national gas transmission

ENGINEERING JUSTIFICATION PAPER (EJP)

OFFICIAL- SENSITIVE

Sites Cathodic Protection

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RIIO-GT3 NGT_EJP09

Contents

1 Summary Table

1.1 Summary Table

1.1.1 Table 1 provides a summary of this paper.

Table 1: Summary table for Sites Cathodic Protection EJP

Name of Project	Sites Cathodic Protection		
Scheme Reference	NGT_EJP09_Sites_Cathodic_Protection_RIIO-GT3		
Primary Investment Driver	Asset Health		
Project Initiation Year	FY2027		
Project Close out Year	FY2031		
Total Installed Cost Estimate (£, 2023/24)	36,255,862.49		
Cost Estimate Accuracy (%)	+/- 30%		
Project spend to date (£m, 2023/24)	0		
Current Project Stage Gate	ND500 4.0		
Reporting Table Ref	6.4		
Outputs included in RIIO-GT3 plan	Yes		
Spend Apportionment (£m, 2023/24)	**RIIO-T2**	**RIIO-GT3**	**RIIO-GT4**
	£1.24m	£34.51m	£0.51m

2 Executive Summary

2.1.1 This paper proposes £36.26m (2023/24) of baseline funding to address Cathodic Protection (CP) defects on 121 (23%) of our National Transmission System (NTS) sites in RIIO-GT3. The spend proposed in this EJP will be assessed via NARMS methodology.

2.1.2 We need to protect our pipework to protect degradation through corrosion. Corrosion can lead to the loss of integrity of buried pipework, loss of containment of high pressure gas and unacceptable safety risks that therefore require shut down of parts of our network which would limit availability of the NTS and service to consumers. The primary corrosion protection for buried pipework is the application of high-quality coating systems which are applied both internally and externally to the pipe. The application of CP is secondary to the primary protection but is required to prevent corrosion where the primary coating is imperfect or has failed. The primary driver for this investment is to maintain compliance with legislation including Pressure System Safety Regulation (PSSR) and Pipeline Safety Regulations (PSR). This investment is also impacted by Asset Deterioration, Defects and Operational drivers.

2.1.3 Many of our CP systems are ageing and their performance deteriorates over time which in turn leads to increased corrosion of buried pipework compromising the integrity of the pipework and non-compliance with PSSR and PSR. A total of 272 CP interventions are required to ensure stable network risk is maintained during RIIO-GT3. This delivers £0.14m of NARMS benefit.

2.1.4 Our CP assets include whole CP Systems, Test Posts, Transformer Rectifiers, Ground Beds, Insulation Joints and Remote Monitors. We considered seven investment options across the site CP portfolio, to establish an optimal programme that would deliver desired regulatory outputs. In summary, we are proposing the interventions mix summarised in Table 2.

Table 2: RIIO-GT3 volumes proposed in this EJP

	Replacement	Strategic Spares	Decommissioning	Total
RIIO-GT3 volumes	262	10	0	**272**

2.1.5 The planning and surveying work that we undertook in the initial years of RIIO-T2 has been instrumental in developing our strategies to optimise efficient delivery, but it has also resulted in lower volumes of works forecast for delivery than anticipated in some areas as summarised in Table 3. As a result, some RIIO-T2 interventions will be deferred to RIIO-GT3. The increase in RIIO-GT3 proposed intervention volumes is a consequence of the continued deterioration of these assets shown through actual, surveyed, and forecast defects. The reduction in forecast RIIO-GT3 cost is due to a higher number of low-cost interventions compared to RIIO-T2.

Table 3: RIIO-T2 vs RIIO-GT3 (£m, 2023/24)

	RIIO-2 Business Plan	RIIO-2 Forecast Delivery	RIIO-GT3 Business Plan
Interventions	219.9	186	272
Investment	£38.9m	£40.1m	£36.26m
Site population	9%	8%	24%

2.1.6 We need to deliver a step change in Sites CP defect rectification during RIIO-GT3 to protect the integrity of our pipework and ensure future network risk levels are not compromised.

2.1.7 The deliverability of this work has been assessed and we have high confidence that this can be delivered during RIIO-GT3. The profile of Site CP Infrastructure investment for RIIO-GT3 is shown in Table 4.

Table 4: *RIIO-GT3 funding request for Site CP infrastructure (£m, 2023/24)*

Asset Sub-Group	2026	2027	2028	2029	2030	2031	2032	Total	Funding Mechanism
CP-Sites-Groundbed Intervention (including SAC Anodes)	0.07	0.36	0.02	-	-	-	-	**0.45**	Baseline
CP-Sites-Install Remote Monitor	-	-	0.00	0.01	0.00	0.01	0.00	**0.03**	Baseline
CP-Sites-Insulation Joint Intervention	0.55	3.30	2.50	2.02	2.81	2.19	0.13	**13.50**	Baseline
CP-Sites-Survey	-	0.28	0.20	0.05	0.07	0.03	-	**0.64**	Baseline
CP-Sites-System Replacement - AGIs	0.07	0.47	0.49	0.57	1.03	1.23	0.07	**3.94**	Baseline
CP-Sites-System Replacement - Compressors	0.55	2.95	0.18	1.11	6.45	3.32	0.18	**14.74**	Baseline
CP-Sites-Test Post Intervention	-	0.02	0.15	0.19	0.39	1.91	0.12	**2.78**	Baseline
IJ Spares x 10	-	0.03	0.03	0.03	0.03	0.03	-	**0.16**	Baseline
Total	**1.24**	**7.42**	**3.59**	**3.99**	**10.80**	**8.72**	**0.51**	**36.26**	

3 Introduction

3.1 Introduction

3.1.1 Investment in sites Cathodic Protection (CP) systems on Above Ground Installations (AGIs), Compressor Stations and Terminals are key in providing the secondary means of corrosion protection to buried assets when the primary corrosion protection system (i.e., coatings) is compromised or fails. Unmanaged corrosion and unresolved defects will ultimately lead to loss of integrity of buried pipework, loss of containment of high-pressure gas, unacceptable safety risks, and therefore require shutdown of parts of NGT's sites limiting the availability of the NTS and service to customers. l.

3.1.2 CP systems are located at compressor stations, terminals and AGIs, but will hereby be referred to solely as AGIs to encompass all types of sites.

3.1.3 Many of our CP systems are ageing and their performance deteriorates over time which in turn leads to increased corrosion of buried pipework compromising the integrity of the pipework and non-compliance with PSSR and PSR. Unmanaged corrosion and unresolved defects will ultimately lead to loss of integrity of buried pipework, loss of containment of high-pressure gas, unacceptable safety risks, and therefore require shutdown of parts of NGT's sites limiting the availability of the NTS and service to customers. **BAU Innovation**

3.1.4 Key elements of CP systems include, but are not limited to Transformer Rectifiers, Ground Beds, CP Test Posts, Insulation Joints and Remote Monitors, with the key drivers for investment being legislation and deterioration.

3.1.5 The RIIO-GT3 worklist has been generated through the assessment of known defects and NGT's ongoing asset health management programme as follows:

- Independent external Close Interval Protection Surveys (CIPS)[1,2,3] of CP systems at 123 sites, including compressor stations, terminals and AGIs across the NTS. This was followed by a separate independent external review of the survey outputs to develop the most pragmatic intervention plan for defects found during the surveys.
- Review and addition of known defects from the NGT defect register.

3.1.6 In RIIO-T2, investment focused on high priority CP system replacements (i.e., those with severe defects critically impacting CP performance). This work was informed by the strategic planning and surveying work that we undertook in the opening years of RIIO-T2 which has been instrumental in effectively prioritising workload, identifying bundling opportunities and optimising resource allocation. RIIO-GT3 will focus on system wide interventions, that have been efficiently planned as a result of the work undertaken and lessons learnt from RIIO-T2, with the addition of a small number of investments deferred from RIIO-T2 and the inclusion of targeted surveys to inform RIIO-GT4 investments.

3.1.7 Learning from investment building and submission experience in RIIO-T1 and RIIO-T2, we have moved from a qualitative and quantitative decision approach to a data driven asset management approach. All asset programmes are bottom-up plans built using defect, redundancy, and obsolescence information (verified by stakeholders across the business) combined with, where applicable, investments recommended by Predictive Analytics (PA).

3.1.8 This Sites CP EJP[4] is linked to, and cognisant of the Civils EJP[5], Valves -Bypass EJP[6], and Valves-Valves EJP[7].

3.1.9 The scope of this document is aligned with our Asset Management System (AMS) and relates to our Legislative Compliance and Asset Health commitments. More information on our AMS and a description of our commitments is provided in the Network Asset Management Strategy (reference – including section number to be provided).

[1] NGT_EJP09_Rosen Analysis Output - 19042-1 - NGT AGI CIPS Review - All Areas Summary Report - Rev 1.0_RIIO-GT3
[2] NGT_EJP09_Appendix 1 - CIPS Survey Outputs Example - CJob0456 - 17 - Soutra_RIIO-GT3
[3] NGT_EJP09_CIPS Survey Outputs Example - CPEL-2273-D5-R0 - Billericay AGI CIPS Report Jan 2023_RIIO-GT3
[4] NGT_EJP09_Sites Cathodic Protection_RIIO-GT3
[5] NGT_EJP19_Civils_RIIO-GT3
[6] NGT_EJP25_Valves: Bypass Installation and Modification_RIIO-GT3
[7] NGT_EJP22_Valves: Valves_RIIO-GT3

4 Equipment Summary

4.1.1 Many of the sites CP assets range from 15 to 45 years old with some being over 50 years old. CP equipment is typically installed separately on sites and pipelines which have Insulation Joints (IJs) separating the two asset sets. Coatings are the primary means of corrosion protection. The application of CP is secondary to the primary protection but is required to prevent corrosion where the primary coating is imperfect or has failed. Additional information on this equipment group such as the health score at the beginning and end of the price control and monetised risk are provided in the accompanying NGT_IDP05_Portfolio EJP Sites Cathodic Protection_RIIO-GT3.

4.1.2 The key elements, some illustrated in Figure 1 and Figure 2, of current CP systems include:

- CP test posts
- Transformer rectifiers
- Ground beds
- Insulation Joints
- Remote monitors

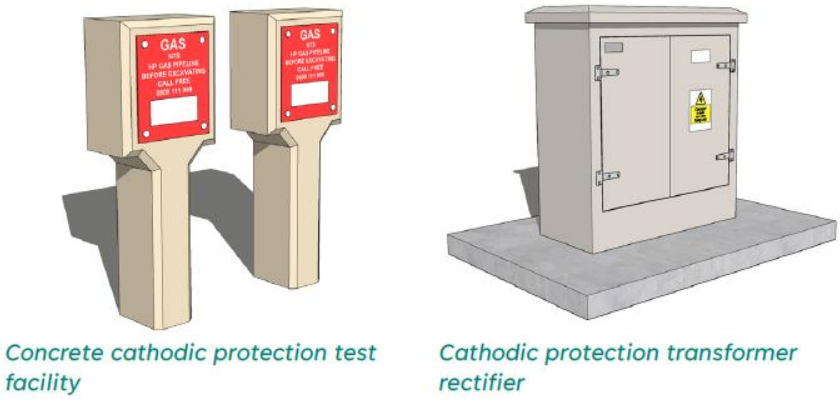

Figure 1: Examples of Cathodic Protection Assets

Figure 2: CP Transformer Rectifier and Test Posts (with reference electrode posts)

4.1.3 AGIs provide connectivity between high-pressure pipelines, enabling the control and management of the flow and pressure of gas. The pipework operates at a range of pressures up to and including the full pressure of the NTS, which is 70 to 94 bar.

4.1.4 A typical AGI will have a proportion of buried site pipework, constructed from carbon steel with a wall thickness of between 5mm and 40mm depending on the diameter and design. Carbon steel is presently the only material technically and economically viable to use for this pipework.

4.1.5 All buried steel pipework and structures will corrode in their given environment. Most of the corrosion occurs externally because if the coating is damaged or failed then all elements are present for a corrosion cell to be initiated, i.e., anode, cathode, metallic pathway and an electrolyte. The primary corrosion protection for buried pipework is the application of high-quality coating systems which are applied both internally and externally to the pipe.

4.1.6 The type and age of CP related assets information is being updated through an ongoing validation exercise and includes information such as:

- **CP Systems** - Some AGIs have discrete systems i.e., are isolated from the pipelines and they are protected by their own separate CP system. Others take current from the pipeline CP system either as a result of being physically connected without an Insulation Joint (IJ) or via a bond arrangement. There are also a number of AGIs that are considered to be fully covered by the pipeline as the amount of additional buried assets is considered minimal (as in the case of a lot of block valves).
- **Technology types** – There is a wide range of technology when it comes to CP systems, both in terms of transformer types and anode/grounded types.

4.1.7 Different CP systems are electrically isolated from each other using insulating/isolation joints (IJs). Separating CP systems enable them to be set up for the specific asset(s) that requires protection. The characteristics of, and therefore management of a CP system on AGI pipework will be subtly different to that of a pipeline. The need to keep these electrical systems separate is of key importance due to the complex current interactions that take place at complex sites with numerous buried plant or equipment assets.

4.1.8 The desired range of energised (On) and polarised (Off) potentials to provide effective cathodic protection is between -850mV and -550mV, further elaborated in Table 5.

4.1.9 The design, construction, operation and maintenance of pipework is subject to both:

- Pressure System Safety Regulations 2000 (PSSR)
- The Pipeline Safety Regulations 1996 (PSR)

5 Problem Statement

5.1 Why are we doing this work and what happens if we do nothing?

5.1.1 The performance of the CP system (i.e., anode/groundbed consumption) deteriorates over time which in turn leads to increasing corrosion of the buried site pipework. Increased severity of defects would increase the frequency of inspection which would result in finding more defects to remediate. The integrity of the pipework must be maintained to enable continued use and compliance with PSSR and PSR.

5.1.2 Not remediating the current poor performance of the CP will result in corrosion of the buried pipework at locations where the coating has deteriorated, thus resulting in anode consumption and eventual failure of the CP system.

5.1.3 Unmanaged corrosion and unresolved defects will ultimately lead to loss of integrity of buried pipework, loss of containment of high-pressure gas, unacceptable safety risks, and therefore require shutdown of parts of our site limiting the availability of the NTS and service to NGT customers. Unmanaged corrosion could also lead to pressure reduction intervention where pipework wall thickness is compromised.

5.1.4 To ensure effective corrosion control, and compliance delivery, in accordance with the relevant standards and specifications, it is essential that CP systems are effective and can be validated at all locations. AGIs generally present significant corrosion risks. This is due to the following circumstances:

- Presence of bi-metallic coupling with large “foreign” cathodes, such as concrete rebar, presenting unfavourable anode/cathode area ratios which can result in high corrosion rates.
- Pipework experiencing higher temperatures is subject to increased corrosion rates. Above 25 degrees Celsius corrosion rate doubles with each 10 degrees increase in temperature.
- Soil resistivity measurements indicate that site conditions are aggressive to carbon steel.
- The existing CP monitoring facilities do not enable pipe-to-soil potential measurements to be made in critical locations, therefore the CP system cannot be validated in these areas.

5.1.5 Where coating systems break down, carbon steel pipework will corrode, and this is the predominant life limiting factor for the buried site pipework across the NTS as a whole. Coating provides primary corrosion prevention for all buried pipework with CP providing secondary protection where the coating is imperfect or has failed. CP is installed along the length of every buried pipe providing a secondary line of defence where coating breakdown or ‘holidays’ exist or form over time in the primary barrier coating. The AGI CP systems protecting our buried site pipework are deteriorating. Many have reached the limits of their original design capacity, to polarise the pipework to a sufficient level to minimise corrosion as summarised in Table 5, and can no longer effectively protect the buried site pipework from the effects of coating degradation.

5.1.6 Close Interval Protection Surveys (CIPS) were conducted at 123 Compressor Stations, Terminals and AGIs across the NTS based on defects raised by operational teams between 2020 and 2023. Further defects raised, following the CIPS surveys (see Appendix 12.1), were assessed internally including by our external partner, Rosen (see Appendix 12.2), and, where relevant, included within the scope of works identified for RIIO-GT3.

5.1.7 The outputs of these surveys have identified more than 3000 defects, with different levels of severity, that need resolving, ranging from the most severe P1+ to the least severe P3. These are summarised in Table 5 and detailed in Table 6.

Table 5: CIPS Survey Defects

Category	Description	Number of Defects	Comment
Category P1+ Defect	Enhanced P1 Defect. Both energised (On) and polarised (Off) potentials are more positive than the minimum protection criteria -850mV and polarised (Off) potentials are more positive than -550mV.	702	The pipe to soil potentials is unsatisfactory and the locations are not cathodically protected.
Category P1 Defect	Both the ‘(On) and instant (Off) potentials are more positive than – 850mV. There is little or no IR factor.	1596	The pipe to soil potentials is unsatisfactory and the locations are not cathodically protected.
Category P2 Defect	The (Off) potential is more positive than – 850mV, the (Off) potential more negative. (This may also occur with a reduction in IR factor).	1240	Cathodic protection levels are unsatisfactory.

Category	Description	Number of Defects	Comment
Category P3 Defect	Positive change in the (On) and instant (Off) potential plot although both remain more negative than –850mV.	171	Indicates location of increased current demand, cathodic protection levels are satisfactory. As long as the CP levels of protection are above minimum criteria there is no need to remedy these defects – they just need to be monitored for further deterioration. Therefore, the majority of them only require additional monitoring/surveys, while some require remote monitor installation, TP installation and DC coupon installation.

5.1.8 These identified defects cover the following peripheral aspects:

- CP Protection Levels.
- CP System.
- CP Furniture.
- Stray Current.

5.1.9 CP defects, based upon UK industry best practice, can be grouped into the defect classification criteria summarised in Table 6.

Table 6: CP Defect classification Criteria

Type	Description	Defect Category
CIPS Defects	Both energised (On) and polarised (Off) potentials are more positive than the minimum protection criteria -850mV and polarised (Off) potentials are more positive than -550mV.	P1⁺
	Both energised (On) and polarised (Off) potentials are more positive than the minimum protection criteria -850 mV.	P1
	The polarised (Off) potential is more positive than the minimum protection criteria, whilst the energised (On) potential remains more negative than the minimum protection criteria -850mV. The IR error value is less than 100 mV.	P2
	There is a significant (>50 mV) positive shift in protection, but both the energised (On) and Polarised (Off) potentials remain more negative than the minimum protection criteria -850mV. The IR error value is between 100mV and 200mV.	P3
CP System	There is damage on the CP system that prevent it be operative i.e.: Transformer Rectifier failure, defective positive or negative DC output cables, anode Groundbed depletion.	P1
	The CP system is operative but with limited performance condition that affect the pipework protection levels. This includes anode depleted, TR over-efficiency, high TR ripple, etc.	P3
CP Furniture	Any CP furniture associated to the CP system with damage, i.e., coupons, TP condition, permanent reference electrodes, mitigation device, etc.	P2
CP Protection Level	CP under-protection level on a section of pipeline longer than 50m, which both energised (On) and polarised (Off) potentials are more positive than the minimum protection criteria -850mV but polarised (Off) potentials are more positive than -450mV.	P1⁺
	CP under-protection level on a section of pipeline longer than 50m, which both energised (On) and polarised (Off) potentials are more positive than the minimum protection criteria -850 mV.	P1
	CP under-protection level on a section of pipeline longer than 50m, which the polarised (Off) potential is more positive than the minimum protection criteria, whilst the energised (On) potential remains more negative than the minimum protection criteria -850mV.	P2
	CP over-protection level on a section of pipeline longer than 50m, which the polarised (Off) potential is more negative than -1450mV.	P2
	CP over-protection level on a section of pipeline longer than 50m, which the polarised (Off) potential is between -1150 and -1450mV.	P3
Stray Current	Potential fluctuations exist due to external influences that may or may not be identified such as AC/DC stray current interference, telluric interference, etc. This include CP system interaction with foreign structure that is not part of the site CP system configuration.	P2

5.1.10 The Specific Desired State within our Asset Management Objectives (AMOs) aligned to Sites CP and focused on directly leading to investments is: 'By 2031, we will have remediated all CP priority 1 and 2 defects and all failed isolation joints, that were identified during the build of our RIIO-T2 business plan'. We will also continue to review and prioritise all newly identified CP defects (in line with improved processes suggested in this strategy), with a risk assessment and/or mitigation in place'. NGT has developed this desired state to ensure we continue to contain and control gas flows through our AGIs and deliver value to our consumers and stakeholders.

5.1.11 Applicable standards and documents guiding CP related investments are summarised in Table 7.

Table 7: Reference Standards / Documentation

Document Ref	Document Type	Document Title
ISO - 15589-1	Industry Standard	Petroleum, petrochemical and natural gas industries -- Cathodic protection of pipeline systems - Part 1: On-land pipelines
BS EN 12954	Industry Standard	Cathodic Protection of Buried or Immersed Metallic Structures. General Principles and Application to Pipelines

Document Ref	Document Type	Document Title
BS 50162	Industry Standard	Protection against corrosion by stray current from direct current systems
IGEM/TD/13	Industry Standard	Applies to the safe design, construction, inspection, testing, operation and maintenance, decommissioning, and disposal of pressure regulating installations (PRIs)
T/PL/ECP/1	Internal NGT Policy	Policy for: Corrosion Control of Buried Steel Systems
T/PM/ECP/2	Internal NGT Policy	The Maintenance and Monitoring of Cathodic Protection on Buried Steel Systems
T/SP/ECP/8	Internal NGT Policy	Above Ground Surveys Cathodic Protection Systems
T/PR/MAINT/5036	Internal NGT Policy	Work Procedure for: Above Ground Surveys of Cathodic Protection Systems
T/PR/MAINT/5038	Internal NGT Policy	Work Procedure for: Analysis of Cathodic Protection Systems

5.1.12 The investments highlighted in this paper are backed by Legislative, Asset Deterioration, Defects and Operational drivers:

- **Legislation** – The above ground pipework at ground installations is affiliated to the pipeline system and are managed as part of the pressure vessel system under PSSR – this is not covered by CP as it is impacted by atmospheric corrosion. The buried part of this pipework is covered by the CP system as it is in intimate contact with the electrolyte/soil and is therefore compliant with PSSR and its inherent safety requirements. Applying recognised industry standards is a key part of demonstrating compliance to the applicable legislation for these assets.
- **Deterioration** – the performance of the CP systems is deteriorating:
  - Performance of the CP system deteriorates as when more of the coating failure occurs then the more the electrical current demand is placed on the CP system.
  - Components within the CP system begin to deteriorate over time due to age and usage, which in turn leads to increasing corrosion of the buried site pipework.
  - The shorting of isolation joints.
- **Defects -** material, manufacturing or installation defects impacting the integrity of the assets. Not remediating defects and poor performance of the CP will result in corrosion of the buried pipework at locations where the coating has deteriorated.
- **Operational -** factors such as fatigue, pressure and temperature cycling, contamination, over pressure, vibration, erosion and abrasion can all affect the integrity of the assets.

What is the outcome that we want to achieve?

5.1.13 We are seeking funding through this submission to ensure that the following outcomes are achieved:

- Meet legal requirements and agreed safety standards, including PSSR.
- Manage deterioration of the assets such that they do not limit availability, performance or cause damage to other assets on the NTS or those of consumers.
- Providing benefit to consumers through optimised investment to ensure the scrubber and condensate tank assets last as long as compression is needed, balancing cost, risk and performance.

How will we understand if the spend has been successful?

5.1.14 The investment plans will be considered successful when the outcomes summarised below are met:

- Maintenance of medium and long-term integrity of the buried pipework asset at lowest whole life cost through the management of the coating and cathodic protection of the buried pipework.
- Ensuring continued compliance with PSSR and PSR and other legislative requirements.
- Stabilisation, and where required remediation of the asset deterioration and specific corrosion issues to ensure that they do not result in a loss of containment of high-pressure gas, present a safety risk, and are not a limiting factor on availability or performance of the NTS.
- We have met our AMO objectives of Safe Operation, Network Reliability and Availability, and Network Resilience.

Narrative Real-Life Example of Problem

5.1.15 Real life examples of CP related problems identified for investment are summarised in Table 8.

Table 8: Examples of Problems

Site	Defects/Problem	Description – necessity for investment
Cambridge Compressor Station	• Five (5) Category P1+ defects - positive pipe to soil potential readings when crossing earthing cables installed in close proximity to Scrub 8. • Fourteen (14) Category P1 Defects and nine (9) Category P2 Defects – unsatisfactory CP levels. • Sixteen (16) Category P3 Defects identified on the buried pipe work. • Twenty-three missing test posts.	• The defects found result in the possibility that fault current from a lightning strike could flow in the pipeline creating the possibility of touch or step potential electric shock risk which could be exported beyond the site perimeter. • The connection between the ISS fence and site earth have increased the CP current requirement detrimentally influencing the level of protection. • Lack of test posts will result in the inability to undertake CIPS readings

Site	Defects/Problem	Description – necessity for investment
		which will prevent understanding of the performance of the CP system. • The nature of defects found here warrant system replacement.
Nether Kellet Compressor Station	• Eleven areas of buried piping where the potentials are more positive than the -850mVDC criteria - receiving unsatisfactory levels of CP. • Some areas of the site piping being more negative than -1100mVDC.	• These defects would result in increase of CP current required for protection and the CP system becoming ineffective, leading to high corrosion rates. • The nature of defects found here warrant component repair/refurbishment/replacement.
Moffat Compressor Station	• 17 x P1, 16 x P2 and 2 x P3 defects. • Moffat transformer output voltage exceeds the recommended 50 volts stated in BS7361 Part 1, section 12.3, with a requirement to keep voltage gradients at safe levels. • Eighty defective and/or damaged test posts.	• These defects present a danger of electric shock. Therefore, interventions need to be put in place to keep the CP supply at the TR below 50v dc. • The defective test posts will result in the inability to undertake CIPS readings which will prevent understanding of the performance of the CP system.

5.2 Project Boundaries

5.2.1 Within scope of spend in this EJP are all identified AGI related CP interventions, covering system replacement, component replacement and repair, over the five-year RIIO-GT3 period commencing April 2026. Any foundation and civil works associated with interventions on the CP assets are included within the scope.

5.2.2 Outside the scope of spend in this EJP are:

- CP interventions on pipelines – these are covered in the Pipeline Cathodic Protection EJP[8].
- CP at St Fergus and Bacton terminals – these are covered in the St Fergus – Electrical Asset EJP[9] and Bacton Site Development Cathodic Protection EJP[10] respectively.
- Alternating Current (AC) induced corrosion which is covered in the AC Inspection and Remediation – AC Corrosion Management EJP.

5.2.3 Other defects have been identified that, either do not require immediate remediation or can be resolved by operational staff and so are not included in this funding request. These include defects such as amending Test Post IDs.

[8] NGT_EJP20_Pipeline Cathodic Protection_RIIO-GT3
[9] NGT_EJP28_St Fergus: Electrical Assets_RIIO-GT3
[10] NGT_EJP09_Sites Cathodic Protection_RIIO-GT3

6 Probability of Failure

6.1.1 Assets within the Sites CP theme have historically failed, see examples in Table 8. There are instances of where ancillary equipment, which is component of an asset, has failed such as insulation joints which are part of Cathodic Protection systems.

6.1.2 Most CP assets do not immediately fail but rather deteriorate resulting in poor performance which leads to further deterioration and eventually failure. The age and frequency of the usage of the CP assets has implications on the rate of deterioration. Failures can happen even with regular maintenance due to age and constant 24/7 operation of CP systems.

Failure Modes

6.1.3 Probability of failure (PoF) has been assessed utilising historical defects, results from surveys and utilising our Network Asset Risk Metric (NARMs) model. This model is built within our copperleaf asset management decision support tool to assess the forward-looking probability of failure. This provides a different lens to consider in addition to looking at historically captured defects.

6.1.4 Not all modelled failures will result in real-world asset failure and this forecast is not a prediction of how many defects will be identified. Likely failure modes for Site CP assets with an average proportion of failures of 0.5 or above are provided in Table 9.

Table 9: Site CP Failure modes

Failure Mode	Average Proportion of Failures
Increased corrosion on pipe	0.63
Increased corrosion rate	0.69

6.1.5 When applied to the asset count with an assumption that no investment is made, a forecast of failures across the RIIO-GT3 period is produced, shown in Table 10. The average failure rate represents the proportion of that asset type with an unresolved failure. The forecast failures per year shows the quantity of new failures modelled to occur each year.

Table 10: Forecasted failures

Asset Type	Cumulative Average Defect Rates					Forecast Failures per Year				
	2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
Electrical (A.2.4)-Cathodic Protection Equipment	0.79	0.82	0.84	0.87	0.90	0.07	0.08	0.09	0.10	0.10
Electrical (A.2.4)-Cathodic Protection Equipment-Test Post	0.93	0.93	0.94	0.94	0.95	1.05	0.81	0.77	0.89	0.89
Electrical (A.2.4)-Cathodic Protection Equipment-Transformer Rectifier	0.93	0.94	0.95	0.96	0.97	1.13	0.99	0.57	0.45	0.50
Mechanical (A.2.3)-Pipeline Protection-CP Insulation Joint	0.85	0.86	0.87	0.88	0.89	0.70	0.82	0.82	0.70	0.80

Historic Defects

6.1.6 NGT's ongoing asset health assessment programme and surveys identified a range of defects, some of which if not addressed would result in loss of asset capability. Analysis of historic data, highlighted in Figure 3 shows the majority of defects being raised against System Assets including, but not limited to, CIPS defects at nodes with electrical potentials outside prescribed parameters, stray DC current, coating defects, missing and/or defective test posts.

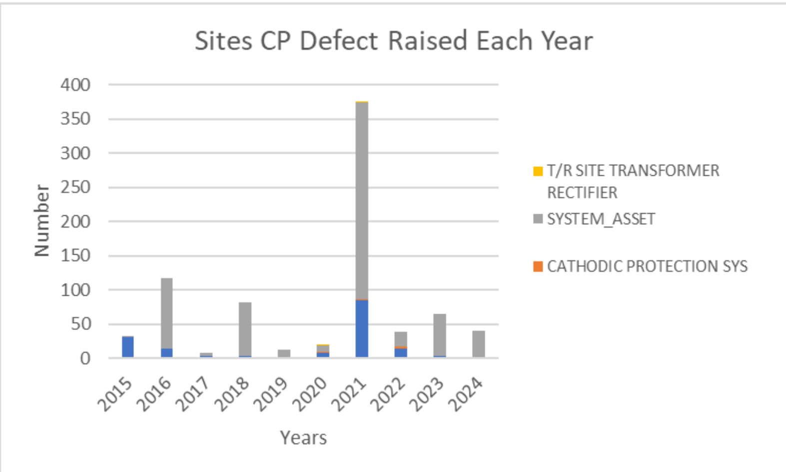

Figure 3: Historic defects raised each year

6.1.7 In addition to defects recorded on our defects management system (Maximo) recent dedicated CIPS conducted at 123 AGIs and Compressor Stations across the NTS identified over 3000 defects, post 2020, with different levels of severity. The identified defects were prioritised based on risk with some single interventions remediating multiple defects as summarised in the Volume Derivation Section 8.3.

6.1.8 An engineering assessment has been undertaken by internal and external independent Subject Matter Experts (SMEs) on the ongoing risk that not rectifying the defects would have on the operation of the CP assets. This assessment resulted in the intervention volumes derived and summarised in Section 8.3.

Probability of Failure Data Assurance

6.1.1 The NARMS Probability of Failure data was sourced from a Power BI dashboard, with data supplied from our Copperleaf asset management decision support system. This data was used in predicting future defects and failures of the CP system assets if no investment was made and also for conducting Predictive Analytics (PA) assessment described in further detail in Chapter 9 and Chapter 10.

6.1.2 Probability of failure data presented above has been determined based on NGTs Defect management system. An extract from the system was undertaken on 30 April 2024, with data analysis undertaken based on the columns of data exported from the system.

6.1.3 Information captured from surveys completed through our RIIO-T2 project delivery was utilised to inform the condition of our installations, as defects were logged within our defect management system where faults were identified through our surveys.

6.1.4 The extract from our defect management system and outputs from our surveys was used to prioritise derivation of the bottom up volumes of investments in our plan.

7 Consequence of Failure

7.1.1 Unmanaged corrosion and unresolved defects will ultimately lead to loss of integrity of buried pipework, loss of containment of high-pressure gas, unacceptable safety risks, and therefore require shutdown of parts of NGT's sites limiting the availability of the NTS and service to customers. The impact/consequence of failure for CP assets is summarised in Table 11.

Table 11: Consequence of Failure Summary

Asset	Impact / Consequence				
	Availability	Environment	Financial	Safety	Other
Site CP Systems and their subcomponents	Corrosion failures related to above or below ground pipework could lead to outages, pressure restriction, isolation of downstream customers and network constraints.	Loss of gas through pipework corrosion associated from CP system degradation and mechanically failed IJs.	***This is the risk with the highest expected stakeholder impact.*** This is associated with the costs of operating and maintaining the network at the current level of risk including resolving existing defects. Significant financial impact of a large-scale failure or loss of service event, due to loss of revenue, impact on reputation, fines and compensation.	The potential for corrosion failure, mechanical failure, or damage, causing a pipework to leak or rupture. The directional nature of a leak poses additional risk to personnel in instances where ignition occurs.	Corrosion related failure does not typically result in a catastrophic failure event e.g., rupture but instead results in a leak event. Gas losses resulting from corrosion will generally vent to air. Self-ignition due to static energy is possible. Where leaking gas does not ignite this potentially increases the risk of explosion.

8 Interventions Considered

8.1.1 In order to mitigate known defects and due to the complexity of the issues identified during CIPS the number of interventions available to remediate CP systems is limited. In evaluating interventions for CP, the following considerations have been taken into account to reduce the risks of CP issues continuing to manifest themselves:

- Location of the defects on the site and in relation to other CP and NGT buried assets.
- Each CP system has a maximum capacity and range of influence in which it is effective based on the location of the anodes.
- Increasing the CP output excessively results in damage to the coating systems increasing their rate of degradation and reducing their effectiveness.
- Increasing CP output can lead to interaction with other buried metallic services and structures which can lead to an accelerated corrosion events rather than reducing corrosion.

8.1.2 Technical optioneering has been undertaken on all the defects proposed for intervention in RIIO-GT3. System replacement, component replacement, refurbishment, repair and deferral interventions were considered. However, refurbishment, repair and deferral interventions on CP systems have been discounted due to the severity (i.e., P1+, P1, P2 and P3) and quantity of defects recorded through our CIPS and defects system including internal and external defect and remediation assessments. These options do not restore the CP systems to their original design intent and could have comparable costs to replacement. Deferral would exacerbate the defects resulting in further degradation of the CP systems leading to risks of loss of containment. Where it isn't clear what the extent of defects is we have proposed additional surveys (re-evaluation of defects) to better inform our assessment of the type of remediation required to meet consumer needs.

Counterfactual (Do Nothing)

8.1.3 This intervention considers no specific action to be undertaken in RIIO-GT3 on NGT CP assets over and above the usual maintenance activities to meet the minimum level of intervention that would be required to remain compliant with all safety regulations. It is funded through Operational Expenditure (Opex). This includes the reactive only investment across CP assets.

8.1.4 This approach leaves a range of components within installations that are obsolete, presenting multiple challenges to GT Operations teams to manage through Opex in an uncontrolled manner.

8.1.5 This presents the lower cost intervention in the short term to consumers. However, doing nothing does not address the obsolescence and defect risk currently being experienced.

8.1.6 This intervention is discounted as it does not result in any tangible benefit to the asset and increases the risk of failure and safety related incidents. It does not mitigate the known defects from the surveys undertaken and has an impact on safety related aspects of PSSR.

Decommissioning the CP system(s)

8.1.7 This intervention comprises disconnecting and removing the severely deteriorated CP assets and/or systems from their defined location, as they are no longer fit for purpose, disposing of them in a safe manner and not replacing them. It is not applicable as effective corrosion control measures are essential for as long as the installation is operational.

8.1.8 This would result in there being no corrosion protection to buried assets. This is unacceptable under PSSR/PSR as a responsible asset owner. This intervention is therefore not being progressed.

Component update/replacement/installation

8.1.9 The replacement of CP system components is undertaken to address the defective assets where replacement of the full CP system is not needed. In this case only the identified components requiring update and /or replacement will be invested in to ensure satisfactory service over the next 40 years of their nominal design life. This ensures the performance of the CP system is sufficient to manage corrosion rates and/or CP compliance in a manner cost beneficial to the consumer. Components to be updated/replaced/installed/location optimised can include:

- Test Posts
- Transformer Rectifiers
- Ground-beds
- Insulation Joints

8.1.10 Where this intervention requires exposure of below ground pipework and/or assets including replacing of associated cabling electrical and/or gas, outages may be required depending on severity of defects.

Whole system replacement

8.1.11 Where the CP system has deteriorated to such an extent that the buried pipework is at risk of corrosion severely compromising effective cathodic protection, a redesign and replacement of the entire CP system is urgently required.

8.1.12 This intervention is largely carried out at locations with an appreciable number of P1+, P1 and P2 defects (see Table 5) identified on the various components of the CP system. This intervention is targeted at:

- Compressor Stations
- AGIs

8.1.13 Activities associated with this intervention include below ground excavation to expose CP systems, welding procedures and replacement/refurbishing of associated cabling, which require site outages.

Re-evaluation of defects

8.1.14 At sites where defect identification and resolution are not clear from the output of the initial survey there is need to conduct further surveys, within RIIO-GT3, to inform intervention plans. The specific intervention in this case is additional survey and does not require any specific outage.

8.1.15 Outputs of the additional surveys will identify specific interventions required in RIIO-GT3 and those that can be deferred. The outputs of the surveys will also guide in informing NGT if decommissioning of some assets is a credible intervention.

Insulation Joint (IJ) emergency spares

8.1.16 Insulation Joints have a particularly long lead time, typically 52 weeks. It is therefore necessary that emergency spares are available to enable IJ related defect resolution. Based on historical interventions on the relative diameter lengths including the planned interventions for RIIO-GT3 it has been determined that holding of 2 x each for 24”, 30”, 36”, 42” and 48” sized IJs as emergency spares would suffice.

8.2 Interventions Summary

8.2.1 Table 12 summarises the interventions assessed against NGT’s Cathodic Protection assets across RIIO-GT3.

Table 12: Interventions Technical Summary Table

Intervention	Scope	Design life	Positives	Negatives	Taken Forward
Counterfactual (Do Nothing)	Do Nothing	N/A	Lowest cost and short-term intervention	Does not address known AH issues that could compromise NTS operation.	No
Decommission	Decommission	N/A	Low-cost intervention	Compromises NTS operation.	No
CP-Sites-Survey	Re-evaluation of defects	N/A	Provides investment certainty	None	Yes
CP-Sites-System Replacement – Compressors	Whole system replacement	40 Years	Addresses known deterioration defect and operational issues which are known investment drivers for Sites CP systems. This intervention is applied where the CP system has deteriorated to such an extent that the buried pipework is at risk of corrosion severely compromising effective cathodic protection and component replacement/refurbishment is not suitable to mitigate against the degradation rates. This provides better value for the consumer.	None	Yes
CP-Sites-System Replacement – AGIs					
CP-Sites-Transformer Rectifier Intervention	Component Replacement and Component update	40 years	Addresses known deterioration defect and operational issues which are known investment drivers for Sites CP systems. This intervention is applied where system components have degraded to the point that their individual refurbishment/replacement returns the CP system to acceptable protection levels. This provides better value for the consumer.	None	Yes
CP-Sites-Test Post Intervention					
CP-Sites-Groundbed Intervention (including SAC Anodes)					
CP-Sites-Install Remote Monitor					
CP-Sites-Insulation Joint (IJ) Intervention					
24” IJ Spares	Component replacement	N/A	Holding of emergency spares to mitigate the long lead times associated with sourcing the IJs.	None	Yes
30” IJ Spares					
36” IJ Spares					
42” IJ Spares					
48” IJ Spares					

8.3 Volume Derivation

8.3.1 The volumes have been developed based on internal and external review of outputs of targeted surveys and addition of known defects from NGT's defect register.

8.3.2 More than 3000 defects have been identified post 2020. The 382 volumes of interventions resulting from these identified defects is a combination of prioritisation based on risk, with some single interventions remediating multiple defects and other defects requiring further assessment to determine pragmatic interventions.

8.3.3 For example, though Moffat Compressor Station has 33 recorded P1 and P2 defects, including two P3 defects, and 80 test posts to be replaced/remediated. This results in three interventions in our RIIO-GT3 plan.

Table 13: Development of bottom-up volumes for RIIO-GT3

Intervention	Volume	Unit of Measure	How this volume has been developed
CP-Sites-Survey	94	Per Site	This is a repeat of a RIIO-T2 scope to assess the quantity and severity of defects alongside re-evaluating those sites/assets where defect identification and resolution are not clear from the output of the initial surveys.
CP-Sites-System Replacement – Compressors	4	Per site	During RIIO-T2 we have redesigned and replaced six CP systems based on the quantity and severity of defects. The same approach has been used to scope similar RIIO-GT3 investments. The RIIO-GT3 investments were developed based on internal and external assessment of targeted CIPS outputs and review of our defects database.
CP-Sites-System Replacement – AGIs	8	Per site	
CP-Sites-Transformer Rectifier Intervention	2	Per site	During RIIO-T2 we have resolved 186 P1 and P2 defects on components across Compressor stations and AGIs. Based on the internal and external assessment targeted CIPS outputs alongside a review of our defects system we identified similar types of CP component interventions to progress in RIIO-GT3.
CP-Sites-Test Post Intervention	197	Per Asset	
CP-Sites-Groundbed Intervention (including SAC Anodes)	16	Per Asset	
CP-Sites-Install Remote Monitor	24	Per Asset	
CP-Sites-Insulation Joint (IJ) Intervention	37	Per Asset	
24" IJ Spares	2	Per asset	Based on historical interventions on the relative diameter lengths including the planned interventions for RIIO-GT3 it has been determined that holding of 2 x each for 24", 30", 36", 42" and 48" sized IJs as emergency spares would suffice.
30" IJ Spares	2	Per asset	
36" IJ Spares	2	Per asset	
42" IJ Spares	2	Per asset	
48" IJ Spares	2	Per asset	

8.4 Cost Derivation

8.4.1 Costs have been derived using a robust methodology using known data for activities which share the scope with the interventions within this EJP. We have mapped RIIO-GT3 interventions to RIIO-T2 Unique identifiers (UIDs) and assessed the available historical outturn and/or forecasted completion costs.

8.4.2 Where historical outturn or tendered costs have not been available, we have undertaken estimating using first principles, including sourcing quotations from the supply chain to calculate the Estimated Cost of Completion (ECC).

8.4.3 Unit costs for the emergency spares were based on supplier quotes.

8.4.4 Table 14 summarises the cost sources and data points used to inform the unit costs in this EJP. A breakdown of the unit costs is also provided in Appendix 0.

Table 14: Sites Cathodic Protection cost sources and data points (£m, 2023/24)

Intervention	Unit Cost	Unit of Measure	Cost Accuracy	Number of Data Points	Source Data
CP-Sites-Survey	0.007	Per Site	+/-10%	7	Historical outturn
CP-Sites-System Replacement - Compressors	3.685	Per site	+/-10%	4	Historical outturn, Estimate at Cost of Completion
CP-Sites-System Replacement - AGIs	0.493	Per site	+/-10%	2	Historical outturn, Estimate at Cost of Completion
CP-Sites-Test Post Intervention	0.028	Per Asset	+/-10%	197	Historical outturn, Estimate at Cost of Completion
CP-Sites-Groundbed Intervention (including SAC Anodes)	0.028	Per Asset	+/-10%	178	Historical outturn, Estimate at Cost of Completion
CP-Sites-Install Remote Monitor	0.005	Per Asset	+/-10%	0	First principles – derived using known rates/activities and Estimate at Cost of Completion
CP-Sites-Insulation Joint Intervention	0.365	Per Asset	+/-10%	14	Historical outturn
Insulation Joint (IJ) Spares (2x24" IJ)	0.010	Per asset	+/-10%	0	Supplier quotes

Intervention	Unit Cost	Unit of Measure	Cost Accuracy	Number of Data Points	Source Data
Insulation Joint (IJ) Spares (2x30" IJ)	0.015	Per asset	+/-10%	0	Supplier quotes
Insulation Joint (IJ) Spares (2x36" IJ)	0.016	Per asset	+/-10%	0	Supplier quotes
Insulation Joint (IJ) Spares (2x42" IJ)	0.022	Per asset	+/-10%	0	Supplier quotes
Insulation Joint (IJ) Spares (2x48" IJ)	0.028	Per asset	+/-10%	0	Supplier quotes

8.4.5 As an example of how we've developed these costs, the unit cost of £3.684m for CP System Replacement is representative of the cost of replacing a CP system on an average sized compressor station. In RIIO-T2, we have undertaken four CP system replacement ranging from £2.655m to £4.280m in total costs for each system replacement.

8.4.6 This is based on the need to resolve P1 and P2 defects involving intrusive surveying, mechanical, electrical, and civil detailed design including Cathodic Protection detailed design and system build.

8.4.7 The scope incudes refurbishment and/or replacement of asset classes such as CP groundbeds and associated Anode Junction boxes; CP feeder cables and CP test posts; CP Drain Points and CP Power Sources, reduced CP levels at pit wall transitions and systems (ISS) fence earthing where these cause excessive drains/interference.

9 Options Considered

9.1 Portfolio Approach

9.1.1 In developing our plans, we focused on value for money and deliverability, while managing the risks of aging assets. We evaluated the cost-effectiveness of our investment program through a full Cost Benefit Analysis (CBA) using the NARMS Methodology within the Copperleaf Decision support tool.

9.1.2 In Line with HM Treasury Green Book advice and Ofgem guidance, we assessed the value of investing in site Cathodic Protection across the RIIO-GT3 period by analysing the cost benefit over a 20-year horizon.

9.1.3 We derived intervention volumes using the engineering assessments described in the previous chapters. Each intervention was assessed via the Ofgem-approved NARMS Methodology embedded in Copperleaf, quantifying risk reduction and Long-Term Risk Benefit (LTRB). Analysing this performance, Copperleaf Predictive Analytics is then able to select further NARM driven interventions to create further options to satisfy certain criteria, such as stable risk across the portfolio.

9.1.4 Under the NARMS methodology currently there is very little monetised risk associated with Site CP systems. That is because failure and consequences are only associated with the CP system itself and not the knock-on consequences of the corrosion that would result from not investing in CP systems. Technical optioneering has been undertaken on the AMP investments (as described in Section 8). Refurbishment, repair and deferral interventions on CP systems and components, including counterfactual and decommissioning have been discounted. Running the CBA with the ruled-out options would provide very little discernible financial/economic difference to the option taken forwards due to the reasons outlined about the NARMS methodology.

9.2 Options

9.2.1 Using the Predictive Analytics Optimisation Module (PA) within Copperleaf, our sites cathodic protection assets have been optimised against the NARMs Methodology to ensure the portfolio achieves a variety of outcome risk levels, to satisfy stakeholder needs.

9.2.2 All the options, applied over all thesis CP asset classes, described have been assessed against our Option 0, Counterfactual (Do Nothing) option, which considers no investment over and above maintenance and corrective repairs.

9.2.3 In all options (except the counterfactual) we include the bottom-up intervention volumes to address known defects and obsolescence issues. A table of these intervention volumes is in Appendix 12.4.

Option 1: Total Monetised Risk Stable to RIIO-T2 Start

9.2.4 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain the overall level of NARMS risk at the end of the RIIO-GT3 period to remain consistent with the levels of risk at the start of the RIIO-T2 period. Individual NARMS service risk measures are not individually constrained, however overall risk outcome is.

9.2.5 The total spend of proposed interventions in this option is £39.48m (2023/24) which addresses known and forecast defects. No additional investment is proposed through our Predictive analytics model to keep overall NARMS risk stable. The proposed intervention volumes and the associated spend for this option are shown in Table 15.

Table 15: Option 1 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom-Up Plan	392	39.48
Total	**392**	**39.48**

Option 1A: Post Deliverability Assessment of Total Monetised Risk Stable to RIIO-T2 Start

9.2.6 This is a variation of Option 1 that has been taken through a deliverability assessment which assesses the programme of works against outputs across our entire capital investment plan. It is therefore more constrained than Option 1.

9.2.7 The total spend of proposed interventions in this option is £36.26m (2023/24) which delivers less volumes and spend than Option1. The proposed intervention volumes and the associated spend for this option are shown in Table 16.

Table 16: Option 1A Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Constrained Interventions	272	36.26
Total	272	**36.26**

Option 2: Lowest WLC

9.2.8 In this option, we applied optimisation to select interventions with the lowest Whole Life Cost. Copperleaf identifies the most beneficial interventions, and no investment is selected if the cost exceeds the asset's lifetime benefit, as per the NARMS methodology.

9.2.9 The total spend of proposed interventions in this option is £39.60 (2023/24). This option is the financial asset management cost benefit option, where PA has made an economical decision to intervene on any asset where the cost is outweighed by the benefit no matter how small the margin. While generally it will reduce risk more over the life of the asset it may make decisions that are not possible i.e., trying to do too much work as shown in Table 17.

Table 17: Option 3 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom-Up Interventions	392	39.48
Predictive Analytics	149	0.12
Total	541	**39.60**

9.3 Option Summary

9.3.1 *Table 18* presents the technical summary table.

Table 18: Options Technical Summary Table (£m, 2023/24)

Option	First Year of Spend	Final Year of Spend	Total Volume of Interventions	Investment Design Life	% of Sites/Assets Intervened On	Total Spend Request
Option 0: Counterfactual (Do Nothing)	2027	2031	N/A	N/A	0	0
Option 1: Total Monetised Risk Stable to RIIO-T2 Start	2027	2031	392	0 to 40 years	24	39.48
Option 1A: Post Deliverability	2027	2031	272	0 to 40 years	17	36.26
Option 2: Lowest WLC	2027	2031	541	0 to 40 years	33	39.60

10 Business Case Outline and Discussion

10.1 Key Business Case Drivers Description

10.1.1 The operating conditions seen across the NTS means that CP assets deteriorate with time and use which leads to their inability to perform their required function. Any failure or significant deterioration causes the associated asset to be unavailable and hence directly affects the availability of the network and compression assets. There is potential for inefficient operation of the NTS, increased operational cost and accelerated asset degradation due to CP assets operating in sub-optimal conditions. The key drivers for investment in CP Systems assets, are:

- **Legislation** - inspection, maintenance and associated remediation is essential to maintaining compliance with PSSR and PSR.
- **Asset Deterioration** - corrosion and the associated metal loss and reduction in wall thickness.
- **Defects** - material, manufacturing or installation defects impacting the integrity of the assets.
- **Operational** - factors such as fatigue (pressure and temperature cycling, contamination, over pressure, vibration, erosion and abrasion can all affect the integrity of the assets.

10.1.2 Managing the number of defects that are being raised on our assets is important in ensuring they continue to deliver the required network capability. Our proposed investment in the site CP assets will ensure that we maintain an appropriate level of risk across all these outcomes. In developing our plans and making our decision we have been fully cognisant of the need to develop plans that are value for money, acceptable, affordable, and deliverable, whilst achieving a suitable level of risk of our aging assets.

10.2 Business Case Summary

10.2.1 NGT has a duty to comply with PSSR legislation. This states NGT must keep its high-pressure gas pipelines properly maintained in good repair to prevent danger. Our investment proposed in this paper maintains statutory compliance whilst striking an appropriate balance between tolerable risk and value for money for consumers.

10.2.2 By undertaking analysis on our site CP systems to geospatially understand performance, we have presented the lowest-cost option whilst adequately protecting our NTS from the threat of corrosion.

10.2.3 Figure 4 shows a decrease in the Net Present Value (NPV) for all options, with no visible payback in the modelled period. Overall, the risk associated with Site Assets is much smaller than other asset health themes and so it takes a long time, beyond the modelled period, to accumulate the benefit needed to pay off the initial investment.

10.2.4 A variety of technical interventions have been considered and combined to create a range of CBA options, the results of which are presented in Table 19.

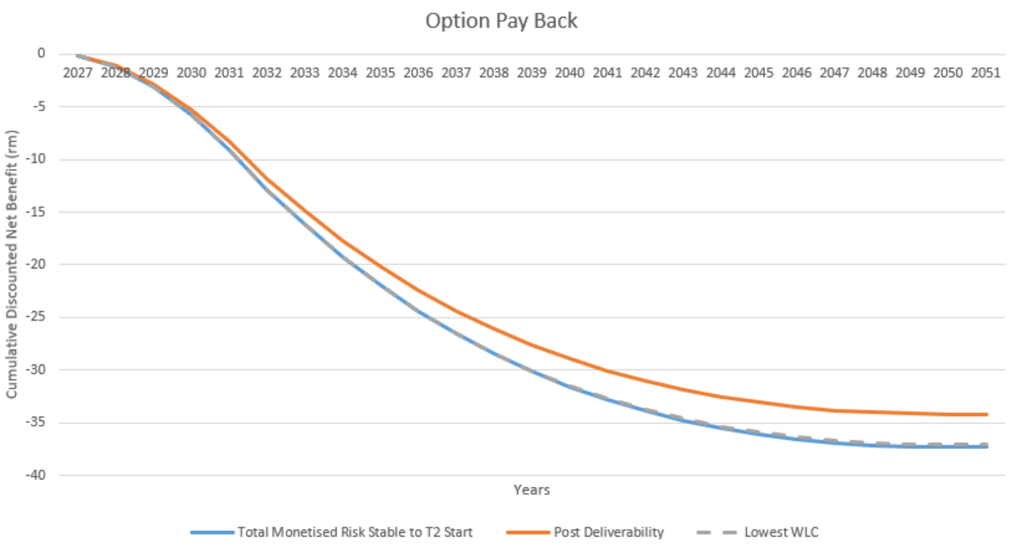

Figure 4: Payback period for different options

Table 19: Option summary of headline business case metrics (£, 2023/24)

Option	Total Volume of Interventions	Total RIIO-GT3 Spend Request	Outcome Risk End of RIIO-GT3	% change in comparison to start of RIIO-T2	NPV	Payback Period from 2031	% change in service risk measures compared to start of RIIO-T2				
							Financial	Health and Safety	Environmental	Availability Reliability	Societal
Option 0: Counterfactual (Do Nothing)	0	0	N/A	N/A	N/A	N/A	117.02%	0.00%	0.00%	0.00%	0.00%
Option 1: Total Monetised Risk Stable to RIIO-T2 Start	392	39.47	0.11	117.02%	38.04	Does not payback in the period	72.01%	0.00%	0.00%	0.00%	0.00%
Option 1A: Post Deliverability	272	36.26	0.07	72.01%	34.91	Does not payback in the period	72.00%	0.00%	0.00%	0.00%	0.00%
Option 2: Lowest WLC	541	39.59	0.07	72.00%	38.13	Does not payback in the period	49.48%	0.00%	0.00%	0.00%	0.00%

10.2.5 NGT needs to invest in maintaining a functioning CP system across its sites on the NTS to prevent and arrest corrosion of buried assets in compliance with PSSR and PSR legislation. The investments presented in this paper aim at maintaining statutory compliance and the asset health of buried site assets while striking an appropriate balance between tolerable risk and value for money for consumers.

10.2.6 By selecting locations and defects highlighted through our targeted surveys and extracted from our defects system we have presented the most pragmatic option while protecting our site assets from corrosion.

10.2.7 We have appraised our investment in Site CP Assets across the RIIO-GT3 period using the NARMS methodology which confirms that the option of surveying, and replacement of CP components including CP systems is the most pragmatic option to maintain compliance.

10.2.8 Based on the validated, defects driven package of investment and the volume of sites this is being undertaken at the modelled benefit is more than risk stable. As it is a bottom-up plan, it is not possible to do less, as we need to resolve these defects as while CP has low risk to itself, it has a large and non-numerate benefit supporting the site below ground pipework. What is not included in the CBA is the large, avoided costs from corrosion management on site below ground pipework from the Cathodic protection actively supporting buried assets to resist corrosion.

10.2.9 Our chosen option shows a decrease in the Net Present Value (NPV) with no visible payback in the modelled period. Overall, the risk associated with cathodic protection on sites is much smaller than other asset health themes and so it takes a long time, beyond the modelled period, to accumulate the benefit needed to pay off the initial investment. Our investment seeks to address known defects from our defects system and survey outputs post 2020. Given that upward of 3,000 defects have been raised since 2020, we need to stabilise and manage this defect base.

10.2.10 Failure of these assets has the potential of impairing the smooth flow of gas on the NTS which would have safety, environmental, financial, and reputational consequences.

10.2.11 The scope has been derived from similar interventions undertaken and completed in RIIO-T2 aimed at maintaining legislative and asset health compliance. The intervention volumes are based on the internal and external assessment of targeted CIPS outputs and review of our defects database. Intervention costs have been derived using a robust methodology using known data for activities which share the scope with the interventions within this EJP. We have mapped RIIO-GT3 interventions to RIIO-T2 Unique identifiers (UIDs) and assessed the available historical outturn and/or forecasted completion costs. Therefore, we propose the investment within this EJP is funded via baseline.

11 Preferred Option Scope and Project Plan

11.1 Preferred Option

11.1.1 The preferred option to manage cathodic protection threat on the NTS is **CBA option 1: Total Monetised Risk Stable to RIIO-T2 Start**. Our programme of investment on site assets has been taken through a deliverability assessment which assesses this programme of works against outputs across our entire capital investment plan. This results in a slightly adjusted **Option 1A** which includes the mixture of interventions for Sites CP listed in Table 20. Our proposed investment maintains statutory compliance whilst striking an appropriate balance between tolerable risk and value for money for consumers.

Table 20: Site Cathodic Protection RIIO-GT3 preferred option summary (£m, 2023/24)

Intervention	Primary Driver	Volume	Unit of Measure	% Sites Intervened Upon	RIIO-GT3 Cost	Funding Mechanism	PCD Measure
CP-Sites-Survey	Asset Health (Legislation and Policy)	94	Per Site	18.0	0.64	Baseline	A1
CP-Sites-System Replacement – Compressors	Asset Health (Legislation and Policy)	4	Per site	1.0	14.74	Baseline	A1
CP-Sites-System Replacement – AGIs	Asset Health (Legislation and Policy)	8	Per site	1.3	3.94	Baseline	A1
CP-Sites-Test Post Intervention	Asset Health (Legislation and Policy)	98	Per asset	2.4	2.78	Baseline	A1
CP-Sites-Groundbed Intervention (including SAC Anodes)	Asset Health (Legislation and Policy)	16	Per asset	0.2	0.45	Baseline	A1
CP-Sites-Install Remote Monitor	Asset Health (Legislation and Policy)	5	Per site	1	0.03	Baseline	A1
CP-Sites-Insulation Joint (IJ) Intervention	Asset Health (Legislation and Policy)	37	Per asset	5.2	13.50	Baseline	A1
24” IJ Spares	Asset Health (Risk Management)	2	Per asset	N/A	0.02	Baseline	A1
30” IJ Spares	Asset Health (Risk Management)	2	Per asset	N/A	0.03	Baseline	A1
36” IJ Spares	Asset Health (Risk Management)	2	Per asset	N/A	0.03	Baseline	A1
42” IJ Spares	Asset Health (Risk Management)	2	Per asset	N/A	0.04	Baseline	A1
48” IJ Spares	Asset Health (Risk Management)	2	Per asset	N/A	0.06	Baseline	A1
Total		**272**			**36.26**		

11.1.2 Refurbishment, repair and deferral interventions on CP systems and components have been discounted due to the severity and quantity of defects recorded through our CIPS and defects system including internal and external defect and remediation assessments.

11.2 Asset Health Spend Profile

11.2.1 Our programme of investment on our Site CP Assets has been taken through a deliverability assessment, including a network access/outage assessment, procurement assessment and contracting strategy development. These constraints enable the assessment of the delivery of this programme of works against our other outputs across our capital investment plan. Figure 5 presents the spend profile of our preferred options interventions.

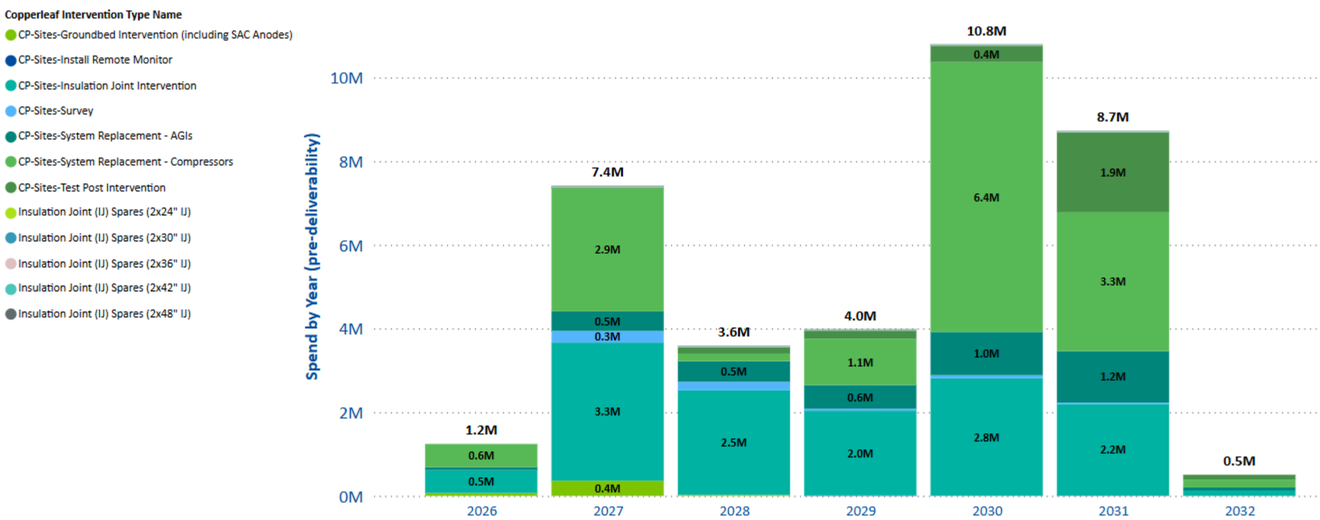

Figure 5: Site CP assets infrastructure preferred option investment spend

11.3 Investment Risk Discussion

11.3.1 Our preferred option can be delivered effectively within outage constraints on our sites and ensures appropriate levels of site and asset availability to deliver effective and efficient network operations.

11.3.2 All Site Cathodic Protection assets identified for intervention are in line with NGT's Needs Case and future strategy of keeping gas flowing in the interests of consumers. Key risks and currently identified mitigations are summarised in Table 21.

Table 21: Site Cathodic Protection key risks and identified mitigations

No.	Risk	Mitigation (based on current view)
1	Additional buried services being identified	Check data banks and internal desktop review but ensure GPR and underground surveys are completed in areas of the works as assurance to de-risk
2	Initial site survey doesn't sufficiently capture required information resulting in additional site surveys which increase intervention cost and delivery time surveys	Minimise number of surveys by optimising contractors site visits
3	Additional scope requirements (including mechanical, design and civil) leading to scope change / creep	Close engagement with contractor and site operations. Detailed surveys to ensure no additional works required
4	Discovery of nesting birds, pests and additional environmental considerations could result in project delays	Carryout intrusive surveys before commencing works.
5	Ground conditions are unsuitable for excavation	Ground investigations and bore holes to be completed to assess ground conditions, weather monitoring around ground related activities. Unforeseen residual risk will always remain.

11.4 Project Plan

11.4.1 Project delivery has been split into three phases which align with our Network Development Process (ND500) as summarised in Table 22. Commissioning dates are not relevant to all intervention types but take place at the end of the delivery phase.

Table 22: Summary Project Plan and Provisional Sanction Dates

Delivery Phase	ND500 Stage Gate(s)
Preparation	T0, T1, F1 (Scope establishment), T2, F2 (Option selection), T3, F3 (Conceptual Design Development and Long Lead Items Purchase), T4
Delivery	F4 (Execute Project), T5, Available for Commercial Load (ACL), T6
Close Out	F5 (Reconcile and Close)

11.4.2 Table 23 shows the summary plan and provisional delivery phases for Site CP sanctions within RIIO-GT3. Internal stakeholder engagement has identified when we can obtain network access, where required, to complete these works.

Table 23: Site Assets Portfolio Programme for RIIO-GT3 period

EJP	Sanctions	RIIO-T2		RIIO-GT3					RIIO-GT4
		FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32
Sites Cathodic Protection	T3_Pipelines_CP Inspection								
Sites Cathodic Protection	T3_Sites_AGI_Construction_FY31								
Sites Cathodic Protection	T3_Sites_AGI_Construction_FY28								
Sites Cathodic Protection	T3_Sites_AGI_Construction_FY30								
Sites Cathodic Protection	T3_Sites_AGI_Construction_FY29								
Sites Cathodic Protection	T3_Pipelines_CP Remediation								
Sites Cathodic Protection	T3_Sites_AGI_NGS_FY27								
Sites Cathodic Protection	T3_Sites_AGI_Construction_FY27								
Sites Cathodic Protection	T3_Pipelines_FY31								
Sites Cathodic Protection	T3_Pipelines_FY28								
Sites Cathodic Protection	T3_Pipelines_FY27								
Sites Cathodic Protection	T3_Pipelines_FY29								
Sites Cathodic Protection	T3_Pipelines_FY30								

11.4.3 Insulation Joint assets have long-lead times of circa 52 weeks, and this is represented by an extended preparation phase.

11.4.4 The work has been profiled based on a deliverability assessment across the whole NGT plan and aligns with outages associated with the in-line inspection programme and major projects.

11.5 Key Business Risks and Opportunities

11.5.1 Changes to system operation or supply and demand scenarios are unlikely to impact upon the proposal in this EJP as the Site CP assets will always be required to provide the necessary corrosion protection to below ground pipework.

11.5.2 Transitioning to hydrogen happening sooner than planned would impact these proposals due to the fact that hydrogen adversely alters the ductility, fracture resistance and fatigue properties of our carbon steel infrastructure.

11.5.3 The interventions scopes identified within this EJP are clearly identified and understood. We have delivered similar scopes in RIIO-T2 with no change to these scopes proposed in RIIO-GT3.

11.5.4 Our programme of investment on our Site CP Assets has been taken through a deliverability assessment, including a network access/outage assessment, procurement assessment and contracting strategy development. These constraints enable the assessment of the delivery of this programme of works against our other outputs across our capital investment plan.

11.6 Outputs Included in RIIO-T2 Plans

11.6.1 In RIIO-T2, investment focus was on high priority CP system replacements. There have been some investment deferrals from RIIO-T2 to RIIO-GT3. Taking additional time at the start of RIIO-T2 to land on the correct solution for specific interventions has been a key focus and although this does show a backloaded programme it is substantially clearer in terms of the work scope to be executed which will result in fewer delivery challenges.

11.6.2 In developing the revised delivery approach a programme of works has been devised that is deliverable within the remaining RIIO-T2 period. However, outputs at Alrewas Multi-Junction, Carnforth Compressor Station and Wooler Compressor Station, have been identified as requiring delivery in the early part of RIIO-GT3.

12 Appendices

12.1 CIPS Survey Outputs Examples

12.2 Rosen Analysis Output Examples

12.3 Unit Cost Derivations

Intervention	External Cost	External %	NG Cost	NG %	Prebuild Cost	Prebuild %	Materials, Plant & Equipment cost	Materials, Plant & Equipment %	Risk & Contingency cost	Risk & Contingency (% of total cost)	Total Cost
New - CP-Sites-Survey	£5,163	76%	£1,101	16%	£135	2%	£403	6%	0	0%	£6,801
New - CP-Sites-System Replacement - Compressors	£2,796,491	76%	£596,358	16%	£73,019	2%	£218,017	6%	0	0%	£3,683,885
New - CP-Sites-System Replacement - AGIs	£373,851	76%	£79,725	16%	£9,762	2%	£29,146	6%	0	0%	£492,483
New - CP-Sites-Transformer Rectifier Intervention	£113,775	76%	£24,263	16%	£2,971	2%	£8,870	6%	0	0%	£149,878
New - CP-Sites-Test Post Intervention	£21,558	76%	£4,597	16%	£563	2%	£1,681	6%	0	0%	£28,399
New - CP-Sites-Groundbed Intervention (including SAC Anodes)	£21,492	76%	£4,583	16%	£561	2%	£1,676	6%	0	0%	£28,312
New - CP-Sites-Install Remote Monitor	£3,161	60%	£265	5%	£810	15%	£811	15%	£252.35	5%	£5,299
New - CP-Sites-Insulation Joint Intervention	£276,892	76%	£59,048	16%	£7,230	2%	£21,587	6%	0	0%	£364,757
New - Insulation Joint (IJ) Spares (2x24" IJ)	£0	0%	£0	0%	£0	0%	£0	0%	0	0%	£0
New - Insulation Joint (IJ) Spares (2x30" IJ)	£0	0%	£0	0%	£0	0%	£0	0%	0	0%	£0
New - Insulation Joint (IJ) Spares (2x36" IJ)	£0	0%	£0	0%	£0	0%	£0	0%	0	0%	£0
New - Insulation Joint (IJ) Spares (2x42" IJ)	£0	0%	£0	0%	£0	0%	£0	0%	0	0%	£0
New - Insulation Joint (IJ) Spares (2x48" IJ)	£0	0%	£0	0%	£0	0%	£0	0%	0	0%	£0

12.4 Intervention Volumes

Intervention / Location	Total Volumes
CP-Sites-Groundbed Intervention (including SAC Anodes)	16
CP-Sites-Install Remote Monitor	5
CP-Sites-Insulation Joint Intervention	37
CP-Sites-Survey	94
CP-Sites-System Replacement - AGIs	8
CP-Sites-System Replacement - Compressors	4
CP-Sites-Test Post Intervention	98
Insulation Joint (IJ) Spares (2x24" IJ)	2
Insulation Joint (IJ) Spares (2x30" IJ)	2
Insulation Joint (IJ) Spares (2x36" IJ)	2
Insulation Joint (IJ) Spares (2x42" IJ)	2
Insulation Joint (IJ) Spares (2x48" IJ)	2