falls and livens a fence.			
8.3.2 DE - Connection / Joint - Bimetal Issue	97	13.7	As above	Tolerable	Task: Detailed poletop photo Lead time: 5-8 years, Detection efficiency: Poor (25%-50%)	Bimetal connections may be identified from images and addressed as a bulk replacement. The volumes of joints in service and the failure rate (e.g. failures per 100 joints per year) are currently unknown and should be evaluated to determine the practicality and economic feasibility of this approach.
8.7.4 DE - Stay Wire - Rust	6	12.0	There are 6 incidents with 12 minutes of SAIDI. This implies structural failures which would have significant safety consequences.	Tolerable	Task: General pole ground inspection Lead time: 5-8 years Detection efficiency: Good (50% - 95%)	Corrosion is normally worst at the ground/air interface or slightly below ground. This is not detectable from the air and therefore requires ground-based inspection.
8.C.1 DE - Insulator - Cracked	53	11.5	Cracked insulator can lead to leakage and tripping of the feeder.	Tolerable	Task: Detailed poletop photo Lead time: 0-1 year Detection efficiency: Poor (25%-50%)	Some large cracks might be detected from aerial photos. Others might be inferred from insulator type (e.g. NZI 2 piece 33kV insulators) and managed by bulk change out. Ultraviolet imaging (corona cam) may detect discharging caused by cracking under suitable environmental conditions.
8.6.1 DE - Crossarm - Rotton	86	8.5	Consequences same for binder or conductor failure	Tolerable	Task: Detailed poletop photo Lead time: 5-15 years Detection: Good (50% - 95%)	Poletop photography is highly effective for detecting timber decay in cross arms.

From the above we can make three key observations:

1. There are some failure modes which would not be addressed by the proposed inspection program. Defective joints are the most significant because of the high rate of occurrence and significant unmitigated safety consequences.
2. Some safety related failure modes, for example defective stays, timber pole ground line decay and steel pole ground line corrosion cannot be effectively detected from the air. These must be managed by ground-based methods.
3. A large proportion of important potential failures can be detected using aerial photography techniques.

Figure 1. below shows the proportion of failure causes grouped by the proposed inspection method and quantified by SAIDI for all failure causes. It should be noted that this chart does not consider the effectiveness of the inspection method, and so the chart cannot be interpreted as indicating that

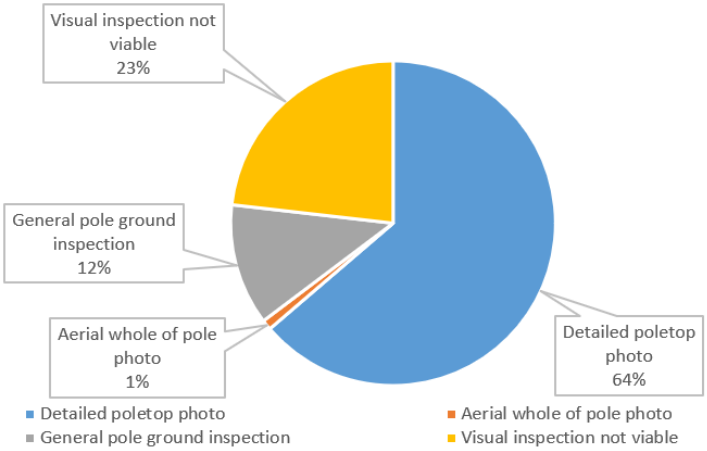


Figure 1. Proportion of SAIDI that potentially may be detected by the inspection method. Note the detection reliability of inspections is related to the task activity and its inspection interval and varies greatly depending on the failure mode being considered. See Appendix 1 for details.

all potential SAIDI producing defects can be detected and prevented, rather it indicates the proportion of SAIDI for which the inspection method is considered most appropriate.

The following observations may be made from the chart in Figure 1:

- The majority of SAIDI producing defects can potentially be detected using aerial inspection techniques.
- A significant proportion of SAIDI producing defects have no viable visual inspection. A small proportion of these carry an intolerable level of risk (as discussed above).
- A proportion of SAIDI causing failures can only be addressed by ground-based inspection.
- The whole of pole photo option has limited utility and may not be cost effective if it incurs additional cost.

Addressing Joint and Conductor Failure Modes

The analysis above also shows that the most significant SAIDI and Safety risk is from conductor joints and that the proposed visual inspection tasks are not effective for detecting potential failures. It is likely however that joint and conductor failures are clustered around intersectional groupings of factors for example:

- Conductor type (e.g. small copper, steel, small ACSR).
- Joint type.
- Age.
- Corrosion environment.
- Fault level / fault rate (i.e., frequency and magnitude of fault current).
- Vegetation environment (e.g., external damage).
- Construction characteristics (e.g., spans/ tension).

An approach that has been used to address this problem by other EDB's is to develop a model to predict conductor and joint health based on contributing variables. While it is likely that data to build such a model is initially sparse, an appropriate model can be the focal point for a program of continuous improvement that progressively collects data and improves the quality of decisions to address issues. A systems analysis diagram illustrating how such a model could be used to progressively understand and address the conductor joint problem is shown in Figure 2 below. Such a model could likely be implemented using the existing modelling platform, Asset Altitude.

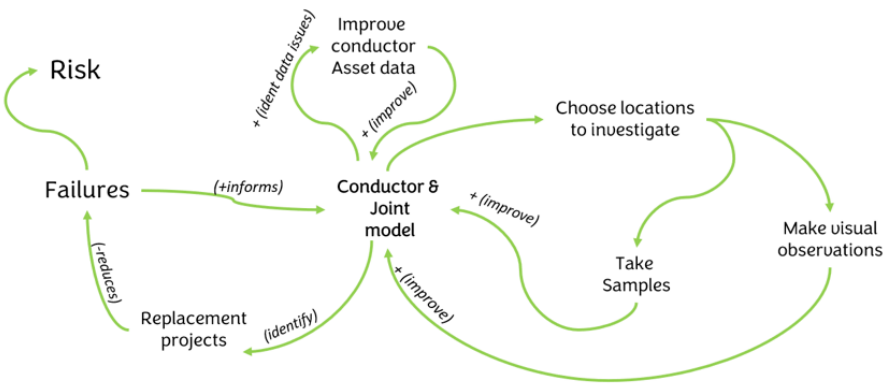


Figure 2. System diagram illustrating how conductor modelling can be used to address conductor and joint failure problems.

Conclusion

This memorandum describes work completed to assess the effectiveness of proposed inspection methods for addressing equipment failures. We can draw the following conclusions from the analysis.

1. Poletop photography covers about 64% of failure modes quantified by SAIDI with varying effectiveness. If combined with effective defect rectification workflow and repair volumes this could contribute to reducing risk and improving service level performance.

2. Ground inspections will still be required to manage safety related structural failure modes for timber poles, steel poles, stay wires and to a lesser extent concrete poles. Further analysis is needed to determine how these should be targeted and the inspection interval required. There is currently no effective inspection task proposed to address joint and conductor failures. A continual improvement methodology is suggested to address this problem.
3. Some more work is needed to develop an optimal inspection program and implementation plan. This is dependent on capabilities and pricing offered by inspection providers.

Next Steps

The analysis discussed above has been used to inform the development of a Request for Proposals for consideration by the market. Responses will be used to identify an optimised combination of inspection tasks and intervals to achieve The Lines Company's objectives of optimising equipment failure related risk and cost.

Appendix A – Failure Mode Analysis

Table 3. Failure modes, proposed inspection tasks and estimated task effectiveness.

Component/Failure Mode	Events	SAIDI	Safety risk (Now)	Inspection task	Lead time to failure (P-F)	Task Effectiveness
8.5.6 DE - Pole / Structure - Crack / Split	6	0.8	Tolerable	Aerial whole of pole photo	5-8 years	Good (50% - 95%)
8.5.8 DE - Pole / Structure - Burnt	6	0.6	Tolerable	Aerial whole of pole photo	0-1 year	Good (50% - 95%)
8.7.5 DE - Stay Wire - Screw anchor let go	1	0.0	Tolerable	Aerial whole of pole photo	0-1 year	Good (50% - 95%)
Concrete spalling above ground			Broadly Tolerable	Aerial whole of pole photo	5-15 years	Poor (25%-50%)
Above ground corrosion Steel Poles-iron rail types			Broadly Tolerable	Aerial whole of pole photo	5-8 years	Poor (25%-50%)
Concrete cracked /damaged non-prestressed			Broadly Tolerable	Aerial whole of pole photo	5-8 years	Poor (25%-50%)
Concrete cracked / damaged - prestressed			Broadly Tolerable	Aerial whole of pole photo	1-5 years	Very Poor (0-25%)
8.A.1 DE - Lightning Arrestor - End cap blown	28	16.8	Broadly Tolerable	Detailed poletop photo	Ineffective	Ineffective
8.C.4 DE - Insulator - Rainshed broken	10	9.4	Broadly Tolerable	Detailed poletop photo	0-1 year	Excellent (>95%)
8.6.1 DE - Crossarm - Rotton	86	8.5	Tolerable	Detailed poletop photo	5-15 years	Good (50% - 95%)
8.6.4 DE - Crossarm - Split	26	8.4	Broadly Tolerable	Detailed poletop photo	1-5 years	Good (50% - 95%)
8.C.3 DE - Insulator - Pin / Nut failed	20	8.3	Tolerable	Detailed poletop photo	0-1 year	Good (50% - 95%)
8.C.2 DE - Insulator - Binder / Tie	34	2.4	Tolerable	Detailed poletop photo	0-1 year	Poor (25%-50%)
8.1.6 DE - OH Conductor - Binder Failure	13	1.7	Tolerable	Detailed poletop photo	1-5 years	Poor (25%-50%)
8.C.7 DE - Insulator - Rusted Pin / Eyebolt	8	1.0	Tolerable	Detailed poletop photo	5-8 years	Good (50% - 95%)
8.C.5 DE - Insulator - Creepage	11	0.6	Broadly Tolerable	Detailed poletop photo	Ineffective	Ineffective
8.8.3 DE - DDO / Fuse - Rust / Corrosion	18	0.3	Tolerable	Detailed poletop photo	5-15 years	Good (50% - 95%)
8.1.5 DE - OH Conductor - Deadend Corrosion	1	0.0	Tolerable	Detailed poletop photo	5-15 years	Good (50% - 95%)
8.6.3 DE - Crossarm - Burnt	1	0.0	Broadly Tolerable	Detailed poletop photo	1-5 years	Good (50% - 95%)

Component/Failure Mode	Events	SAIDI	Safety risk (Now)	Inspection task	Lead time to failure (P-F)	Task Effectiveness
8.9.2 DE - Switchgear - Rust / Corrosion	1	0.0	Broadly Tolerable	Detailed poletop photo	5-15 years	Good (50% - 95%)
Timber poletop failure decay			Tolerable	Detailed poletop photo	5-8 years	Good (50% - 95%)
8.3.2 DE - Connection / Joint - Bimetal Issue	97	13.7	Tolerable	Detailed poletop photo	5-8 years	Poor (25%-50%)
8.C.1 DE - Insulator - Cracked	53	11.5	Tolerable	Detailed poletop photo	0-1 year	Poor (25%-50%)
8.6.2 DE - Crossarm - Loose bolts	12	0.6	Tolerable	Detailed poletop photo	0-1 year	Poor (25%-50%)
8.9.3 DE - Switchgear - Contact failure	1	0.0	Broadly Tolerable	Detailed poletop photo	0-1 year	Poor (25%-50%)
8.7.5 DE - Stay Wire - Screw anchor let go			Tolerable	Detailed poletop photo	5-15 years	Very Poor (0-25%)
8.4.7 DE - Transformer - Tank Failure	4	0.1	Broadly Tolerable	Detailed poletop photo	5-15 years	Poor (25%-50%)
8.1.2 DE - OH Conductor - Corrosion	18	2.8	Tolerable	No viable inspection available	1-5 years	Very Poor (0-25%)
8.7.1 DE - Stay Wire - Broken / Snapped	8	0.7	Tolerable	General pole ground inspection	1-5 years	Good (50% - 95%)
Conductor clashing			Broadly Tolerable	General pole ground inspection	0-1 year	Good (50% - 95%)
8.7.5 DE - Stay Wire - Screw anchor let go			Tolerable	General pole ground inspection	5-8 years	Good (50% - 95%)
Concrete spalling above ground			Broadly Tolerable	General pole ground inspection	>15 years	Excellent (>95%)
Concrete cracked /damaged			Broadly Tolerable	General pole ground inspection	0-1 year	Excellent (>95%)
Steel Poles-iron rail types			Tolerable	General pole ground inspection	>15 years	Excellent (>95%)
8.7.4 DE - Stay Wire - Rust	6	12.0	Tolerable	General pole ground inspection	5-8 years	Good (50% - 95%)
8.5.2 DE - Pole / Structure - Dry rot	10	2.9	Tolerable	General pole ground inspection	5-8 years	Good (50% - 95%)
8.7.3 DE - Stay Wire - Stay grip failure	1	0.0	Tolerable	General pole ground inspection	1-5 years	Good (50% - 95%)
8.4.5 DE - Transformer - Qloss of oil	13	0.8	Broadly Tolerable	General pole ground inspection	0-1 year	Poor (25%-50%)
8.8.4 DE - DDO / Fuse - Malallignment	5	0.2	Tolerable	General pole ground inspection	1-5 years	Poor (25%-50%)

Component/Failure Mode	Events	SAIDI	Safety risk (Now)	Inspection task	Lead time to failure (P-F)	Task Effectiveness
8.5.4 DE - Pole / Structure - Iron Rust	1	0.1	Tolerable	General pole ground inspection	5-8 years	Poor (25%-50%)
8.7.5 DE - Stay Wire - Screw anchor let go			Tolerable	General pole ground inspection	5-15 years	Poor (25%-50%)
8.3.1 DE - Connection / Joint - Wire break at joint	87	18.4	Intolerable	No viable inspection available	Ineffective	Ineffective
8.A.2 DE - Lightning Arrestor - MoV Blown	51	7.9	Broadly Tolerable	No viable inspection available	Ineffective	Ineffective
8.8.2 DE - DDO / Fuse - Insualtion failure	27	3.0	Broadly Tolerable	No viable inspection available	Ineffective	Ineffective
8.1.4 DE - OH Conductor - Deadend Slippage	6	1.8	Tolerable	No viable inspection available	Ineffective	Ineffective
8.4.3 DE - Transformer - Core Collapse	5	0.4	Broadly Tolerable	No viable inspection available	Ineffective	Ineffective
8.1.1 DE - OH Conductor - Metal Fatigue	15	0.3	Broadly Tolerable	No viable inspection available	Ineffective	Ineffective
8.9.5 DE - Switchgear - Operating mechanism failure	3	0.2	Tolerable	No viable inspection available	Ineffective	Ineffective
8.C.6 DE - Insulator - Pinhole	1	0.1	Broadly Tolerable	No viable inspection available	Ineffective	Ineffective
8.9.4 DE - Switchgear - Connection failure	1	0.0	Broadly Tolerable	No viable inspection available	Ineffective	Ineffective
8.4.2 DE - Transformer - Oil Impurities	2	0.0	Acceptable	No viable inspection available	Ineffective	Ineffective
8.1.3 DE - OH Conductor - Aeoloan Vibration	1	0.0	Broadly Tolerable	No viable inspection available	Ineffective	Ineffective
8.9.1 DE - Switchgear - Insulation failure	5	15.8	Broadly Tolerable	No viable inspection available	Ineffective	Ineffective
8.4.1 DE - Transformer - Insulation Failure	42	2.0	Broadly Tolerable	No viable inspection available	Ineffective	Ineffective
8.4.4 DE - Transformer - Tap Changer Failure	2	0.0	Broadly Tolerable	No viable inspection available	Ineffective	Ineffective

Component/Failure Mode	Events	SAIDI	Safety risk (Now)	Inspection task	Lead time to failure (P-F)	Task Effectiveness
8.4.6 DE - Transformer - Bushing Failure	2	0.0	Broadly Tolerable	No viable inspection available	Ineffective	Ineffective
Timber ground line failure - decay			Tolerable	Non Destructive tests.	5-15 years	Good (50% - 95%)
8.5.1 DE - Pole / Structure - Honeycomb rot	4	0.5	Tolerable	Wood pole ground inspection	5-8 years	Good (50% - 95%)
Timber poletop failure decay			Tolerable	Wood pole ground inspection	5-8 years	Poor (25%-50%)
Timber ground line failure - decay			Tolerable	Wood pole ground inspection	5-15 years	Poor (25%-50%)

Memo

From	**Ben Noll, NIWA meteorologist** **ben.noll@niwa.co.nz**
To	Craig Hackett The Lines Company PO Box 281, Te Kuiti 3941 craigh@thelines.co.nz
CC	Mark Bojesen-Trepka Richard Turner
Date	8 August 2023
Subject	Extreme weather days - update

This is an update to the previous report issued on 4 August 2023. The data is now reflective of the regulatory year (1 April to 31 March).

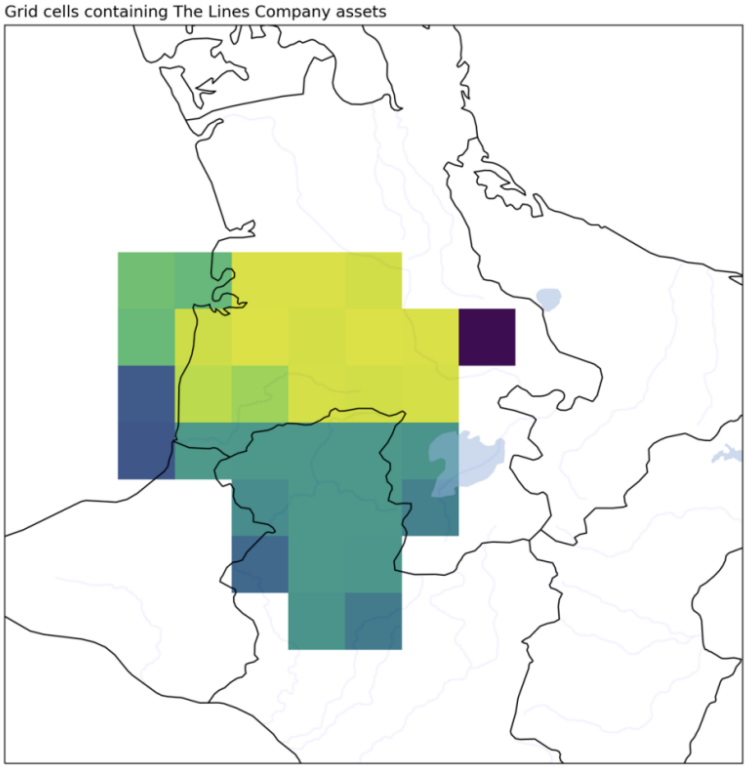
The following information provides a high-level overview of extreme precipitation, wind, and weather days from 1 January 1940 through 27 July 2023 across The Lines Company assets. The dataset used was ECMWF-ERA5, *an atmospheric reanalysis that combines model data with observations from across the world into a globally complete and consistent dataset using the laws of physics*. The dataset has an approximate horizontal resolution of 30 km. This makes it useful for assessing regional trends, but not location specifics.

The attached folder "outputs" contains the spreadsheets described below and images in this report.

- Extreme precipitation is defined as average total daily precipitation exceeding the 90th - 95th percentile across The Lines Company assets.
    - The days on which extreme precipitation occurred are contained in "very_wet_days.csv". A value of "1" means extreme precipitation occurred, while "0" means it did not.
    - The annual number of days that featured extreme precipitation are contained in "annual_very_wet_days.csv".
- Extreme wind is defined as the average daily wind gust exceeding the 90th - 95th percentile across The Lines Company assets.
    - The days on which extreme wind gusts occurred are contained in "high_wind_days.csv". A value of "1" means extreme wind occurred, while "0" means it did not.
    - The annual number of days that featured extreme wind gusts are contained in "annual_high_wind_days.csv".
- An extreme weather day is defined as having both extreme rainfall and extreme wind.
    - The days on which extreme weather occurred are contained in "extreme_weather_days.csv". A value of "1" means extreme weather occurred, while "0" means it did not.
    - The annual number of days that featured extreme weather are contained in "annual_extreme_weather_days.csv".

The image below shows the region for which historical data was extracted in order to complete this analysis (inclusive of assets belonging to The Lines Company).

Grid cells containing The Lines Company assets



The information below has been updated to be reflective of the regulatory year (1 April to 31 March).

The following sections provide a brief overview of the findings for extreme weather, wind, and precipitation days. The data is presented for both the 90th and 95th percentile.

1. **Extreme weather days – 90th percentile**