ATTACHMENT 12.2
ASSET LIFECYCLE STRATEGY - CORROSION PROTECTION SYSTEMS

ATCO 2020-24 PLAN

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CORROSION PROTECTION SYSTEMS

ASSET LIFECYCLE STRATEGY

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Abbreviations

ALARP	As Low As Reasonably Practicable
ALS	Asset Lifecycle Strategy
AMP	Asset Management Plan
AMS	Asset Management System
Capex	Capital Expense
CP	Corrosion protection
DCVG	Direct Current Voltage Gradient
EPR	Earth Potential Rise
ER	Electrical Resistance
ERP	Enterprise Resource Planning
FS	Foreign Structures
FSA	Formal Safety Assessment
GDS	Gas Distribution System
HPR	High-pressure Regulator
IJ	Insulation Joints
LFI	Low Frequency Induction
MAE	Major Accident Event
MAOP	Maximum Allowable Operating Pressure
MGL	Mandurah Gas Lateral
NACE	National Association of Corrosion Engineers
NGR	National Gas Rules
NPV	Net Present Value
Opex	Operating Expense
PC	Polarisation Cells
PGP	Parmelia Gas Pipeline
PRS	Pressure Reduction Stations
RMAPs	Risk Management Action Plans
SP	Corrective Maintenance
TP	Test Points
TRU	Transformer Rectifier Units

Executive Summary

This Asset Lifecycle Strategy (**ALS**) provides an overview of ATCO's Corrosion Protection (**CP**) Systems, the lifecycle management approach to be used, and planned investments over the next 10 years. This ALS is updated annually and details the investment strategies for this asset class based on the performance, condition, and service (regulatory) requirements of the asset class.

The ALS is a key component of ATCO's Asset Management System (**AMS**) and should be read in conjunction with other key documents such as ALS for other assets, and the Asset Management Plan (**AMP**).

Scope of the ALS

The scope of this asset class is CP used in the Gas Distribution System[1] (**GDS**). These include:

- Sacrificial anode system – utilising magnesium anodes
- Impressed current system – utilising Transformer Rectifier Units (**TRU**)
- Earth Potential Rise (**EPR**) and Low Frequency Induction (**LFI**) Mitigation systems

Strategic Alignment

The ALS supports alignment between ATCO's corporate objectives and its day-to-day activities by aligning its corporate objectives with those informing investment and maintenance programs in the asset class. This approach helps to ensure ATCO efficiently delivers a safe and reliable distribution network meeting the levels of services expected by its customers.

The following table includes the CP assets' KPI's that have been identified to support the delivery of ATCO's overarching asset management objectives.

Table OV.1: Key objective that supports corporate alignment

CORPORATE OBJECTIVE	AM OBJECTIVE	MEASURE	TARGET
Safe	Network Integrity	% of network protected by CP	99% of pipelines rated fair or good

Asset Class Overview

All ATCO high-pressure steel gas pipelines, and most medium pressure steel pipelines and steel pipeline crossings, have corrosion protection systems to protect against corrosion.

Sacrificial Anode System

Sacrificial anode systems protect approximately 85% of the underground metallic mains and pipelines. These systems deplete at rates specific to the environmental conditions that the protected sections

[1] The GDS, covered by the Access Arrangement, operates in the Coastal Gas supply areas under the conditions defined in Gas Distribution License 8. Our Albany and Kalgoorlie networks are non-regulated networks (not covered by GDL8) and are not included in the GDS.

operate within, thereby consuming these anode banks at varying rates. These systems are generally working well, and the anodes are replaced when protection levels are underperforming. Installation of these systems for protection are preferred due to their lower lifecycle costs and they are installed on most new underground steel assets.

Impressed Current System

Impressed current systems protect approximately 15% of the underground metallic mains and pipelines. These systems use a TRU to impress current to the pipelines and mains to mitigate corrosion. The TRU have expected technical lives of approximately 40 years, but are replaced on poor condition or performance. Installation of impressed current systems remain on the older steel network and are preferred over anode systems when highly complex interactions, such as in the Perth Central Business District. These complex networks require considerable quantities of anodes to adequately protect them and therefore, the lifecycle costs of installing an impressed current system become viable.

EPR and LFI Mitigation Systems

There are two distinct mechanisms for transient and steady state AC voltage to occur on a buried metallic pipeline. LFI occurs when a pipeline is parallel to a high voltage overhead power line. The magnetic field produced by the current flowing in the power line conductors can induce an alternating current on the pipeline. The other mechanism is when a fault occurs on a power line, or an earthed tower is struck by lightning, the current surge is conducted to earth via the earthing at the power line tower earthing system. Therefore EPR is the effect of the power line passing a very high current to earth, causing a substantial rise in voltage potential of the ground close to the tower earth and onto the metallic pipeline in the vicinity. Both EPR & LFI have the potential for significant risk to personnel and the pipeline asset.

The ATCO GDS has numerous EPR and LFI mitigation assets, which have recently been installed and are inspected annually to ensure they are fit for purposed and in a functional state.

Investment Drivers

Investment drivers for this asset class are derived from the basic need for ATCO to manage the cost, risk and performance of its assets. To evaluate specific drivers applicable for each project the following criteria has been implemented:

1. **Cost** – Projects that are driven through the realisation of cost improvements or revenue expansion are categorised with this driver. The projects are evaluated using Net Present Value (**NPV**) calculations for the asset's lifecycle and accepted on this basis when NPV is positive. Project priority is ranked by applying projects in descending order of NPV.
2. **Risk** – Projects driven through the reduction of risk apply this investment driver. Risks can include increase in security of supply, reduction in safety risk, reduction in business risk, etc. Where possible these projects are qualified using a Formal Safety Assessment (**FSA**) risk analysis approach, but can also relate to deteriorating asset condition.
3. **Performance** – These projects are initiated where a gap has been identified between service level targets and actual service levels. These may relate to gaps in customer service, asset reliability, safety performance, etc.

Specific drivers for the CP systems asset class are: system performance levels, service life and demand for new underground steel installations. Inadequate protection levels of installed systems can lead to: diminished life realisable from steel pipelines and mains requiring increased Operating Expense (**Opex**);

requirements from more frequent anode bank replacements, and early Capital Expense (**Capex**) requirements for mains and pipeline replacement.

Personnel protection along with pipeline safety is the primary driver for EPR and LFI installations. Unmitigated installations can be a major hazard to the public / pipeline personnel as well as cause the accelerated premature failure of the actual pipe itself.

A primary driver for the management of the CP systems is to develop replacement and maintenance strategies that achieve desired performance requirements, minimise lifecycle costs and reduce volatility in work programs.

The asset management strategies set out in this document seek to maintain operational excellence in accordance with the ATCO GDS Safety Case and Gas Standards in a prudent manner consistent with good industry practice.

Achievement of asset management objectives

Each project described under this strategy is aligned to at least one, and in most cases, all of the ATCO asset management objective areas.

- **Regulatory Compliance:** ATCO was issued a corrective action request in 2010 to install step touch mitigation measures to protect against stray voltages. This is an ongoing project to ensure adequate protection on all facilities.
- **Customer and Public Safety:** ATCO is required to ensure facilities are maintained and operated to minimise hazards and risks to the public. Each of the facility upgrade projects has the aim of maintaining the integrity of CP installations through increased protection levels between distribution assets and the public. This minimises the likelihood of electric shock, resulting in reduced hazards and risks to the public.
- **Workforce Safety:** ATCO is required to ensure the safety of its workforce, and therefore must mitigate any voltage hazards potentially present at the workplace.
- **Network Integrity**: By ensuring protection levels are optimised through proactive maintenance and by replacing aged assets, pipeline integrity is maintained for longer period of time.
- **Customer Service:** CP projects do not directly affect ATCO's quality of customer service.
- **Prudent and efficient investment**: The development of annual programs allows for unit rates to be adequately controlled and also helps to minimise the project delivery risks.

Table OV.2: Alignment between proposed investments and asset management objective areas

	ASSET MANAGEMENT OBJECTIVE AREA				
Project	**Regulatory Compliance**	**Customer and Public Safety**	**Network Integrity**	**Customer service**	**Prudent and efficient investment**
Facility Upgrade – Resistance Probes		✓	✓		✓
Facility Upgrade – Step touch Mitigation	✓	✓	✓		✓
Facility Upgrade – Insulation joints & surge protectors		✓	✓		✓

ASSET MANAGEMENT OBJECTIVE AREA					
Facility Upgrade – CP Test Points		✓	✓		✓
EOL Replacement – Anodes			✓		✓
EOL Replacement – Transformer Rectifier Unit			✓		✓
Install permanent reference cells at all CP units			✓		✓
Decommission and remove redundant CP facilities and signage		✓		✓	✓
Capture GPS coordinates for all CP facilities			✓		✓
Investigate foreign structure interference on PL39		✓	✓		✓
Relocate CP points out of PTA rail reserves				✓	✓

Planned Expenditure

To address the investment drivers discussed above, a 10-year investment plan has been developed. The forecast expenditure for this period is summarised in **Table OV.3** by asset lifecycle stages.

Table OV.3 illustrates the alignment of each proposed expenditure within the assets' lifecycles to each regulatory expenditure category and to the specific investment driver for these expenditures. Investment drivers are categorised into cost, risk and performance, to align with common nomenclature and industry practice.

Table OV.3: Summary of forecast expenditure 2019$ ($'000)

Lifecycle Stage	Project	CAPEX ($'000)	OPEX ($'000)	Reg category	Investment Driver
Creation & Acquisition	Facility Upgrade – Resistance Probes	156		Network safety and performance	Risk - mitigation
Operations & Maintenance	Preventive Maintenance		1470	Variable volume opex	Cost - lifecycle cost Risk - mitigation
	Corrective Maintenance		312	Variable volume opex	Cost - lifecycle cost Risk - mitigation
	Opex Projects		39	Opex Projects – non-recoverable	Cost - lifecycle cost Risk - mitigation
Renewal & Replacement	Facility Upgrade – Step touch Mitigation	2381		Network safety and performance	Risk - mitigation
	Facility Upgrade – Insulation joints & surge protectors	509		Network safety and performance	Risk - mitigation

Lifecycle Stage	Project	CAPEX ($'000)	OPEX ($'000)	Reg category	Investment Driver
	Facility Upgrade – CP Test Points	181		Network safety and performance	Risk - mitigation
	EOL Replacement – Anodes	460		Sustaining – Asset Replacement	Cost - lifecycle cost
Disposal & Abandonment	None				
	TOTAL	**3688**	**1820**		

1. Introduction

This chapter outlines the purpose and objective of the ALS and where this document fits within the broader asset management system of ATCO.

1.1 Document Purpose

The ALS provides a summary of the lifecycle activities and planned investments on ATCO's CP systems. It supports the network management strategic objective:

> *Continue to focus on the **long-term interests of consumers** by providing a **safe, reliable, and affordable** gas distribution network while supporting a **competitive retail market, enabling state growth**, and building the foundation for **a clean energy future**.*

The ALS document suite, describe the asset management practices for each major asset class and are utilised as part of an overall lifecycle management strategy for the Mid-West and South-West Gas Distribution System (**GDS**).

Maximising asset utilisation and minimising lifecycle costs through well-managed maintenance and capital investment programs contributes to achieving this objective. Implementation of the GDS Safety Case continues to enhance the safe management of these assets.

The main purposes of the ALS are to:

- identify the levels of service required for the assets
- set lifecycle asset management objectives, strategies and targets that promote continual improvement
- outline activities, action plans and works programs, optimised and prioritised by risk, to deliver the objectives and targets
- describe risk management practices for the ongoing identification and assessment of asset management related risks and to identify and implement appropriate control measures
- ensure investments in lifecycle activities are prudent and optimised based on a whole of life approach
- monitor and measure the performance and condition of the assets and the implementation of the AMP

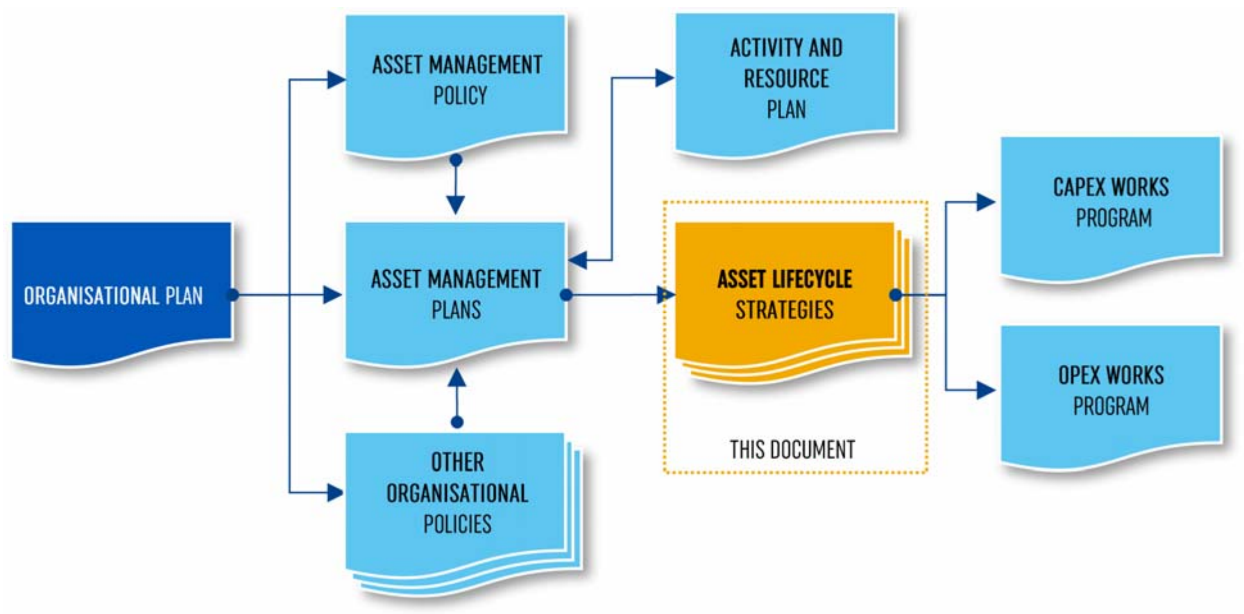
The ALS looks ahead ten years and is revised annually. Annual reviews ensure that the program of works is continually optimised, including the reprioritisation of existing plans and the addition of new projects where required.

All expenditure forecast in this ALS has been escalated to 2019 dollars and includes overheads.

1.2 Asset management document framework

The asset management document framework is the set of documents, systems and processes that addresses ATCO's asset management responsibilities, and ensures asset management objectives are clearly traceable to organisational objectives. This ALS forms part of the document framework and describes the specific asset class strategies and plans for ATCO's CP assets. The relationship to other documents is shown in Figure 1.1.

Figure 1.1: Asset Management Document Framework



This ALS is effectively a subordinate document to the overarching AMP. The AMP ensures consistency across all asset classes.

1.3 Document Structure

The table below sets out the structure of the ALS and provides brief explanations of the content and purpose of each section.

Table 1.1: Document Structure

CHAPTER		DESCRIPTION
1	Introduction	Introduction to the document (*this chapter*).
2	Overview of Asset Class	Provides important information regarding the specific asset class, including general asset descriptions, asset statistics (e.g. population and age profiles) and asset characteristics (e.g. safety considerations, condition, and asset performance).
3	Asset Objectives	Sets out relevant asset management objectives, strategies, and targets, including the levels of service required from the asset class.
4	Asset Lifecycle Management	Explains ATCO's approach to managing the asset class throughout its lifecycle, including typical interventions and related investment drivers.
5	Continual Improvement	Sets out ongoing and planned improvements in ATCO's approach to managing the asset class.
6	Financial Summary	Sets out ATCO's planned capital and operational expenditure for the asset class over the ALS planning period.
A	Work Plan Details	Provides additional detail on planned works over the ALS planning period.
B	Maintenance Parameters	Includes further detail on the maintenance regime applied to metering assets.

1.4 Key Stakeholders

ATCO's approach to managing this asset class considers the needs of its stakeholders. The stakeholder groups and their main interests are outlined in **Table 1.2.**

Table 1.2: Key Stakeholders

STAKEHOLDER	MAIN INTEREST
Customers	Gas consumers are the ultimate stakeholders across the network footprint. They include residential, commercial and industrial users that are served through ATCO's distribution networks. They want a safe, reliable supply at a reasonable price.
Retailers	Retailers own the gas that is distributed by ATCO and have the contracted delivery responsibility with end-consumers. They want to understand ATCO's: investment plans, ability to respond to faults (and to provide them information) and approach to connecting new customers.
Economic Regulation Authority	The ERA is responsible for regulating third party access to gas pipelines in Western Australia. The coastal network, which excludes the Albany and Kalgoorlie gas networks, is a fully regulated gas distribution system and as such, the ERA periodically review amendments to ATCO's access arrangement.
Department of Mines, Industry Regulation and Safety (DMIRS) – Building and Energy Division, and Dangerous Goods and Petroleum Safety Branch	Building and Energy is responsible for the technical and safety regulation of the GDS. This includes administering gas technical and safety legislation, and setting and enforcing minimum safety standards for gas networks. The Dangerous Goods and Petroleum Safety Branch is responsible for the technical and safety regulation of the Mandurah Gas Lateral.
WA Communities	It is important that ATCO consult effectively with the communities that host ATCO assets and those that may be affected by network performance. Engagement during the planning of activities, allows ATCO to better understand potential effects and to mitigate/leverage these as far as reasonably practicable.
Service Providers	A number of field activities and other roles are outsourced to a group of 'service providers'. Ensuring sustainable and effective working relationships is important to ATCO's overall effectiveness.
Staff	ATCO staff are also stakeholders. Ensuring they have appropriate skills is an essential element of managing the safety and reliability of assets.
Shareholder	The owners of ATCO seek financial returns that are commensurate with investment risk. Working with the Board and Executive Team they ensure that ATCO is an efficient and effectively managed business with appropriate governance processes.
Other Stakeholders	Other stakeholders with an interest in ATCO's asset management approaches include: government ministries, financial institutions, the media and other industry bodies.

2. Overview of the Asset Class

This chapter provides an overview of the asset class with a focus on:

- **Scope of the asset class**: including general asset descriptions, overview of the population, uses and operation of the assets and any relevant historical context
- **Asset statistics**: including fleet population and age profiles
- **Asset characteristics**: including safety considerations, criticality, condition and their performance

2.1 Scope of the Asset Class

Corrosion protection (CP) systems are used to protect buried steel pipes from external corrosion. All of ATCO's HP gas pipelines and a number of medium pressure steel pipelines as well as steel pipeline crossings have CP systems to protect against pipeline corrosion.

There are several types of CP systems used in the GDS:

1. **Sacrificial CP systems;** utilising sacrificial magnesium anodes to make the pipeline an electrical cathode.
2. **Impressed current CP systems;** utilising a Transformer Rectifier Unit (**TRU**) to make the pipeline an electrical cathode.
3. EPR and LFI Mitigation Systems; utilising multiple components to mitigate stray voltages.
4. Pipeline coatings; utilising specialised pipeline coating materials, paints, or tapes.

Supporting components which are included as part of this ALS include:

- Polarisation Cells (**PC**); a solid-state device designed to concurrently provide DC decoupling and AC continuity/grounding when used with corrosion protected structures
- Surge protectors; protects the installation from voltage spikes
- Resistance Probes; measure the rate of corrosion at a particular location.
- Insulation Joints (**IJ**); used to electrically insulate one section of pipeline from another
- Test and Interference test points; allows for various measurements to be taken to determine the effectiveness of the CP system
- Earthing; is required for equipotential bonding of structures, and remote earthing of the CP system

2.1.1 Sacrificial CP System

Sacrificial CP systems are installed on approximately 85% of the high-pressure pipelines, as well as steel medium-pressure pipelines and road crossings. The method of protection involves connecting the steel pipe to a more easily corroded "*sacrificial metal*" (such as magnesium) to act as the anode. The sacrificial metal then corrodes instead of the protected metal.

A sacrificial CP system is effective when the sacrificial metal is more electronegative than the protected steel. This is due to the tendency for the sacrificial anode metal to go into solution when the formation of metal ions increases, which leaves an excess of electrons on the metal surface.. Since zinc, aluminium and magnesium are more electronegative than steel, they are increasingly able to supply electrons to the more electropositive steel when in electrical contact in an electrolyte, and therefore will effect corrosion protection of the steel surface.

Sacrificial CP systems are typically used on smaller diameter pipelines of limited length. As the system does not require any external power supply and is relatively easy to install, they can be more economically viable than other protection methods. However, consideration is given to the current capacity and driving voltage limitations of such a system, in particular on old pipelines with high current demand.

CP system design guidelines are articulated in NCN PR0002: *Corrosion Mitigation Systems*.

2.1.2 Impressed Current CP System

For larger pipelines, or where electrolyte resistivity is high, sacrificial anodes cannot economically deliver enough current to provide protection. In these cases, impressed current corrosion protection systems are used.

Impressed current systems deliver current to the pipeline or structure by means of an AC to DC rectified power supply. The AC to DC system uses a transformer to step down the voltage from 240V (AC) to 50-12V (AC) which is the lower voltage required by the CP system. This AC voltage is then rectified to DC voltage through a Transformer Rectifier Unit (TRU), which is the main component of an impressed current CP system.

TRUs are installed with telemetry devices to allow remote monitoring. System Monitoring analyses the data on a monthly basis to ensure and confirm the operating level of the system. End-of-life replacement for TRUs is based on age of equipment. This is due to the finite life of the transformer windings. Coupled with this technology refresh is the requirement to ensure that the equipment is compatible with the current monitoring system. Major components of the TRU are electronic devices such as: power supply, rectifier and current interrupter. These components will also become obsolete as the TRUs age.

2.1.3 Earth Potential Rise (EPR) and Low Frequency Induction (LFI) Mitigation Systems

EPR and LFI mitigation systems protect ATCOs workforce and metallic pipelines from hazardous voltages. Workforce electrocution is mitigated by the use of equipotential grids (spot mitigation) such that a person cannot touch the pipe unless they are standing on an equipotential grid which is connected to the pipeline and ensures that there is no voltage potential difference between pipeline and worker that could cause harm.

The protection of pipelines is achieved by gradient control wires (continuous mitigation) that drain off standing AC voltages present on a pipeline to a target of 5V (AC). This is to mitigate against AC corrosion, which depending on certain conditions, can lead to an accelerated premature failure of a metallic pipeline.

2.1.4 System Components

Various components are used to implement the CP, EPR and LFI mitigation systems, many of which are required for multiple systems. These components are described in this section.

2.1.4.1 Polarisation Cells

Polarisation cells are used in EPR and LFI mitigation systems to drain stray AC voltages from protected systems to minimise voltage differential.

2.1.4.2 Surge Protectors

Corrosion protected pipelines are provided with insulating flanges at terminal points on the pipeline system, such as PRSs, gate stations, etc. In order to limit the extent of the applied corrosion protection and prevent the loss of protective current to other buried metallic structures.

In these locations, in the event of a lightning strike onto any above ground pipe work or connected structure, or an electrical fault causing a voltage surge on the pipe, a flashover across the insulating components to the flange could occur. In case of a potential difference between two sides of insulation flanges, the spark gap is a space between electrical terminals across which a transient discharge passes.

2.1.4.3 Resistance Probes

The electrical resistance (**ER**) technique is a method of monitoring the rate of corrosion and the extent of total metal loss for any buried metallic equipment or structure. The ER technique measures the effects of both the electrochemical and the mechanical components of corrosion such as erosion or cavitation. It is the only on-line, instrumented technique applicable to virtually all types of corrosive environments.

An ER monitoring system consists of an instrument used to measure change at a probe. The instrument may be permanently installed to provide continuous information, or may be portable to gather periodic data from a number of locations, where the latter is ATCO’s preferred option. The probe is equipped with a sensing element having a composition similar to that of the process equipment of interest.

The electrical resistance of a metal or alloy element is given by:

$$R = r \times \frac{L}{A}$$

Where:

L = Element length

A = Cross sectional area

r = Specific resistance

Reduction (metal loss) in the element's cross section due to corrosion will be accompanied by a proportionate increase in the element's electrical resistance.

Practical measurement is achieved using ER probes equipped with an element that is freely ’exposed‘ to the corrosive fluid, and a ’reference‘ element sealed within the probe body. Measurement of the resistance ratio of the exposed to protected element is made.

2.1.4.4 Insulation Joints

Insulated joints at above to below ground transition points require surge protection devices to prevent damage in the event of an electrical surge. The surge protection device is intended to preferentially fail or divert an electrical surge, in order to protect the insulated joint. Damaged insulated joints are expensive and difficult to repair.

2.1.4.5 CP Test Point

The CP Test Points provide a complete solution for making pipeline potential measurements. The test points provide connection and measurement points for the pipes/structures, ER probes, anodes, foreign structures, earthing and reference electrodes if fitted. Test points can be used to temporarily disconnect the CP current from the pipe or structure to conduct instant-off measurements.

The test points are housed in a weatherproof enclosure and utilise corrosion resistant components, allowing them to be used in harsh environments.

2.1.4.6 Earthing

The general earthing componentry for all systems (CP, EPR & LFI) includes remote earth ground beds, step touch earth mats and grids as well as gradient control wires. Each earth system is designed for the location specific soil resistivity, voltage potential and pipeline protection requirements.

2.2 Asset Statistics

The following section sets out key statistics for this asset class including fleet population and age profiles. This data is valid as of 31st December 2017.

2.2.1 Asset Population

ATCO owns and operates a large asset base including CP systems. This section describes the populations for each of these asset categories.

2.2.1.1 Sacrificial CP System

Table 2.1 shows the summary of sacrificial CP systems within the ATCO high-pressure system.

Table 2.1: Sacrificial CP system summary

NUMBER OF CP SYSTEMS	ATCO PIPELINE NETWORK	MAOP[2] (kPa)	TOTAL LENGTH (km)
129	High Pressure	≥ 500 kPa	825.2
1	City High Pressure	≥ 350 kPa	4.8
1	Fremantle High Pressure	≥ 700 kPa	6.3

The age profile for sacrificial CP systems, is only representative of the total number installed and indicative of the installation configuration. The driving factor that represents a sacrificial anode system condition is rate of consumption versus installed anode mass. This is directly inferred from the structure to electrolyte voltage measurement for each pipeline test point.

2.2.1.2 Impressed Current System (TRU)

There are 13 TRUs across North Metro, South Metro, Geraldton, and Busselton. Table 2.2 contains key data for the TRUs recorded in SAP. Age related information is used as a key TRU replacement driver with output current (and voltage) directly used to infer pipeline coating condition.

Table 2.2: Corrosion protection system components physical parameters

TAG #	Functional Location	LOCATION	INSTALL. DATE	RECTIFIER STATUS	MANUFACTURER (MODEL)	OUTPUT [amps]	OUTPUT [volts]
TRU1	01029038	North Metro	30.11.2015	ON	Corrosion Elect (Ce1286)	25	50
TRU2	00681984	Geraldton	11.11.2011	ON	Advance CPS	10	50

2 Maximum Allowable Operating Pressure

TAG #	Functional Location	LOCATION	INSTALL. DATE	RECTIFIER STATUS	MANUFACTURER (MODEL)	OUTPUT [amps]	OUTPUT [volts]
TRU3	00681983	Busselton	01.01.1987	ON	John McCoy & Assoc.	10	60
TRU4	00681980	North Metro	01.01.2010	ON	Advance CPS	10	30
TRU5	00455953	North Metro	01.01.1982	OFF	Radix	25	70
TRU6	00455941	North Metro	01.12.2011	OFF	Advance CPS	15	50
TRU7	00455967	South Metro	01.01.2000	ON	Advance CPS	10	30
TRU8	00676379	North Metro	01.01.2006	ON	Advance CPS	10	50
TRU9	00683089	North Metro	01.12.2006	OFF	Advance CPS	10	50
TRU10	00815120	South Metro	01.01.2007	OFF	Advance CPS	10	50
TRU11	00879939	North Metro	01.01.2009	OFF	Bartronics (M159501a)	15	50
TRU12	00960514	South Metro	01.01.2010	ON	Advance CPS (12005-Cc)	5	12
TRU13	00960517	North Metro	01.12.2006	OFF	Advance CPS	10	50

2.2.1.3 EPR and LFI Mitigation Systems

Table 2.3: EPR & LFI system parameters

Type	Tag Type	No. of assets
AC pipe volts	CPACPIPV	168
Earth amps	CPEHAMPS	161
Earth resistance	CPEHRESO	140
Earth volts	CPEHVOLT	159
Insulation joint plant volts	CPIJPLTV	7
Insulation joint pipe	CPIJPP2V	1

2.2.2 Age Profiles

The useful lives of pipelines depend on factors such as material type, operating pressure, installation practices, soil type, coating quality, and level of corrosion protection. Age profiles are set out below, showing the current age of the assets within the CP asset class.

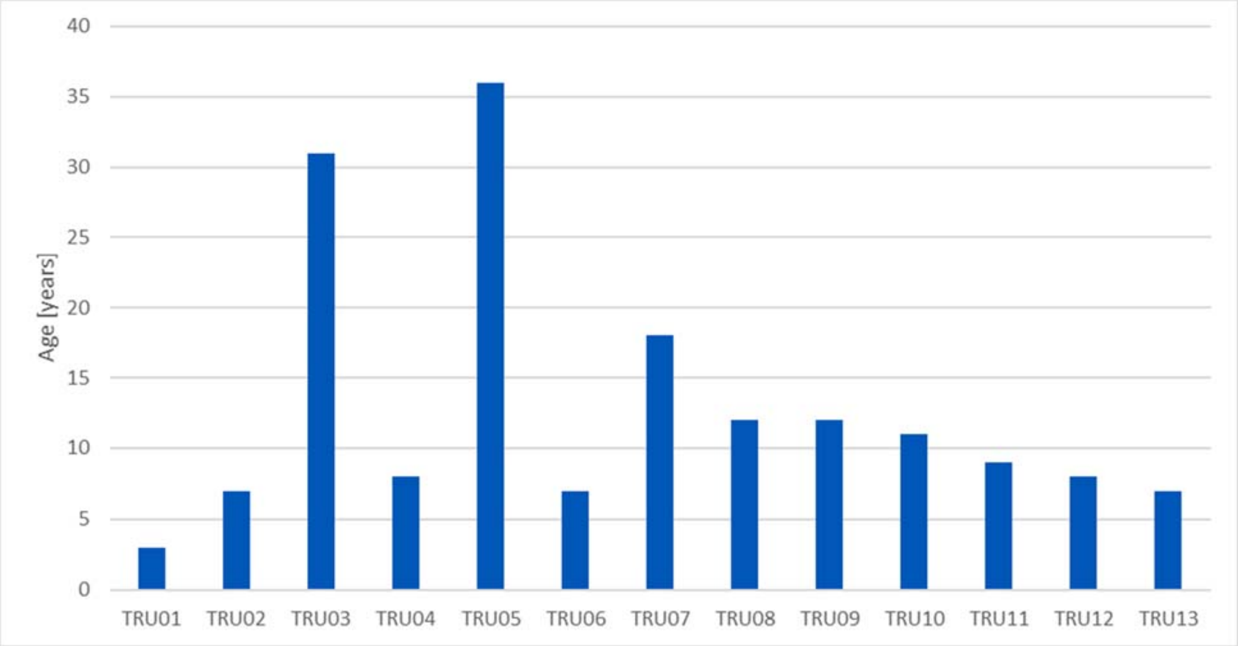
2.2.2.1 Sacrificial CP System

Age profile is not maintained for sacrificial anode systems due to the varying depletion rates of each anode bank for each pipeline. Anodes are treated as a condition-based replacement, where when the performance of the system reaches its limit, the anodes are flagged for replacement.

2.2.2.2 Impressed Current CP Systems

Transformer Rectifier Units (TRUs) are the predominant component in an impressed current CP system. Figure 2.1 shows age related distribution for installed TRUs.

Figure 2.1: Age profile for TRUs

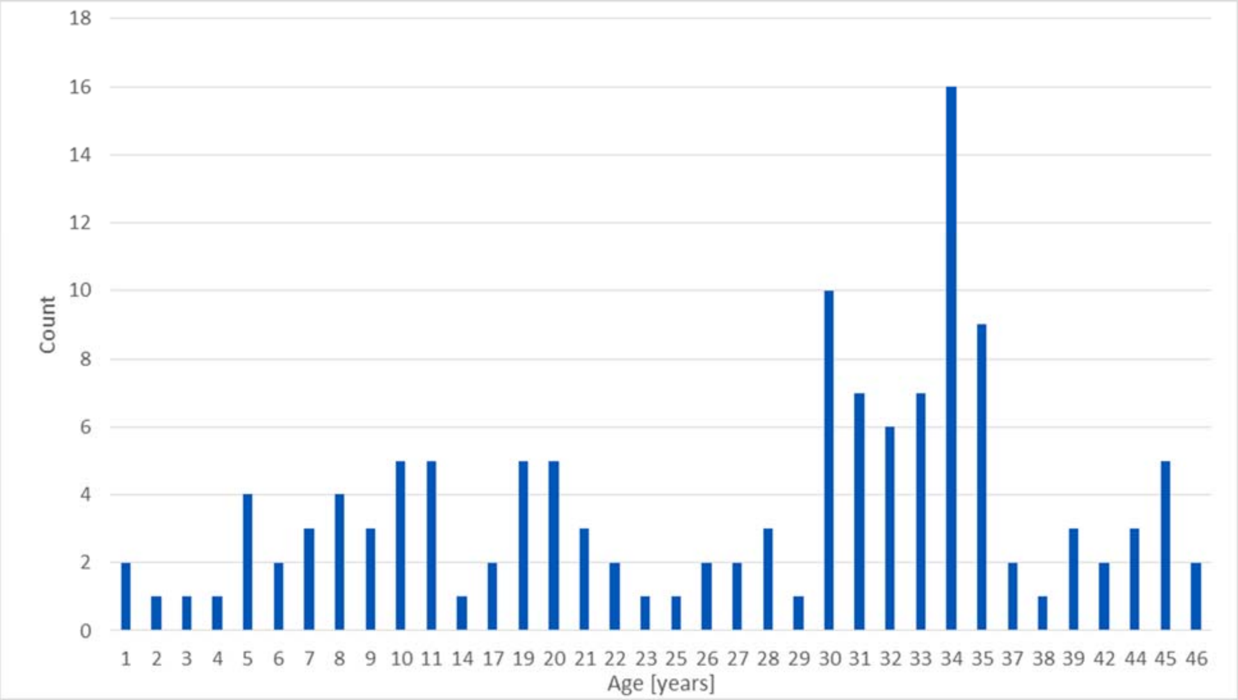


There are 13 TRUs installed on the network and the average age of a TRU is 14 years with two TRUs aged more than 30 years.

2.2.2.3 EPR and LFI Mitigation Systems

Earth Potential Rise (EPR) & Low Frequency Induction (LFI) mitigation systems are generally installed when the pipeline is built. Depending on 3rd party infrastructure impact, these systems are expanded or added to on an as required basis.

Figure 2.2: Age profile for EPR and LFI systems



2.3 Asset Characteristics

The systems and equipment described above in the scope of this asset class, are used as protection systems to the main asset class of pipelines. This section explains the current condition and performance of this asset class as applied to the pipelines they protect, together with an analysis of past performance. Analysis of asset reliability is performed annually and used to inform the reliability improvement program for this asset class.

2.3.1 Overview of Performance

The main functions of the CP, EPR and LFI mitigation systems are to protect people and minimise wall loss where there is damage to pipe coatings. This is to ensure maximal lifetime of the steel pipelines the systems are designed to protect. Safe distribution of gas is achieved by appropriate design, quality control during construction, testing and commissioning as well as periodic maintenance and inspection. The failure on CP, EPR and LFI Mitigation systems will result in:

- Under-protected asset
- Over-protected asset
- Hazardous AC voltage on asset
- Elevated standing AC voltage on asset

2.3.1.1 Corrosion protection Systems

ATCO manage the performance of the CP systems by measuring the performance of the systems they protect. These systems are steel pipelines, stranded steel assets and interference from foreign structures. These system performances are described in this section.

High Pressure Pipelines

The condition of the CP assets is determined from the routine CP surveys that involve recording pipe On-Voltages. Measuring points have been established against each relevant asset for recording the CP survey data and details of inspections. Any resulting work requirements are recorded as notifications in SAP (ATCO's ERP solution) or reports in EIM (ATCO's document management system).

As a prudent operator of the GDS, ATCO aims for a target that all pipelines are rated Fair or Good. This means that 100% of CP test points (**TP**) are to experience an on-voltage more negative than -1.0V (on potential).

The overall performance of the corrosion protection systems is summarised in Table 2.4.

Table 2.4: CP overall performance[3]

PIPE ON READING [DC VOLTS]	RATING OR CLASSIFICATION	QUANTITY 2016	% OF TOTAL PIPELINES IN 2016	QUANTITY 2017	% OF TOTAL PIPELINES IN 2017
above -2.0	Over protected	0	0%	0	0%
above -1.2	Good	51	46%	53	47.30%
-1.0 → -1.19	Fair	50	45%	58	51.80%

3 The table above does not include the medium pressure steel crossings.

PIPE ON READING [DC VOLTS]	RATING OR CLASSIFICATION	QUANTITY 2016	% OF TOTAL PIPELINES IN 2016	QUANTITY 2017	% OF TOTAL PIPELINES IN 2017
-0.85 → -0.99	Poor	3	2.60%	0	0.00%
below -0.85	Under protected	8	7.10%	1	0.90%
	TOTAL PIPELINES	112	100%	112	100%

The ratings/classifications are explained below:

- **Good Pipelines**: there were 53 pipelines rated as Good in 2017. In accordance with the pipeline classification system in use, these pipelines are meeting the protection criteria set out in AS 2832.1. No additional action is recommended for these pipelines.
- **Fair Pipelines**: There were 58 pipelines rated as Fair in 2017. In accordance with the pipeline CP rating system in use these pipelines are probably meeting the protection criteria set out in AS 2832.1. Remedial works to improve the CP ratings on these pipelines will be considered once all the Under Protected and Poor pipelines have been addressed
- **Poor Pipelines**: There were zero pipelines rated Poor in 2017.

The pipelines by rating are listed in Appendix A. The Poor Pipelines are summarised in the Table 2.5.

Table 2.5: Poor pipeline summary

PL#	CP SYSTEM	QTY OF TP'S	RECOMMENDED REMEDIAL ACTION	COMMENTS
N/A				There were no pipelines rated as Poor in 2017

In accordance with the pipeline CP rating system in use, these pipelines are *only possibly* meeting the protection criteria set out in AS 2832.1.

- **Under-protected Pipelines**: there was one pipeline rated as 'Under-protected' in 2017. This result is summarised in the Table below.

Table 2.6: Under-protected pipeline summary

PL#	CP SYSTEM	QTY OF TP'S	DESCRIPTION	REMEDIAL ACTION
44	Sacrificial Anodes	14 out of 16 test points on the pipeline had readings below -0.85V (more positive)	March 2017, 1 pipeline was found under protected. Further investigation was carried out in November 2017, with DBP at GS on Russell Rd. Found Insulation Joints (IJ) shorted between PL44 and DBP PRS earth	Shorted IJ was repaired in March 2018. Currently waiting on DBP to isolate temperature probe from downstream of IJ, which is still shorting PL44 to DBP electrical earth via PRS.

Islanded Assets

Islanded assets are discrete standalone metal assets not electrically connected to any pipeline, e.g. a steel crossing under a railway line or a freeway. This means that each islanded asset requires its own CP protection with a sacrificial anode CP system.

The assessment of the corrosion protection systems on the islanded assets in 2017 shows a slight reduction in the number of sites ranked as Poor since their last report in 2016. The under protected and poor islanded assets are considered for the 2018 anode replacement program.

Table 2.7 below is a summary of the ratings for the islanded assets.

Table 2.7: Islanded Assets summary

RATING OR CLASSIFICATION	QUANTITY IN 2016	% OF TOTAL PIPELINES IN 2016	QUANTITY IN 2017	% OF TOTAL PIPELINES IN 2017
Good	45	67%	48	74%
Fair	15	22%	15	23%
Poor	5	8%	2	3%
Under protected	2	3%	0	0%

The two poor protected islanded assets below (A10 and A57) have been included in the 2018 anode replacement program.

Table 2.8: Islanded Assets recommended action

TP NO.	CONDITION	RECOMMENDED REMEDIAL ACTION	COMMENTS
A 10	Poor (-0.87)	Install deep anodes with slurry, it needs more current	Resurvey after new anodes
A 57	Poor (-0.88)	Install deep anodes with slurry, it needs more current	Resurvey after new anodes

Foreign Structure Interference

When an external source of power with an associated ground bed is used to provide corrosion protection to an underground structure, this can accelerate corrosion on neighboring structures that are not a part of the corrosion protection system. This is due to the flow of interference currents on these neighboring structures.

The criteria used to determine foreign structure interference is consistent with AS 2832.1.

Table 2.9: Foreign structure interference

FOREIGN STRUCTURES (FS)	TARGET	ACCEPTABLE RANGE
Pipe vs Foreign Structure Voltages	Foreign structure and ATCO pipe voltages are not linked unintentionally	0 - 20 mV DC positive shift of pipe CP voltage 0 - 200 mV DC negative shift of pipe CP voltages

ATCO plots the CP pipeline on voltage readings at all foreign structure crossing points, on pipelines selected for Maximum Allowable Operating Pressure (**MAOP**) review. Readings are taken at one-metre intervals in all four directions for indications of interference. Any depressions in the on-voltage readings are analysed to determine if this is attributed to the CP system installed on the foreign structure. If this is found to be the case, the owner of the foreign structure is asked to pulse their CP system to confirm if they are the source of the depressed voltage.

The measurements of CP pipe On Volts are recorded in SAP as the 'CPPIPONV reading' for each test point on each pipeline. The above Table 2.9 refers to the acceptable range of foreign structure interference on the CPPIPONV reading. As previously articulated in Table 2.4, the minimum level of protection for pipelines is a rating of Fair or higher, this means that readings are to be more negative than -1.2V (on potential) exclusive of allowing for the above mentioned acceptable CP voltage shift. Remedial action must be taken, should actual readings fall outside of the acceptable limits.

Foreign Structure Testing

Thirteen of the twenty pipelines in the 2017 MAOP program had foreign structures and their respective test points. No interference was detected at any of the foreign crossing test points tested in 2017

The table below shows the total number of foreign structure crossings on each pipeline that were accessible and thus able to be plotted for pipe ON potentials. It also provides comments for any sites listed that were not tested and why.

The interference assessments are completed by correlating all available readings. Any test points omitted due to inaccessibility are considered in this assessment and allowed for by utilising adjacent test point readings. However, should the assessment identify that it is not possible to infer interference levels from adjacent TPs, then remedial action must be undertaken to obtain adequate levels of data.

Table 2.10: Foreign structure crossing

PIPELINE NO.	# OF FOREIGN STRUCTURE SITES LISTED	TOTAL # OF SITES TESTED	COMMENTS	INTERFERENCE INDICATED
9	1	-	PL09 Linked to PL105	N/A
12	1	-	TP06 - crossing under road	N/A
17	5	4	TP11 Parallel with FS	NO
19	2	2	-	NO
22	1	1	-	NO
41	4	3	TP02 PL41 does not cross PL12	NO
42	3	3	-	NO
43	3	3	-	NO
47	1	-	TP02- crossing under road	N/A
57	17	9	TP3, TP05, TP8A, TP9, TP16, TP18, TP19,TP25A crossings under road	NO
58	9	3	TP02, TP03, TP05, TP08, TP09, TP14	NO
72	5	4	TP07 centre of crossing is under road	NO

2.3.1.2 EPR and LFI Mitigation Systems

EPR and LFI Mitigation is used to decrease the induced AC voltages on metallic pipelines. This is accomplished by installation of different grounding techniques such as linear zinc ribbon, gradient control wire and/or grounding rods attached to the pipeline with decouplers for DC isolation. Induced voltage can cause accelerated corrosion, especially at existing coating holidays, leading to premature pipeline failure.

The criteria used to monitor the performance of the earthing systems are set out below. The acceptable ranges are stated in Table 2.11. The 0-5 volts standing AC voltage is in line with current National Association of Corrosion Engineers (**NACE)** guidelines and is further explained below. The hazardous level of 32 volts AC is consistent with AS 2832.1 and AS 4853-2012.

Table 2.11: CP Earthing system acceptable range

EARTHING SYSTEMS	TARGET	ACCEPTABLE RANGE
AC Voltages	Minimal AC voltages on pipeline	0 - 5 V (AC) [above 32 volts is considered hazardous and unacceptable]

Pipelines with a standing AC Voltage above 5 Volts have previously been identified as requiring an upgrade of the earthing protection system. AS 2832.1, appendix G (G4) defines this value as being 15 Volts but indicates that research is still ongoing in this area.

The performance of the ATCO induced voltage mitigation earthing systems on pipelines with elevated AC voltages is summarised in the tables below.

Table 2.12: Induced voltage mitigation earthing system summary

PIPE STANDING AC READING [VOLTS]	CATEGORY	QUANTITY
Pipe > 5V <32V	Detrimental to CP System	7
Pipe ≥32 V	Hazardous to Staff[4]	0

There were seven pipelines with a standing AC voltage greater than 5 volts in 2017.

There is no clear trend in these results over time, with six pipelines recording an increase and one recording a decrease in the standing AC voltage. Details of all pipelines with a reading above 5V (AC) can be seen in Table 2.13.

Table 2.13: Pipelines with a reading above 5V (AC)

PIPELINE NO.	PEAK STANDING AC VOLTAGE READING	COMMENTS
9	14.72	This has increased from 2.49 at previous survey
19	7.5	This has increased from 6.2 at previous survey
20	6.73	This has increased from 6.6 at previous survey
21	8.35	This is increased from 5.1 at previous survey
28	11.4	This is increased from 11.1 at previous survey
90	5.53	This has increased from 5.4 at previous survey
91	11.3	This is decreased from 13.7 at previous survey

2.3.2 Asset Risk and Condition

The following sections discuss the risk and condition associated with the individual components used within each of the systems.

2.3.2.1 Polarisation Cells

- Risk; Shorted through failure which will compromise the CP system.
- Condition; 100% functional and tested annually

[4] As per Australian Standard AS/NZS 4853- 2012 Electrical Hazards on Metallic Pipelines

2.3.2.2 Surge protectors

- Risk; Failure to operate which will cause the insulation joint to rupture through surges.
- Condition; 100% functional and tested annually

2.3.2.3 Resistance Probes

- Risk; Failure to identify severe rates of corrosion on assets.
- Condition; Rates of corrosion monitored and reported annually and reviewed.

2.3.2.4 Insulation Joints

- Risk; Failure to electrically isolate pipe and plant. This will compromise the CP system and potentially expose workers to hazardous voltages.
- Condition; 100% functional with faulty IJs scheduled for replacement immediately.

2.3.2.5 CP Test Points

- Risk; Failure to provide correct pipeline potential measurements.
- Condition; 100% functional and inspected annually.

2.3.2.6 Earthing

- Risk; Failure to mitigate EPR or LFI effects.
- Condition; 100% functional and tested annually.

3. Asset Objectives

This section sets out the main objectives of this asset class. The objectives are aligned with the asset management objectives described in the AMP, which are based on six strategic goals derived from ATCO's organisational objectives. The strategic goals are set out below.

- **Safe**: Continue to provide a safe gas distribution network in accordance with good industry practice
- **Reliable**: Maintain reliable access to gas
- **Affordable**: Provide affordable access to gas at the best price we can
- **Retailer Support**: Support a competitive retail market
- **Growth**: Enable the growth of the WA state economy
- **Innovation**: Build the foundation for a clean energy future

3.1 Legislative Requirement and Technical Standards

ATCO reviews legislative requirements and standards (Australian and international) to determine the levels of service to be provided by this asset class.

The asset management strategies set out in this document seek to attain operational excellence in accordance with the ATCO Safety Case. The investment and maintenance strategies have been designed to maintain operating efficiency whilst ensuring compliance with the Safety Case. To fulfil the obligations under the Safety Case, a number of CP testing and replacement programs are undertaken. These programs are described in section 4.

A summary of the documents reviewed in the development of the ALS is shown in Table 3.1.

Table 3.1: Legislative requirement and technical standards

REFERENCE	SUMMARY OF REQUIREMENTS
Gas Standards (Gas Supply and System Safety) Regulations 2000 (GSSSR 2000)	Sets out standards, roles, responsibilities and safety requirements for the gas supply and system safety
ATCO GDS Safety Case (TCO PL 00005)	Provides a road map for the systems ATCO has put in place for the safe operation of the GDS, including those for design, construction, operation, maintenance, training and supervision to manage the risks arising from hazards that have been identified as having the potential to result in an incident on the GDS.
Mandurah Gas Lateral (**MGL**) Safety Case (TCO PL00006)	Provides a road map for the systems ATCO has put in place for the safe operation of the MGL, including documented procedures to manage the risks arising from hazards that have been identified as having the potential to result in a Major Accident Event (**MAE**), and to continue to identify, assess and take action to treat those risks as they may arise throughout the life of the MGL.
National Gas Rules (**NGR**)	Governs access to natural gas pipeline services and elements of broader natural gas markets

REFERENCE	SUMMARY OF REQUIREMENTS
AS 2885.3:2001 Pipelines – Gas and Liquid Petroleum Part 3: Operation and Maintenance	Specifies the minimum requirements for the operation and maintenance of pipelines (and facilities) complying with AS2885.1 and AS2885.2,
AS 2832.1:2015 Corrosion protection of Metals	Provides information on the structure and design for corrosion protection, coatings, protection criteria, measuring techniques, the design, installation and maintenance of corrosion protection systems and the control of interference currents
AS/NZS 4853:2012 Electrical hazards on metallic pipelines	Sets down the minimum requirements for managing the safety of personnel working in the vicinity of pipelines, and equipment installed on pipelines and specifically addresses the requirements for the control of electrical hazards on transmission and distribution pipelines.
AS 4799:2000 Installation of underground utility services and pipelines within railway boundaries	Specifies the requirements for the installation, use and maintenance of utility services and pipelines within railway boundaries.
AS 2239-2003 Galvanic (sacrificial) anodes for corrosion protection	Specifies requirements for galvanic (sacrificial) anodes for use in the corrosion protection of metals against corrosion. It specifies the composition of suitable alloys for magnesium, zinc and aluminium anodes and gives details of shapes and design features of some commonly used anodes. It also includes details of backfill compositions and properties, for buried magnesium and zinc anodes.
AS 4352-2005 Tests for coating resistance to cathodic disbonding	Specifies the test methods for the determination of the ability of coatings to resist disbonding caused by the application of corrosion protection
AS 4832-2007 Corrosion protection - Installation of galvanic sacrificial anodes in soil	Specifies requirements for the installation of galvanic anodes in soils.

Where ATCO is required to incur capital expenditure in order to meet legislative obligations within applicable technical standards, licences or regulations, this expenditure is considered to meet the National Gas Rule 79(2)(c)(iii) in that the capital expenditure is necessary to comply with regulatory requirements.

3.1.1 Corrosion protection Rating

The corrosion protection ratings for pipelines were developed originally considering AS 2832.1, Paragraph 2.2.2.1. The criteria given in clause 2.2.2.2 *ferrous structure* applies; provided there is no significant voltage gradient in the electrolyte between the structure and the reference electrode.

The voltage gradient in the electrolyte between the structure and the reference electrode can be filtered from the CP Readings by measuring the instantaneous OFF potentials. On ATCO pipelines, recording of instant OFF potentials on all pipelines is largely not possible due to the interconnections between pipelines.

The fact that instant OFF readings on all pipelines could not be achieved, lead to the development of a CP rating system that considered the effect of electrolyte voltage gradient when measuring ON potential readings. It was determined that using the average voltage drop of 200 millivolts (mV), that a pipeline with pipe to soil readings at or more negative than –1.2 Volts ON (classified as Good) would clearly meet the minimum protection criteria of –0.85 Volts (or more negative) instant off.

Using this CP rating system it was intended that all pipelines should be moved to the Good rating in order to be confident that they are all satisfying the minimum protection criteria set out in AS 2832.1 of –0.85 Volts. ATCO will continue taking instant OFF measurements (periodically) on pipelines where this can be achieved and will use this to verify that a 200 millivolt gradient allowance is adequate and supports the grading rating system that has been applied.

The CP rating system used by ATCO has been formulated in house, as AS2832.1 is not prescriptive in this area. In addition, the audit rating system has been reviewed during audits by Building and Energy (formally Energy Safety). The rating system has been developed to help gauge the performance of different pipeline CP systems. These pipeline CP ratings are used as a guide for prioritising maintenance and capital expenditure to address the pipelines most in need.

ATCO as a minimum conducts CP surveys annually on all pipelines and monitors any changes to their CP ratings. Table 3.2 defines the CP performance criteria applied to review pipeline corrosion protection readings.

Table 3.2: CP performance criteria

ACTIVITY	TARGET	ACCEPTABLE RANGE
CP Voltage Surveys		
On Voltages	- 1.2 V (DC)	- 0.85 to -1.6 and < 10% variation from last reading
Anode Resistance	< 1 ohm	0 – 500 ohms
Impressed Current System		
TRU Output Current		Up to maximum unit current output. Large change in current requirement warrants pipeline review.
Earthing Systems		
AC Voltages	Minimal AC voltages on pipeline	0 - 5 V (AC) [above 32 volts is considered hazardous]
Foreign Structures (FS)		
Pipe Vs Foreign Structure Voltages	Minimal CP voltage shift	0 - 20 mV (DC) positive shift of pipe CP voltage 0 - 200 mV (DC) negative shift of pipe CP voltages
MAOP Reviews		
DCVG Surveys	5 dig-ups per pipeline with three highest, a mid-point and a low % drop readings investigated. Sleeves make up the 5 sites plus any suspected mechanical damage to the pipeline.	
Coating and Pipe Assessment	No coating or pipe wall loss	Pipe wall loss that does not require MAOP adjustment based on AS 2885.3

Further to Table 3.2, the CP performance on the high-pressure pipelines is classified according to Figure 3.1. This classification takes into consideration the criteria outlined in the annual CP reporting requirements, as well as the maintenance history and historical performance of the individual pipeline.

Figure 3.1: CP Rating

S

- **Good:** A negative Pipe On Volt Reading ≤ -1.2 Volts

  These pipelines do not require additional maintenance or capital expenditure to improve the corrosion protection system. A pipeline with this CP rating is deemed to meet the minimum protection criteria set out in AS 2832.1, based on the average electrolyte voltage gradient (volt drop) as outlined above.

- **Fair:** A negative Pipe On Volt Reading in the range ≤ -1.0 Volts and ≥ -1.19 Volts

  A pipeline with this classification is probably meeting the minimum protection criteria set out in AS 2832.1, based on the average recorded OFF Volt readings of 200 millivolts as outlined above. These pipelines will require additional maintenance or capital expenditure to improve their CP rating to Good. Maintenance on these pipelines is not prioritised over pipelines that have ratings of Poor or Under Protected.

- **Poor:** A negative Pipe On Volt Reading in the range ≤ -0.85 Volts and ≥ -0.99 Volts

  These pipelines have the second highest priority for maintenance and capital expenditure to improve their corrosion protection systems.

  A pipeline with this CP rating is probably not meeting the minimum protection criteria set out in AS 2832.1, based on the average recorded OFF Volt readings of 200 millivolts as outlined above. ATCO has historically surveyed these pipelines every six months to determine if remedial corrosion protection works have improved the corrosion protection system rating.

- **Under Protected**: A negative Pipe On Volt Reading > -0.85 Volts (less negative than)*

  A pipeline with this CP rating requires attention to improve the corrosion protection system. These pipelines have the highest priority for maintenance and capital expenditure to improve their corrosion protection systems. This rating comes directly from AS 2832.1, Paragraph 2.2.2.2:

  > *"The criteria for protection of a buried ferrous structure is to maintain a potential on all parts of the structure equal to, or more negative than, -850 mV with respect to a saturated copper/copper sulphate reference electrode."*

This criterion applies for pipelines at near ambient temperature where the electrolyte near the metal/electrolyte interface comprises natural soils and waters (which are substantially free of sulphur reducing bacteria).

This criterion is based on maintaining the pipeline at a potential with respect to the surrounding electrolyte (soil and water) such that the potential of the pipe is maintained above the freely corroding potential.

Pipelines have been rated in accordance with the categories listed above by their least negative reading taken during the last CP survey. *AS 2832.1 requires that all parts of the pipeline meet the protection criteria in order for the pipeline to meet the classification*.

The CP ratings of each pipeline are identified on the table in **Appendix A – 2017 Pipeline Ratings**. They allow us to compare their current rating against their previous performance with an indicator showing if they have trended up or down since their last survey.

The field pipe to soil measurements of the CP pipe volts (volts DC) is recorded as the 'CPPIPONV' and the pipe AC volts are recorded as the 'CPPIPACV'. These readings are taken at each test point on every pipeline.

3.1.2 Medium pressure steel crossings

The CP on medium pressure steel crossings consists of magnesium anodes connected to the carrier pipe or steel encasement sleeve at one or both ends of the crossing. It is not a requirement under AS2885.3 to protect these as they are not high-pressure pipelines and hence they historically have not been rated in the same way in the annual reports. However, if these carrier pipes and steel crossings are in a rail reserve (e.g. crossing under a railway line), they should be reviewed in accordance with AS4799:2000 Installation of Underground Utility Services and Pipelines within Railway Boundaries, where it states in section:

> *3.4.1 – Most metallic materials in contact with soil are subject to corrosion. The rate of corrosion is accelerated due to the presence of electrical currents in the ground, especially direct currents. In existing and proposed electrified areas, the requirement to protect against corrosion due to electrolysis caused by the traction system becomes particularly important. The owner of underground metallic services and pipelines installed within the property of the Corporation shall take adequate precautions to protect this installation against corrosion by coating or covering the pipes with suitable plastic material, galvanizing or other proven methods. Protection shall be in accordance with AS/NZS 2832.1 and statutory requirements and shall be maintained as agreed between the owner and the Corporation.*
>
> *5.2.4.1 – All steel carrier pipes shall be corrosion protected (see Clause 3.4). Corrosion protection should not be applied to casing where the annular space is fully or partially filled (or may become filled subsequent to installation) with any electrolytic material*

3.2 Asset Class Objectives

The ALS guides ATCO's long-term approach to asset management, ensuring that the long-term interests of customers are supported. ATCO seeks to balance lifecycle cost, risk and performance through well managed maintenance and capital investment programs. This requires that ATCO maintains reliability, safety and efficiency while meeting agreed service levels and complying with regulatory requirements.

The asset management objectives set out in the AMP are reflected and ATCO ensures that the asset class objectives are:

- consistent and aligned with corporate objectives
- consistent with the asset management policy and other applicable business policies
- established and updated using asset management decision-making criteria
- measurable (if practicable)

The objectives applicable to this asset class are summarised in Table 3.3.

The objectives of CP system design is to:

- provide facilities that will ensure the steel pipelines are protected from corrosion.
- provide enough test stations to monitor the effectiveness and efficiency of the CP system.
- minimise maintenance on both pipeline and corrosion protection systems.

Table 3.3: Asset Class Objective

CORPORATE OBJECTIVE	AM OBJECTIVE	MEASURES	TARGET
Network Safety	Network Integrity	% of network protected by CP	99% of pipelines rated fair or good

The above objective sets an optimised level of expected performance. The strategies contained in this ALS seek this expected performance levels.

4. Asset Management Lifecycle

This section sets out how ATCO manages the lifecycle of the asset class. It explains the approach to the creation, operation, maintenance, renewal, refurbishment, and disposal of the assets. Discussion on the lifecycle approach in general is set out in the Asset Management Plan.

ATCO's approach to asset management reflects the specific activities undertaken during each stage of an asset's lifecycle. As explained in the AMP, ATCO identify four lifecycle stages:

- **Creation and Acquisition** stage covers all demand analyses for new assets, project planning, engineering design, and construction processes.
- **Operation and Maintenance** stage covers all monitoring and controlling of the gas network and includes preventive maintenance, corrective maintenance, and reactive maintenance.
- **Renewal and Replacement** stage covers the process to decide when to renew and/ or replace assets. Generally, assets that are approaching the end of their useful life are identified for replacement or refurbishment.
- **Disposal and Abandonment** stage covers the process to dispose of assets that are no longer required or have been replaced.

4.1 Creation and Acquisition

This stage of the lifecycle focuses on the identification of capex projects to create or acquire an asset through an efficient and deliverable work program that meets the asset class objectives. As discussed in the AMP, ATCO's asset investment generic processes involve identifying required projects or types of projects that are consistent with strategies, comparing options and estimating cost.

New CP assets are integrated within any new installation of a steel pipeline. Corrosion mitigation and monitoring of steel pipelines is controlled in accordance with AS 2832 Corrosion protection of metals and Formal Safety Assessments.

ATCO's replacement strategy for pipelines, mains and services and therefore their symbiotic CP systems is based on the following main drivers:

- Customer Initiated Connections
- Demand

4.1.1.1 Customer Initiated Connections

Customer Initiated Connections are not applicable to this asset class.

4.1.1.2 Demand

Forecasting demand for gas services enables ATCO to plan and identify the best way to meet future needs of customers. The forecasting approach determines future demand for both gas connections and gas consumption across different customer segments, including residential, commercial and industrial. Demand for new steel pipelines requiring CP protection is described in the Pipelines, Mains and Services ALS. Costs to install CP systems required to protect these pipelines are incorporated into the construction costs of the pipelines themselves and not separated out for discussion in this ALS.

4.1.2 Investment Summary

By applying the creation and acquisition investment strategy to ATCO's assets, a set of projects has been identified. These projects, along with their investment drivers, forecasting approach and costing methodology are described, and a financial summary provided.

4.1.2.1 Investment Approach

The following table is an extract from the Pipelines, Mains and Services ALS that describes the investment approach for the pipeline project requiring CP protection and summarises the main investment drivers and the associated forecasting approach. It also sets out the basis for cost estimates.

Table 4.1: Summary of Investment Approach

PROJECT	DRIVER AND FORECASTING APPROACH	COSTING
AS4645 Security of Supply - 91/140/91/19 (Two Rocks)	***Risk*** – Security of Supply Forecast growth in the region, coupled with network modelling, identified requirements for increased network capacity. These pipeline segments have also received a supply risk identified as High as per *Supply Risk Assessment – Northern Region (TCO RP 0209).* ***Performance*** – Customer Service ATCOs 2017 Voice of Customer (VoC) initiative identified that 97% of residential and Small to Medium Enterprise (SME) participants valued long-term security of supply and fewer disruptions over short term savings in their bill.	Approved tender process.

4.1.2.2 Expenditure Summary

No costs have been separated out specifically for this asset class. These costs are incorporated into the construction costs for the pipeline itself and included in the Pipelines, Mains and Services ALS.

4.2 Operation and Maintenance

The way assets are operated and maintained is a key factor in how they perform and how long they remain serviceable. ATCO's maintenance tactics aim to ensure assets perform within their design guidelines to enable lowest lifecycle costs. This includes operating assets within acceptable operating parameters, which may change over the life of an asset as they degrade. This maintenance approach ensures assets remain safe and serviceable over their expected lives in a cost-effective manner.

Operations and maintenance strategies have been determined to ensure that assets perform at the required service levels, assets remain in appropriate condition, and lifecycle costs are optimised.

4.2.1 Investment Strategy

This section describes how CP maintenance activities and associated intervals are developed. It describes criteria used to define the strategies along with their implementation to establish the operational works program.

Expenditure on CP systems during their operations and maintenance phase of their lifecycle has been separated by ATCO to distinguish between variable volume maintenance activities such as preventive, corrective and fault management activities, and specialty operational expenditure projects that require input from Engineering Services.

4.2.1.1 Variable Volume Operational Expenditure

Variable volume maintenance activities are those where a standard job requirement are performed on a repeatable basis. These jobs usually have very similar unit rates as actual costs to implement these tasks is similar. ATCO classifies these activities into specific job types, which are seasonally trended to forecast resource requirements and cost allocations. Job types are grouped into three categories: (1) preventive maintenance; (2) corrective maintenance, and (3) fault management.

Preventive Maintenance

Preventive maintenance is a variable volume activity that includes inspection, testing and monitoring. The criteria for initiating preventive maintenance may be time-based, condition based, or usage based, but always takes account of risk. These non-intrusive checks are used to confirm safety and integrity of assets and to provide information for continued operations or determining corrective maintenance and renewal needs.

Routine operations and maintenance is managed using the preventive maintenance module of the SAP Enterprise Resource Planning (**ERP**) database.

The CP operational and maintenance activities required for the complete CP management of the steel pipeline network are:

- CP potential survey
- Galvanic anode output current, anode to soil potential, and anode resistance measurements
- Potential readings across insulation joints
- Verification of surge protector functionality
- Potential and current (AC and DC) readings at all earthing sites
- TRU output current and potential readings and ground bed resistance measurements
- Electrical inspections of impressed current systems
- Inspection of surge protection devices at TRUs and insulation joints
- Inspection and testing of all polarisation and/or mitigation devices
- Monitoring and testing of all foreign structure crossings
- Construction of new CP facilities on existing assets
- Inspection of above ground pipe work
- Direct Current Voltage Gradient (**DCVG**) surveys
- Assessment of third party work and activity in the vicinity of CP protected assets – done as part of the MAOP and HP Locates programs

The main activities are discussed below.

Corrosion protection Potential Survey

Periodic CP potential surveys are necessary to assess the effectiveness of the ATCO CP systems. AS 2832.1-2015 states that survey frequencies should be determined after consideration of the design lives of the CP system components and structure, CP operator history, operator experience and an assessment of the consequence and probability of any failure of the system.

The frequency of the CP potential survey is based on the performance of the CP systems:

- Pipelines with CP systems classified as good or fair will be surveyed annually.

- Pipelines with CP systems classified as poor or under protected will be surveyed six monthly.
- Medium pressure steel pipelines where the CP facilities have been maintained and crossings shall also be surveyed annually.

The classification of pipeline CP performance and frequencies for the CP surveys are reviewed annually by ATCO. The most recent survey rating is applied to the pipeline for the following maintenance period.

The CP survey includes the measuring and recording of the following parameters where applicable:

- Anode to soil open circuit potential, anode output current and resistance (two pin test)
- Pipeline DC potential (On and where possible instant Off Volts) and current
- Pipeline AC potential and current
- Potential readings across insulation and monolithic joints
- Potential at foreign structure crossings
- Test of earthing system on HP valves, PRS, HPR, etc.

At the time of conducting potential surveys, the integrity of the following structural items is verified as outlined in AS2832.1-2004:

- All CP system equipment
- Insulating joints integrity check and cable connections
- Where applicable, casing isolation and protection level
- Earthing systems installed to control induced voltages
- Foreign structures
- Electrical equipment, including rectifiers and transformers

Other than anodes, any CP components (such as insulation joints and test points) identified as requiring replacement during the routine CP surveys, are replaced on a separate **SPL** job type order and not as part of CP survey activity. Operations investigate test points indicating under -0.85 volts and recommend actions to mitigate the situation.

At the completion of each pipeline CP survey (anode/TRU voltage and current and anode resistance measurements and FS and IJ as well as earthing system inspections) a tabular summary of all readings taken along the pipeline is completed, that includes:

- Calculation of the average DC pipe voltage and variation of this voltage from the last reading
- Graphs of DC and AC Voltage trends across the pipeline with reference indicators of performance (poor, fair, good etc.)
- Comments on pipeline CP performance regarding DC and AC voltages, FS interference issues if any, IJ and earthing system performance
- Any modifications made to the pipeline (e.g. anode replacement, test point repairs etc.)
- Recommendations for changes to the pipeline CP system

Any necessary investigations on the CP facility as a result of problems identified during the routine survey are carried out as a planned work activity.

Impressed Current Systems

According to AS 2832.1-2015, ATCO is required to inspect all impressed current TRUs every two months to confirm the operating level of the systems. Following the installation of monitoring equipment to all

TRUs in the GDS, all sites with remote monitoring are inspected every six months to confirm operability. ATCO Operations monitor and analyse the data on a monthly basis to ensure and confirm the operating level of the system.

On an annual basis, the TRU is inspected for general condition and cleanliness. This includes an electrical inspection, where the integrity of fuses and surge protectors is checked, and readings are taken to ensure the unit is functioning normally.

Inspection of Pipe Work

Other than bridge crossings, all exposed pipework is visually inspected during scheduled facility maintenance for evidence of corrosion, damage, or deterioration of anti-corrosion coatings. The inspection also includes checking for signs of coating defects, crevice corrosion and mechanical damage.

Case crossings are tested for short circuits between the casing and the carrier pipe where there is a test point installed to facilitate this. Visual inspections are also applied to exposed pipe contained in facility pits. Unless complete refurbishment or replacement is required, the inspection team will repair the defects while on site.

Where applicable, the survey for bridge crossings entails a visual inspection of:

- Pipe condition at ground entry and exit locations.
- Insulation pads.
- Conditions of brackets, saddles and supports, and signs of crevice corrosion.
- Casing integrity (no bridging).
- Vent condition (if present) and testing for the presence of gas at the vents.
- Sign of soil erosion for water crossing mains and coating condition for exposed pipe section.
- Blistered or coating disbondment areas for signs of corrosion.
- Pipe coating at crevice areas (e.g. under the pipe supports and on the underside of the pipe work), especially around the interface between carrier pipe and pipe support.
- Insulation joints, such that water cannot reach and collect within the joint. A check on insulation performance and short-circuiting will also be conducted.
- Polarisation cells across the insulation flange. An operational and performance check on the cell will also be conducted.

Where severe corrosion is present, the wall thickness and pit depths are measured to ascertain the integrity of the pipe work and a field report submitted for assessment by Engineering Services. Severe corrosion is defined as those with pitting and loss of material greater than 10% of nominal wall thickness. Any corroded pipe work section that cannot be repaired by the inspection team will be budgeted and scheduled for replacement the following year.

Maintenance personnel inspect exposed pipe work contained within HP regulator set pits every 4-months and service valve pits every 12-months. Likewise, maintenance personnel inspect the exposed pipe work contained within MP regulator set pits and valve pits at the time of the 18-month maintenance. MP regulator set pits that cannot be maintained or repaired will be replaced. Exposed pipe work within HP valve pits is also inspected.

Inspection of above ground assets, identification of associated faults and the remedial work carried out is documented in SAP.

Earthing

The following earthing tests are carried out 6-monthly or annually on all induced voltage earthing systems associated with Pipelines, Pressure Reduction Stations (**PRS**) and HP regulator sets depending on pipelines CP rating:

- Two pin pipe to earth grid resistance test if below 500mA
- AC volt on pipe and earth
- AC current between pipe and earth
- DC volt on pipe and earth

Earthing tests are conducted as part of the pipeline CP potential survey.

Foreign Structure Crossings

In addition to the foreign structure potentials taken as part of the CP survey, where applicable, the potential profile at all foreign structure crossings are surveyed and plotted on a five-yearly cycle. These inspections occur during the 5-year MAOP review program.

Coating Defect Surveys (DCVG) and Pipeline Inspection

Direct Current Voltage Gradient (**DCVG**) surveys are conducted on steel pipelines to determine the condition of the pipeline coating. DCVG surveys required due to third party activities are conducted on an as required basis and when it is necessary to determine the condition of the coating of a section of pipe, usually due to third party interference or future restricted access. DCVG surveys are also required as part of the MAOP reviews conducted on steel pipelines in the network.

MAOP Review

MAOP reviews are conducted on HP pipelines every five years to assess the condition and ongoing operability of the pipeline throughout its lifecycle, and to reassess and confirm the safe MAOP of the pipeline. A summary of the activities undertaken as part of the MAOP Review is further described within the Asset Lifecycle Strategy – Pipelines Mains and Services.

At the completion of each pipeline inspection for the MAOP review, a report that includes the following details for each review, is provided for each coating survey completion in the year the review was conducted:

- DCVG survey results
- locations of dig-ups, photographic and written details of coating and its condition as well as measured projected length and depth of corrosion (in accordance with AS2885.3 – 2001) for each point inspected along the pipeline both before and after repair
- thickness of pipe and depth of cover at each dig-up location
- soil sample analysis outlining the ground water pH if present and resistivity of the soil at the dig-up locations
- assessment of pipeline condition
- assessment of sleeve conditions

Reporting

Monthly:

- Progress of actual versus planned CP activities and reasons for variances

Annual:

- Review of CP Readings with graphs of CP potentials for individual pipelines
- Identification of performance of each HP/MP pipeline based on CP potential readings
- If required, identification of HP/MP pipelines where CP facilities need to be upgraded (i.e. anodes can no longer provide required CP)
- Identification and resolution of problems with current earthing protection systems
- Identification of interference to each HP pipeline based on foreign structure potential readings

Corrective Maintenance

Corrective maintenance (**SP**) is maintenance undertaken to prevent (reduce the risk of) faults, failures or excessive deterioration from occurring. Tasks can also be initiated by the retailer and include work such as demolishing/cutting of a service. Corrective maintenance activities that are activities as a direct result of unacceptable asset conditions found during the performance of preventive maintenance include rectifying failed component such as surge protectors, polarisation cells etc.

Fault Management

Faults such as TRU alarms are managed under Corrective maintenance (SP) for this assets class. This is due to the inherent latency from fault to actual potential corrosion of assets. Therefore, prudent operation means timely response to faults is achieved by corrective maintenance and for ongoing service assurance and reliable network operation.

4.2.1.2 Operational Expenditure Projects

Due to the complexity of some maintenance activities, Engineering Services are required to ensure this maintenance is performed safely, effectively and efficiently. These activities are executed using ATCO's project management methodology and not standard work management processes typically used by variable volume maintenance. These jobs are also estimated using engineering estimates and not from regression analysis of historical data to forecast unit costs. Operational projects identified for this planning period are described below.

- Removal of CP test points from PTA rail reserve
- Decommissioned and disconnected from Parmelia Gas Pipeline (**PGP**)at PL8

4.2.2 Investment Summary

By applying the operations and maintenance investment strategy to ATCO's assets, a set of maintenance activities and projects have been identified. The volumes of the variable volume activities and the costs for all operational expenditure is summarised.

4.2.2.1 Investment Approach

The following sections summarise the main investment drivers and the associated forecasting approach. It also sets out the basis for the cost estimates.

Variable Volume Maintenance

ATCO develops maintenance plans from a bottom-up point perspective utilising existing asset lifecycle data. As a prudent operator, ATCO assesses operations and maintenance requirements utilising an asset lifecycle view as part of an efficient and robust asset management system. Maintenance strategies and activities are driven from ATCO's AMS and the business develops plans and utilises its resources within the constraints of its regulatory arrangements.[5]

Table 4.2 summarises the forecast number of variable volume maintenance activities per year.

Table 4.2: Forecast number of variable volume maintenance activities

OPEX CATEGORY	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	TOTAL
PREVENTIVE MAINTENANCE											
SM2 – HP CP Test Point Survey	226	222	227	229	229	229	230	230	230	230	2282
CORRECTIVE MAINTENANCE											
SPL – Planned work (CP)	80	80	80	83	81	85	85	85	85	85	829
FAULT MANAGEMENT											
N/A	-	-	-	-	-	-	-	-	-	-	-
TOTAL	306	302	307	312	310	314	315	315	315	315	3111

Operational Expenditure Projects

The following Table 4.3 summarises the main investment drivers and the associated forecasting approach. It also sets out the basis for cost estimates.

Table 4.3: Summary of Investment Approach

PROJECT	DRIVER AND FORECASTING APPROACH	COSTING ($'000)
Removal of CP test points from PTA rail reserve	Risk – mitigation. Engineering estimate	23
Decommissioned and disconnected from Parmelia Gas Pipeline at PL8	Cost - lifecycle cost. Engineering estimate.	16

4.2.2.2 Expenditure Summary

Using a base-step-trend approach to forecasting unit rates for these activities has led to the development of the variable volume expenditure forecast. This is summarised in Table 4.4.

5 Note: ATCO's overarching maintenance expenditure forecasts are developed using a 'base-step-trend' approach, which is used to inform proposed allowances for the regulated business

Table 4.4: Expenditure forecast for maintenance activities ($'000)

OPEX CATEGORY	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	TOTAL
Preventive Maintenance											
SM2 – HP CP Test Point Survey	156	136	141	144	147	149	149	149	149	149	1470
Corrective Maintenance											
SPL – Planned work (CP)	30	30	30	31	30	32	32	32	32	32	312
Fault Management											
N/A	-	-	-	-	-	-	-	-	-	-	-
TOTAL ($'000)	**186**	**166**	**171**	**175**	**178**	**181**	**181**	**181**	**181**	**181**	**1781**

Expenditure requirements for operational projects are summarised in Table 4.5.

Table 4.5: Forecast expenditure for operational expenditure projects ($'000)

OPEX CATEGORY	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	TOTAL
Decommissioned and disconnected from PGP at pipe 8	16	-	-	-	-	-	-	-	-	-	16
Removal of CP test points from PTA rail reserve	23	-	-	-	-	-	-	-	-	-	23
TOTAL ($'000)	**39**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**39**

4.3 Renewal and Replacement

Asset replacement and renewal includes projects or work programs to replace ageing and damaged (end-of-life) assets to ensure the ongoing safety and reliability of the network. ATCO forecasts long-term renewal of CP systems using a program-based approach.

These volumetric based renewals are forecast based on expected end-of-life. These forecasts don't specify specific assets for renewal but estimate total replacement volumes. Forecast volumes are scoped into specific projects (i.e. the individual assets to be replaced are identified based on the variables articulated in the condition schema) closer to delivery time, with some expenditure retained for reactive renewals where appropriate. The forecast expenditure for the planning period is determined volumetrically using forecast renewal volumes and average unit replacement costs.

4.3.1 Investment strategy

ATCO's replacement strategy for its corrosion protection systems is based on the following main drivers:

- Asset Replacement
- Network Safety and Improvement

4.3.1.1 Asset Replacement

Assets within the scope of the CP systems asset class may be replaced on factors that influence the cost, risk or performance of the asset. The following list summarises the basis from which decisions are made that affect these investment drivers:

1. **Cost** – Factors that affect cost are typically based around the lifecycle costs of the asset and are influenced by repair/replace decisions. The sections below describe the replacement criteria applied to determine when an asset should be replaced.
2. **Risk** – factors affecting risk are typically derived from risk analyses. Where projects have been identified to reduce risk to an acceptable level the particular risk driver and risk analysis source is identified in the sections below.
3. **Performance** – where required service levels are not being met, particular projects identified to reach service level targets are described below if a replacement of an asset is required. Or, a replacement strategy has been developed for anodes, which uses the CP test point voltage to indicate the performance of the anode. When CP on-voltage range becomes poor, or under protected, the anode is considered for replacement. Anodes become depleted at varying rates depending on the asset for which it is providing protection.

Replacement of CP assets is based on the following main drivers:

Replacement Criteria - TRU

Historical trending has identified that TRUs used on Impressed Current Corrosion protection (ICCP) deteriorate and become unreliable as they approach 40 years. The TRU replacement strategy takes into consideration compatibility issues with modern monitoring systems, obsolescence, functionality and effectiveness of the TRUs. Underperforming protection systems may result in increased asset degradation, posing a risk to the public. CP equipment is replaced frequently due to the findings of CP survey activities (discussed in Section 4.2).

In addition, replacement of TRU's can be undertaken due to the following main drivers:

- Device functionality no longer meets operational requirements
- Device technology is considered obsolete
- Device age has exceeded the economic asset life authorised in the current Access Arrangement
- The device has failed prematurely and is beyond economical repair

How ATCO's planned investments will address these drivers over the ALS period are explained below.

Replacement of CP assets is based on the following main drivers:

- TRUs approaching, or above 40 years in service, or with identified functionality or compatibility issues are to be replaced. Analysis of historical trends, and current TRU asset ages, shows that on average, one TRU will require replacement during the planning period.

Cost forecasts for these works are based on historical unit rates.

Replacement Criteria - Anodes

A replacement strategy has been developed for anodes, which uses the CP test point voltage to indicate the performance of the anode. When CP on-voltage range becomes poor, or under protected, the anode is considered for replacement. Anodes become depleted at varying rates depending on the asset for which it is providing protection.

Replacement of anodes is based on the following main drivers:

- Anode replacement when CP on-voltage measures below -1V. This is considered poor or under-protected. Analysis of historical trends, and current anode asset ages, shows that on average, 15 replacements per year will be required over the planning period.

Cost forecasts for these works are based on historical unit rates.

4.3.1.2 Network Safety and Performance

Improvement projects are identified during the risk and performance analyses. Many of these continual improvement activities are process or documentation related, but those that require budget approval and execution under the capital or operational works program are listed in this section.

FSAs performed for the CP system asset class have identified Risk Management Action Plans (**RMAPs**) in order to reduce identified risks to a level deemed As Low as Reasonably Practicable (**ALARP**). RMAPs raised from various FSAs are included within a register to ensure projects are tracked to completion, and that the resulting reduction of risk is reflected.

A summary of the current projects that address safety and/or supply risks identified in these FSAs and are justified (in part) by National Gas Rule 79 (2)(c)(i) to maintain or improve the safety of services are set out below.

Facility Upgrade – Step Touch mitigation

Above-ground assets connected to metallic mains in the vicinity of electrical infrastructure have the potential to receive electrical faults posing a hazard to personnel and the public who may come into contact with the asset. A network wide base line risk assessment has identified 35 pipelines where equipotential facilities may be required to be installed on adjoining High-Pressure Regulator (**HPR**) assets to mitigate this hazard.

A 2010 Building and Energy (formerly EnergySafety) WA Audit provided a corrective action stipulating "Where ATCO personnel interact often with an asset, it is recommended that the asset in question is earthed by the use of earth grids or polarisation cells to reduce the potential levels of induced voltage from Earth Potential Rise". As a result of this action, ATCO undertook a Technical Investigation (ENS TI 0139) which lead to the initiation of the Step Touch Project to review all pipelines with the risk approach identified in AS/NZS 4853.3:2012 and to install mitigation as appropriate.

To-date 10 pipelines, seven HPR and 18 CP Test points have been installed with step touch mitigation equipment, and installations are expected to continue through the 10-year planning period.

To address this risk, ATCO will undertake the following works during the AA5 period:

- Install Step touch mitigation on 7 HPRs or Meter Sets per year over the AA5 period (35 in total)
- Install Step touch mitigation on 35 CP Test Point per year.

Costs are based on bespoke designs, which are informed by specific quotes.

Facility Upgrade – CP Test Points

CP test points have historically been installed on the network in plastic boxes, which are prone to damage (e.g. from vehicular impact and vandalism). As damaged plastic enclosure test points are identified, they will be replaced with full metallic enclosures in order to reduce susceptibility to damage and vandalism. Based on historical quantities of damaged test points identified on the network per year requiring replacement, ten plastic boxes are estimated to be replaced per year with full metallic enclosures.

Facility Upgrade – Insulation Joints and Surge Protectors

Insulated joints at above to below ground transition points require surge protection devices to prevent damage in the event of an electrical surge. The surge protection device is intended to preferentially fail or divert an electrical surge, in order to protect the insulated joint. Damaged insulated joints are expensive and difficult to repair.

Not all facilities are currently equipped with surge protection devices. Installation of devices at these facilities (identified via site inspections) is being undertaken to ensure consistent application of controls across facilities. On average, 12 above ground to below ground transitional insulation joints are currently being installed per year with surge protection devices as identified via site assessment.

Facility upgrade – Resistance Probes

Resistance probes are utilised on the network where low pH and pitting is identified, to assist in the determination of whether corrosion is active or inactive. Ten resistance probes per year are to be installed along high pressure pipelines and medium pressure crossings to provide indication of corrosion rates and active corrosion. Priority is given to locations where the pipeline is assessed to have active corrosion indicated by poor pH levels with evidence of pitting. This will provide additional condition data in known problem areas.

4.3.1.3 Investment Approach

The following Table 4.6 summarises the main investment drivers and associated forecasting approach. It also sets out the basis for the cost estimates.

Table 4.6: Summary of Investment Approach

PROGRAM	DRIVER AND FORECASTING APPROACH	COSTING
Replace underperforming CP equipment	**Cost – Lifecycle Cost** TRUs approaching, or above 40 years in service, or with identified functionality or compatibility issues are to be replaced. **Risk – Asset Condition** Anode replacement when CP on-voltage measures below -1V. This is considered poor or under-protected.	Average historical cost and defined contractual rates
Installation of equipotential facilities at above ground assets	**Risk – Safety** Projects are undertaken in response to risk identified due to earth potential rises. Work volumes based on historical trending.	Costings based on bespoke design using current contracted supplier costs, current in-house rates

PROGRAM	DRIVER AND FORECASTING APPROACH	COSTING
Facility upgrades of CP equipment	**Cost – Lifecycle cost** All plastic boxes will be upgraded to full metallic enclosures to minimise test point repairs due to vandalism. **Performance – Network Integrity** Above ground to below ground transitional insulation joints will be installed with surge protection devices as identified via site assessment. **Cost – Prudent Investment** Resistance probes will be installed along all high-pressure pipelines and medium pressure crossings to determine corrosion rates. Work volumes based on historical trending.	Costings based on bespoke design using current contracted supplier costs, current in-house rates

Expenditure Overview

The following Table 4.7 summarises the proposed forecast expenditure over the ALS planning period that encompasses the above approach.

Table 4.7: Forecast AA5 CP Capex ($'000)

Asset Class	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total ($'000)
SUSTAINING CAPEX - NETWORK SAFETY AND PERFORMANCE											
Facility Upgrade - Step Touch Mitigation	296	292	260	240	208	214	214	217	219	221	2,381
Facility Upgrade - Resistance Probes	26	25	26	26	26	27	0	0	0	0	156
Facility Upgrade - Insulation Joints & Surge Protectors	30	30	30	31	31	32	81	81	82	82	509
Facility Upgrade - CP Test Points	17	17	17	18	18	19	19	19	19	19	181
SUSTAINING CAPEX - ASSET REPLACEMENT											
EOL Replacement - Anodes	43	43	44	45	46	47	47	48	48	49	460
EOL Replacement - TRUs	0	0	0	0	0	0	0	0	0	0	0
Total ($'000s)	**412**	**407**	**378**	**359**	**329**	**338**	**361**	**364**	**367**	**371**	**3,688**

4.4 Disposal and Abandonment

Asset disposal and abandonment is required when an asset has reached the end of its useful life. Disposal activities include the processes from when planning for disposal of an asset begins through to the point where the asset is no longer owned by ATCO.

4.4.1 Disposal Strategy – TRU

When an impressed current system is no longer required, the TRU's are decommissioned and assessed for condition. If the TRU is deemed to be in good condition the asset is placed into stock holding as a spare part to back the remainder of systems in use.

Should the TRU require disposal due to poor condition it is given to a scrap metal company for recycling.

4.4.2 Disposal Strategy – Anodes

Once anodes are identified for replacement their dissolution is usually well advanced. Therefore remaining anode mass is left in the ground along with newly installed assets.

5. Continual Improvement

This chapter discusses the continual improvement initiatives supporting the management of this asset class. Ensuring ATCO matures its approach to achieve consistent and high-quality asset management is important in continuing to providing safe, reliable and affordable gas distribution services. ATCO understands the importance of continual improvement and efficiency in its asset management practices in order to maintain this position.

As an organisation ATCO is committed to continually improving its asset management approach, understanding that capability development (e.g. embedding appropriate processes, systems, and techniques in the culture of the organisation) is a key enabling step and ATCO continues to focus on this for the foreseeable future.

Robust asset knowledge is critical to good asset management decision-making. Asset knowledge comes from a variety of sources, including peer utilities, experience from assets on the ATCO network, theoretical modelling, and information from the manufacturers and service providers. This asset knowledge must be captured and recorded in such a way that it can be conveniently accessed when future asset management decisions are made.

5.1 AA4 Improvements

Improvements realised during AA4 period have included:

1. Significant progress over the AA4 period to improve CP ratings of all protected pipelines. The goal at the end of AA4 is to have no pipelines within the poor or under protected category.
2. Improved process with regards to seasonal requirements has led to no outstanding MAOP reviews to undertake testing and dig up activities.
3. Replacement of plastic CP test points with metal casings and retrofitting of surge protection devices (10 casings per year, 12 surge protectors).
4. Installation of corrosion resistance probes along high pressure pipelines for improved monitoring of CP performance.
5. Improved process with regards to training regional staff in corrosion survey and TRU checks to improve response time and cost efficiency.

5.2 Current Initiatives

To continually improve the asset management practices, ATCO has proposed a set of initiatives for improving the performance around ATCO's CP assets. The improvement initiatives are outlined in Table 5.1

Table 5.1: Improvement Initiatives

IMPROVEMENTS	DUE	REMARKS
Optimise maintenance and replacement intervals	2019	In progress
Investigate characteristics of AC corrosion on PI28 and using the findings to develop a process to collect additional data such as: • AC levels on the pipeline. This will indicate the potential to introduce AC onto the pipeline. • Levels of low soil resistivity to identify the potential for accelerated AC corrosion to occur The data is used inform ATCO on the likelihood of AC corrosion to be incorporated into the overall pipeline integrity management and implement mitigation actions.	2019	In progress
Rationalise SAP fault codes for more accurate analysis of failures	2021	To be implemented with updated field mobility solution
Increase site data capture on field mobility devices	2019	In progress
Install permanent reference cells at CP units 002, 004, 007 and 008.	2020	To commence 2020.
Decommission & remove redundant CP facilities and signage - Identify from the odd size steel replacement projects which CP facilities have been decommissioned and remove any assets such as TRU units, CP test post and pipeline signage that are no longer required.	2020	To commence 2020.
Capture GPS coordinates for all CP facilities - Capture GPS coordinates for all CP test points (approx. 1000), Rectifier Units (6), ground beds (6) and earth stakes (approx.30). Record these in IBIS/SAP under the pipeline attributes, complete with as built drawings of ground bed and earthing cable routes.	2020	To commence 2020.
Relocate CP points out of PTA rail reserves - Cable approx. 20 test points out of the PTA rail reserves by hand digging only.	2019	To commence 2019.
Investigate foreign structure interference on PL39 - This can be done under an SPL maintenance task.	2019	To commence 2019.
Install Corrosion Resistance Probes on all HP pipelines - Install corrosion probes at key locations on all Corrosion Protected pipelines to monitor corrosion rates to identify early signs of corrosion through routine CP surveys.	2021	To commence 2021.
Install Current Measurement Coupons - Install current measuring coupons and permanent references at key locations on all Corrosion Protected pipelines subjected to AC induced corrosion.	2022	To commence 2022.
Install SCADA System on CP Units and Test Points	2021	To be included with SCADA business case.

6. Financial Summary

This chapter sets out a summary of ATCO's expenditure forecasts over the ALS 10-year planning period. It is structured to align with regulatory expenditure categories (in support of AA5 expenditure plans), and reflects the programs discussed in earlier chapters.

The chapter also provides further commentary and context for the forecasts including key assumptions. It discusses the cost estimation methodology and how this has been used to develop the forecasts for the planning period.

Box 6.1: Note on Expenditure Charts

- Expenditure is presented to align with ERA regulatory expenditure categories (in support of ATCO's AA5 expenditure plans).
- All expenditure is denominated in Real 2019 dollars including overheads.

ATCO expects the expenditure profiles described in this section, particularly later in the period, to be further refined as modelling approaches are enhanced and the accuracy and performance of underlying asset information frameworks improves. This will lead to periodic reviews of proposed levels of investment.

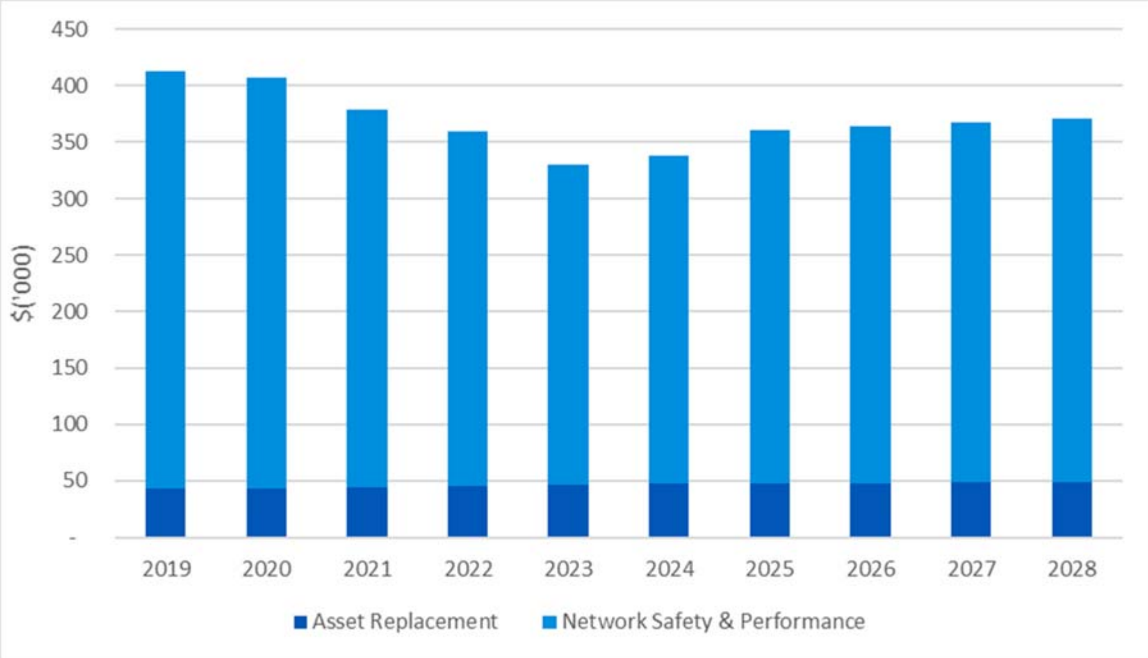
6.1 Planned Capex Investments

The following Table 6.1 and chart in Figure 6.1 summarise ATCO's planned total Capex on CP systems during the ALS planning period.

Table 6.1: Total Capex by regulatory expenditure category ($'000)

Program	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
GROWTH											
Customer Initiated	-	-	-	-	-	-	-	-	-	-	-
Demand	-	-	-	-	-	-	-	-	-	-	-
SUSTAINING											
Asset Replacement	43	43	44	45	46	47	47	48	48	49	460
Network Safety & Performance	369	364	334	314	284	291	314	316	319	322	3228
TOTAL ($'000)	**412**	**407**	**378**	**359**	**329**	**338**	**361**	**364**	**367**	**371**	**3,688**

Figure 6.1: Total Capex on Corrosion protection Facilities ($'000)



ATCO's Capex profile reflects the underlying drivers articulated in this ALS. As discussed in previous chapters, the main driver for the forecast over the planning period is the need to implement step touch mitigation to comply with the stipulated corrective action request. The profile above also includes largely stable levels of replacement driven expenditure.

6.2 Planned Opex Investments

In accordance with the NGR, Opex must be such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of delivering pipeline services. Projects and activities have been prepared to ensure all operational expenditure conforms to this requirement and to those that are outlined in ATCO's Safety Case.

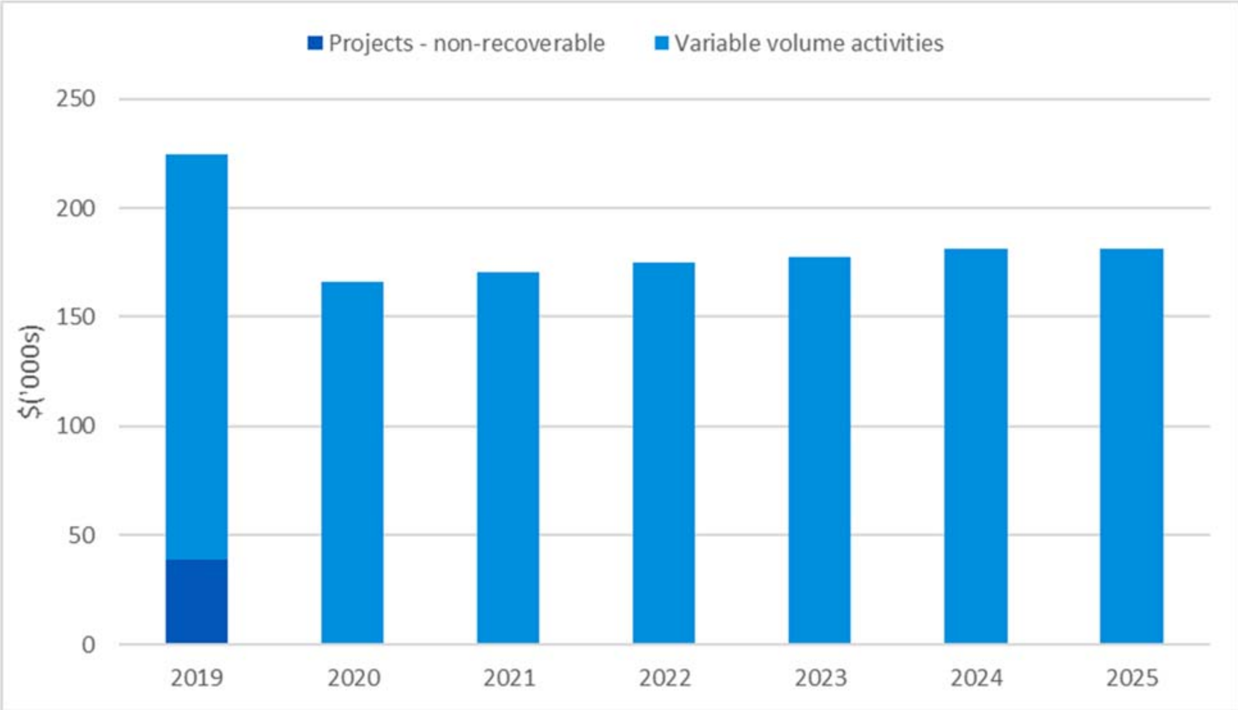
The following Table 6.2 and chart in Figure 6.2 summarise ATCO's planned maintenance on CP systems during the ALS planning period.

Table 6.2: Opex expenditure summary ($'000)

OPEX CATEGORY	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	TOTAL
Variable volume Opex	186	166	171	175	178	181	181	181	181	181	1,781
Opex Projects	39	-	-	-	-	-	-	-	-	-	39
TOTAL ($'000)	**225**	**166**	**171**	**175**	**178**	**181**	**181**	**181**	**181**	**181**	**1,820**

Opex is relatively constant, except for the implementation of the Opex project in 2019. The slight increase year on year is due to organic growth, consistent with increased volumes of CP assets requiring maintenance

Figure 6.2: Total Opex on Corrosion protection Systems ($'000)



It can be seen in the chart illustrated above in Figure 6.2 that the predominant cost for maintaining these assets is variable volume maintenance.

6.3 Forecasting Inputs and Assumptions

As explained in the AMP, ATCO's overarching maintenance forecasts are developed using a base-step-trend approach. The impact of expected changes to CP systems, obligations or requirements has been incorporated into this forecast.

APPENDIX A

Work Plan Detail

A1. Work Plan Detail

This appendix provides links to business cases and project briefs that provide further detail and justification for the proposed work plan for the metering facilities asset class.

Table A1.1: Work Plan Detail

PROJECT	SUPPORTING BUSINESS CASE / PROJECT BRIEF
Facility Upgrade - Step Touch Mitigation	See Section 4.3.1 of this ALS
Facility Upgrade - Resistance Probes	See Section 4.3.1 of this ALS
Facility Upgrade - Insulation Joints & Surge Protectors	See Section 4.3.1 of this ALS
Facility Upgrade - CP Test Points	See Section 4.3.1 of this ALS
EOL Replacement - Anodes	Project Brief: 96909848

APPENDIX B

Further Technical Detail

B1. Further Technical Detail

Table B1.1: Relevant measuring points used in NEON to monitor asset condition

MEASUREMENT POSITION	MEASUREMENT POINT CATEGORY	DESCRIPTION	UNIT
WC01 PRIM DEV BAT V	W	primary device battery voltage	V
WC02 SEC DEV BAT VLT	W	secondary device battery voltage	V
WC03 MODEM BAT VLT W	W	modem battery voltage	V
WC04 VOLT ACT BF CAL	W	volts actual BF calibration	V
WC05 CUR ACT BF CAL	W	current actual BF calibration	mA
WC06 VOLT DEV BF CAL	W	volts device BF calibration	V
WC07 CUR ACT BF CAL	W	current device BF calibration	mA
WC08 VOLT ACT AF CAL	W	volts actual AF calibration	V
WC09 CUR ACT AF CAL	W	current actual AF calibration	mA
WC10 VOLT DEV AF CAL	W	volts device AF calibration	V
WC11 CUR DEV AF CAL	W	current device AF calibration	mA

B1.1 2017 Pipeline Rating

Table B1.2: 2017 Pipeline Rating

P.L NO'S	LOCATIONS	CP RATING 2016	CP RATING 2017	CP SURVEY FREQUENCY
1	Wellington St / Thomas St, Perth	FAIR	FAIR	12
2	Vincent St To Loftus, Perth	FAIR	FAIR	12
3	Anzac Rd To Wellington St, Perth	FAIR	FAIR	12
7	Bassendean Compound / Daly St, Belmont	FAIR	FAIR	12
9	Bayswater To Bassendean	GOOD	GOOD	12
10	West Swan Rd, Caversham	GOOD	GOOD	12
12	Hail Rd, Forrestfield	FAIR	FAIR	12
13	Hale Rd Wattle Grove To Gilwell Ave,Kelmscott	POOR / FAIR	FAIR	12
14	Miguel Rd To Hatch Pl, Bibra Lake	POOR / GOOD	FAIR / FAIR	6
15	Prout Way To Murdoch Dr, Murdoch	FAIR	FAIR	12
16	Mandurah Rd Sulphur Rd, Parmelia	UNDER PROTECTED / UNDER PROTECTED	FAIR/FAIR	6
17	Mandurah Rd To Kwinana Beach Rd, Kwinana	UNDERPROTECTED	FAIR/FAIR	6
18	Railway Res To South West Hwy, Pinjarra	FAIR	FAIR	12
19	Burns Beach Rd To Balga	FAIR	FAIR	12

P.L NO'S	LOCATIONS	CP RATING 2016	CP RATING 2017	CP SURVEY FREQUENCY
20	Ocean Reef Rd	FAIR	FAIR	12
21	Prout Way To Railway Reserve, Cannington Vale	FAIR	FAIR	12
22	Railway Reserve Canning Vale To Willeri, Willetton	GOOD	GOOD	12
24	Sheffield Rd, Welshpool	FAIR	GOOD	12
26	Midland Brick, Middle Swan	FAIR	FAIR	12
27	Balga Av To North Beach Rd	FAIR	FAIR	12
28	Harrow Rd To Ballajura Gas Depot	POOR / FAIR	FAIR	12
29	Ballajura Gas Dept To Princess Rd, Balga	FAIR	FAIR	12
30	Gilwell Ave Kelmscott To Kiln Rd, Byford	FAIR	FAIR	12
31	Hazelmere To Midland	GOOD	GOOD	12
32	Miguel Rd Yangebup To Railway Ave, Armadale	GOOD	GOOD	12
33	Armadale Rd Forrestdale To Railway Res,Canningvale	GOOD	GOOD	12
34	Welshpool Gate Stn To John St To Davison St,Kewdale	FAIR	FAIR	12
35	Brook St To Nicholson Rd, Beckenham	GOOD / GOOD	GOOD	12
36	Prinsep Rd, Jandakot	GOOD	GOOD	12
37	Hazelmere, High Wycombe	FAIR	FAIR	12
38	Ballajura Gas Depot To Hyde Park	POOR/ FAIR	FAIR	12
39	Office Rd To Read St, Rockingham	FAIR	FAIR	12
40	Viveash To Pioneer Quarry	GOOD	GOOD	12
41	Welshpool Gate Stn To Mlv 120 Dundas Rd, Forrestfield	GOOD	GOOD	12
42	M.L.V.122 Anstey Rd To Armadale Rd, Forrestdale	FAIR	FAIR	12
43	Bayswater Gate To Bayswater Compound	GOOD	GOOD	12
44	Russell Rd, Munster	FAIR	UNDER PROTECTED	12
45	M.L.V. 159 Boyanup Rd To Bussell Hwy, Bunbury	GOOD	GOOD	12
46	Leath Rd, Naval Base	POOR/ GOOD	GOOD	12
47	M.L.V. 159 Boyanup Rd To Boyanup, Bunbury	GOOD	GOOD	12
48	M.L.V. 156/157 Clifton Rd To Brunswick Junction	FAIR	FAIR	12
49	Geraldton	FAIR	FAIR	12
50	South Western Hwy To Estuary Dr (Vege Oils) Bunbury	GOOD	GOOD	12
51	Daddow Rd Kewdale To The International Airport	GOOD	GOOD	12

P.L NO'S	LOCATIONS	CP RATING 2016	CP RATING 2017	CP SURVEY FREQUENCY
52	Mandurah Rd / Beach Rd To Thomas Rd Kwinana	UNDER PROTECTED	FAIR/FAIR	6
53	Leghorn Rd / Read St To Anstey Rd Secret Harbor	GOOD	FAIR	12
54	M.L.V.120 Dundas Rd To Kalamunda Rd High Wycombe	GOOD	GOOD	12
55	Wesfi Moore Rd Bunbury	GOOD	GOOD	12
56	M.L.V. 156/157 Clifton Rd To Millennium Australind	FAIR	FAIR	12
57	Hamilton St Queens Park To Bannister Rd Canning vale	FAIR	FAIR	12
58	North Perth To Wembley	FAIR	FAIR	12
59	East Perth To Hyde Park	FAIR	FAIR	12
60	Geraldton	GOOD	GOOD	12
61	John St Welshpool To Goodwood Pde Rivervale	POOR/ FAIR	FAIR	12
62	Angus Ave Spearwood To Marine Tce Fremantle	FAIR	FAIR	12
63	Angus Ave Spearwood To Butler / North Lake Willagee	POOR /UNDER PROTECTED	FAIR/FAIR	6
64	South / Jarvis O' Connor To Marine Tce Fremantle	UNDER PROTECTED	FAIR/FAIR	6
66	Marine Tce To Beach St Fremantle	FAIR	FAIR	12
67	Miguel Rd Yangebup To Angus Ave Spearwood	FAIR	FAIR	12
69	Marmion Ave To North Beach Rd	FAIR	FAIR	12
70	Winthrop Ave To Monash Ave	FAIR	FAIR	12
71	Marriott Rd Kemerton	GOOD	GOOD	12
72	Office Rd / Patterson Rd / Ward St Kwinana Beach	FAIR	FAIR	12
73	Crocker Rd Malaga	GOOD	GOOD	12
74	Inverness To Transperth Malaga	GOOD	GOOD	12
75	Hope Rd To Seventh Rd Harvey	GOOD	GOOD	12
76	Stirling Cres Hazelmere	GOOD	GOOD	12
77	Rhone Poulenc Pinjarra	GOOD	FAIR	12
78	Sulphur Rd Parmelia To Orton Rd Casuarina	UNDER PROTECTED	POOR/FAIR	6
79	Tiwest Muchea	FAIR	FAIR	12
80	Miguel Rd Yangebup To Russell Rd Munster	POOR	GOOD	12
81	Jersey St To Stephenson And Monash Av	FAIR	FAIR	12
82	Barter Rd Hismelt Naval Base	FAIR	FAIR	12
83	Marmion Av Craigie	FAIR	FAIR	12
84	McCabe St. North Fremantle	FAIR	FAIR	12

P.L NO'S	LOCATIONS	CP RATING 2016	CP RATING 2017	CP SURVEY FREQUENCY
85	Ellen brook	UNDER PROTECTED / POOR	POOR/ GOOD	6
86	Anstey Rd Secret Harbour To Lanyon St Mandurah	FAIR	FAIR	12
87	Vincent St Aberdean St North Bridge	FAIR	FAIR	12
88	Joondalup Dr Lakeside Joondalup	GOOD	GOOD	12
89	Payne St Boyanup To Gate Station Tuart Dr Capel	GOOD	GOOD	12
90	Joondalup Dr Via Wanneroo Rd To Hester Av	FAIR	FAIR	12
91	WANNEROO RD FLYNN DR TO MLV117 (CL600 Only)	FAIR	FAIR	12
92	Lanyon To Old Coast Rd / Peelwood Pde Mandurah	GOOD	GOOD	12
94	Forsyth / Jones St O'Connor To Rome Rd Melville	GOOD	GOOD	12
95	Rome / Mc Coy St Melville To Marmion St Booragoon	GOOD	GOOD	12
96	Herdsman Pde Wembley To Scarborough	GOOD	GOOD	12
97	Willeri Dr / Killara St To Rhonda St Willeton	GOOD	GOOD	12
98	Railway Pde Welshpool To Manning Rd Manning	GOOD	GOOD	12
99	Mlv 122 Anstey Rd To Leslie St Southern River Gosnells	GOOD	GOOD	12
100	Mosman Park To Mt Claremont	GOOD	GOOD	12
101	Malaga To Lansdale	GOOD	GOOD	12
102	Geraldton Lateral	GOOD	FAIR	12
103	Eneabba Lateral	FAIR	FAIR	12
104	Bunbury Lateral	GOOD	GOOD	12
105	East Perth Lateral	GOOD	GOOD	12
106	Viveash Lateral	GOOD	GOOD	12
107	South Caversham	FAIR	GOOD	12
109	Hatch Pl Bibra Lake To Phoenix / Doolette Spearwood	POOR	FAIR	12
110	Bootenal To Geraldton Brickworks	GOOD	GOOD	12
111	Gosnells	FAIR	FAIR	12
113	Rockingham Bus depot	Good	Good	12
114	Welshpool Bus depot	FAIR	FAIR	12
117	Wellard Rd Calista	UNDERPROTECTED	FAIR/FAIR	6
120	Mandurah Lateral	GOOD	GOOD	12
125	Karrinyup	GOOD	GOOD	12
127	Farrington RD	GOOD	GOOD	12
128	Abbey Rd Morley	GOOD	GOOD	12

P.L NO'S	LOCATIONS	CP RATING 2016	CP RATING 2017	CP SURVEY FREQUENCY
129	PRS015 to Mandurah	GOOD	GOOD	12
131	QE II Aberdare Rd, Nedlands	GOOD	GOOD	12
132	Pinaster Pde, Ellenbrook to Park St HENLEY BROOK	GOOD	GOOD	12
134	Soldiers Rd, Byford	GOOD	GOOD	12
C/Block	City Of Perth	UNDER PROTECTED / UNDER PROTECTED	UNDER PROTECTED /FAIR	6
Albany Gas Plant	Albany	GOOD	GOOD	12