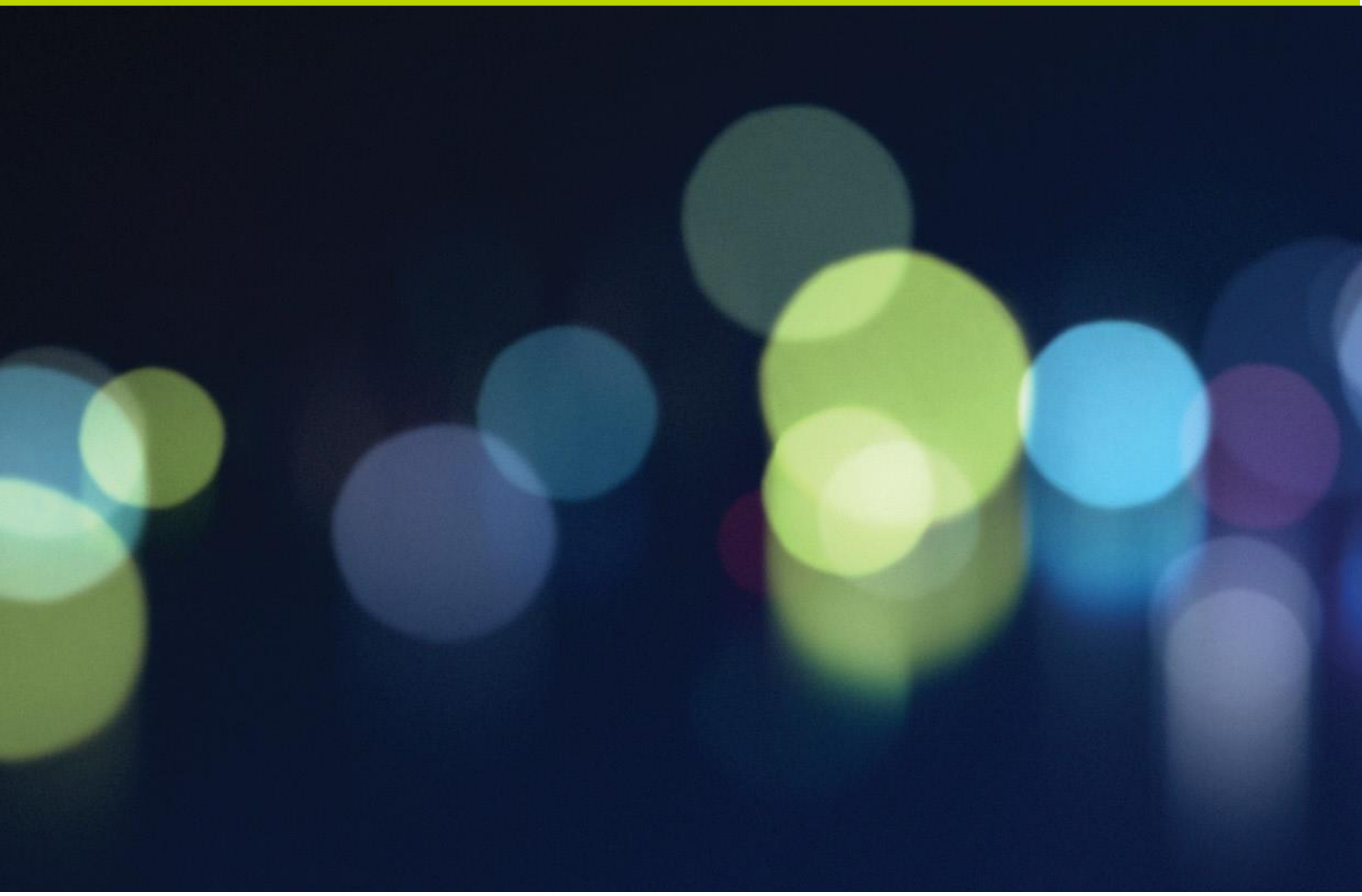
Overhead Conductors Asset Class Plan

Mains Assets

November 2022



Endeavour Energy

Version control

Version	Date	Comments
1.0	Nov 2022	Initial Release

Contents

1. Executive Summary

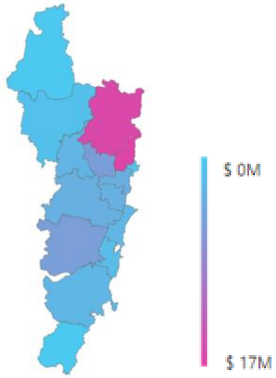
A 10-year strategy for Overhead (OH) Conductors has been defined, driven by the risk associated with the ageing population of the asset class. The forecasted risk, strategy, cost breakdown, and performance metrics are outlined below and include OH conductors at the following voltages Low Voltage (LV), High Voltage (HV) and Sub-Transmission (TR) lines. Overhead Earths wires associated with lines and services are not included in the scope below.

Risk Forecast

The failure of OH Conductors may lead to Safety, Reliability or Bushfire consequences.

These consequences are quantified in $'s and coupled with statistical modelling to determine the risk associated with the linear assets of in-service OH Conductors.

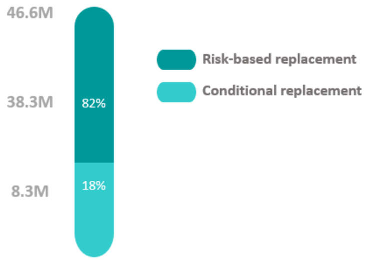
As these assets age, the risk associated with their failure also increases and this is geographically represented.



Strategy and Cost

The selected intervention option to address the risk associated with OH Conductors includes a mix of conditional and risk-based replacement.

Continued maintenance is also to be applied however the cost associated with this cannot be broken down to this level.
The total cost of this strategy for the 2023-2032 period is $46.6M and is categorised based on the intervention type.
The CFI for this asset has been prepared in parallel with a resilience CFI "HV Distribution Network Resilience and Bushfire Ignition Risk Mitigation". Since the two CFI's were looking at the same assets, a review of any overlaps has been performed and removed from the recommended proposed works.



Key Performance Indicators

OH Conductors performance is defined based on the following performance categories and objectives.

For all asset types, the targets for these objectives are either already met, or cannot currently be measured. In these cases, monitoring systems are to be setup to allow for appropriate data collection to determine if objectives are being achieved.

All objectives are forecasted to be improved or achieved based on the 10-year strategy proposed in this asset class plan.

Performance Category	Objective	Status
Asset Utilisation	TBC	-
Safety	Reduce the number incidents (excluding General Hazards)	●
Reliability	Reduce the number of unplanned outages associated with functional failures	●
Resilience	TBC	-
Bushfire	Reduce the percentage of fire starts as a proportion of the asset base	●

2. Overview

2.1 Purpose

The purpose of this document is to outline previous, current, and proposed asset management practices for Overhead (OH) conductors and define a 10-year strategic plan for the asset class based on the asset's risk and cost.

The 10-year plan seeks to use all current knowledge of the asset in context with the whole network to establish Key Performance Indicators (KPI) to assist in understanding and monitoring the ongoing performance of the asset. The adopted levels of service for OH conductors are based on risk / benefit trade-offs versus cost options, legislative requirements, customer expectations, and strategic goals set by Endeavour Energy.

This document is intended to function as part of the "Performance Monitoring and Review Process" as established in the Asset Management System (AMS) outlined in Section 8 of this report. The document plays a key role in ensuring:

- A continuous feedback loop is established between the performance of the individual assets and the performance of the more macro level Asset Class
- Monitoring of the performance of the asset class against Key Performance Indicator (KPI's) set
- Changes in the performance or risk (positive or negative) are identified as early as possible
- Communicating the historic, current and proposed balance of risk and cost (as shown via the number of asset replacements caused by functional failures, condition-based replacements and risk-based replacements).

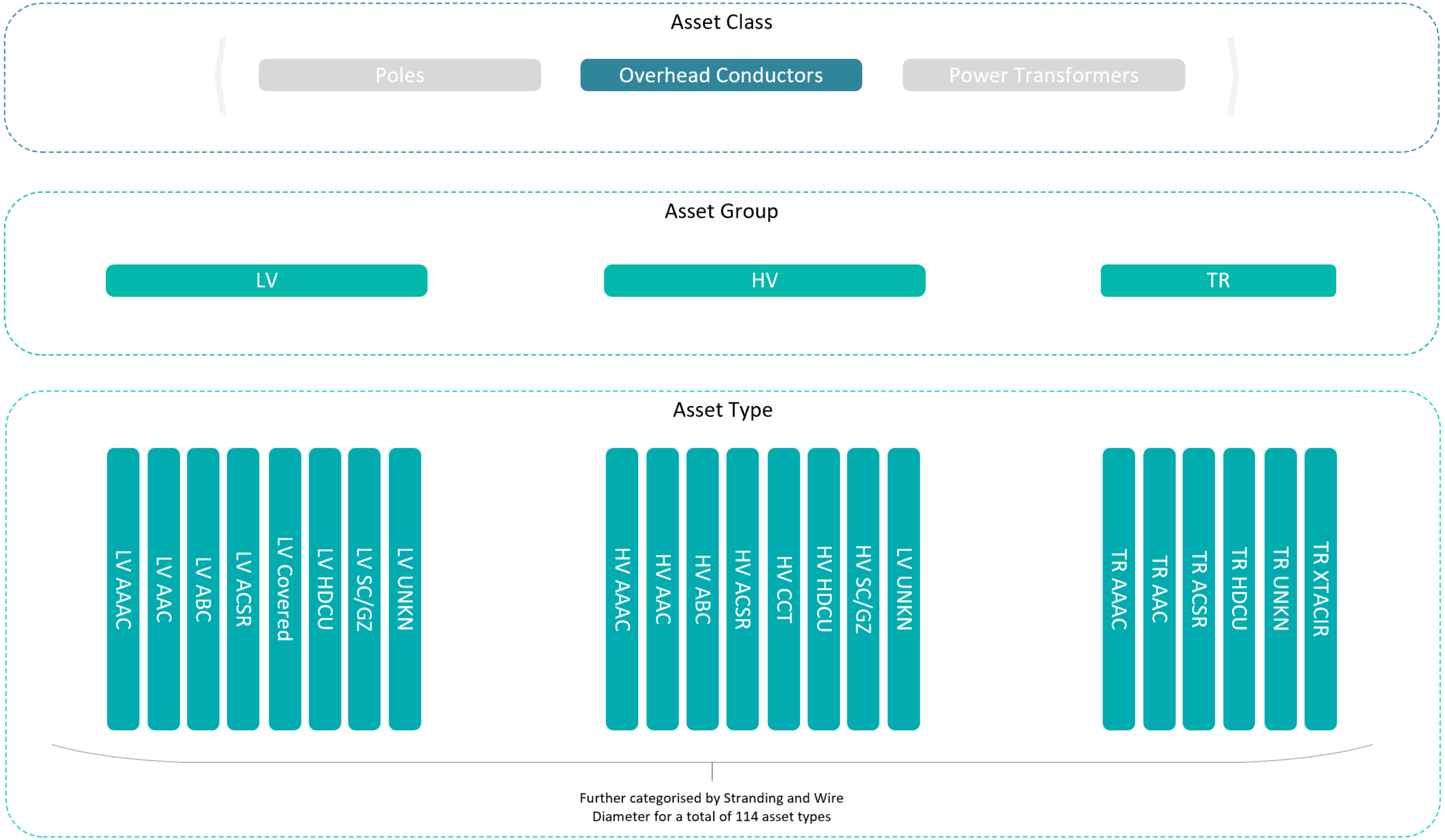
The document will highlight and discuss historical trends and future forecasts for three primary asset management strategies:

- Risk Based asset replacements (e.g., those proposed to be completed on a risk / cost justification basis)
- Condition Based asset replacements (e.g., asset triggered for replacement due to inspection and/or maintenance program)
- Functional asset failures (e.g., assets replaced post an asset failure whilst in service)

The forecasted "outcome" risk projections (for safety, reliability, bushfire etc) throughout this document are based on the optimal investment profiles proposed in the Case for Investments (CFI's) as well as the continuation of the existing maintenance strategies. The "baseline" risks outlined throughout this document represent the natural increase in risk without an asset replacement program.

2.2 Scope

This report covers all Endeavour Energy owned OH Conductors (excluding OHEW's and overhead services) which includes the following highlighted assets:



3. Asset Portfolio

3.1 Asset Function

OH conductors are a vital component of the network and perform the primary function of providing a physical medium to distribute electricity from one place to another. They are required to carry load and fault currents without annealing or sagging below limits for conductor height clearances and must maintain continuity under these conditions. Currently within Endeavour Energy's network, there are 114 different types of OH conductor's in-service which vary in construction, conductor material and stranding type. Furthermore, each of these kinds of conductors can be operating at low voltage, high voltage, or sub-transmission. The current role, minimum performance measures and insulation coordination for OH conductors in the distribution network is underpinned by Company Policy 9.2.5 Network Asset Design. This policy states that the following sub populations of overhead conductors must be designed per these conditions:

1. **Low Voltage (LV) network** - The collection of assets (lines, conductors, and associated equipment) the traditional purpose of which is to distribute electricity from distribution substations to individual customers, however, is increasingly being used to distribute local generation between customers. The LV network in the company's area operates at nominal voltages of 400V (phase to phase) three phase and 230V (phase to earth) single phase.
2. **High Voltage (HV) distribution** - A voltage nominally greater than 1,000V. In particular, the 11kV, 12.7kV and 22kV networks are the standards adopted by Endeavour Energy for HV distribution. Covered conductor systems at HV must be protected by appropriately designed lightning protection systems. Surge arrestors must be used to protect critical HV equipment from lightning surges.
3. **Sub-Transmission (TR) network** - The collection of assets (sub-transmission lines, conductors, substations and associated equipment) the purpose of which is to transmit power in bulk from a TransGrid supply point to a sub-transmission or zone substation which feeds the sub-transmission network. The sub-transmission voltage of the company's network is ranges between 132kV and 33kV.

The sub-transmission and distribution network must be planned, designed, and operated to satisfy the following requirements, according to the Company policy 9.2.10:

1. The network must not exceed the fault levels above those set out in this policy under normal and foreseeable emergency situations. However, the maximum fault levels may be exceeded for momentary periods during changeover operations.
2. Network equipment must be specified to withstand the foreseeable maximum fault levels as set out in this policy; and
3. Network equipment must operate within the thermal capability of primary plant under normal and foreseeable abnormal load conditions.

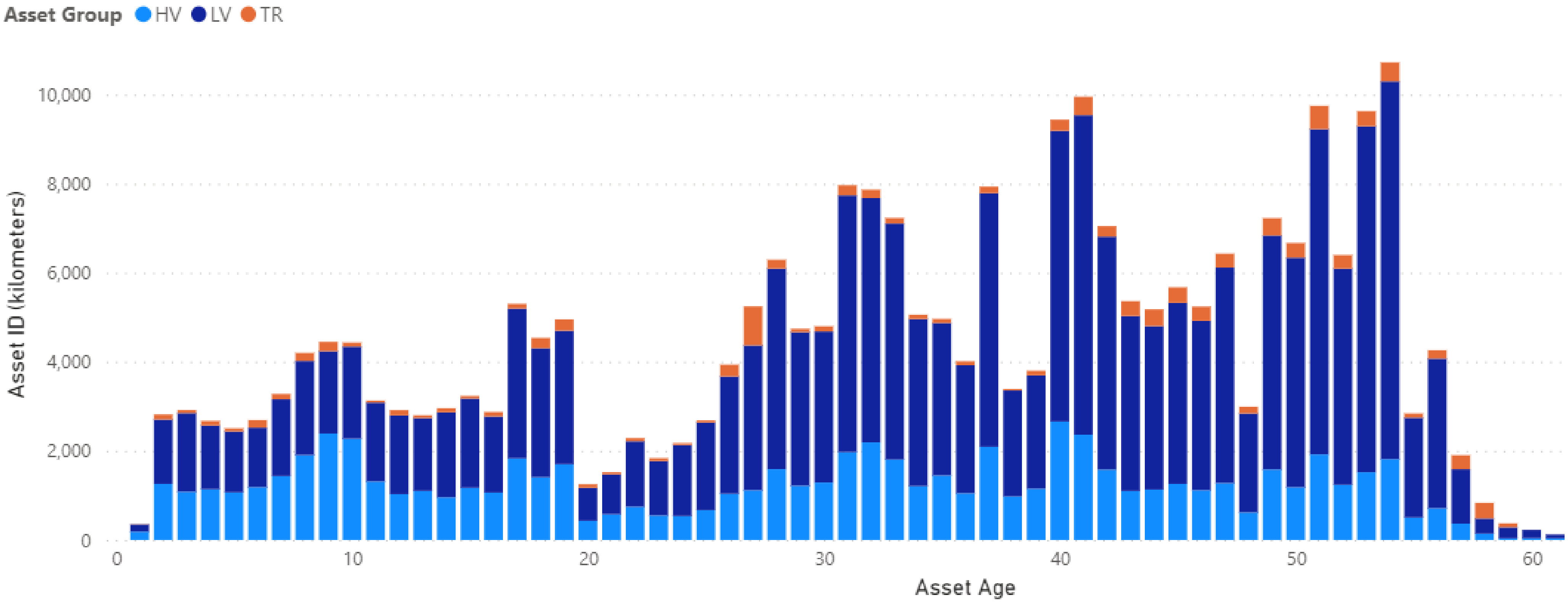
The breakdown of risks that are attributed to this asset class are shown in section 4 to illustrate performance measures and key drivers.

3.2 Asset Population

Endeavour has approximately 28,031 kilometres of OH conductors in service represented by 365,744 unique OH conductor linear segments in the distribution network.

The total number of assets in the network is relatively consistent over the previous 10 years as most network extensions are in the underground network. A continued overall reduction in the number of LV and HV OH conductors in urban areas are expected in coming regulatory period(s) (and can already be witnessed) due to further undergrounding of the distribution systems.

The age profile of LV, HV and sub-transmission OH Conductors is summarised in the below figure.



4. Asset Performance

This section quantifies the risks and asset performance measures associated with the fleet of OH conductors. The weighting for different risk categories illustrates the areas of focus for managing the maintenance, life cycle and intervention options for this asset class. These are further broken down into performance measures that enable clear relationships to be drawn between risk and the asset performance.

The level of risk (by risk category) is determined for each individual asset, based on its location in the network and probability of failure (as per the risk-based replacement review). The following table summarises the risk categories and provides an overview of the average risk contribution made by each risk category (e.g., safety, reliability bushfire etc), illustrating the primary risk drivers for the asset class.

The largest risk for this asset class is associated with reliability.

Risk Category	Consequence	Risk Contribution
Safety	- If a failed OH conductor was to remain energised on the ground or caught on an object or structure, there is a potential risk of electrocution to members of the public if they come in contact with the conductor or object/structure while it is energised. Electrocution has the potential to cause minor or major injuries and loss of life.	0.4%
Reliability	- Loss of supply along feeders and the customers supplied by the feeders.	73.0%
Bushfire	- Arcing of live contacts and damaged insulation may create sparks and initiate a bushfire.	26.6%
Environmental	- No significant environmental consequences have been experienced or are anticipated and are therefore not considered a risk to be managed.	0%
Financial	- Not replacing the asset before a failure may lead to capital expenditure related to reactive replacement.	0%

The table below summarises the asset performance service level and objectives across the fleet of OH conductors.

Performance Category	Objective	Performance Measure	Asset Type	Current Performance	Performance Target	Status	Trend
Asset Utilisation	TBC	Availability of sections lengths / impact to network	LV	-	To be determined	—	—
			HV	-			—
			TR	-		—	—
			All	-			—
Safety	Reduce the number incidents (excluding general hazards)	5-year rolling average of total incidents (excluding general hazards)	LV	0.4	Reduce in line with forecasts	● (green)	— (green)
			HV	1.2		● (amber)	▲ (amber)
			TR	0.0		● (green)	— (green)
			All	1.6		● (green)	— (green)
Reliability	Reduce the number of unplanned outages associated with functional failures	5-year rolling average of unplanned outages	LV	16.6	Reduce in line with forecasts	● (green)	— (green)
			HV	32.0		● (amber)	▲ (amber)
			TR	1.0		● (green)	— (green)
			All	49.6		● (amber)	▲ (amber)
Resilience	TBC	Not currently measured	All	-	To be determined	—	—
Bushfire	Reduce the percentage of fire starts as a proportion of the asset base	5-year rolling average of fire starts	LV	1.4	Reduce in line with forecasts	● (green)	▼ (green)
			HV	2.0		● (amber)	▲ (amber)
			TR	0.8		● (green)	— (green)
			All	4.2		● (green)	— (green)

4.1 Asset Utilisation - TBC

4.1.1. Objective

4.1.2. Performance

4.1.3. Gap

4.1.4. Response

4.2 Safety

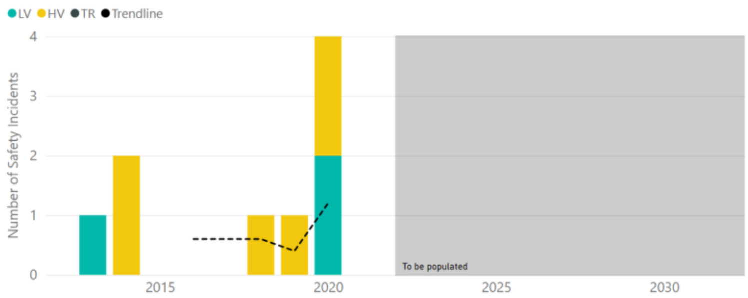
4.2.1. Objective

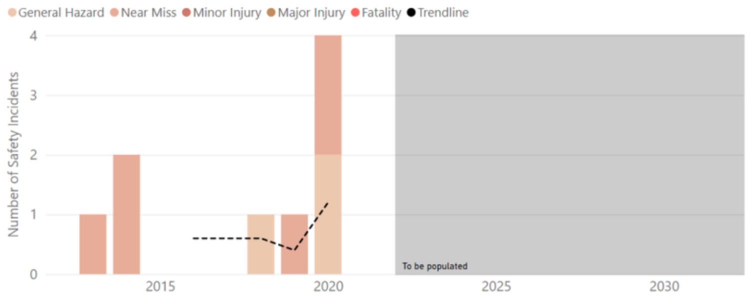
Reduce, monitor, and reduce safety risk across the asset base over the next 10-years.

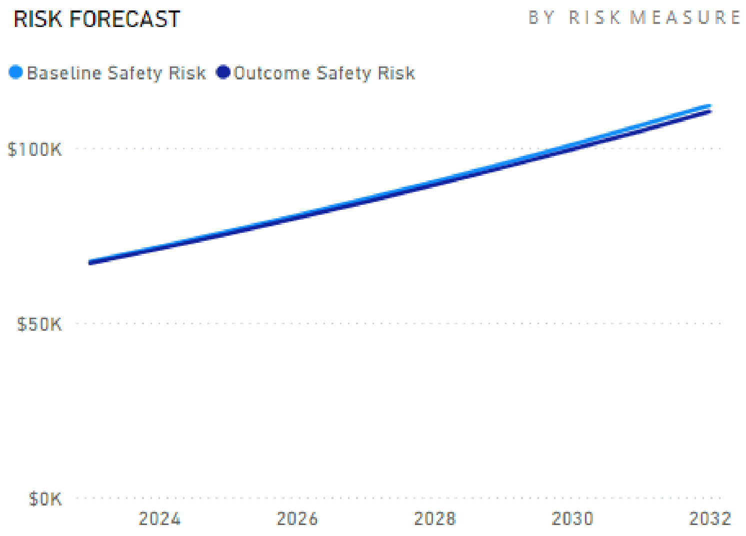
4.2.2. Performance

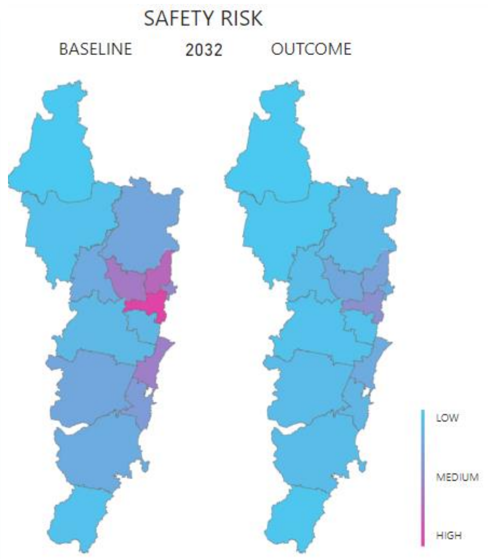
Safety incidents are categorised by severity and include general hazards, near misses, minor injuries, major injuries, and fatalities. The number of safety incidents associated with OH conductors vary between 0 to 2 between 2012 and 2019 and then show an increase to 4 in 2020. The organisation is recommended to monitor these safety incidents in the upcoming regulatory period to ensure there is no further increase of safety incidents. The proposed asset strategies (refer to Section 6) is not expected to have a significant impact on the frequency of events or the total organisational safety risk associated with the asset class.

The Safety Risk Concentration indicates that at present areas of the network have a higher normalised safety risk profile, the proposed program (refer to Section 6) will facilitate balancing the normalised safety risk across the network.









Performance Category	Objective	Performance Measure	Asset Type	Current Performance	Performance Target	Status	Trend
Safety	Reduce the number incidents (excluding general hazards)	5-year rolling average of total incidents (excluding general hazards)	LV	0.4	Reduce in line with forecasts	●	—
			HV	1.2		●	▲
			TR	0		●	—

4.2.3. Gap

Previous investment strategies were unable to separate out safety as an individual risk. The safety data captured on MySafe does not categorize the safety incidents based on the asset type, which can be improved on in the next regulatory period with the use of SAP.

4.2.4. Response

Safety risk will continue to be monitored and risk modelling reviewed as new external factors are identified / occur to improve future forecasts.

4.3 Reliability

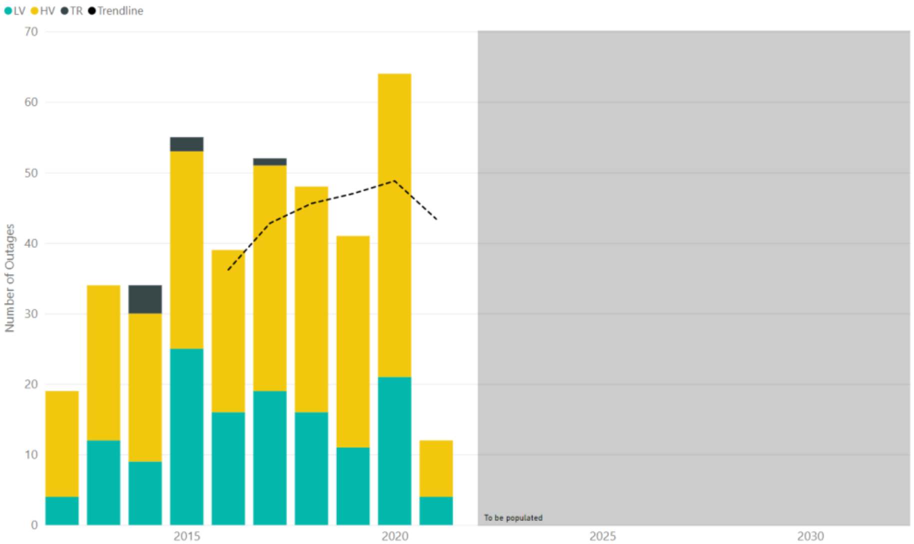
4.3.1. Objective

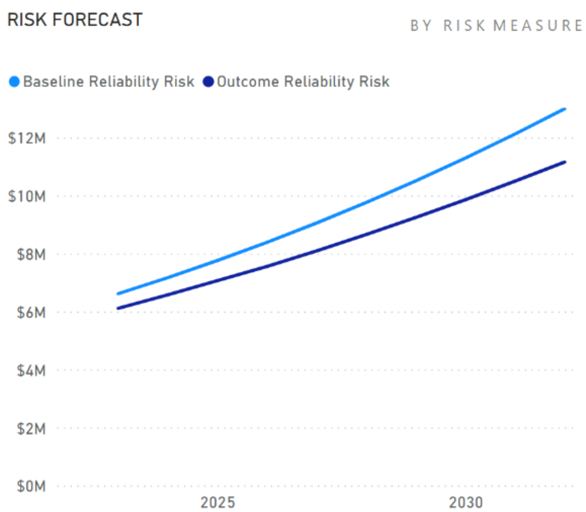
Reduce the level of network reliability risk and number of outages caused by unassisted asset failures associated with OH conductors.

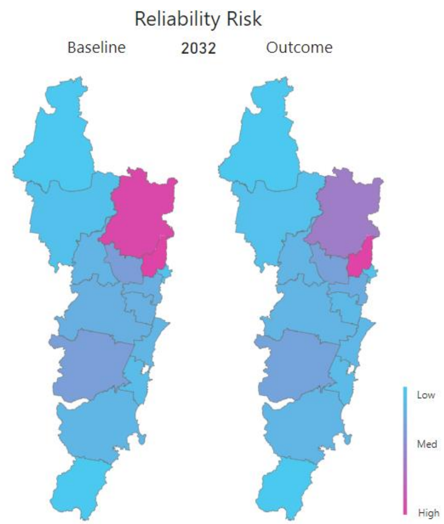
4.3.2. Performance

The number of functional failures associated with OH conductors has been relatively stable over the last 5 years and the move to an asset level model is expected to continue to main this performance. The proposed asset strategies (refer to Section 6) is expected to slightly reduce the overall reliability risk associated with the asset class from a traditional reactive program, however it is forecast to continue to grow in the coming regulator period.

The normalised risk concentration across the network is not currently uniform, however is expected to improve over the coming regulatory period.







Performance Category	Objective	Performance Measure	Asset Type	Current Performance	Performance Target	Status	Trend
Reliability	Reduce the number of unplanned outages associated with functional failures	5-year rolling average of unplanned outages	LV	16.6	Reduce in line with forecasts	●	—
			HV	32		●	▲
			TR	1		●	—
	Reduce the asset contribution to SAIDI	5-year rolling average of SAIDI contribution	-	-	-	-	-
	Reduce the asset contribution to SAIFI	5-year rolling average of SAIFI contribution	-	-	-		-

4.3.3. Gap

No Gaps are currently identified in the reliability risk associated with OH conductors.

4.3.4. Response

The current proposed asset management strategy indicates a increasing risk profile, with a steady number of functional failures. Continued monitoring of both metrics will be performed to ensure this continues to hold true.

4.4 Network Resilience - TBC

4.4.1. Objective

4.4.2. Performance

4.4.3. Gap

4.4.4. Response

4.5 Bushfire

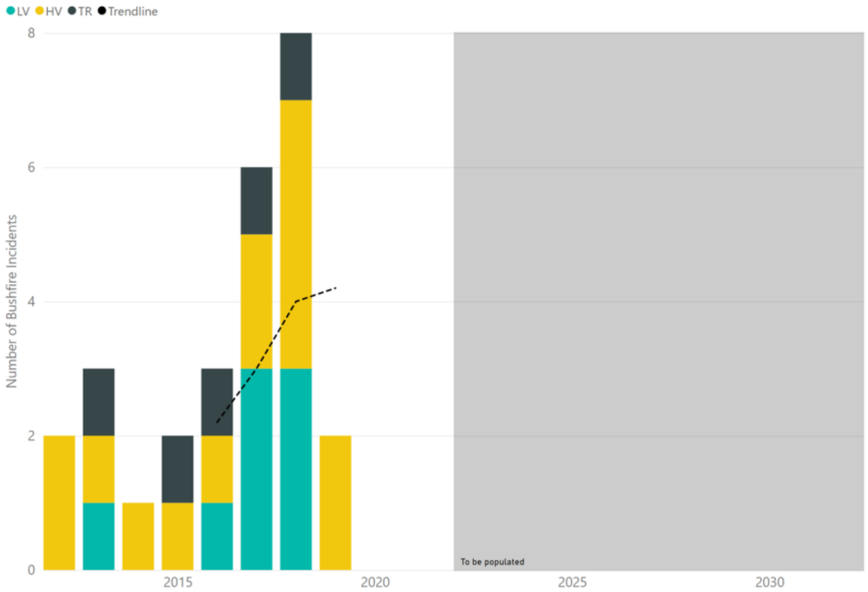
4.5.1. Objective

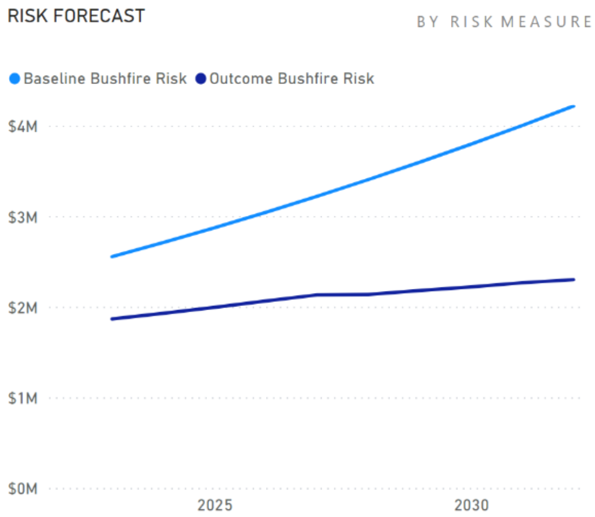
To reduce the number of functional failures and therefore the likelihood component of bushfire risk associated with OH conductors.

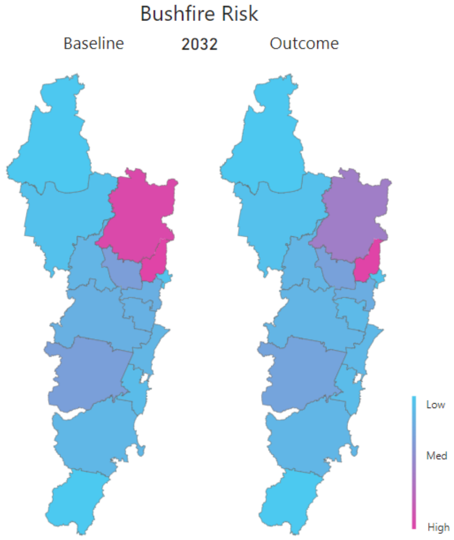
4.5.2. Performance

Bushfire performance is measured by monitoring the quantity and severity of fire starts that are initiated by asset failures across the network. The data extracted from fire starts caused by OH conductors, shows an increase in the number of incidents caused by the HV OH lines in the last 5 years. Limitations in the fire start data prevent further analysis to determine the severity of these fire starts.

The proposed asset management strategy is targeted to reduce failure events and fire starts, however overall bushfire risk with OH conductors is forecast to increase by approximately 13% over the next regulatory period. This increase is predominantly driven by an increased likelihood of asset failure due to the asset aging population and a forecasted increase in high fire danger weather events.







Performance Category	Objective	Performance Measure	Asset Type	Current Performance	Performance Target	Status	Trend
Bushfire	Reduce the percentage of fire starts as a proportion of the asset base	5-year rolling average of fire starts	LV	1.4	Reduce in line with forecasts	●	▼
			HV	2.0		●	▲
			TR	0.8		●	—

4.5.3. Gap

Bushfire performance, as monitored by first starts, is expected to remain stable as older, higher risk assets are replaced under existing replacement programs. Although fire-starts remain stable, the severity of these starts is not adequately monitored to align real world events with the organisation's bushfire risk model. The *DS422 – High voltage distribution bushfire mitigation* (2020 - 2023) program have been carried out by the organisation to manage the risk posed by OH conductors on the network. Additionally, the organisation has undertaken a resilience modelling strategy to investigate the impacts of climate change and to improve the resilience of major assets in this network.

4.5.4. Response

To further minimise controllable bushfire risk, OH conductors will consider possible improvements in the capture of data associated with actual network fire events (e.g. the comparison of the actual consequence with modelled consequence).

Bushfire risk will also be monitored at a network wide level to ensure investment is conducted in the most appropriate areas to ensure appropriate investment / prioritisation decisions are made.

4.6 Financial

Not applicable to this asset class.

Only reactive replacement costs associated with functional failures of OH conductors are considered.

4.7 Environmental

Not applicable to this asset class.

5. Asset Lifecycle

This section discusses OH conductors throughout the asset lifecycle and brings to light key factors that currently (or may) impact the asset class performance.

5.1 Acquisition

Currently, within Endeavour Energy's network, there are 114 different kinds of OH conductor's in-service which vary in construction configuration, metal type and size. Furthermore, each of these kinds of conductors can operate at low voltage, high voltage, or sub-transmission. The location and type of OH conductors are determined by the different electrical and mechanical requirements for a line. The typical factors, as defined in MDI 0031, to consider when selecting the size, stranding and type of conductors are:

- The required continuous current rating of the line;
- mechanical factors such as sag and span length.
- fault rating and voltage regulation requirements as per Clause 8.1 in MDI 0031;
- availability of conductor; and
- environmental and safety considerations (e.g., selection of bundled / covered conductors).

Historically, programs applicable to the OH conductor asset class have primarily been reactive in their identification of assets requiring intervention. In recent years proactive programs such as *DS011 – High voltage steel mains replacement* (2014 – 2021), *DS414 – Copper distribution mains replacement* (2015 - 2019), and *DS422 – High voltage distribution bushfire mitigation* (2020 - 2023) have been carried out to manage the risk posed by OH conductors on the network. These programs have targeted steel mains and hard drawn copper conductors identified to be in poor condition and targeted high bushfire risk areas suitable for augmentation to covered conductor thick (CCT) for mitigation of bushfire ignition risk. The historical installation / operation of HV steel and copper lines in bushfire prone areas could contribute to the safety, reliability and bushfire risk to these assets. With an introduction of CCT and composite poles in these areas, the safety risk associated with the asset class will be reduced.

The continued monitoring of the asset class will allow further refinement of technology mix and network configurations options being implemented.

The current technical criteria for this asset class are defined in Equipment Technical Specifications (ETS) as listed in Section 8.1. Asset types have largely been defined based on the technology type, however as performance data indicated the current asset types will continue to be further subdivided.

5.2 Operations

The operation of OH conductors are crucial to the network. The primary function of OH conductors are to transfer bulk power between the generation sources to the various designated locations within its prescribed performance. The operating performance of OH conductors can be largely influenced by the environmental conditions, age profile of assets and the type of material.

5.3 Maintenance

An overview of the current maintenance activities being performed on OH conductors are summarised below. These maintenance activities result in the current asset performance (e.g. risk and number of unassisted / conditional asset failures). The shift to an asset level risk-based replacement strategy is expected to provide a step change (improvement) in risk during the FY25-FY29 regulatory period, however the underlying risk will continue based on the following maintenance strategy.

5.3.1. Inspections & Preventative Maintenance

The following table summarises the frequency of different inspection programmes and preventative maintenance applicable to OH conductors.

	Programme Name		Interval (Years)	Distribution lines		Sub-Transmission Lines					Reference
				All lines	Lines located within bushfire prone areas	Non-Critical lines	Critical lines	132kV lines	132kV Steel Tower lines	Lines located within bushfire prone areas	
Inspection	OLI/GLI[1]	Visual Inspection	5			✓					MDI 0031 MMI 0012
			3				✓		✓		
			4.5[2]	✓							
	Access track patrol		2.5			✓					MMI 0012
	PSBI[3]		1		✓					✓	MMI 0034
	Waterway Crossing	Inspection of line clearances	4.5	✓		✓	✓				MDI 0031 MMI 0012
		Inspection of warning signs	1			✓	✓				
	Thermovision survey		4					✓			MMI 0032
			2				✓				MMI 0032 MMI 0012
	Earthing resistance test[4]		12			✓					MMI 0012

[1] Applicable to only distribution assets

[2] Applicable to pole Inspections. First three (3) inspections OLI only, fourth and subsequent inspections are full OLI and GLI.

[3] Applicable to only assets that fall within the defined bushfire prone area

[4] First and last 2km of all lines

5.3.2. Essential Spares

The requirement for an essential spares' strategy is governed by the criticality of the equipment's function in the network and is dependent on the lead time for acquisition.

Given the availability of various suppliers, the ease of procuring items and the level of inventory maintained for OH conductors there are existing essential spares strategy for OH conductors. Currently, the warehouse holds spare conductors for the majority of conductor types.

Endeavour Energy's procurement and logistics section is responsible for the on-going sourcing strategy of OH conductors including its supply chain security.

5.4 Disposal

There are no unique requirements governing the disposal of the majority of the OH conductor asset class. The OH conductors that reach the disposal stage usually do not have any economic value beyond their scrap metal value which is disposed into the dedicated bins for different metal types provided at FSCs, according to the waste management standard EMS0007.

6. Intervention Options

A range of options have been considered as possible intervention options to address the risk presented by OH Conductors. These options are initially considered at an asset type / class level to determine if they are technical feasible and/or practical. Intervention options deemed to be a viable option are then considered at an asset level to determine the most appropriate option for each individual asset.

Intervention Type	Option	Assessment of effectiveness	Credibility
Non-Network Based	-	OH conductors are a vital component of the network and provide a physical medium to distribute electricity from one place to another. OH conductors function is to carry load and fault currents without annealing or sagging below limits for conductor height clearances and must maintain continuity under these conditions. There are no credible non-network solutions capable of replacing their functionality under the assumption that the feeder in which they service is still required.	Not A Feasible Solution
Condition Based	Additional maintenance to extend the life of the existing asset	Maintenance procedures are unable to further extend the life of an OH conductors. The ongoing management and maintenance of OH conductors typically involve routine OH line inspections for defects. Current practices still result in on average 56 unassisted failures p.a.	Not A Feasible Solution
Risk Based	Reduce the load on the asset through network reconfiguration, network automation or demand management or other non-network options	The risk of failure due to corrosion and fatigue is relatively independent of load. A minor reduction in the consequences of failure could be achieved by transferring load from any of the feeders in which OH conductors are installed; however, these options are very limited within the low voltage and high voltage distribution network. OH conductors provide a physical medium to distribute electricity from one place to another on the distribution and sub-transmission network, there are no practicable non-network solutions for replacing the function they provide.	Not A Feasible Solution
	Reactive repair and/or replacement of OH conductors after conditional or functional failure	This approach forms part of the business-as-usual practice but does not entirely mitigate the impact of failures. The historical observed quantities of unassisted functional failures are inclusive of Endeavour Energy's existing BAU practice. Unidentified conditional failures which lead to functional failures are not avoided under a purely reactive repair approach. Furthermore, repairs where a small section of new conductor is joined into an existing larger section of conductor post failure do not typically improve the overall condition and future probability of failure across the larger segment of conductor.	Technically feasible solution but does not effectively mitigate the risk of future failures
	Staged replacement to maintain option value and reduce the consumer's long-term service cost	On replacement, risk associated with a conductor will be reduced to the risk associated with the replacement option.	Feasible Option

6.1 Non-Network Based Interventions

No non-network-based interventions have been identified to replace the primary function of this asset class.

6.2 Condition Based Interventions

The inspections and preventative maintenance programs outlined in 5.3 Asset Maintenance results in the following condition-based repairs, replacements, and defects on OH Conductors. The objective of the condition-based maintenance is to identify functional asset failures prior to them occurring, however as close as possible to the assets technical / economic end of life.

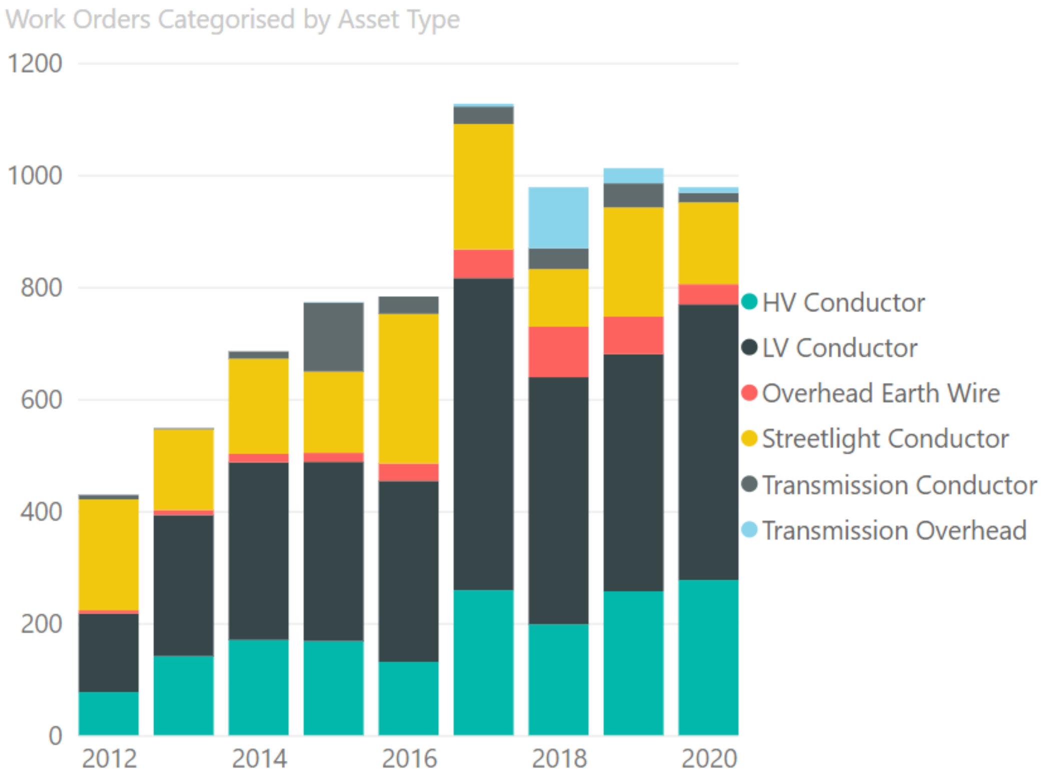
Defects are directly linked to an asset's failure mode(s) and aim to identify issues with the defect that will result in it being unable to perform its primary intended function. Defects are currently prioritised based on a qualitative assessment of the likelihood the defect will result in a functional failure.

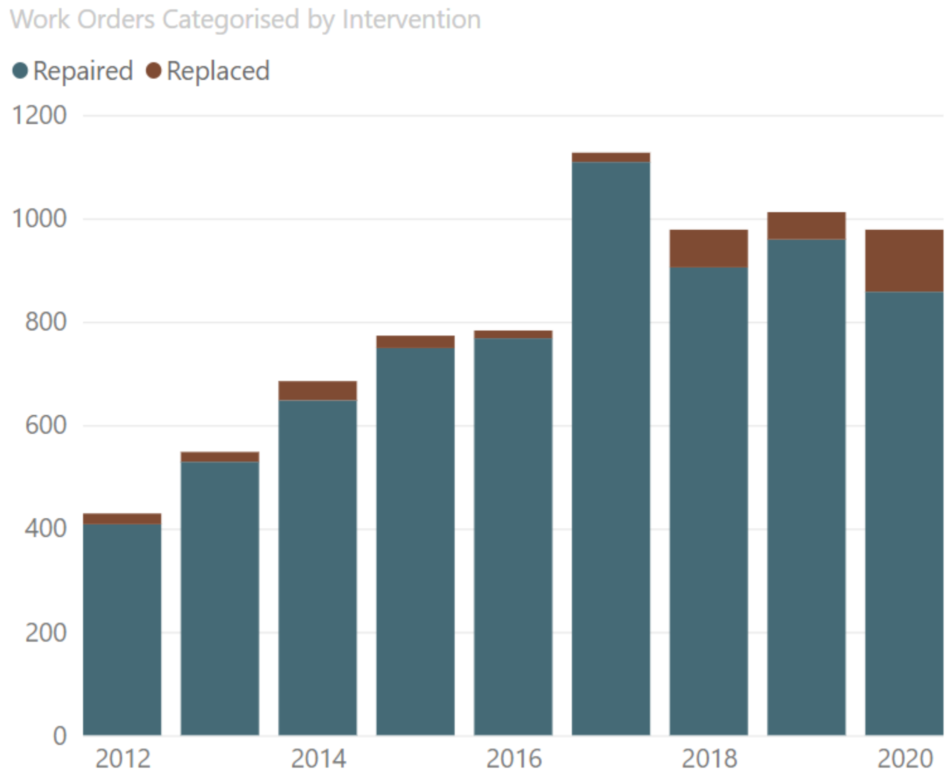
Endeavour Energy determines what constitutes a defect based on Failure Modes Effects and Criticality Analysis (FMECA). FMECA is an analytical process that is derived from an assessment of an asset's ability to sustain technical function and purpose and relies on information relating to failure modes, their probability, and consequences of failure. FMECA establishes a condition-based approach to asset maintenance that enables a risk-based determination of the maintenance requirements for assets.

MMI 0002 provides further detail on what is to be recorded as a defect, the required actions, and the corresponding priority for each failure mode, the table below provides an overview of applicable defects associated with OH conductors.

Type	Defects	Repair / Replacement	Standard job description
Transmission Overhead	1TROH	Repair	Repair OHEW Strands
Overhead Earth Wire	1OHEW	Repair Replace	Repair Down Earth Replace Down Earth
Streetlight Conductor	1SLCDR	Repair Replace	Repair streetlight conductor Replace damaged streetlight conductor
LV Conductor	1LVCDR	Repair Replace	Repair LV conductor bonds Replace damaged HV conductor
HV Conductor	1HVCDR	Repair Replace	Repair HV conductor Replace damaged HV conductor
Transmission Conductor	1TRCDR	Repair Replace	Repair transmission conductor Replace spacer

The overall volume of OH conductor defects has shown to be consistent over the past five years, with a slight increase of defects in both LV conductors and Sub-Transmission Overheads. However, upon further investigation of the work order data, the interventions from the maintenance inspection programs are predominantly asset repairs, which indicates the deterioration in the asset condition mostly related to the aging of the asset population.


Work Orders Categorised by Asset Type
1200
1000
800
600
400
200
0
2012
2014
2016
2018
2020
HV Conductor
LV Conductor
Overhead Earth Wire
Streetlight Conductor
Transmission Conductor
Transmission Overhead

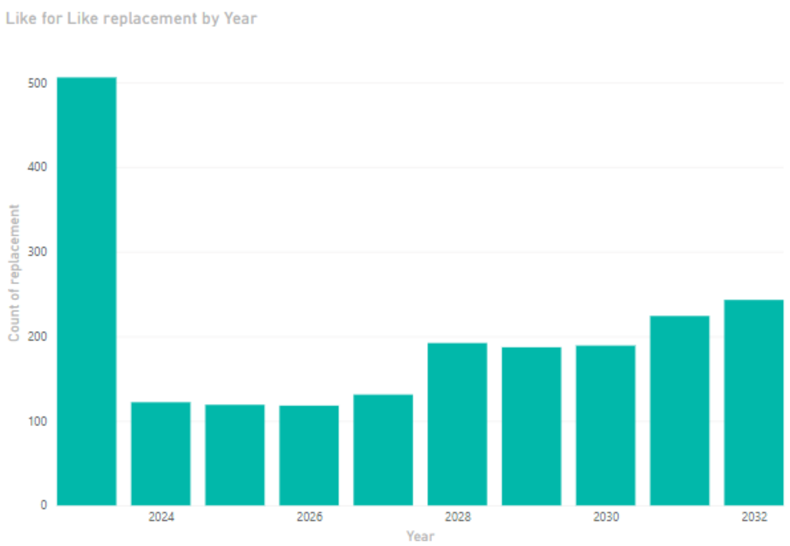

Work Orders Categorised by Intervention
Repaired
Replaced
1200
1000
800
600
400
200
0
2012
2014
2016
2018
2020

6.3 Risk Based Interventions

Risked based intervention options considered as possible feasible intervention options have been further considered to address the risk presented by OH Conductors at the asset level. The customer benefit achieved by the proposed intervention option is compared with the cost of the proposed intervention(s) to determine if the option is financially viable and in the customer's interest. This approach generates a cost to benefit ratio / NPV for every asset and intervention option being considered.

For each asset proposed to have an intervention (as specified in the CFI's), the option considered for OH Conductors are staged replacement to maintain option value and reduce the consumer's long-term service cost. The intervention includes the complete replacement of overhead conductor linear assets in a planned proactive manner with a like-for-like equivalent conductor. The per kilometre unit rates used for estimating the cost of replacement for overhead conductors vary with operating voltage and conductor type. These values are estimates based on past programs and ongoing experience of replacing similar type conductors within Endeavour Energy's network over the past 5 years. The following volume of forecasts are based on the results of the CFI's associated with this asset class, due to the linear nature of the asset, the chart indicates a like-for-like replacement of OH conductors totalling a quantity of interventions required.

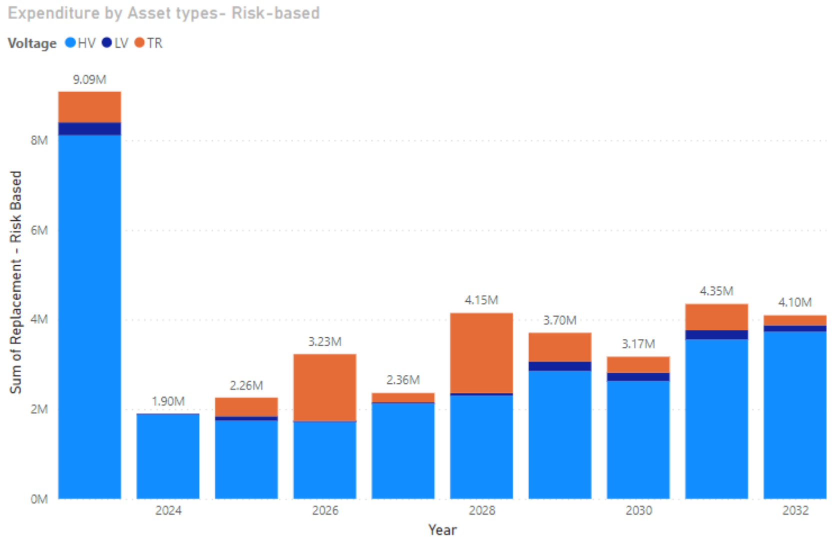
The CFI of this asset had been prepared in parallel with the "HV Distribution Network Resilience and Bushfire Ignition Risk Mitigation" CFI. Since the two CFI's were looking at the same assets a review of any potential overlap in recommendations has been conducted. The same asset, PoF and LoC data (excluding factoring in new climate change modelling) has been used in both CFI's. Since the same assets are under review and the benefits associated the proposed resilience CFI are higher than those in this CFI, all overlaps will be removed from the recommendations made in this proposal.

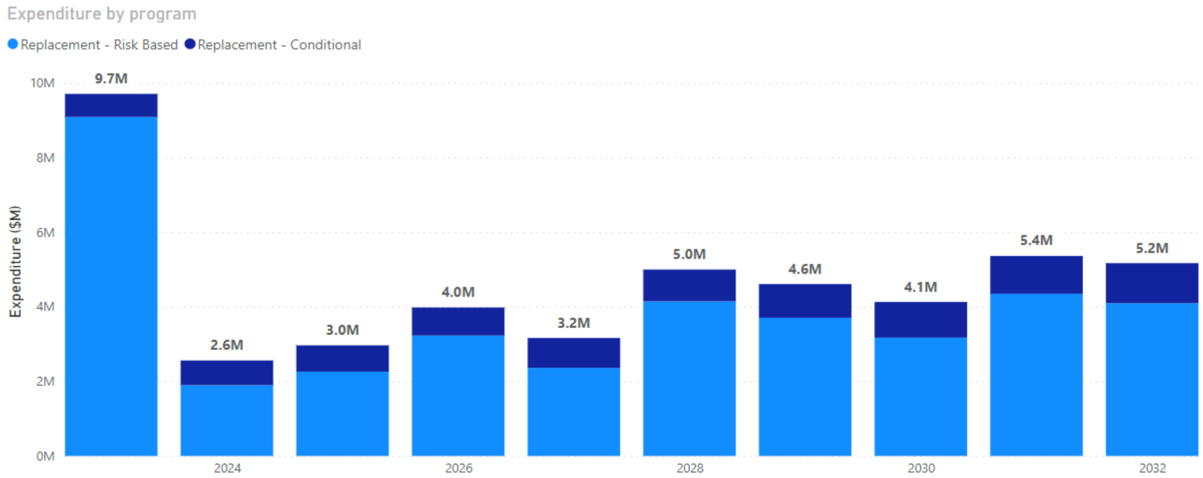


7. Forecasts

7.1 Cost

The risked based replacement program has identified assets within this asset class that are currently justified for a risk-based asset intervention over the upcoming regulatory period. Assets that reach their NPV maximum point are illustrated in the images below. A number of other assets will have reached the point of being NPV positive (e.g., risk is higher than intervention costs), however these will not be considered as part of the portfolio optimisation process. The proposed investment profile shows the period of FY23 to have the highest proportion of assets identified for intervention as this is the first practical opportunity with the positive NPV. This has resulted in a peak in investment costs in FY23 as indicated in the expenditure profiles, however additional constraints (e.g., labour, outage availability etc) will likely see this peak flattened over the regulatory period. Over the next 5 years, inspection and maintenance spend is expected to remain stable.



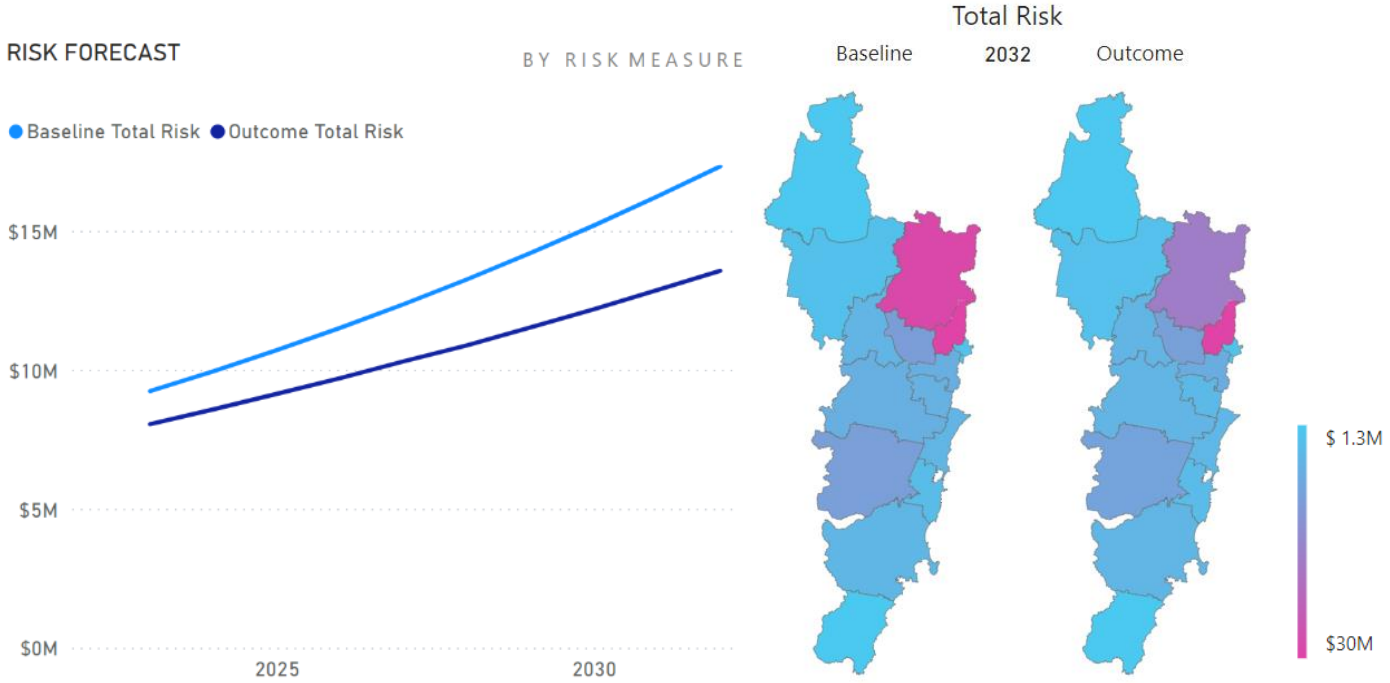


7.2 Risk

Network risk associated with OH conductors has been calculated as per the current value framework. The total risk in this asset class is made up from Reliability (73%), Bushfire (26.6%) and Safety (0.4%)

The baseline risk (no intervention) associated with this asset class is projected to reach approximately $17 million if no action is taken. The outcome risk based on the proposed intervention profile is however projected to approximately reach $13 million over the following ten-year period,

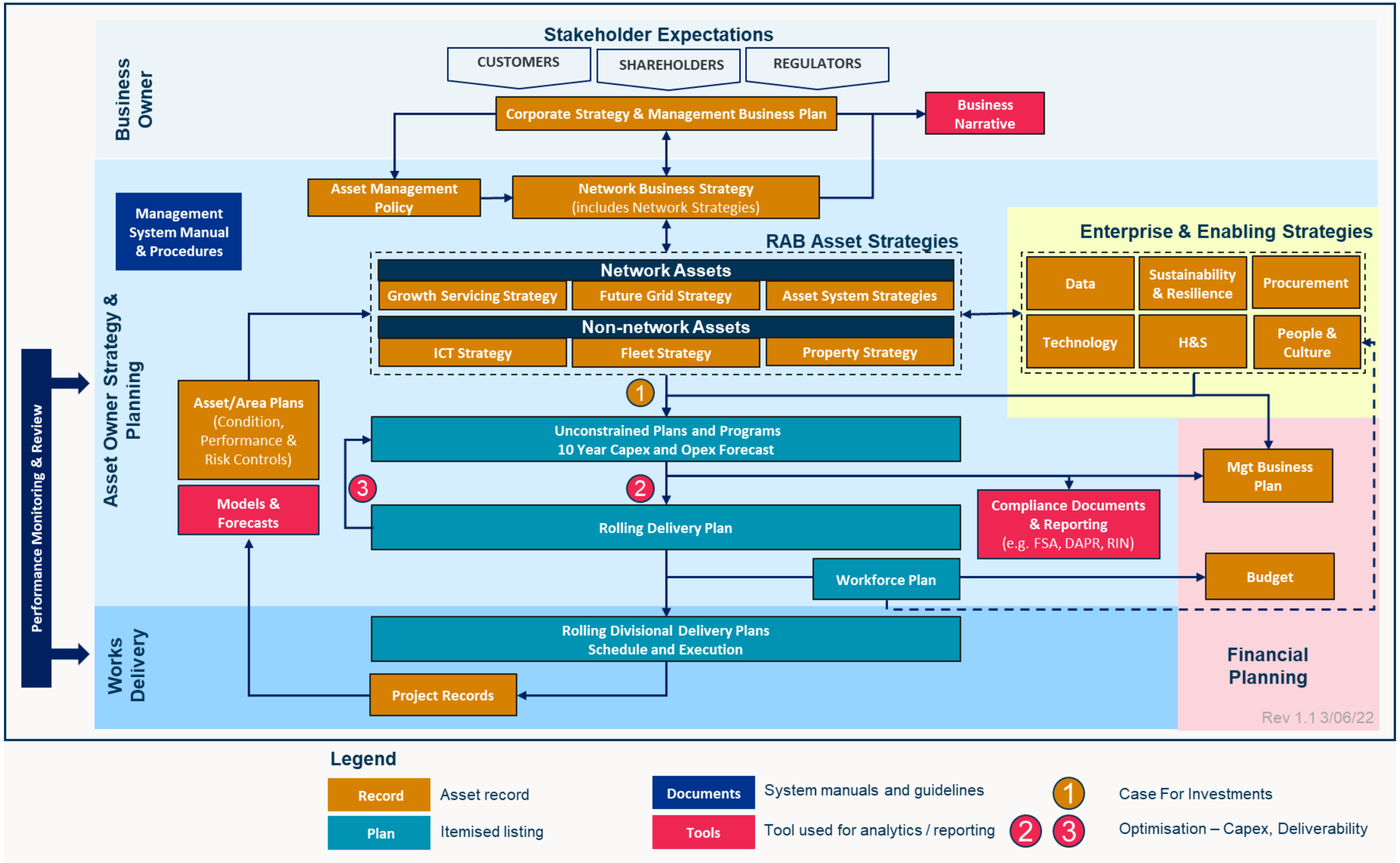
It can also be seen that the total risk will become much more uniform across the network with majority of the investment focused on higher density residential / CBD areas as well as bushfire prone areas, as the risk is predominantly driven by network reliability and bushfire.



8. Asset Management Systems

This section identifies the strategies, practices and guidelines supporting the management of this asset class. A detailed description of Endeavour Energy's asset management system and its constituent parts is available in the Asset Management System Manual and the Asset Management System Guidelines.

The relationship between this document and the other artefacts within Endeavour Energy's asset management system is illustrated below:



8.1 Standards, Guidelines & Policies

Endeavour Energy's asset management practises are governed and guided by numerous legislative requirements, guidelines, and industry best practises throughout Australia and Internationally. Endeavour Energy's manuals, procedures and workplace policies are all underpinned by these key documents as documented in 'GQY 1190 Policy and Procedure Framework' and demonstrated in the adjacent figure. Legislation, regulations, and high-level Australian Standards applicable to HV network operations are detailed in the Endeavour Energy Asset Management System.

Endeavour Energy has developed the following documentation to specifically guide the life-cycle management of OH conductors:

Company Policies

9.1.6	Approved Materials List
9.1.7	Commissioning network Electrical Assets
9.1.9	Network Technical Compliance
9.2.1	Network Planning
9.2.2	Network Protection
9.2.5	Network Asset Design
9.7.1	Network Asset Construction
9.8.3	Network Operations
9.9.1	Network Asset Maintenance
9.9.2	Essential Spares

Approved Materials Lists & Specifications

ETS 0059	Aerial Bundle Cable (ABC)
ETS 0060	Covered Conductor Thick (CCT)
ETS 0062	Line fault Indicators
ETS 0064	Bare Overhead Conductors
ETS 0106	Overhead Line Fittings

Design Instructions

MDI 0031	Overhead Line Design
MDI 0042	Overhead Conductor Ratings

Construction & Commissioning Standards

MCI 0005	Overhead Construction Standards Manual
SDI 120	Testing and Commissioning for Distribution Systems

Maintenance & Operations Standards

MMI 0001	Pole and Line Inspection and Treatment Procedures
MMI 0002	Distribution Overhead Defect Handbook
MMI 0012	Overhead Transmission Line Routine Inspection
MMI 0013	Vegetation Clearance Management
MMI 0032	Thermovision of Distribution & Transmission Lines
MMI 0034	Pre-summer Bushfire Inspections
SMI 101	Minimum Requirements for Maintenance of Distribution Equipment

8.2 Asset Management Tools

Endeavour Energy use numerous integrated data-base and geographical information system related tools to aid in the management of OH conductor assets.

Key tools used for the management of OH conductors include:

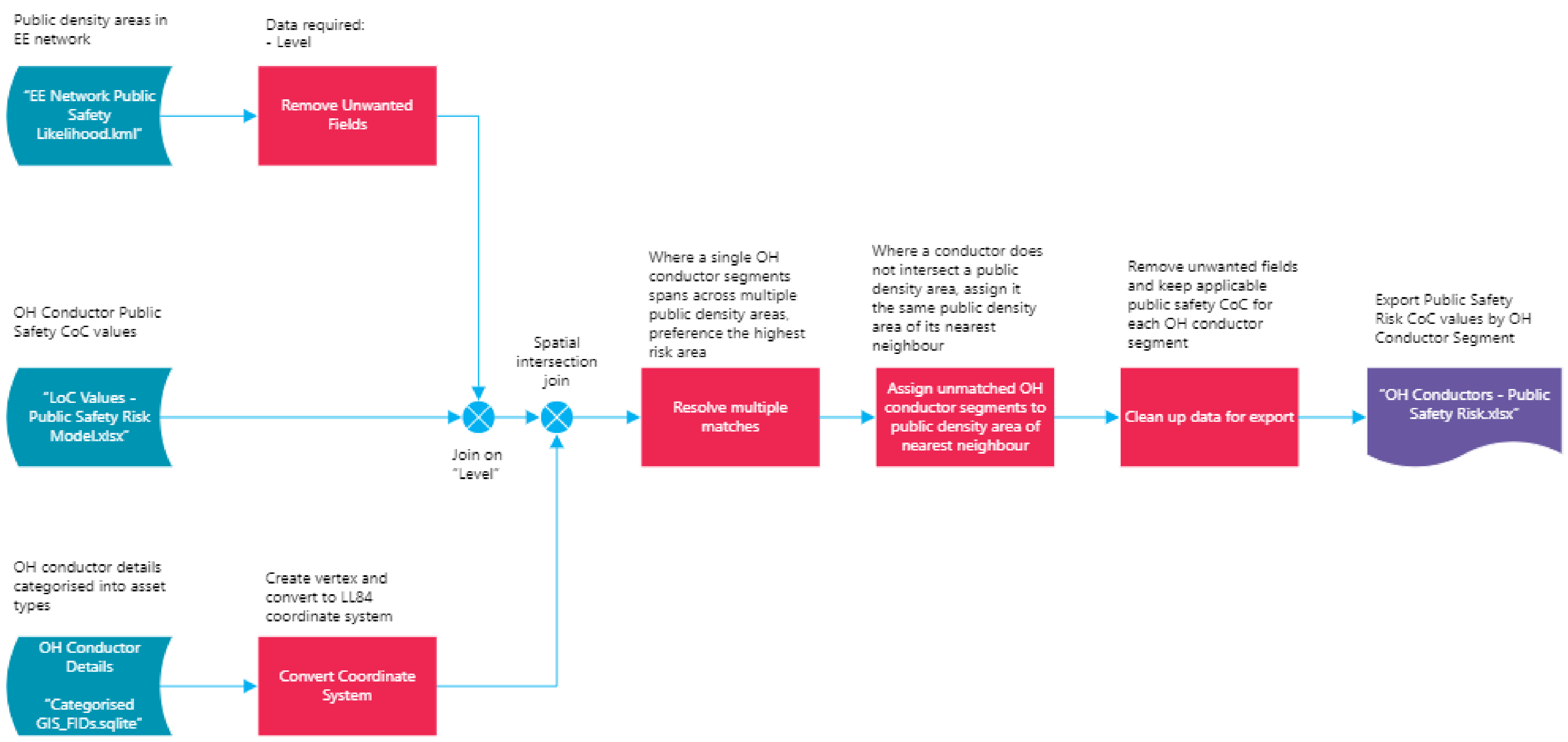
Tools	Current Purpose	Future Purpose
Ellipse Database	Used for historical (2010-2021) routine maintenance scheduling, defect workorder recording and management	Superseded by SAP
SAP	Used for recent (2021-Current) asset nameplate details, routine maintenance scheduling, defect workorder recording and management	To be used as the primary data source for: • Asset characteristics • Financials • Safety – safety incidents are to be categorised by asset class, asset type, and severity • Bushfire – bushfire incidents are to be categorised by asset class, asset type, and severity • Environmental – environmental incidents such as SF6 gas leaks are to be captured and categorised by asset class, asset type, and severity
ADMS	Not currently used	To be used as the primary data source for: • Reliability – reliability incidents are to be categorised by asset class, asset type, and include SAIDI and SAIFI contributions. • Resilience – Benefits from network automation to be quantified • Utilisation – switching events are to be categorised by asset class and asset type.
OMS	Used for historic (2012-2021) asset related reliability incidents	Superseded by ADMS
FireStart	Used for historic (2005-2021) asset related firestart incidents	Superseded by SAP
MySafe	Used for historic (2012-2021) asset related safety incidents categorised by severity	Superseded by SAP
GIS	Used for historic (2012-2021) geo-spatial locations for linear assets and conductor details (name and conductor size)	To be used as the primary data source for asset location data particularly for linear assets.

Appendix A – Cost of Consequence

Safety

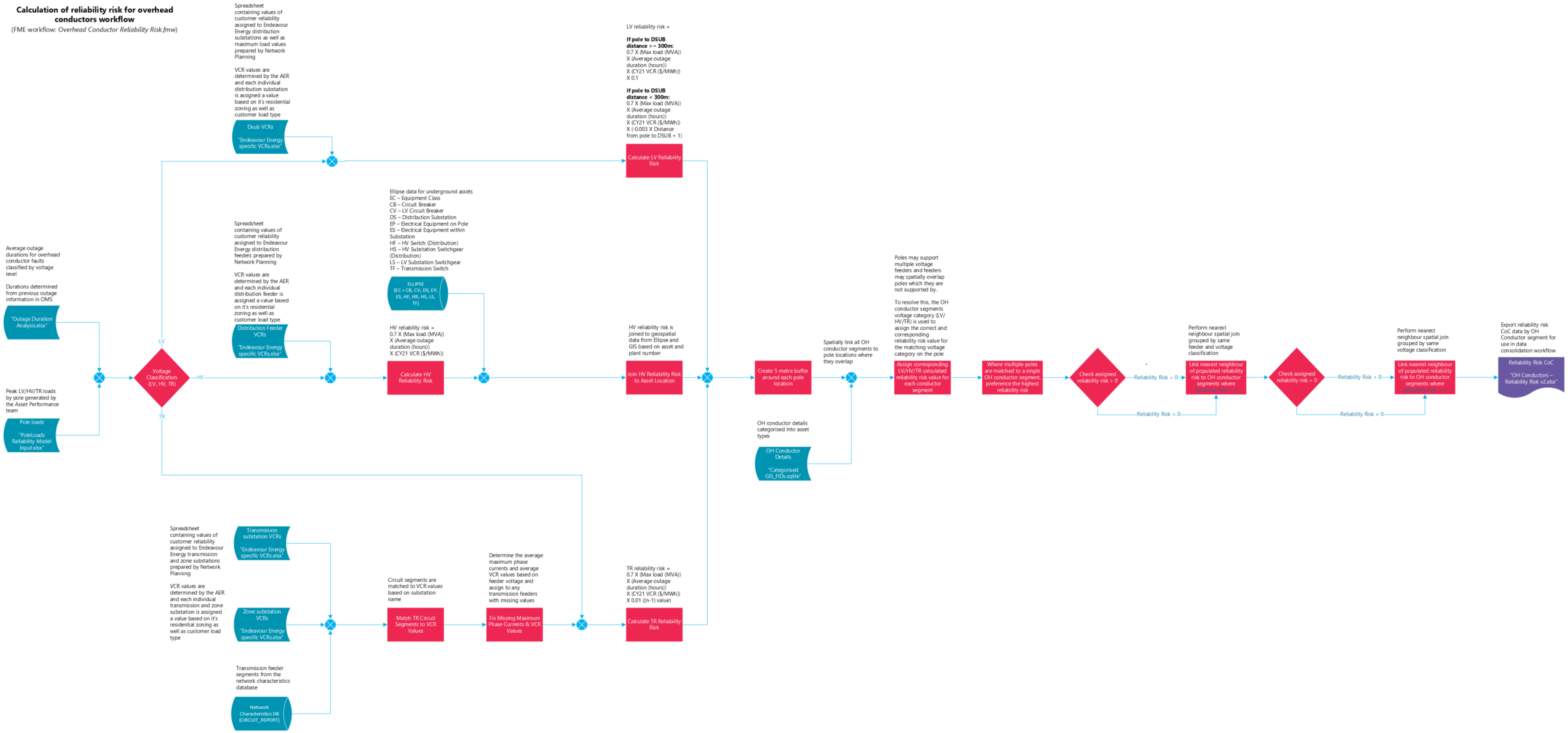
Overhead conductor public safety model workflow

(FME workflow: *OH Conductor Public Safety Model.fmw*)



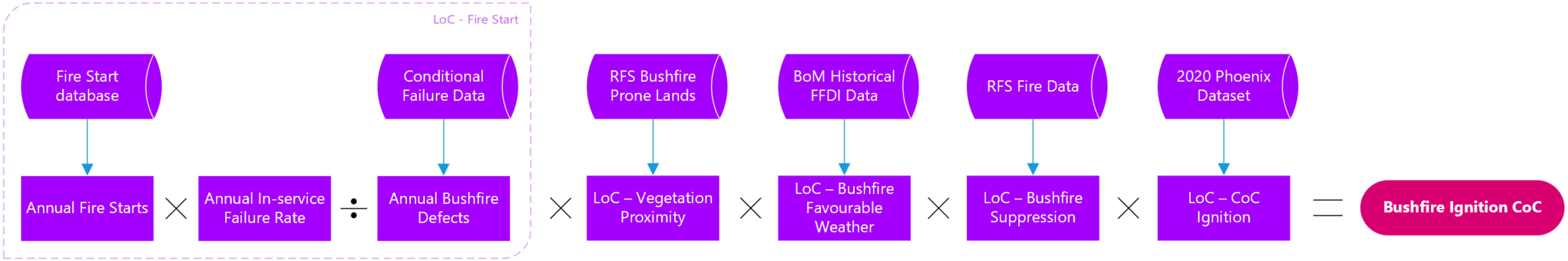
Parameter	Value	Description/justification	Source/assumptions
Value of a fatality	$4,800,000	Value of statistical life (VoSL)	GNV1119
Value of a major injury	$2,400,000	50% of VoSL	GNV1119
Value of a minor injury	$758,400	15.8% of VoSL	GNV1119
Safety Public – LoC **By level of public presence (1 to 4)**	Level 1 - $4333 Level 2 - $2145 Level 3 - $675 Level 4 - $653 Level 1 – Highly trafficked Level 2 – Moderately trafficked Level 3 – lowly trafficked Level 4 – Rarely trafficked	LV Safety CoC Fatality: 80% Major injury: 15% Minor injury: 5% Disproportionate factor: 1 Qty of people impacted: Level 1: 3 Level 2: 2 Level 3: 1 Level 4: 1 LoC: 0.0008% to 0.0273%	Public safety modelling EE Network Public Safety Likelihood.kml
	Level 1 - $3100 Level 2 - $1127 Level 3 - $63 Level 4 - $35 Level 1 – Highly trafficked Level 2 – Moderately trafficked Level 3 – lowly trafficked Level 4 – Rarely trafficked	HV Safety CoC Fatality: 90% Major injury: 10% Minor injury: 0% Disproportionate factor: 1 Qty of people impacted: Level 1: 3 Level 2: 2 Level 3: 1 Level 4: 1 LoC: 0.0001% to 0.0204%	Public safety modelling EE Network Public Safety Likelihood.kml
	Level 1 - $3193 Level 2 - $1134 Level 3 - $37 Level 4 - $7 Level 1 – Highly trafficked Level 2 – Moderately trafficked Level 3 – lowly trafficked Level 4 – Rarely trafficked	TR Safety CoC Fatality: 100% Major injury: 0% Minor injury: 0% Disproportionate factor: 1 Qty of people impacted: Level 1: 3 Level 2: 2 Level 3: 1 Level 4: 1 LoC: 0.0001% to 0.0222%	Public safety modelling EE Network Public Safety Likelihood.kml

Reliability



Parameter	Value	Description/justification	Source/assumptions
Duration of interruption	LV: 3.3 hours HV: 3.1 hours TR: 2.3 hours	Average outage durations based on historical OMS outage records.	OMS data 2012 -2021
Loss of supply to customers - LoC	LV: 100% HV: 100% TR: 1%	1% likelihood of loss of load when N-1 supply security is available	RisCAT - 1% likelihood the alternate supply path will not be available due to maintenance, or failure.
Load factor	70%	Load assumed to be lost is 70% of the summer maximum demand value for the supplied substation(s)	Source – studies by Protection Manager.
Load impacted	Varies based on the estimated load of supported by section of conductor	PowerFactory load flow analysis for feeder loads. MDI readings for distribution substation loads. Network Planning distribution feeder loads.	Spreadsheets based on 2021 PowerFactory load flow analysis results. Endeavour Energy specific VCRs.xlsx
VCR	Varies based on the customer make-up supplied by a section of overhead conductor	Value of customer reliability for an occasional short-term outage. This value varies based on the make-up of customer types supplied by the section of overhead conductor.	Endeavour Energy specific VCRs.xlsx

Bushfire



Parameter	Value	Description/justification	Source/assumptions
Bushfire LoC	Bushfire ignition risk LoC varies by voltage classification and conductor insulation: ABC HV - 10% ABC LV - 5% Bare HV - 13% Bare LV - 6% Bare TR - 20% CCT HV - 2%	Likelihood that a conductor failure will ignite a small fire:	Based on historical fire start data. Fire Database.xlsx
Bushfire CoF	Bushfire ignition risk CoC varies by location	Likelihood and consequence that a small fire would be realised into a large bushfire with financial impacts.	Bushfire ignition risk CoC modelling based on the Phoenix Fire Characteristic Simulations

Appendix B – Weibull Parameters

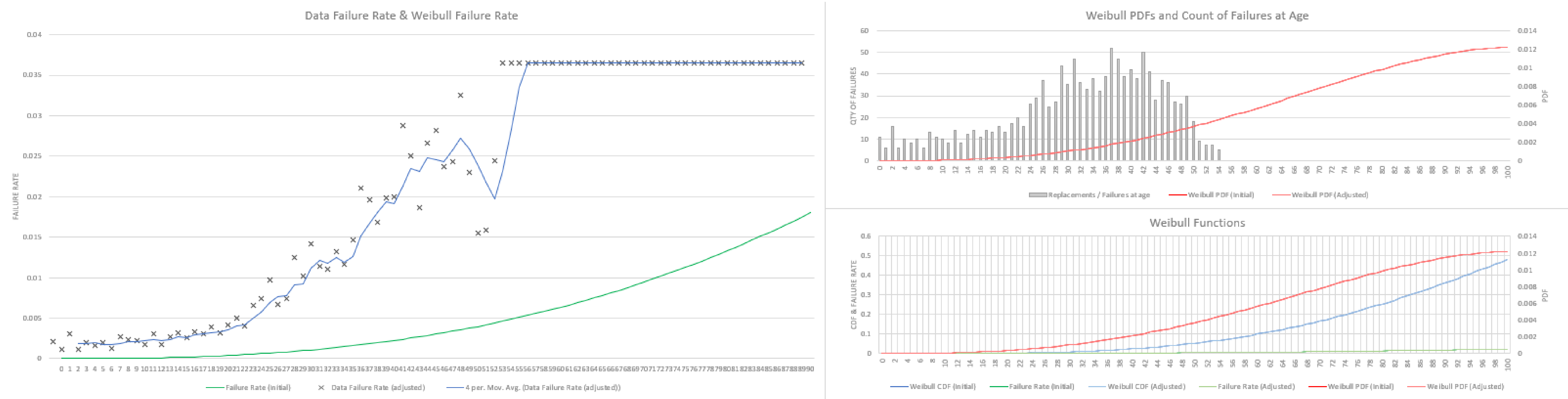
Conditional Weibull Parameters

Index	Sheet Name	C55 asset name	Population size (km)	Mean replacement / repair age (data)	Historical annual failures (5-year avg)	Predicted No. of annual failures	Predicted avg failure age	Alpha	Beta	Shift	Fitting Weibull R-Squared
1	LA - AAAC 7 2.50	AAAC 7/2.50	682	17	2.2	2.2	63	3.6	69.8	0	0.82
2	LA - AAAC 7 4.50	AAAC 7/4.50	224	22	0.4	0.4	79	3.6	87.7	0	0.79
3	LA - AAC 19 3.25	AAC 19/3.25	1269	32	2.6	2.6	102	3.6	112.7	0	0.30
4	LA - AAC 19 3.75	AAC 19/3.75	329	26	0.4	0.4	104	3.6	115.2	0	0.68
5	LA - AAC 19 4.75	AAC 19/4.75	187	19	0.2	0.2	114	3.6	126.6	0	0.44
6	LA - AAC 7 3.00	AAC 7/3.00	782	31	2.2	2.2	94	3.6	104.6	0	0.68
7	LA - AAC 7 3.75	AAC 7/3.75	930	37	1.4	1.4	122	3.6	135	0	0.84
8	LA - AAC 7 4.50	AAC 7/4.50	5172	32	10	10.0	101	3.6	112.5	0	0.89
9	LA - ACSR 3 4 1.68	ACSR 3/4/1.68	140	22	0.4	0.4	83	3.6	92.1	0	0.90
10	LA - ACSR 3 4 2.50	ACSR 3/4/2.50	412	5	1	1.0	58	3.6	64	0	0.43
11	LA - ACSR 30 7 3.00	ACSR 30/7/3.00	242	29	0.2	0.2	124	3.6	138	0	0.13
12	LA - ACSR 30 7 3.50	ACSR 30/7/3.50	319	34	0.6	0.6	102	3.6	112.9	0	0.42
13	LA - ACSR 54 7 3.00	ACSR 54/7/3.00	373	38	0.2	0.2	128	3.6	141.5	0	0.71
14	LA - ACSR 6 1 2.50	ACSR 6/1/2.50	833	28	4	4.0	74	3.6	82.5	0	0.59
15	LA - ACSR 6 1 3.00	ACSR 6/1/3.00	549	26	0.8	0.8	105	3.6	116.3	0	0.62
16	LA - ACSR 6 1 3.75	ACSR 6/1/3.75	655	28	1	1.0	147	2.5	165.8	0	0.70
17	LA - ACSR 6 4.75 + 7 1.60	ACSR 6/4.75 + 7/1.60	774	27	1.4	1.4	97	3.6	108.2	0	0.45
18	LA - HDCU 19 2.00 or 7 0.136	HDCU 19/2.00 or 7/0.136 or 19/0.083	809	31	2	2.0	98	3.6	108.6	0	0.51
19	LA - HDCU 19 2.57	HDCU 19/2.57	97	33	0.4	0.4	90	3.6	99.9	0	0.38
20	LA - HDCU 7 0.104 or 19 0.064	HDCU 7/0.104 or 19/0.064	1448	33	3.2	3.2	103	3.6	114.2	0	0.75
21	LA - HDCU 7 1.75	HDCU 7/1.75	1955	29	4.6	4.6	92	3.6	101.9	0	0.43
22	LA - HDCU 7 2.00	HDCU 7/2.00	631	32	3.8	3.8	75	3.6	83.5	0	0.42
23	LA - HV ABC	HV ABC	277	16	17	16.9	27	3.6	30.5	0	0.75
24	LA - HV CCT	HV CCT	473	9	0.8	0.8	60	3.6	66.2	0	0.87
25	LA - LV ABC	LV ABC	1749	18	2.6	2.6	80	3.6	89.3	0	0.79
26	LA - LV UNKN	LV UNKN	4644	34	4.8	4.8	129	3.6	142.7	0	0.80
27	LA - SCGZ 3 2.00	SC/GZ 3/2.00	288	24	0.6	0.6	89	3.6	98.6	0	0.74
28	LA - SCGZ 7 1.63	SC/GZ 7/1.63	94	24	0.2	0.2	92	3.6	102.5	0	0.82
29	LA - TR UNKN	TR UNKN	208	32	0.8	0.8	85	3.6	94.4	0	0.73
30	LA - AAAC Generic	AAAC Generic	1072	18	3	3.0	67	3.6	74.8	0	0.78

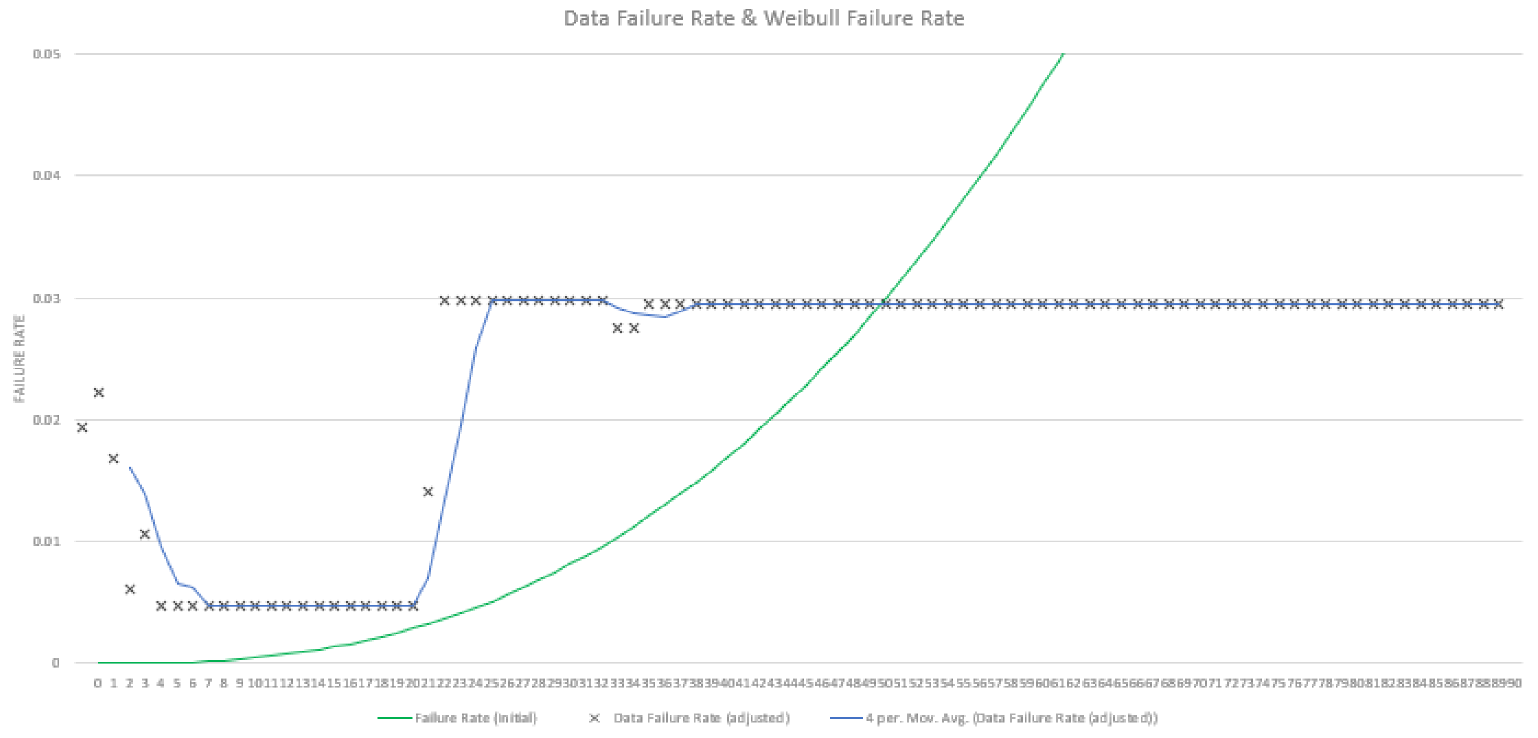
31	LA - AAC Generic	AAC Generic	8963	32	17	17.0	103	3.6	114.4	0	0.51
32	LA - ACSR Generic	ACSR Generic	4681	27	10	10.0	93	3.6	103.3	0	0.48
33	LA - HDCU Generic	HDCU Generic	4973	31	14	14.0	92	3.6	102.4	0	0.52
34	LA - SCGZ Generic	SC/GZ Generic	487	24	0.8	0.8	96	3.6	106.1	0	0.78
35	LA - LV Covered	LV Covered	23	9	0.2	0.2	36	3.6	40	0	0.78
36	LA - HV UNKN	HV UNKN	90	24	0.2	0.2	91	3.6	100.9	0	0.77
37	LA - TR XTACIR	TR XTACIR	8	13	0.1	0.1	29	3.6	31.7	0	0.27

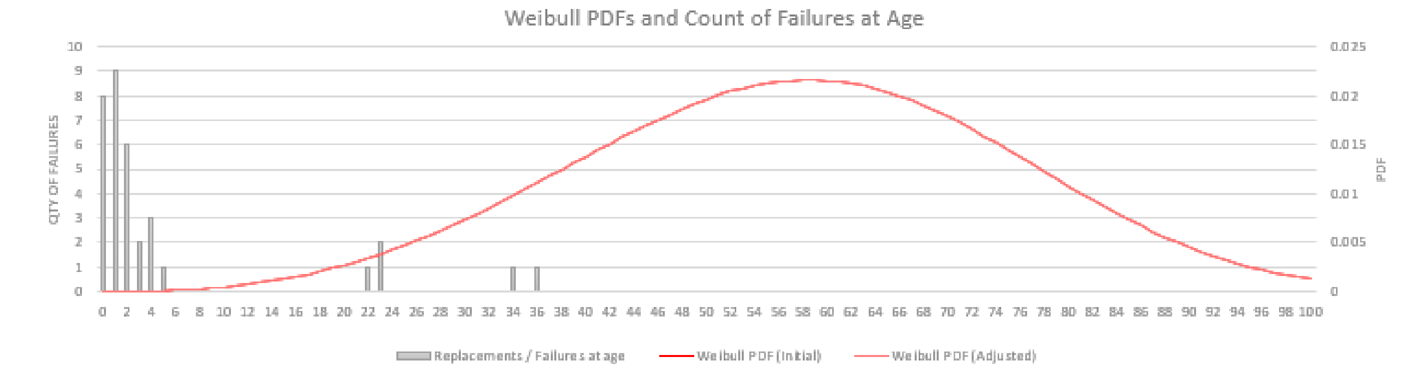
Included within this appendix is a sample of Weibull charts to illustrate the above parameters.

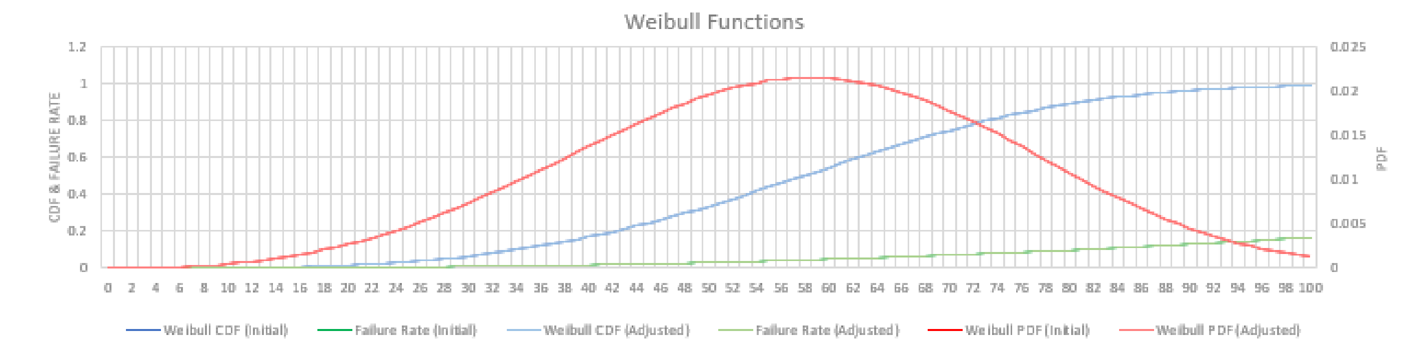
Example 1: AAC 7/4.50



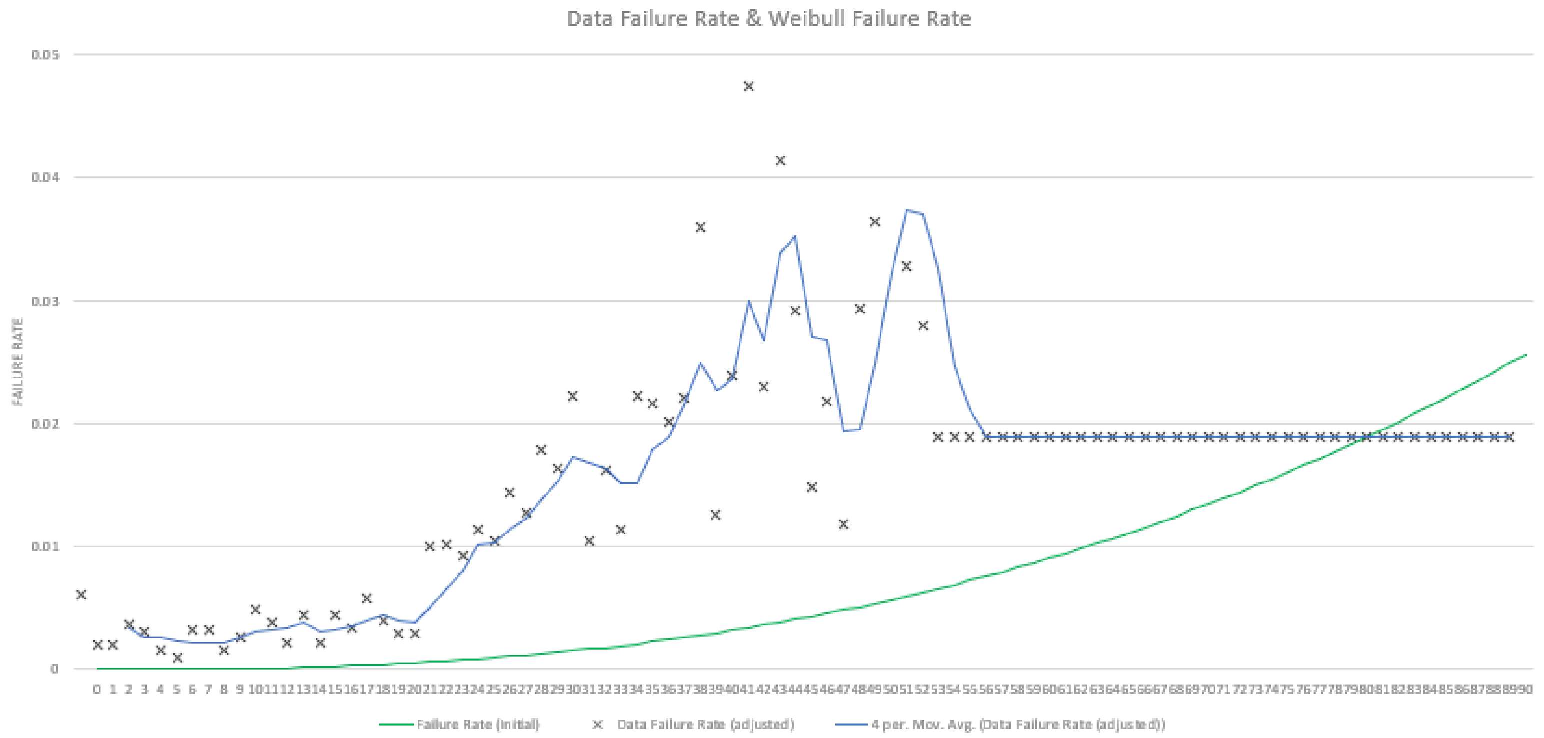
Example 2: ACSR 3/4/2.50

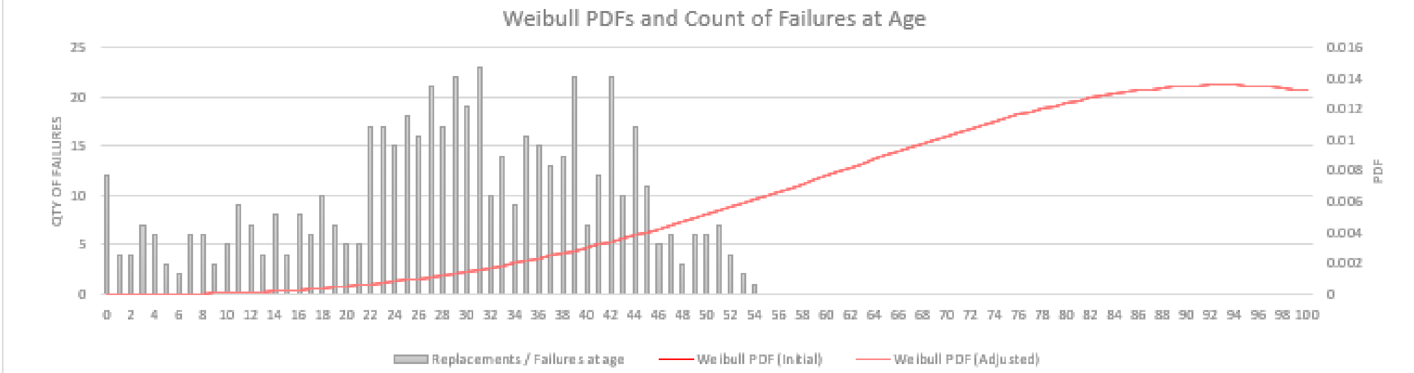


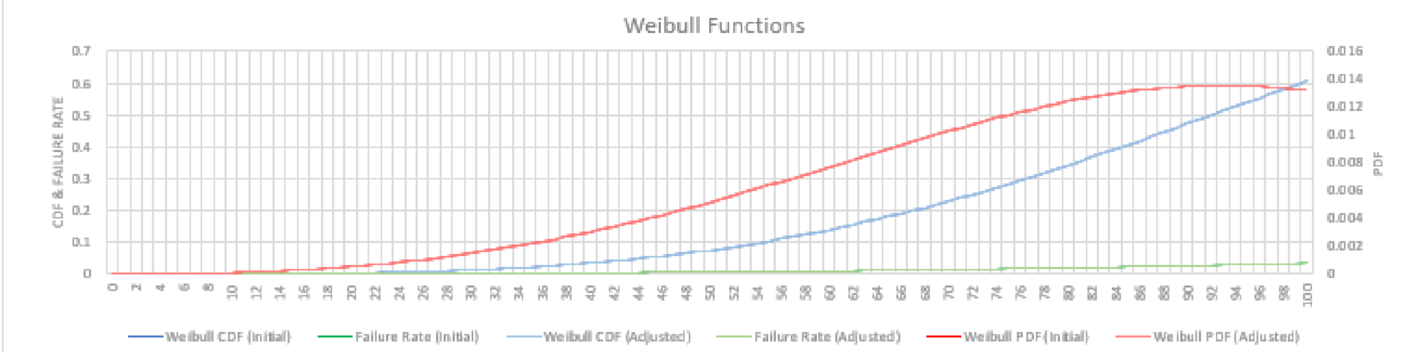


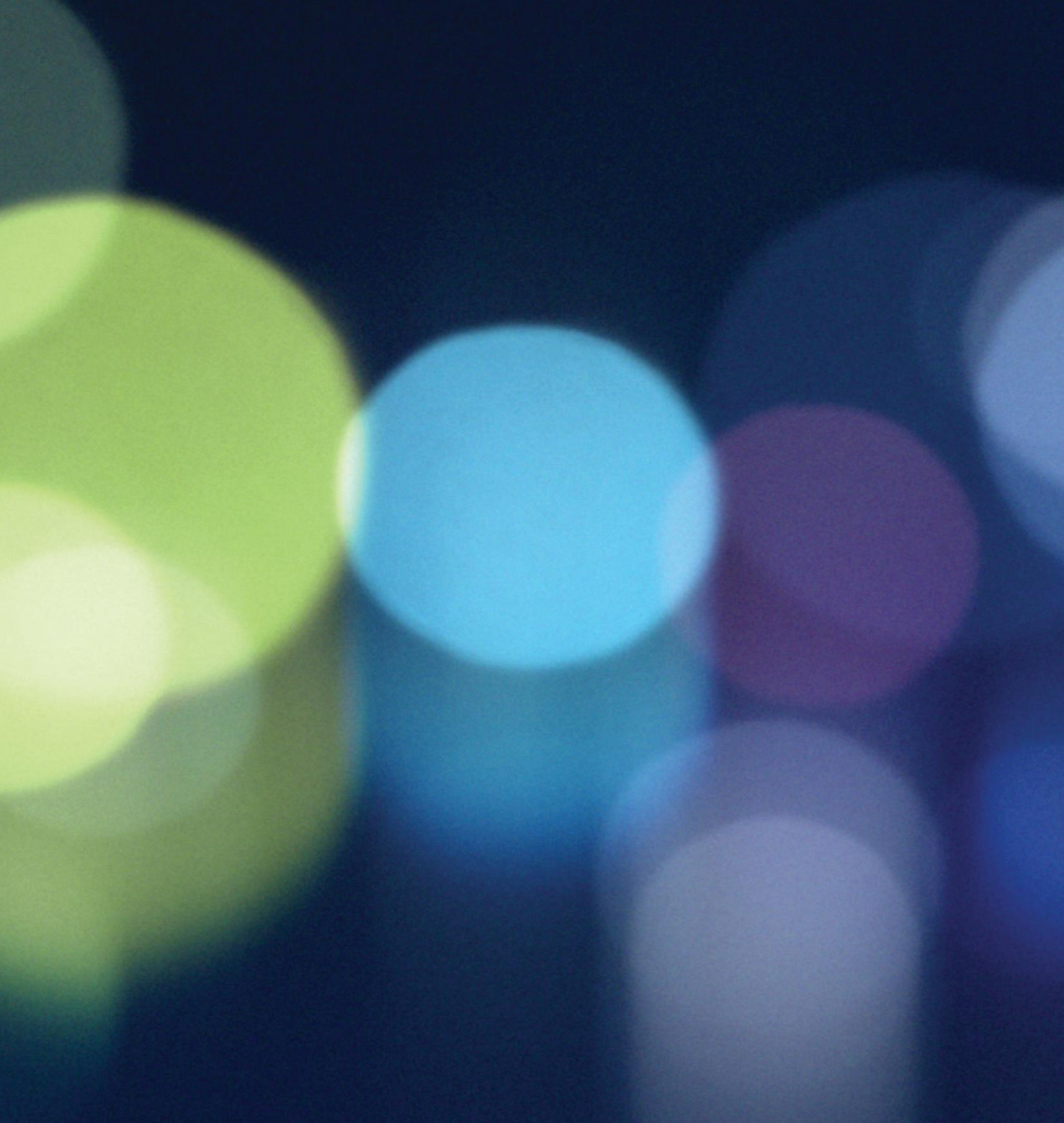


Example 3: HDCU 7/1.75









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