national gas transmission

ENGINEERING JUSTIFICATION PAPER (EJP)

OFFICIAL- SENSITIVE

Valves - PCVs and FCVs

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RIIO-GT3 NGT_EJP24

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December 2024

Contents

1 Summary Table

Table 1: Summary table for Pressure Control and Flow Control Valves EJP

Name of Project	*Pressure Control and Flow Control Valves*		
Scheme Reference	NGT_EJP24_Valves: PCVs and FCVs_RIIO-GT3		
Primary Investment Driver	*Asset Health*		
Project Initiation Year	*FY2026*		
Project Close Out Year	*FY2032*		
Total Installed Cost Estimate (£m, 2023/24)	Baseline: 77.25		
Cost Estimate Accuracy (%)	+/- 50% (Highest value, most interventions are +/- 10%)		
Project Spend to date (£)	*0*		
Current Project Stage Gate	*Stage 4.0*		
Reporting Table Ref	*6.4, 6.5*		
Outputs included in RIIO-T2 Business Plan	*No*		
Spend apportionment	**RIIO-T2 (£m 2023/24)**	**RIIO-GT3 (£m 2023/24)**	**RIIO-GT4 (£m 2023/24)**
	0.86	72.97	3.42

2 Executive Summary

2.1.1 This paper proposes £77.25m of funding to address defects/ obsolescence/ redundancy on 86 (7.4%) of our Pressure Control Valve (PCVs) and Flow Control Valves (FCVs) population in RIIO-GT3. It is part of our Valves Investment Decision Pack (IDP) which requests a total of £286.3m in 2023/24 prices, this is shown in Table 2 below. The delivery of this program will be measured through our Asset Health Network Asset Risk Metrics (NARMs) and Redundant Assets Price Control Deliverables (PCDs).

Table 2: Valves IDP investment request (£m, 2023/24)

Valves	Actuators	Pressure & Flow Control Valves	Bypass Installation & Modification	Total
Baseline: 110.64 Uncertainty Mechanism: 3.32 Total: 113.96	Baseline: 17.20	Baseline: 77.25	Baseline: 36.91 Volume Driver: 41.01 Total: 77.92	Baseline: 242.00 Uncertainty Mechanism: 3.32 Volume Driver: 41.01 Total: 286.33

2.1.2 There are 1691 interventions required across our pressure and flow control valves and over pressurisation safety systems to ensure operation of these critical operational assets. These assets are utilised to maintain pressure and flows as part of our efficient network operations. Any loss of functionality has the potential to result in interruptions to the supply of gas to our customers, has the potential to result in damage to operational assets from over pressurisation events and impacts on our ability to manage network capability against the varied supply and demand patterns that our network experiences. To ensure continued operation, we need to ensure we modify their design to meet industry guidance, invest to address asset deterioration, obsolescence and address the impact these assets have on the environment. It is important we deliver a stepped increase in PCVs/ FCVs investment during RIIO-GT3 to ensure future network risk levels are not compromised.

2.1.3 These interventions are required to reduce increasing risk across RIIO-GT3, while also factoring deliverability of the interventions in terms of outage, resource and supply chain constraints. These are part of our preferred option (Option 1A post deliverability) for our Valves IDP. PCVs / FCVs interventions have a NARMS Long-Term Risk Benefit (LTRB) of £6.61m.

2.1.4 We considered several interventions across our PCV and FCV portfolio and overpressure protection systems to establish an optimal programme that would deliver desired regulatory outputs. In summary, we are proposing the intervention mix shown in Table 3.

Table 3: Volumes of interventions and their classification types

	Replacement	Overhauls	Decommission	Survey	Total
PCVs/FCVs interventions	[redacted]	[redacted]	[redacted]	[redacted]	86
Overpressure protection of relief valves / HIPPS	[redacted]	[redacted]	[redacted]	[redacted]	1605
Total	[redacted]	[redacted]	[redacted]	[redacted]	**1691**

2.1.5 As part of our **RIIO-T2 Plant and Equipment Uncertainty Mechanism** submission, we have proposed a revised unit cost and delivery volume for PCVs/FCVs investment. In RIIO-T2 we will have delivered fewer interventions on PCVs/FCVs than our original allowance due to this change. A comparison of RIIO-GT3 volumes and investment compared to RIIO-T2 are shown in Table 4.

Table 4: Volumes of investment in in RIIO-T2 compared to RIIO-GT3 (£m, 2023/24)

	RIIO-T2 PCVs / FCVs Baseline & Uncertainty Mechanism	RIIO-T2 PCVs / FCVs Forecast Delivery	RIIO-GT3 Business Plan (PCVs / FCVs)	RIIO-GT3 Full Business Plan
Intervention count	72	74	86	1691
Investment	17.8	18.6	57.9	77.3
% of PCVs/FCVs population	6.2%	6.4%	7.4%	

2.1.6 The significant volume of investment in RIIO-GT3 is predominantly driven by our proposed investment on overpressure protection relief valves ([redacted] volumes), alongside our High Integrity Pressure Protection Systems (HIIPS), which are new themes in RIIO-GT3, to protect assets against overpressure scenarios. These are installed on pressure vessels that could be undersized resulting in hazardous, safety events. It is an achievable intervention as it involves repeatable calculations done on relief valves to meet legislative compliance.

2.1.7 Table 5 shows the intended PCVs / FCVs investment profile in RIIO-GT3.

Table 5: PCVs / FCVs RIIO-GT3 funding request spend profile (£m, 2023/24)

Asset	2026	2027	2028	2029	2030	2031	2032	Total	Funding Mechanism
PCVs/FCVs	0.86	5.15	8.83	16.31	21.88	20.81	3.42	**77.25**	Baseline

3 Introduction

3.1 Asset Overview

3.1.1 This EJP provides justification for RIIO-GT3 investments in our 10-year Pressure Control Valves and Flow Control Valves programme. These interventions have been developed to manage the health of PCVs / FCVs across the fleet, address defects, redundancy, environmental emissions and obsolescence and safety concerns of 86 (7.4%) of our PCV / FCV population in RIIO-GT3.

3.1.2 Regulator streams, compromising flow control and / or pressure control valves are installed on the NTS to enable the supply of certain volumes of gas at a set pressure to certain locations. Pressure control valves are primarily a safety function used to limit pressure in a downstream system to a safe level while flow control valves are designed to control flow and to some degree, pressure across the NTS to optimise network operation.

3.1.3 Learning from investment building and submission experience in RIIO-T1 and RIIO-T2, we have moved from a qualitative and quantitative decision approach to a data driven asset management approach. PCVs / FCVs programmes are bottom-up plans built using defect, redundancy, and obsolescence information (verified by stakeholders across the business).

3.1.4 A programme commenced in RIIO-T2 to start to replace obsolete and / or defective pressure control valves and flow control valves and this is proposed to continue into RIIO-GT3.

3.1.5 However, the type of intervention we have proposed in RIIO-GT3 to replace whole regulator streams, comprising multiple PCVs / FCVs and associated control systems. Learnings from RIIO-T2 delivery, where challenges with fitting new valves within existing streams and limited outage windows to delivery outputs without affecting customers and consumers have been taken into account in our intervention development.

3.1.6 The scope of this document is aligned with our Asset Management System (AMS) and three of our Business Plan Commitments (BPCs). More information on our AMS and a description of our commitments is provided in our **NGT_A08_Network Asset Management Strategy_RIIO_GT3** and our BPCs are detailed within our **Main Business Plan**. The BPCs are as follows:

- Meeting our critical obligations every hour of every day.
- Delivering a resilient network fit for the future.
- Ensuring world class safety levels of our workforce and the public

3.1.7 The decisions made upon assessing the PCVs / FCVs investments as part of Valves Investment Decision Pack (IDPs) have interactions with other Investment Decision Packs:

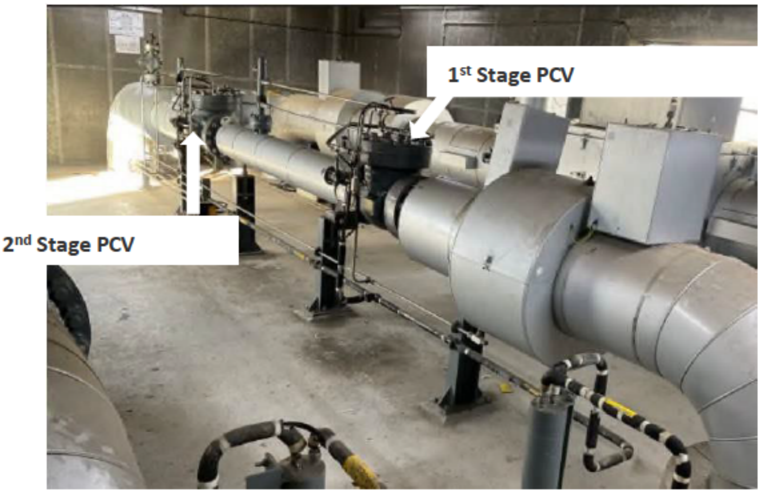
- **NGT_EJP02_Site Assets - Preheating, Filters & Pipework_RIIO-GT3** – Any changes to PCVs / FCVs including decommissioning would mean associated preheat may need to be modified to suit new requirements i.e., removal or modification.

4 Equipment Summary

Pressure Control Valves

4.1.1 Pressure reduction streams comprising Pressure Control Valves (PCVs) are typically pneumatically operated installations used to control the pressure between two different pressure tiers. Their prime purpose is a safety function to control and regulate the pressure into the downstream pipeline or pipework. This could be utilised to manage pressure tiers and a boundary interface within the NTS (e.g., where a 70-bar pipeline connects to a 75-bar pipeline) or at the extremity of the NTS where we connect to downstream customers.

4.1.2 PCVs are configured in a stream arrangement with usually a two-stage valve (regulator) arrangement. This configuration is utilised because each valve is only able to reduce to a certain pressure without excess vibration/noise, necessitating a series of pressure control valves in series. Figure 1 shows an example of PCVs.



[redacted].

4.1.3 Within the regulator stream, a number of additional assets to the PCVs are installed. These include non-return valves; valves that are used for stream discrimination, and a slam-shut valve, which is utilised to prevent over-pressurisation of the downstream supply. These are included within the scope of our investment.

4.1.4 Figure 2 shows a simplified view of a twin stream pressure regulator, similar to those installed on our network offtakes. This contains two pressure control valves, inlet and outlet isolation valve and slam shut valve. On some installations the slamshut acts as the inlet isolation valve. A relief valve (creep relief valve) can be installed on these streams. This is a safety device that is used to release pressure that builds up in our pressure regulator stream when demand is low, or zero flows are seen. This avoids damage occurring to our assets due to these flow conditions.

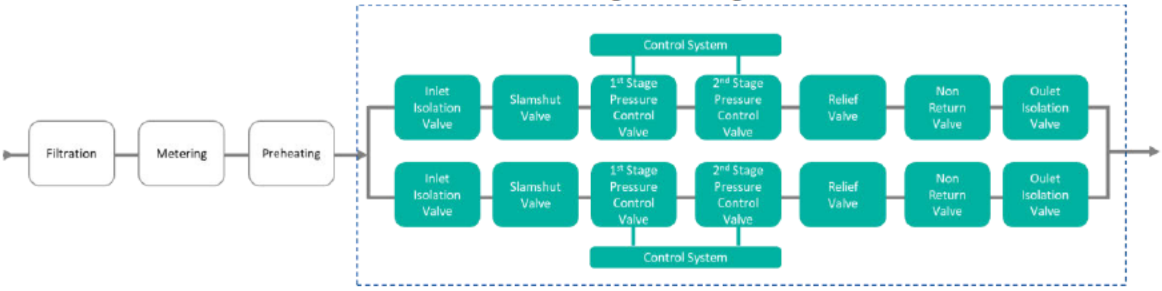


Figure 2: Regulator Stream Arrangement

4.1.5 Across the NTS we have 1098 pressure control valves, contained within various installation assemblies. These assets are installed into several types of installations:

- Main Process Regulators
- Boundary Control Regulators
- Preheating Fuel Gas Regulators
- Compressor Fuel Gas and Power Gas Regulators

4.1.6 Further details of these installations can be found in Appendix 1- Pressure Control Valves and Flow Control Valves Equipment Summary.

Flow Control Valves

4.1.7 Flow Control Valves (FCVs) are installed on the NTS to control the flow of gas and, to some degree, pressure between two or more sections of pipework. FCVs are installed on Multi-junctions across the NTS and control flow volumes down a certain feeder and are critical to managing the flexibility, operation and linepack of the NTS, ensure we meet pressure and flow requirements from our customers. We have 61 flow control valves in total.

4.1.8 Multiple FCV streams can be installed on a single site if different functionalities are needed that cannot be managed with a single stream, such as where a multijunction has multiple connected feeders. Multiple FCVs also provide resilience should maintenance be required on assets within a given stream, due to the critical functionality of these systems.

4.1.9 An example of this is at [redacted] where three FCVs operate in parallel at the site (Figure 3). They are used to manage bulk north-south transmission along Feeders 10 and 11 and associated pressures. Given the limitations in the volume that each valve can control three streams are required, usually operating in two working and one standby stream arrangement.

Figure 3: [redacted] Flow Control Valve

4.1.10 Table 6 shows the equipment count for PCVs / FCVs. Additional information on this equipment group such as the asset health score at the beginning and end of the price control and monetised risk are provided in the accompanying **NGT_IDP10_Portfolio EJP Valves_RIIO-GT3**.

Table 6: PCVs / FCVs equipment count.

Actuator types	Equipment counts
Pressure Control Valves	1098
Flow Control Valves	61
Total	**1159**

Pressure relief valves

4.1.11 We have [redacted] mechanical pressure relief valves (PRV) that are currently installed across our operational network. These are present as pressure protection for our assets as they can be lower rated due to some of the higher pressures typically seen on the NTS.

5 Problem/Opportunity Statement

5.1 Why are we doing this work?

5.1.1 Our investments on our PCVs and FCVs seeks to ensure they remain in a safe condition, are reliable and maintainable and are fit for purpose for the duty that is required from them.

5.1.2 In developing our investment proposals, we have considered a range of investment drivers, which are detailed below. These issues are applicable to all types of PCVs and FCVs.

Legislation

5.1.3 Defective equipment or equipment with poor control functionality can result in a lack of compliance with Pressure Systems Safety Regulations (PSSR) legislation.

Efficient Operation

5.1.4 Most PCVs on the NTS are [redacted] These PCVs were developed in the late 1980s/early 1990s specifically to suit the requirements of gas fired power station. Over the years the power station requirements have changed (increase or decrease in flow, increase ramp rates, non-continuous running) and now in some instances the PCVs suffer from performance issues including those related to mechanical vibration.

5.1.5 Our current PCVs can be tuned for either high flow, or low flow performance, but cannot be effectively tuned to meet both extremes meaning that they suffer from performance issues which manifest as pressure/flow fluctuations at site outlet. This results in unstable outlet gas flow characteristics, impacting the operations of our customers and leading to customer complaints.

Industry Guidance

5.1.6 Some of our PCVs and FCVs do not meet current design standards (IGEM/TD/13). IGEMs IGEM/TD/13 requires stream discrimination, i.e., both streams operating independently of each other and two safety devices per stream. To achieve stream discrimination, [redacted]. This can require complex pneumatic or electronic systems to manage this interaction which adds complexity and operational costs to manage.

5.1.7 Our current PCVs/FCVs were not designed to give bubble-tight shut off, meaning that during periods of non-flow the downstream pressure slowly increases to a point where the creep-relief valve operates causing a venting of natural gas. With more variation in flow conditions due to the flexibility of gas sources periods of low and no flow are more likely, resulting in the operating of our creep relief valves.

5.1.8 [redacted] Downstream customers will also have further devices. This means that there are multiple control devices connected in series which results in equipment falling out of synchronisation with the customer owned pressure control devices. This causes pressure and flow fluctuation that affects the downstream customers process and efficiency of their processes and outputs which customers are not happy about.

5.1.9 Our older installations do not comply with IGEM/TD/13 standard for the following reasons.:

- The installations have no non-return valves and creep relief valves installed within them. These devices are used to protect the installation from overpressure events, which can result in diaphragm rupture within the pressure control valves.
- [redacted] in accordance with IGEM/TD/13

Environmental Emissions

5.1.10 Many of our PCVs/FCVs control packages are methane operated venting systems, where methane is constantly vented through their operation.

5.1.11 A study was undertaken by [redacted] To mitigate our impact on the environment we are seeking approaches to manage these emissions from our own operation e.g., moving to electrically controlled systems for PCVs/FCVs.

5.1.12 Not investing will continue to mean more harmful emissions of methane into the environment.

Obsolescence

5.1.13 The existing [redacted] PCVs are obsolete, having been designed in the 1980s. They are no longer supported by manufacturers and due to the age of the assets have limited overhaul and refurbishment options. New PCVs are found to have differing flange-to-flange dimensions compared to the existing valves. This necessitates modification of the stream pipework, associated impulse pipework, pipe supports and ancillary assets resulting in a significant project undertaken to complete.

5.1.14 Twenty of our FCVs across 12 sites have Pneumatic Control systems, using natural gas as the control medium, that are made up of obsolete, and unsupported components. These control systems are typically made up of a minimum of one, and in some cases a maximum of 4, [redacted] and various other components.

5.1.15 We have limited viable spares to keep these control packages functioning. The only known external source of support ceased trading in late 2022. Lack of functionality of the control system can mean the National Control Centre (NCC) cannot remotely control the FCV, and the valve can fluctuate from its set-controlled point affecting the desired level of control.

5.1.16 Replacement devices cannot always be accommodated within the existing control systems due to space restrictions. The photos in Figure 4, show the control systems at Longtown and Roxwell. The identified components are the affected control components. Replacement components of the same duty have differing dimensions and configurations and will not fit without completely remodelling the cabinets.

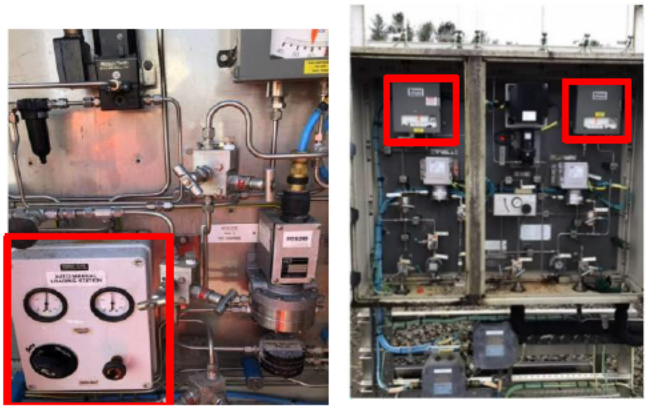


Figure 4: Controllers of varying design, size that impacts retrofitting.

5.1.17 Fuel Gas/Domestic Gas Supply Pressure Regulator Skids are installed on our Above Ground Installations (AGIs) to provide low pressure gas to other process assets (Valve actuators, preheating) and Multistage Pressure Reduction Skids installed on our compressor stations to provide fuel gas to gas compressors. In these installations several PCVs are installed in series configuration. Given the challenges with PCVs, they may require significant modifications to pipework due to the flange-to-flange distance of the new valve being different to the existing valve. This can involve not only the main process pipework, but impulse pipework used for the control of PCVs/FCVs.

Change in Network Conditions

5.1.18 The majority of our FCVs assets were installed in the period from the mid 80's to late 90's. In the years since installation, the way the NTS needs to be operated has changed in line with the changes to overall network flows.

5.1.19 The primary change relates to a reduction in North South transmission and the development of LNG Terminals in the South-East and South-West. The result is that the profile of gas flow has significantly changed across the NTS and, in some cases this means that the original control intent for our FCVs is not how they currently need to operate, resulting in control issues and pressure constraints affecting the efficiency of network operations. The table below summarises key changes:

Table 7: FCVs affected by changing network conditions.

FCV Site	Key Issues
[redacted]	Capacity Deficiency: Only capable of flowing [redacted]), and therefore FCV currently by-passed due need to control higher volume. Obsolete controller installed. Our System Operator have confirmed that the FCV is needed in the future to control flows on the NTS and is also utilised as a primary pressure protection system separating 75/70 barg pressure boundary. Failure to invest means the network lacks capability in certain supply and demand scenarios.
[redacted] FCV	Capacity Deficiency: FCV is only capable of flowing [redacted] in very poor condition and has obsolete controllers. Bi-direction capability is required and there are critical issues with differential pressures when the bypass is closed. All of these provide issues for NCC operation.

Redundancy

5.1.20 Across several sites there are FCVs that are redundant to operational requirement. This is generally where there has been a change in the control requirements that now render this flow control valve redundant e.g., [redacted] FCVs where the valves are part of the operational gas stream, however, are sat wide open. In the event of defects occurring on the valves with the potential to affect network flows these will require asset health interventions. We seek to avoid undertaking asset health interventions on valves that provide no benefit to the operation of the network as that would not be good use of consumer money.

Pressure Relief Valves

5.1.21 [redacted]

5.1.22 Legislation (PSSR and Health and Safety at Work Act) requires that vessels are protected against hazardous overpressure scenarios. However, where protective devices are installed, there is generally no documentation to show the basis of design, the sizing and dispersion calculations or mechanical consideration. All of this is required to be compliant.

5.1.23 In the event of an incident, the initial enquiry would seek the available documentation and evidence of the suitable sizing of these over pressurisation assets, and [redacted] in addition to this documentation, we need to ensure that any calculations undertaken that show undersized relief valves are mitigated to avoid the risks.

HIPPS

5.1.24 Regular inspections by HSE COMAH (Control of Major Accident Hazards) inspectors triggered a HSE Action Legal at [redacted] in 2022 which concluded that we could not assume that protection measures owned by upstream suppliers are effective and needed to ensure its own High Integrity Pressure Protection Systems (HIPPS) met a Safety Integrity Level (SIL) 2 rating.

5.1.25 No such installation was installed at the terminal and therefore we commenced a project to install a HIPPS on all of the [redacted] and [redacted] incomers into the terminal.

5.1.26 The installation of HIPPS was not a common design standard at the time our sites were installed and therefore we need to investigate the requirement for HIPPS across our other gas entry points, including [redacted]

5.1.27 The consequence of pressure exceedance may result in failure of pipework and loss of containment. This could lead to injury and fatality.

5.2 What is the outcome we want to achieve?

5.2.1 Our investment seeks to ensure that the following outcomes are achieved:

- Conformance with the legal obligations of PSSR: Lack of investment in the remediation of failures found during inspections will also render the assets unable to be used in a pressurised environment.
- For each Flow Control Valve/Pressure Control Valve as per **NGT_IDP10_Portfolio EJP Valves_RIIO-GT3** to perform the duty required of it to manage the flexibility, operation, and line-pack of the NTS such that failure to meet network pressure/flow control demand is mitigated.
- For each Offtake Pressure Reduction system to reliably provide customers with gas at the required pressure/flow and to operate to reliably protect the downstream network from over pressurisation.
- A complete, or significant reduction in our environmental impact caused by the current continual venting of gas to atmosphere from obsolete control systems.
- Manage obsolescence affecting assets in a planned manner, preventing multiple asset management risks that require swift mitigation with limited supportability.

5.3 How will we understand if the spend has been successful?

5.3.1 The investment plans will be considered to be successful when the outcomes summarised above are met.
5.3.2 Reduction in risks across NARMs service risk levels.

5.4 Narrative Real-Life Example of the problem

PCV – [redacted]

5.4.1 The operating conditions and requirements of the power station have changed over recent years. The power station now has a higher maximum flow requirement as well as a low flow requirement. Both changes potentially contributed to vibration related failures within the PCV. In one instance, internal components within a PCV suffered vibration related failure.

5.4.2 We have experienced two instances of vibration related failure at [redacted] the first being where internal components within a PCV failed due to vibration induced fatigue, see Figure 5.

[redacted]

5.4.3 The component shown connects to and indicates - via other connected parts - the position of the regulator piston. The loose, broken part, then caused damage shown in the original Left-hand image. It damaged the piston preventing the regulator operating smoothly. It was determined that vibration related fatigue failure caused the end of the component to break off in service.

5.4.4 The second incident occurred at [redacted] in January 2019 (shown in Figure 6) where a significant gas leak occurred when a section of pipework on a PCV stream cracked causing a significant, RIDDOR[1] reportable, gas leak.

[1] Reporting of Injuries, Diseases and Dangerous Occurrences Regulations - RIDDOR

Figure 6: [redacted] *PCV*

5.4.5 In both instances, the repetitive on/off nature of the running of the power station, as opposed to steady-state running was shown to be a contributory factor.

5.4.6 A project, completed in Q1 of 2022, and shown in Figure 6 to install a pair of new PCV streams at the site has reduced vibration to almost negligible levels. The long-term vibration monitoring programme is ongoing and has – to date – identified vibration related concerns at several other Pressure Regulating installations.

PCV Control System – Keadby

5.4.7 [redacted] failed. Spares are no longer being able to be obtained due to the age and obsolescence of the PCV. A replacement PCV was identified, [redacted] as a direct replacement within the same flange to flange dimensions and the required performance duty to meet the inlet and outlet pressures.

5.4.8 However, the model 270 is internally impulse and the model 372 requires external impulse source. The design of the existing installation is such that there is no provision for that impulse arrangement. Additionally, the physical dimensions of the Model 372 are also such that the whole stream would need to be re-engineered due to other existing pipework clashing with the physical envelope of the model 372.

5.4.9 Carrying out those modifications would result in a system engineered to suit the model 372 regulator that would be at risk of needing further remodelling in the event of failure of a different component.

5.5 Project Boundaries

5.5.1 Our investment on our Pressure Control Valves and Flow Control Valves includes all types and configurations of pressure and flow control valves installed in the NTS.

5.5.2 It includes all assets within our regulator streams between the inlet and outlet isolation valves, including PCVs and FCVs, main process pipework, impulse pipework, slam-shuts and non-return valves. This is highlighted in Figure 2.

5.5.3 Out of scope are the pressure control valves and flow control valves being intervened on in RIIO-T2. These are shown in **Appendix 2**.

5.5.4 PCVs / FCVs interventions specifically at the St Fergus gas terminal – these will be covered under the **NGT_EJP29_St Fergus: Valves and Actuators_RIIO-GT3**.

5.5.5 No PCVs / FCVs at Bacton gas terminal are considered in this paper.

5.5.6 The buildings that contain these assets, if this is applicable, are out of scope and included within the **NGT_EJP19_Civils_RIIO-GT3**.

6 Probability of Failure

6.1 Failure Modes

6.1.1 Probability of failure (PoF) has been assessed both utilising historical defects but also utilising our Network Asset Risk Metric (NARMs) model 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 historic defects.

6.1.2 Not all modelled failures will result in real-world asset failure and this forecast is not a prediction of how many defects will be identified. Failures help determine the likelihood of a consequence occurring for each asset. Assets can have multiple failure modes and the impact of failure depends on factors like the asset's age, location, and criticality. A failure may lead to various service risks, including environmental, health and safety, availability, and reliability, societal or financial impact.

6.1.3 Likely failure modes for PCVs / FCVs with an average proportion of failures of 0.5 or above are provided in Table 8. The full list of failure modes is available in the NARMS methodology.

Table 8: PCVs / FCVs failure modes

Failure mode	Average proportion of failures
Corrosion no leak	0.52
Loss of stream regulator slam shut – trip	0.53
Failure of compressor gas seal	0.64
Unable to wash engine	0.54

6.1.4 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. Please see **NGT_A01_Asset Management Plan (AMP)_RIIO_GT3** for more details on failures vs defects.

Table 9: Forecast PCVs / FCVs failure rates and failures per year.

Asset Type	No. of Assets	Cumulative Average Forecast Failure Rates					Forecast Failures per Year				
		2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
FCVs	61	0.90	0.91	0.92	0.93	0.94	1.70	0.83	0.53	0.51	0.53
PCVs	1098	0.53	0.55	0.57	0.59	0.62	23.92	24.05	24.60	24.78	25.48

6.1.5 Pressure control valves and flow control valves do not immediately fail, however deteriorate through operation. The forecast defect rates include faults and issues that will not result in an immediate failure, however a combination of these issues will. Our asset health campaign seeks to manage these assets to ensure they continue to perform their critical function for managing pressure within the network for our customers.

Historical defects

6.1.6 Defects are raised through inspection and maintenance activities and captured within our Maximo defect management system. Asset equipment data was extracted from Maximo in April 2024.

6.1.7 We have assessed the defects from our defect management system, our data repository within Maximo. As of April 2024, 131 defects had been raised against our PCVs and FCVs since 2006. This includes defects that have been closed and those still currently open. Of these defects, 55 have been raised against FCVs and 77 against PCVs.

6.1.8 Figure 7 plots these defects over time against both sets of assets. It can be seen that there was a peak in raised defects in 2018 followed by ongoing levels higher than previously experienced.

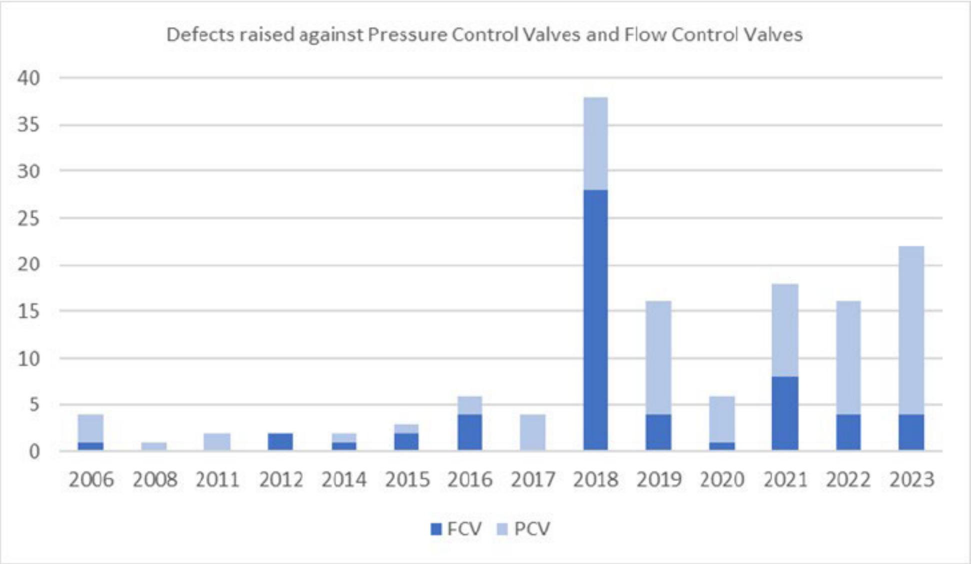


Figure 7: Defect rate for PCVs and FCVs

6.1.9 Table 10 below, shows the volume of defects against our PCVs by fault categorisation, split by capex and opex.

6.1.10 A significant number of PCV defects are categorised against regulators that have failure during operation, where main process streams and impulse pipework are impacted by vibration related issues. A significant number of FCV defects are categorised against assets with obsolete control packages presenting issues with our ability to control flow in network operations, our ability to service these assets and obtain parts to rectify faults.

Table 10: Defect Categorisation

Capex	PCV Defect Count	FCV Defect Count
Corrosion	7	8
Obsolescence (Control Package and Regulators)	6	30
Regulator Failure (Failed, not sealing etc)	18	2
Slamshut Failure	7	1
Policy Compliance	2	0
Redundant Equipment	1	0
Vibration Issues requirement asset modifications	18	0
Regulator Capacity	1	3
Total Capex	**60**	**44**
Opex	**PCV Defect Count**	**FCV Defect Count**
Fault Rectification	15	11
Labelling & testing	1	0
Total Opex	**16**	**11**

6.1.11 To understand the condition of our PCVs and our FCVs, FEED studies have been completed on a cross section of these assets. Copies of these studies can be found in **Appendix 3**.

Probability of Failure Data Assurance

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

6.1.13 Information captured from FEED studies, completed through our RIIO-T2 project delivery was utilised to inform the condition of our installations.

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

7 Consequence of Failure

7.1.1 This section of the EJP shall provide an overview of the consequence of failure for our PCVs and FCVs assets. Table 11 presents the consequences of failure for the various types of PCVs and FCVs. Consequence of failure information has been mapped against our NARMS service risk measures.

Table 11: Consequence of Failure for Pressure Control Valves and Flow Control Valves

Sub-Asset Type	NARMS Service Risk Measures		
	Availability	Environment	Safety
Pressure Control Valves - Offtakes	***This is the risk with the highest expected stakeholder impact.*** (1) This is associated with the failure of pressure reduction which has potential to affect the availability of third-party customers including power stations. (2) Failure of slamshut to close on demand could lead to downstream over pressurisation leading to loss of containment or over stressing of pipework. (3) Poor PCV control resulting in pressure fluctuations affecting customers' operational processes	(4) The continual venting of gas to atmosphere from obsolete control systems. (5) The loss of gas due to leaks from the equipment caused by a lack of a seal between two mechanical assets. (6) Venting of gas to atmosphere, due to bleed over non bubble tight regulators in zero flow states, caused by operation of creep relief valves	(7) This is associated with the possible risk of ignition and fires/explosions following a loss of gas event. This risk is small due to the low probability a of a fire/explosion event and the low chance of employees or staff being near the asset at the time of failure. (8) Continued use of these assets without investing in inspections, revalidation and remediation will breach legal obligations of PSSR.
Pressure Control Valves - Compressors	(9) Loss of compressor station (fuel gas/power gas) PCVs would lead to compressor unit unavailability, which can impact upon ability to manage network pressures efficiently. May need to run alternative units in a sub-optimal configuration. This could then mean increased emissions if it pushes us to use older/dirtier units which negatively affects environment. (10) Incorrect pressures can also lead to damage to the integrity of any downstream equipment.		
Flow Control Valves	As (2) above (11) Loss of main line pressure/flow control can lead to failure to meet network demand.		

7.1.2 Figure 8 and Figure 9 below present the modelled baseline risk over RIIO-GT3 for our FCVs and PCVs respectively, assuming no investment in the period.

7.1.3 The graph shows that for PCVs monetised risk starts RIIO-GT3 at £790k and reaches £969k at the end of the period, an increase of 23%. For FCVs, monetised risk at the start of RIIO-GT3 is £28k and reached £34k, a 23% increase. The overall value is lower due to having significantly less assets.

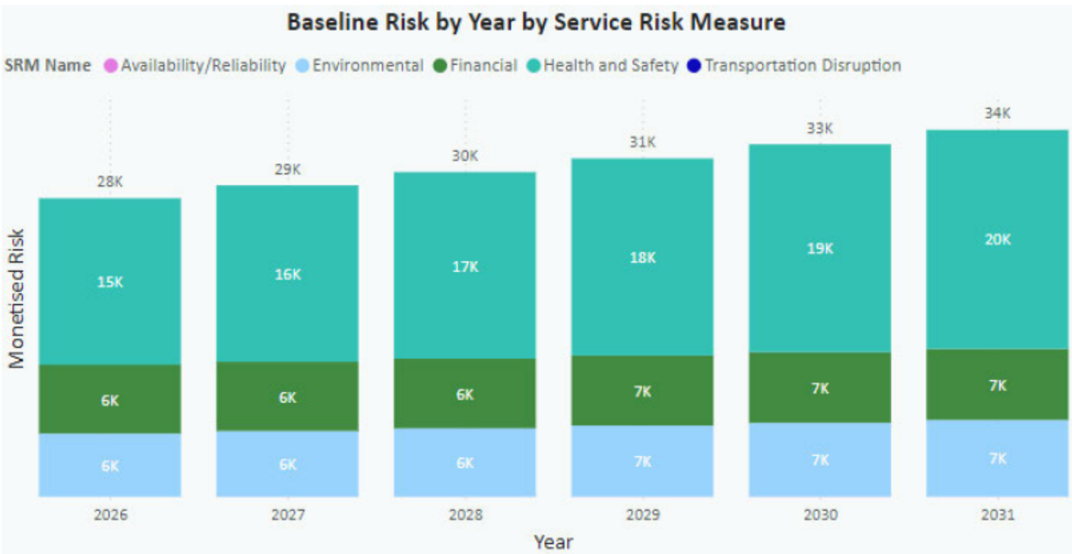


Figure 8: Flow Control Valve Baseline Risk

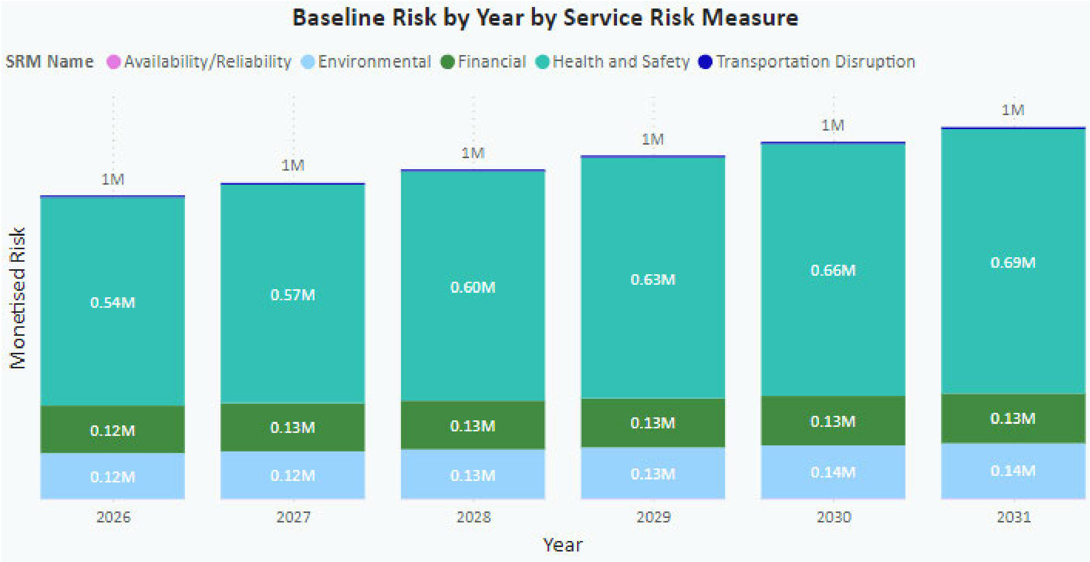


Figure 9: Pressure Control Valve Baseline Risk

8 Interventions Considered

8.1 Interventions

8.1.1 We have assessed a variety of interventions to meet the investment drivers defined within the problem statement. In considering the available investments our objective has been to develop a plan that balances and optimises cost, risk, and performance.

8.1.2 Where common investments exist across the types of PCVs and FCVs they will be presented once in the investment summaries below and include all relevant information across the different types of assets. Table 12 provides a summary of this mapping.

Table 12: PCV/FCV Intervention Summary Mapping

Investment	Main Process Regulators / Boundary Control Regulators	Compressor Regulator Skids	Fuel Gas Pressure Control Skid	Flow Control Valve stream	Combined Flow/Pressure Control Valve stream
Counterfactual (Do Nothing)	X	X	X	X	X
Replace Individual Regulator	X	X	X	X	X
Replace Regulator Stream	X			X	X
Decommission of Redundant Regulator Stream	X	X	X	X	X
Pressure Regulator PSSR Inspection Remedial Minor Refurbishment	X	X	X	X	X
Refurbishment of Flow Control Valve				X	X
Fuel Gas/Domestic Gas Supply Pressure Regulator Skid Replacement			X		
Replacement of Multistage Pressure Reduction Skid		X			

Counterfactual (Do Nothing)

8.1.3 The counterfactual intervention considers no specific action to be undertaken in RIIO-GT3 over and above our usual PCV/FCV maintenance and repair to meet the minimum level of intervention that would be required to remain complaint with all relevant safety regulations.

8.1.4 Maintenance and pressure system inspections are conducted on operational assets in accordance with policies T/SP/TR/18 Engineering of Pipelines and Installations Operating at Above 7 Barg & T/PM/PS/3 Ensuring Compliance with the Pressure Systems Safety Regulations 2000. Defects shall be rectified when budgets allow.

Pressure Regulator PSSR Inspection Remedial Minor Refurbishment

8.1.5 Progress defect remediation from defects identified from the statutory PSSR inspections completed in accordance with policies T/SP/TR/18 Engineering of Pipelines and Installations Operating at Above 7 Barg & T/PM/PS/3 Ensuring Compliance with the Pressure Systems Safety Regulations 2000.

8.1.6 This involves replacements of individual slam shut devices, replacement of corroded small bore impulse pipework.

Replace Individual Regulator

8.1.7 The replacement of an individual PCV within an existing regulator stream or multistage pressure reduction skid.

8.1.8 The PCV shall be of the same control technology to enable connection to the existing control system, the latter is not within the scope of this intervention.

8.1.9 The intervention to replace individual regulators can only be progressed where the dimensions of the stream permit installation of a new regulator which may be a different make/model into the existing stream.

Refurbishment of Flow Control Valve

8.1.10 The removal of the existing FCV to a workshop and complete refurbishment of the FCV through stripping down the valve, checking operation, replacement of soft parts, if these are available.

8.1.11 A spare FCV will be installed in place for the duration of the refurbishment process.

Replace PCV Stream / FCV Stream

8.1.12 This intervention proposes the replacement of the FCV, PCV stream in its entirety, including all assets from the inlet isolation valve to the outlet isolation valve, including slam shut and relief valve.

Pressure Control Valve

8.1.13 Replacement of all assets within the inlet and outlet isolation valves of the pressure regulator stream. This includes both first and second stage PCVs and the slam shut valve.

8.1.14 New streams will be configured to an Active regulator and Standby-monitor design, so that the influence of one control device can be removed from the chain.

8.1.15 The control package is proposed to be replaced, ideally with a non-venting package, such as electrical control valves with electronic controllers.

8.1.16 Where multiple PCVs streams are installed assessments of the condition, obsolescence status and control methodology of each of the PCV streams has been undertaken.

8.1.17 The stream would be manufactured offsite, pressure tested, and factory acceptance tested (FAT). It would then be transported to site with the old stream dismantled and the new stream lifted into place and connected within the same flange to flange distance.

Flow Control Valve

8.1.18 Replacement of the FCV, slam shut valve and associated control package, using electric or gas hydraulic control methodology.

8.1.19 All assets from the inlet isolation valve to the outlet isolation valve would be replaced.

8.1.20 The stream would be manufactured offsite, pressure tested, and factory acceptance tested. It would then be transported to site with the old stream dismantled and the new stream lifted into place and connected within the same flange to flange distance.

Fuel Gas/Domestic Gas Supply Pressure Regulator Skid Replacement

8.1.21 The replacement of a pressure reduction skid utilised on AGIs for Fuel Gas or domestic gas supplies to downstream connected systems, e.g., Preheating modular boiler packages.

8.1.22 The skid would be manufactured offsite, pressure tested, and Factory Acceptance Tested (FAT) reducing the outage requirements from a system that is crucial for the continuous operation of the connected systems and the site operations.

Replacement of Multistage Pressure Reduction Skid

8.1.23 The replacement of a multistage pressure reduction skid utilised on our compressor stations for supply of gas for fuel gas for compressors and actuator power gas supply.

8.1.24 The skid would be manufactured offsite, pressure tested and FAT tested for FCV, PCVs or combined FCV and PCV stream. This includes all assets from the inlet isolation valve to the outlet isolation valve.

Decommission Redundant PCVs/FCVs

8.1.25 Decommissioning of identified redundant valves, through the demolition and removal of the affected assets.

8.1.26 As part of a network review of our assets we have identified two PCV regulator streams at [redacted], and FCVs at [redacted] offtake and [redacted] offtake as redundant to operational requirements. These have progressed through needs case assessments and no future requirement was identified for the assets.

8.1.27 Redundant valves would be decommissioned by demolishing the assets, removing them from the sites and where operational flow paths remain install a pipework spool piece.

HIPPS FEED Study

8.1.28 In this option we progress the completion of a FEED study of the current HIPPS overpressure protection arrangement on 7 entry points across the NTS. [redacted]

Installation of Terminal HIPPS

8.1.29 In this option we complete the installation of HIPPS systems onto entry points (Terminal and AGIs), to ensure our sites are not subject to pipework stresses caused by an over pressurisaton event. Installation of HIPPS are industry best practise and ensure our installations meet a SIL2 rating.

8.2 Intervention Summary

8.2.1 Table 13 shows the interventions considered to resolve PCV / FCV issues.

Table 13: PCVs and FCVs intervention technical summary table

Intervention	Investment Design Life	Positives	Negatives	Taken Forward
Counterfactual (Do Nothing)	N/A	• Lowest CAPEX intervention for PCVs and FCVs.	• For redundant FCVs or PCVs these shall remain in their current state, in some cases connected to the operational flow paths of a site, requiring maintenance and inspection to ensure we maintain asset integrity. This is an issue as consumers pay for maintenance on assets that provide no benefit.	No
Replace Individual Regulator	30	• Smaller CAPEX intervention is required for the actuator compared to an actuator replacement.	• Flange to flange distances of new PCVs are not always the same as the existing PCVs meaning that modifications would be needed to be made to site pipework configuration to fit the valves into the existing streams. • Valves cannot be installed too close together due to issues with turbulent flows occurring, affecting PCV operation. Increasing the distance between 1st and 2nd stage cannot always be accommodated due to flange-to-flange distances. • Does not address problems with the design of our creep relief valves. • Replacement of PCVs installed in series (Multistage Pressure Reduction Skids, Fuel Gas/Domestic Gas Supply Pressure Regulator Skid) may require significant modifications to pipework due to the flange-to-flange distance of the new valve being different to the existing valve.	No
Refurbishment of Flow Control Valve	15	• Provides life extension to FCV assets so decreases the risk of failure in the future.	• There is a risk around the remaining life of the asset post refurbishment. Soft parts are scarce and therefore this intervention may solve issues in the short term but store up longer term intervention, that future consumers who have had no benefit of the output from our network will need to pay for.	No

Intervention	Investment Design Life	Positives	Negatives	Taken Forward
			• Refurbishing the valve does not including overhauling the control package. The pneumatic control packages on several of our PCVs and FCVs are obsolete and unsupported. • They are also venting systems, contributing to our overall methane emissions, a type of system we propose to move away from; to non-venting pneumatic or electric control. • Intervention is only viable when FCV is not obsolete and still supported by OEM.	
Replace PCV Stream / FCV Stream	30	• Addresses all obsolescence issues (Control System and PCVs) • Ensures that the stream configuration does not impact on operational flows. • Improved performance and less interaction with downstream devices. As the current regulators are not capable of this arrangement, only this intervention addresses this problem. • Similar outage requirements to other interventions due to undertaking construction and Factory Acceptance Testing offsite, limiting need for lengthy outages. • Delivers an asset configuration that complies with the latest industry standards.	• Higher cost intervention	Yes
Pressure Regulator PSSR Inspection Remedial Minor Refurbishment	5	• Addresses defects on operational assets following PSSR inspections on pressure regulator installations not intervened with more major intervention.	• Does not address the obsolescence issues we have on our PCVs and PCV control systems. Any defect that occurs on these assets cannot be rectified through minor remediation (Component replacement) due to the unavailability of spares in the market. • Does not resolve the interactions that our PCVs are experiencing with downstream customers devices, resulting in the lack of synchronisation, which results in pressure and flow fluctuations.	Yes
Fuel Gas/Domestic Gas Supply Pressure Regulator Skid Replacement	30	• Addresses all obsolescence issues (Control System and PCVs) • Delivers an asset configuration that complies with the latest industry standards. • Ensures that the stream configuration does not impact on operational flows. • Prevents considerable pipework modifications needed to fit new PCVs into existing stream configurations, limiting outage requirements.	• Higher cost intervention to replacing individual PCV. • Does not give improved performance by less interactions with downstream devices.	Yes
Replacement of Multistage Pressure Reduction Skid	30	• Addresses all obsolescence issues (Control System and PCVs) • Delivers an asset configuration that complies with the latest industry standards. • Ensures that the stream configuration does not impact on operational flows. • Prevents considerable pipework modifications needed to fit new PCs into existing stream configurations, limiting outage requirements.	• Higher cost intervention to replacing individual PCV. • Does not give improved performance by less interactions with downstream devices.	Yes
Decommission Redundant PCVs/FCVs	N/A	• Demolition of these assets removes the potential asset health spend to maintain the integrity of these assets, on operational flow paths, when they provide no benefit to the operation of the network and our pressure management activities. Decommissioning also removes the safety risk of them being on site and deteriorating. • Ensures societal fairness where customers who have had the benefit of these assets pay for the demolition.	• High CAPEX investment in the short term	Yes
Overpressure protection study and	N/A	• Intervention ensures that necessary calculations on pressure vessels are completed, and replacement protective	• N/A	Yes

Intervention	Investment Design Life	Positives	Negatives	Taken Forward
replacement of relief valve		devices installed should deficiencies be identified		
HIPPS FEED Study	N/A	• Low-cost intervention • Completion of studies to understand the current protection levels. • Protects us from potential future HSE action legals, resulting in projects needing to progress at pace to meet regulator timeframes	• N/A	Yes
Installation of Terminal HIPPS	N/A	• Ensures compliance against SIL ratings	• High-cost intervention	Yes

8.2.2 As the scope of each of the Decommissioning projects is bespoke, individual project scopes have been created. The projects in scope of this EJP are shown in Table 14 below.

Table 14: Redundant Pressure Control and Flow Control Valves

Project
[redacted]
[redacted]
[redacted]

8.3 Volume Derivation

8.3.1 For more information about the development of bottom-up intervention volumes for PCVs / FCVs see **Appendix 4.**

8.3.2 Table 15 summarises how the bottom-up intervention volumes for PCVs/ FCVs have been developed for RIIO-GT3.

Table 15: Development of bottom-up volumes for RIIO-GT3

Intervention	Volume	Unit of Measure	How this volume has been developed
Replace Regulator Stream (Single)	[redacted]	Per Asset	Volume derived from the completed FEED studies undertaken, an engineering assessment of the options based on the outcome and learning from the delivery of similar investments in RIIO-2. Our RIIO-2 programme recommend overhauls, however through the Plant & Equipment Uncertainty mechanism this was re-stated to reflect a preferred option of stream replacement, due to the significant challenged in overhauling these assets, as explained in the problem statement. .
Replace FCV Stream (Single)	[redacted]	Per Asset	
Fuel Gas / Domestic Gas Supply Pressure Regulator Skid Replacement	[redacted]	Per Skid	
Replacement of Multistage Pressure Reduction Skid	[redacted]	Per Skid	
Replace Regulator Stream PCV / FCV (Single)	[redacted]	Per Asset	
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	Per Asset	Run rate based on defects from RIIO-T2
[redacted] Redundant asset decom	[redacted]	Per Project	Volume of [redacted] as this intervention has been estimated as a project so cost includes all scope of works.
[redacted] Redundant asset decom	[redacted]	Per Project	
[redacted] Redundant asset decom	[redacted]	Per Project	
Overpressure protection study and replacement of relief valve	[redacted]	Per Asset	Volume is based on the number of relief valves installed on the NTS.
HIPPS FEED Study	[redacted]	Per Site	[redacted] Sites have been identified by our Safety Engineering department as sites where studies are required to understand the current safety system configuration and its suitability
Installation of Terminal HIPPS	[redacted]	Per Site	Based on the number of FEED studies and the likely solution that is required to address the issues based on historical project information.

8.4 Unit Cost Derivation

8.4.1 Costs have been derived using known data for activities which share the scope with the interventions within this EJP.

8.4.2 Where historical outturn or tendered costs have not been available, we have undertaken estimating using first principles, including sourcing quotations from the supply chain.

8.4.3 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) and the similarity of the scope of these historical data points against our RIIO-GT3 investment programme.

8.4.4 Our Installation of Terminal HIPPS intervention has a +/-50% cost accuracy due to the limited data points we have for this intervention, reflective of 1 data point from our investment on the incomers at [redacted] and the early stage of project development (NDP stage 4.0). Our Overpressure protection study and relief valve replacement intervention has a +/-50% cost accuracy. This cost has been derived from a tender event that occurred in 2020 for a review of overpressure protection devices for the [redacted]. The +/-50% cost accuracy has been derived given the single data point and NTS wide scheme proposed in RIIO-GT3.

8.4.5 Table 16 summarises the cost sources and data points used to inform the unit costs in this EJP with cost breakdowns included in **Appendix 5** – PCVs / FCVs Interventions Cost Breakdown.

Table 16: PCVs / FCVs intervention cost sources and data points (£m, 2023/24)

Intervention	Unit Cost	Unit of Measure	Cost Accuracy	Number of Data Points	Source Data
Replace Regulator Stream (Single)	[redacted]	Per Asset	+/- 10%	0	First principles – derived using known rates/activities and supplier costs.
Replace FCV Stream (Single)	[redacted]	Per Asset	+/- 10%	0	
Fuel Gas / Domestic Gas Supply Pressure Regulator Skid Replacement	[redacted]	Per Skid	+/- 10%	0	
Replacement of Multistage Pressure Reduction Skid	[redacted]	Per Skid	+/- 10%	0	
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	Per Asset	+/- 10%	0	
Replace Regulator Stream PCV / FCV (Single)	[redacted]	Per Asset	+/- 10%	0	
[redacted] Redundant asset decom	[redacted]	Per Project	+/- 10%	0	
[redacted] Redundant asset decom	[redacted]	Per Project	+/- 10%	0	
[redacted] Redundant asset decom	[redacted]	Per Project	+/- 10%	0	
HIPPS FEED Study	[redacted]	Per Site	+/- 10%	0	First principles – derived using known rates/activities
Overpressure protection study and replacement of relief valve	[redacted]	Per Asset	+/- 50%	1	Derived from engineering assessment
Installation of Terminal HIPPS	[redacted]	Per Site	+/- 50%	1	Derived from engineering assessment

8.4.6 An example of how we have developed costs for Valve PCV/FCV works is the estimate produced for the "Replace Regulator Stream PCV/FCV (Single)" intervention. This estimate was generated utilising our estimating cost database and supplier material costs but does assume no restrictions/delays and excludes design. The scope for this cost was provided by an internal subject matter expert with material costs sourced from historic supplier quotations. This intervention has a high percentage of material cost with [redacted] of the Unit Cost made up of our procurement costs for parts. [redacted] On top of this, costs for testing and commissioning have been included with the intention for works to be carried out in parallel. A [redacted] risk and contingency provision has been applied to the estimate build up (excluding materials).

9 Options Considered

9.1 Portfolio Approach

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

9.1.2 While this EJP emphasises interventions on PCVs / FCVs, we have assessed the benefit from options across the entire Valves portfolio including valves, actuators, PCVs and FCVs, to meet investment drivers, business plan commitments, and consumer priorities. Therefore, a single CBA covers this EJP, **NGT_EJP22_Valves: Valves_RIIO-GT3 NGT_EJP23_Valves: Actuators_RIIO-GT3, NGT_EJP25_Valves: Bypass Installation and Modification_RIIO-GT3**

9.2 Options

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

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

9.2.3 In all options (except the counterfactual) we include investment volumes that have been developed through our bottom-up intervention development, to address known defects and obsolescence issues. These are consistent in all options (except 1A). A table of these intervention volumes in **Appendix 6** and is included in the top row of each respective option. **NOTE:** All values provided for each option are rounded to 2 dp. Total given is correct but might be different to sum of interventions due to rounding.

9.2.4 The Options 1-6 are therefore differentiated on the volumes outside of the core bottom-up build, the volumes identified in these options have been developed from a combination of bottom-up build plus modelling using Predictive Analytics. This comprises categories as follows: Actuator Overhaul, Actuator Replacement, Pressure Regulator PSSR Inspection Remedial Works, Replace Individual Regulator, Valve Overhaul, Valve Replacement.

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

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

9.2.6 The total spend of proposed interventions in this option is £541.0m (2023/24) which addresses known and forecast defects.

Table 17: Option 1 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	0.65

Actuator Replacement	[redacted]	27.66
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.02
Replace Individual Regulator	[redacted]	0.18
Valve Overhaul	[redacted]	28.53
Valve Replacement	[redacted]	170.74
Total	**3769**	**541.04**

Option 1A: Post Deliverability

9.2.7 In this option, our programme of investments on valves assets from Option 1 has been taken through a deliverability assessment which factors in network outage, resource and supply chain constraints. Due to the constraints, this is the only option that does not have the same bottom-up volumes as the others. The total spend in this option is £286.3m (2023/24) and the intervention breakdowns are shown in Table 18 below.

Table 18: Option 1A Intervention and spend summary.

Intervention	Total Volume in RIIO-GT3	Total spend in RIIO-GT3 (£m, 2023/24)
Bolted/Flanged NRV overhaul	[redacted]	2.86
Welded/Buried NRV Overhauls	[redacted]	3.32
NRV replacement	[redacted]	2.08
Replace Regulator Stream (Single)	[redacted]	32.09
Replace FCV Stream (Single)	[redacted]	13.84
Fuel Gas/Domestic Gas Supply Pressure Regulator Skid Replacement	[redacted]	2.51
Replacement of Multistage Pressure Reduction Skid	[redacted]	3.86
Replace Regulator Stream PCV/FCV (Single)	[redacted]	4.20
[redacted] Redundant Asset Decom	[redacted]	0.18
[redacted] Redundant Asset Decom	[redacted]	0.21
[redacted] Redundant Asset Decom	[redacted]	0.77
Actuator Control Replacement	[redacted]	3.62
Stem seal replacement	[redacted]	1.83
Tighten/ Adjust Stem Seals	[redacted]	1.16
Sealant Port Adaption	[redacted]	0.87
Vent & sealant line replacement	[redacted]	1.71
Replace plug valve with double block and bleed valve	[redacted]	3.16
Pipethrough of block valve site	[redacted]	2.57
Pipethrough of single valve on a site (uncongested)	[redacted]	9.76
Valve strip and condition assessment	[redacted]	1.82
Valve spares	[redacted]	1.36
Block Valve Replacement	[redacted]	26.66
Block Valve modification after pits have been broken out	[redacted]	1.31
Overpressure protection study and replacement of relief valve	[redacted]	5.94
Stopple & Bypass	[redacted]	19.55
HIPPS FEED Study	[redacted]	1.78
Installation of Terminal HIPPS	[redacted]	11.60
Removal of [redacted]	[redacted]	0.14
Installing a new standard Valve Bypass Arrangement at [redacted]	[redacted]	0.31
[redacted] Redundant Asset Decom	[redacted]	0.32
[redacted] Redundant Asset Decom	[redacted]	0.46
[redacted] Redundant Asset Decom	[redacted]	0.43
[redacted] Redundant Asset Decom	[redacted]	0.75

[redacted] Redundant Asset Decom	[redacted]	0.30
[redacted] Redundant Asset Decom	[redacted]	0.66
[redacted] Redundant Asset Decom	[redacted]	0.40
Install bypass pipework	[redacted]	18.46
Modify bypass pipework	[redacted]	59.46
Bottom-up volumes total	[redacted]	**242.32**
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.26
Actuator Replacement	[redacted]	13.44
Actuator Overhaul	[redacted]	0.15
Valve Replacement	[redacted]	29.76
Valve Overhaul	[redacted]	0.41
Total	**2437**	**286.33**

Option 2: Additional 10% Risk Reduction

9.2.8 In this option we have utilised our Copperleaf Portfolio optimisation tool to achieve a 10% additional monetised risk reduction by the end of the RIIO-GT3 period. Copperleaf has selected the most cost-effective investments to meet the lower risk constraint.

9.2.9 The total spend of proposed interventions in this option is £560.0m (2023/24), addressing known and forecast defects. This option has greater spend than option 1 as the model has to work harder to achieve benefit on assets that provide less benefit than those selected in Option 1.

Table 19: Option 2 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	0.73
Actuator Replacement	[redacted]	29.44
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.02
Replace Individual Regulator	[redacted]	0.18
Valve Overhaul	[redacted]	21.55
Valve Replacement	[redacted]	194.82
Total	**3856**	**560.01**

Option 3: Lowest Whole Life Cost (WLC)

9.2.10 In this option, we applied optimisation to select interventions with the lowest WLC. Copperleaf identifies the most beneficial interventions, and no investment is selected if the cost exceeds the asset's lifetime benefit, as per the NARMS methodology. None of our service risk measures (Availability & Reliability, Safety, Environmental, Societal and Transport) have an outcome constraint applied.

9.2.11 The total spend of proposed interventions in this option is £680.3m (2023/24). In this option Predictive Analytics has made a decision to intervene on any asset where the cost is outweighed by the benefit no matter how small the margin. While generally it will reduce risk more over the life of the asset, it may make decisions that are not possible i.e., trying to do too much work.

Table 20: Option 3 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	2.70
Actuator Replacement	[redacted]	63.36
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.26
Replace Individual Regulator	[redacted]	5.24
Valve Overhaul	[redacted]	0.82
Valve Replacement	[redacted]	294.67
Total	**4844**	**680.30**

Option 4: Availability and Reliability Risk Stable to RIIO-T2 Start

9.2.12 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.

9.2.13 The total spend of proposed interventions in this option is £655.6m (2023/24).

Table 21: Option 4 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	2.70
Actuator Replacement	[redacted]	58.94
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.27
Replace Individual Regulator	[redacted]	5.05
Valve Overhaul	[redacted]	45.36
Valve Replacement	[redacted]	230.00
Total	**4755**	**655.60**

Option 5: Health and Safety Risk Stable to RIIO-T2 Start

9.2.14 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain our health and safety 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.

9.2.15 The total spend of proposed interventions in this option is £547.5m (2023/24).

Table 22: Option 5 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	2.51
Actuator Replacement	[redacted]	44.45
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.24
Replace Individual Regulator	[redacted]	2.39
Valve Overhaul	[redacted]	19.29
Valve Replacement	[redacted]	165.33
Total	**4124**	**547.48**

Option 6: Environmental Risk Stable to RIIO-T2 Start

9.2.16 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain our environmental 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.

9.2.17 The total spend of proposed interventions in this option is £655.5m (2023/24).

Table 23: Option 6 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	2.70
Actuator Replacement	[redacted]	58.94
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.19
Replace Individual Regulator	[redacted]	5.05
Valve Overhaul	[redacted]	45.36
Valve Replacement	[redacted]	230.00
Total	**4745**	**655.51**

9.3 Option Summary

9.3.1 Table 24 below shows the technical summary table comparing Options 0 to 6.

Table 24: Portfolio Options Technical Summary table

Option	First Year of Spend	Final Year of Spend	Total Volume of Interventions	Investment Design Life	% of Assets intervened on	Total Spend Request (£m 2023/24)
Option 0: Counterfactual (Do Nothing)	FY25	FY32	N/A	N/A	0	0
Option 1: Total Monetised Risk Stable to RIIO-T2 start	FY25	FY32	3769	0 – 30 years	15.0	541.04
Option 1A: Post Deliverability	FY25	FY32	2437	0 – 30 years	9.8	286.33
Option 2: Additional 10% Risk Reduction	FY25	FY32	3856	0 – 30 years	15.4	560.01
Option 3: Lowest WLC	FY25	FY32	4844	0 – 30 years	19.4	680.30
Option 4: Availability and Reliability Risk Stable to RIIO-T2 start	FY25	FY32	4755	0 – 30 years	19.0	655.60
Option 5: Health and Safety Risk Stable to RIIO-T2 start	FY25	FY32	4124	0 – 30 years	16.5	547.48
Option 6: Environmental Risk Stable to RIIO-T2 start	FY25	FY32	4745	0 – 30 years	19.0	655.51

10 Business Case Outline and Discussion

10.1 Key Business Case Drivers Description

10.1.1 Valve assets (valves, NRVs, actuators, pressure control & flow control valves and valve bypasses) deteriorate over time and with use. This in turn prevents them from performing their required functions and can also result in them no longer complying with current and future legislative requirements.

10.1.2 Therefore, in developing our desired outcomes we have considered the impact of the following drivers for investment on valve assets:

- Legislation requirements
- Asset deterioration, linked to our ageing asset base and asset type.
- Change of operational requirement (redundancy)
- Obsolescence
- Health and safety
- Decommission and remove assets that are no longer required to manage overall whole life cost and risk.
- Reducing the environmental risk of emissions

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

10.2 Business Case Summary

10.2.1 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 cost benefit analysis (CBA) utilising our Copperleaf Portfolio Optimisation tool.

10.2.2 Only interventions assigned to an asset have been assessed in the CBA because no benefits can be applied to interventions that are assigned to various locations (i.e., Based on forecast defects).

10.2.3 A variety of technical interventions have been considered and combined to create a range of CBA options, the results of which are presented in Table 25.

Table 25: Option summary of headline business case metrics (£, 2023/24)

Option	Total Volume of Interventions	Total Spend Request (£m)	Outcome Risk End of RIIO-GT3	% change in comparison to start of RIIO-T2	PV Benefit	PV Cost (£m)	NPV (£m)	Payback Period from 2031	% change in service risk measures compared to start of RIIO–T2				
									Financial	Availability / Reliability	Environmental	Health and safety	Societal
Option 0: Counterfactual (Do Nothing)	0	0	19.12	134.20	N/A	N/A	N/A	N/A	97.01	170.00	113.83	167.86	176.51
Option 1: Total Monetised Risk Stable to RIIO-T2 start	3769	541.04	13.39	94.01	160.20	521.01	360.81	Does not payback in the period	90.99	148.60	105.62	81.22	117.76
Option 1A: Post Deliverability	2437	286.33	16.66	115.96	97.57	275.73	178.16	Does not payback in the period	92.73	160.35	108.10	131.96	145.71
Option 2: Additional 10% Risk Reduction	3856	560.01	12.61	88.48	178.93	539.27	360.34	Does not payback in the period	90.84	147.69	105.27	67.95	110.82
Option 3: Lowest WLC	4844	680.30	11.33	79.55	217.80	655.11	437.32	Does not payback in the period	89.51	95.47	103.16	54.27	75.64
Option 4: Availability and Reliability Risk Stable to RIIO-T2 start	4755	655.60	11.06	77.63	218.84	631.32	412.48	Does not payback in the period	89.32	94.56	102.27	50.11	74.53
Option 5: Health and Safety Risk Stable to RIIO-T2 start	4124	547.48	13.29	93.28	159.95	528.06	368.11	Does not payback in the period	90.05	94.90	103.46	90.81	75.55
Option 6: Environmental Risk Stable to RIIO-T2 start	4745	655.51	11.05	77.55	219.05	631.24	412.19	Does not payback in the period	89.32	94.56	102.01	50.11	74.53

10.2.4 In Figure 10, we have plotted the cumulative Payback period for different options presented in Table 25.

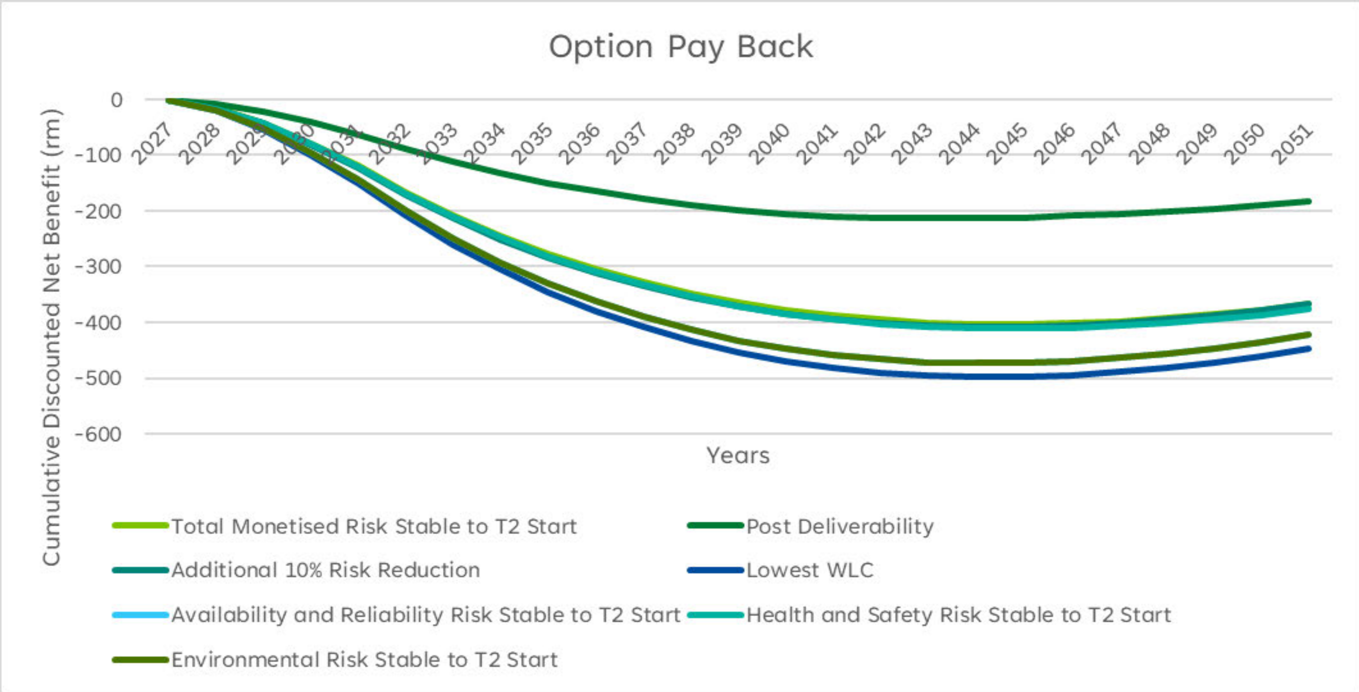


Figure 10: Cumulative payback period for all valves options

10.2.5 A variety of technical interventions have been considered and combined to create a range of CBA options, the results of which are presented in Figure 10 above. The graph illustrates the Net Present Value (NPV) of each option over a 20-year period, from 2031 (the end of RIIO-GT3), to 2051. As can be seen from the graph, Option 1A Post Deliverability shows the lowest net NPV, illustrating a greater benefit. Option 3 lowest WLC has the worst return of the options on offer. Options 4 and 6 are almost identical. The graph also shows that none of the options provide enough benefit from the investment being proposed to allow them to be paid back within the 20-year period.

10.2.6 Based on a combination of factors such as addressing known issues, maintaining network risk levels across valves assets, cost to consumer and deliverability of intervention volumes, Option 1A was selected to have the best balance of all factors. All other options will reduce overall risk compared to the start of RIIO-T2 but will come at a significantly higher cost, lower benefit and aren’t deliverable due to constraints.

10.2.7 We are aware of the risk of choosing Option 1A, as it doesn’t meet our organisational objective of maintaining stable risk of our assets back to RIIO-T2 start. Other options are not possible due to supply chain constraints identified in our deliverability assessment where only 40 valves per year and 80 actuators could be delivered. We will work with our suppliers to ensure more assets can be delivered in future price controls to prevent risk across valves assets increasing at an undesired rate. In the meantime, to mitigate this risk, internal groups will assess defects across valve assets based on severity, and short-term requirement for valves assets (i.e., if it’s required for isolation to facilitate an outage) and those will be prioritised for remediation to prevent any incidents or delay to capital delivery of our plan. Interventions have been prioritised for defective valves and actuators involved in PSSR inline inspections (ILI) for pipelines to enable the valves to be able to seal during the ILI run to prevent deferring legislative work.

10.2.1 Option 1A does not pay back within the period. This is due to NARMs not capturing the full consequence of valves asset failures (valves, actuators, NRVs, PCVs / FCVs) and their intrinsic value to the network. It is also important to note that in Option 1A, the majority of the interventions address known issues on a subset our assets.

11 Preferred Option and Project Plan

11.1 Preferred Option

11.1.1 Option 1 (Total Monetised Risk Stable to RIIO-T2 start) is our preferred option in an idealistic sense where all its intervention volumes are deliverable. Our programme of investment on valves 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 becomes the preferred option and includes the mixture of interventions listed in Table 18.

11.1.2 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 Valves assets (Valves, NRVs, Actuators, Pressure and Flow Control Valves and Valve Bypasses).

11.1.3 For PCVs/FCVs, our preferred option of interventions manages known obsolescence risks, addresses redundancy, reduces emissions, ensures legislative compliance and manages rising levels of defects on these assets to ensure they can carry out their critical function of pressure protection and flow control. PCVs / FCVs interventions from our preferred option are shown in Table 26. Please see NGT_IDP10_Portfolio EJP Valves_RIIO-GT3 for more information. PCVs / FCVs interventions proposed give a Long-Term Risk Benefit (LTRB) of £6.61m.

11.1.4 The outputs from this investment will be included in the Asset Health – NARMS and Redundant Assets PCD reporting mechanisms, and cost variance through the Totex Incentive Mechanism (TIM).

11.1.5 The plan is funded through baseline as volumes have been built using engineering assessments and FEED studies on our PCVs / FCVs assets and costs have been estimated using bottom-up estimates. NOTE: There are no PA interventions for PCVs / FCVs in our preferred option as they all got removed as part of our deliverability assessment.

11.1.6 The outputs from this investment will be included in the Asset Health NARMs and Redundant Assets PCDs reporting mechanism and cost variance managed through the TIM mechanism.

Table 26: PCVs / FCVs RIIO-GT3 preferred option Summary (£m, 2023/24)

Intervention	Primary Driver	Volume	Unit of Measure	% Assets Intervened Upon	Total RIIO-GT3 Request	Funding Mechanism	PCD Measure
Replace Regulator Stream (Single)	Asset Health (Policy)	[redacted]	Per Asset	[redacted]	32.09	Baseline – NARMS PCD	A1
Replace FCV Stream (Single)	Asset Health (Policy)	[redacted]	Per Asset	[redacted]	13.84	Baseline – NARMS PCD	A1
Fuel Gas / Domestic Gas Supply Pressure Regulator Skid Replacement	Asset Health (Policy)	[redacted]	Per Skid	[redacted]	2.51	Baseline – NARMS PCD	A1
Replacement of Multistage Pressure Reduction Skid	Asset Health (Policy)	[redacted]	Per Skid	[redacted]	3.86	Baseline – NARMS PCD	A1
Pressure Regulator PSSR Inspection Remedial Works	Asset Health (Legislation)	[redacted]	Per Asset	[redacted]	0.26	Baseline – NARMS PCD	A1
Replace Regulator Stream PCV / FCV (Single)	Asset Health (Policy)	[redacted]	Per Asset	[redacted]	4.20	Baseline – NARMS PCD	A1
[redacted] Redundant asset decom	Redundant Assets	[redacted]	Per Project	[redacted]	0.77	Baseline – Redundant Assets PCD	A3
[redacted] Redundant asset decom	Redundant Assets	[redacted]	Per Project	[redacted]	0.21	Baseline – Redundant Assets PCD	A3
[redacted] Redundant asset decom	Redundant Assets	[redacted]	Per Project	[redacted]	0.18	Baseline – Redundant Assets PCD	A3
Overpressure protection study and replacement of relief valve	Asset Health (Policy)	[redacted]	Per Asset	N/A	5.94	Baseline – NARMS PCD	A1
HIPPS FEED Study	Asset Health (Policy)	[redacted]	Per Site	N/A	1.78	Baseline – NARMS PCD	A1
Installation of Terminal HIPPS	Asset Health (Policy)	[redacted]	Per Site	N/A	11.60	Baseline – NARMS PCD	A1
	Total	1691		7.42	77.25	Baseline	

11.2 Asset Health Spend Profile

11.2.1 The below spend profile provides an indicative view on when the above interventions are to be carried out. More information is discussed in **Chapter 11.4**.

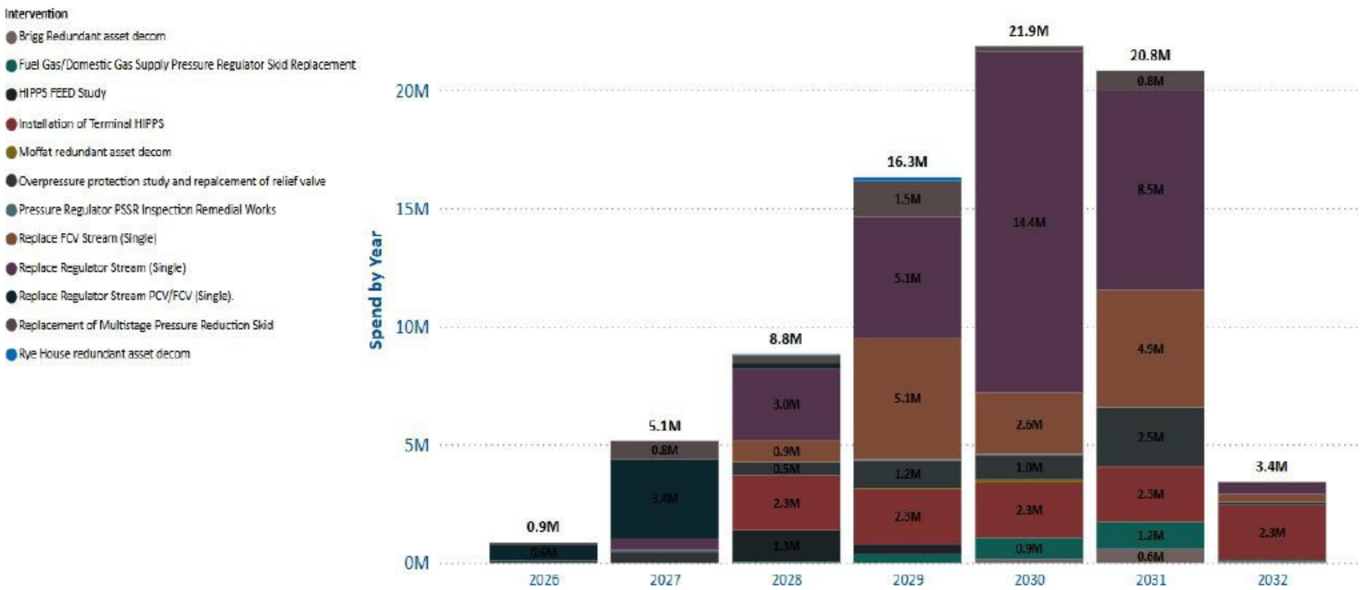


Figure 11: PCVs / FCVs preferred option investment spend profile.

11.3 Investment Risk Discussion

11.3.1 Key risks and currently identified mitigations are summarised in Table 27 below.

Table 27: Actuator key risks and identified mitigations.

No.	Risk	Mitigation (based on current view)
1	There is a risk of additional site surveys, delaying the project and leading to additional costs.	Try to minimise number of surveys by getting multiple contractors to site for each aspect of works
2	There is a risk of increase to materials prices impacting project launch	Project team to work with Main Works Contractor (MWC) to make sure that materials are procured in a timely manner and multiple quotes for materials from a number of supplies to ensure value for money
3	There is a risk of diluted operational resource support due to a number of concurrent projects running on site	Assessed through our deliverability assessment and shall be monitored through our plan delivery.
4	There is a risk of additional scope requirements (including electrical, design & 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.
5	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.
6	There is a risk of policy changes impacting upon project requirements	Close engagement with Safety Engineering to any upcoming specification updates.
7	There is a risk of unavailability / delayed delivery of long lead items, e.g., actuators and PCVs / FCVs	Frequent communication with Contractor to ensure that Long Lead Items are ordered,
8	There is a risk of lack of contractor availability	Engagement with the market has been undertaken through our deliverability assessment to understand where constrains may apply and factored into our investment planning.
9	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 customer and stakeholder demand	This shall partly be mitigated through the CPI-H inflation and real price effect mechanisms within our RIIO-GT3 regulatory framework

11.4 Project Plan

11.4.1 Project delivery has been split into three phases which align with our Network Development Process (ND500) as shown in

11.4.2 Table 28 below. Commissioning dates are not relevant to all intervention types but take place at the end of the delivery phase.

Table 28: 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)

11.4.3 Table 29 below shows the summary plan and provisional delivery phases for PCVs / FCVs related sanctions within RIIO-GT3. Internal stakeholder engagement has identified when we can obtain network access, where required, to complete these works. It has also identified who will deliver the work between our construction team and National Gas Services (NGS).

Table 29: PCVs / FCVs Portfolio Programme for RIIO-GT3 period

Sanction	RIIO-T2		RIIO-GT3					RIIO-GT4
	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32
T3 Bacton Valves								
T3 Pipelines PSSR								
T3 Sites AGI Construction FY27								
T3 Sites AGI Construction FY28								
T3 Sites AGI Construction FY29								
T3 Sites AGI Construction FY30								
T3 Sites AGI Construction FY31								
T3 Sites AGI NGS FY27								
T3 Sites AGI NGS FY28								
T3 Sites AGI NGS FY29								
T3 Sites AGI NGS FY30								
T3 Sites AGI NGS FY31								

11.4.4 Both PCVs and FCVs are assets that have long lead times for delivery and therefore these assets have an extended preparation phase. The work has been profiled based on a deliverability assessment across our whole plan.

11.4.5 Backloaded profile is due to outage availability, lengthy conceptual and detailed design, and long lead items procurement, offsite build and FAT.

11.5 Key Business Risks and Opportunities

11.5.1 Changes to system operation or supply and demand scenarios is unlikely to impact upon the proposal in this EJP. Significant changes could mean that particular sites and assets become redundant which would remove the need for some interventions but in general, assets will still need to be maintained until the point at which decommissioning is completed.

11.5.2 Fast tracking of the transition to hydrogen within RIIO-GT3, would mean any pipelines and sites chosen to be repurposed for hydrogen transport, would require maintenance on key assets such as PCVs / FCVs before they are repurposed. This would mean any open defects could be remediated earlier than initially phased.

11.6 Outputs included in RIIO-T2 Plans

11.6.1 No interventions have been deferred from RIIO-T2 to RIIO-GT3 due to work being re-baselined as part of the **RIIO-T2 Plant and Equipment Uncertainty Mechanism.**

12 Appendices

12.1 Appendix 1- Pressure Control Valves and Flow Control Valves Equipment Summary

12.1.1 **Main Process Regulators** – Regulators installed on main process pipework to reduce NTS pressure gas to the customers requirement, based on our contract. These reduce pressures from c70 bar to c16-30 bar depending on the requirements of the downstream customer. Typically, these consist of a pair of streams in Working / Standby configuration. Figure 12 shows a process regulator at [redacted], with both working and standby streams located within the same enclosure.

Figure 12: [redacted] *Pressure Control Valves.*

12.1.2 In event of failure of the working stream or to facilitate maintenance on this stream the standby stream can be utilised to maintain supply through the installation. Each comprise of a pair of pressure control valves.

12.1.3 Connected customers greatly vary the volume of gas they take from the NTS, as evidenced by the graph below, Figure 13. This graph shows the demand measured at 6 network offtakes with pressure regulators across a period of 1 year from 1st April 2023. The graph shows the demand from these customers fluctuates greatly. Therefore, our pressure regulators are utilised to provide the necessary control to limit the flow and pressure to these customers.

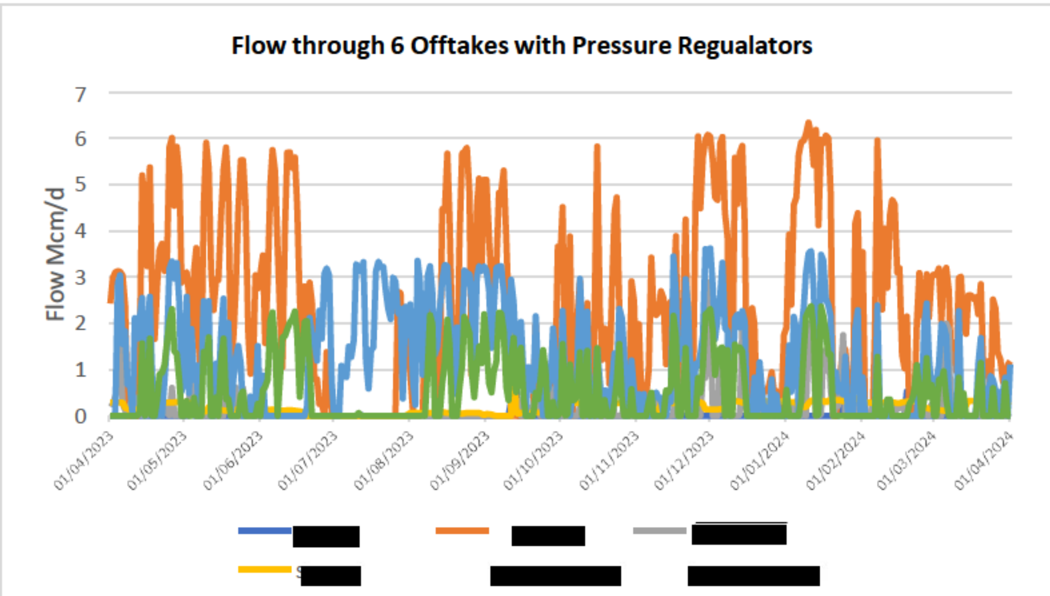


Figure 13: Graph showing variability of flow through pressure regulators.

12.1.4 **Boundary Control Regulator** – We operate pipelines at a range of Maximum Operating Pressures (MOPs) based on the safe operating parameters of our installed assets. At some locations we have a pressure boundary whereby two feeders with two different MOPs connect[redacted] At these locations we have regulators installed to reduce the pressure to below the Pipeline MOP to prevent downstream over-pressurisation.

12.1.5 [redacted] The regulator keeps the downstream pressure below the MOP with the slam shut the primary protective device. Figure 14 shows the NTS map showing Sapperton boundary control.

Figure 14:[redacted] Boundary Control

12.1.6 **Preheating Fuel Gas Regulator Skid** – On certain AGIs (Pressure Reduction Installations and Network Offtakes) we have regulator streams within a skid arrangement to reduce process gas pressure from the main site pipework to supply fuel gas to our domestic boiler preheating packages. These provide preheating to the process gas prior to the main process regulator streams to mitigate the Joules-Thompson effect. The photo below, Figure 15, shows the preheating fuel gas regulator skid at[redacted] offtake. Each Preheating skid will contain a series of pressure control valves to reduce the pressure in a cascading approach.

Figure 15:[redacted] Preheating Fuel Gas Regulator Skid

12.1.7 **Compressor Regulator Skid –** On certain Compressor Stations a multi-stage Pressure Regulator skid is installed to reduce site process pressures to supply gas to compressors as fuel gas and to other ancillary assets utilised within Compressor Station operation, e.g. Actuator power gas supplies. The skid usually consists of a number of streams with multiple pressure control valves that have cascading pressure tiers where often the outlet of one stream forms the inlet to another stream. The photo below, Figure 16, shows a typical arrangement from [redacted] The twin main fuel gas streams are in the centre of the photo, each containing multiple pressure control valves, and to the left is the actuating gas supply pressure reduction streams.

Figure 16: [redacted] Main Pressure Reduction Skid

12.2 RIIO-T2 PCVs / FCVs interventions

12.2.1 The following assets shown in Table 30 are out of scope in this EJP as they are being intervened on in RIIO-T2.

Table 30: Assets out of scope of RIIO-GT3 Investment

Site	Pressure Control Valve/Flow Control Valve
[redacted]	Main Process Pressure Control Valve Stream replacement x2 Domestic Pressure Control Valve Skid replacement
[redacted]	Boundary Pressure Control Valve Stream replacement
[redacted]	Flow Control Valve decommissioned in RIIO-T2
[redacted]	Flow Control Valve decommissioned in RIIO-T2
[redacted]	Pressure Control Valve replaced in RIIO-T1
[redacted]	Flow Control Valve Stream 4 replacement
[redacted]	Flow Control Valve/Pressure Control Valve Combined Stream Replacement x2
[redacted]	Main Process Pressure Control Valve Stream x1 replacement
[redacted]	Main Process Pressure Control Valve Stream x1 replacement
[redacted]	Main Process Pressure Control Valve Stream x1 replacement
[redacted]	Domestic Pressure Control Valve Skid replacement
[redacted]	Compressor Main Pressure Reduction Stream Skid replacement
[redacted]	Main Process Pressure Control Valve Stream x1 replacement Domestic Pressure Control Valve Skid Replacement

12.3 Appendix 3- Pressure Control Valves and Flow Control Valves FEED Studies

12.3.1 Please see accompanying documents for more information.

12.4 Appendix 4 Intervention decision-making methodology for FCVs and PCVs

12.4.1 The flow chart (shown in Figure 17 below) shows the decision-making methodology for the application of interventions for pressure and flow control valves.

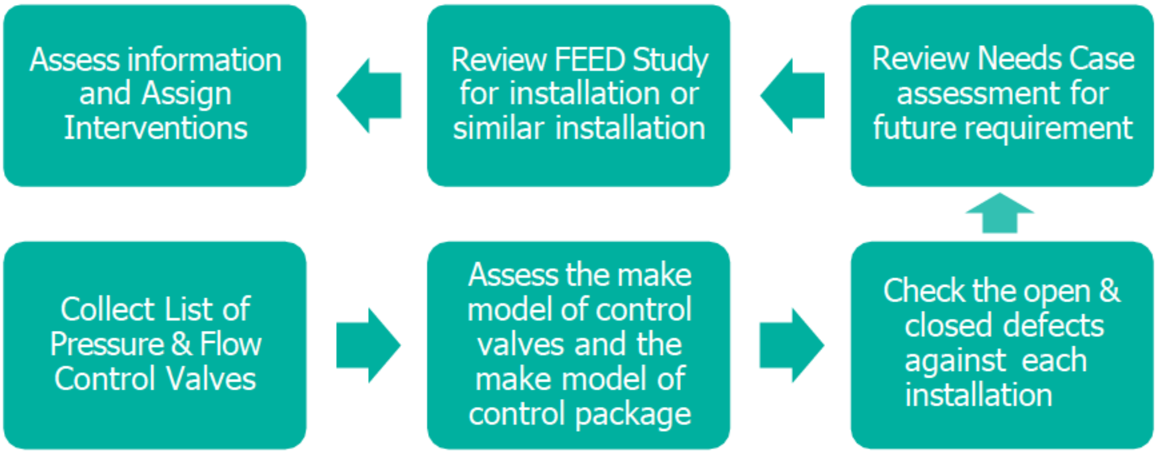


Figure 17: Methodology for developing PCV / FCV investments.

Additional information Pressure & Flow Control Valves in Business Case Discussion

12.4.2 Across our Pressure Control valves and Flow Control valves we have completed individual assessments on the assets across our sites, against the drivers for investment identified in the needs case.

12.4.3 Where [redacted] are installed, we propose to continue the programme that commenced in RIIO-T2 to remove these assets that are end of life, obsolete and unsupported. This also addresses the issue where our control valves fall out of synchronisation with the downstream equipment causing pressure and flow fluctuation that affects the downstream customers process and efficiency of their processes and outputs.

12.4.4 Where we have identified Flow Control valves with [redacted], also obsolete, unsupported, and subject to control drifting affecting network operations we propose to undertake a whole stream replacement. This includes replacing all assets from the inlet valve to the outlet valve, all mechanical control devices, adds tight shut off valves into the stream to assist providing pressure separation in periods of no flow, and replaces the control package.

12.5 Appendix 5 – PCVs / FCVs Interventions Cost Breakdown

12.5.1 Please see Table 31 below for PCVs/FCVs intervention cost breakdowns.

Table 31: Cost breakdown for PCVs/FCVs interventions

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 cost %	RIIO-GT3 Unit Cost (2023/24)
Replace Regulator Stream (Single)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Replace FCV Stream (Single)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Fuel Gas/Domestic Gas Supply Pressure Regulator Skid Replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Replacement of Multistage Pressure Reduction Skid	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Replace Regulator Stream PCV/FCV (Single).	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted] redundant asset decom	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted] redundant asset decom	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted] redundant asset decom	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Overpressure protection study and replacement of relief valve	N/A – Early-stage development										[redacted]
HIPPS FEED Study	N/A – FEED study quote										[redacted]
Installation of Terminal HIPPS	N/A – Early-stage development										[redacted]

12.6 Appendix 6 – Bottom-up Interventions Considered in Every Option except 1A.

12.6.1 Table 32 below shows the bottom-up interventions in every CBA option considered except Option 1A.

Table 32: Bottom-up Intervention Volumes and Value

Intervention	Total Volume in RIIO-GT3	Total Spend in RIIO-GT3 (£m, 2023/24)
Bolted/Flanged NRV overhaul	[redacted]	2.86
Welded/Buried NRV Overhauls	[redacted]	3.32
NRV replacement	[redacted]	2.08
Replace Regulator Stream (Single)	[redacted]	32.09
Replace FCV Stream (Single)	[redacted]	13.84
Fuel Gas/Domestic Gas Supply Pressure Regulator Skid Replacement	[redacted]	2.51
Replacement of Multistage Pressure Reduction Skid	[redacted]	3.86
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.26
Replace Regulator Stream PCV/FCV (Single)	[redacted]	4.20
Rye House Redundant Asset Decom	[redacted]	0.18
Moffat Redundant Asset Decom	[redacted]	0.21
Brigg Redundant Asset Decom	[redacted]	0.77
Actuator Control Replacement	[redacted]	3.62
Actuator Replacement	[redacted]	19.43
Actuator Overhaul	[redacted]	0.15
Valve Replacement	[redacted]	28.95
Valve Overhaul	[redacted]	0.41
Stem seal replacement	[redacted]	1.83
Tighten/ Adjust Stem Seals	[redacted]	1.16
Sealant Port Adaption	[redacted]	0.87
Vent & sealant line replacement	[redacted]	1.71
Replace plug valve with double block and bleed valve	[redacted]	3.16
Pipethrough of block valve site	[redacted]	1.03
Pipethrough of single valve on a site (uncongested)	[redacted]	9.76
Valve strip and condition assessment	[redacted]	1.82
Valve spares	[redacted]	1.36
Block Valve Replacement	[redacted]	49.21
Block Valve modification after pits have been broken out	[redacted]	2.10
Stopple & Bypass	[redacted]	19.55
Overpressure protection study and replacement of relief valve	[redacted]	5.94
HIPPS FEED Study	[redacted]	1.78
Installation of Terminal HIPPS	[redacted]	11.60
Removal of [redacted]	[redacted]	0.14
Installing a new standard Valve Bypass Arrangement at [redacted]	[redacted]	0.31
[redacted] Redundant Asset Decom	[redacted]	0.32
[redacted] Redundant Asset Decom	[redacted]	0.46
[redacted] Redundant Asset Decom	[redacted]	0.43

[redacted] Redundant Asset Decom	[redacted]	0.75
[redacted] Redundant Asset Decom	[redacted]	0.30
[redacted] Redundant Asset Decom	[redacted]	0.66
[redacted] Redundant Asset Decom	[redacted]	0.40
Install bypass pipework	[redacted]	18.46
Modify bypass pipework	[redacted]	59.46
Total	**2535**	**313.26**