Asset Management Plan
Communications Linear Assets
2020-25

January 2019

Part of the Energy Queensland Group

Executive Summary

This Asset Management Plan (AMP) covers the class of assets known as “Communications Linear Assets”.

Communications linear assets are made up of fibre optic and metallic pilot cable, utilised to enable communications services within the power network. Communications linear assets connect substation sites, dedicated communications sites, Control Centre locations, office locations, and depot facilities.

They are an essential component of electrical infrastructure which enables advanced protection and control services, vastly improving the safety for personnel and plant equipment, power network asset lives, power network performance during and after network abnormalities, and ensuring the power network performs within legislated and engineering limits.

Presently, Energy Queensland Limited (EQL) communications linear assets are comprised of metallic pilot cable and fibre cables, with 42 and 1,610 kilometres of cable respectively in the Northern and Southern Regions (Ergon Energy) and 828 and 2,585 kilometres respectively within the South Eastern (Energex) Region.

Communications linear assets are relatively low volume compared to other EQL linear assets. They are managed on a population basis using continuous monitoring, some periodic inspection for condition and serviceability, and a systemic review of recorded performance.

Metallic pilot cabling is considered obsolete for many applications and is being replaced with fibre optic cable. The installation base of the cable in EQL is significantly aged, has increasing failure trends and is becoming more difficult to repair after failures. EQL is actively moving away from the use of metallic pilot cabling to fibre optic cable.

Document Tracking Details

Network and Non-Network Document Hierarchy Reference Number	Regulatory Proposal Chapter Reference	Document	File Name
NET AMP – 003	7.029	Asset Management Plan - Communication Linear Assets	EGX ERG 7.029 Asset Management Plan - Communications Linear Assets JAN19 PUBLIC

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1 Introduction

Energy Queensland Limited (EQL) was formed 1 July 2016 and holds Distribution Licences for the following regions:

- South East Region (Legacy organisation: Energex Limited); and
- Northern and Southern Regions (Legacy organisation: Ergon Energy Corporation Limited).

There are variations between the EQL regions as a result of geographic influences, market operation influences and legacy organisation management practices. This Asset Management Plan (AMP) reflects the current practices and strategies for all assets managed by EQL, recognising the differences that have arisen due to legacy organisation management. These variations are expected to diminish over time with integration of asset management practices.

1.1 Purpose

The purpose of this document is to demonstrate the responsible and sustainable management of Communications Linear Assets on the EQL network. The objectives of this plan are to:

1. Deliver customer outcomes to the required level of service.
2. Demonstrate alignment of asset management practices with EQL's Strategic Asset Management Plan and business objectives.
3. Demonstrate compliance to regulatory requirements.
4. Manage the risk associated with operating the assets over their lifespan.
5. Optimise the value EQL derives from the asset class.

This AMP will be updated periodically to ensure it remains current and relevant to the organisation and its strategic objectives. Full revision of the plan will be completed every five years as a minimum.

This AMP is guided by the following legislation, regulations, rules and codes:

- *National Electricity Rules (NER)*
- *Electricity Act 1994 (QLD)*
- *QLD Electrical Safety Act 2002 (QLD)*
- *QLD Electrical Safety Regulation 2013 (QLD) (ESR)*
- *QLD Electrical Safety Code of Practice 2010 - Works (QLD) (ESCOP)*
- *QLD Work Health & Safety Act 2014 (QLD)*
- *QLD Work Health & Safety Regulation 2011(QLD)*
- Ergon Energy Corporation Limited Distribution Authority No D01/99
- Energex Limited Distribution Authority No. D07/98.

This AMP forms part of EQL's strategic asset management documentation. It is part of a suite of Asset Management Plans, which collectively describe EQL's approach to the lifecycle management of the various assets which make up the network used to deliver electricity to its customers. Appendix 1 contains references to other documents relevant to the management of the asset class covered in this AMP.

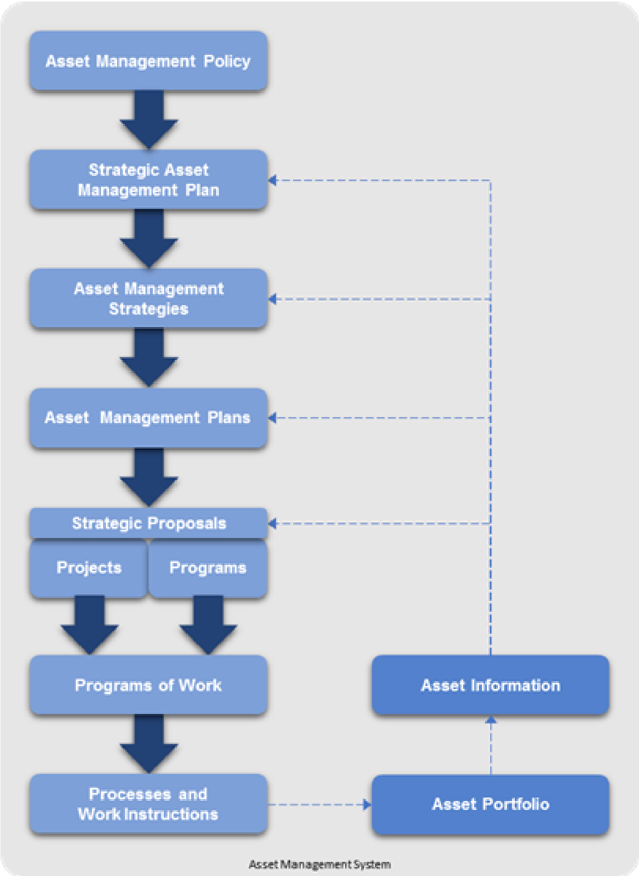


Figure 1: EQL Asset Management System

1.2 Scope

This AMP considers only communications linear assets owned by EQL in the South East Region, Northern and Southern Regions, and which fall into the following category:

- Inter-site fibre optic cable.
- Inter-site Metallic pilot cable.

This AMP does not cover the following assets:

- Intra-site fibre optic cable.
- Intra-site metallic pilot cable.
- Substation termination equipment.

It should be noted that EQL has a subsidiary company (trading as Nexium) that is a registered telecommunications carrier. Nexium utilise EQL owned fibre cable for the provision of services and these cables are included within the scope of the AMP. Dedicated Nexium Fibre cables are not included in this scope. EQL also provides various services to other telecommunications carriers, some of which facilitate the provision of equivalent “communications linear assets” for these carriers. EQL does not provide condition and maintenance services for any of these third-party communications linear assets except as an unregulated independent service. This AMP relates to EQL (Energex and Ergon Energy owned) assets only and excludes any consideration of these other commercial services.

1.3 Total Current Replacement Cost

Communications linear assets are relatively low volume compared to other EQL linear assets. These services are low total cost assets and are typically asset managed on an asset population basis using continuous monitoring, some periodic inspection for condition and serviceability, and systemic review of recorded performance.

Based upon asset quantities and replacement costs, EQL communications linear assets have a replacement value of the order of $460 million (Northern and Southern Regions: $240 million, South East Region: $220 million). This valuation is the gross replacement cost of the assets, based on the cost of replacement of modern equivalents, without asset optimisation or age assigned depreciation. Figure 2 provides an indication of the relative financial value of EQL Services compared to other asset classes.

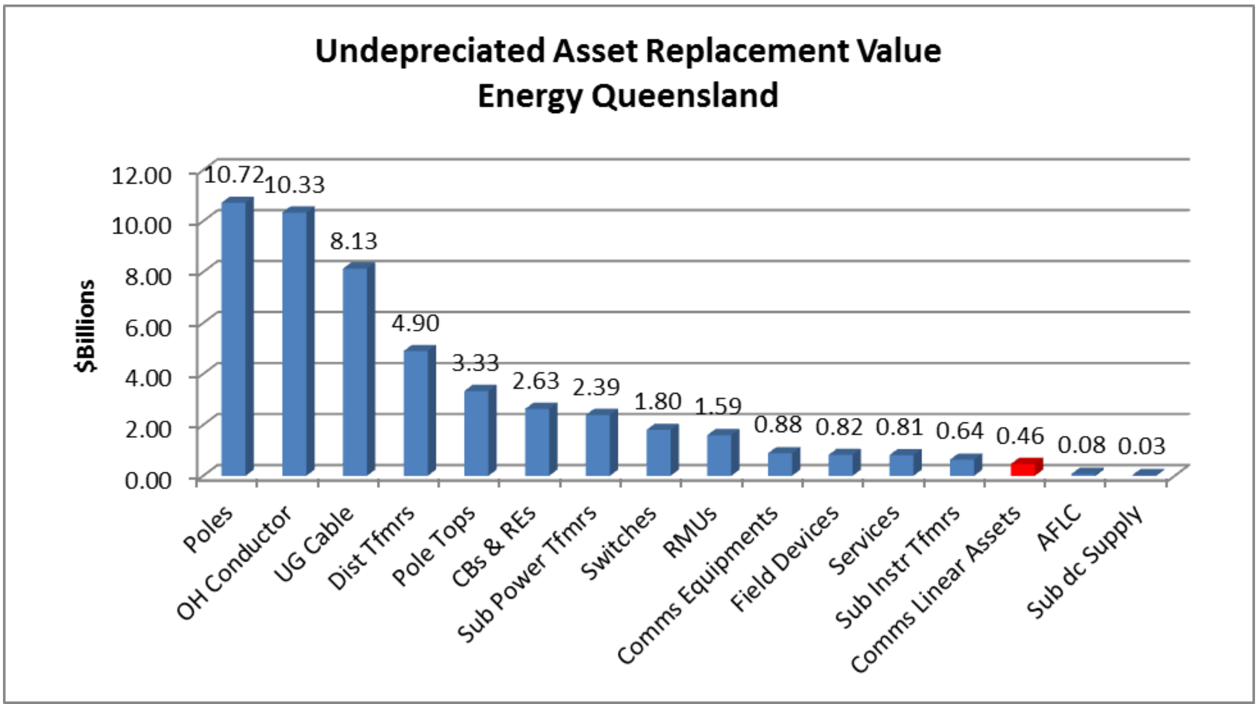


Figure 2: EQL – Total Current Asset Replacement Value

1.4 Asset Function and Strategic Alignment

Communications linear assets are an essential component of electrical infrastructure which enable advanced protection and control services, vastly improving the safety for personnel and plant, power network asset lives, power network performance during and after power network abnormalities, and ensuring power networks perform within legislated and engineering limits.

Communications linear assets connect substation sites, dedicated communications sites, Control Centre locations, office locations, and depot facilities.

The cables can be used to carry multiple services including protection signalling and control and Supervisory Control and Data Acquisition (SCADA) communications links and other services, including:

- Internal telephone services,
- Substation alarming,
- Security (video, alarms, access control),
- Equipment management, and
- Corporate data.

Among these communications services, protection is the most important service carried via the network in its role to ensure the safety and reliability of the electricity distribution network.

Failure of any communications linear asset to achieve its designed function can result in negative impacts to EQL's objectives related to safety, customer outcomes, or legislative compliance.

Table 1 details how communications linear assets contribute to the corporate strategic asset management objectives.

Relevant Asset Management Objectives	Relationship of Asset to Asset Management Objectives
Ensure network safety for staff, contractors, and the community	Diligent and consistent maintenance and operations support asset performance and hence safety for all stakeholders
Meet customer and stakeholder expectations	Continued asset serviceability supports network reliability and promotes delivery of a standard quality electrical energy service.
Manage risks, performance standards and asset investment to deliver balanced commercial outcomes	Failure of this asset can result in increased public safety risks and increase levels of disruption of the electricity network. Asset longevity assists in minimising capital and operational expenditure.
Develop asset management capability and align practices to the global ISO 55000 standard	This AMP is consistent with ISO 55000 objectives and drives asset management capability by promoting a continuous improvement environment.

Table 1: Asset Function and Strategic Alignment

1.5 Owners and Stakeholders

Role	Responsible Party
Asset Owner	Chief Financial Officer
Asset Operations Delivery	EGM Distribution
Asset Manager	EGM Asset Safety & Performance

Table 2: Stakeholders

2 Asset Class Information

The following sections provide a summary of the key functions and attributes of the assets covered in this AMP.

2.1 Asset Description

Communications linear assets carry electromagnetic energy in order to transmit information between locations. This information transfer enables various functions, the most important of these being the protection and control of the power network.

2.1.1 Metallic Pilot Cables

The function of a metallic pilot cable is to allow voltage waveforms to be transmitted between locations. Equipment attached to the cables generates/interprets these waveforms allowing for information transfer between sites. In most cases the information transfer is in the form of digital data, however, for some equipment analogue type transmission is used.

Most metallic pilot cables utilise copper as the transmission medium, however, aluminium and in some cases other alloys can also be used. The cables contain multiple individual metallic cores, each covered in an insulation medium, with cores arranged such that two cores are twisted together (called a pair), promoting even levels of induced noise into each core (noise being electromagnetic energy that has radiated from the surrounding environment which degrades the quality of the signals being transmitted). Noise present in both cores of a pair (called common mode noise) can be significantly attenuated by the attached equipment, allowing faster and longer communications service over the cables. Currently, a standard cable contains 20 pairs. A metallic sheath over central components is provided for further immunity to induced noise and to provide a level of lightening protection. Cabling used in the overhead network also includes a strengthening member to allow the cable to hold its form over large spans. Sample pictures of a typical multi-pair metallic in building (left), under-ground (centre), and overhead (right) cables are shown below.

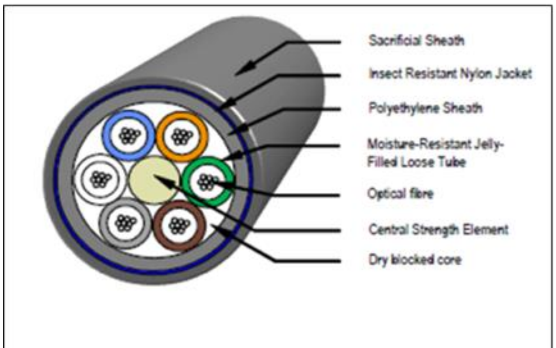
Figure 3: Typical Multi-Pair Metallic in building (left), Under-Ground (centre), and overhead (right) cables

A very small number of cables will also be configured as Over Head Earth Wire (OHEW) cables, such that within the metallic cable there is a tube containing several individual cores or pairs.

2.1.2 Fibre Cables

The function a fibre cable is to allow light pulse waveforms to be transmitted between locations. Equipment attached to the cables generates and interprets these waveforms, allowing information transfer between sites. The fibre can be of either single-mode or multi-mode construction. Single mode / multimode refers to how light propagates down the fibre. Single mode allows only parallel light paths through the cabling which allows for long distance transmission, Multi mode allows for multiple paths through the cabling such that the light can reflect off the outer edge of the cable which reduces total transmission length and speed but reduces the cost of the transmission equipment. In most cases information transfer is in the form of digital data however for some very limited cases analogue type transmission is used.

Most fibre cable utilise glass as the transmission medium. Plastic can also be used but is not utilised in inter-site links with EQL. EQL employs predominantly single-mode fibres. The cables contain multiple individual glass cores, each covered in an insulation medium. The cables are arranged with a central strength member surrounded by "tubes" of individual cores with multiple tubes per cable. The current standard is to have cables with 72 individual cores. A typical cross-section of fibre cable construction is shown in Figure 4. Outer layers are provided for protection of cores. Most fibre optic cables do not have any metallic components.



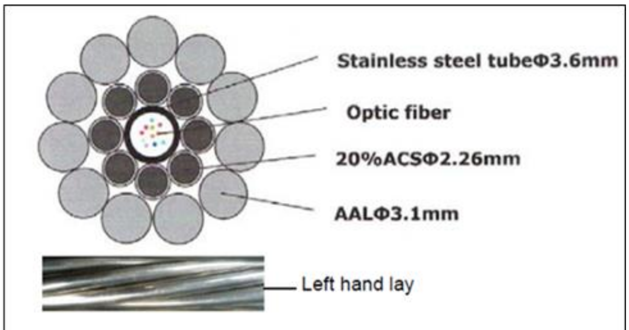


Figure 4: Typical cross-section of Fibre cable

A number of the fibre cables are configured to replace OHEW cables, still providing the functions that the OHEW provide, but also providing the fibre optic cabling to allow communications services to operate over them. These are given there own acronym Optical Pilot Ground Wire (OPGW). The cables are constructed such that the metallic cable has a tube containing several individual fibre cores. Figure 4shows the typical construction of the cables.

2.2 Asset Quantity and Physical Distribution

Table 3 indicates the total number of assets per region by type within the scope of this AMP.

Asset Type	South East	Northern & Southern	TOTAL
Fibre Cable (km)	2,585	1,610	4,195
Metallic Pilot Cable (km)	828	42	870
Total	3,413	1,652	5,065

Table 3: Asset Quantity and Description

2.3 Asset Age Distribution

The following sections provide information about the age distribution of assets across the South Eastern Region and the Northern and Southern Regions.

2.3.1 South East Region (Energex)

Figure 5 depicts pilot cable quantities in the Southeast Region installed by date and type.

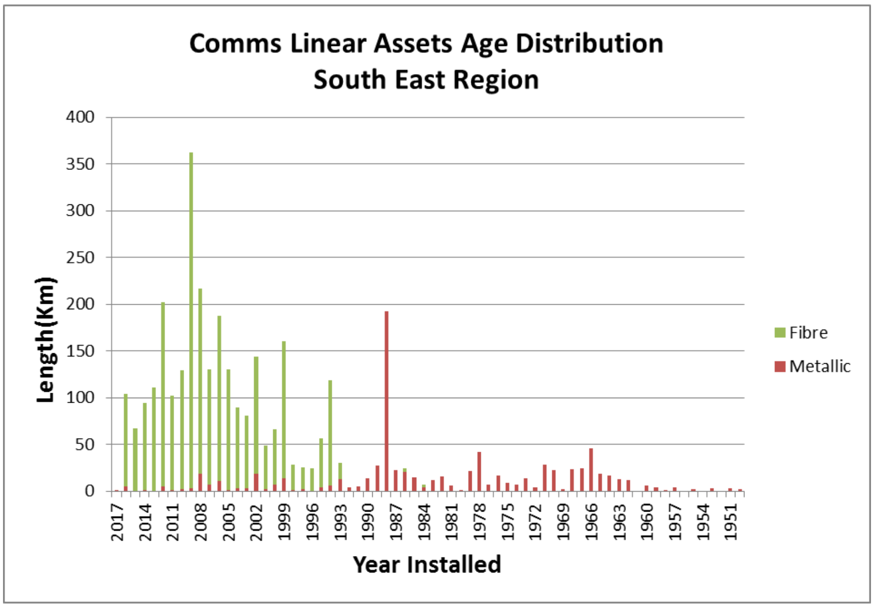


Figure 5: South Eastern Region Communications Linear Assets Age Distribution

The age distribution graph show the clear trend away from the use of metallic pilot cabling commencing around 1992. The large spike of metallic pilot cable installation shown in 1989 is associated with a transfer of cabling assets from Powerlink.

2.3.2 Northern and Southern Regions (Ergon)

Figure 6 shows the fibre cables quantities installed in the Ergon controlled Regions.

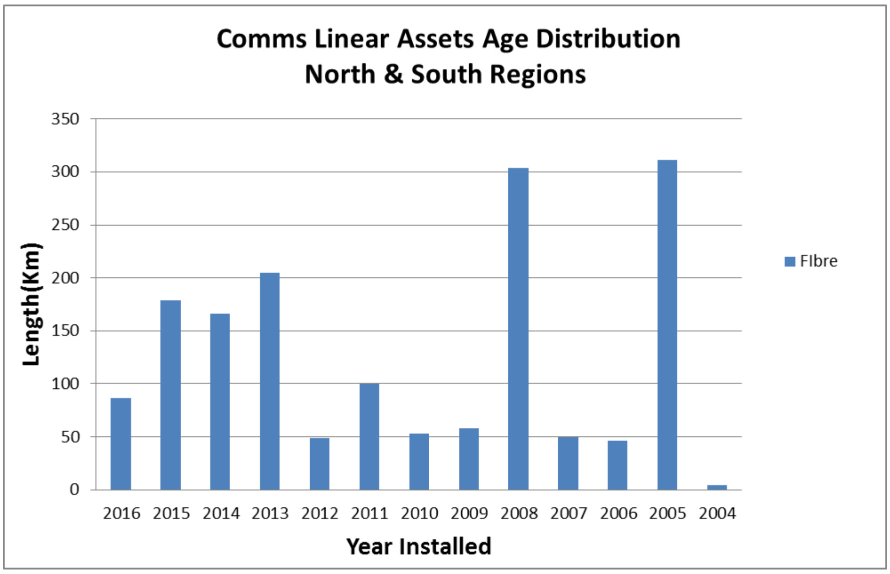


Figure 6: Northern and Southern Regions Communications Linear Assets Age Distribution

Currently, across the Northern and Southern Regions, there are around 25 operational metallic pilot cables for which installation data records are not available. There are ongoing and planned projects in place to replace all metallic pilot cabling with fibre.

2.4 Population Trends

EQL metallic pilot cable failure data shows that there is a direct relationship between age and the failure of individual cores (as seen in Figure 7 below). These failures are predominately insulation failures and it is reasonable to assume that these are primarily due to water ingress. However, no trends have been detected between cables installed in locations where flood inundation likely results in cabling being continually submerged for prolonged periods compared to cables in non-flood areas. This suggests that failure due to water ingress is not related to the integrity of the outer sheath of the cable but rather by water ingress in the terminated ends of the cable.

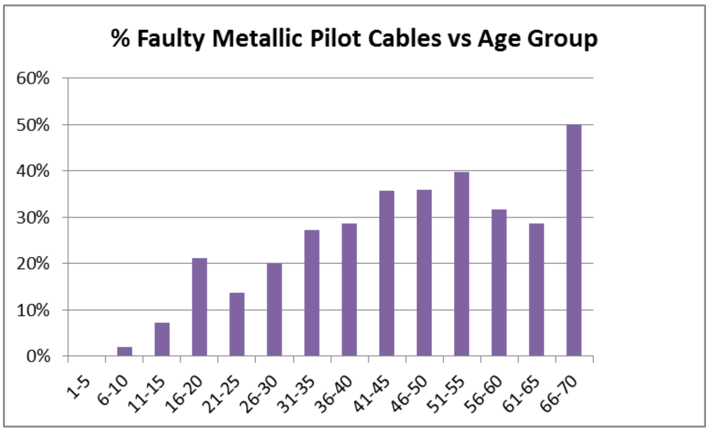


Figure 7: Percentage of Faulty Pilot Cables vs Age Group

There have been a number of observed mechanical cable failures such that integrated strength members (often called catenary cable) separates from the rest of the cable, such that the remainder of the cabling will hang significantly lower than the catenary. With the relatively low occurrence, no real trend can be inferred from the available data. It is possible that localised exposure to storms and resulting extensive cable swaying, exerts strain on the aging sheath, resulting in tearing that then continues as further strain is imposed.

Fibre optic cable performance can be affected by increased propagation loss as a result of penetration of hydrogen ions to the fibre core, especially in the case of first generation fibre cables and underground cables.

Various factors can increase hydrogen ion absorption into fibre cores:-

- Excessive mechanical vibration and cable strain can result in microcracks in cladding materials speeding absorption,
- Corrosion of metallic components of the cable.

2.5 Asset Life Limiting Factors

Manufacturers typically design cables in line with Australian and international standards. Design lives of cables vary, with some cables only lasting 30 years and other cables lasting in excess of 60 years.

Various factors affect how long the cables will be useful for, including environmental factors and (rare) manufacturing defects which can impact the physical integrity of the cables. Technology advancement also renders some cabling obsolete, as some modern terminal equipment is unable to operate appropriately when utilising older cables.

2.5.1 Metallic Pilot Cables

Component parts of these assets and associated equipment may be subject to the following types of damage and deterioration, which may lead to failures:

- Ageing of insulation,
- Electrical breakdown of insulation,
- Contamination of internal insulation,
- Moisture ingress,
- Mechanical failure or components such that continuity is lost for cores,
- Corrosion of surfaces,
- Breakdown of sheaths such that strength members detach from the remainder of the cable,
- Lightening,
- Inherent manufacturing defects leading to gradual deterioration/ degradation of cable, and
- Fatigue failure due to mechanical movement due to weather or other causes, particularly relevant to overhead construction.

The potential consequences of failure of these assets can include:

- Catastrophic failure of cabling resulting in all related services ceasing to operate. Overhead cables also create a potential risk to traffic should the cable fall onto roads, footpaths, rivers etc.
- Individual core failures resulting in selective services failing. This can be caused by water ingress, mechanical fatigue due to vibration or in rare cases lightening induced currents fusing the cores.

2.5.2 Fibre Cables

Component parts of these assets and associated equipment may be subject to the following types of damage and deterioration, which may lead to failures:

- Ageing of cladding,
- Moisture ingress,
- Corrosion of surfaces,
- Breakdown of sheaths such that strength members detach from the remainder of the cable,
- Lightening,
- Strength member failure leading to fibre breakage, particularly overhead cables,
- Fatigue failure due to mechanical swings or swaying due to weather or other causes, particularly relevant to overhead cables, and
- Other issues including partial gnawing at cable sheaths, deliberate actions, vandalism, rodent damage etc.

The potential consequences of the failure of these assets can include:

- Catastrophic failure of cabling resulting in all related services ceasing to operate. Overhead cables also create a potential risk to traffic should the cable fall onto roads, footpaths, rivers etc.
- Individual core failures resulting in selective services failing.

3 Current and Desired Levels of Service

The following sections define the level of performance required from the asset class, measures used to determine the effectiveness of delivering corporate objectives, and any known or likely future changes in requirements.

3.1 Legislative Requirements

EQL is bound by the National Electricity Rules (NER). Whilst various aspects of the NER are impacted by metallic pilot and fibre cable reliability, the most pertinent is the requirement outlined in S5.1.2.1(d): Chapter 5 Table S5.1a.2, with different requirements, depending on the voltage of the scheme:

“The Network Service Provider must ensure that all protection systems for lines at a voltage above 66 kV, including associated inter-tripping, are well maintained so as to be available at all times other than for short periods (not greater than eight hours) while the maintenance of a protection system is being carried out.”

To adhere to this requirement, EQL needs to ensure the pilot and fibre cable network associated with protection for high voltage lines is well maintained. For instances where a protection function is unavailable due to a pilot cable fault, whether faults are a result of progressive cable degradation or some form of external mechanical damage, EQL (Ergon Energy and/or Energex) has an obligation to restore the protection function of the line “as quickly as possible”.

In the event of a failure of any 132kV, 110kV, 66kV or certain 33kV protection schemes, EQL is required to notify Powerlink who will subsequently notify the Australian Energy Market Operator (AEMO) of the outage. AEMO may determine that having a line in-service without the relevant protection function will compromise the security of the network should a fault occur and require EQL to de-energise the line. Without suitable alternative communications paths that can be relied upon during service outages, EQL risks its ability to meet these legislative requirements.

3.2 Performance Requirements

Communications linear assets are implemented expecting typical service lives of 30-60 years of continuous operation in most cases. The performance parameters that the cable must achieve to be considered as “still operational” are in many cases dependent on the equipment utilising the cable. There are a number of parameters that are generic to most equipment that utilises the cable and as such these can be used to monitor performance.

Common to all services utilising the cable is the availability of the cable. Should faults occur that require the cable to be out of service for maintenance, then the availability requirement for services running on the cable will not be able to be met. As an example, many of the services provided for Operational Technology (OT) environments generally require service availability in the order of 99.99% of available time. In some cases, there are higher availability requirements, but these are generally achieved using diverse sets of cabling. It should be noted that this is an end to end requirement and likely requires multiple cables and terminal equipment to collectively achieve the 99.99%. As such performance for individual cables will be higher than this figure. Availability performance of the complete system is monitored by Network Operation Centres (NOCs) of Energex (STOC) and Ergon Energy (CNOC).

Other performance parameters include insulation resistance and capacitance for metallic cables and optical attenuation and chromatic dispersion for fibre cables. Table 4 and Table 5 list the relevant parameters for metallic and fibre cable cables (sample test records are listed in Appendix 5 and Appendix 6).

Performance Parameter of Copper Pilot Cable	
Availability	>99.99%
Insulation resistance (pair to pair)	>10 MΩ
Insulation resistance (each core to all cores and earth)	>10 MΩ
Loop resistance (Ω/km)	< 30Ω
Maximum mutual electrostatic capacitance of each pair at 50Hz (nF/km)	< 60

Table 4: Performance Parameter of Copper Pilot Cable

Performance Parameter of Fibre Cable (Single Mode)	
Availability	>99.99%
Linear Loss (dB/km)	< 0.2 (@1550nm) < 0.3 (@1310nm)
Connector/Splice loss (2km between splices)	< 0.2 (@1550nm) < 0.2 (@1310nm)
Chromatic dispersion Coefficient	< 0.325 (ps/nm.km @1550nm)

Table 5: Performance Parameter of Fibre Cable (Single Mode)

There are no specific business targets beyond the NER requirements relating to communications linear assets with regard to failures or failure rates.

3.3 Current Level of Service

The current level of performance is significantly different between the two construction types (fibre versus metallic pilot cable) primarily due to the average age difference and the technologies used. The metallic pilot cable network as a whole is in poor condition with a large percentage of the fleet nearing end of economic life. The fibre cable network, on the other hand, is in generally good condition with only a small percentage of the fleet approaching end of economic life.

3.3.1 South East Region (Energex)

The following sections detail the current levels of service for communications linear asset types in the South East Region.

3.3.1.1 Metallic Pilot Cables

The EQL metallic pilot cable infrastructure has been in use for decades and was designed to provide a variety of communications functions. The bulk of the services still operating on metallic cable are protection circuits, with most of these services being legacy electromechanical and analogue protective equipment. Modern digital protective equipment can be implemented over the metallic cables, however, the numbers of manufacturers providing equipment designed to operate with this obsolete metallic technology are dwindling.

The EQL metallic pilot cable network as a whole is in poor condition with a large percentage of the fleet nearing end of economic life. The historic cable failures for metallic pilot cable is shown in the following figure. These are failures associated with the cabling that has required immediate remediation due to affecting one or more services where the cause was found to be the metallic pilot cable.

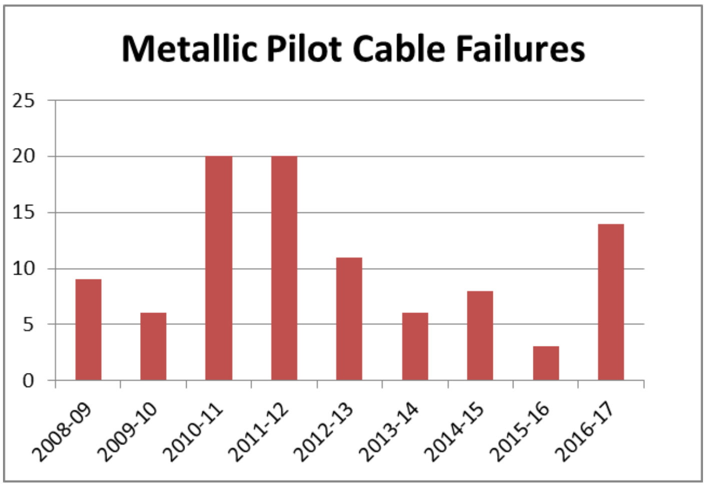


Figure 8: Metallic Pilot Cable Failures

One key challenge that is faced periodically is after the failure of a cable, cables have degraded to such an extent that the service cannot operate correctly over it. This results in services (predominately protection) being out of service until either repair to the cabling are completed or the service is re-configured to operate over a modern fibre cable.

A significant source of degradation of insulation is moisture, drawn in from the atmosphere as the metallic pilot cable breathes with changing temperature. This can cause the insulation on individual cores to break down, shorting the cores of a pair together, to adjacent cores or to the earth screen.

An impact of the aging metallic pilot cable network is the decrease in available data bandwidth. As the copper pilot cables age, their insulation resistance decreases and the loop resistance increases over time (See Appendix 8– Test records of a failed metallic cable for an example of measured performance of a cable). This also has an effect on the capacitance of the cable, resulting in an inability for the cable to support high data rate services. In most cases, this results in increased errors on a link, with maintenance staff than trying alternative cores on the same cable to restore performance or to utilise other cables to replace the poorly performing cable.

The following figure provides an indication of the overall condition of metallic pilots for the Southeast Region, showing the percentage of cables for each age group that have failed cores. As expected the health of cables deteriorates as the cable ages.

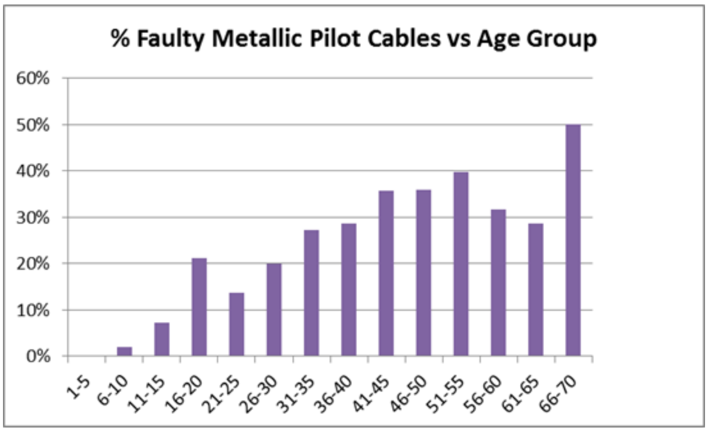


Figure 9: Percentage of Faulty Pilot Cables vs Age Group

3.3.1.2 Fibre Cables

Energex started introducing fibre cables to support the South East telecommunications network in the 1980's. It has expanded the fleet size to 1542 cables, a relatively modern Fibre Optic cable network providing a range of services to predominantly digital equipment. Comparatively, few cable issues per kilometre of installed cable are noticed each year with the Fibre cables compared to the metallic cabling.

The historic cable failures for fibre optic cable are shown in the following figure. These are failures associated with cabling that has required immediate remediation.

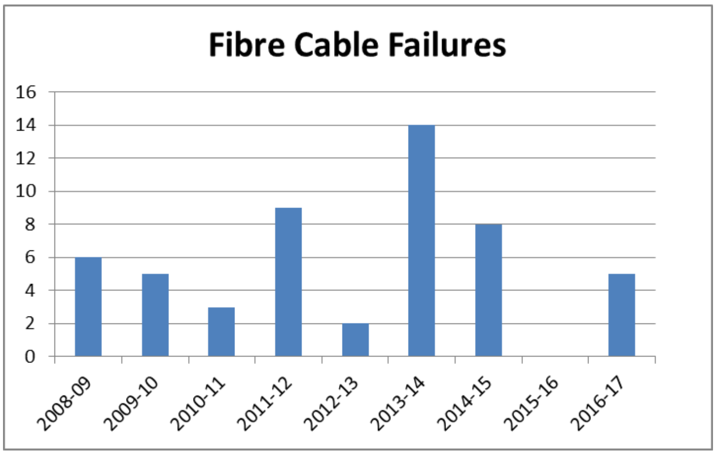


Figure 10: Fibre Cable Failures

The following figure provides an indication of the overall condition of Fibre Cables for the Southeast Region, showing the percentage of cables for each age group that have failed cores. As expected, occurrences of faults increase with age.

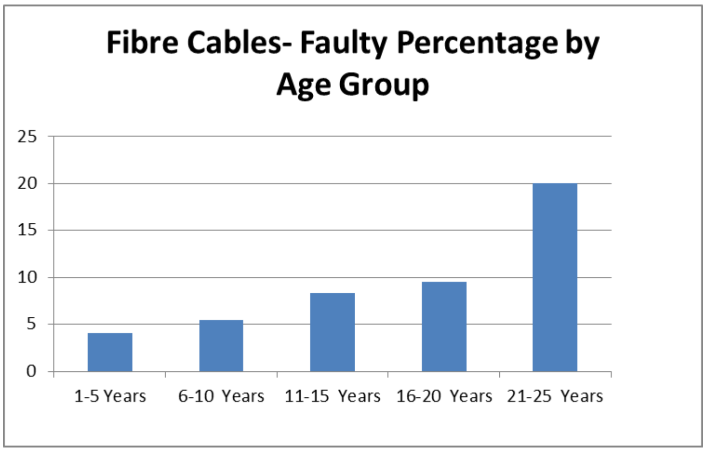


Figure 11: Percentage of core failures in fibre cables by age group

Another measure that is an indication of the performance of the cabling network is the availability of services operating over the network. Table 6 indicates that the availability of services does not fall below 99%, suggesting that the network (including the fibre cable) is performing well. Appendix 7the end to end performance availability for the services operating on the fibre network.

Month	Operational Support Services	Control Zone Services
Jul-17	100	100
Aug-17	100	99.99
Sep-17	100	100
Oct-17	100	100
Nov-17	100	100
Dec-17	100	100
Jan-18	100	99.99
Feb-18	100	99.95
Mar-18	100	100
Apr-18	100	100
May-18	100	99.99

Table 6: Monthly Availability Figure of Fibre for Services (in 2017-18) – South East Region

3.3.2 Northern and Southern Regions (Ergon)

The following sections detail the current levels of service for communications linear asset types in the Northern and Southern Regions.

3.3.2.1 Metallic Pilot Cables

There are only a limited number of operational metallic pilot cables (around 25 cables of total length of 42km) in Northern and Southern Regions. There is no available failure data for the limited number of pilot cables currently in service. Anecdotal advice is that the cabling is in a very poor state.

3.3.2.2 Fibre Cables

The Northern and Southern Regions started a significant improvement project in their telecommunications network in 2003 and completed implementation in the period 2008 -14. This saw a ramp-up of fibre optic cable installations and implementation of the Message Protocol Label Switching (MPLS) and other associated communications equipment.

Historic cable failures for fibre optic cable is shown in Figure 12. These are failures associated with the cabling that have required immediate remediation due to affecting one or more services, where the cause was found to be the fibre cable.

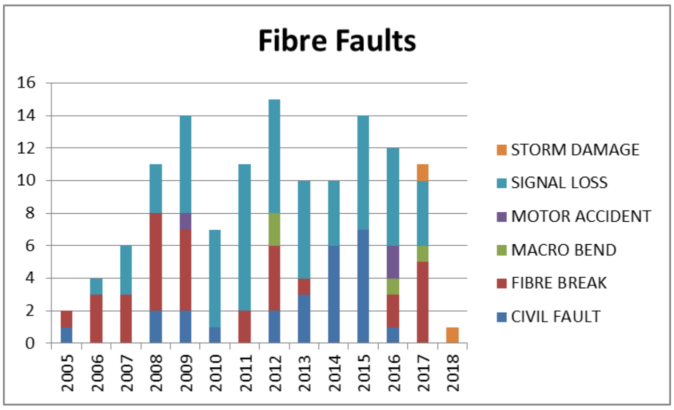


Figure 12: Fibre Cable Failure History (sourced from VQSM)

Another measure that is an indication of the performance of the cabling network is the availability of services operating over the network. Table 7 indicates that the availability of services does not fall below 99%, suggesting that the network (including the fibre cable) is performing well.

Year	Operational	SCADA
2013	99.9978%	99.9999%
2014	99.9961%	100.0000%
2015	99.9848%	99.9989%
2016	99.9707%	99.9960%
2017	99.9926%	99.9992%
2018 (June)	99.7976%	99.9975%

Table 7: Fibre Cable Current Levels of Service - Northern and Southern Region

3.4 Desired Levels of Service

In order to best meet the obligations expressed under the NER, communications linear assets need to provide continuous service in all conditions. These assets are therefore ideally replaced before complete in service failure or can be allowed to fail in service if suitable contingency arrangements are in place prior to failure (normally in the form of suitable alternative cabling for services to be swapped too). The current level of in-service faults has not resulted in an inability to meet NER requirements and maintaining the performance at the current levels is proposed.

Asset management strategies for this asset will focus on ensuring cabling remaining in service meets current NER legislative requirements. For cable approaching end of life, a phased approach of replacement will be required to ensure the desired levels of service / NER requirements are met.

4 Asset Related Corporate Risk

As detailed in Section 3.1 and Table 1, Queensland legislation details that EQL has a Duty to ensure its works are electrically safe. This safety Duty requires that EQL take action So Far as is Reasonably Practical (SFAIRP) to eliminate safety related risks, and where it is not possible to eliminate these risks, to mitigate them SFAIRP[1].

Figure 13 provides a threat-barrier diagram for EQL communications linear assets. Many threats are unable to be controlled (e.g. third-party damage), although EQL undertakes a number of actions to mitigate them SFAIRP. Failure of these assets risks public and staff safety in several ways, and most notably exposes EQL to a range of risks including:

- Cable falling to the ground with the potential to cause road accidents / public safety issues,
- EQL Telecommunications Network Outage,
- Power outages,
- Loss of network control and protective functions for feeders/ Substations, and
- Regulatory penalties.

The following sections detail the ongoing asset management journey necessary to continue to achieve high performance standards into the future. Action items have been raised in the following sections where relevant, detailing the specific actions that EQL will undertake as part of program delivery of this Asset Management Plan.

[1] Queensland Electrical Safety Act 2002 s10 and s29

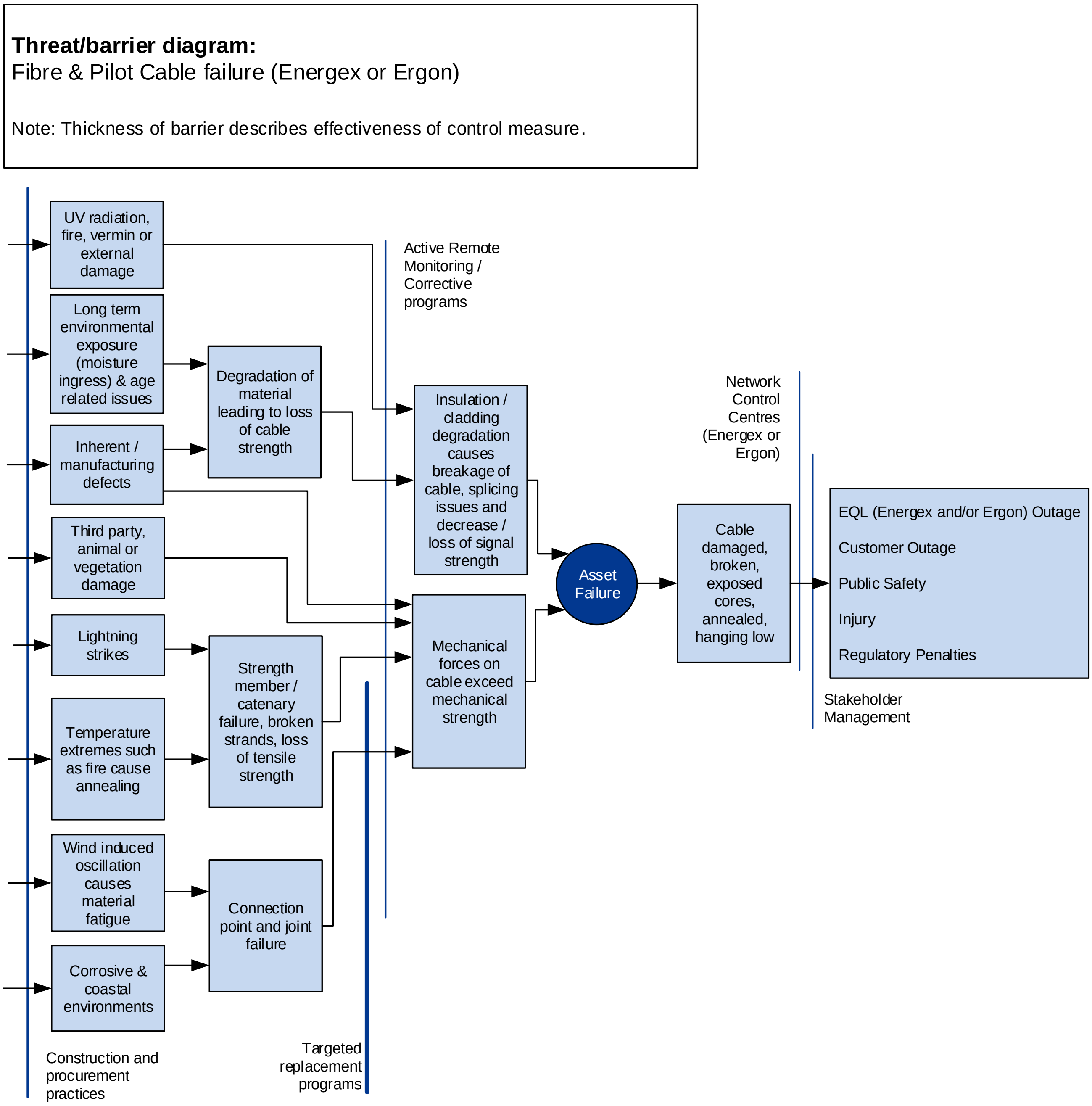


Figure 13: Threat Barrier Diagram EQL (Energex or / and Ergon) Fibre / Metallic Pilot Cables

5 Health, Safety & Environment

Communications linear assets (fibre and metallic cables) are unlikely to cause any major health, safety or environmental (HSE) issues. EQL commits to ensuring that the entire asset lifecycle is managed with standard processes and practices, conforming with regulatory requirements and adhering to AU / ANZ standards where applicable.

6 Current Issues

The following sections outline current issues that have been identified as having the potential to impact EQL's ability to meet corporate objectives.

6.1 Catenary Detachment of Metallic Pilot Cables

Several cases of metallic pilot cable catenary detachments have been reported in the South East Region (Energex) and were confirmed via a desktop study utilising freely available imagery data. Refer to Appendix 9for a sample list of damaged cables. The issue is further discussed in Sections 7.2 - 7.3.

6.2 Degradation of metallic pilot cable network

Due to age-related factors, metallic pilot cable performance is naturally degrading. This reduction in performance is causing increasing issues with maintaining services over the network, risking EQL's ability to remain compliant with NER legislative requirements.

In many cases when services stop operating due to age-related degradation, no alternative cabling is available to swap services to. Furthermore, repair of the existing cabling is impractical due to the need to replace entire cable lengths to ensure services are adequately returned to operation.

Where capacity appears available, field teams are spending large amounts of time trying alternative cabling only to find it is unusable for services due to deterioration. This problem is further exacerbated if the services must utilise the metallic cable (due to aged terminal equipment) and cannot be relocated onto an available fibre cable.

Planned replacement of cable is necessary to manage the risk that degradation of the cable poses.

6.3 Fibre Creep

Due to environmental factors and asset age fibre cable performance is being degraded through an increased occurrence of fibre creep. Fibre creep is the gradual elongation of individual fibre cores, such that core moves within termination assembles and can push against other components causing bending radiuses tighter than the specification of the cable. Fibre creep could cause increasing transmission errors if the movement is relatively little, but left untreated would render the cores inoperable. In some cases, no pre-failure signs would be present and the core would fail without warning. Fibre creep may be identified by routine inspection and by sudden degradation of the performance of the systems using the cabling. In some cases, no pre-failure symptoms would be present and the cable would fail when the core suddenly moves. When fibre creep is identified it is rectified by re-terminating the impacted cores. Failure to remove the cable that is affected with fibre creep significantly increases the potential of an asset failure and significant signal degradation. This is an ongoing business as usual (BAU) activity.

7 Emerging Issues

This section reflects ongoing issues and continuous improvement opportunities. This work can be prioritised but can generally occur in parallel when resources permit. Action items have been raised in the following sections where relevant, detailing the specific actions that EQL will undertake as part of program delivery of this Asset Management Plan.

7.1 Intelligent Grid

EQL faces the challenges of increasing distributed energy resources in the network, the need to enable customer choice, the need to increase the safety of services provided, and the need to accommodate yet unknown requirements of customers and stakeholders. These challenges together present a need for more communications facilities and increasing demand for bandwidth for existing services and continue to increase the importance of communications systems performance including the performance of communications linear assets.

7.2 Technology Obsolescence

Metallic pilot cable, while still a valuable asset, is an obsolete technology whose importance will continue to reduce as the proportion of equipment incompatible with these cables grows over time. Eventually, suppliers will begin to discontinue equipment compatible with metallic pilot cables as demand falls. EQL must focus on improving and expanding the fibre cable network where possible and only retaining the outdated metallic pilot cable where it is not economic to move to the newer fibre cable.

7.3 Catenary separation

An increase in the number of reports of internal catenary detachment in the metallic pilot cable fleet of the South East Region (see example pictures in Figure 14) prompted a desktop study to evaluate the extent of the issue. Utilising publicly available imagery to evaluate the extent of the issue, the study identified a relatively low number of further issues in the network. Appendix 9 contains the results of the desktop study. It should be noted that some of the imagery used was up to three years old and as such, some of the issues may have already been resolved and or in some cases may now be worse.

Figure 14: Catenary Detachments of Metallic Pilot cables

Action 7.3-1: Demand inspections of the worst of the cable catenary issues identified have been requested, however, it should be noted that this work competes with many of the other defect work identified via inspection processes and will likely take some time to be completed.

7.3.1 Cable congestion

Due to the increased usage of fibre cable, statewide capacity congestion issues have occurred and continue to occur with greater frequency. Continual and increased protection requirements are placing additional demand on fibre cable capacity and redundancy requirements.

A potential improvement currently being considered to address congestion issues is Dense Wavelength Division Multiplexing (DWDM), an optical technology used to increase bandwidth over existing fibre optic backbones. DWDM works by combining and transmitting multiple signals simultaneously at different wavelengths on the same fibre. In effect, one fibre core is transformed into multiple virtual fibres.

7.3.2 Cable management tools

The cable management tool for the South East Region has been at end of life for at least ten years and no longer supports the needs for the modern services being provisioned on the network.

8 Improvements and Innovation

The following sections outline any improvements or innovations to asset management strategies relevant to this asset class, being investigated by EQL.

8.1 Cable Risk Prioritisation

A need to review the metallic pilot cable network after a number of cable failures that significantly impacted the power network, resulted in the need to develop a risk prioritisation criterion for metallic pilot cables, specific to protection services operating over the South East Region’s metallic pilot cable network.

The analysis allows EQL to have a prioritised list of cables where a complete failure will have a significant loss of protection function. The outcomes of this analysis are presented in Appendix 10. This methodology will be used along with standard Condition Based Risk Management (CBRM) analysis in making recommendations for metallic pilot replacement projects.

8.2 Alignment across Regions

Various opportunities exist to improve performance by aligning across the Regions as detailed below:

- Alignment of cable management tools – Within the Northern and Southern Regions the “Stride” documentation systems are utilised to record details of cabling and within the South East Region the “Communications Bearer Management Database” (CBMD) is utilised. The CBMD management tool is at end of life there is potential to align arrangements.
- Management approach – With the establishment of EQL there is an opportunity to align management approaches for fibre cabling.

Action 8.2-1: Investigate alignment of cable management tools and evaluate if there are advantages in aligning the approach to management of fibre cabling.

9 Lifecycle Strategies

The following sections outline the planned approach of EQL to the lifecycle asset management of this asset class.

9.1 Philosophy of Approach

EQL actively manages communications linear assets through a condition-based risk approach. The replacement of the assets is driven from estimated operational life and asset conditions:

- Operational life – supplied from the manufacture and adjusted by known performance,
- Asset condition – information from field assessments/inspections, monitored asset performance and failure data.

The risk of in service failures is mitigated by the Return to Service Program. Historically, risk analysis of in service failure resulted in many known issues that cause in-service failure being accepted (for example fibre creep, sudden increases of pair failures) without remediation activities. Further analysis is required to determine if this arrangement is prudent.

Action 9.1-1: Develop an EQL position for issues remediation where currently known issues are not resolved.

9.2 Supporting Data Requirements

The following sections detail some of the data quality issues that can impact efficient asset lifecycle assessment and management, such as historical supporting databases, legacy data management practices, and data collection methods.

9.2.1 Historical failure data

Due to inconsistent data capturing practices in EQL, actual historical failure data cannot be obtained without comprehensive manual assessment for failure of linear assets. Most of the available failure data is associated with impacts to the primary plant, for example, a loss of protection signalling recorded in the corporate repository could be caused by a number of factors one of which is a failure of a metallic pilot cable. Only with manual analysis of each service order and the notes provided by the officer repairing the issue is it possible (in some cases) to determine if the fault was caused by cable failure.

Action 9.2-1: Investigate improvement in failure data capture and visualisation.

9.2.2 Asset data

As outlined in Section 2.2 there is currently a significant amount of fibre cable data missing in EQL's corporate systems. This is significantly limiting the effective asset management of the asset.

Action 9.2-2: Initiate a statewide desktop audit of the fibre cable records to determine where information is missing and in which corporate systems. The desktop audit would recommend where further improvements are required and specific improvement activities to be undertaken.

9.3 Acquisition and Procurement

Present procurement and acquisition practices of 'Communications Linear Cable' assets are governed by requirements for refurbishments and replacements forecast by augmentation programs. Fibre requirements for maintenance are provided through surplus items from project works. For metallic pilot cables only, re-configuration and repair activities drive the requirements for procurement.

9.4 Operation and Maintenance

EQL has an obligation under the Electricity Act and Regulations to maintain a safe and reliable electrical supply network. This obligation is in turn reflected by the need to achieve and demonstrate compliance with the applicable EQL maintenance policies and standards.

9.4.1 Preventive Maintenance

Preventive maintenance activities consist of inspection, testing and routine maintenance activities. Inspection, testing and defect management and repair are completed as required under legislation. The inspection and maintenance programs include:

- Non-intrusive “inspection” – Monitoring of the of communications linear assets majority (bulk of fibre cables and a significant segment of metallic cabling) is performed by the terminating equipment which continuously monitors the performance of the assets and generates alarms in the event of signal degradation or other faults alerting maintenance staff.
- Visual inspection of physical condition – Limited regular inspections identify any unacceptable safety risk to personnel and the public, detect defects requiring action, and collect condition data for performance and risk analysis and replacement programs.
- Out of service condition assessment – This involves a variety of tests including insulation, continuity etc. testing for metallic pilot cables. Presently, no regular assessments of communications linear assets are conducted with this testing done as part of projects or fault remediation.

9.4.2 Corrective and Forced Maintenance

Corrective and forced maintenance is predominantly generated out of faults detected by monitoring equipment attached to the cabling, but in limited cases is also initiated from (ad-hoc) inspection process or based on historical observations of failures and public reporting. Cable repairs are undertaken if cost effective to meet current standards while taking into consideration programs such as augmentation and future replacement or retirement plans. In some cases, cable must be repaired regardless of future directions to maintain compliance with AEMO and NER rules.

9.4.3 Strategic Spares

Wherever possible, replacement activities attempt to utilise current contract cables to replace cabling during fault remediation. In some limited cases, this is not possible and strategic spares are held for these occasions. Strategic spares (and normal stock levels of current contract cables) are managed through Ellipse asset management system for the South East Region and the North and Southern Regions.

9.4.4 Metallic Pilot Cable

For metallic pilot cables, current practice is to use current contract cables to replace old construction with new construction types. For example, if a 10 pair metallic pilot cable is damaged, the faulted section will be replaced with current contract 20 pair cabling, with the extra cable pair un jointed to the existing cable. Similarly for fibre optic cable if a 6 core cable is damaged the faulted section would be replaced with 72 core cable.

9.4.5 Fibre Cable

As with the Metallic pilot cable, wherever possible, current contract cabling is used to repair all cabling faults. Fibre spares are usually managed through strategically maintained fibre cable buffer stocks acquired through other projects. In case of unavailability of similar standard spares, this is achieved by/through resorting to the use of latest generation fibres.

9.5 Refurbishment and Replacement

Refurbishment and replacement practices are important aspects of lifecycle asset management, that can serve to extend the serviceable lifetime of assets and define necessary end of life assessment criteria.

9.5.1 Refurbishment

On identification of defects or improvements through monitoring, inspections, and testing, EQL undertakes refurbishment of communications linear assets to ensure they remain safe. Financial assessment is sometimes used when determining if certain defects that only impact capacity or performance and not the safety of the asset can be tolerated. Examples of this include individual core failures and fibre creep, whilst it would be possible to remove failed sections of cabling to return cabling to near new performance, in most cases the small reduction of overall performance can be tolerated and is often designed into cable installation to avoid the need for this type of refurbishment activity.

It is noted that the mechanical properties of the cable itself cannot be restored once lost, however, replacement of sections of cabling, joints, termination assemblies, and fittings can be performed. For the specific case of catenary separation defects, cabling can have life extension via the use of cable ties to re-attach the cable to the catenary.

9.5.2 Replacement

Communications linear cable systems are designed and constructed to ensure that they are fit for purpose and will continue to perform and operate safely under the anticipated ecosystem it is installed in. When the asset can no longer safely perform its function due to obsolescence, is uneconomic to refurbish, or presents an unacceptable risk to the business, it is considered end of life and planned replacement is proposed.

With the metallic pilot cable now an obsolete technology, as each cable’s condition deteriorates such that replacement is warranted, fibre optic cable is installed to replace the older metallic cable wherever possible.

9.6 Disposal

Metallic pilot cables have high metallic content and there are well-established processes to recover/recycle metallic and outer plastic for reuse.

Disposing of optical fibre cables and components requires the use of sealed bins, without leaving pieces or cut-offs in public areas. The AS / NZS 2967:2014 standard refers to “Safe Practices in the handling, installation, testing, use and disposal of optical Fibre cabling and associated materials and equipment”. The compliant work practices of Energex are specified in WP1113 and WCS105 documents listed in Appendix 1- References.

Ergon Energy assets will be disposed in accordance with standard corporate process outlined in BS000311F100 and BS000311R100 documents listed in Appendix 1- References.

10 Program Requirements and Delivery

The programs of maintenance, refurbishment and replacement required to outwork the strategies of this AMP are documented in Network Program Documents and reflected in corporate management systems. Programs are typically coordinated to address the requirements of multiple asset classes at a higher level such as a substation site or feeder to provide delivery efficiency and reduce travel costs and overheads. The Network Program Documents provide a description of works included in the respective programs as well as the forecast units.

Program budgets are approved in accordance with Corporate Financial Policy. The physical and financial performance of programs is monitored and reported on a monthly basis to manage variations in delivery and resulting network risk.

11 Summary of Actions

The following provides a summary of the specific actions noted throughout this AMP for ease of reference.

Action 7.3-1: Demand inspections of the worst of the cable catenary issues identified have been requested, however, it should be noted that this work competes with many of the other defect work identified via inspection processes and will likely take some time to be completed.

Action 8.2-1: Investigate alignment of cable management tools and evaluate if there are advantages in aligning the approach to management of fibre cabling.

Action 9.1-1: Develop an EQL position for issues remediation where currently known issues are not resolved.

Action 9.2-1: Investigate improvement in failure data capture and visualisation.

Action 9.2-2: Initiate a statewide desktop audit of the fibre cable records to determine where information is missing and in which corporate systems. The desktop audit would recommend where further improvements are required and specific improvement activities to be undertaken.

Appendix 1. References

It takes several years to integrate all standards and documents after a merger between two large corporations. This table details all documents authorised/approved for use in either legacy organisation, and therefore authorised/approved for use by EQL, that supports this Management Plan.

Legacy organisation	Document Number	Title	Type
Ergon Energy **Energex**	EPONW01 EX 03595	Network Asset Management Policy	Policy
Ergon Energy **Energex**	PRNF001 EX 03596	Protocol for Network Maintenance	Protocol
Ergon Energy **Energex**	PRNF003 EX 04080	Protocol for Refurbishment and Replacement	Protocol
Ergon Energy **Energex**	STNW0330 EX 03918	Standard for Network Assets Defect/Condition Prioritisation	Standard
Ergon Energy **Energex**	STNW1160 EX STD00299	Maintenance Acceptance Criteria	Manual
EQL		Risk Management and Resilience Policy	Policy
Ergon Energy	EP26	Risk Management Policy	Policy
Ergon Energy	EP51	Defect Management Policy	Policy
Ergon Energy	SGNW0004	Network Optimisation Asset Strategy	Strategy
Ergon Energy	STNW0717	Standard for Preventive Maintenance Programs for 2017-18	Standard
Ergon Energy		Substation Defect Classification Manual	Manual
Ergon Energy	STNW1002	Standard for Substation Protection	Standard
Ergon Energy	STNW1156	Standard for Protection Systems	Standard
Ergon Energy	ETS03-01-07	Technical Specification for Optic Fibre Cable	Specification
Ergon Energy	BS000311F10	Disposal of Fixed Assets Form	Work Process
Ergon Energy	BS000311R100	Disposal of Fixed Assets Quick Reference Guide	Reference
Energex	WP1159	Working with Optical Glass Fibre Cable	Work Practice
Energex	WCS105	Fibre Optic Cable Systems Installation and Maintenance	Work Category Specification
Energex		Telecommunications Strategic Plan 2015-20	Strategic Plan
Energex		Pilot Cable Replacement	Business Case
Energex		Network Asset Management Program - Opex Planned Maintenance V4	Document
Energex		Core IP-MPLS Telecommunications Network Rollout	Business case
Energex		Energex Optical Fibre Cable In-Fill	Business Case
Energex		Obsolete Telecommunications Equipment	Business Case
Energex		DRAFT Pilot cable refurb Business Case	Business Case

Appendix 2. Definitions

Term	Definition
Condition Based Risk Management	A formal methodology used to define current condition of assets in terms of health indices and to model future condition of assets, network performance, and risk based on different maintenance, asset refurbishment, or asset replacement strategies.
PCB	Polychlorinated Biphenyls are synthetic chemicals manufactured from 1929 to 1977 was banned in 1979 and found in transformers, voltage regulators and switches
Corrective maintenance	This type of maintenance involves planned repair, replacement, or restoration work that is carried out to repair an identified asset defect or failure occurrence, in order to bring the network to at least its minimum acceptable and safe operating condition. An annual estimate is provided for the PoW against the appropriate category and resource type.
Preventative maintenance	This type of maintenance involves routine planned/scheduled work, including systematic inspections, detection and correction of incipient failures, testing of condition and routine parts replacement designed to keep the asset in an ongoing continued serviceable condition, capable of delivering its intended service
Voltage Transformers	Voltage or potential transformers are used to provide/transform voltages suitable for metering and protection circuits where accuracy is required.
Forced Maintenance	This type of maintenance involves urgent, unplanned repair, replacement, or restoration work that is carried out as quickly as possible after the occurrence of an unexpected event or failure; in order to bring the network to at least its minimum acceptable and safe operating condition. Although unplanned, an annual estimate is provided for the PoW against the appropriate category and resource type.
All-dielectric self-supporting cable (ADSS)	All-dielectric self-supporting cable is a type of optical fiber cable that is strong enough to support itself between structures without using conductive metal elements. It is used by electrical utility companies as a communications medium, installed along existing overhead transmission lines and often sharing the same support structures as the electrical conductors.
Intersite	Cable running between each site and location outside the site boundary.
Intrasite	Cable located with the boundary of a site.
Fibre Cable	12 to 96 core cables containing multiple individual glass cores each is covered in an insulation medium
Pilot Cable	Metallic (copper) cable covered in an insulation medium
Electromagnetic Waves	Waves that are propagated by simultaneous periodic variations of electric and magnetic field intensity and that include radio waves, infrared, visible light, ultraviolet, X-rays, and gamma rays.
Active Equipment	Equipment with a function of gain or control, with the connection of the controlling parameters being nonlinear.
Smart Grid	A smart grid is an electrical grid which includes a variety of operational and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficient resources. Electronic power conditioning and control of the production and distribution of electricity are important aspects of the smart grid.
Fibre Creep	Creep is a material property and can be defined as the continued extension of a material when subjected to constant, long-term static loading.
Core Network (backbone)	The core network (or backbone) is the part of a network that connects the different parts of the access network of Northern and Southern (Ergon) Regions. The core network also provides the gateway to other networks.
VQSM	Visual QSM (early versions were called Quetzal) is a service request system.

Appendix 3. Acronyms and Abbreviations

The following abbreviations and acronyms may appear in this asset management plan.

Abbreviation or acronym	Definition
ADSS	All-dielectric self-supporting cable
AIDM	Asset Inspection & Defect Management system
ALARP	As low as reasonably practical
AEMO	Australian Energy Market Operator
AMP	Asset Management Plan
Augex	Augmentation Expenditure
AS/NZ	Australia/New Zealand
CBRM	Condition Based Risk Management
CBMD	Cable Bearer Management Database
CD	Chromatic Dispersion
DEE	Dangerous Electrical Event
EQL	Energy Queensland Limited
ESCOP	Electricity Safety Code of Practice
ESR	Queensland Electrical Safety Regulation (2013)
HV	High voltage
IoT	Internet of Things
IED	Intelligent Electronics Device
ISCA	In-Service Condition Assessment
LDCM	Lines Defect Classification Manual
LV	Low Voltage
MPLS	Message Protocol Label Switching
MSS	Minimum Service Standards
NER	National Electricity Rules
NOC	Network Operations Centre
OHEW	Over Head Earth Wire
OPGW	Optical Ground Wire
OT	Operational Technology
PCB	Polychlorinated Biphenyls
POC	Point of Connection (between EQL assets and customer assets)
PD	Polarisation Mode Dispersion
QLD	Queensland
REPEX	Renewal Expenditure
RIN	Regulatory Information Notice
SCADA	Supervisory Control and Data Acquisition

Abbreviation or acronym	Definition
SCAMS	Substation Contingency Asset Management System
SDCM	Substation Defect Classification Manual
SDH	Synchronous Digital Hierarchy
SFAIRP	So far as is reasonably practical
SHI	Security and Hazard Inspection
TDM	Time-division multiplexing
STOC	SCADA and Telecommunications Operations Centre
UV	Ultra Violet
VQSM	Visual Quetzal Service Manager (Service and ticketing system used by CNOC of Ergon Energy)

Appendix 4. Asset Quantity Ergon Fibre Cable Geographical Representation (sourced from Google Earth)

Location	Approx.: Length (km)	Region	Location	Approx.: Length (km)	Region
Atherton	22.5	Nth	Barcaldine	2	Sth
Babinda	2.8	Nth	Blackwater	110	Sth
Bowen	11	Nth	Bundaberg	35	Sth
Burdekin	58	Nth	Charleville	4.8	Sth
Burton Mine	10	Nth	Childers	0.75	Sth
Cairns	100	Nth	Chinchilla	2.8	Sth
Charters Towers	3.4	Nth	Daandine	2.5	Sth
Chumvale	0.5	Nth	Dalby	72	Sth
Cloncurry	0.8	Nth	Dysart	8.1	Sth
Goonyella	0.2	Nth	Emerald	7	Sth
Gregory Mine	2.4	Nth	Gladstone	85	Sth
Home Hill	0.6	Nth	Goondiwindi	90	Sth
Hughenden	1.05	Nth	Hervey Bay	49	Sth
Ingham	8	Nth	Kilkivan	0.2	Sth
Julia Creek	0.8	Nth	Kingaroy	2	Sth
Mackay	92	Nth	Longreach	1.9	Sth
Mareeba	1.5	Nth	Maryborough	20	Sth
Merinda	9.8	Nth	Miles	1.46	Sth
Moranbah	39	Nth	Millmerran	2.9	Sth
Mt Molloy	2.2	Nth	Monto	2.3	Sth
Mt Isa	4.25	Nth	Mundubbera	2.95	Sth
Norwich Park	1.9	Nth	Murgon	1	Sth
Peak Downs	3.85	Nth	Near Miles	0.8	Sth
Pinnacle	0.5	Nth	Rockhampton	65.5	Sth
Proserpine	5.05	Nth	Roma	12.5	Sth
Ravenshoe	0.15	Nth	Stanthorpe	8.16	Sth
Richmond	1.2	Nth	Toowoomba	137.9	Sth
Sth Walker Mine	4	Nth	Warwick	2.75	Sth
Towers Hill	0.2	Nth	Wilkie Creek	12.55	Sth
Townsville	121.5	Nth	Yarranlea	21.6	Sth
Tully	4.44	Nth	Unknown	457.04	both
Vermont	11.8	Nth			
Winton	1.9	Nth			
Yeppoon	17.25	Nth			

APPENDIX 5. Test Results of Metallic Pilot Cable - Passed

(Source: Energex - Metallic (Copper) Pilot Cable Test Data).

energex

2400 26.08.2005
Page 1 of 2

PILOT CABLE TESTS

1. SITE DATA

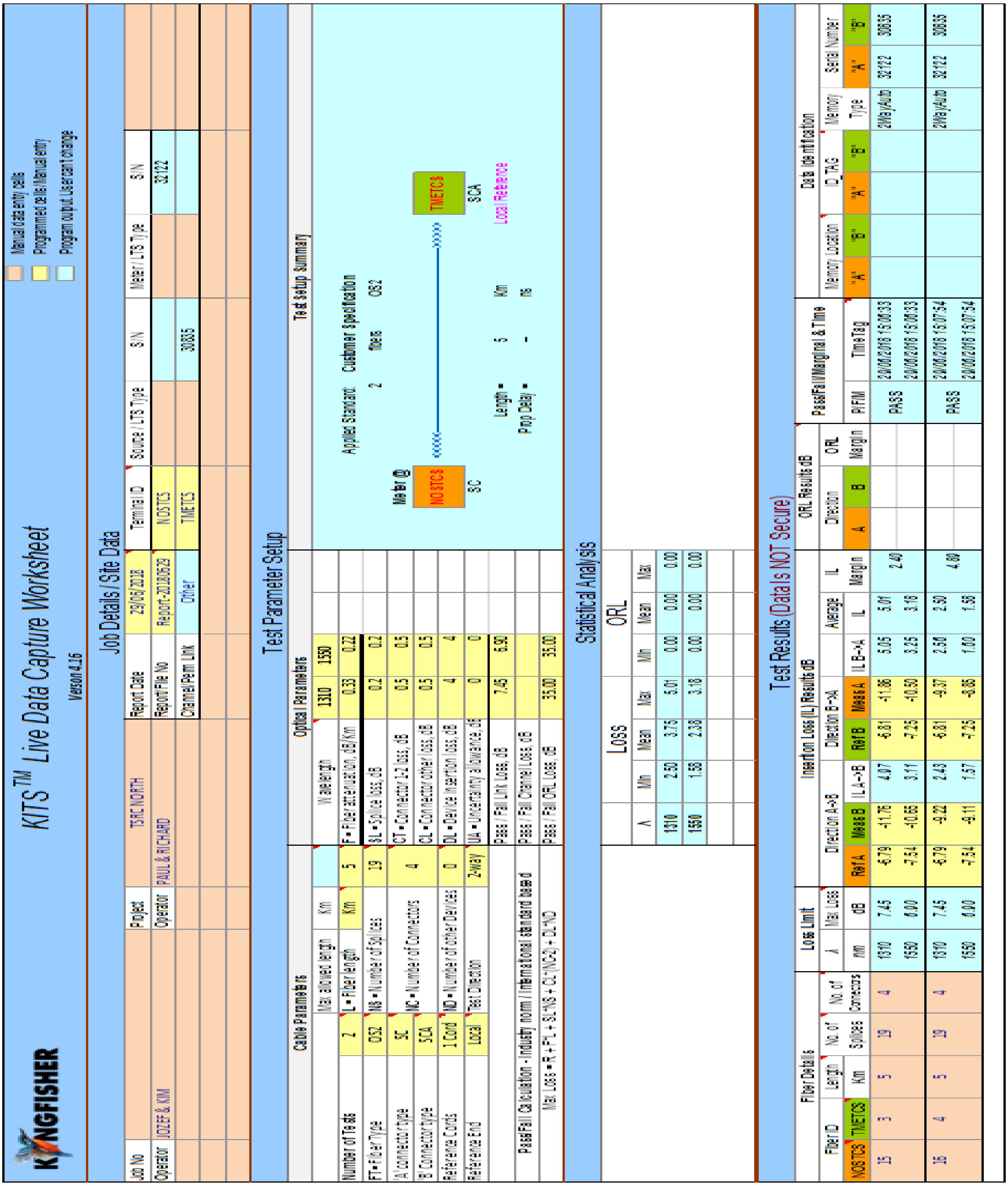
Pilot Cable	141	Technician	Ken Batchelder	Date	28 / 08 / 2016
Location	SSKRN	Instrument No.'s	MEGGER - 33096 MULTIMETER - 22015		

2. TEST RESULTS

CORE NO.	COLOUR	IDENTIFY EACH CORE	INSULATION RESISTANCE: EACH CORE TO ALL CORES AND EARTH (MΩ)	INSULATION RESISTANCE: BETWEEN EACH PAIR (MΩ)	LOOP RESISTANCE (Ω)	PILOT CAPACITANCE (μF)
1A	W	Y	2	200	237	.2
1B	B	Y	100			
2A	W	Y	100	200	237	.2
2B	O	Y	100			
3A	W	Y	100	200	238	.2
3B	G	Y	100			
4A	W	Y	30	100	238	.2
4B	BR	Y	100			
5A	W	Y	200	100	237	.2
5B	GREY	Y	75			
6A	R	N	O/C	200	O/C	-
6B	B	Y	200			
7A	R	Y	200	200	236	.2
7B	O	Y	200			
8A	R	Y	200	100	237	.2
8B	G	Y	15			
9A	R	Y	20	100	237	.2
9B	BR	Y	100			
10A	R	Y	1.5	2	236	.22
10B	GREY	Y	.25			
11A	BLACK	Y	100	200	238	.2
11B	B	Y	100			
12A	B	Y	.05	1.8	237	1.9
12B	O	Y	.08			
13A	B	Y	200	200	238	.2
13B	G	Y	1			
14A	B	Y	.01	.08	235	-
14B	BROWN	Y	.1			
15A	B	Y	100	100	236	.27
15B	GREY	Y	.1			
16A	Y	Y	200	100	237	.2
16B	B	Y	3.5			

Appendix 6. Sample of Fibre Cable Test Results

(Source: Energex - Fibre Optic Cable OTDR Test Data)



KINGFISHER

KITS™ Live Data Capture Worksheet

Version 4.16

Manual data entry cells
Programmed cells/Manual entry
Program output. User can't change

Job Details / Site Data

Job No		Project	TSRC NORTH	Report Date	29/06/2018	Terminal ID	Source / LTS Type	S/N	Meter / LTS Type	S/N
Operator	JOZEF & KIM	Operator	PAUL & RICHARD	Report/File No	Report-20180629	NOSTCS				32122
				Channel/Perm Link	Other	TMETCS		30835		

Test Parameter Setup

Cable Parameters				Optical Parameters		
		Max allowed length	Km	Wavelength	1310	1550
Number of Tests	2	L = Fiber length	Km 5	F = Fiber attenuation, dB/Km	0.33	0.22
FT = Fiber Type	OS2	NS = Number of Splices	19	SL = Splice loss, dB	0.2	0.2
'A' connector type	SC	NC = Number of Connectors	4	CT = Connector 1-2 loss, dB	0.5	0.5
'B' Connector type	SCA			CL = Connector other loss, dB	0.5	0.5
Reference Cords	1 Cord	ND = Number of other Devices	0	DL = Device insertion loss, dB	4	4
Reference End	Local	Test Direction	2-way	UA = Uncertainty allowance, dB	0	0
				Pass / Fail Link Loss, dB	7.45	6.90
Pass/Fail Calculation - Industry norm / International standard based				Pass / Fail Channel Loss, dB		
Max Loss = R + F*L + SL*NS + CL*(NC-2) + DL*ND				Pass / Fail ORL Loss, dB	35.00	35.00

Test Setup Summary

Applied Standard: Customer Specification
2 fibers OS2
Meter @
NOSTCS SC — TMETCS SCA
Length = 5 Km
Prop Delay = - ns
Local Reference

Statistical Analysis

	Loss			ORL		
λ	Min	Mean	Max	Min	Mean	Max
1310	2.50	3.75	5.01	0.00	0.00	0.00
1550	1.58	2.38	3.18	0.00	0.00	0.00

Test Results (Data Is NOT Secure)

Fiber Details					Loss Limit		Insertion Loss (IL) Results dB								IL	ORL Results dB			Pass/Fail/Marginal & Time		Data Identification						
Fiber ID		Length	No. of Splices	No. of Connectors	λ	Max Loss	Direction A->B			Direction B->A			Average			Direction		ORL			Memory Location		ID_TAG		Memory	Serial Number	
NOSTCS	TMETCS	Km			nm	dB	Ref A	Meas B	IL A->B	Ref B	Meas A	IL B->A	IL		Margin	A	B	Margin	P/F/M	TimeTag	"A"	"B"	"A"	"B"	Type	"A"	"B"
15	3	5	19	4	1310	7.45	-6.79	-11.76	4.97	-6.81	-11.86	5.05	5.01		2.40				PASS	29/06/2018 15:06:33					2WayAuto	32122	30835
					1550	6.90	-7.54	-10.65	3.11	-7.25	-10.50	3.25	3.18							29/06/2018 15:06:33							
16	4	5	19	4	1310	7.45	-6.79	-9.22	2.43	-6.81	-9.37	2.56	2.50		4.80				PASS	29/06/2018 15:07:54					2WayAuto	32122	30835
					1550	6.90	-7.54	-9.11	1.57	-7.25	-8.85	1.60	1.58							29/06/2018 15:07:54							

Appendix 7. Availability: Service Type/ Customer Class Based

(Source: Energex – Telco data)

IP/MPLS network

Customer Name	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18
PDH Transport Service	100	100	100	100	100	100	100	100	100	100	100	100
Corporate Services	99.95	99.99	100	99.99	99.79	99.92	99.99	99.95	99.99	100	99.99	99.98
Teleprotection Services	100	100	100	100	100	100	99.86	100	100	100	100	100
Operational Support Services	100	100	100	100	100	100	100	100	100	100	100	100
Powerlink	100	100	100	100	100	100	100	100	100	100	100	100
Controllers	100	100	100	100	100	100	100	100	100	100	100	100
Distribution Zone	100	99.99	100	100	100	100	99.99	99.95	100	100	99.99	100
Measurement Zone	99.99	99.99	100	100	100	100	99.98	99.95	100	99.99	99.99	100
Site Security Services	100	99.99	100	100	100	100	99.99	99.95	100	100	99.99	100
Control Zone Services	100	99.99	100	100	100	100	99.99	99.95	100	100	99.99	100
Total	**99.994**	**99.995**	**100**	**99.999**	**99.979**	**99.992**	**99.98**	**99.975**	**99.999**	**99.999**	**99.995**	**99.998**

Customer Name	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18
PDH Transmissions Nodes	99.941%	99.975%	99.992%	99.958%	99.970%	99.999%	99.997%	99.967%	99.982%	98.674%	98.674%	99.7638%
Total	**0.999411**	**0.999749**	**0.999917**	**0.999584**	**0.999704**	**0.999988**	**0.999966**	**0.999673**	**0.999817**	**0.986741**	**0.986741**	**0.9976384**

Appendix 8. Test Results of Metallic Pilot Cable - Failed

(Source: Energex - Metallic (Copper) Pilot Cable Test Data)

energex

2400 26.08.2005
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PILOT CABLE TESTS

1. SITE DATA

Pilot Cable	PC351	Technician	David James	Date	5 / 9 / 2017
Location	SSZMR - SSBHL	Instrument No.'s	Fluke 26280 (Resistance & Capacitance), Meggar 15250 (Insulation)		

2. TEST RESULTS

CORE NO.	COLOUR	IDENTIFY EACH CORE	INSULATION RESISTANCE		LOOP RESISTANCE (Ω)	PILOT CAPACITANCE (μF)
			EACH CORE TO ALL CORES AND EARTH (MΩ)	BETWEEN EACH PAIR (MΩ)		
1A	Yellow - White	Y	0	0.05	238	4.2
1B	Yellow - Blue	Y	0			
2A	Yellow - White	Y	0.05	0.05	237	1.4
2B	Yellow - Orange	Y	0			
3A	Yellow - White	Y	0.05	0.1	238	1.0
3B	Yellow - Green	Y	0			
4A	Yellow - White	Y	0.1	0.1	237	2.2
4B	Yellow - Brown	Y	0.05			
5A	Yellow - White	Y	0	0	237	OL
5B	Yellow - Grey	Y	0			
6A	Yellow - Red	Y	0.01	0.02	238	5.6
6B	Yellow - Blue	Y	0.01			
7A	Yellow - Red	Y	0.05	0.08	237	1.4
7B	Yellow - Orange	Y	0.05			
8A	Yellow - Red	Y	0.02	0.05	237	2.1
8B	Yellow - Green	Y	0.01			
9A	Yellow - Red	Y	0.02	0.01	3130	OL
9B	Yellow - Grey	Y	0.01			
10A	Yellow - Red	Y	0.05	0.05	238	1.9
10B	Yellow - Brown	Y	0.05			
11A						
11B						

Appendix 9. Metallic Pilot Cable Investigation Results

Cable Code	Location of damage and record date of data used for analysis
PC105	Cable damaged: 120 Station Rd, Silkstone (as at April 2017)
PC60	Cable damaged: 23399 Sandgate Rd, 2174 Sandgate Rd Boondall (as at Jul 2017)
PC749	Cable damaged: Cable hanging over foot path at 188 Appleby Rd (as at June 2017)
PC355	Cable damaged: 50 Raven St, 41 Chat way St (as at Sept 2013); 35 Buzacott St (as at Jul 2015), 14 Wrecker St (as at Jul 2017)
PC312	Cable damaged: PC312 Boundary Rd Inala (as at July 2017)
PL101	Cable damaged: Slight damage detected at Pellow St and Young St
PC273	Cable damaged: Freeman Rd Inala (as at Apr 2017), 7-9 Barbery St Inala (as at Sept 2013), 17/ 23/ 81 Deodar St Inala (as at Sept 2013)
PC316	Cable damaged: 93/ 111/ 135 Postle St Acacia Ridge (as at Mar 2017)
PC493	Cable damaged: (PC493 runs along the same path as PL44) 197 Dawson Parade Keperra (as at Jun 2017)
PC141	Cable damaged: Newmarket Rd Newmarket (as at July 2017) , 78 Lamont Rd Wilston (as at May 2017), 39 Jean St Grange
PC80	Cable damaged: 35/ 102 Boxgrove Ave Wynnum West (as at Jul 2017), 104 Stradbroke Ave Wynnum (as at Aug 2015) , 96 West Ave Wynnum (as at Mar 2106)
PC40	Cable damaged: 3 Boundary St at across Kate St (as at Nov 2013), 7 Boundary St Indooroopilly (as at Nov 2013)
PC91	URGENT > Cable damaged: 12, 88 Freeman Rd Oxley and Over / along footpath on 26 Eucalypt St/ 100 Lilac St/ Over Lilac St / Over Hydrangea St (as at April 2016)
PL45	Cable damaged: 117 Keung Rd Albany Cr (as at Jun 2017)
PC668	Cable damaged at junction over Hebert and Moss St (as at July 2017)
PC141	Cable damaged: Newmarket Rd Newmarket (as at July 2017) , 78 Lamont Rd Wilston (may 2017), 39 Jean St Grange
PC273	Cable damaged
PC312	Cable damaged
PC40	3, Boundary St at across Kate St (as at Nov 2013), 7 Boundary St, Indooroopilly
PC411	Cable damaged
PC474	Cable damaged
PC60	Cable damaged: 23399 and 2174 Sandgate Rd Boondall , PC312 Boundary Rd, Freeman Rd Inala, Freeman Rd Inala (as at Apr 2017), 7 Barbery St Inala, 9/ 21/ 23/ 81 Deodar St Inala, 9 Barberry St Inala (Sep as at 2013)
PC75	URGENT > Cable Damaged
PC80	Cable damaged: 35 and 102 Boxgrove Ave Wynnum West (as at Jul 2017), 104 Stradbroke Ave Wynnum (as at Aug 2015) , 96 West Ave Wynnum (as at Mar 2106)
PC99	Cable damaged
PL101	Slight damage detected at 119 Keong Rd near Dawn Rd (as at July 2017)

Appendix 10. Metallic Pilot Cable Risk Prioritisation Score

	Weighting:	1	8	1	7	1	4	3	1	100			100		100	
VISUAL BEARER CODE	Bearer ID	No of New Comm Types	No of Old Comm Types	Total No of Comm Services	No of BSPs	No of BSP to ZS	No of BSP to BSP Links	No Of 110kV Services	No of 33kV Services	No of Old Comm Types > 30%	No of Feeders	PRIORITY Feeders	Score > 50% of PRIORITY Feeders	Service Age	Age score	Total Risk Score
PC143	86082	7	6	13	3	11	0	8	5	100	10	7	1	51	100	**429**
PC274	87215	3	2	5	2	7	1	3	2	100	5	0	0	50	100	**260**
PC33	84576	3	3	6	0	0		1	5	100	5	1	0	50	100	**241**
PC98	85494	0	4	4	0	0		0	4	100	3	0	0	53	100	**240**
PC355	88193	0	3	3	1	2		0	3	100	3	0	0	47	100	**239**
PC505	90036	7	0	7	0	0		7	0	0	5	6	1	42	100	**235**
PC12	84070	4	2	6	0	0		1	5	100	5	1	0	48	100	**234**
PC258	87045	1	3	4	0	0		0	4	100	2	0	0	51	100	**233**
PC379	88541	1	3	4	0	0		0	4	100	2	0	0	42	100	**233**
PC268	87139	0	3	3	0	0		1	2	100	3	0	0	50	100	**232**
PL78	97830	1	2	3	1	1		0	3	100	2	0	0	52	100	**231**
PC96	85477	0	3	3	0	0		0	3	100	3	0	0	55	100	**230**
PC363	88302	1	2	3	0	0		0	3	100	3	0	0	44	100	**223**
PC34	84602	1	1	2	1	2		0	2	100	2	0	0	59	100	**222**
PC432	89042	1	1	2	1	2		0	2	100	2	0	0	44	100	**222**
PC340	88038	1	1	2	1	2		0	2	100	2	0	0	46	100	**222**
PC127	85904	0	2	2	0	0		0	2	100	2	0	0	57	100	**220**
PC95	85466	0	2	2	0	0		0	2	100	2	0	0	55	100	**220**
PL26	97128	0	4	4	0	0		0	4	100	3	0	0	39	80	**220**
PL29	97191	0	4	4	0	0		0	4	100	3	0	0	39	80	**220**
PL77	97809	0	3	3	1	1		0	3	100	3	0	0	39	80	**218**

Appendix 11. Fibre Optic Cable - Current Standards

(Source: Energex Technical Instructions 2017- Standards Fibre Optic Cables).

Fibre Optic Cable -Current Standard Used for OPGW, ADSS(OH) and UG

Fibre Count	Description
72SM	OPGW; 72 fibre; Single Mode;G.652 9.2/125um;1310nm & [1550nm]0.33dB/km [0.20dB/km] loose tube; Overhead; **fault level 1sec, 4.9kA;** **cable OD 11.0mm;** 600m span; left hand lay; 300mm min bend radius.
48 SM	OPGW; 48 fibre; Single Mode;G.652 9.2/125um;1310nm & [1550nm]0.33dB/km [0.20dB/km] loose tube; Overhead; **fault level 0.5sec, 16kA;** **cable OD 14.48mm;** 600m span; left hand lay; 300mm min bend radius.
72 SM	ADSS; 72 fibre; **Single Mode**;G.652 9/125um; 1310nm & [1550nm];0.33dB/km[0.20dB/km]; jelly filled loose tube; cable OD 12.5mm; 250m span; 250mm min bend radius.
8 MM	ADSS; 8 fibre; **Multi Mode;G.651 62.5/125um**; 850nm & {1310nm}; 3.5 dB/km {1.0 dB/km}; jelly filled loose tube; cable OD 12.5mm; 250m span; 250mm min bend radius.
8MM	ADSS; 8 fibre; **Multi Mode;OM4; 50/125um**; 850nm & {1310nm}; 3.0 dB/km {1.0 dB/km}; jelly filled loose tube; loose tube; cable OD 12.5mm; 250m span; 250mm min bend radius.
72 SM	UG Telecom; 72 fibre; Single Mode;G.652 9.2/125um; 1310nm & [1550nm]; 0.33dB/km[0.20dB/km]; jelly filled loose tube; c/w termite protection; Underground (in duct); cable OD 11.7mm; 234mm min bend radius.
48 (SM) + 4 (MM)	UG DTS; 52 (48SM+4MM) fibre; Single Mode + Multi Mode;G.652 9/125umx48 + OM2 50/125umx4; 1310nm [1550nm] + 850nm {1310nm}.33dB/km[0.21dB/km] + 3.5 dB/km {1.0 dB/km} jelly filled loose tube; c/w termite protection; Underground (duct & direct buried); cable OD 11.7mm; 234mm min bend radius.

Appendix 12. Fibre Optic Cable – Congestion issues

North / South Regions cable congestion issues

There is a requirement for two new diverse paths:

- Peter Arlett to Dan Gleeson
- Aitkenvale to Garbutt

There is a requirement for the following four constraint/congestion alleviations:

- Fibre Loop OCCN/GACC & CRAN/PEAR
- Maryborough cable 5001, 5002, 5008 & 5009
- Cable 6005 (12 core) from P6286 to SOTOCS
- ADST-MARY, MARY-MASR

Future substation connection:

- Bohle to Dan Gleeson for the connection of Bohle Plains Substation

South East Region cable congestion issues

Appendix 13. Fibre Optic Cable – Ergon Energy Fibre Spares

Current list of Ergon Energy strategic Fibre spares, as at February 2018.

ITEM DESCRIPTION	Length
Aerial, ADSS, Short Span, Dry Core, 12 Fibres, SMOF (4000m Drum)	3786m
Aerial, ADSS, Short Span, Dry Core, 12 Fibres, SMOF (4000m Drum)	2965m
Aerial, ADSS, Short Span, Dry Core, 12 Fibres, SMOF (4000m Drum)	3850m
U/Ground, Dry Core, 12 Fibres, SMOF, c/w Termite Protection (4000m Drum)	4000m
U/Ground, Dry Core, 12 Fibres, SMOF, c/w Termite Protection (4000m Drum)	5560m
Aerial, OPGW, 11.0mm Dia, 24 Fibres, SMOF	6000m
Aerial, OPGW, 11.0mm Dia, 24 Fibres, SMOF	6000m
Aerial, OPGW, 11.0mm Dia, 24 Fibres, SMOF	6000m
Aerial, OPGW, 11.0mm Dia, 24 Fibres, SMOF	6000m
Aerial, OPGW, 11.0mm Dia, 24 Fibres, SMOF	6000m
Aerial, OPGW, 11.0mm Dia, 24 Fibres, SMOF	6000m
Aerial, OPGW, 11.0mm Dia, 24 Fibres, SMOF	6000m
Aerial, OPGW, 11.0mm Dia, 24 Fibres, SMOF	6000m
Aerial, OPGW, 11.0mm Dia, 24 Fibres, SMOF	6000m
Aerial, OPGW, 14.0mm Dia, 24 Fibres, SMOF	6650m