



RIIO-T2 Re-opener

St Fergus Avon Operability and Availability

**Engineering Justification Paper
January 2023**

Contents

| | | |
|-----------|--|-----------|
| 1. | Executive Summary | 3 |
| 2. | Introduction and Background | 5 |
| 3. | Equipment Summary | 7 |
| 4 | Problem Statement and Needs Case | 11 |
| 5 | Probability of Failure | 12 |
| 6 | Consequence of Failure | 12 |
| 7 | Options Considered | 13 |
| | Option 1: Do Nothing | 13 |
| | Option 2: Relife Unit 1C | 13 |
| | Option 3: Relife Unit 2B | 15 |
| | Option 4: Build a new Unit | 16 |
| 8 | Final Option Selection, Costs and Programme | 18 |
| 9 | Appendices | 21 |
| 9.1 | Appendix 1 – St Fergus Short-Term Strategy (2021 -2030) | 21 |
| 9.2 | Appendix 2 – Unit Decommissioning Engineering Justification | 21 |
| 9.3 | Appendix 3 – [REDACTED] – Conditional Survey Report | 21 |
| 9.4 | Appendix 4 – Project Programme | 21 |
| 9.5 | Appendix 5 – Supplementary Questions and NGGT Responses | 21 |

1. Executive Summary

- 1.1. National Grid Gas Transmission, hereafter referred to as NGGT, are requesting funding to refurbish the cab, upgrade the ventilation and replace the exhaust system to return the St Fergus compressor Unit 2B to operation. This is as part of work to ensure there are four operational Avon compressor units and to ensure there is gas compression across two plants for greater resilience.

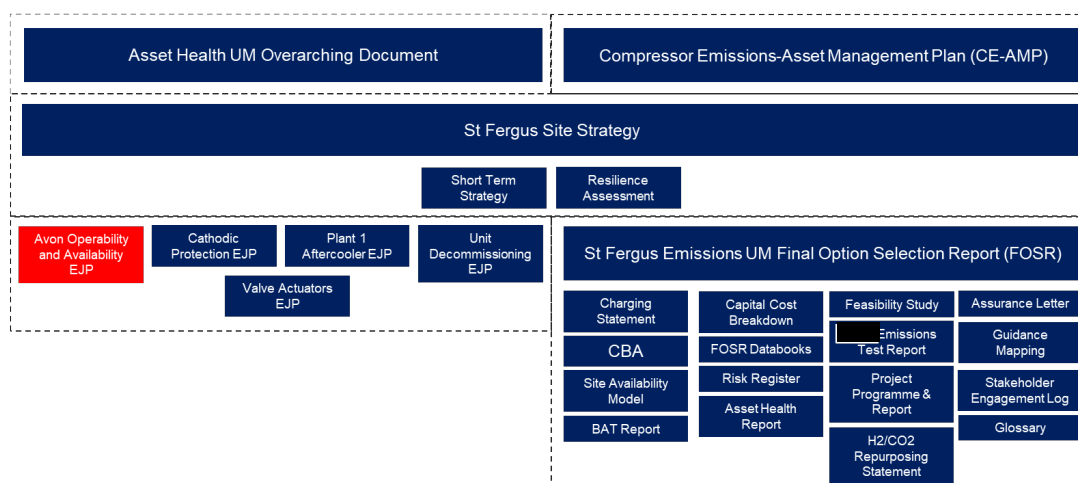


Figure 1: St Fergus Submission Documents Structure

- 1.2. This is part of a suite of documents, shown in Figure 1, and should particularly be read in conjunction with the St Fergus Site Strategy and its appendices. The St Fergus Site Strategy describes the gas terminal's function, its criticality to the network and the proposed investments in line with the site's short and long-term strategy. It also includes our Resilience Assessment as an appendix which assesses the potential for rationalisation across the site to optimise our proposed capex and long-term opex.
- 1.3. There are currently two Avons which are non-operational: Units 1C and 2B. These gas compression assets at the site were installed in 1977 and for many years have operated, in conjunction with other site compression, to provide the required compression for supplies from the PX terminal to allow it to enter the NTS.
- 1.4. The St Fergus Short-Term Strategy confirms a requirement for four Avon compressors at the site until 2030 based upon a Cost Benefit Analysis (CBA). This is because the three currently operational Avons do not provide sufficient resilience to back-up the Variable Speed Drives (VSDs). As they are all located on a single plant, there are also multiple single points of failure for gas compression and known issues mean that Plant 1 outages will be required in the coming years leaving the site fully reliant on the VSDs (and the RB211 while still available).
- 1.5. Therefore, the recommendation of the Short-Term Strategy was to carry out cab infrastructure work to reinstate Unit 2B in addition to carrying out planned cyber and Asset Health works to enable its continued operation with sufficient availability levels to 2030. It is critical that the reinstatement of Unit 2B is completed before Unit 2A (an RB211) ceases operation 31 December 2023 due to the Large Combustion Plant Directive (LCPD).
- 1.6. The R110-T2 business plan included all work associated with Plant 1 and Plant 2 under the Emissions Uncertainty Mechanism as the uncertainty about the future solution affected all of those assets. However, investment in these units was needed immediately to ensure continued operation of the site in the short-term out to 2030.
- 1.7. The options considered as alternatives to doing nothing, were to reinstate either Units 1C or Unit 2B. Initial estimates indicated a slight difference in cost between these units. However, in order to continue operating the site safely and deliver all the other planned investments,

RIIO-T2 Re-opener St Fergus Avon Operability and Availability Engineering Justification Paper

gas compression is needed on both Plant 1 and Plant 2 to mitigate the risk of constraints and enable maintenance and outages. More information on this is included in the Resilience Assessment, which is an appendix to the St Fergus Site Strategy. Therefore, the recommended option is to reinstate Unit 2B, thus maintaining some gas compression on Plant 2. Another benefit of carrying out this work is that it will remove the asbestos present in the Galbestos cladding of Unit 2B which has deteriorated and poses a risk to site staff. An investment to address the asbestos on other units is being developed and will follow in the June 2023 submission.

- 1.8. In addition to making a fourth Avon operational, work will be completed on all four Avons including planned cyber works, modern fuel gas conditioning systems and refurbishment of the oil supply systems. The remaining fifth Avon will remain in place until the long-term needs of site are confirmed and any required decommissioning is included in the Emissions re-opener or will form part of future submissions. The primary benefit of this investment is the continued operation of the site until 2030 at the full range of flows and enablement of all other planned investments in line with the Short-Term Strategy.
- 1.9. The indicative cost of this investment is ██████████ (18/19 price base). The estimated RIIO-T2 cost profile is shown in the table below. This project is at stage 4.4 in the ND500 process: Detailed Design and Delivery. Therefore, the cost accuracy is estimated at +/-10% in accordance with the Infrastructure and Projects Authority (IPA) cost estimating guidance.

| £m 18/19 | FY2022 | FY2023 | FY2024 | FY2025 | FY2026 | Total |
|-------------------|------------|--------|--------|--------|--------|-------|
| Total Cost | ██████████ | | | | | |
| Baseline | ██████████ | | | | | |
| Funding Requested | ██████████ | | | | | |

Table 1: Current estimated RIIO-T2 spend profile

- 1.10. NGGT are making this funding application for the Avon Operability Programme RIIO-T2 investment costs through the Asset Health Re-opener, in line with Special Condition 3.14, requesting an adjustment to the value of the NARMAHOT term. This is summarised, along with other investments, within section 9 of the Asset Health Overarching Document provided as Product 1 of the January 2023 Asset Health Re-opener Submission.
- 1.11. However, the work had to begin prior to the submission to successfully have four operational Avons by the LCPD deadline of 31 December 2023. A draft of this paper was shared with Ofgem prior to this submission.

2. Introduction and Background

2.1 This paper provides the justification for works to reinstate Unit 2B. This work is needed to increase the number of operating Avons to four which will ensure sufficient reliability at the St Fergus gas terminal to 2030. Funding for this activity was initially expected to tie into the wider St Fergus uncertainty mechanism due to the alignment of the gas compression to the future solution which will ensure compliance with emissions legislation. However, investment in this unit is needed immediately to ensure the site has sufficient reliability in the short-term due to the impact of the LCPD deadline 31 December 2023.

2.2 In developing our investment programmes at the St Fergus Gas Terminal since the RIIO-T2 Final Determinations, we have adopted a two-phase strategy to ensure clarity between short-term asset health and long-term site operating strategy. Our St Fergus Short-Term Strategy provides certainty on the terminal operation requirements, including minimum compression across Plant 1 and 2, for operation out to 2030. The long-term strategy will deliver the enduring terminal solution, including compression, required for operation beyond 2030.

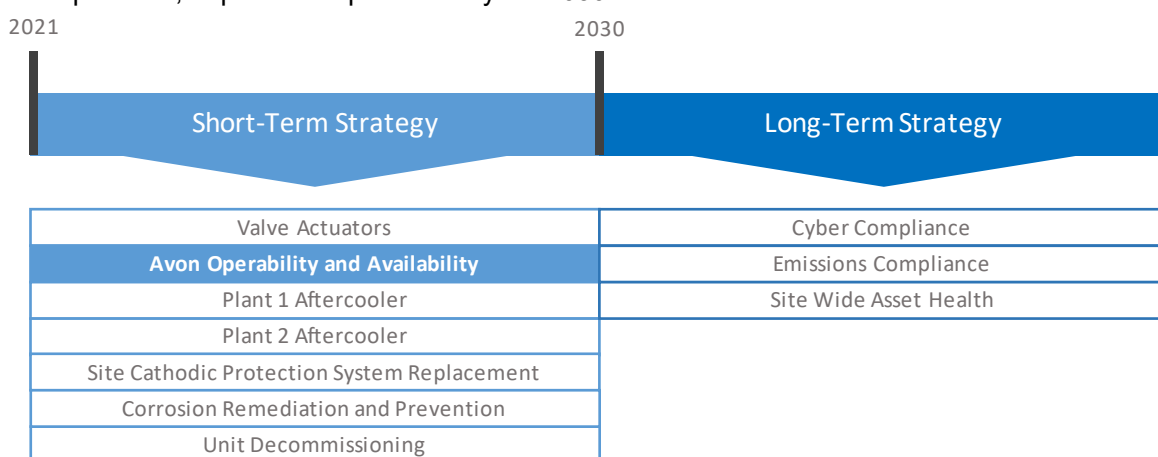


Figure 2: St Fergus Strategies Summary

2.3 The St Fergus short-term strategy supports the decision to rationalise the compression units across Plant 1 and 2 to four Avon units (1A, 1B, 1D and 2B) and maintain these in operation to at least 2030. That recommendation is fundamental to the proposals in this paper; therefore, it is important that these two documents are considered in parallel.

2.4 The investment outlined in this justification paper concerns gas compression units which are fundamental to the ability to flow gas from the PX terminal onto the National Transmission System (NTS). These units have been in operation since the terminal was commissioned in 1977-78. The units specifically concerned in this investment are the those which contain Siemens Avon gas turbines; of which there are five in total. These are highlighted in orange in Figure 3.

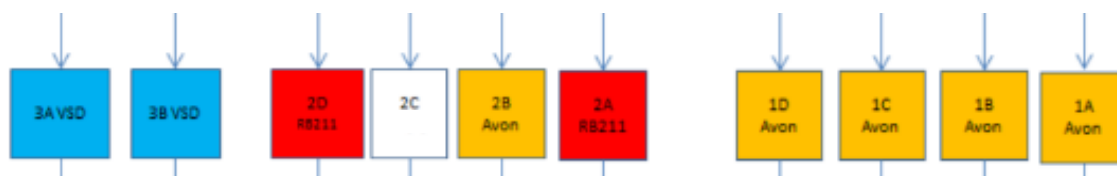


Figure 3: Compression Units at St Fergus

2.5 Of the five existing Avons (1A, 1B, 1C, 1D and 2B), two (1C and 2B) are currently non-operational. These units serve two roles: accommodating flows in particular ranges and overall back-up to the electric VSDs. A failure of one of these units isn't necessarily critical, however four are needed to back-up both VSDs and two are needed for flows in a specific range.

2.6 Not included within this investment are the other compression units on site of which there are two electrical VSDs, two RB211s and one further berth. The Unit Decommissioning EJP also being

submitted under the Asset Health UM covers the planned decommissioning of one RB211 (Unit 2D) and Unit 2C where the Avon and power turbine have been removed previously.

- 2.7 The original design of the site included a fairly balanced split of gas compression between Plants 1 and 2. The ceasing of operation of various units has resulted in the majority of gas compression being located on Plant 1. If nothing is done then, following the LCPD deadline, gas compression will only be present on Plant 1. This results in insufficient gas resilience and multiple single points of failure for the gas compression which is unacceptable. More information on the benefits of having compression on both Plants 1 and 2 is provided in the Resilience Assessment document.
- 2.8 Work to deliver sufficient gas-powered unit resilience and availability could not wait to begin until the results of this submission were known, because Unit 2A will cease operation on 31 December 2023 and the fourth Avon will need to be operational before that date. Therefore, work has begun prior to funding being agreed. The contract has been awarded and [REDACTED] are now in a brief planning and design phase. They will proceed onto onsite delivery early in 2023, with the first activities set to be the removal and replacement of the Galbestos cladding.

3. Equipment Summary

Site Summary

3.1 Comprehensive background information about the St Fergus Gas Terminal is available in the St Fergus Site Strategy provided with the Emissions Final Option Selection Report (FOSR). A high-level overview of the site layout is provided in Figure 4.

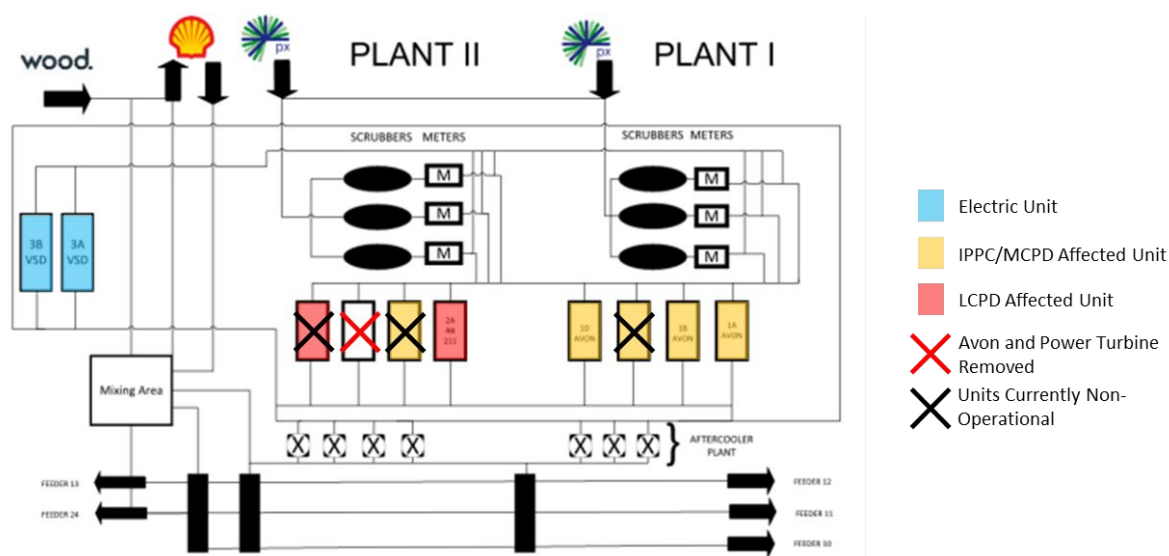


Figure 4: St Fergus Terminal Site Layout

Compression Summary

- 3.2 The compression assets on site specifically facilitate the supply of gas from the PX sub-terminal. This compression is comprised of a mixture of Gas Turbine (GT) units (mostly Avons and one remaining RB211) and two electrical VSD units.
- 3.3 The terminal operates 24/7/365 and is not afforded regular outages from sub-terminals to undertake maintenance. Sections of Plant 1 and Plant 2 serve as redundancy for each other allowing NGGT to undertake statutory inspections and critical testing of our safety critical and emergency shutdown system in addition to any maintenance needed as a result of regular inspections and testing. The scrubbers, metering, suction / discharge manifolds and Aftercoolers are interchangeable to enable maintenance. At least one of each is required at all times to support compression on the three plants. Therefore, these can be viewed separately to the need for compression across the two plants.

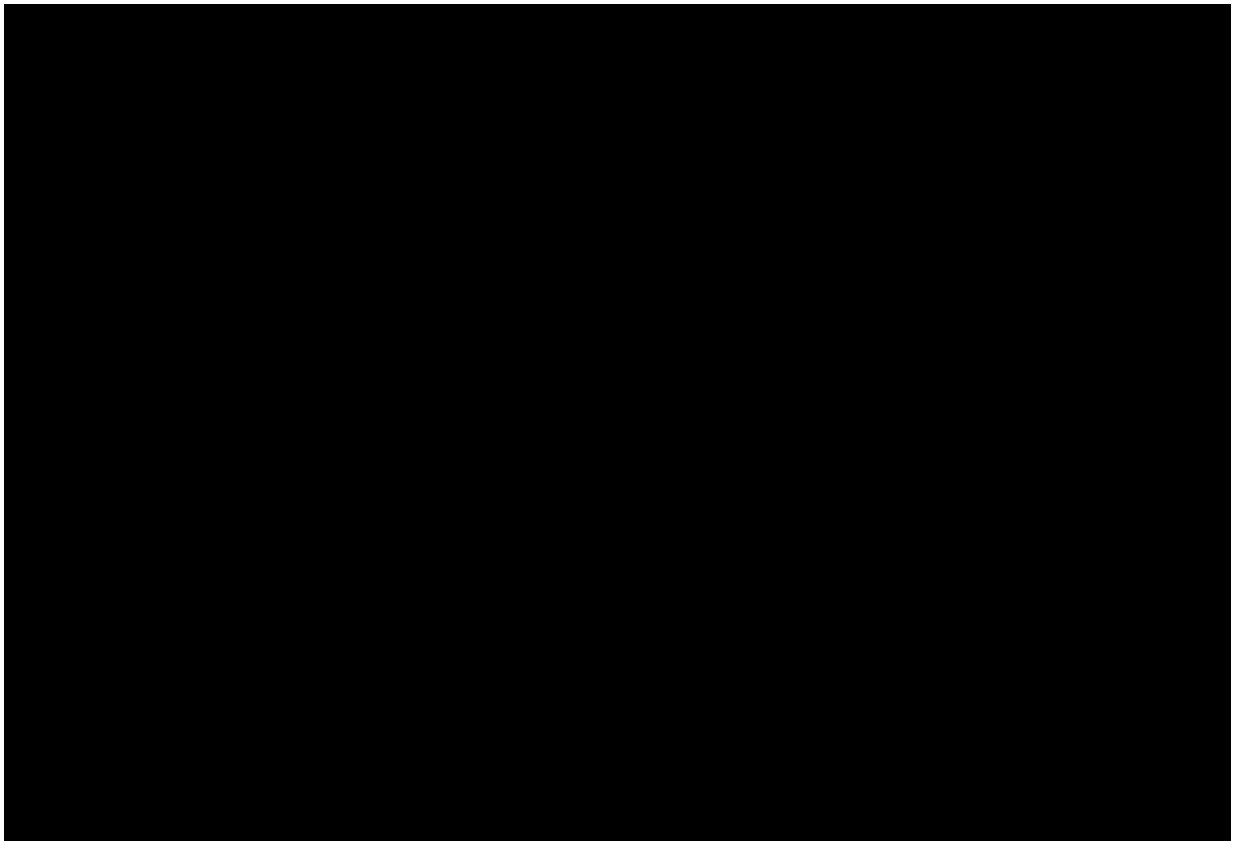


Figure 5: Aerial photograph of the St Fergus terminal highlighting the location of all Avon units

3.4 All the gas compressors were built in 1977-78. The Avon units considered in this paper are highlighted in the aerial photograph above. Units 1A, 1B and 1D are currently operational.

Avons Summary

- 3.5 The three currently operational Avons do not provide sufficient resilience to back-up both VSDs. As they are all located on a single plant, there are also multiple single points of failure for gas compression and known issues mean that Plant 1 outages will be required in the coming years leaving the site fully reliant on the VSDs (and the RB211 while still available).
- 3.6 The Avons provide capability which is utilised in various scenarios. At least one Avon is required to provide duty for 9 - 15 mcmd flow and two Avons in parallel also provide duty for 15 - 17 mcmd flow range. The Avons also provide backup to the Electric VSDs. At least four Avon units are required to operate in parallel to provide nominal backup to both VSDs. These varying roles are summarised in Figure 6. For each of these situations, at least one Avon would also be necessary as backup.

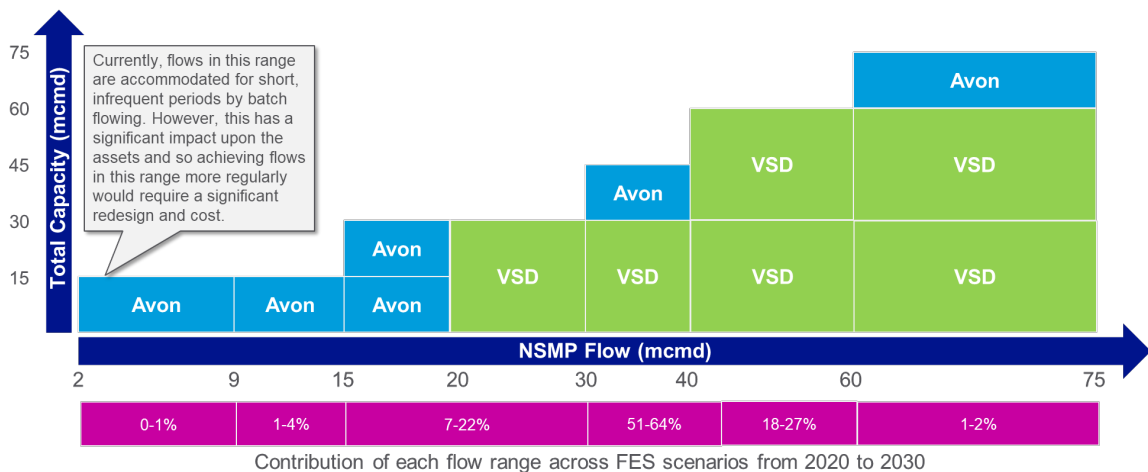


Figure 6: Unit Capability Across Flow Ranges

3.7 The maximum capability possible for the years remaining to 2030, if we do nothing, is shown in Figure 7; the periods when interventions are planned and the removal of the RB211 from operation are highlighted.

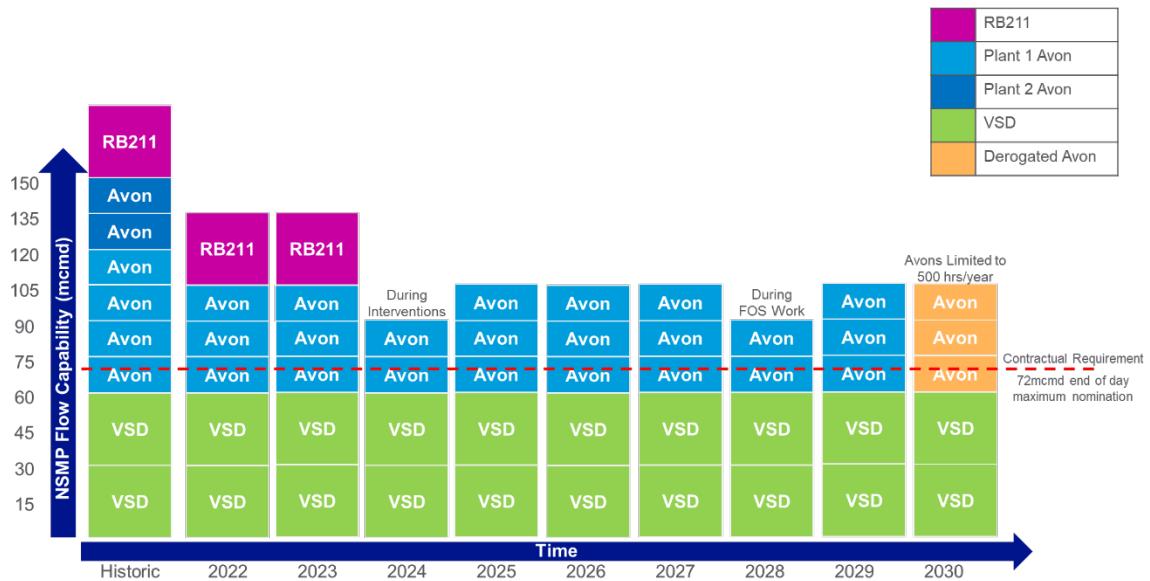


Figure 7: Capability with Three Avons to 2030

3.8 The image above assumes that all operational units on site are available, however individual units would require planned maintenance and there are known issues that would require an entire Plant 1 outage to resolve which would make all the remaining Avons unavailable simultaneously. This would result in a capability below our contractual requirement. A comparison of the impact of these situations with either three or four Avons in operation is shown in Figure 8.

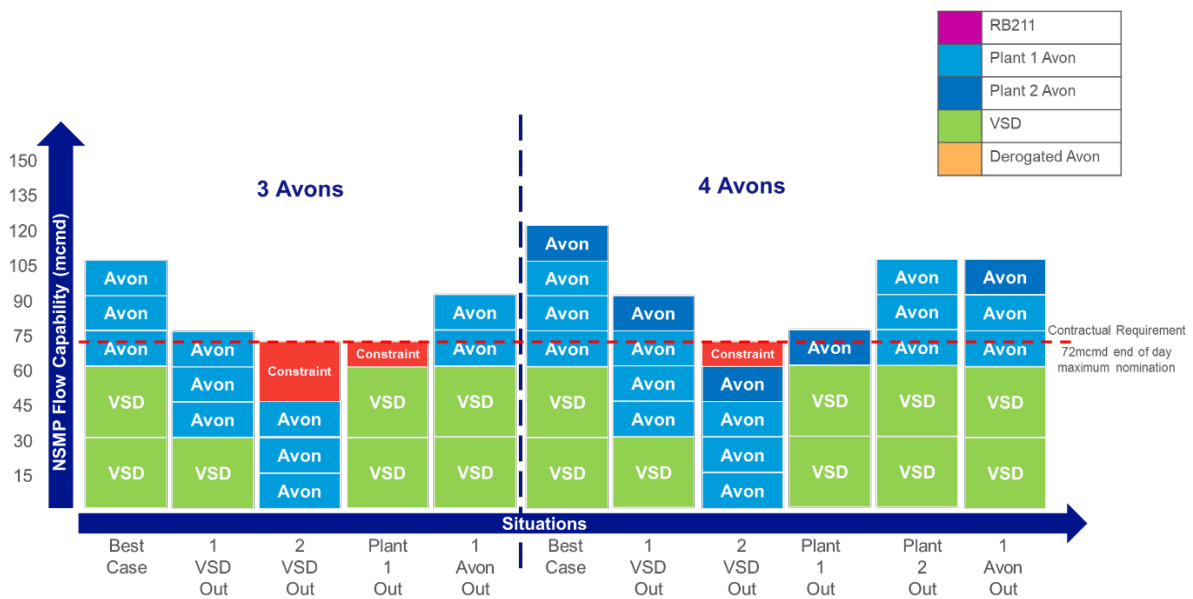


Figure 8: Site Capability 2024 to 2030 in Various Situations

Avons' Condition

3.9 Unit 1C ceased operation in July 2021. An inspection carried out by the Original Equipment Manufacturer (OEM) uncovered cab structural integrity issues which did not support the continued operation of the unit. In addition to the cab issues, the main line discharge valve was passing badly;

after this was identified the unit was depressurised and isolated. To return to an operational state, it would also require work on the ventilation and power turbine.

3.10 Unit 2B ceased operation around three years ago. The Cab structure, outer cladding and exhaust are in a very poor state and would require major investment to bring it back to an operational state. The Power Turbine would need also need to be removed and overhauled along with work on the ventilation system.

3.11 These two non-operational Avons are in a similar condition, so [REDACTED] were enlisted to carry out a survey to further assess their condition and the work required to reinstate one of them. Their report is included in Appendix 3. There are also some known issues which were not captured in the scope of this survey. This is discussed further in **Section 7 – Options Considered**.

4 Problem Statement and Needs Case

- 4.1 The gas compressors are deeply aged assets. Whilst the St Fergus terminal has been operated and maintained for over 40 years with minimal disruption to its upstream and downstream customers, this is a testament to the original design and to the capability of the maintenance and operations teams.
- 4.2 The justification for requiring four operational Avons is set out in the accompanying Short-Term Strategy. For more information on the analysis, refer to the Short-Term Strategy in Appendix 1.
- 4.3 In addition to the need for four operational Avons, the Short-Term Strategy outlines interventions required to address the current issues on these Avons which are causing the most unplanned outages. In the CBA, it was assumed that carrying out these interventions will allow the units to maintain an availability of 79% to 2030.
- 4.4 As of February 2022, there were 899 open defects associated with the Avons 1A, 1B, 1C, 1D and 2B. A summary of these by defect category and Unit is provided below. Please note that these numbers indicate the quantity of defects but not the severity.

| Defect Category | Defect Count – 1A | Defect Count – 1B | Defect Count – 1C | Defect Count – 1D | Defect Count – 2B |
|---------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Breakage | 0 | 0 | 0 | 0 | 1 |
| Corrosion | 125 | 84 | 75 | 139 | 123 |
| External Corrosion | 1 | 2 | 1 | 1 | 7 |
| Leakage | 5 | 1 | 3 | 5 | 2 |
| Leakage - Oil/Water | 0 | 0 | 1 | 0 | 0 |
| Mechanical damage | 7 | 3 | 2 | 3 | 2 |
| Mis-alignment | 0 | 0 | 1 | 0 | 0 |
| Obsolete Equipment | 1 | 0 | 5 | 0 | 7 |
| Other | 55 | 45 | 70 | 18 | 38 |
| Restricted Movement | 2 | 0 | 0 | 0 | 0 |
| Structural failure | 20 | 13 | 0 | 18 | 0 |
| Subsidence | 0 | 0 | 0 | 0 | 0 |
| Wear | 1 | 3 | 3 | 10 | 8 |
| Total | 205 | 151 | 161 | 194 | 188 |

Table 2: Avon defect count (Feb-2022)

- 4.5 As of February 2022, there were a further 5428 open DSEAR defects associated with the Avons 1A, 1B, 1C, 1D and 2B. A summary of these by defect category and unit is provided below.

| Defect Category | DSEAR Defects – 1A | DSEAR Defects – 1B | DSEAR Defects – 1C | DSEAR Defects – 1D | DSEAR Defects – 2B |
|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| Category B | 202 | 70 | 146 | 211 | 297 |
| Category C | 786 | 831 | 784 | 531 | 622 |
| Low Risk | 173 | 179 | 195 | 165 | 236 |
| Grand Total | 1161 | 1080 | 1125 | 907 | 1155 |

Table 3: Avon DSEAR defect count (Feb-22)

- 4.6 As the site requires four operational Avons to provide sufficient resilience, work is required to address the issues causing unplanned outages on the currently operational units utilising baseline funding and to restore a fourth unit to operation. These interventions will ensure gas compression is available to support continued site operation to 2030.
- 4.7 The St Fergus site asbestos management plan highlights that clusters of residues found throughout and around the inner and outer cabs of all the gas turbine units are asbestos containing.

This is because the metal cladding is lined with an asbestos containing bitumen called Galbestos. Asbestos is not considered harmful when in large pieces and undamaged. However, when damaged it can release smaller fibres that can be breathed in or swallowed.

- 4.8 A conditional survey conducted by [REDACTED] indicates that Unit 2B cab is in bad condition where large areas of the Galbestos coating are already peeling off.
- 4.9 As part of operationalising Unit 2B, remedial action will be required to address Galbestos to stop residual asbestos from damaged cladding from blowing around the plant resulting in health concerns to all personnel.

5 Probability of Failure

- 5.1 There are currently three operational Avons on the site, two which are not operational. The non-operational units have already failed. Therefore, if nothing is done then the site will have to operate with only three Avons and two VSDs from 31 December 2023.
- 5.2 Doing nothing not only compromises the site's compression capability but also poses a health and safety risk to personnel on site as the GTs cab cladding has already failed.
- 5.3 As mentioned in section 4, flakes of Galbestos coating (contains asbestos) have been found around the plant. To eliminate this health risk to site personnel, remedial action is necessary to prevent the further peeling, loss of coating and exposure to Asbestos dust.

6 Consequence of Failure

- 6.1 The Short-Term Strategy demonstrates the potential consequences of operating to 2030 with only three Avons. As part of the CBA carried out for the Short-Term Strategy, the impact of varying levels of gas compression on the site's ability to flow gas from PX was analysed.
- 6.2 Two CBA sensitivities looked at the potential Section I constraint costs of two different scenarios if only three Avons are retained. The first showed that retaining only three Avons could expose us to up to [REDACTED] in constraint costs if both VSDs were unavailable. The second sensitivity estimated that an outage of Plant 1 could cost [REDACTED] constraint costs on a low flow day (10 mcmd). Analysis shows that approximately 25% of days meet the required flow criteria and would lead to a constraint if Plant 1 were unavailable.
- 6.3 The consequence of continuing with only three operational Avons, all of which are on a single plant, is a considerable risk to security of supply due to the multiple single points of failure this would introduce leading to constraint costs for NGGT and consumers. Therefore, it was concluded that having four operational Avons provides resilience in the event of a Plant 3 outage, Plant 1 outage and any general breakdowns during delivery of capital works.
- 6.4 By investing to return a fourth Avon to operation, we ensure resilience beyond the Large Combustion Plant Directive (LCPD) deadline of 31 December 2023 and ensure we can facilitate efficient delivery of planned investments including Cyber, Asset Health and any work required to facilitate the Future Strategy solution.
- 6.5 For more information on this analysis, refer to the St Fergus Short-Term Strategy (Appendix 1).
- 6.6 From a health and safety perspective, doing nothing will have negative long-term consequences on site staff quality of life and lead to heavy penalties from the HSE and other bodies

7 Options Considered

7.1 Based on the recommendation of the St Fergus Short-Term Strategy to have four operational Avons, four options were considered which are outlined below.

Option 1: Do Nothing

7.2 Continue to operate to 2030 with only three Avons

- This option is the lowest cost, requiring only currently funded work to maintain the availability of the currently operational Avons at an average of 79%.
- This option is technically viable but significantly reduces the resilience of gas compression on site to 2030 as it would all be located on a single plant, introducing multiple single points of failure.
- Potential constraints of up to [REDACTED] if both VSDs were unavailable or [REDACTED] in Section I costs on a low flow day (10mcmd) in the event of a Plant 1 outage.

Option 2: Relife Unit 1C

7.3 Carry out works to reinstate Unit 1C as the fourth operational Avon

- This option is viable when considered in isolation but may not be possible to deliver when combined with all the other planned interventions; doing so would result in operating with only the VSDs while the work is carried out due to a required Plant 1 outage. This is a significant risk to security of supply
- This option significantly reduces the resilience of gas compression on site to 2030
- This option also has the potential to be delayed due to other planned interventions on site which delays the implementation of a fourth operational Avon past the point at which Unit 2A ceases operation.

7.4 Pros

- Facilitates one potential solution for the Long-Term strategy where all Plant 2 compression is decommissioned and used as the location for new compression.
- Utilises an asset which was more recently operational and is in a generally better condition due to completed remedial work.

7.5 Cons

- As outlined in Section 6, the impact of a Plant 1 outage is estimated at [REDACTED] in Section I constraint costs for flow conditions which are seen on 25% of days. The reinstatement of Unit 1C requires a Plant 1 outage of several weeks to replace the discharge valve which does not seal. There will then be other remaining known issues (outlined in the Short-Term Strategy) and planned investments (e.g. Unit control system replacements) which would also result in a Plant 1 outage over the remaining years to 2030. Each of these outages would expose NGGT to the estimated constraint cost outlined above.
- Carrying out the work on Unit 1C will require a Plant 1 outage. This means that during the work, there will only be two VSDs and one RB211 available.
- During any Plant 1 outages between 2024 and 2030, the site will be reliant on only the VSDs (Units 3A and 3B). This in turn would mean that flows below 17mcmd and between 30-45 mcmd could not be accommodated. It is also worth noting that over the past four months, the site has experienced four 'power dips' which could have tripped the electric VSDs and interrupted supply. These did not result in a ceasing of flows because the Avons were available which would not be the case while any work on the Unit 1C discharge valve is being completed.

- Due to the need for an outage of the Plant 1 discharge manifold, there is the potential for a delay of around 18 months. This is dependent upon the condition of the Plant 2 Aftercoolers. These will soon be taken offline for critical inspections and CM/4 remedial works. Full condition assessments on Plant 2 Aftercooler are proposed to be undertaken including intrusive inspections, however at present Bank D of this unit is already isolated requiring intervention. If the condition of the whole unit is confirmed to be similar to that of Plant 1 prior to recent investment, it would prevent the use of the Plant 2 discharge manifold until the work on the Aftercoolers is completed. Delaying the reinstatement of a fourth Avon increases the resilience risk on site, particularly if the work is not completed before Unit 2A ceases operation on 1 January 2024.
- May not be possible to deliver in combination with other planned interventions due to the required isolations, while keeping the site operational.

Option 2 Cost Assessment

- 7.6 Based on the initial findings from [REDACTED], the indicative cost of an investment to make Unit 1C operational is [REDACTED] (18/19).
- 7.7 In addition to this cost there are three other issues which would need to be resolved as part of reinstating this unit which are described further below:
- Unit 1C discharge valve
 - Plant 1 manifold pipework
 - Unit 2B Galbestos cladding

Discharge Valve

- 7.8 The Unit 1C discharge valve is unable to seal; the main reason it ceased operation due to the impact on Emergency Shutdown systems (ESD). This discharge valve doesn't seal on ESD tests and instead freezes up due to the Joule-Thomson effect of gas continuing to pass through the closed valve. Whereas both the main-line discharge and suction valves for 2B are in a satisfactory condition based on the last test carried out in 2019.
- 7.9 Therefore, it would need to be replaced at an indicative cost of [REDACTED] (18/19). This would require an outage of the discharge manifold resulting in the three currently operational Avons being unavailable and leaving the site to rely on the two VSDs and RB211. This in turn would mean that flows below 17 mcmd and between 30-45 mcmd could not be accommodated while the work is carried out.

Manifold Pipework

- 7.10 There is severe corrosion on the Plant 1 manifold pipework. The corrosion defects are categorised as severe/extreme damage and extends across circumferential weld. Finite element analysis has been undertaken to allow continued service but any outage of Plant 1 (as would be required to reinstate Unit 1C) would result in the need to remove this pipe-section.
- 7.11 In carrying out works to reinstate Unit 1C and replace the discharge valve, a full outage of Plant 1 would be required which would result in a need to replace a section of the Plant 1 manifold pipework with severe corrosion. The estimated cost of this work is [REDACTED] (18/19).

Galbestos Cladding on Unit 2B

- 7.12 The condition of the Galbestos cladding on Unit 2B is very poor, all the lower sections have been corroded with pieces of the lower cladding falling off. Large areas of the mid and upper cladding have the Galbestos coating peeling off. This is of some concern as this material contains Asbestos and is a risk to health and safety. Therefore, this will need to be addressed regardless of which unit is reinstated. Unit 1C is also heavily corroded on the lower areas of Galbestos cladding with small pieces falling away, however this appears to be limited to bottom of the cladding and above the doors. The mid to upper areas of the cladding appear to be in a better condition with no peeling.

7.13 Based on the [REDACTED] initial findings, if the decision were made to reinstate Unit 1C the Galbestos cladding on Unit 2B would still need to be addressed due to the significant safety risk it presents. This risk is similar to that presented by the condition of the Galbestos cladding on Units 2C and 2D which are being recommended for full decommissioning as they have no future use. The indicative cost of this work is [REDACTED] (18/19).

7.14 The risk could also be removed by fully decommissioning the unit however, it is still being considered in options for the long-term solution for the site. This is in accordance with the short-term strategy which recommended retaining the fifth Avon until the long-term solution is determined.

7.15 Therefore, the overall indicative cost for reinstatement of Unit 1C would be [REDACTED] (18/19).

Option 3: Relife Unit 2B

7.16 Carry out works to reinstate Unit 2B as the fourth operational Avon.

- This option is viable
- This option significantly increases the resilience of gas compression on site to 2030
- This option can be delivered efficiently in combination with other planned interventions and allows continued operation of the existing three operational Avons while the work is undertaken

7.17 Pros

- During any required Plant 1 outage between now and 2030, one Avon would still be available. This would mean that all flows except 15-17 mcmd could be accommodated as long as the VSDs are available. This significantly reduces the risk of constraints.
- Carrying out the work on Unit 2B will require a Plant 2 outage, however Plant 1 will still be operational. This means that during the work, there will be three Avons and two VSDs available.
- Facilitates one potential solution for the Long-Term strategy where assets are 'tied-in' to Plant 1 compression, as this would allow one Avon to remain operational during the work.

7.18 Cons

- Unit 2B's combustion intake filter house and oil cooler splitters were not upgraded as part of the unit upgrades in 2006. It has been noted that the filter house is in very poor condition with severe corrosion noted in some areas. However, Unit 1C was part of the unit upgrades in 2006 and subsequently has had the combustion intake filter house and oil cooler splitters upgraded already.
- Unit 2B has not had remedial work such as inner cab sealing, fuel gas shields, bleed pipe insulation and stagnant air pipework carried out. In comparison Unit 1C has had all of this remedial work implemented already.
- Utilises an asset which has not been operational for around three years and is in a generally worse condition.
- Risk of asset stranding if the Long-Term strategy solution requires demolition of Plant 2 compression; however, there will be three plinths available for new assets and Unit 2B could be put on outage during the works and then used as part of the future solution. This would leave site with three operational Avons during the works which does increase the risk of constraints but is significantly less than the risk of having all gas compression on a single plant.

Option 3 Cost Assessment

7.19 Based on the initial findings from [REDACTED], the indicative cost of this investment was [REDACTED] (18/19 price base). There has been an increase in cost from this initial survey, due to an additional scope item to replace the combustion intake and an increase in steel pricing and labour costs.

Option 4: Build a new Unit

7.20 Build a new unit with similar capability to an Avon on Plant 2:

- This option would have the highest cost. A previous estimate used for a new unit installed on brownfield is approximately [REDACTED]
- This option could not be completed before Unit 2A ceases operation 31 December 2023.
- This option is therefore not considered a viable solution for the short-term resilience requirement.

Option Analysis and Selection

7.21 Considering the above rationale and options assessment, the following table provides a comparison of the options considered and highlights the preferred options against a range of considerations for the options presented previously.

| Solution considerations | | Options Considered | | | |
|--------------------------|--------------------|---|---|---|---|
| | | Option 1 | Option 2 | Option 3 | Option 4 |
| | | Do Nothing | Relife 1C | Relife 2B | New Unit on Plant 2 |
| Meeting HSE Requirements | | No impact | No impact | No impact | No impact |
| Cost | | Lowest Cost – only funded works carried out | Medium cost – Current estimate of █████ (18/19) | Medium cost – Current estimate of █████ (18/19) | High cost – rough estimate █████ to install new unit on brownfield |
| Time to Deliver | | No time required | May be completed before Unit 2A ceases operation | Can be completed before Unit 2A ceases operation | Could not be completed before Unit 2A ceases operation |
| Compliance | COMAH | No impact | No impact | No impact | No impact |
| | PSSR | No impact | No impact | No impact | No impact |
| | DSEAR | No impact | No impact | No impact | No impact |
| Environmental Impact | | No impact | No impact | No impact | No impact |
| Maintenance | Ongoing OPEX | High cost - increased complexity due to difficulty in taking Plant 1 outages | Low impact on cost of maintenance | Low impact on cost of maintenance | Low risk - able to take Plant 1 or 2 outages without removing all compression |
| | Risk | High risk - known issues likely to require intervention resulting in plant 1 outage | High risk - known issues likely to require intervention resulting in plant 1 outage with greater risk of constraints | Low risk - able to take Plant 1 or 2 outages without removing all compression | Low risk - able to take Plant 1 or 2 outages without removing all compression |
| Operational Resilience | Point of Failure | High risk - multiple assets result in single point of failure for Plant 1 compression and single points of failure associated with VSDs | Medium risk - multiple assets result in single point of failure for Plant 1 compression | Low risk - gas compression available on both Plant 1 and 2 removes significant point of failure | Low risk - gas compression available on both Plant 1 and 2 removes significant point of failure |
| | Security of Supply | High risk – likely disruption to flows in the event of Plant 1 outage or loss of both VSDs | Medium risk - likely disruption to flows in the event of Plant 1 outage | Low risk – majority of flows can still be accommodated even in event of Plant 1 outage | Low risk – majority of flows can still be accommodated even in event of Plant 1 outage |
| Overall viability | | Low viability | Medium viability - may not be possible to deliver when combined with all the other planned interventions; doing so would result in operating with only the VSDs while the work is carried out which is a significant risk to security of supply | High viability | Low viability |

Table 4: Option Comparison

7.22 For a similar cost to Option 2, Option 3 offers a crucial level of resilience. Based on a CBA sensitivity, it is estimated that an outage of Plant 1 could cost █████ in Section I costs on a low flow day (10 mcmd). Analysis shows that approximately 25% of days meet the required flow criteria and would lead to a constraint if Plant 1 compression were unavailable.

8 Final Option Selection, Costs and Programme

8.1 The assessments outlined in this paper and costing of options demonstrates that the most cost effective and logical option to take forwards is: Option 3 - Relife Unit 2B.

8.2 The scope of this investment is:

- Ventilation system upgrade to comply with BS ISO 21789
- Cab internal integrity repair
- Gas detector upgrade
- Outer cab integrity roof and cladding
- Replace combustion exhaust
- Combustion intake upgrade
- Replace roof and remove degraded Galbestos cladding

8.3 In addition to this, there is work proposed to ensure availability of all four Avons which is outlined in the table below. This work is baseline funded through various themes as described below.

| Work Proposed | Reason | Estimated Cost (18/19) | Funding Position |
|---|--|------------------------|-----------------------|
| Replacement of the unit control systems and fuel governor system. | The fuel governors on St Fergus Plant 1 are the original 1970s equipment. Spares can't be obtained and repairing failed governors is becoming a major problem that causes long outages. Other 1970s Avon units have had up to four governor upgrades throughout their life. The control system and fuel governor account for 75% of trips on Plant 1 in the last five years. | £ | Funded - Cyber |
| Installation of modern fuel gas conditioning systems. | Lack of proper fuel gas treatment was highlighted as a causal factor of the catastrophic failure of Unit 1D gas generator in 2013. | £ | Funded – Asset Health |
| Refurbishment of the oil supply systems. | This is the cause of 10% of Plant 1 trips in the last five years. Two major lube oil pump failures have resulted in outages lasting 6 weeks and 8 weeks on Unit 1A. | £ | Funded – Asset Health |
| Minor electrical works (e.g. cab lighting). | This would be done for safety purposes while a Unit is on outage. | £ | Funded – Asset Health |
| Minor cab structure works due to corrosive environment | This would be done for safety purposes while a Unit is on outage. | £ | Funded – Asset Health |

Table 5: Baseline Funded Works

8.4 The focus is therefore on ensuring this is delivered at the lowest overall cost. The following factors support this:

- The St Fergus Short-Term Strategy confirms minimum compression units eliminating the short-term need for a fifth Avon.
- The possibility of utilising existing spares (e.g. from Unit 1C) to reduce the cost will be investigated however utilising aged parts does carry additional risk.
- The work may be tendered in combination with the decommissioning of Units 2C and 2D to reduce costs.

Final costs and programme

8.5 The table below, Table 6, provides a breakdown of the final costs for the project split by several cost categories.

| | Cost Category | Outturn Costs (£m) | Costs (£m, 18/19) |
|----------|-----------------------------|--------------------|-------------------|
| | OEM costs | | |
| Direct | EPC Estimate | | |
| Indirect | EPC PM | | |
| | EPC Site Establishment | | |
| Direct | NGGT Direct Company Costs | | |
| Indirect | NGGT Indirect Company Costs | | |
| Direct | Contractor Risk | | |
| Split | NGGT Project Risk | | |
| | FEED | | |
| | Development / Optioneering | | |
| | Land / Easements | | |
| | TOTAL | | |
| | | | |
| | Direct Total | | |
| | Indirect Total | | |

Table 6: Cost Breakdown

8.6 Table 7 shows the spend profile for our preferred option.

| £m 18/19 | FY2022 | FY2023 | FY2024 | FY2025 | FY2026 | Total |
|----------------------------|--------|--------|--------|--------|--------|-------|
| Avon Operability Programme | | | | | | |

RIIO2 Volume UIDs

8.7 Costs associated with this project have been assigned against the RIIO-T2 Unique Identifiers (UIDs) detailed below. Table 8 provides a summary of the UIDs and associated funding for the scope of works as outlined in this paper.

| UID | Baseline volume of Intervention (by unit of measure) | Baseline total funding available (18/19) | ECC unit cost (£k, 18/19) | Current volume of intervention | ECC total funding required (£k, 18/19) | Output Year | UID funding requested through UM (£k, 18/19) |
|---|--|--|---------------------------|--------------------------------|--|-------------|--|
| | | | | (by unit of measure) | | | |
| ██████████ ST FERGUS TERMINAL – Air Intake Major Refurb | 0 | 0 | | | | | |
| ██████████ ST FERGUS TERMINAL - Cab Ventilation Major Refurbishment | 0 | 0 | | | | | |
| ██████████ ST FERGUS TERMINAL - Exhaust Replacement | 0 | 0 | | | | | |
| ██████████ ST FERGUS TERMINAL - Cab Structure Major Refurbishment | 0 | 0 | | | | | |
| Totals | 0 | | | | | | |

Table 8: Summary of UIDs and Associated Funding

8.8 This report has explained the operational concerns NGGT has regarding the number of gas compressors available and the implications of these on terminal operations. The intervention is necessary to ensure ongoing 24/7 365 operation of the terminal facility. Investing in order to restore a fourth Avon compressor to operation ensures sufficient resilience to continue operation to 2030. We plan to seek to recover these RIIO-T2 incurred costs as part of the January 2023 Asset Health Re-opener Submission.

8.9 The contract has been awarded and ██████████ are now in a brief planning and design phase. They will proceed onto onsite delivery early in 2023, with the first activities set to be the removal and replacement of the Galbestos cladding.

9 Appendices

9.1 Appendix 1 – St Fergus Short-Term Strategy (2021 -2030)

Full report provided, filename:

RIO-T2 St Fergus Short Term Strategy V7.pdf

9.2 Appendix 2 – Unit Decommissioning Engineering Justification

Draft report provided, filename:

St Fergus - Unit Decommissioning 2C and 2D EJP v2 May22 Submitted

9.3 Appendix 3 – [REDACTED] – Conditional Survey Report

The below report presents the initial findings from [REDACTED] following a survey undertaken on the week commencing 7 of February 2022 with the aim to determine the current state of Units 1C and 2B and the required actions to renovate the units to an acceptable standard.

Full report provided, filename:

20606-DDR-002-B Conditional Survey Units 1C and 2B1

9.4 Appendix 4 – Project Programme

Current draft delivery programme provided, filename:

16.12.22 PJ20659 - St Fergus Programme Rev A

9.5 Appendix 5 – Supplementary Questions and NGGT Responses

Ofgem supplementary questions submitted in response to an early draft and NGGT responses:

310822 StF Avon Relife SQs_V1