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ENGINEERING JUSTIFICATION PAPER (EJP)

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Electrical Infrastructure : Site Lighting, Earthing and Lightning Protection

Version: 1.0

Issue: Final

December 2024

RIIO-GT3 NGT_EJP12

Contents

1 Summary Table

Table 1 Summary Table

Name of Project	*Electrical Infrastructure: Site Lighting, Earthing and Lightning Protection*		
Scheme Reference	*NGT_EJP12_Electrical Infrastructure : Site Lighting, Earthing and Lightning Protection_RIIO-GT3*		
Primary Investment Driver	*Asset Health*		
Project Initiation Year	*2026*		
Project Close Out Year	*2032*		
Total Installed Cost Estimate (£m, 2023/24)	*£18.65m*		
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-GT2 Business Plan	*Yes*		
Spend apportionment (£m)	**RIIO-T2**	**RIIO-GT3**	**RIIO-GT4**
	0.06	18.57	0.02

2 Executive Summary

2.1.1 This paper proposes £18.65m of baseline funding to address defect, obsolescence and safety related issues on 37% (4,464) of the Site Lighting, Earthing and Lightning protection and miscellaneous electrical asset population in RIIO-GT3. This is part of a wider request for £74.08m, measured through a non-lead asset PCD (summarised in Table 2).

Table 2: RIIO-GT3 Electrical Infrastructure Summary (£m, 2023/24)

Engineering Justification Asset Group	Intervention Volumes	Funding Request
Associated EJP (Switchgear and Transformers)	90	19.86
Associated EJP (Standby Power Systems and LV Distribution)	504	35.56
This EJP (Site Lighting, Earthing and Lightning protection)	**4,464**	**18.65**
Total	**5,058**	**74.08**

2.1.2 5,058 interventions are required across our electrical infrastructure to ensure we maintain electrical distribution to critical operational assets, utilised to maintain efficient network operations. Any loss of compression has the potential to cause significant impact to customers, making it essential that our fleet remains available and resilient to the demands put on the NTS. Without this investment we are at increased risk from asset failures and consequential security of supply impacts. To ensure this operation we must operate in accordance with all standards and legislation. Our investment seeks to address defects and significant obsolescence issues and, for certain assets, to undertake a proactive intervention programme to avoid unmanageable levels of defects.

2.1.3 Across our electrical infrastructure investment 5,058 interventions are required to ensure stable network risk is maintained during RIIO-GT3, 4,464 on the assets within this Engineering Justification Paper (EJP). The Network Asset Risk Metric (NARMs) Long Term Risk Benefit (LTRB) of the interventions within this paper is £11.18m. For our Site Lighting, Earthing and Lightning and Miscellaneous electrical assets we developed 70 intervention options within five portfolio options. In summary, we are proposing the intervention mix summarised in Table 3.

Table 3: RIIO-GT3 volumes proposed in this EJP

	Replacement	Overhauls/ Refurbishments	Survey	Total
Site Lighting	[redacted]	[redacted]	[redacted]	**4,253**
Earthing and Lightning protection	[redacted]	[redacted]	[redacted]	**97**
Miscellaneous electrical asset	[redacted]	[redacted]	[redacted]	**114**
Total	[redacted]	[redacted]	[redacted]	**4,464**

2.1.4 In RIIO-T2 we are forecasting, across our electrical infrastructure portfolio, to deliver 273 fewer interventions than in our RIIO-T2 business plan. Original intervention volumes have been re-evaluated as condition, including compliance data have become available. This has resulted in a reduction in refurbishment interventions for our LV switchgear in favour of replacements.

2.1.5 The growth in proposed RIIO-GT3 intervention volumes is driven by two reasons: (1) It is a consequence of the continued deterioration of these assets shown through actual and forecast defects and widespread obsolescence challenges for which it is crucial that we deliver a stepped increase to ensure future network asset performance is not compromised which has the potential to impact on security of supply; (2) We have redefined interventions, moving away from major and minor refurbishment interventions to specific activities on our assets, e.g. Transformer coating replacement, and individual luminaire replacements compared to site lighting replacement intervention in RIIO-T2. The latter of which represents 4,253 (84%) of our proposed 5,058 volumes. This provides greater granularity on our outputs but drives the significant increase in investment volumes without the equivalent increase in investment cost. This is summarised in Table 4.

Table 4: RIIO-T2 vs RIIO-GT3 for overall Electrical Infrastructure

	RIIO-T2 Business Plan Final Determination	RIIO-T2 Forecast Delivery	RIIO-GT3 Business Plan
Interventions	452	179	5,058
Investment	£29.97m	£28.88	£74.08m
Asset Interventions	3%	1%	36%

2.1.6 The deliverability of this investment programme has been assessed, incorporating a network access assessment and supply chain capability analysis. We have high confidence that this can be delivered during RIIO-GT3. The Site Lighting, Earthing and Lightning protection and Miscellaneous electrical asset investment profile for RIIO-GT3 is shown in Table 5.

Table 5: RIIO-GT3 funding request for Site Lighting, Earthing & Lightning Protection and Miscellaneous Electrical assets (£m 2023/24)

	2026	2027	2028	2029	2030	2031	2032	Total	Funding Mechanism
Site Lighting	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	13.23	Baseline – Non lead asset PCD
Earthing and Lightning protection	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	3.57	Baseline – Non lead asset PCD
Miscellaneous electrical asset	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1.83	Baseline – Non lead asset PCD
Total in this EJP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	18.65	
Total for Electrical Infrastructure	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**74.08**	

3 Introduction

3.1.1 Site Electrical Infrastructure assets generate, convert, distribute, control or utilise electrical energy to enable the safe operation of sites across the National Transmission System (NTS). A large proportion of National Gas Transmission (hereafter NGT) assets rely on the safe, secure and reliable supply of electricity to fulfil their function, including critical assets such as those utilised to support the operational running of Variable Speed Drive (VSD) or Gas compression units, and electrical supplies for Gas Quality and Metering systems required for ensuring compliance with GSM(R) and billing processes.

3.1.2 Compressor stations have complex electrical systems involving High Voltage Electrical connections, Transformers, Standby Generators and Low Voltage Switchgear with Low Voltage Distribution, Direct Current (DC) and Alternating Current (AC) Uninterruptible Power Supplies (UPS) and connected electrical equipment such as Site Lighting, heaters, motors etc. Above Ground Installations (AGIs) have simpler electrical infrastructure involving a Low Voltage Electrical connection, single or multiple distribution boards and small numbers of connected loads, such as Lighting.

3.1.3 In total across our network, our electrical infrastructure is composed [redacted] assets.

3.1.4 In addition to the two associated electrical EJPs the decisions made upon assessing the Electrical Infrastructure investments has interactions with other Investment Decision Packs (IDPs). This EJP interacts with Compressor Fleet, Civils, Valves and Site Asset IDPs, as electrical infrastructure supports asset operation within scope of those papers. There are also interactions with the NGT_EJP28_St_Fergus-_Electrical_Assets_RIIO-GT3 around the consistency of our investment proposals.

3.1.5 The RIIO-GT3 worklist has been generated specifically for each asset theme, aligned to each of the chapters across our Electrical Infrastructure EJPs. This has included analysis of historical defect data and survey data, and an assessment of industry standards and legislation and their impact on our Electrical Infrastructure asset base.

Business plan commitments

3.1.6 The scope of this document is aligned with our Asset Management System (AMS) and relates to our Business Plan Commitments (BPCs) 'Meeting our critical obligations every hour of every day' and 'Delivering a resilient network fit for the future'. More information on our AMS and a description of our commitments is provided in our NGT_A08_Network Asset Management Strategy_RIIO_GT3 annex[1] and our NGT_Main_Business_Plan_RIIO_GT3.

Document structure

3.1.7 This document has been structured into several chapters, each specific to a group of Electrical Infrastructure assets aligned to our ISO 14224 equipment taxonomy as shown in Figure 1.

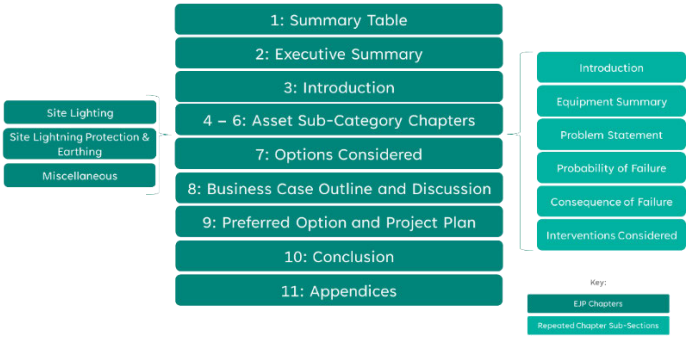


Figure 1: Document structure of the Site Lighting, Earthing and Lightning protection and miscellaneous electrical EJP.

3.1.8 Three Engineering Justification Papers are included within the investment decision pack, each covering a range of electrical assets as shown in Figure 2.

Figure 2: IDP document structure

[1] NGT_A08_Network Asset Management Strategy_RIIO_GT3

4 Site Lighting (£13.23m)

4.1 Equipment Summary

4.1.1 Lighting assets provide illumination to internal and external situations necessitating a wide variety of types depending on location and purpose.

4.1.2 External lights include bollard and bulkhead lights installed along site roads and walkways to aid safe access and egress. Task lights are installed at specific locations to enable maintenance on certain assets and specific areas such as pits. High level lights are installed on columns or masts to provide wide area lighting for roadways along with flood lights mounted on buildings. Columns are typically 8m and 10m tall with generally 1 or 2 luminaires per column.

4.1.3 Internal lighting is installed in all compressor cabs, equipment rooms and control buildings. Workshops, stores, boiler houses and other internal areas also contain lighting systems. Table 6 provides a summary of the lighting assets we have across the NTS.

Table 6: Lighting assets across the NTS

Asset Type	Asset Count
Site Lighting	7,463
Emergency Lighting	2,489
Flood Lighting	1,127
Indoor Lighting	93
Road Lighting	120
Total	**11,292**

4.1.4 Lighting systems must be appropriate for the intended purpose and installation location. This includes the luminaire, cabling, and supporting structure (e.g., column). Additionally, external lighting must have suitable ingress protection to be operable outside.

4.1.5 Standards stipulate the types of luminaires that can be procured and used in certain circumstances. For example, Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) states the legal requirements for managing the risk of fire, explosion or similar events arising from dangerous substances at the workplace.

4.1.6 Equipment and protective systems intended to be used in zoned areas are required to meet the requirements of the 'Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016'[2].

4.1.7 In many installations, the lighting serves a dual purpose with luminaires operating as normal building lighting in normal conditions, plus providing escape lighting in an emergency. Emergency lighting must be installed to meet the requirements of BS 5266-1 (installing, maintaining, and testing of emergency lighting systems in commercial premises) and BS EN 50172/BS 5266-8 (requirements for emergency lighting in buildings). Non-emergency lighting in buildings must meet the requirements of BS EN12464-1 (lighting of indoor workplaces) in line with policy.

4.1.8 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 Excel EJP[3].

4.2 Problem/Opportunity Statement

4.2.1 There are three primary problems on these assets:

- **Legislation/Obsolescence** – Breaching legislative and best practice requirements, such as Electricity at Work Regulations (EAWR), DSEAR and the Institute of Engineering and Technology (IET) Wiring Regulations (BS 7671). Legislation also has a direct impact on the supportability of site lighting systems. UK sales of halogen lamps was banned in September 2021 following a gradual phasing out under EU-wide rules from 2018. Production of fluorescent lamps was banned in 2024 under the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (2012) (the RoHS regulations). This impacts on our ability to maintain our lighting within operational areas, resulting in the need to replace complete luminaire fixtures. As asset investment has been undertaken hazardous area zones have changes and investment is required to ensure that lighting

[2] The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016

[3] NGT_IDP02_Portfolio EJP Electrical Infrastructure_RIIO-GT3

installed within hazardous areas that is rated to the required ATEX Equipment Category (Zone 1 or Zone 2 ATEX rated).

- **Asset Condition -** Lighting assets degrade with time. External luminaires exposed to climatic conditions suffer from corrosion and can fail following the ingress of rainwater. To account for the decline of condition with age, CIBSE's indicative economic life expectancy of lighting installations is 15-25 years. The average asset age of lighting assets on the NTS is 24 years, therefore representing a significant asset management challenge that needs managing, to ensure the safe access, egress and operation of our operational NTS sites.

  Additionally, road lighting is mounted on 6m or 8m columns made from galvanised steel. Our visual assessment, and surveys completed by a third party contractor, [redacted] have identified corrosion defects on the columns. We need to ensure that lighting columns are fit for purpose to avoid safety related issues and potential damage to assets on sites. Lighting is used in many industries and sectors, including council street lighting. In assessing our investment approach, we conducted a literature review of lifecycle plans for street lighting. Plymouth Council manages their estate of Street lighting assets through a 5 year street lighting asset lifecycle plan. A reference to an action age of 20 years[4] is used where columns are assessed and replaced should structural issues be found. Our investment plan is consistent with this approach.

- **Energy Efficiency** – A significant proportion of our lighting assets are fluorescent and halogen which have limited asset life and can require 3x the power for the same output light levels. This has implications on energy usage with LED lighting using 40 -50% less energy compared to legacy fluorescent, halogen, SON sodium lights etc. luminaires (a 70 W Fluorescent tube can be replaced by a 24W LED equivalent).

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

4.2.2 Investment in our site lighting seeks to ensure the assets operate reliably and do not negatively impact towards the safe and continual operation of our NTS sites. Several of these sites have a 24/7 presence to ensure efficient network operation, and therefore we need to ensure areas are illuminated.

4.2.3 Doing nothing is not an option, corrosion issues on the site lighting would continue to increase to a point where columns will need to be taken down, to prevent accidents due to the collapse of a column. As well as being dangerous to site staff, this could also delay other site works and impact efficient NTS operations and require operations to set up emergency temporary lighting.

What is the outcome that we want to achieve?

4.2.4 The outcome of this investment in site lightning is to:

- Ensure that the site lighting assets are available and reliable when required and perform their duty.
- Ensure the site lighting assets are fit for purpose and meet the required standard(s), such as EAWR, DSEAR and IET, for operation.

How will we understand if the spend has been successful?

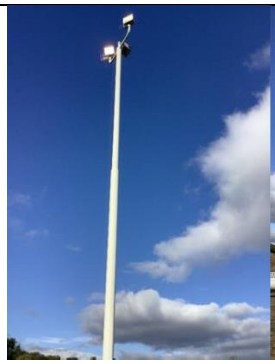
4.2.5 Site lighting is operational with all known condition issues resolved and progressed through our managed programme of obsolescence and fluorescent lighting replacement programme.

Narrative Real Life Example of the problem

4.2.6 Table 7 presents real life examples of lighting assets which require intervention across the NTS. These present problems that have been raised through our lighting inspection and risk assessments, surveys completed by third parties [redacted]) and through surveys completed during our RIIO-T2 National Electrical Asset Health Campaign.

[4] Street Lighting Lifecycle Plan, Pg 9, https://www.plymouth.gov.uk/sites/default/files/2022-12/Highways-street-lighting-lifecycle-plan.pdf

Table 7 Real Life Examples of problem - Lighting

Site	Defect Summary	
[redacted]	At [redacted] fluorescent luminaires have failed in the Auxiliary Equipment Room (AER) building. This building houses the nitrogen generating equipment and hydraulic starter package for the units at the site and therefore needs to be accessed at all times in the event of action needing to be required to maintain compressor operations. We cannot source replacement fluorescent lighting tubes and therefore the full fixture needs to be replaced. This will be replaced with an LED sealed unit in our RIIO-T2 National Electrical Asset Health Campaign.	
[redacted]	Internal Cab Lighting is obsolete, and luminaires are deteriorating. Areas of the cab remain poorly illuminated and poses an inherent safety risk for access and egress, where this is needed 24/7 to maintain compressor availability.	
[redacted]	Three flood lights on the north of the site are halogen lamps. One is not operational and it is recommend all three are replaced with a LED equivalent fixture to ensure functionality needs replacing. Three flood lights on the south of the site are halogen luminaires and need replacing with a LED equivalent .	 North  South
[redacted]	Site lighting is isolated due to water ingress and requires replacing/upgrade. Three EX rated fluorescent light fittings above actuator valves are isolated at present as one has severe water ingress. The fittings in general are in poor condition.	 

Project Boundaries

4.2.7 This investment theme includes cab lighting, road lighting and task lighting in pits and enclosures, however, excludes consumables e.g., lamp replacement as this is captured in opex.

4.2.8 Excludes any lighting which is part of our enhanced site security solutions as this is included within our Physical Security investment theme ([redacted]

4.3 Probability of Failure

4.3.1 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.

4.3.2 Within our NARMs model Site Lighting specific failure modes are associated with the loss of the lighting systems and the consequential impact on the following failure modes. Each failure mode is presented with the failure rate, representing the rate of defects per asset per year:

Table 8: Site Lighting Failure Modes

Failure Mode	Average proportion of failures
Security System failure	0.64
Failure to control or monitor plant on site	0.15
Loss of illumination	0.15
Loss of illumination in emergency	0.14

4.3.3 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 9. 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, however not all defects will result in a real world asset failures.

Table 9: Site Lighting defect rates

Asset Type	No. of Assets	Cumulative Average Failure Rates					Forecast Failures per Year				
		2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
Site Lighting	7463	0.71	0.75	0.79	0.84	0.88	307	336	345	330	258
Site Lighting Emergency	2489	0.73	0.77	0.81	0.85	0.88	94	97	97	88	70
Site Lighting – Flood Lighting	1127	0.68	0.73	0.79	0.85	0.90	56	64	71	54	27
Site Lighting – Indoor Lighting	93	0.72	0.78	0.85	0.89	0.93	6	6	3	4	4
Site Lighting Road Lighting (Columns)	120	0.62	0.68	0.74	0.81	0.89	7	7	8	10	8

Historical Defects

4.3.4 Defects are raised against lighting assets, and from 2022 when changes to our equipment taxonomy allowed more granular recording of defects, emergency lighting assets. As of April 2024, 303 defects had been raised on Emergency lighting assets and 755 defects raised on column, cab and task lighting since 2010. Of these, 88 defects are open for emergency lighting assets and 273 open for column and task lighting. Figure 3 presents when these have been raised within our defect management system.

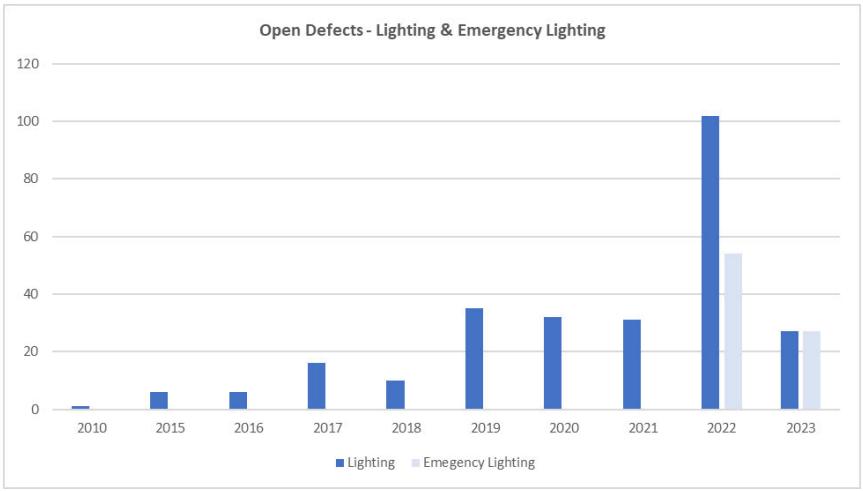


Figure 3 Open Defects for Lighting and Emergency Lighting as of April 2024

4.3.5 An increase in defects is seen across the reporting period with a specific increase seen in 2022. This increase was driven for two reasons:

- Corrective actions from the outcome of our electrical DSEAR inspections were uploaded into our defect management system.
- Corrective actions from the results of our RIIO-T2 National Electrical Asset Health Campaign surveys.

4.3.6 Open defects present a range of issues that need rectification:

- Luminaries in hazardous areas being non-compliant with DSEAR legislation and needing to be replaced with ATEX rated equipment.
- Failed lamps being identified impacting the levels of illumination to key areas of the site.

- Cab luminaires experiencing deterioration resulting in areas of the cab being poorly illuminated which poses a safety risk for access and egress, where this is needed 24/7 to maintain compressor availability.

4.3.7 A site survey programme was completed in RIIO-T2 to support the electrical capital delivery programme. These surveys provided a snapshot of condition at the time they were undertaken, with the information used to inform and prioritise scopes of work. A summary of some of the issues found were presented in Table 10, with sample reports included in Appendix 2 - Electrical Survey Reports.

4.3.8 Other surveys, such as a specific internal risk assessment completed by operational teams have highlighted issues with luminaire and column assets. An example of the issues identified is shown in Table 10. These three sites specifically have been assessed through the development of our RIIO-GT3 investment plan:

Table 10 Lighting Risk Assessment Results

Site name	No. of columns	How many of your columns are showing considerable signs of corrosion on the pivot cam?	How many of your columns do the base hinges do not line up?	How many of your columns are showing structural signs of failure i.e., bent, leaning or at an angle?
[redacted]	18	18	-	-
[redacted]	42	-	-	25
[redacted]	16	7	1	-

Probability of Failure Data Assurance

4.3.9 Probability of failure (PoF) has been assessed utilising defects extracted from our Maximo defects management system in April 2024, survey results from internal risk assessments and survey results from our National Electrical Asset Health Campaign.

4.3.10 Forecast probability of data information, utilising our Network Asset Risk Metric (NARMs) model, has been collated using the Copperleaf asset management decision support system and connected Power BI dashboards.

4.3.11 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.

4.4 Consequence of Failure

4.4.1 This section of the EJP shall provide an overview of the consequence of failure for our Lighting Assets, which is presented in Table 11 mapped against NGTs NARMS Consequence of Failure service risk measures.

Table 11 Lighting consequence of failure

	Impact / Consequence				
	Availability	**Environment**	**Financial**	**Safety**	**Other**
Lighting	(1) Lighting must be reliable and operate as intended when required Failure of permanent lighting assets may result in insufficient illumination being available. Although this is unlikely to have an immediate impact on service, consequential impacts may arise. For example, temporary lighting may be required to conduct maintenance activities which may delay completion or result in other work being postponed.	(2) The Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS) regulations aim to remove or reduce harmful and hazardous substances in electrical and electronic equipment. The consequence of failing to address these regulations increase the burden associated with treating used lamps as hazardous waste. (3) Failure of lighting may result in needing to rely on diesel generator powered lights, thereby increasing emissions of noise and carbon.	(4) Continuing to operate with obsolete technology involves using more energy compared with LED lighting. (5) The consequence of lighting failing presents a risk of non-compliance with legislation, such as HSE including DSEAR which would have financial impacts.	(6) Emergency lighting is installed to enable safe egress from buildings in the event of power failure or during evacuations. If lighting was to fail, this could impact the ability of personnel to reach safety in the event of an incident. (7) NTS sites are complex with assets and equipment dispersed across them. Moving around on foot or in a vehicle must be done safely to avoid incidents. For example, poor illumination is often cited during investigations into trips, slips and falls alongside uneven terrain. Permanent lighting installations mitigates against the need for extension cables used with portable lighting. (8) If lighting is not managed within hazardous areas or is not suitably rated in accordance with HSE DSEAR, additional consequences could occur which may pose a risk to health and safety such as debris being created from assets no longer being suitably explosion protected. (9) the failure of a lighting column resulting in its collapse could be significant to people, plant, and equipment.	**N/A**

4.4.2 Figure 4 shows the modelled baseline risk over RIIO-GT3 for our site lighting assets, assuming no investment in the period. Overall modelled risk increases from £1.89m to £2.26m over the RIIO-GT3 period, an increase of 19.5%, with increases projected due to additional maintenance and corrective interventions on these assets.

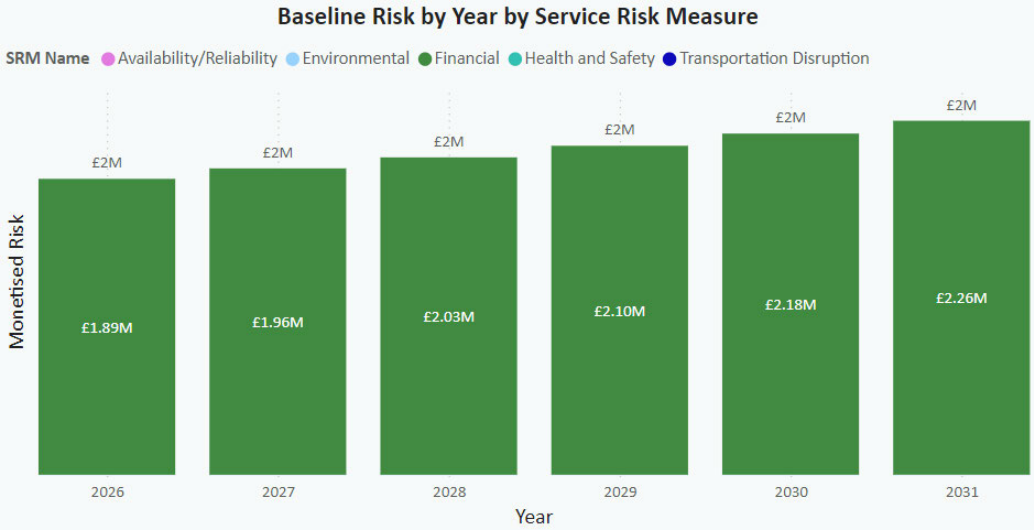


Figure **4** *Baseline Risk levels for Lighting Assets*

4.5 Interventions Considered

Interventions

4.5.1 A range of interventions on our Site Lighting assets have been considered to address the drivers for investment.

Counterfactual

4.5.2 Our Counterfactual intervention considers no specific intervention to be undertaken on our Site lighting assets with the exception of planned maintenance activities. Investment is deferred into future price control periods.

Replace Luminaire (non-hazardous area)

4.5.3 This intervention proposes the replacement on luminaires in non-hazardous site areas. These luminaires are usually mounted on columns of buildings so require the replacement of a length of cable. Includes internal and external assets. External assets to have suitable Ingress Protection (IP) rating.

4.5.4 LED luminaires are designed to be 'maintenance free' as the sealed units do not contain consumable lamps. However, this drives the need to replace whole luminaires rather than changing the lamp when the luminaires fail or suffer from lumen depreciation and luminous flux degradation.

Replace Column Light Luminaire

4.5.5 This intervention proposes the replacement of the luminaire mounted to existing column and involves the replacement of a new unit with a new internal cable. LED luminaires are designed to be 'maintenance free' as the sealed units do not contain consumable lamps. However, this drives the need to replace whole luminaires rather changing the lamp when the luminaires fail or suffer from lumen depreciation and luminous flux degradation.

Replace Luminaire (hazardous area)

4.5.6 This intervention proposes the replacement of the luminaire within a hazardous area. This installation will need to be ATEX rated and DSEAR compliant to prevent the risk of fires and explosions should gas releases occur.

Intervention Summary

4.5.7 Table 12 presents a summary of the Site Lighting interventions considered.

Table 12: Interventions considered

Intervention	Equipment Design Life	Positives	Negatives	Taken Forward
Counterfactual (Do nothing)	N/A	Lowest cost solution	Does not address condition of luminaires identified from defects and surveys. Decreasing availability of direct replacements due to halogen and fluorescent lighting ban, with no programme to manage this risk. Therefore this option is discounted	No

Intervention	Equipment Design Life	Positives	Negatives	Taken Forward
Replace Luminaire (non-hazardous area)	15-30 Years	Lowest Cost Capex solution Ensures lighting remains operational due to the inability to purchase fluorescent and halogen lamps Addresses asset deterioration and obsolescence. Complies with latest regulations. LED Luminaires can only be replaced (no consumable parts). LED lighting has a longer lifespan, with new LEDs lasting 50,000 to 100,000 hours or more vs fluorescent lamps around 10,000 hours, reducing maintenance and replacement costs.	Significant programme to deliver across a large portfolio of sites geographically spread across the UK	Yes
Replace Column Light Luminaire	25-30 Years	Addresses asset deterioration and obsolescence. Complies with latest regulations. Ensures lighting remains operational due to the inability to purchase fluorescent and halogen lamps Makes use of existing infrastructure LED lighting has a longer lifespan, with new LEDs lasting 50,000 to 100,000 hours or more vs fluorescent lamps around 10,000 hours, reducing maintenance and replacement costs.	Significant programme to deliver across a large portfolio of sites geographically spread across the UK	Yes
Replace Luminaire (hazardous area)	25-30 Years	Addresses asset deterioration and obsolescence. Complies with latest regulations. Ensures lighting remains operational due to the inability to purchase fluorescent and halogen lamps LED lighting has a longer lifespan, with new LEDs lasting 50,000 to 100,000 hours or more vs fluorescent lamps around 10,000 hours, reducing maintenance and replacement costs.	Significant programme to deliver across a large portfolio of sites geographically spread across the UK	Yes

Volume Derivation

4.5.8 The investment programme has been developed through the collation of a range of data sources, from defects captured in our Maximo defect management system, surveys completed as part of our National Electrical Asset Health Campaign, and surveys and risk assessment completed as part of our lighting asset lifecycle management.

4.5.9 Figure 5 explains the development process for Site Lighting interventions. Interventions in this theme are defined at the fixture or column level, compared to the per site unit of measure utilised in RIIO-T2.

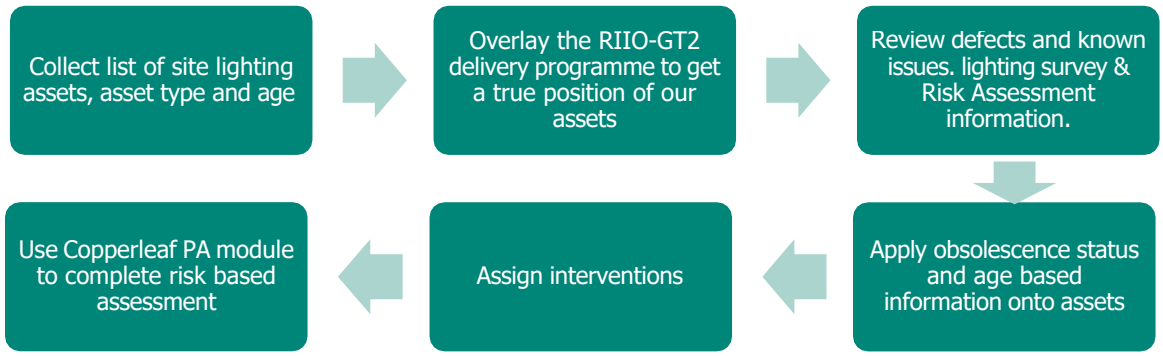


Figure 5: Site Lighting Volume Derivation

4.5.10 All fluorescent lights on the NTS were identified through interrogation of our Maximo asset repository, assets were categorised based on asset type (Fluorescent, halogen, LED) and the age of the assets. A programme of interventions was developed for the phasing out of these luminaires given the risk around luminaire availability driven by the cease in production. This programme was phased over a 10-year period, commencing at the start of RIIO-GT3.

4.5.11 Additionally, condition information from lighting asset risk assessments, undertaken at an asset level were used to make investment decisions on column lights. Dependent on the survey information, do nothing, luminaire replacement or column and luminaire replacement interventions were proposed.

4.5.12 Table 13 presents a summary of the volume derivation approach for our bottom up RIIO-GT3 volumes.

Table 13: Volume Derivation for Site Lighting Interventions

Intervention	RIIO-GT3 Volumes	Unit of Measure	How this volume has been developed
Column Light - Replace Luminaire and internal column cable RIIO3	[redacted]	Per Asset	[redacted]
Column Light - Replace Column, Luminaire and Cable RIIO3	[redacted]	Per Asset	
Hazardous Area lighting - replace luminaire and cable	[redacted]	Per Asset	
Non-Hazardous Area lighting - replace luminaire and cable RIIO3	[redacted]	Per Asset	
Total	**4,253**		

Unit Cost Derivation

4.5.13 In developing our RIIO-GT3 investments we have assessed our intervention options against historically completed or in delivery investments. In this assessment we have mapped RIIO-GT3 interventions to RIIO-T2 Unique Identifiers (UIDs) and assessed the available historical outturn and/or in delivery forecasted completion costs.

4.5.14 Our cost accuracies are determined based on the type of cost data available, the quantity of this data (i.e., the number of data points), the similarity of the scope of these historical data points against our RIIO-GT3 investment programme and in line with government cost estimating guidance[5] and IPA standard. Cost accuracies of +/-10% are defined where the scope of the historical data points directly align to the investment proposed, or estimates have been derived from 4.0 level scopes. [redacted]

4.5.15 Table 14 provides an overview of our costing approach for Site Lighting asset interventions. All costs have been derived from completed interventions in RIIO-T2. Whilst the intervention in RIIO-T2 had a per site unit of measure, costs have been captured per asset enabling NGT to utilise these costs for costing our RIIO-GT3 interventions.

Table 14: Cost Derivations

Intervention	Unit of Measure	Unit Cost (£) 23/24 prices	Cost Accuracy	Data Points	Source Data
[redacted]					

Unit Cost Development

4.5.16 An example of cost data for a Site lighting intervention is the "Column Light - Replace Luminaire and internal column cable" intervention. The unit cost for this project has been produced using data from an Area Form Project at [redacted] Following discussions with the relevant subject matter experts it was determined that on this site we had undertaken the replacement of [redacted] column mounted luminaires to ensure that the site is adequately illuminated via the external lighting. This was specifically related to perimeter lighting and external building lighting. This was our only source of data for these works but was validated as a correct reflection of the scope.

4.5.17 For the "Non-Hazardous Area lighting - replace luminaire and cable" intervention our unit cost has been produced using data from Area Forms Projects across [redacted]. It was determined that across the sites we had changed approximately [redacted] and that the data points available were a correct reflection of the RIIO-GT3 intervention scope. Unit costs for these sites were similar in value but examples at [redacted] had slightly more complexity due to working at height. Due to the nature of these works, this is common and therefore was not excluded from the average.

4.5.18 We have not allocated any additional risk or contingency within the costs for these interventions due to having actual historic data.

4.5.19 Both of these examples have a 10% cost accuracy due to the number of data points available to derive costs from and the similarities between the historical unit costs scope with the proposed RIIO-GT3 intervention volumes.

[5] Cost Estimating Guidance - GOV.UK

5 Earthing and Lightning Protection (£3.57m)

5.1 Equipment Summary

5.1.1 Earthing and lightning protection systems are installed on NGT owned sites and also third party owned sites (Shared Sites) where we have assets installed. Naturally occurring static electricity may range from lightning storms to frictional disturbances between parts of equipment which are moving relative to each other. All of this energy needs to be safely diverted into the ground, for which NGT utilises earthing and lightning protection systems.

5.1.2 Earthing and lightning protection systems are an integral part of any electrical installation to enable the proper function of protection systems and the safety of personnel and plant besides providing a controlled method to prevent the build-up of static electricity, especially pertinent in hazardous areas.

5.1.3 Regulation 8 of the EAWR states that precautions shall be taken either by earthing or other suitable means (usually impractical or special conditions) to prevent danger arising from a fault in a system and that conductors be of sufficient strength and capability to discharge the energy to earth.

5.1.4 Bonding and earthing connections shall not be able to transfer dangerous voltages or currents into hazardous areas. If this cannot be prevented by additional electrode earthing, specialised surge diverters are fitted at strategic positions to ensure the lightning discharge occurs in a non-hazardous area.

5.1.5 Earthing systems generally comprise of components such as conductors, terminals, earth bars, connections (bolted or welded) and electrodes.

5.1.6 Typically, earthing and/or equipotential bonding is provided for HV transformers, standby generators, LV distribution systems, electrical current using equipment, instrumentation, intrinsically safe systems and for some sites HV Variable Speed Drives, HV harmonic filters and HV motors.

5.1.7 The complexity of the earthing network is generally proportional to the overall site electrical systems, for example large compressor stations and AGIs will have more complex systems with multiple earth rods, and conductors across the site. Small AGIs typically have 2 earth rods, 2 earth bars.

5.1.8 NGT has 194 sites with earthing and lightning protection systems, including all Compressor Stations and 171 AGIs. Within our asset management repository, Maximo, we have 3,269 assets within earthing and lightning protection systems across these 192 sites. When bundled into equipment units the volumes of assets, summarised in Table 15, are seen.

Table 15: Equipment count of Earthing and Lightning protection assets

Assets	Asset count
Site Earthing	255
Lightning Protection	185
Total	**440**

5.1.9 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_IDP02_Portfolio EJP Electrical Infrastructure_RIIO-GT3

5.2 Problem Statement

5.2.1 There are three primary problems on these assets which our investment seeks to address:

- **Legislation –** Regulation 8 of the EAWR states that precautions shall be taken either by earthing or other suitable means to prevent danger arising from a fault in a system and that conductors be of sufficient strength and capability to discharge the energy to earth. Regulation 6 of the EAWR also applies to these systems, that such electrical equipment which may reasonably foreseeably be exposed to – (b) the effects of the weather, natural hazards, temperature or pressure (d) any flammable or explosive substance, including dusts, vapours or gases, shall be of such construction or as necessary protected as to prevent, so far as is reasonably practicable, danger arising from such exposure. Earthing and Lightning Protection systems that are defective will be non-compliant to these standards.
- **Surveyed Condition** – Earthing condition surveys and lightning protection surveys and risk assessments were undertaken on Compressor stations in RIIO-GT1 initiated by an HSE inspection [redacted]. Due to the extent and complexity of the issues identified by ERM [redacted] [redacted] the funds allocated to

the site were exhausted undertaking investigation and remedial work and neither the investigation work nor the remedial work was fully completed, unlike at the other compressor stations where all issues were addressed. There are currently outstanding very significant issues at the site which need to be addressed. A copy of the report can be found in Appendix 3 - Aberdeen Earthing and Lighting Protection system.

Although AGIs generally do not contain structures which are typically believed to be at high risk of lightning strikes, the installations are typically at risk from overvoltage due to lightning strikes on assets located in close proximity to our sites, e.g., overhead lines, and therefore have suspected non-conformance to this standard. We have limited information on the condition of these systems and the affected sites, however, have identified defects across our AGI sites on these systems that are in need of rectification, and it is anticipated that further issues will be found due to the age of these systems.

- **Asset Deterioration** –Earthing and Lightning systems on our AGIs are generally of original site construction and are aged, with a variety of defects being identified through maintenance and site inspections. Earth tape will deteriorate over time with weathering, and earth rods will naturally deteriorate over time, accelerated by soil temperature, humidity and the salinity (salt content). Our systems are inspected every year in accordance with our maintenance policy, with assets inspected to assess their condition and rods and circuits tested to ensure that electrode resistance and insulation resistance remain in line with acceptable readings. Where issues are identified defects are raised within our Maximo defect management system. Defects raised include:
    - High earth electrode readings – due to ageing for reasons as identified above.
    - Chemical reactions due to soil conditions.
        - Galvanic erosion due to stray DC currents in the earth, or different soils acting on sections of the same electrode forming cathodic and anodic areas and loss of surface metal from the anodic area.
        - Oxidation
    - Earth bars are corroded or damaged.
    - Connections not accessible to repair.
    - Damaged concrete earth pits.

5.2.2 As of April 2024, 45 defects are open on our defect management system in need of investigation and remediation.

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

5.2.3 Our investment seeks to maintain the operation of our earthing and lightning protection assets, ensuring that our site operatives and contractors, visitors and members of the public are kept safe from the natural potential of our asset and the risks posed by lightning strikes onto our asset base (e.g., Electrical Shocks, fires).

5.2.4 Failure to ensure the effectiveness of our site earthing and lightning protection systems could result in assets that are non-compliant with EAWR and British standards on earthing and lightning systems, resulting in damage to our assets impacting their operational availability, affecting network operations, and could result in harm and injury to our operatives.

What is the outcome that we want to achieve?

5.2.5 The outcome of the investment on Site Lightning and Earthing assets is to:

- Maintain the safe operational availability, through management of static electricity, of compressor stations and AGIs that have electrical equipment installed.
- Ensure our earthing and lightning assets are fit for purpose against their duty and that operatives are safe around our assets.
- Ensure compliance with all legal obligations and required standards, such as EAWR.

How will we understand if the spend has been successful?

5.2.6 The investment plans will be considered to be successful when:

- We are able to maintain the safe operational availability of NTS sites, and electrical and mechanical assets installed on them, with continued compliance with all legal obligations and required standards such as EAWR.

Narrative Real Life Example of Problem

5.2.7 At [redacted] an Earthing and Lightning protection survey was completed in July and September 2015, which identified a range of recommendations based on a site assessment, analysis of earthing and lightning system readings and results, and a computer simulation of the earthing system under fault conditions.

5.2.8 The report identified the following issues in need of rectification:

- Continuity tests across the site provided resistance values that exceed an acceptable value at various points across the site, (Base of the Vent Stack, Diesel Tank (Station 1)) as shown in Figure 6.

Figure 6 [redacted]

- The fence system is specifically earthed, separately to the rest of the site, however high resistance readings are being measured on assets in close proximity to this system, e.g., camera towers 4, 8,14, 19, and therefore, assessment is needed to understand whether the system is interacting correctly with the site wide earthing and lightning protection system.
- Earth rods around the perimeter fence were sampled, and out of the 10 earth rods 7 were found to have high earth rod resistance (in excess of 120 Ohms), the maximum expected reading given the distance between rods and the proximity to the fence (Appendix 3, Page 36)
- The resistance between the earth bards and the earth cables used to connect major plant items to the earthing system were checked. A pass value of 50μΩ or less is required, but it was found that 14 of the 18 earth bar joints had resistance in excess of this limit, requiring refurbishment or replacements of the joints.
- Across [redacted] Continuity tests between the MES and the electrodes for the AGI Module are higher than would be expected and indicate degraded joints or damaged earth conductors.

5.2.9 Further information can be found in the [redacted]

Project Boundaries

5.2.10 Investment in this theme is only associated with replacing components within site earthing systems and site lightning protection systems, including earth rods, busbars and electrodes.

5.2.11 Inspection and maintenance activities on these assets, including minor component replacement are included within our opex submission.

5.2.12 All Compressor stations, except for [redacted], are outside the scope of this investment, having had system remediation completed in RIIO-GT1. Installations at Bacton and St Fergus are also outside the scope of this investment.

5.3 Probability of Failure

5.3.1 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.

5.3.2 Within our NARMs model site earthing and lightning specific failure modes are associated with the loss of the systems and the consequential impact on the operation of our sites. Each failure mode is presented with the average proportion of failures.

Table 16 Earthing and Lightning protection failure modes

Failure Mode	Average Proportion of Failures
Loss of site earthing and lightning protection	0.05

5.3.3 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 17. 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, which for earthing and site lightning assets is forecast to remain broadly flat across the RIIO-GT3 period.

Table 17 Forecast Earthing and Lightning Protection defect rates

Asset Type	No. of Assets	Cumulative Average Failure Rates					Forecast Failures per Year				
		2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
Earthing & Bonding	255	0.94	0.95	0.96	0.97	0.97	2	2	2	2	1
Lightning Protection	185	0.91	0.92	0.94	0.95	0.97	2	2	3	3	3

Defects

5.3.4 Every year our site earthing and lightning protection systems are inspected through both visual assessment and the measurement of resistance and continuity. Any issues or deficiencies in the readings taken are logged as defects.

5.3.5 One hundred and fifty-nine defects have been raised on our site earthing and lightning protection systems, since 2008, with the majority of these, 119 (75%), logged since 2018. Figure 7 shows the distribution of defects by date raised.

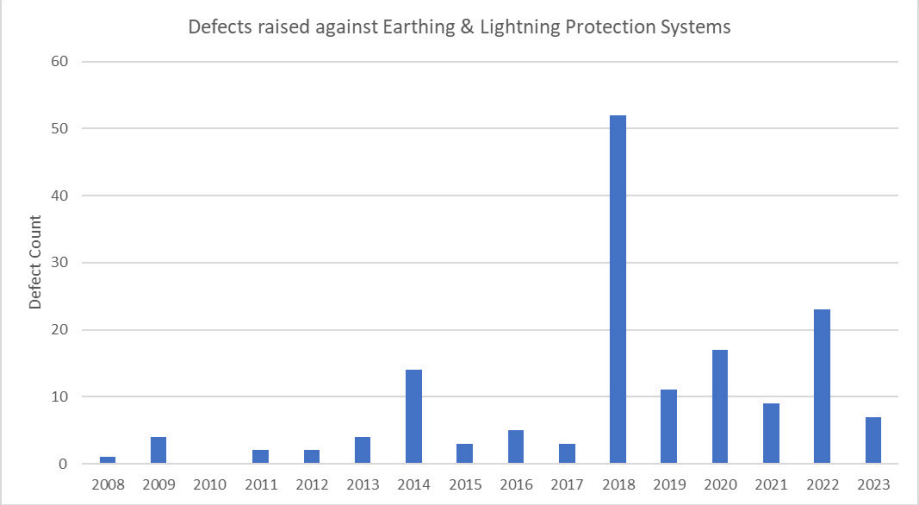


Figure 7: Distribution of Defects by Date Raised

5.3.6 Defects in the system cover a broad range of issues, including component deterioration and corrective maintenance actions. An example of a defect is; *"High impedance readings on earth bed and bonding"*, *"E15 when tested, results above the required 20 Ohms" & "At time of testing the Earthing / Earth rods, I was unable to locate Earth Rod E2. All the Earthing is poorly marked and needs further investigation".*

5.3.7 As of April 2024, 45 of these defects are still open, across 32 sites, with corrective actions required to close out the issues. The types of issues are summarised as follows:

- System Repairs – 28
- System Reconfiguration – 9
- Minor asset modifications, labelling and drawings - 8

5.3.8 Based on the type of issues being logged historically for specific earthing and lightning protection assets, and our experience from the compressor station projects it is expected that further faults and system deficiencies will be identified upon survey of the sites not currently captured within our defects system.

5.3.9 At [redacted] a survey completed by ERM in 2015 identified a range of corrective actions that need progressing to ensure the efficiency and robustness of the sites earthing and lightning protection system.

Probability of Failure Data Assurance

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

5.3.11 We have made the best engineering assessments of the defect description and corrective actions to understand this probability of failure.

5.3.12 Forecast probability of data information has been collated using the Copperleaf asset management decision support system and connected Power BI dashboards.

5.4 Consequence of Failure

5.4.1 In the event of a failure of our Earthing and Lightning Protection assets there are a range of potential impacts to our site operations.

5.4.2 Table 18 provides an overview of the consequence of failure for these assets, mapped against NGTs NARMs Consequence of Failure service risk measures.

Table 18: Consequence of Failure

	Impact/Consequence			
	Availability	**Environment**	**Financial**	**Safety**
Earthing & Lightning Protection Systems	(1) Failure or deficiencies in the earthing and lightning protection system can result in faults and power surges that may damage operational assets, impacting on the efficiency of network operations, e.g. loss of metering equipment impacting on billing processes (2) Inadequate earthing can cause electromagnetic interference, affecting the proper functioning of sensitive electronic equipment and communication systems, e.g. telemetry systems.	N/A	(3) The financial risk of non-compliance with legislation, such as EAWR could be significant. (4) The remedial works resulting from overvoltage, fire or explosion could be extensive at high financial cost	(5) Failure or deficiencies of the Earthing and Lightning Protection systems could lead to injury to operational staff, visitors and contractors from the risk of burns, fire, arcing or explosion. (6) Assets installed within Hazardous areas, need suitable protection, which if not satisfied could result in an explosion or fire.

5.4.3 Figure 8 shows the level of risk, which is a combination of probability of failure and consequence of failure, for Site earthing and Lightning Protection systems with no investment across the RIIO-GT3 period.

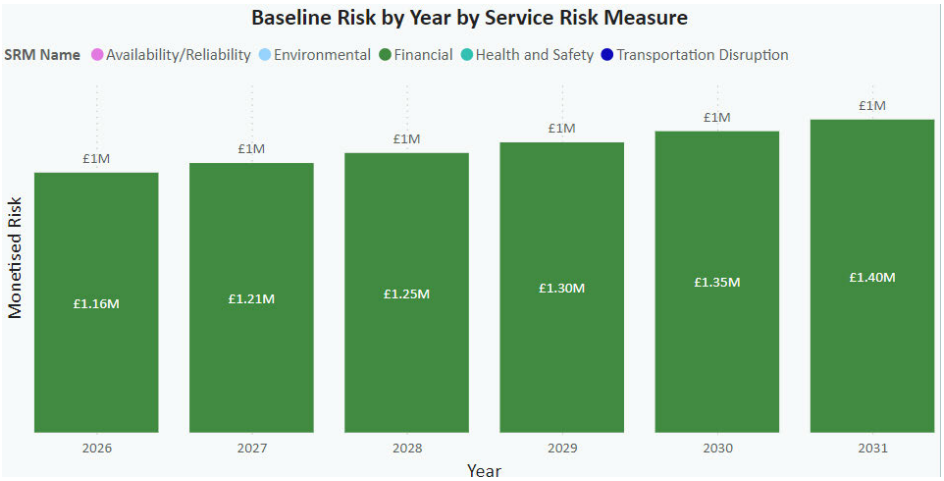


Figure 8: Level of Risk

5.4.4 The modelled failure impact is associated with the loss of the system and the impact this has on additional maintenance and remedial activities to protected assets. This is forecast to increase over the RIIO-GT3 period by 16%.

5.5 Interventions Considered

Interventions

5.5.1 In reviewing the investment options on our site earthing and lightning protection systems to address the drivers for investment a range of options have been considered.

Counterfactual

5.5.2 Our counterfactual option considers no specific intervention to be undertaken on site earthing and lightning protection systems, apart from our planned inspection, maintenance and testing activities.

5.5.3 Given this leaves site installations with known issues and deficiencies both on our AGIs and at [redacted] this option has not been progressed.

Refurbishment of Earthing and Lightning Protection Systems (Small Site, Large Site and [redacted]

5.5.4 The refurbishment of earthing and lightning protection systems option includes the replacement of a combination of assets within a sites earthing and lightning system to address the defective assets identified through maintenance activities and additional deficiencies identified from our surveys.

5.5.5 New assets would be installed to replace defective, undersized or non-compliant existing assets. Given the interaction between the complexity of the system and the size of the sites, driven from the number of operational assets we have split this intervention into small and large site variations. Small sites include block valves, small AGIs (including offtakes). Large sites include terminals, large AGIs, such as multi-junction and large offtakes).

5.5.6 Given the specific reported deficiencies with the system at [redacted], a specific refurbishment intervention would be proposed at [redacted] to resolve the specific identified defects and to ensure the system continuity and resistance readings ensure assets are suitable protected and site operatives kept safe.

Replacement of Earthing and Lightning Protection Systems

5.5.7 The intervention for replacement of earthing and lightning protection systems proposes the replacement of all components of the earthing and lightning protection system, including installing new earth rods, a new busbar, earthing tape etc and disposal of the existing assets on site.

5.5.8 Given the specific reported deficiencies with the system at [redacted], a specific replacement intervention would be proposed at [redacted] to resolve the specific identified defects.

Intervention Summary

5.5.9 Table 19 presents a summary of the interventions considered:

Table 19 Earthing and Lightning intervention summary

Intervention	Equipment Design Life	Positives	Negatives	Taken Forward
Counterfactual (Do nothing)	N/A	Lower Capex cost solution	Leaves site installations which have known issues and defects both on our AGIs and at [redacted]. These issues could result in damage to assets, injury to site personnel and presents an unmitigated risk that we are not willing to accept.	No
Refurbishment of Earthing and Lightning Protection Systems (Small Site/Large Site	30 Years	Addresses deficiencies within the system for the lowest cost. Ensures earthing and lightning system is sized for the required duty through modifying the existing installation		Yes
Refurbishment of Earthing and Lightning Protection System [redacted]	30 Years	Addresses deficiencies within the system at [redacted] for the lowest cost.		Yes

Intervention	Equipment Design Life	Positives	Negatives	Taken Forward
		Ensures earthing and lightning system is sized for the required duty through modifying the existing installation		
Replacement of Earthing and Lightning Protection Systems (Small Site/Large Site)	30 Years	Provides completely new earthing and lightning protection system, sized for the current asset footprint on the site.	Highest cost intervention Higher cost than refurbishment intervention Defect data does not highlight the need to complete. Refurbishment intervention can ensure system is sized	No
Replacement of Earthing and Lightning Protection Systems [redacted]	30 Years		Highest cost intervention. Limited needs case tor progress option Higher cost than refurbishment intervention Survey information, whilst identifying deficiencies does not highlight the need to completely replace the earthing and lightning system at the site.	No

Volume Derivation

5.5.10 For this site earthing and lightning protection themes a defect assessment was completed against all AGI sites with earthing and lightning protection systems within our Maximo asset management repository. In addition, a subset of our AGIs had been surveyed through the survey and Front End Engineering Design (FEED) stage of our RIIO-T2 National Electrical Campaign project. These identified issues with the earthing system as identified in the problem statement section.

5.5.11 An engineering assessment of the defects was undertaken by our Electrical Subject matter experts along with an assessment of the expected system life, against British standards and legislation.

5.5.12 Sites were categorised into two groups depending on the site, type, with compressors, terminal and multijunction being categorised as large and offtakes and smaller AGIs (Pig traps sites), and Block valves as small sites.

5.5.13 This resulted in [redacted] volumes of Refurbishment of earthing and lightning protection system (large) and [redacted] volumes of Refurbishment of earthing and lightning protection system (small) being proposed within our investment plan.

5.5.14 For [redacted], an engineering assessment of the survey was undertaken. Based on this assessment it is proposed to complete these recommended corrective investments, resulting in a refurbishment of the system.

Unit Cost Development

5.5.15 In developing our RIIO-GT3 investments we have assessed our intervention options against historically completed or in delivery investments. In this assessment we have mapped RIIO-GT3 interventions to RIIO-T2 Unique identifiers (UIDs) and assessed the available historical outturn and/or in delivery forecasted completion costs.

5.5.16 No funding was awarded through the RIIO-T2 determination for these assets and therefore we have no outturn or tendered data points for these investments. The investment at [redacted] is based on RIIO-T1 sanction values for similar projects completed at 20 compressor stations and terminal sites. £[redacted] was spend addressing systems at [redacted] sites, resulting in an average per site cost of £[redacted]

Table 20 Earthing and lightning protection unit cost development (£, 2023/24)

Intervention	Unit Cost	Unit of Measure	Cost Accuracy	Data Points	Source Data
Refurbishment of Earthing & Lightning Protection Systems (Large Site)	£[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Refurbishment of Earthing & Lightning Protection Systems (Small Site)	£[redacted]	[redacted]	[redacted]	[redacted]	[redacted] assessment
[redacted] Earthing & Lightning System Remediation	£[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

6 Miscellaneous Electrical Assets (£1.83m)

6.1 Equipment Summary

6.1.1 In addition to the electrical assets included within this document , NGT_EJP10_Electrical Infrastructure: Switchgear and Transformers_RIIO-GT3, and NGT_EJP11_Electrical Infrastructure: Standby Power Systems and LV Distribution_RIIO-GT3, there are many other types of electrical systems distributed across our operational sites. These have been grouped into this miscellaneous electrical assets chapter.

6.1.2 The Miscellaneous Electrical equipment group includes the following assets within its scope:

- **Motors** – such as those used within compressor units for auxiliary oil systems.
- **Pumps**, including pumps and control panels used for site drainage.
- **Trace Heating** – utilised within cabs and other enclosures.
- **Site Cabling** – located within site ducting and utilised to connect electrically powered assets to LV distribution systems (e.g., actuator cabling)

6.2 Problem Statement

6.2.1 Assets within our miscellaneous electrical asset group perform vital functions for the continued safe operation of NTS sites, not only for primary transmission functions, such as pumps and motors supporting operation of our gas compressor fleet, but also facilitating conditions that are optimum for operation. e.g., heating within cabs enclosures, pumps located in valve pits and pipework pits, used to facilitate access to these assets for maintenance and inspection purposes.

6.2.2 Several issues are being identified through inspection and testing of these assets, such as:

- Components are unserviceable, affecting site asset performance.
- Staff have the inability to work on the assets safely.
- Assets that become non-compliant with EAWR and DSEAR regulations due to asset deterioration; and
- Assets being redundant, not fit for current operation or being inefficient.

6.2.3 The key drivers for investment are:

- **Asset Deterioration** - Elements of the assets are deteriorating due to age, and through corrosion related failure modes, resulting in the unavailability of these assets. This results in disruption to operational processes, and wider site operations. Examples include cable failures through external sheath deterioration due to UV exposure, or pit pumps failing due to corrosion. Many cables feeding lighting columns are failing their BS 7671 periodic tests. Many pyro (fire protected) cables within the compressor cabs are damaged with their metal sheaths starting to break.
- **Legislation** - DSEAR inspections have identified numerous cables that have cable terminations that are non-compliant with the relevant standard (BS EN 60079) and cables that have damaged external sheath. These regulations are designed to ensure that the working environment is as safe as reasonably practicable, to avoid harm to persons.

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

6.2.4 The use of these miscellaneous electrical assets without investment in inspection, assessment and remediation could breach legal obligations under EAWR and DSEAR.

6.2.5 The impact of doing nothing could be varied depending on volume of assets, and type of assets, that fail and require investment within the RIIO-GT3 period. With no investment the quantity of defective assets could increase which could lead to unavailability of the assets leading to unavailability of other operational assets.

6.2.6 The impact is varied and is dependent upon the nature of the connected asset. Examples include not being able to operate actuating valves, or compressor auxiliary systems not being available to operate compressor units.

What is the outcome that we want to achieve?

6.2.7 The desired outcomes for the investment during the period are to:

- Ensure that miscellaneous electrical systems, such as pumps, motors, trace heaters and site cabling are operational fit for purpose, addressing failures as and when they occur in RIIO-GT3. This shall ensure we maintain site operations.

How will we understand if the spend has been successful?

6.2.8 The investment plans will be considered to be successful when:

- We are able to maintain the safe operational availability of NTS sites, and electrical and mechanical assets installed on them, with continued compliance with all legal obligations and required standards such as EAWR and DSEAR.

Narrative Real-Life Example of Problem

6.2.9 In the following section, two examples are summarised of motors and pump system issues.

[redacted] Drainage Pump System

6.2.10 At [redacted] the site drainage system utilises a series of pumps to manage water levels within pits, to prevent equipment within pits from being submerged, which can lead to damage. The system is controlled through a control panel located within an enclosure.

6.2.11 The current control panel, shown in Figure *11* is obsolete and failures of the pumps have been seen, impacting on the safe operation of the station. Several of the pumps have already been replaced but the legacy control panel remains.

Figure **9** [redacted] *Drainage Pump Control Panel*

[redacted] Auxiliary Pump System

6.2.12 At [redacted] there are 6 Flame Proof (FLP) motor stop-start control stations (see *Figure* 10) for the auxiliary oil systems situated around each of Cab A and B.

6.2.13 These FLP motor stop start enclosures require upgrading to single Exe control panel removing all Mineral Insulated Copper Cable (MICC) to ensure compliance with BS EN 60079 (governing electrical apparatus in explosive atmospheres). There are also FLP junction boxes which would be removed.

6.2.14 Not rationalising these assets could result in operational expenditure to maintain these assets to ensure we comply with all relevant legislation and statutory policies.

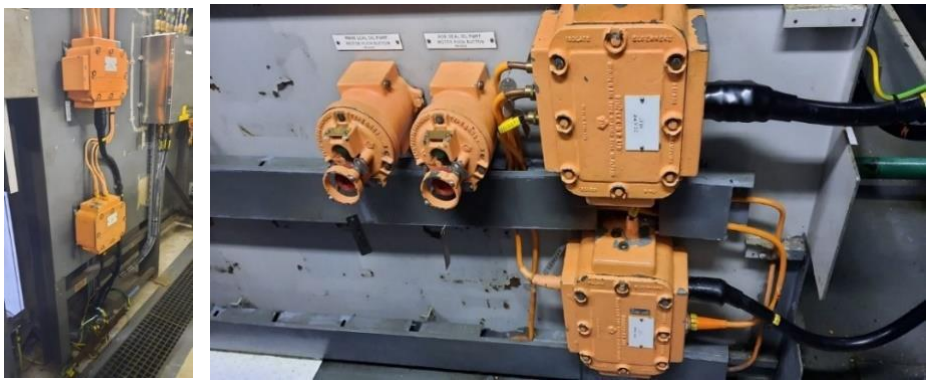


Figure **10** [redacted] *Compressor FLP Motor Stop Start*

Project Boundaries

6.2.15 The investment seeks to manage asset failure risks of our pumps, motors, trace heating and site cabling assets. The investment does not include the cost of maintenance of these assets.

6.2.16 Our investment seeks to manage known defects that occur in the RIIO-GT3 period to ensure the continued operation of electrical assets and site operations. No proactive investment scheme is planned.

6.3 Probability of Failure

Defect Analysis

6.3.1 As part of our assessment of miscellaneous electrical asset performance we have reviewed the defects logged within our asset management system (Maximo) for the assets within the scope of this theme. Forecast probability of failure is hard to define given the breadth and the scale of the assets.

6.3.2 Four defects have been raised against on motors since 2020 which required motor replacement, representing a failure rate of one per year.

6.3.3 Ten defects have been raised on defective pumps in pits. These ten defects span the period from 2015 to 2023 and necessitated replacement of equipment, representing a rate of nearly 1 per year.

6.3.4 A review of DSEAR defects from DSEAR inspections completed in RIIO-T2 identified 6 defects, where a site cable had the outer sheath damaged with the Steel Wire Armoured (SWA) cabling exposed, or where the SWA cable was too short within a gland, requiring a cable replacement.

For Probability of Failure Data Assurance

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

6.4 Consequence of Failure

6.4.1 The consequence of failure of these assets is wide ranging due to the assets also varying greatly.

6.4.2 Failure of pumps and motors can result in unavailability of compressor units or damage occurring to those compressor units (Availability and Reliability). This can result in un-safe environments for our operatives, cause potential damage to these units that impact on the safe and reliable operation of the network.

6.4.3 Failure of drainage pump control panels will result in possible flooding of pits. This results in hazardous environments accessing the pit (Health and Safety concerns), and damage to assets located within the pit.

6.4.4 Damage to cabling if unmitigated can result in a risk or fire and electric shock to site operatives (Health and Safety), and potential disruption to the supply of electricity to the connected asset impacting on network operations (Availability)

6.5 Interventions Considered

Interventions

6.5.1 A range of interventions on our miscellaneous assets have been considered to address the drivers for investment.

Counterfactual

6.5.2 Our Counterfactual intervention considers no specific intervention to be undertaken on our miscellaneous electrical assets, with the exception of maintenance. Investment is deferred into future price control periods.

6.5.3 Given the historical defects that have required investment to ensure the continued safe operation of these electrical assets, this option has been discounted.

Miscellaneous Electrical Assets Replacement

6.5.4 The miscellaneous electrical assets replacement intervention proposed the replacement of this system on a like for like basis, including a complete circuit for an auxiliary compressor system, or all pumps within an AGI site.

6.5.5 It would include the replacement of all components within this system to rectify faults and issues to ensure the systems provide the supporting function to the availability of associated process asset.

Miscellaneous Electrical Assets Major Refurbishment

6.5.6 This option proposes the replacement of several miscellaneous electrical assets on a site, such as Pumps, Motors.

6.5.7 It would include the replacement of the identified defective/obsolete components within this system to rectify faults and issues to ensure the systems provide the supporting function to the availability of associated process assets.

Electrical Cabling replacement

6.5.8 This option proposes the replacement of a site electrical cable from the distribution board to the connected asset, e.g., actuator, gas quality equipment, where it has been identified that an asset is defective; in its operation or against DSEAR compliance.

Intervention Summary

6.5.9 Table 21 provides a summary of the interventions on our miscellaneous electrical assets.

Table 21 Miscellaneous electrical assets intervention option summary

Intervention	Equipment Design Life	Positives	Negatives	Taken Forward
Counterfactual (Do nothing)	N/A	Lowest Cost	These types of issues are not always known and cannot always be forecasted due to the types of failure modes. However, could result in conditions that promote increased asset deterioration, loss of control of connected asset systems, and increased probability of asset failures. Use of available opex funding to remediate these issues, which is not available and divert funding away from other operational expenditure	No
Miscellaneous Electrical Assets Replacement	20-40 years	This will address issues with these assets that could result in non-functionality of the connected assets, impact on safe operations of the site, and the safety of site operatives	Highest cost option	Yes
Miscellaneous Electrical Assets Major Refurbishment	20-40 years	This will address issues with these assets that could result in non-functionality of the connected assets, impact on safe operations of the site, and the safety of site operatives	N/A	Yes
Electrical Cabling replacement	15-40 years	Addresses issues with cabling that if unmitigated could impact the operation of downstream connected assets, e.g. metering, telemetry, gas quality equipment or electric actuators. The unavailability of these has significant consequences to network operations, such as inability to control valve assets, provide isolations or control flows	N/A	Yes

Volume Derivation

6.5.10 Table 22 presents a summary of the volume derivation approach for our bottom up RIIO-GT3 volumes.

Table 22 Miscellaneous Electrical asset volume derivation

Intervention	RIIO-GT3 Volumes	Unit of Measure	How this volume has been developed
Miscellaneous Electrical Assets Replacement	[redacted]	Per Site	Volumes for these three interventions were derived through an assessment of the historic and current defects within Maximo. Theses defects included defects raised through maintenance and inspection and through our DSEAR inspection regime. Miscellaneous Electrical Assets Replacement – Based on historic defects, investment on ancillary systems were identified as in need of replacement. This information was utilised to generate a run rate for RIIO-GT3. Miscellaneous Electrical Assets Major Refurbishment – An assessment of the defects for pumps, trace heating was undertaken with [redacted] defects identified as raised across a 5-year period that required investment. This run rate was projected forward. Electrical Cabling replacement – An assessment of defects was undertaken. A range of defects were found where cabling sheathing or glanding was identified. This was utilised to identify cable replacement interventions.
Miscellaneous Electrical Assets Major Refurbishment	[redacted]	Per Asset	
Electrical Cabling replacement	[redacted]	Per Asset	
Total	[redacted]		

Unit Cost Development

6.5.11 In developing our RIIO-GT3 investments we have assessed our intervention options against historically completed or in delivery investments. In this assessment we have mapped RIIO-GT3 interventions to RIIO-T2 Unique identifiers (UIDs) and assessed the available historical outturn and/or in delivery forecasted completion costs.

6.5.12 Our cost accuracies are determined based on the type of cost data available, the quantity of this data (i.e. the number of data points), the similarity of the scope of these historical data points against our RIIO-GT3 investment programme and are in line with government cost estimating guidance[6] and IPI standard.

6.5.13 Table 23 provides an overview of our costing approach for miscellaneous electrical asset interventions. Two costs have been developed utilising the estimate at cost of completion information from investments in progress during RIIO-T2 and one developed through internal estimation The two interventions with a +/-50% cost accuracy are due to the limited data points available and the stage of these projects (in progress rather than completed).

Table 23 Miscellaneous Electrical unit cost summary table (£, 2023/24)

Intervention	Unit Cost	Unit of Measure	Cost Accuracy	Data Points	Source Data
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

6.5.14 The electrical cabling replacement intervention was estimated through a scope to supply cabling to an electric valve actuator on an AGI, utilise a 10mm2, 3 core XLPE/SWA/PVC cable of 75m in length. Following installation, it would require testing and a hazardous area inspection to be undertaken, it would then require functional tests of the actuator to be undertaken by Operations the Gas National Control Centre (NCC). The cost was developed utilising a supplier quote on top of which costs to the removal of the existing cable, the laying a connection of the new cable and testing was applied. Our project management overheads were then applied to this cost.

[6] Cost Estimating Guidance - GOV.UK

7 Options Considered

7.1 Portfolio Approach

7.1.1 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.

7.1.2 We have assessed the benefit from options across the entire electrical portfolio to meet investment drivers, business plan commitments, and consumer priorities. Therefore, a single CBA covers switchgear, transformers, standby power systems, LV distribution, site lighting, earthing and lightning protection (NGT_IDP02_V5 CBA Electrical Infrastructure_RIIO-GT3).

7.1.3 The options considered combine the interventions discussed previously, and those in the other electrical EJPs, in varying combinations and volumes to identify the optimal investment for our electrical assets.

7.1.4 In line with HM Treasury Green Book advice and Ofgem guidance, we assessed the value of investing in Electrical Infrastructure across the RIIO-GT3 period by analysing the cost benefit over a 20-year horizon.

7.1.5 We derived bottom-up intervention volumes using the engineering assessments described in the previous chapters. Each investment 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. A table of these intervention volumes is shown in Appendix 1 - Bottom up plan intervention volumes. This resulted in the following options summarised in Table 24 and Appendix.

Table 24: Portfolio Options Summary

Option	Option Name	Description
Option 0	Counterfactual (Do Nothing)	Maintenance and corrective repairs only
Option 1	Total Monetised Risk Stable to RIIO-T2 start	This option is a programme of investments developed to achieve risk level at the start of RIIO-T2.
Option 1A	Total Monetised Risk Stable to RIIO-T2 start – Post deliverability	This option is a programme of investments developed to achieve risk level at the start of RIIO-T2, constrained by our deliverability assessment.
Option 2	10% Additional Risk Reduction	This option is a programme of investments developed to achieve 10% lower than the risk level at the start of RIIO-T2.
Option 3	Lowest WLC	This option is a programme of investments developed to achieve the lowest total cost of CAPEX incurred over the operational life of the assets based on unconstrained service risk measures.
Option 4	Availability and Reliability Risk Stable	This option is a programme of investments developed to maintain availability and reliability risk level to that at the start of RIIO-T2 only, without controlling the levels of other risk measures.

7.2 Options

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

7.2.2 All the options described below have been assessed against our Option 0, Counterfactual (Do Nothing) option, which considers no investment over and above maintenance and corrective repairs.

7.2.3 In all options (except the counterfactual) we include bottom-up intervention volumes to address know defects and obsolescence issues. A table of these intervention volumes is in Appendix 1.

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

7.2.1 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 (Availability and Reliability, Environmental, Health and Safety, Financial, Societal) are not individually constrained, however overall risk outcome is.

7.2.2 The total spend of proposed interventions in this option is £75.56m (2023/24) which addresses known and forecast defects. No additional investment is proposed through our Predictive analytics model to keep overall NARMs risk stable.

7.2.3 The proposed intervention volumes and the associated spend for this option are shown in Table 25 below, with a full intervention breakdown in Appendix.

Table 25: Option 1 Total Monetised Risk Stable to RIIO-T2 start Intervention Summary (£, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions (Appendix 1)	[redacted]	£75,559,820.26
Total	[redacted]	**£75,559,820.26**

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

7.2.4 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. The deliverability assessment reduced volumes by 272 to meet network access, contract strategy and supply chain availability constraints.

7.2.5 The total spend of proposed interventions in this option is £74.08m (2023/24) which addresses known and forecast defects. No additional investment is proposed through our Predictive analytics model to keep overall NARMs risk stable.

7.2.6 The proposed intervention volumes and the associated spend for this option are shown in Table 26, with a full intervention breakdown in Appendix.

Table 26 Option 1A Post Deliverability Total Monetised Risk Stable to RIIO-T2 start Intervention Summary (£, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions (Appendix 1)	[redacted]	£74,075,124.68
Total	[redacted]	**£74,075,124.68**

Option 2: 10% Additional Risk Reduction

7.2.7 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain the overall level of risk at the end of the RIIO-GT3 period to 10% lower than the levels of risk at the start of the RIIO-T2 period.

7.2.8 In this output we seek to ensure overall NARMs monetised risk is 10% lower but Individual service risk measures are not individually constrained, hence service risk measures achieve a blend of outcomes to overall meet the 10% lower NARMs risk.

7.2.9 The total spend of proposed interventions in this option is £80.80m (2023/24) which addresses known and forecast defects.

7.2.10 The proposed intervention volumes and the associated spend for this option are shown in Table 27.

Table 27: Option 2 10% Additional Risk Reduction Intervention Summary (£, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions (Appendix 1)	[redacted]	£75,559,820.26
Electrical Cabling Replacement	[redacted]	£64,749.46
Integral fuel transfer system replacement	[redacted]	£ 288,725.86
Non-Hazardous Area lighting - replace luminaire and cable RIIO3	[redacted]	£3,010,191.13
Refurbishment of Earthing & Lightning Protection Systems (Large Site)	[redacted]	£51,338.51
Replace Batteries (Nicad) (Small) (AGIs)	[redacted]	£1,632,028.03
Replace Batteries (VRLA) (Small) (AGIs)	[redacted]	£194,247.35
Total	**7419**	**£80,801,100.59**

Option 3: Lowest Whole Life Cost (WLC)

7.2.11 In this option we have utilised our Copperleaf Portfolio optimisation tool to deliver a combination of intervention options which achieves the lowest total cost of CAPEX incurred over the operational life of the assets. Individual service risk measures are not individually constrained, however overall risk outcome is.

7.2.12 The total spend of proposed interventions in this option is £82.56m (2023/24).

7.2.13 The proposed intervention volumes and the associated spend for this option are shown in Table 28.

Table 28: Option 3 Lowest Whole Life Cost (WLC) Intervention Summary (£, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions (Appendix 1)	[redacted]	£75,559,820.26
Converter Transformer Coating Replacement	[redacted]	£37,983.30
Electrical Cabling Replacement	[redacted]	£64,749.46
Integral fuel transfer system replacement	[redacted]	£288,725.86
Non-Hazardous Area lighting - replace luminaire and cable RIIO3	[redacted]	£4,309,441.59
Replace Batteries (Nicad) (Small) (AGIs)	[redacted]	£1,687,040.21
Replace Batteries (VRLA) (Small) (AGIs)	[redacted]	£225,080.26
Replacement of LV Switchgear Installation	[redacted]	£385,257.49
Total	**8263**	**£82,558,098.42**

Option 4: Availability and Reliability Risk Stable

7.2.14 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain our availability and reliability service risk measure to achieve a stable risk at the end of RIIO-GT3 to the start of RIIO-T2. No other service risk measures have been constrained and they have been left un-optimised.

7.2.15 The total spend of proposed interventions in this option is £81.86m (23/24).

7.2.16 The proposed intervention volumes and the associated spend for this option are shown in Table 29.

Table 29: Availability and Reliability Risk Stable (£, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions (Appendix 1)	[redacted]	£75,559,820.26
Electrical Cabling Replacement	[redacted]	£64,749.46
Integral fuel transfer system replacement	[redacted]	£224,564.56
Non-Hazardous Area lighting - replace luminaire and cable RIIO3	[redacted]	£4,309,441.59
Replace Batteries (Nicad) (Small) (AGIs)	[redacted]	£1,118,581.01
Replace Batteries (VRLA) (Small) (AGIs)	[redacted]	£200,413.93
Replacement of LV Switchgear Installation	[redacted]	£385,257.49
Total	**8,221**	**£81,862,828.29**

7.3 Options Summary

7.3.1 Table 36 presents the technical summary table comparing our Portfolio Options 1 to 4.

Table 30: Options technical summary table (£m, 2023/24)

Description	First Year of Spend	Last year of spend	Volume of Interventions	Equipment or investment design Life	% of assets intervened on	Total Spend Request
1. Total Monetised Risk Stable to RIIO-T2 start	2027	2031	[redacted]	15-40 years	[redacted]	£75.56
1A. Total Monetised Risk Stable to RIIO-T2 start Post Deliverability	2027	2031	[redacted]	15-40 years	[redacted]	£74.08
2. 10% Additional Risk Reduction	2027	2031	[redacted]	15-40 years	[redacted]	£80.80
3. Lowest WLC	2027	2031	[redacted]	15-40 years	[redacted]	£82.56
4. Availability and Reliability Risk Stable	2027	2031	[redacted]	15-40 years	[redacted]	£81.86

8 Business Case Outline and Discussion

8.1 Key Business Case Drivers Description

8.1.1 Electrical assets deteriorate over time through their operation and through age-based asset deterioration mechanisms. This in turn can result in immediate and unplanned failures which results in the loss of function of downstream assets, non-compliance with current legislation and industry standards and can result in an environment that is unsafe.

8.1.2 In developing our investment proposals, a range of investment drivers have been identified:

- Legislative requirements.
- Health and Safety – unsafe working conditions (e.g., asset condition related failures that result in assets unsafe to operate).
- Asset deterioration, linked to our ageing asset base and asset type.
- Obsolescence.

8.1.3 Specific Outcomes associated with this investment are:

- To maintain compliance and safe operation of electrical infrastructure assets across the NTS, through interventions that balance cost, risk and performance outcomes.
- To ensure that electrical infrastructure assets with high consequence of failure do not reach the point of failure, and result in impact to network operations, network constraints or contribute to the failure to supply gas to our customers and stakeholders.

8.2 Business Case Summary

8.2.1 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.

8.2.2 In considering the most effective combination of efficient interventions, we have challenged whether our preferred programme of investments is the most cost-beneficial by carrying out a full CBA utilising our Copperleaf Portfolio Optimisation tool.

8.2.3 We have appraised these portfolio options through completing a cost benefit analysis, the results of which are shown in Figure 11 and Table 31, including the post deliverability option.

Figure 11: Graphical representation of option payback periods

Table 31: Option summary of headline business case metrics (£m, 2023/24)

Option	Total Volume of Interventions	Total Spend Request	Outcome Risk End of RIIO-GT3	% change in comparison to start of RIIO-T2	Present Value (PV) Costs	PV Benefits	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	-	-	6.54	130.09%	-	-	-	-	122.97%	167.91%	140.56%	227.98%	166.67%
Option 1: Total Monetised Risk Stable to RIIO-T2 start	5,329	£75.56	4.06	80.79%	£72.76	£50.00	£(22.76)	Does Not payback in the Period	77.70%	167.91%	87.87%	106.35%	166.67%
Option 1A: Post Deliverability	5,058	£74.08	4.72	93.85%	£71.33	£45.61	£(25.73)	Does Not payback in the Period	91.35%	167.91%	100.73%	108.23%	166.67%
Option 2: 10% Additional Risk Reduction	7,419	£80.80	3.75	74.49%	£77.81	£57.01	£(20.80)	Does Not payback in the Period	71.28%	167.91%	87.80%	68.96%	166.67%
Option 3: Lowest WLC	8,263	£82.56	3.69	73.47%	£79.50	£58.34	£(21.16)	Does Not payback in the Period	70.34%	167.91%	87.80%	60.61%	166.67%
Option 4: Availability and Reliability Risk Stable	8,221	£81.86	3.74	74.41%	£78.83	£57.36	£(21.47)	Does Not payback in the Period	70.46%	167.91%	87.80%	84.84%	166.67%

8.2.4 The portfolio options have a variety of payback periods and PV benefits. The selection of a preferred option has been based on an assessment of the outcome risk levels, the cost of the options, the compliance with legislation and ensuring we deliver value to our customer and stakeholders. The following narrative shall explain the rationale for the discounting of portfolio options and the selection of our preferred option, with a summary overleaf.

8.2.5 In Option 2 our electrical outcome risk position is 10% lower at the end of RIIO-GT3 than at the start of RIIO-T2 period. This results in increased investment position compared to our other options with the exception of the lowest whole life cost option. The risk outcome achieves a position that is not aligned to our business plan commitments and the feedback from customers and stakeholders, achieving a lower risk outcome.

8.2.6 The Option 3, Lowest Whole Life Cost (WLC), increases investment volumes by 55% compared with Option 1. With this option seeking to deliver a combination of intervention options which achieves the lowest total cost of CAPEX incurred over the operational life of the assets it recommends a high volume of low value interventions. We have deliverability challenges in having outage and resources available to deliver this significant increase volume of investments in this option, evidenced through the reduction in volumes between Option 1 and 1A.

8.2.7 The Option 4, Availability and Reliability Risk Stable, delivers a similar outcome to the 10% Additional Risk Reduction with a similar level of investment across the RIIO-GT3 period. Not all to the service measures are constrained to risk stable, which could lead to asset deterioration leading to asset failures. Additionally, this option has the second higher investment spend across our portfolio options and the second highest number of interventions, which have deliverability challenges, evidenced through the reduction in volumes between Option 1 and 1A.

8.2.8 Table 32 summarises the positives and negatives of the 4 options considered within our Cost Benefit Analysis

Table 32: Positives and negatives of the options considered

Option	Option Name	Description	Positives	Negatives
Option 1	Total Monetised Risk Stable to RIIO-T2 start	This option is a programme of investments developed to achieve stable risk level at the end of RIIO-GT3 as of risk at the start of RIIO-T2.	• Option with the lowest investment forecast. • Meets the expectations of our customers and stakeholders and keeps total monetised risk stable at the risk level at the start of RIIO-T2. • Balances investment now vs investment in the future across an aged asset base.	
Option 1A	Total Monetised Risk Stable to RIIO-T2 start (Post Deliverability)	This option is a programme of investments developed to achieve risk level at the start of RIIO-T2, constrained by our deliverability assessment.	• Option with the lowest investment forecast, Option built against our overarching strategy to achieve stable risk across the RIIO-T2 and RIIO-GT3 periods.	
Option 2	10% Additional Risk Reduction	This option is a programme of investments developed to achieve 10% lower than the risk level at the start of RIIO-T2, therefore 10% additional risk reduction.	• Exceeds the expectations of our customers and stakeholders and achieves a lower total monetised risk than that at the start of RIIO-T2 • 3rd highest PV benefit of all options.	• 2nd most expensive option
Option 3	Lowest Whole Life Cost (WLC)	This option is a programme of investments developed to achieve the lowest total cost of CAPEX incurred over the operational life of the assets based on unconstrained service risk measures.	• Option provides the highest benefit of all options. • Option has the lowest payback period.	• Most expensive option (11% higher than option 1A)
Option 4	Availability and Reliability Risk Stable	In this option the Availability and Reliability service risk measure is constrained only, and other service risk measure are left unconstrained.	• Achieves the highest total monetised risk benefit. • This option provides the highest risk benefit in all service risk measures. • Payback period within the 20 year period.	• 2nd most expensive option •

9 Preferred Option and Project Plan

9.1 Preferred Option

9.1.1 The preferred option to manage our electrical assets is **Option 1.** Our programme of electrical investments 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: Post Deliverability** which includes the mix of interventions listed in Table 33.

Table 33: Preferred option summary (£, 2023/24)

Intervention	Primary Driver	Volume	Unit of Measure	% Assets Intervened Upon	Total RIIO-GT3 Request	Funding Mechanism	PCD Measure
[redacted] Earthing & Lightning System Remediation	AH Legislation	[redacted]	Per Site	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Column Light - Replace Column, Luminaire and Cable	AH Risk Management	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Column Light - Replace Luminaire and internal column cable	AH Risk Management	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Electrical Cabling Replacement	AH Risk Management	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Hazardous Area lighting - replace luminaire and cable	AH Legislation	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Miscellaneous Electrical Assets Major Refurbishment	AH Risk Management	[redacted]	Per Site	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Miscellaneous Electrical Assets Replacement	AH Risk Management	[redacted]	Per Site	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Non-Hazardous Area lighting - replace luminaire and cable	AH Legislation	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Refurbishment of Earthing & Lightning Protection Systems (Large Site)	AH Legislation	[redacted]	Per Site	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Refurbishment of Earthing & Lightning Protection Systems (Small Site)	AH Legislation	[redacted]	Per Site	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Survey of Electrical Assets	AH Risk Management	[redacted]	Per Site	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
	Total	**4,464**			**£18,652,227.00**		

9.1.2 To deliver the required outcomes for all our stakeholders, we have developed the most effective combination of efficient interventions to maintain stable risk across the RIIO-T2 and RIIO-GT3 periods and completed a robust deliverability assessment of this investment proposal within our wider capex investment programme (Option 1A).

9.1.3 We have developed these investments both from engineering assessment of the identified problems but also through undertaking risk based assessments using our Copperleaf Asset management decision support tool, underpinned by our NARMs framework. This combined plan forms our preferred programme of work on our Electrical Infrastructure.

9.1.4 Our preferred option of interventions manages known obsolescence risks, addresses safety risks posed by our current assets and rising levels of defects on these installations to ensure these systems continue to support our critical site operations whilst managing the cost to consumers.

9.1.5 It can be delivered effectively within outage constraints on our stations and ensures appropriate levels of site and asset availability to deliver effective and efficient network operations.

9.1.6 The preferred option for Site Lighting, Earthing and Lightning Protection delivers £15,04m of NARMs Long Term Risk Benefit with our full programme of electrical infrastructure investment in RIIO-GT3 delivering £43.6m.

9.1.7 The outputs from this investment will be included in the Non-lead asset PCD reporting mechanism, and cost variance managed through the TIM mechanism.

9.2 Asset Health Spend Profile

9.2.1 The spend profile, in Figure 12, provides an indicative view on when the above interventions are to be carried out for our Electrical Infrastructure Site Lighting, Earthing and lightning protection and miscellaneous electrical asset investments.

9.2.2 Our programme of investment on our Electrical Infrastructure Site Lighting, Earthing and Lightning Protection, and miscellaneous electrical 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.

9.2.3 A increase in our lighting intervention programme is forecast across the RIIO-GT3 period. Supply chain analysis against our current supply chain partners [redacted], shows available capacity to deliver this increased investment programme without needing to modify our existing supply chain framework.

9.3 Investment Risk Discussion

9.3.1 The risk associated with our preferred options revolves around the difference in condition between the information utilised to build our investment proposals, defect information, defects identified through construction surveys at the time of delivery. This has the potential to increase the scope in excess of that identified through the development of the plan.

9.3.2 Our costs have been built through unit cost analysis and estimates from the market, however there is a risk that costs of materials may increase due to macro-economic conditions and the demand from other operators of electrical infrastructure. This shall partly be mitigated through the CPI-H inflation and real price effect mechanisms within our RIIO-GT3 regulatory framework

9.3.3 Key risks and currently identified mitigations are summarised in Table 34.

Table 34: Electrical Infrastructure key risks and identified mitigations

No.	Risk	Mitigation (based on current view)
1	There is a risk of additional scope requirements (including electrical, design and civil) leading to scope change / scope creep	Close engagement with contractor and site operations, development of standard scopes to capture baseline requirements early in the development process.
2	There is a risk of outage issues (prior, during or post mobilisation)	Assessed through our deliverability assessment and shall be monitored through our plan delivery.
3	There is a risk of unavailability / delayed delivery of long lead items, e.g. transformers	Frequent communication with Contractor to ensure that Long Lead Items are ordered,
4	There is a risk of additional works after commissioning relating to unresolved defects	Known concern due to nature of the discipline. Project to produce a commissioning plan and report, and investigation methodologies to minimise impact of identification and rectification processes

9.4 Project Plan

9.4.1 Project delivery has been split into three phases, as shown in Table 35, which align with our Network Development Process (ND500) as follows. Commissioning dates are not relevant to all intervention types but take place at the end of the delivery phase.

Table 35: Delivery phase alignment with ND500

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)

9.4.2 Table 36 shows the summary plan and provisional delivery phases for Electrical Infrastructure sanctions within RIIO-GT3, for the investments within scope of this paper. An annual sanction approach for all electrical infrastructure investments is proposed to ensure efficient bundling of investment, with delivery of this investment bundled with investments from our wider capex investment plan.

Table 36: Electrical Infrastructure Portfolio Programme for RIIO-GT3 period

Sanctions	RIIO-T2		RIIO-GT3						
	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33
T3_Sites_AH_Electrical_FY31									
T3_Sites_AH_Electrical_FY28									
T3_Sites_AH_Electrical_FY30									
T3_Sites_AH_Electrical_FY29									
T3_Sites_AH_Electrical_FY27									

9.5 Key Business Risks and Opportunities

9.5.1 Changes to supply and demand scenarios are unlikely to impact upon the proposal in this EJP. Significant changes could mean that particular assets or sites become redundant which would remove the need for some interventions, but this has been assessed through our network capability analysis as defined within our Network Capability assessment and through the development of this electrical infrastructure investment programme.

9.5.2 Our programme of investment on our Electrical infrastructure site lighting, site earthing and lightning protection systems and miscellaneous electrical investments 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.

9.5.3 A transition to hydrogen for NTS sites would still require supporting electrical infrastructure, to enable asset operations.

9.6 Outputs included in RIIO-T2 Plans

9.6.1 In RIIO-T2 our investment in electrical infrastructure focussed on addressing defective and obsolete assets on compressor stations. A programme of surveys was undertaken during the design development stage of the project, and this included surveying neighbouring AGIs to the compressor stations. No investment within this EJP has been deferred from RIIO-T2, however investment was identified and planned for delivery in RIIO-T2 on our AGI distribution assets, although not included as outputs in our RIIO-T2 determination. Due to funding constraints these investments have been included into our RIIO-GT3 investment plan and are included within the Electrical Infrastructure funding request.

10 Appendix

10.1 Appendix 1 - Bottom up plan intervention volumes

10.1.1 Table 37 presents the bottom up intervention volumes proposed across our electrical infrastructure portfolio. Interventions highlighted in yellow are within the scope of this engineering justification paper.

Table 37: Bottom Up Intervention Volumes (£, 2023/24)

Intervention	Pre Deliverability Bottom Up Volumes	Pre Deliverability Bottom Up RIIO-GT3 Investment Value £ (23/24)		Post Deliverability Bottom Up Volumes	Post Deliverability Bottom Up RIIO-GT3 Investment Value £ (23/24)
[redacted]					

Intervention	Pre Deliverability Bottom Up Volumes	Pre Deliverability Bottom Up RIIO-GT3 Investment Value £ (23/24)		Post Deliverability Bottom Up Volumes	Post Deliverability Bottom Up RIIO-GT3 Investment Value £ (23/24)
[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
[redacted]	[redacted]	[redacted]		[redacted]	[redacted]

10.2 Appendix 2 - Electrical Survey Reports

Files Provided

- [redacted]
- [redacted]

10.3 Appendix 3 - [redacted] Earthing and Lighting Protection system

Files Provided

- ERM R1156 Earthing Condition Assessment for [redacted] GCS_i1

10.4 Appendix 4 - Cost Breakdown

Intervention Name	External Cost	External %	NG Cost	NG %	Pre build Cost	Pre build %	Materials, Plant & Equipment cost	Materials, Plant & Equipment %	Risk & Contingency cost	Risk & Contingency (% of total cost)	Total
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			[redacted]
Intervention Name	**External Cost**	**External %**	**NG Cost**	**NG %**	**Pre build Cost**	**Pre build %**	**Materials, Plant & Equipment cost**	**Materials, Plant & Equipment %**	**Risk & Contingency cost**	**Risk & Contingency (% of total cost)**	**Total**
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			[redacted]
[redacted]			[redacted]	[redacted]	[redacted]	[redacted]			[redacted]	4%	£4,614.12