Asset Management Plan

Conductors and Hardware – Distribution

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Responsibilities

This document is the responsibility of the Asset Strategy Team, Tasmanian Networks Pty Ltd, ABN 24 167 357 299 (hereafter referred to as "TasNetworks").

Please contact the Asset Strategy Team Leader with any queries or suggestions.

Implementation	All TasNetworks staff and contractors.
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Record of revisions

Section number	Details
	New Document

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1 Purpose

The purpose of this document is to describe for Conductors and Pole-top Hardware Distribution related assets:

- TasNetworks' approach to asset management, as reflected through its legislative and regulatory obligations and strategic plans;
- The key projects and programs underpinning its activities; and
- Forecast CAPEX and OPEX, including the basis upon which these forecasts are derived.

2 Scope

This document covers Conductors and associated Pole-top Hardware Distribution.

3 Strategic Alignment and Objectives

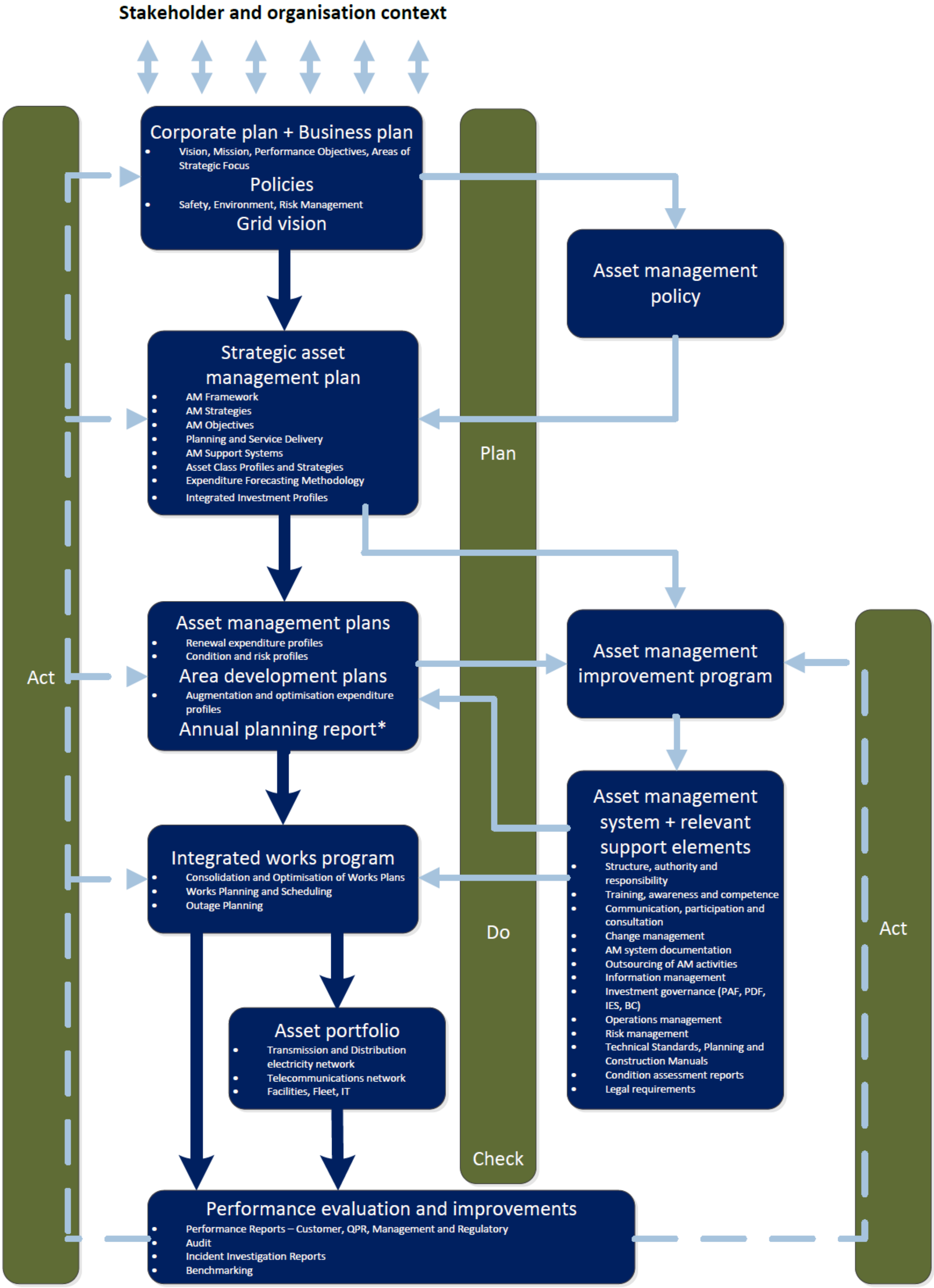
This asset management plan has been developed to align with both TasNetworks' Asset Management Policy and Strategic Objectives.

The asset management policy, contained within the Strategic Asset Management Plan, states 'Consistent with our vision and purpose, we strive for excellence in asset management and are committed to providing a safe working environment, value for our customers, sustainable shareholder outcomes, care for our assets and the environment, safe and reliable network services, whilst effectively and efficiently managing our assets throughout their life-cycle'.

It is part of a suite of documentation that supports the achievement of TasNetworks strategic performance objectives and, in turn, its mission. The asset management plans identifies the issues and strategies relating to network system assets and detail the specific activities that need to be undertaken to address the identified issues.

Figure 1 represents TasNetworks documents that support the asset management framework. The diagram highlights the existence of, and interdependence between, the Plan, Do, Check, Act components of good asset management practice.

Figure 1 – TasNetworks Asset Management Documentation Framework



* The Annual Planning Report (APR) is a requirement of sections 5.12.2 and 5.13.2 of the National Electricity Rules (NER) and also satisfies a licence obligation to publish a Tasmanian Annual Planning Statement (TAPS). The APR is a compilation of information from the Area Development Plans and the Asset Management Plans.

4 Asset Support Systems

4.1 Systems

TasNetworks maintains an asset management information system (AMIS) that contains detailed information relating to the distribution conductors and hardware asset populations. AMIS is a combination of people processes and technology applied to provide the essential outputs for effective asset management.

4.2 Asset Information

The asset information contained on conductors is stored in the Spatial Data Warehouse (GIS data) and WASP asset management system.

The following sections detail the information contained in each location.

4.2.1 Data Warehouse (G-Tech Data)

The information contained in the Data Warehouse (G-Tech Data) includes:

- G-Tech Conductor Type;
- Pole Install Date;
- Distance from Coastline;
- Fire Danger Area;
- Protection Zone;
- Substandard conductor (as per AS 7000);
- Conductor Failure;
- Protection Device Operations;
- Pole IDs;
- Owner; and
- Regional Area (South, North and North West).

4.2.2 WASP Asset Data

The data contained in WASP includes:

- WASP Conductor Type;
- WASP Asset ID;
- Owner; and
- Install date.

5 Network Performance

5.1 Key performance indicators

TasNetworks monitors distribution assets for major faults through its outage and incident reporting processes.

Asset failures resulting in unplanned outages are recorded in the InService outage management tool by field staff, with cause and consequence information being subsequently made available to staff for reporting and analysis. Those outages with a significant enough consequence are also recorded in RMSS and are investigated by the business to establish the root cause of the failure and to recommend remedial strategies to reduce the likelihood of reoccurrence of the failure mode. Reference to individual fault investigation reports can be found in RMSS.

TasNetworks also maintains a defect management system that enables internal performance monitoring and statistical analysis of asset faults and/or defects that either may not result in unplanned outages, or whose failure may only result in a minor consequence not requiring full investigation.

TasNetworks' Service Target Performance Incentive Scheme (STPIS), which meets the requirements of the Australian Energy Regulator's (AER's) Service Standards Guideline, imposes service performance measures and targets onto TasNetworks with a focus on outage duration and frequency. While the STPIS does not target specific asset classes, good asset performance will have a significant impact on TasNetworks' ability to meet the STPIS targets.

STPIS parameters include:

- System Average Interruption Duration Index (SAIDI); and
- System Average Interruption Frequency Index (SAIFI).

Details of the STPIS scheme and performance targets can be found in the "*Electricity distribution network service providers - Service target performance incentive scheme - November 2009*".

5.2 Benchmarking

TasNetworks' service performance is benchmarked against other DNSPs through the AER's RIN framework.

In addition, TasNetworks also works closely with its DNSP counterparts, to compare asset management practices and performance.

6 Description of the Assets

6.1 Overhead Conductors and Cables

Overhead conductors provide the means for electricity to be transported over medium to long distances in urban and rural areas across the distribution network system.

Table details the types of overhead conductor and cable installed in the system.

Table 1: Overhead conductors and cables installed in TasNetworks' distribution system (as at Jan 2015)

Description	**Length Installed (km)**
HV Conductors – Copper	1,288
HV Conductors – Aluminium	8,436
HV Conductors – GI	5,888
HV Conductors – ACSR	730
HV ABC	18
LV Conductors	4,973
Total	**21,323**

The size of the cross sectional area of each strand or group of strands determines the current carrying capacity of the conductor – the larger the cross sectional area the greater the current capacity flow. Although there are many varying sizes of bare conductor, standardised sizes have been introduced which satisfy the network management of voltage levels and current flow in conjunction with the electrical equipment employed in the distribution system.

The varying types and sizes of overhead conductor is a legacy of the changing customer supply requirements, cost constraints, improvements and efficiencies in technology, the refinement of planning tools/models and design standards of the day.

Table 2: Failure Statistics for Bare Wire Conductor Failures

Cond Type	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Total**
AA	1	1	3	7	8	10	13	11	9	3	12	9	12	8	63
AAA	2	0	2	2	4	1	6	10	9	8	3	5	10	13	36
ACSR	0	0	0	1	2	0	4	6	2	1	4	3	4	1	15
Cu	0	0	4	2	1	5	7	7	8	4	5	1	11	13	34
GI	7	3	1	7	11	7	20	13	15	4	14	9	17	28	84
ALL (known)	10	4	10	19	26	23	50	47	43	20	38	27	54	63	232
All TOTAL	**38**	**40**	**48**	**48**	**46**	**44**	**67**	**53**	**43**	**20**	**38**	**27**	**54**	**63**	**428**

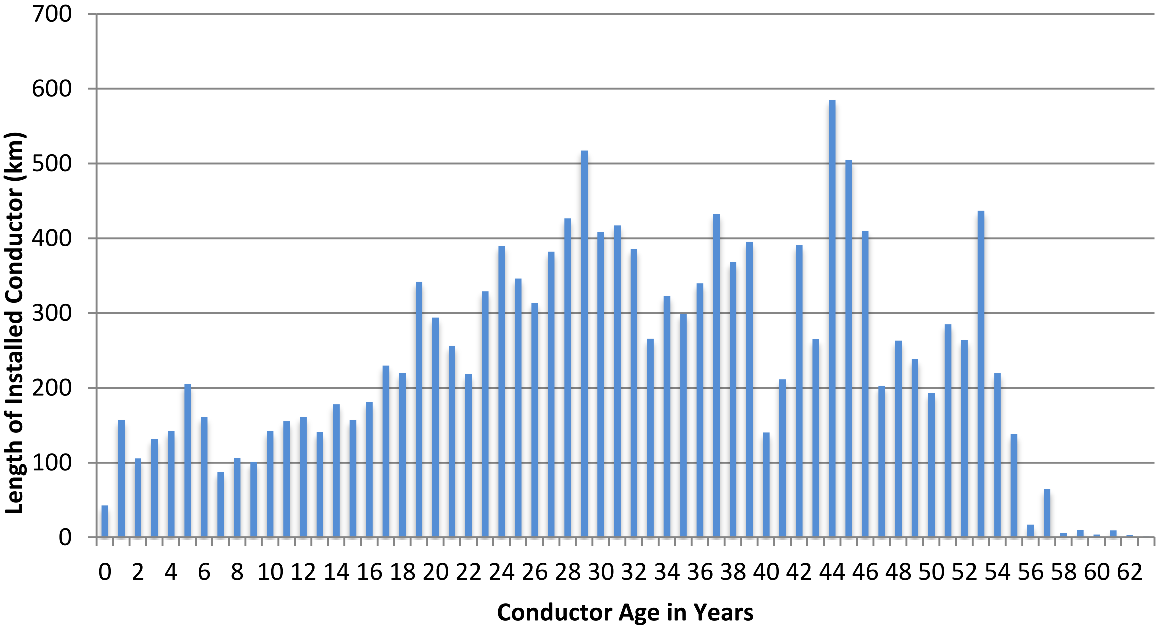


Figure 2: Estimated Age Profile for all HV Conductor in the Network

6.1.1 Bare Open Wire Conductors

The most commonly used type of conductor installed in the overhead system is bare open wire type conductor. The support structures and pole top equipment are designed to maintain phase to phase separation and provides the required clearance to ground and third party infrastructure.

HV bare open wire conductor is by far the easiest and most cost effective conductor to install, replace and augment of the conductor types presently in use within the industry.

The current standard materials used as bare open wire conductors are:

1. All Aluminium Conductor 19/3.25 AAC (Neptune);
2. All Aluminium Conductor 7/4.50 AAC (Mercury);
3. All Aluminium Alloy Conductor 7/3.00 AAAC (Fluorine); and
4. Steel Conductor 3/2.75 SC/GZ (GI).

Other legacy materials found in the overhead system but no longer installed include:

1. Aluminium Conductor Steel Reinforced (ACSR/GZ): multi-strand conductor with a strengthening galvanized steel core;
2. Copper (Cu): multi-strand conductor; and
3. Galvanised Iron (GI): both single strand (such as No.8 GI) and multi-strand (such as 3/12 GI).

6.1.2 Aerial Bundled Cable (ABC)

Aerial Bundled Cable (ABC) is an insulated overhead conductor of either two or three wire bundled or twisted configuration. Both HV and LV ABC are installed within the distribution system.

ABC can reduce safety and bushfire risks, minimise the vegetation clearing around the overhead power lines and improve supply reliability through minimising the impacts of vegetation, birds, animals and windborne objects on the overhead power lines.

LV ABC is TasNetworks' standard conductor for any new LV networks and the replacement of existing LV networks unless the LV ABC is unsuitable, such as for long single phase spans. In this situation, bare overhead LV conductor is used.

HV ABC is a fully screen insulated cable consisting of three phases wrapped around a catenary wire. Due to problems with installation leading to greater costs of installation, HV ABC is primarily installed in selective locations, such as heavily vegetated areas or areas prone to wind and bird and animal affected areas to reduce the impact of these on the overhead system.

6.1.3 Covered Conductors (CC)

Covered Conductor (CC) differs from HV ABC in that CC is a single core unscreened self-supporting cable with an XLPE insulation thickness of 2 mm. If the insulation thickness is equivalent to that required for the rated voltage it is termed Covered Conductor Thick (CCT). HV ABC is touch safe while, due to the lack of screen, covered conductor, both CC and CCT, is not.

PVC is the predominant material used as the insulating cover on LV service cables.

Covered conductors are primarily used for the overhead service cables connecting the customer's installation to the LV distribution network. There is a small amount of LV covered conductor used elsewhere in the system.

The use of covered HV conductors is being investigated as a cost effective solution as it has potential to reduce the impact of vegetation, wind and wildlife on the overhead system. However, there are currently installation issues to be overcome before it can be used in the system.

6.1.4 Pilot Cables and Fibre Optic Cable

Pilot cables are used to facilitate protection and control between various distribution substations within Hobart's central business district.

Fibre optic cables are used for protection and control between TasNetworks' 110/33 kV substations and urban zone substations.

6.1.5 Earthing Conductors

Earthing conductors are used to connect non-current-carrying metallic parts of overhead system equipment, such as pole mounted transformer tanks and switchgear operating handles, to the HV earthing system. They provide a low impedance path for the flow of earth fault current into the ground for the reliable operation of protection devices, and they help to control voltage rises associated with faults.

6.2 Pole-top Hardware

TasNetworks’ Pole-top Hardware comprise of:

- Insulators;
- Cross-arms;
- Conductor fittings;
- Surge arrestors;
- Bird diverters;
- Aircraft warning markers;
- Live line clamps; and
- Vibration Dampers

6.2.1 Insulators

The insulators provide an insulated means of attaching the conductors to the poles. The type of insulator, size and make used are dependent on the level of voltage of the conductors, the design requirements of the overhead line and various external influences such as pollution, weather conditions, and geographic location.

Generally HV and LV insulators are porcelain or glass and bolt to the cross arm or pole by the means of a steel pin or bolt.

6.2.2 Cross Arms

Cross arms are used to connect the insulators to the structure and provide adequate clearance between conductors.

HV cross arms are steel as it offers the structural integrity to withstand the high conductor load tensions and associated loads imposed.

LV cross arms are predominantly manufactured from timber as this medium is cost effective and offers insulation qualities to allow live line activities to be performed safely.

Investigations of alternative crossarms have recently taken place and a fibreglass LV crossarm is currently being trialled in the Hobart area.

Figure 3: Steel HV crossarms

Figure 4: Wooden LV crossarms

Figure 5: Fibreglass LV crossarm

6.2.3 Conductor Fittings

Conductor fittings are used to secure conductors to their supports and for connections between conductors. Various types of fittings are used depending on the size and type of conductor to be joined, the geographical and electrical location within the network and electrical loading of the conductors.

The general methods of connection include welds, compression, bolted, tension methods or AMPAC (wedge).

Bare overhead conductors are attached to insulators using conductor ties. The ties are generally the same material as the conductor.

6.2.4 Surge Arresters

Surge arresters are installed to prevent damage to equipment in the event of a direct lightning strike on the overhead system.

Generally surge arresters are installed on specific equipment, such as pole mounted transformers. However, the surge arresters may also be placed in the overhead system at strategic locations prone to lightning strike.

HV ABC installations and where underground cable connects to the overhead system are examples of locations where lightning arresters would be installed.

6.2.5 Bird Diverters

Swans, geese, waterfowl and other large birds commonly collide with conductors. Bird diverters are installed to make conductors more visible to birds. Birds cause over 400 outages a year on TasNetworks' distribution system.

Figure 6: Bird diverters installed on conductor

6.2.6 Aircraft Warning Markers

Aircraft warning markers are installed on certain overhead conductors and equipment to warn aircraft pilots about the presence of aerial obstacles. Under AS/NZ 3891.1-2008 (reference 2) requires any conductor installed more than 90 metres above the ground or with a span length longer than 1500 metres to be marked with Aircraft warning markers. This standard also requires any overhead line installed within specified limits of a CASA registered airport to be marked.

AS/NZ 3891.2-2008 (reference 2) specifies the responsibilities of pilots regarding line marking.

6.2.7 Live Line Clamps

In the past, live line clamps were used to connect new transformers directly to HV feeders without requiring an outage. This connection was intended to be a temporary connection and to be changed to a ‘D-clamp’ at the next planned outage. However, records were not well kept of installations connected using live line clamps and many were not changed to D-clamps and it is estimated that there are approximately 10,000 live line clamps still connected (according to the WASP defect pool).

The connection of a live line clamp directly onto a live tensioned conductor can result in arcing, eroding individual strands of the conductor and greatly reducing its strength. The risk is greater for Galvanised Iron (GI) conductor as this arcing can remove the galvanising, which exposes the iron to moisture build up underneath the clamp. This results in corrosion of the conductor, which will lead to conductor failure or the fusing of the conductor to the clamp.

Figure 7: Live line clamp directly connected

Figure 8: Live line clamp connected via D-clamp

6.2.8 Vibration Dampers

A damper is a relatively simple device used for minimising the effects of wind-induced vibration on power lines. Sustained vibration can lead to wearing and abrasion of a conductor and the ties near the connection point. It is for this reason that dampers are normally installed within a hand's width of where the conductor finishes at a pole. Dampers are helically wound around the outside of the conductor and clamped at one end. As the vibrating conductor hits the inside of the damper coil the coil disturbs the build-up of natural frequency, thereby reducing vibration.

TasNetworks installs vibration dampers in areas prone to heavy winds such as close to the coast, subject to Aeolian vibration.

7 Associated Risk

TasNetworks' Integrated Risk Management Model (Risk Management Model) provides the essential supporting structure for risk management across the organisation. The Risk Management Model is based on the international standard for risk management AS/NZS ISO3100 Risk Management – Principles and Guidelines.

Risks are assessed considering the potential impacts on:

1. Financial performance;
2. Business continuity;
3. Customer outcomes;
4. Regulatory and legal obligations;
5. Corporate reputation;
6. Environment and community; and
7. People and safety.

The following section details the business risks specific to this project, as identified in TasNetworks Risk Management Framework as at March 2015.

7.1 Risk Matrix

TasNetworks business risks are analysed utilising the 5x5 corporate risk matrix, as outlined in TasNetworks Risk Management Framework.

Tables 3 & 4 contain the relevant strategic business risk factors that apply to distribution conductors and hardware.

Table 3: Strategic business risk factors for distribution conductors

Risk Category	Risk	Likelihood	Consequence	Risk Rating
Financial	Excessive payout of reliability incentive schemes (STPIS, GSL, NCEF) from declining network reliability	Unlikely	Moderate	Medium
	Conductor failure results in catastrophic bushfire. Insurance providers refuse to cover TasNetworks for future events	Unlikely	Severe	High
Customer	Disruption to customers from declining network reliability	Possible	Minor	Low

Regulatory Compliance	Increased number of unplanned outages leads to systemic NCEF breaches	Possible	Moderate	Medium
Network Performance	Localised interruption of supply to customers	Likely	Minor	Medium
Reputation	Conductor failure results in catastrophic bushfire with significant media coverage	Unlikely	Moderate	Medium
Environment and Community	Conductor failure results in a catastrophic bushfire with widespread loss of property	Unlikely	Severe	High
Safety and People	Conductor failure results in a fatality or permanently impairs a person’s life	Unlikely	Severe	High

Table 4: Strategic business risk factors for distribution line hardware

Risk Category	Risk	Likelihood	Consequence	Risk Rating
Financial	Excessive payout of reliability incentive schemes (STPIS, GSL, NCEF) from declining network reliability	Unlikely	Moderate	Medium
	Asset failure results in catastrophic bushfire, insurance providers refuse to cover TasNetworks for future events	Unlikely	Severe	High
	Wider asset damage results from a minor fault not being rectified (e.g an unfixed broken tie causes a pole fire, contact with a low conductor pulls poles down)	Likely	Minor	Medium
Customer	Disruption to customers from declining network reliability	Moderate	Likely	High
Regulatory Compliance	Increased number of unplanned outages leads to systemic NCEF breaches	Possible	Moderate	Medium
Network Performance				
Reputation	Asset failure results in bushfire with significant media coverage	Possible	Moderate	Medium
	Asset failure results in catastrophic bushfire with significant media coverage	Unlikely	Major	Medium

Environment and Community	Asset failure results in bushfire with some loss to property	Possible	Major	High
	Asset failure results in catastrophic bushfire with widespread loss of property and potential fatality	Unlikely	Severe	High
Safety and People	Asset failure results in injury or death to member of the public	Unlikely	Severe	High

8 Management Plan

8.1 Historical

TasNetworks asset management practices on the overhead and structures asset classes have been stable for a number of years, however current practices are under review, with the approach changing to Reliability Centred Maintenance (RCM).

Although there is a robust condition based replacement process for structures, condition based replacements of overhead assets can be improved. Better understanding of the condition of the overhead assets is required; hence the historic inspection process will be reviewed to support this.

Operational expenditure on the overhead system is increasing. This is due to an increase in the volume of defects reported along with a growing pool of existing defects carried over from previous years where tasks have been put on hold due to resource and budget constraints. This has prompted a review of TasNetworks' defect management process and has resulted in some restructuring of programs.

8.2 Strategy

8.2.1 Routine Maintenance

There is a fundamental requirement for TasNetworks to periodically inspect its overhead conductors and hardware to ensure their physical state and condition does not represent a hazard to the public. Other than visiting the assets, there is no other economic solution to satisfy this requirement.

8.2.2 Planned Asset Replacement versus Reactive Asset Replacement

Failure of overhead conductor and hardware assets have the potential to result in a bushfire or a serious injury or fatality to a member of the public. It is therefore seen as prudent to inspect the condition of assets on a regular basis and replace or reinforce assets in poor condition before it fails. Poor condition assets are identified from the maintenance and inspections activities and feed into the list of proposed capital expenditure projects for prioritisation. While poor condition assets are primarily replaced for safety reasons, there is also an economic advantage as reactive replacements are generally several times more expensive, incurring overtime, call out penalties and additional repair costs to cable terminations and nearby infrastructure. By identifying weak spots and defects prior to asset failure, reactive maintenance can be undertaken with less disruption to customers at lower cost, and potential fire starts can be avoided.

8.2.3 Non Network Solutions

Non Networks Solutions are generally not applicable for conductors and hardware asset class.

Other options do exist to minimise customer disruption, including temporary mobile generation substitution while an asset is out of service. TasNetworks currently has one mobile generator and has leasing arrangements in place to source additional units as required.

8.3 Routine Maintenance

8.3.1 Overhead System Aerial Inspections (AIOFD)

The business objectives driving this program are:

1. Managing Business Operating Risk (through identifying defects before they impact on safety or fire risks – primary driver); and
2. Maintaining Network Performance (through identifying defects before they impact on reliability – secondary driver).

The overhead system contributes to over 60 percent of total asset failure contribution to TasNetworks' SAIDI and SAIFI (reference 3). The aim of this program is to effectively target maintenance and replacement activities.

In early 2012 a Reliability Centred Maintenance (RCM) review of the overhead system identified that the best way to manage the failure modes of overhead assets and poles was to decouple the overhead asset inspection from the ground-line pole inspection.

This RCM review resulted on the ground-line inspection of poles moving to a five year cycle.

The review also recommended the introduction of the following inspection programs:

1. Aerial inspection program for pole top assets (5 year cycle);
2. Thermal imaging program (2 year cycle); and
3. OH transformers earthing inspection (10 year cycle)[1]

A visual inspection from ground level limits the Asset Inspector from completing a full assessment of the pole top assets making the identification of critical asset failures such as broken tie wires and faulty cross-arms difficult. The RCM review identified that TasNetworks should visually inspect pole tops from above every five years as part of its new overhead system maintenance strategy.

The use of high definition imagery and remote sensing technologies for asset inspection is becoming commonplace throughout the utility sector across the world, and is gaining acceptance as standard industry best practice. A detailed trial in 2013 of various available technologies (including unmanned aerial vehicles and hi-mast) found that helicopters provided the most cost effective solution. Helicopters also have an added advantage of being able to assist with vegetation inspections due to their ability to efficiently patrol long stretches of feeder.

This program consists of using a helicopter to inspect feeders from the air. The inspections will run on a rolling five year program and cover approximately 44,000 poles per year. In the years 17/18-19/20 additional funds have been allocated to also inspect TasNetworks' poor performing feeders.

This is a new program that commenced in 2014/2015. TasNetworks has used aerial inspections in the past on an ad-hoc basis, for example for fault finding. However previously they have not used aerial inspections as part of a long term routine program.

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[1] *OH transformers earthing inspection program is inculded in the Distribution Pole Mounted Transformers Asset Management Plan*

Figure 9: The same pole seen from the ground and from the air

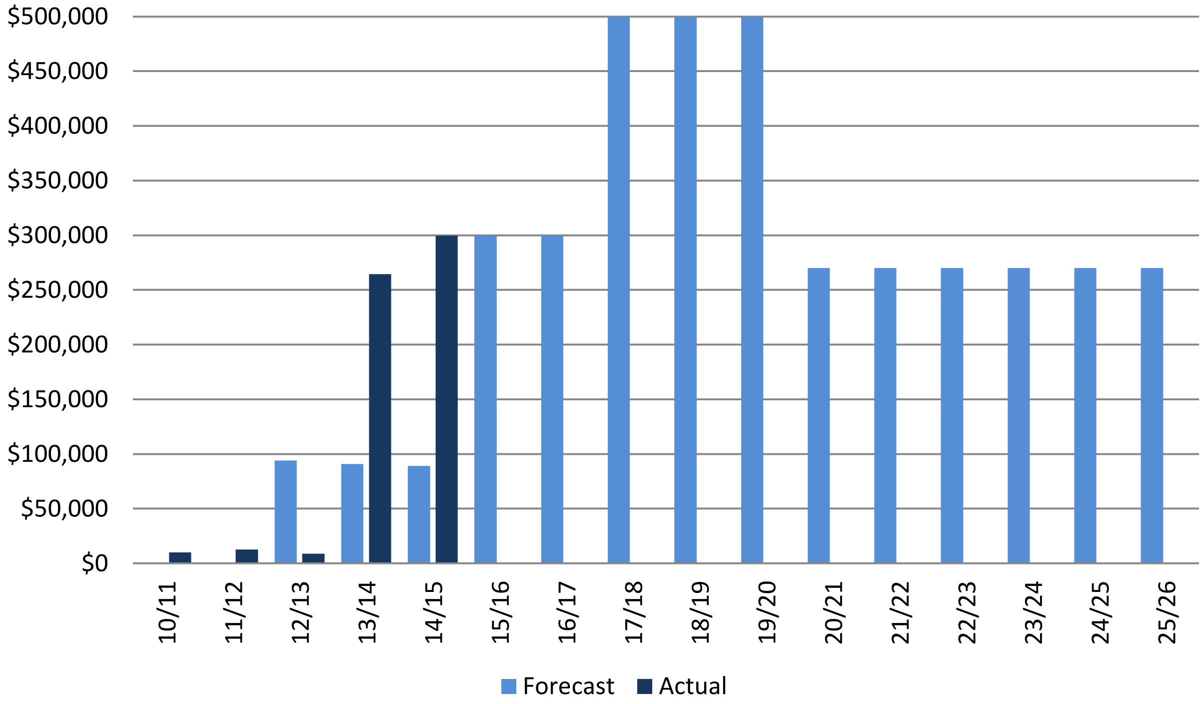

Figure 10: Overhead System Aerial Inspections Expenditure

8.3.2 Thermal Inspections – O/H Feeders (AIOTI)

The driver for this program is managing business operating risks (safety) through preventing fire starts. Network reliability improvement was considered as a secondary benefit of the implementation of this program. From 01 July 2012 to 27 April 2015 (this regulatory period), TasNetworks experienced 2311 outages as a result of asset failure that may have been identified through the thermal inspection program.

This program entails the use of a thermal imaging camera to identify joints or connections that are displaying signs of high resistance within the network. The results of a recent RCM analysis identified this work as being critical to the overhead strategy of no failures that matter. By identifying weak spots and defects prior to asset failure, reactive maintenance can be undertaken with less disruption to customers at lower cost, and potential fire starts can be avoided.

This program commenced as part of the 2013/2014 POW and was expanded in 2014/2015 to include systematic inspections of all poles containing joints/connections and mid-span connections with greater than 1000 kVA connected downstream over a three year inspection cycle.

In April 2015 a review of this program was undertaken (see AIOTI Strategy Review, reference 6) which identificated a number of opportunities for improving the program's effectiveness and efficiency. This resulted in a more targeted approach and co-ordinating the inspection so feeders are inspected at a times when they are more heavily loaded. From 15/16 onwards for particular areas of the network such as the high bushfire consequence area and on the seven worst performing feeders the 1000 kVA threshold will be maintained. For all other areas of the network it is the inspection threshold will be raised to 4000 kVA, to maximise the likelihood of finding asset defects.

Figure 11: A Live Line Clamp through a thermal imaging camera and a normal camera

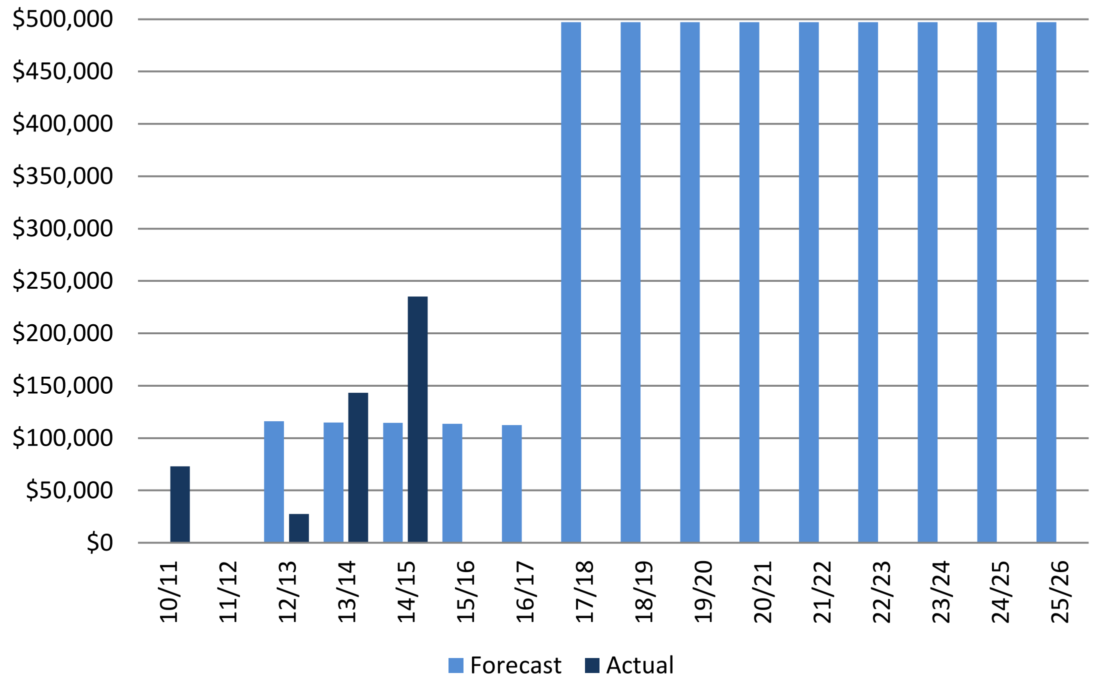

Figure 12: Thermal Inspections of Overhead Feeders Expenditure

8.4 Non Routine Maintenance

8.4.1 OH System Asset Repairs (Defects) (AROCO)

The drivers for this program are managing business operating risks and maintaining network reliability.

This program covers minor asset repairs that have been identified and have the potential to cause asset failure in the future or shorten the expected life of the asset.

The majority of these defects are reported through the Pole inspection program (AIOHS) and the Overhead System Aerial Inspections program (AIOFD. Defects identified include minor work involving asset repair such as refixing loose material, replacing possum guards, replacing loose ties, etc.

A review of the defect pool has resulted in changes to priorities. Some defects, such as missing pole caps and possum guards will no longer be rectified. Replacement of decayed cross arms has been separated into a new targeted capital program (Refer to RELSA Replace Cross Arms (Safety)).

In 2014/2015 TasNetworks began inspecting its assets from the air. This provided a previously hidden view of the network that showed many assets were in worse condition than previously thought. The first aerial inspection which focused on the High Bushfire Loss Consequence Zone, found a total of 1700 defects (5 per 100 poles), all of which were considered to be potential fire start risks, this resulted in expenditure much higher than forecast. As aerial inspections are done on a five year cycle there is expected to be an increase in overhead maintenance over the next five years, following the first round of aerial inspections as these will pick up defects that have gone undetected for many years. The second round of aerial inspections is expected to yield a much lower volume of maintenance work.

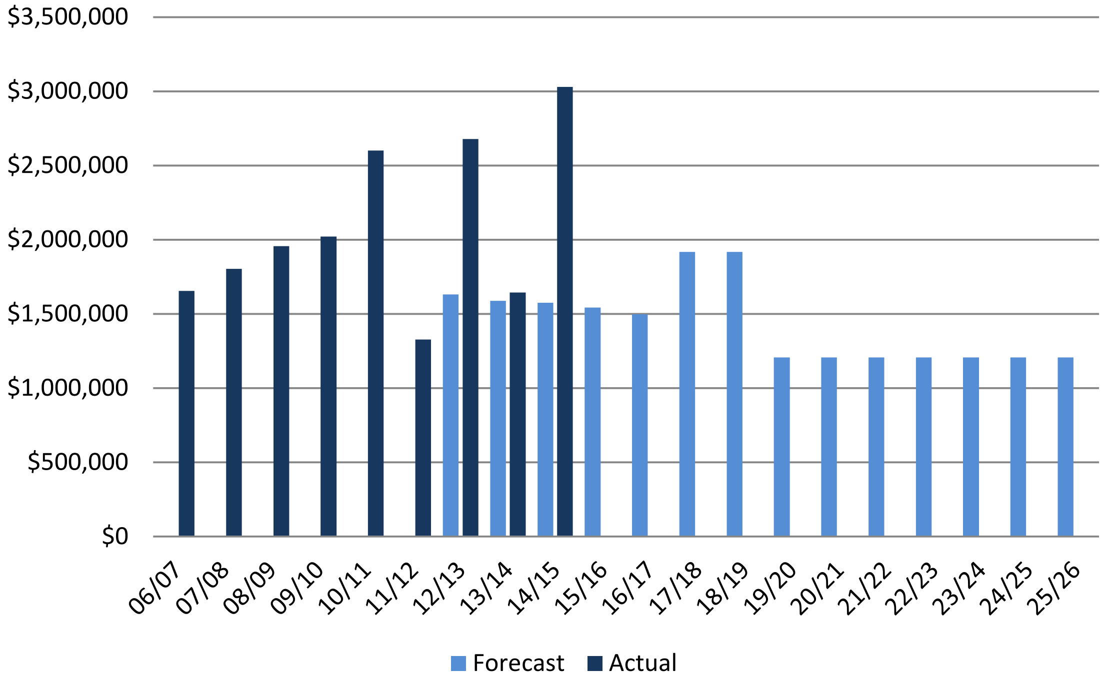

Figure 12: OH System Asset Repairs (Defects) Expenditure

8.4.2 OH System Low Conductor Clearance (AROLC)

The driver for this program is managing business operating risks.

TasNetworks experiences approximately 30 incidents every year where third party vehicles contact/pull down overhead services.

This program covers simple repair tasks such as the re-tensioning of slack spans of LV and HV conductor to address conductor clearance issues. Where a more complex solution is required (such as the installation of a pole), this work is undertaken as an asset replacement task.

Approximately 1,100 low voltage and LV service conductor clearance defects are identified every year.

There are no major changes to this program and the proposed expenditure is to remain consistent with historical spend.

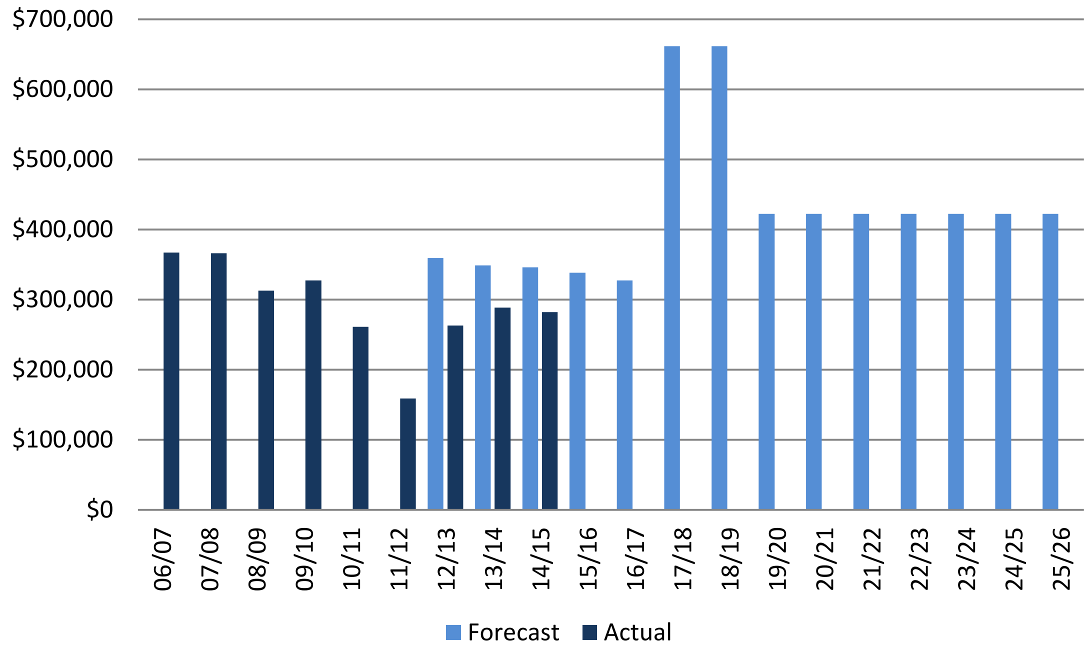

Figure 13: OH System Low Conductor Clearance Expenditure

8.4.3 Maintain Access Track and Weed Management (RMOTC)

The budget for this program has historically been commandeered by the Vegetation team. Therefore the budget in the 2014/2015 POW has been substantially reduced to reflect the low level of spend by the Overhead/Structures team in this program.

There are two components to this program:

1. Access track maintenance; and
2. Weed management.

8.4.3.1 Access Track Maintenance

The aim of this program is to maintain tracks to a level and condition such that safe all-weather access to TasNetworks lines and equipment is possible for the purposes of routine maintenance and emergency fault repairs.

Experience within TasNetworks has shown existing access tracks need to be maintained approximately every four years for optimum cost versus benefit and to stop them degrading to the stage where they require extensive works.

8.4.3.2 Weed Management

There are specifically designated clean and unclean sites, farms and areas with respect to weed and disease around the state. Although TasNetworks has strict weed and disease management procedures in place when travelling between these areas, the aim of this program is to reactively address situations where TasNetworks' activities have contributed to the spread of weeds, such as gorse outbreaks in gorse-free areas within TasNetworks' easements.

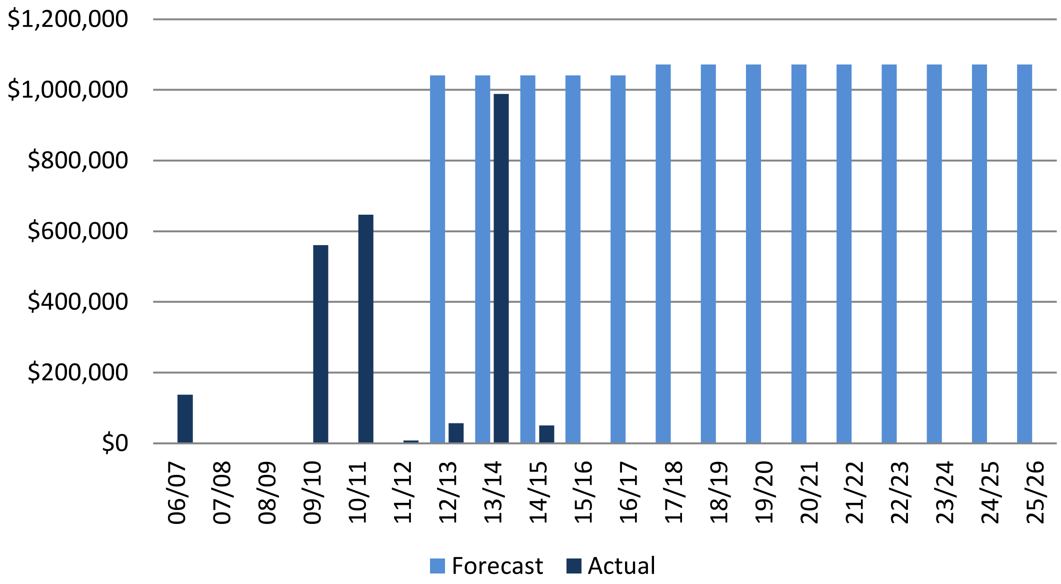

Figure 14: Maintain Access Track and Weed Management Expenditure

8.5 Reliability and Quality Maintained

8.5.1 Low HV Conductors (REHCR)

The driver for this project is managing business operating risks.

This program covers the relocation or replacement of HV overhead conductor to address low clearance associated with road crossings and plant contact that cannot be repaired under the reactive maintenance program such as the installation of a pole to fix the clearance issue.

Low HV conductors pose a significant public safety risk and are addressed as soon as possible.

There are no major changes to this program and the proposed expenditure is decreased compared to historical spend.

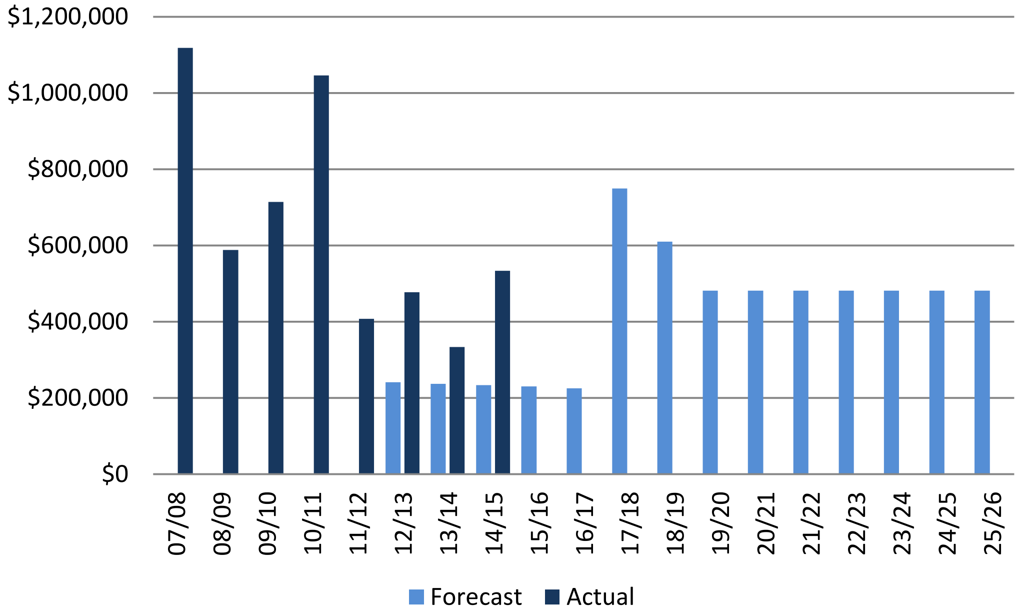

Figure 15: Low HV Conductors Expenditure

8.5.2 Rectify Low LV Clearances Public Safety (RELCR)

This program covers the relocation or replacement of LV overhead conductor to address low clearances associated with road crossings and plant contact that require more complex solutions, for example new pole installations, than available under the reactive maintenance program (AROLC).

TasNetworks experiences approximately 30 incidents every year where third party vehicles contact/pull down overhead services.

Approximately 1,100 low voltage and LV service conductor clearance defects are identified every year.

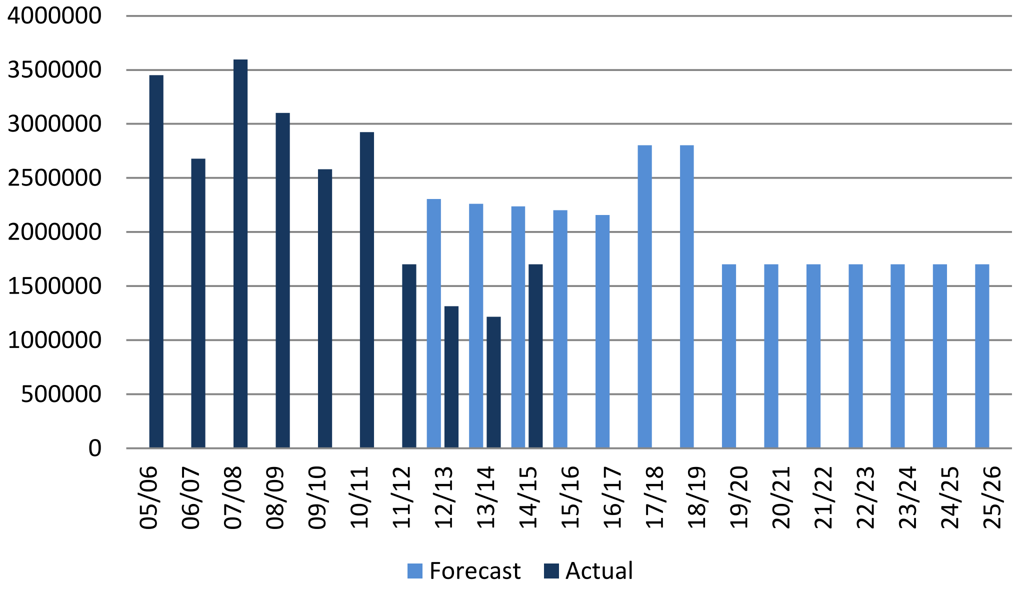

Figure 16: Rectify Low LV Clearances Public Safety Expenditure

8.5.3 Replace/Relocate HV due to Vegetation Issues (REHVE)

The driver for this program is minimising costs to customers and managing business operating risks (fire).

The aim of this program is to address the issue of high vegetation maintenance costs in certain areas. Historically, there have been cases where it is more efficient to relocate assets around vegetation rather than managing the vegetation near the assets such as areas where vegetation is protected (national parks) or where there are community or environmental considerations or where there are onerous vegetation management requirements due to bushfire risk management.

This program has been in place for a number of years but as part of Replace HV Feeders (Safety) and Fire Mitigation asset replacements.

There are no major changes to this program however the budget will be developed in response to incoming work only.

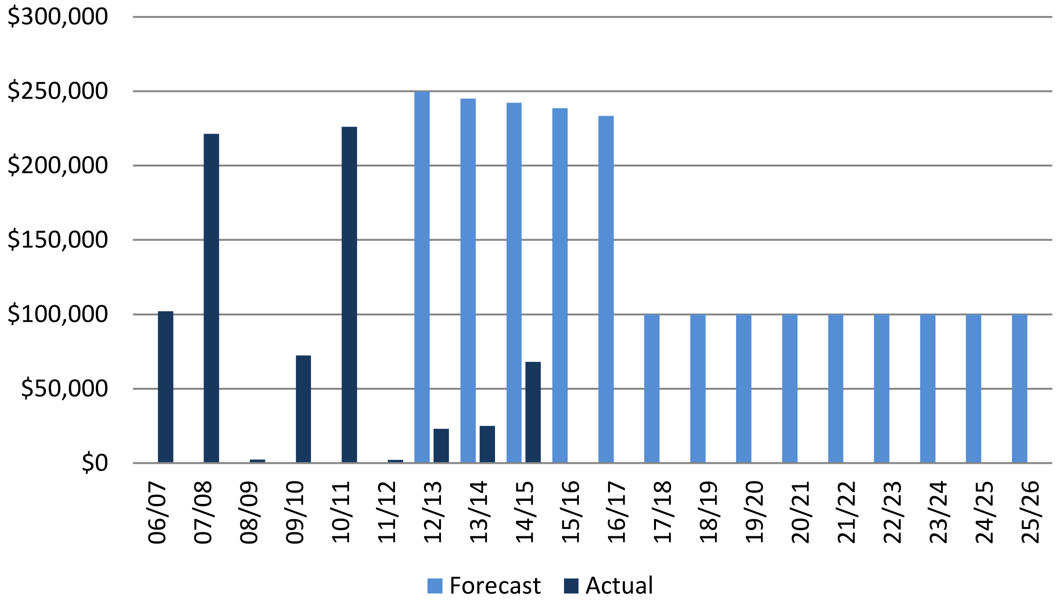

Figure 17: Replace/Relocate HV due to Vegetation Issues Expenditure

8.5.4 Replace Cross Arms (RELSA)

The drivers for this program are managing business operating risks. This program commenced midway through 2013/2014 and will continue on throughout the next regulatory period. This is a targeted asset rectification program which focuses mainly on decayed timber cross arms, but also includes other cross arm related defects (such as loose/missing steelwork and transformers hung directly on timber cross arms). This work was previously done under AROCO OH System Asset Repairs Defects, but has been separated into a dedicated program in order to drive efficiencies.

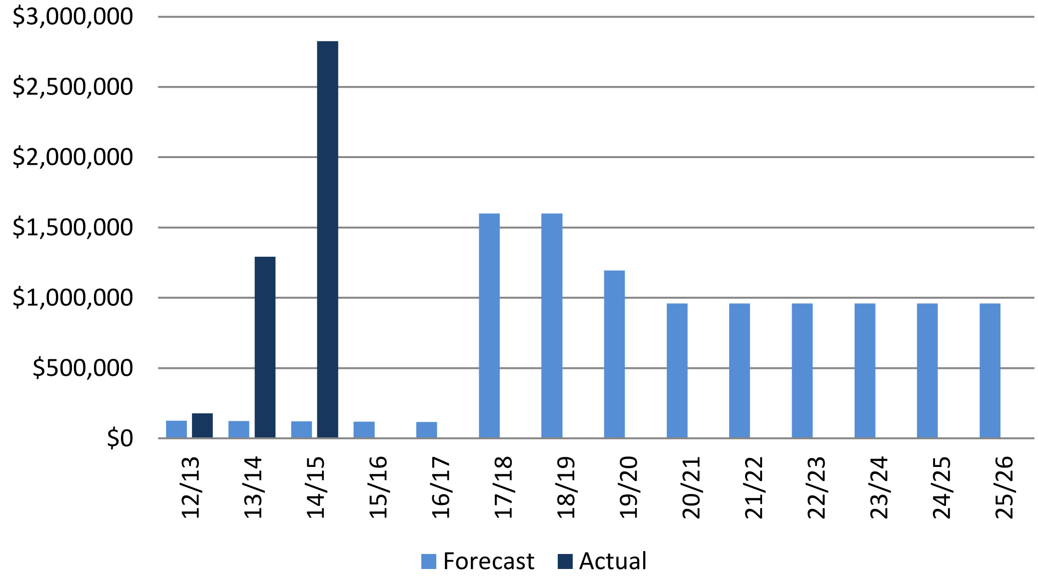

Figure 18: Replace Cross Arms Expenditure

8.5.5 Replace Substandard Overhead Conductor (REMCU/REMGI)

Substandard overhead conductor may result in broken wires, presenting fire and safety risks as well as interrupting supply to customers. Copper and Galvanised Iron Conductor have been identified as representing the highest proportion of conductor failures and so have been targeted for replacement programs. There are two programs for replacing substandard overhead conductor:

1. Replace Substandard Overhead Copper Conductor (REMCU)
2. Replace Substandard Overhead Galvanised Iron (GI) Conductor (REMGI)

TasNetworks records on average approximately 100 outages caused by conductor failures every year. In 2013/2014, conductor failures contributed 10.6 minutes SAIDI (or 11% of the total asset related failure contribution TasNetworks records on average approximately 100 outages caused by conductor failures every year. In 2013/2014, conductor failures contributed 10.6 minutes SAIDI (or 11% of the total asset related failure contribution to SAIDI of 99.8 minutes) and 0.07 interruptions SAIFI (or 9% if the total asset related failure contribution to SAIFI of 0.77 interruptions).

Table 5 shows the results of analysis of conductor failures by distance from the coast. These results show that over 36% of all conductor failures occur within 5 km of the coast (with 21% of all conductor located within 5 km of the coast). Conductor close to the coast is more susceptible to salt spray from the prevailing winds and therefore is more likely to fail due to corrosion.

Table 5: Conductor failure statistics by distance from coast (as at June 2015 – from WASP Outage Data)

	Distance to Coastline (km)						
Conductor Type	**0 - 5**	**5 - 10**	**10 - 20**	**20 - 30**	**>30**	**Total Failures**	**% of Total Failures**
Number of AAC failures	57	11	4	13	24	109	25%
% of all AAC failures	52%	10%	4%	12%	22%		
Number of AAAC failures	30	14	6	3	24	77	18%
% of all AAAC failures	39%	18%	8%	4%	31%		
Number of ACSR Failures	5	4	6	2	12	29	7%
% of all ACSR failures	17%	14%	21%	7%	41%		
Number of Copper failures	15	5	2	4	42	68	15%
% of all Copper failures	22%	7%	3%	6%	62%		
Number of GI failures	53	31	12	18	43	157	36%
% of all GI failures	34%	20%	8%	11%	27%		
Total Number of Failures	160	65	30	40	145	440	100%
% of All Failures	36%	15%	7%	9%	33%		

The guideline to overhead conductor replacement programs prioritisation (reference 5) details prioritisation for the replacement programs for Copper and GI conductor and the desktop analysis used to identify which conductors that have the highest severity rating.

8.5.5.1 Replace Substandard Overhead Copper Conductor (REMCU)

The drivers for this program are maintaining network performance, and compliance with regulatory responsibilities. The aim of this program is to remove substandard condition copper conductor from the overhead system.

Analysis of conductor failures has shown that the percentage of copper conductor failures in the network is higher than any other conductor type. Copper conductors make up 15% of the total failures while only representing 7.8% of total installed conductors.

Figure 19 gives the age profile of copper conductor. As the majority of copper conductor in the LV and HV system was installed prior to 1964 and will be in excess of 53 years old by the end of the current determination period (2016/2017).

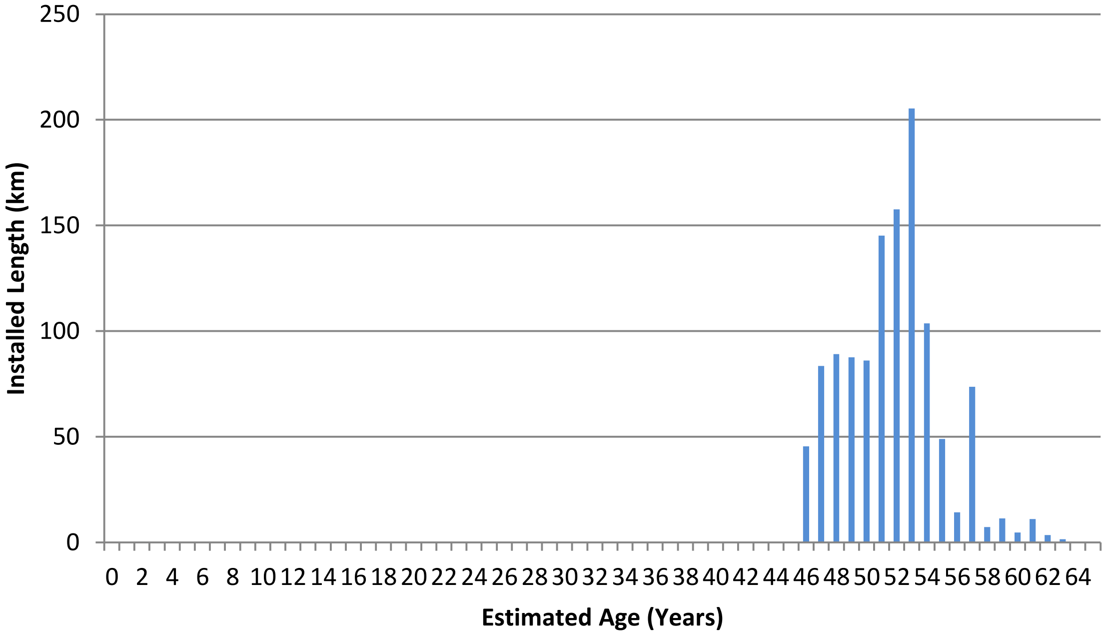

Figure 19: Copper HV Conductor Estimated Age Profile

Table 6 shows there have been an increasing trend of copper conductor failures over the past few years.

Table 6: Copper conductor failure statistics by year

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of failures	5	7	7	8	4	5	1	11	13

During their life these conductors are exposed to significant fault currents that could cause the copper to anneal (reduction in tensile strength) and scale (reduction in diameter). This deterioration, which is easily identified by its orange and scaling appearance, affects the tensile strength.

Smaller stranded conductor (7/.044 and 7/.048) does not comply with AS 7000, which requires conductors to have an ultimate breaking strength of at least 5 k.N.

Small size copper conductor is particularly susceptible to corrosion and failure in marine type environments.

The number of joints in a span can be used as an indication of the condition of the conductor.

Initial inspections have shown that approximately 35% of all inspected conductor will require replacement in the near future however, conductor failure rates will be monitored and conductor inspections undertaken.

This program has been in place for a number of years but as part of Replace HV Feeders (Safety) (REHSA). A new work category was created at the beginning of the 2012-2017 Determination Period for this work.

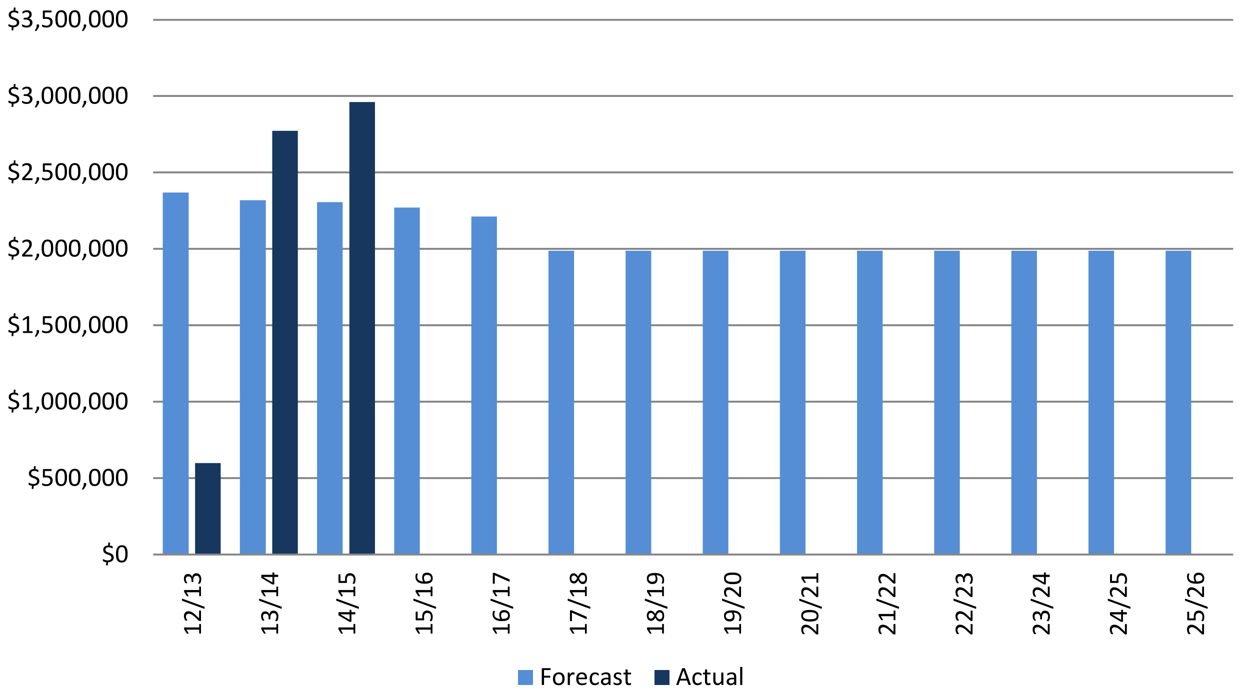

Figure 20: Replace Substandard Overhead Copper Conductor

8.5.5.2 Replace Substandard Overhead Galvanised Iron (GI) Conductor (REMGI)

The drivers for this program are maintaining network performance and managing business operating risks (safety). The aim of this program is to remove substandard condition GI conductor from the overhead system and to replace sections of overhead GI conductor around coastal areas.

Galvanised Iron (GI) conductor came into service in the 1940s. TasNetworks stopped installation of single strand No. 8 GI conductor in the 1970s and the imperial 3/12 GI conductor was replaced with the metric 3/2.75 GI conductor around 1976, which is the present day TasNetworks standard for rural conductors across private property. By the end of the current determination period (2011/2012), the minimum age of any 3/12 GI conductor will be 41 years with the majority greater than 50 years.

AS 7000 (Reference 8) rates GI conductor as a very poor conductor in marine environments. When subjected to wind borne salt spray and sea fogs containing salt contaminants, salt crystals are deposited on to the steel conductors. A galvanic cell is formed and removal of the zinc coating results over time. Once the zinc coating has been removed, severe corrosion of the steel leads to loss of mechanical strength and eventual conductor failure.

The risk of public safety as a result of conductor failure in marine environments is exacerbated by the fact that most of these conductors are at the end of long feeders and the ground is sand, having a high resistance, making it highly probable that the protection will not see the event as a fault and isolate the line.

Table 7 shows the number of galvanised iron conductor failures by year.

Table 7: Galvanised iron conductor failure statistics by year

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of failures	7	20	13	15	4	14	9	17	28

Table 7 shows the results of geospatial analysis of galvanised iron conductor failures from 2010-2014. These results indicate that conductor closer to the coast is more susceptible to salt spray from the prevailing winds and therefore are more likely to fail due to rusting. It can also be seen that galvanised iron conductor represents an average of 36% of all failure.

Table 7: Conductor failure statistics by distance from coast (2010-2014)

	Distance to Coastline (km)				
Row Labels	**0 - 5**	**5 - 10**	**10 - 20**	**20 - 30**	**>30**
AA	57	11	4	13	24
AAA	30	14	6	3	24
ACSR	5	4	6	2	12
Cu	15	5	2	4	42
GI	53	31	12	18	43
Grand Total	160	65	30	40	145

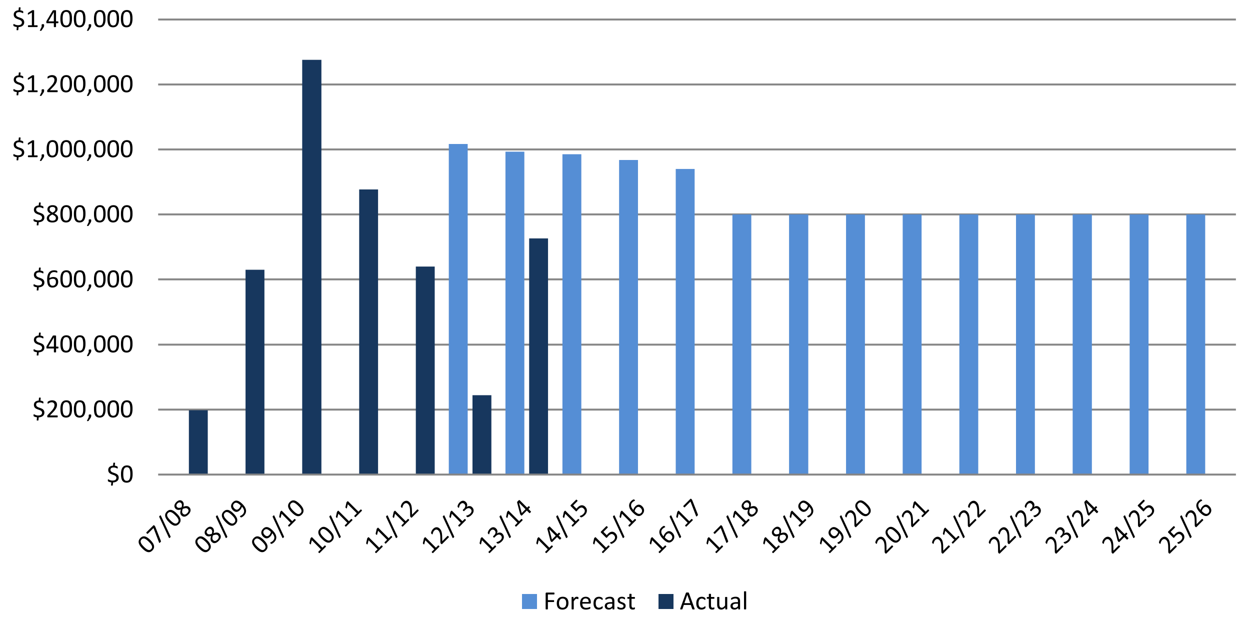

Figure 21: Replace Substandard Overhead Galvanised Iron (GI) Conductor Expenditure

8.6 Regulatory Obligations

8.6.1 Replace HV Feeders – Safety (REHSA)

This category is for miscellaneous small scale capex jobs that are scoped in response to specific one off situations to do with the HV overhead system. Jobs under this category will be raised throughout the year as they arise with urgent jobs to be processed in the current financial year, and non urgent jobs to be deferred till the following year.

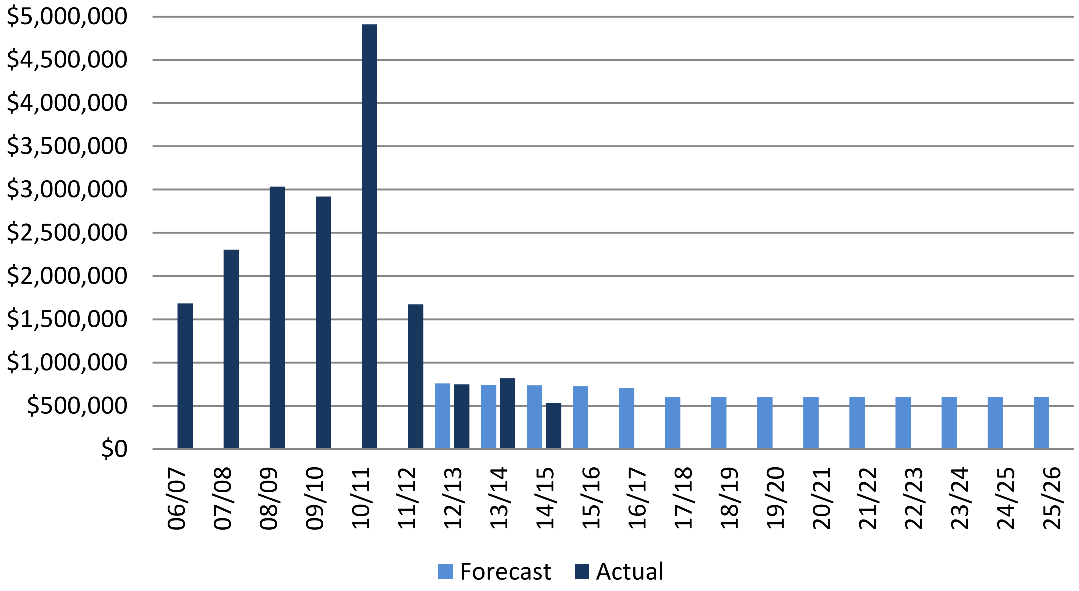

Figure 22: Replace HV Feeders – Safety Expenditure

8.6.2 Replace/Relocate LV OH (Building Clearances) (RELCL and RELCU)

The drivers for this project are compliance with regulatory requirements and managing business operating risks (safety).This program covers relocation or replacement LV overhead conductor because of issues with building clearances e.g. when new buildings are erected that infringe on TasNetworks' clearance, that cannot be repaired under the reactive maintenance program (AROLC).

This program has two components:

1. Relocating or replacing with LV ABC (RELCL); and
2. Replacing with underground cable (RELCU)

Approximately 1,100 low voltage and LV service conductor clearance defects are identified every year.

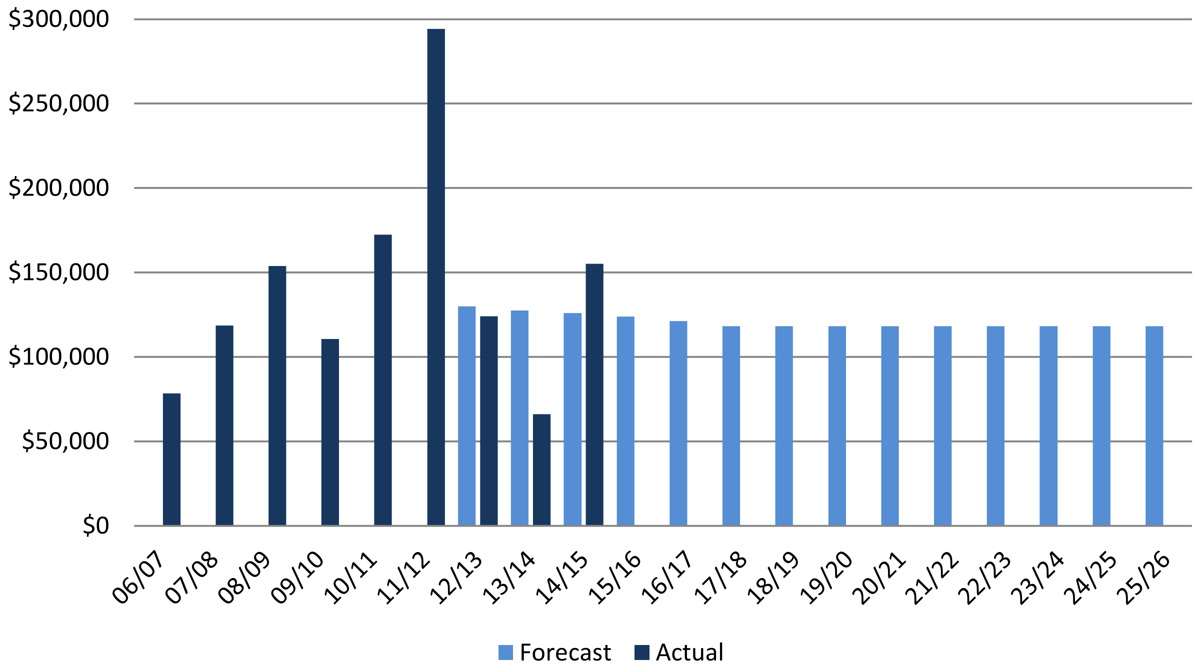

Figure 22: Replace/Relocate LV OH (Building Clearances) Expenditure

8.6.3 Endangered Species (SIWES)

The drivers for this project are compliance with regulatory requirements and maintaining network reliability.

This aim of this program is to proactively mitigate pole top assets to ensure that protected species (such as wedge tail eagles) are not harmed when interacting with poles or wires. The secondary and complementary aim is to protect overhead assets from damage due to wildlife contact. This program is based on asset failures and outage information. TasNetworks records approximately 500 outages caused birds and animals every year (including mid-span collisions). The separation distances between conductors and pole top hardware are generally adequate to prevent current tracking down the pole to the ground. However, birds and animals occasionally bridge this gap, resulting in phase-to-phase contact of the conductors and the electrocution and potential combustion of the animal. This project involves insulating live components and parts on pole tops in high wildlife trafficked areas.

This program is coordinated by the Regional Asset Manager (South) in collaboration with the relevant authorities.

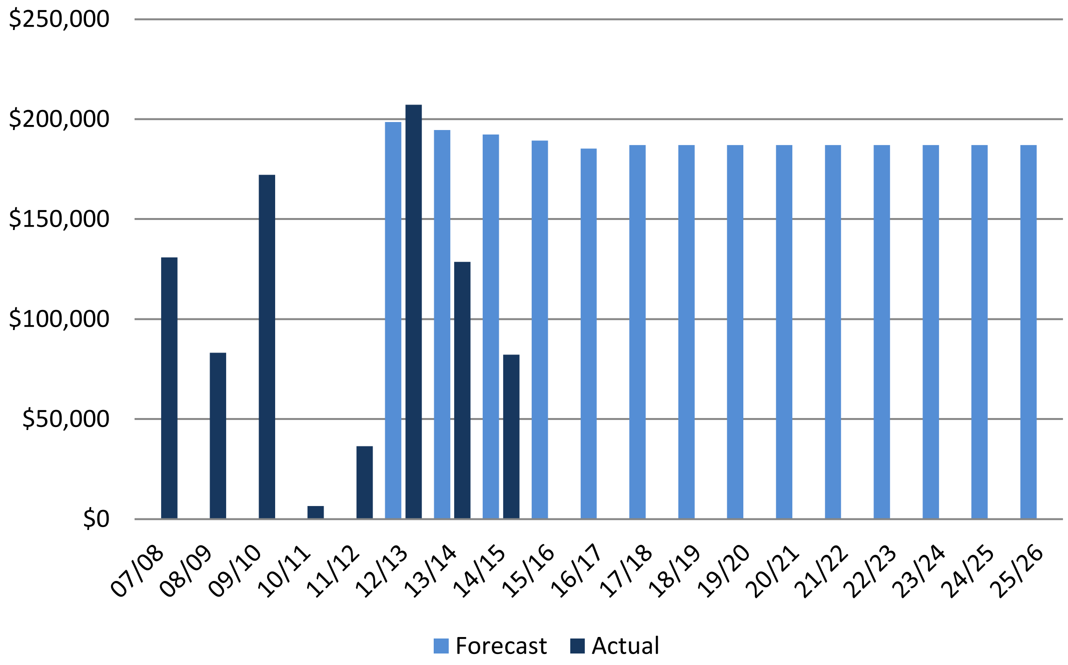

Figure 23: Endangered Species Expenditure

8.6.4 Fire Mitigation Projects (SIFIC)

TasNetworks has a number of fire mitigation programs in place to address the risk of fire start posed by the assets. These programs are pritorised by assets in the HBCA (High Bushfire Consequence Area).

Over this period the Fire Mitigation Projects program is focusing on 3 main components:

- Replace EDO fuses with Boric Acid fuses in HBCA
- Install Vibration Dampers
- Install LV Spreaders

8.6.4.1 Replace EDO fuses with Boric Acid fuses

The aim of this program is to replace EDOs with fire safe alternatives, such as boric acid fuses, to reduce the risk of fire start associated with the operation of EDO fuses.

Devices such as boric acid fuses only expel gases and not plasma and particles like EDOs, are more resilient to lightning strikes and do not 'hang up' like EDOs.

The program is to be prioritised by sites in the HBCA first then once these are complete sites in other areas of bushfire concern will be addressed. There are approximately 2590 EDO fuse sites in the HBCA. The proposed volumes for this program are 723 sites per year. At this rate it is expected that the HBCA be completed within 4 years. The program will be prioritised so that transformers and control stations in areas of high fault levels (>6 kA) and with large loads are replaced first. $1,500,000 per annum is allocated for this part of the program.

8.6.4.2 Install Vibration Dampers

This program to install vibration dampers and armour rods on long spans greater than 300m. A desk top audit and prioritisation will be performed to get volumes. At this stage it is estimated that $250,000 per annum will be required for this program.

8.6.4.3 Install LV Spreaders

This program is to retrofit LV Spreaders within all rural areas. Priority will first be within HBCA. Desktop audit is still required to be performed to get exact volumes. At this stage it is estimated that $250,000 per annum will be required for this program.

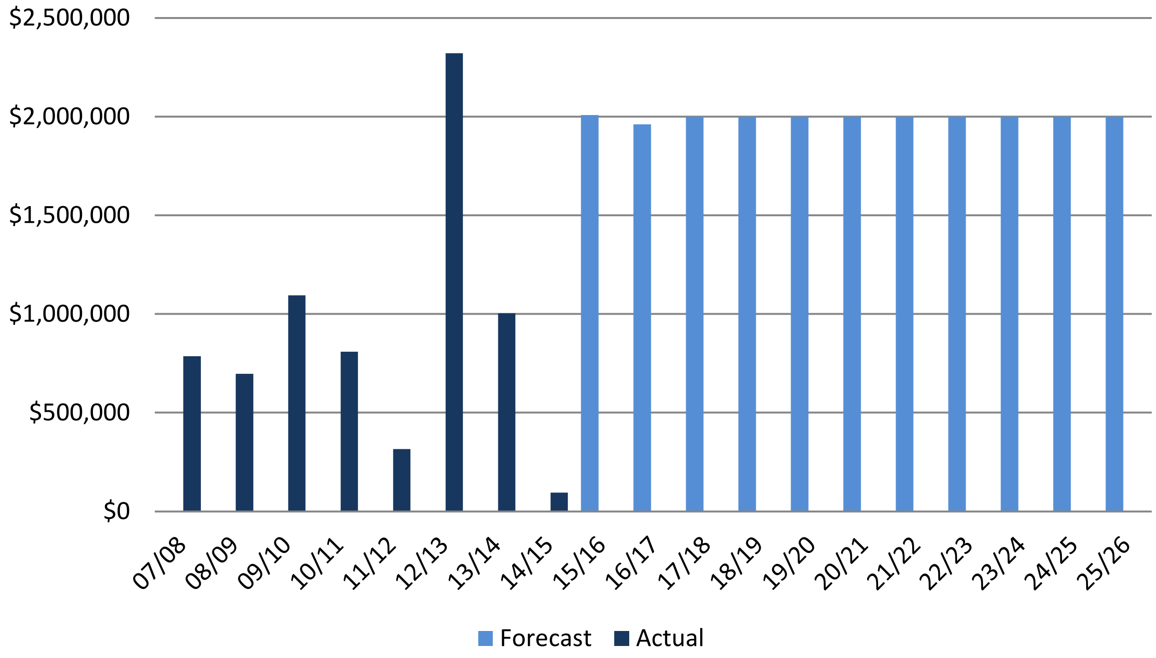

Figure 24: Fire Mitigation Projects Expenditure

8.7 Removed/obsolete programs

The following programs have been removed as deemed no longer required.

8.7.1 High Load Route Inspection (AIOHL)

The high load route inspection program is used to ensure TasNetworks' infrastructure is not damaged by transportation of high load, which is triggered by requests from the public.

This task is generally undertaken by a TasNetworks preferred contractor under the request of the customer, however, TasNetworks previously retained this program to address the infrequent situations when customers bypass this process. The costs involved are now usually recovered from the customer, this category was used for when costs were not able to be recovered. Historically this category has been underutilised so is deemed no longer required.

8.7.2 Replace Live Line Clamps Fitted on Tensioned Conductors

In the 2013/2014 POW the approach to this issue was to replace all live line clamps attached directly to a conductor with a live line clamp and dee-loop configuration (the dee-loop provides a more secure double attachment to the conductor so is less likely to wiggle loose. The live line clamp may still become loose but will only burn through the dee-loop and not the conductor so consequences are much lower). The area targeted was the High Bushfire Consequence Loss Zone.

The strategy to deal with this risk has been changed since the 2014/2015 POW. Now, loose live line clamp connections will be identified through the Thermal Imaging Inspections and only the loose connections will be replaced with dee-loop arrangements. This has resulted in a much smaller and more efficient targeted program and the budget and volumes reflect this.

8.8 Investment Evaluation

Investment evaluation is undertaken using TasNetworks' investment evaluation tool, see Gated Investment Framework (Reference 7). Investment Evaluation Summaries (IES) are used to provide information in support of a project for inclusion in the Capital Works Program. This information provides a record of the project as it progresses from initiation to finalisation and is required to support a request for funding approval. This IES aims to improve the efficiency and delivery of the capital investment justification and approval process and is a requirement for regulatory and governance purposes.

8.9 Summary of Programs

Table8 provides a summary of all of the programs described in this management plan.

Table 8: Summary of Conductors & Hardware Programs

Work Program	Work Category	Category Code	Project/Program
Routine Maintenance	OH Feeder Ground Auditing and Inspection	AIOFD	OH System Feeder Inspections by Helicopter
	OH Feeder High Vehicle Load Auditing and Inspection	AIOHL	High Load Route Inspection
	OH System thermal inspections	AIOTI	Thermal Inspection – O/H Feeders (Defined)
Non-Routine Maintenance	OH System Asset Repair	AROCO	OH System Asset Repair (Defects)
	OH System Low Conductor Clearance	AROLC	OH System Low Conductor Clearance
	Access Track Clearing	RMOTC	Maintain access tracks and

Work Program	Work Category	Category Code	Project/Program
			weed management
Reliability and Quality Maintained	Replace/relocate HV OH (Low Clearance)	REHCR	Low HV Conductors
	Replace/relocate HV (Vegetation)	REHVE	Replace/relocate HV due to vegetation issues
	Replace/relocate LV OH (Low Clearance)	RELCR	Rectify low LV clearances public safety
	Replace/relocate LV OH (Low Clearance)	RELSA	Replace Cross arms
Regulatory Obligations	Replace HV Feeders Safety	REHSA	HV Feeders (Safety)
	Replace/relocate LV OH (Building Clearances)	RELCL	Replace/relocate LV OH (Building Clearances)
	Replace/relocate LV OH (Building Clearances) with UG	RELCU	Replace/relocate LV OH (Building Clearances) with UG
	Wildlife Endangered Species Protection	SIWES	Endangered species

9 Financial Summary

TasNetworks' makes a concerted effort to prepare a considered deliverability strategy based on the planned operational and capital programs of work for distribution network assets. A number of factors contribute to the successful delivery of the program of work. These factors are utilised as inputs to prioritise and optimise the program of work and to ensure sustainable and efficient delivery is maintained. This program of work prioritisation and optimisation can impact delivery of individual work programs in favour of delivery of other programs. Factors considered include:

- Customer-driven work we must address under the National Electricity Customer Framework (NECF).
- Priority defects identified through inspection and routine maintenance activities.
- Identified asset risks as they relate to safety, the environment and the reliability of the electrical system.
- Adverse impacts of severe storms and bushfire events.
- System outage constraints.
- Changes to individual project or program delivery strategy.
- Size and capability of its workforce.
- Support from external contract resources and supplementary service provision.
- Long lead equipment and materials issues.
- Resolution of specific technical and functional requirement issues.
- Complex design/construct projects with long lead times.
- Approvals, land acquisition or wayleaves.
- Access issues.

Specific to overhead conductors & hardware distribution asset management plan, these factors have resulted in the (essentially) successful delivery of the operational and both delayed and successful delivery of the capital programs of work.

9.1 Proposed OPEX Expenditure Plan

TasNetworks proposes a total operational expenditure of $19.6 million over the next 5 years, with an average expenditure of $3.93 million per annum.

Table 9: OPEX for period between 2012/2013 and 2019/2020 financial years

	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20
Budget	$3,255,304	$3,196,311	$3,177,978	$3,177,978	$3,348,649	$3,290,778	$4,647,660	$4,647,660
Actual	$3,034,984	$3,328,956	$3,897,412	-	-	-	-	-

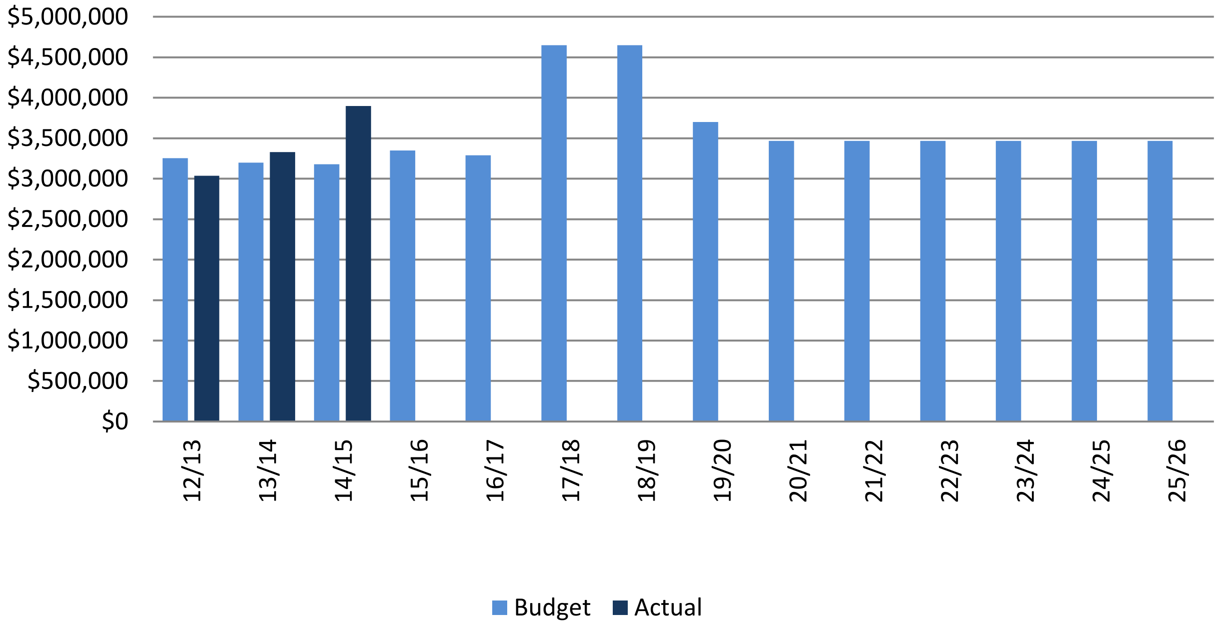

Figure 24 : OPEX Expenditure Profile

9.2 Proposed CAPEX Expenditure Plan

The capital programs and expenditure identified in this management plan are necessary to manage operational and safety risks and maintain network reliably at an acceptable level. All capital expenditure is prioritised expenditure based on current condition data, field failure rates and prudent risk management.

TasNetworks proposes a total capital expenditure of $49.4 million over the next 5 years, with an average expenditure of $9.88 million per annum.

Table 10: CAPEX for period between 2012/2013 and 2019/2020 financial year

	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20
Budget	$8,906,634	$8,725,782	$8,649,796	$9,338,678	$9,117,572	$10,946,410	$10,807,310	$9,172,010
Actual	$6,238,069	$8,383,670	$8,956,765	-	-	-	-	-

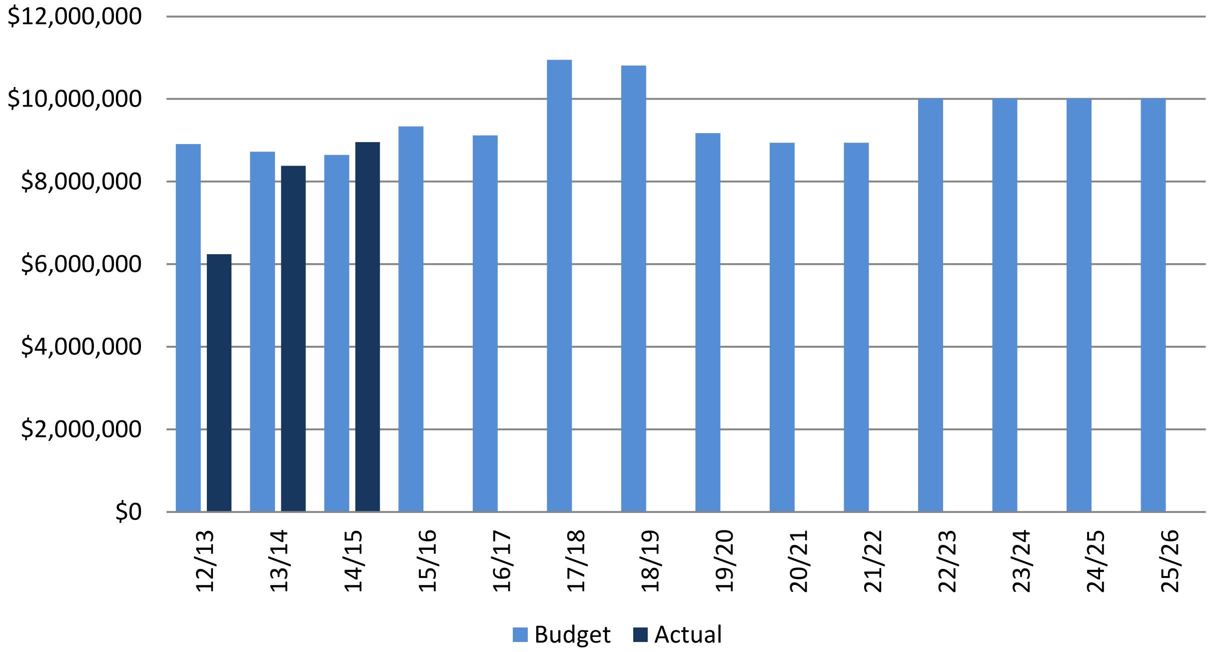

Figure 25: Capex Expenditure Profile

10 Responsibilities

Maintenance and implementation of this management plan is the responsibility of Overhead & Structures Asset Strategy Engineer.

Approval of this management plan is the responsibility of the Asset Strategy Team Leader.

11 Related Standards and Documentation

The following documents have been used either in the development of this management plan, or provide supporting information to it:

1. Asset Management Strategic Plan (R94876)
2. Air navigation - Cables and their supporting structures - Marking and safety requirements AS/NZ 3891.1-2008
3. Overhead and Structures Asset Reporting 2012-2013 (R295196)
4. REMGI & REMCU Investment Evaluation Summary (R150772)
5. Overhead Conductor Replacement Programs Prioritisation Guideline (R208597)
6. AIOTI Program Strategy Review April 2015 (R159945)
7. Gated Investment Process – Investment Evaluation Summary (R150791)
8. Standard for Design and Maintenance of Overhead Distribution and Transmission Lines AS/NZS 7000 - 2010

12 Appendix A - Summary of Programs and Risk

Description	Work Category	Risk Level	Driver	Expenditure Type	Residual Risk	11/12 (Actual)	12/13	13/14 (Actual)	14/15 (Actual)	15/16 (Budget)	16/17 (Budget)
OH System Feeder Inspections by Helicopter	AIOFD	High	Safety	OPEX	Medium	$12,671	$8,790	$264,370	$299,457	$300,000	$300,000
Thermal Inspection – O/H Feeders (Defined)	AIOTI	High	Safety	OPEX	Medium	-	$27,706	$143,159	$235,200	$113,617	$112,525
OH System Asset Repair (Defects)	AROCO	High	Safety	OPEX	Medium	$1,327,308	$2,678,522	$1,644,635	$3,030,317	$1,543,599	$1,498,162
OH System Low Conductor Clearance	AROLC	High	Safety	OPEX	Medium	$158,914	$263,055	$288,512	$281,952	$338,279	$327,375
Maintain access tracks and weed management	RMOTC	High	Safety	OPEX	Medium	$8,072	$56,912	$988,279	$50,486	$1,040,896	$1,040,896
Low HV Conductors	REHCR	High	Safety	CAPEX	Medium	$407,660.57	$477,289.29	$333,499.45	$533,781	$230,264.35	$225,450.82
Replace/relocate HV due to vegetation issues	REHVE	High	Safety	CAPEX	Medium	-	$23,074	$24,886	$68,064	$238,466	$233,319
Rectify low LV clearances public safety	RELCR	High	Safety	CAPEX	Medium	$1,702,257	$1,314,099	$1,218,031	$1,702,904	$2,202,680	$2,156,838
Replace Cross arms	RELSA	High	Safety	CAPEX	Medium	$504,277	$179,679	$1,292,790	$2,824,946	$120,435	$117,916

HV Feeders (Safety)	REHSA	High	Safety	CAPEX	Medium	$1,671,440	$748,273	$817,697	$533,128	$724,732	$704,195
Replace/relocate LV OH (Building Clearances)	RELCL	High	Safety	CAPEX	Medium	$294,308	$124,062	$66,001	$155,180	$123,863	$121,291
Replace/relocate LV OH (Building Clearances) with UG	RELCU	High	Safety	CAPEX	Medium	-	-	-	$35,488	$264,140	$259,633
Endangered species	SIWES	High	Environment	CAPEX	Medium	$36,395	$207,173	$128,605	$82,186	$189,276	$185,226