Jemena Gas Networks (NSW) Ltd

Northern Trunk - Lic 8c - Pigging Facilities

Options Analysis

GAS-1295-RP-PL-006

24 October 2023

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Appendix A Network Risk Assessment Summary

1. EXECUTIVE SUMMARY

1.1 PROJECT AND KEY DRIVERS

The Licence 8c Pipeline is a critical asset managed by Jemena Gas Networks (JGN) supplying gas to the largest single customer on the network. The pipeline was constructed at the same time as the rest of the Northern Trunk Pipeline (Licences 3, 7, 8a and 8b), with the same construction techniques, quality control and materials. In-line inspections (ILI) of these upstream pipelines have revealed an ongoing risk with the dis-bonding of heat shrink sleeves (HSS) which could potentially pose significant safety risks. Traditional DCVG inspections that were carried out on this pipeline in lieu of ILI are not capable of detecting these disbonded coatings. To address these challenges, Jemena has developed a strategy, outlined in the Jemena Asset Class Strategy[1], which involves reconfiguring this section of the pipeline to enable in-line inspection.

The primary driver behind the "Licence 8c Pigging Facilities" project is the need to proactively address the integrity and safety concerns identified on the rest of the Northern Trunk Pipeline which potentially extend to the Licence 8c section of the pipeline. These concerns are primarily linked to corrosion occurring beneath disbonded heat shrink sleeves (HSS) at field joints (i.e. girth welds) as mentioned above. This leads to the potential risk of through-wall corrosion leading to gas escape and is rated as "High" according to both Jemena's risk assessment matrix and the AS2885 Risk Matrix.

Additionally, the project addresses critical obligations under the Gas Supply Act 1996, including ensuring the continuity of natural gas supply to customers and the development of efficient and safe gas distribution systems. The aging condition of the pipeline, situated in a high-consequence industrial environment, combined with the presence of corrosion, requires immediate attention. The existing controls, such as cathodic protection (CP) and direct current voltage gradient (DCVG), are insufficient to guarantee pipeline integrity, making it imperative to take proactive measures to safeguard public safety and ensure the reliability of gas distribution system.

[1] Refer to GAS-999-PA-PL-002 JGN – Pipelines Asset Class Strategy: http://ecms/otcs/cs.exe/open/322879221

1.2 CREDIBLE OPTIONS

The following options were assessed for this project and are provided in Table 1 below. The table shows the capital and operational costs of each option in present value terms.

Table 1: Options Summary

Option	Option Name	Description	Cost (A$ 000's) in present value terms		Treated Risk (Highest Risk)	
					Jemena	AS2885
1	Maintain Status Quo **(Not recommended)**	This involves existing inspection techniques including DCVG (coating surveys) and digging up the pipeline to perform inspections for any metal loss.	Capex	Nil	High	High
			Opex	$ 10M[2]		
2	Reconfigure the pipeline to enable in-line inspection (pigging facilities) **(Recommended option)**	In-Line Inspection (pigging) is capable of inspecting the entire pipeline condition and it doesn't impact customers supply. Using this technology is industry standard and recognised as an efficient means of managing a pipeline.	Capex	$ 6.91M (one off)	Moderate	Low
			Opex	$1.42M[3] (ILI – every 10 yrs) $ 1.75M[4] (validation digs – every 10 yrs)		
3	Replace pipeline **(Not recommended)**	This option is to replace the pipeline with one of similar specification but built to modern standards with more advanced materials for corrosion protection.	Capex	$ 30.0M[5]	Moderate	Low
			Opex	Nil		
4	Direct inspection of pipeline **(Not recommended)**	This option involves digging up the entire length of the pipeline (~1600m), inspecting the general coating condition and replacing all the field joint coating with a modern product	Capex	Nil	Moderate	Low
			Opex	$ 16.5M[6]		

[2] 3 digs per year at a cost of $300k per dig, along with 1 DCVG at 5 years interval @ $50k. The cost of $10M is based over 10 year period

[3] Northern Trunk (Lic 8c) – ILI will be carried out after the construction of the pigging facilities, under OPEX project BAB-RAK-000137 (refer to PEM BAB-RAK-000137 - Northern Trunk (Lic 8C) - ILI v1.97R-1.xlsm)

[4] Northern Trunk (Lic 8c) – Validation digs will be carried out after the ILI, under OPEX project BAB-RAK-000135 (refer to PEM BAB-RAK-000135 - Northern Trunk (Lic 8c) - Validation Digs v1.97R-2.xlsm)

[5] Cost estimate based on Kurri Kurri Lateral pipeline price, 450m of DN350 for $8.4M ($18,000/m)

[6] Cost estimate based on exposing 2 welds per integrity dig at a cost of $300k per dig (total number of welds is expected to be 110).

Note: Other potential options, such as “hydrostatic testing” were excluded because they do not align with the Jemena Asset Class Strategy requirements. Hydrostatic testing requires a network shutdown, which would impact the gas supply. Similarly, de-rating the pipeline pressure of this section is unfeasible as we need to maintain supply to JGN’s largest industrial customer.

1.3 RECOMMENDATION

Option 2: Reconfigure the pipeline to enable in-line inspection by constructing pigging facilities is the recommended solution.

Based on the options analysis considering the identified threats, associated risk ratings, and the pressing business needs, it is recommended that the most viable, practical and cost effective solution for addressing the integrity issues associated with the Licence 8c pipeline is to proceed with the reconfiguration of the pipeline to enable in-line inspection. This option aligns with the imperative of ensuring public safety, maintaining the integrity of JGN’s gas distribution system, and safeguarding Jemena’s financial stability.

Consistent with customer feedback, the recommended solution applies new technology to improve asset management and keep ongoing costs as low as practicable, without compromising safety. While the capital cost of reconfiguring the pipeline is significant, it will reduce the intensity of ongoing operating costs by reducing the need and frequency of integrity digs, which can prove costly and disruptive. Having access to the more accurate pipeline condition data provided by ILI may also enable us to extend the useful life of the Licence 8C further, negating the need to incur the high costs of pipeline replacement.

Reconfiguring the pipeline to enable in-line inspection not only represents the most prudent approach to addressing these critical issues but also stands as a fiscally responsible choice that aligns with long term sustainability objectives. It provides the necessary assurance of safety, reliability, and compliance while mitigating the financial risks associated with unexpected and costly repair works. This recommendation underscores the significant benefits and prudent risk mitigation offered by this option, making it the best choice for Jemena’s strategic approach to the Licence 8c pipeline’s project.

The total cost estimate (Gate 1 $\pm$30%) for this option including overheads is $6.918 M (CAPEX) for the construction of the pigging facilities. The ILI and validation digs will be carried out as separate projects under OPEX BAB-RAK-00137 and BAB-RAK-000135, respectively, at a cost of $1.42M for ILI and $1.75M for validation digs.

Note: After the construction of the pigging facilities, ILI tools will be deployed in the pipeline to detect and size anomalies that pose a threat to pipeline integrity. Validation digs are performed after the ILI run to verify in-line inspection data and enable calibration. Thus, both ILI and validation digs are critical components of pipeline integrity management.

1.4 CUSTOMER FEEDBACK

Customers have told us they value a safe and reliable gas supply, and expect JGN to ensure the gas network remains safe and that gas is available when customers need it. In recent engagements, customers have indicated a preference for targeted investment in safety and reliability, encouraging JGN to proactively manage integrity issues with the aim of reducing ongoing maintenance costs. A strong theme that emerged from our customer engagement program is that while customers expect JGN to keep costs as low as practicable and encourage non-critical investments to be deferred where prudent to do, safety must not be compromised.

Customers have suggested JGN should carefully consider the pace of investment, and take a considered approach to how the network may be used in the future. Customers want us to consider affordability over the short and long term when making decisions. Customers expect us to act now and plan for a net zero emissions future, rather than delaying investment. This includes looking at how new technology could be applied to improve asset management.

Customers continue to connect to the gas network. While growth in demand for natural gas services has slowed in recent years, new connections will continue during the next regulatory period, with growth expected in some pockets of the network. The distribution network is expected to continue to play a major role in NSW's energy future. Customers have told us that that they value choice and diversity in their energy supply. Though there is a current trend towards electrification of industries, 85% of Sydney customers agree that NSW needs a mix of energy sources – including solar, wind and gas – and that we should not 'put all energy eggs in one basket'. 78% of customers support having the choice of renewable gas options as part of the energy transition.[7]

Thousands of customers remain dependent on the gas network, with many not be willing or able to switch away from gas as an energy supply. As such, while investment in network growth may be more conservative than compared to historical levels, it is important JGN continues to invest to sustain the network and ensure compliant pressures and uninterrupted supply.

1.5 CONSISTENCY WITH NATIONAL GAS RULES & NATIONAL GAS OBJECTIVE

When developing this Options Analysis, we have given regard to the requirements of the National Gas Rules (NGR) and the National Gas Objective (NGO).

NGR 79(1)

We submit that the proposed solution is prudent, efficient, consistent with good industry practice, and will achieve the lowest sustainable cost of providing services.

- **Prudent** – The expenditure is necessary in order to ensure the ongoing integrity of the Licence 8c is maintained and to reduce the risk of major gas escapes that could impact public safety and reliability of supply. ILI is proven to help address the risk associated with high pressure pipelines and therefore represents an investment that a prudent pipeline operator would incur.
- **Efficient** – The forecast expenditure is based on rates applied in previous ILI reconfiguration projects, and costs will be undertaken subject to a detailed engineering assessment and design.
- **Consistent with accepted and good industry practice** – ILI is accepted industry good practice and has become commonplace among Australian gas distribution pipeline operators. AS2885.3 mandates that pipeline integrity and condition be assessed to confirm the pipeline's ability to safely operate at the nominated MAOP. AS2885.3 requires ILI to be considered where practicable.

[7] Redbridge, Sydney energy attitudes and sentiments, December 2023.

- **Achieve the lowest sustainable cost of delivering pipeline services** – The proposed expenditure is necessary to maintain the long term integrity of the Licence 8c pipeline. Failure to do so would result in additional expenditure (reactive response to a major gas escape and bringing forward replacement) and increase the long term operating cost of the pipeline. The project is therefore consistent with the objective of achieving the lowest sustainable cost of delivering services. It may also enable us to extend the technical design life of the Licence 8c and manage the future replacement/maintenance schedule more efficiently. Deferring replacement costs and being able to utilise fully depreciated assets for as long as is safe and practicable will eventuate in the lowest sustainable cost of providing pipeline services.

NGR 79(2)

The proposed capex is justifiable under NGR 79(2)(c)(i) and 79(2)(c)(ii), as it is necessary to maintain the safety and integrity of services. Corrosion is one of the primary failure modes associated with steel high pressure pipelines, and any pipeline failure has the potential to interrupt supply to thousands of customers at any one time. Early detection of corrosion is essential to maintain the safety and integrity of services, particularly with pipelines that are beyond their design life.

The current practice of DCVG surveys and dig ups alone is insufficient to manage the integrity risk to an acceptable level. Since the pipeline is in a waterlogged area with high water table, there are too many sections of the Licence 8c pipeline that cannot be dug up or inspected without inserting an inline inspection tool. It is therefore prudent to reconfigure the pipeline to allow pigging and extend the life of the asset, negating the need to incur the high costs of pipeline replacement.

NGR 74

The forecast costs have been arrived at on a reasonable basis by following realistic assumptions of costs, informed by previous ILI reconfiguration projects in JGN. Rates are comparable with the market and the volume of pipeline that is to be reconfigured is being limited for the next access arrangement period, with a view to informing more accurate forecasts in future periods. We therefore consider the costs estimates represent the best forecast possible in the circumstances.

NGO

The Licence 8c Pipeline is a vital asset to the JGN gas distribution network as it supplies natural gas to the largest single customer on the network, which will continue throughout the next regulatory period and for the foreseeable future. The Licence 8c pipeline is likely to have a significant role throughout Australia's energy transition, therefore maintaining its efficient operation is in the long term interests of consumers.

2. PROJECT BACKGROUND AND KEY DRIVERS

2.1 PROJECT BACKGROUND

The Licence 8c Pipeline is a critical asset managed by Jemena Gas Networks (JGN) supplying gas to the largest single customer on the network. The maximum allowable operating pressure (MAOP) of the pipeline is 6.895 MPa, and it operates in compliance with the Gas Supply (Safety and Network Management) Regulation[8] (2022), and by extension, the Australian Standard AS2885.3[9].

The Pipeline was commissioned in 1981 and transports gas from the Incitec (now Orica) Bulk Metering Station (BMS), to the Orica production site on Kooragang Island, to the north of Newcastle, NSW. The pipeline section is only 1,633m long and constructed of API 5L X52, DN250 pipe with a 5.26mm wall thickness operating it at a 0.5 design factor at MAOP.

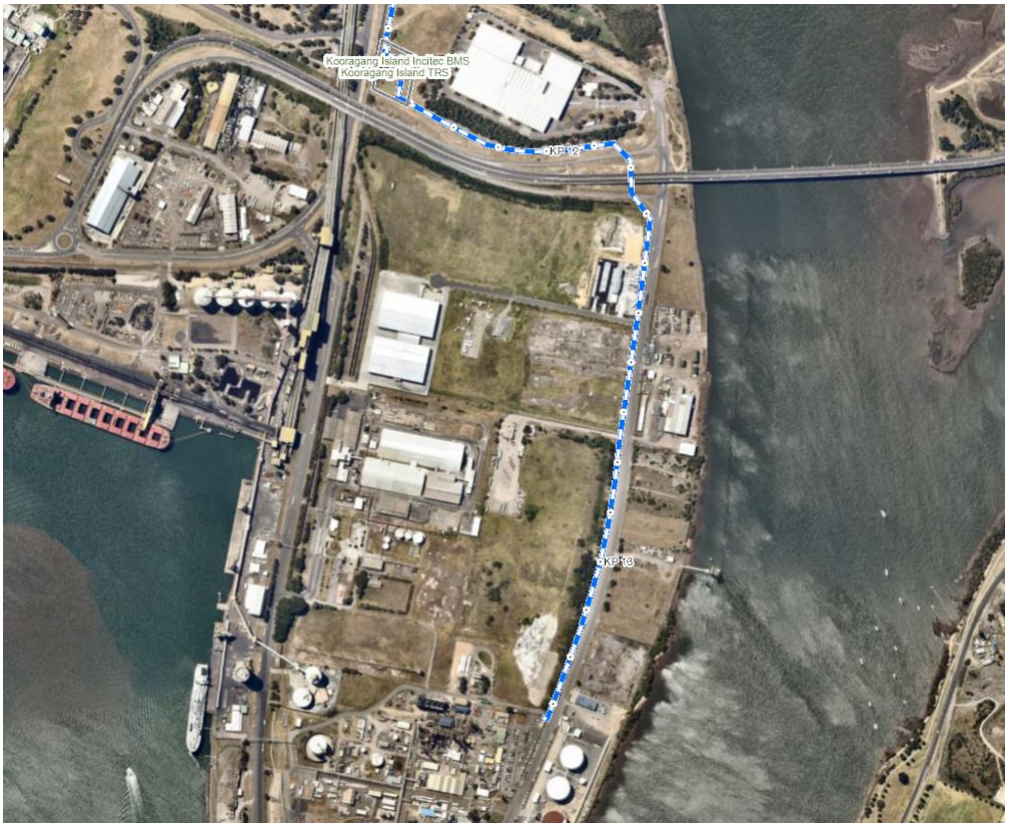

Figure 1: Licence 8c location

[8] Gas Supply (Safety and Network Management) Regulation 2022 Link

[9] AS2885.3 – 2022 – Pipeline – Gas and Liquid Petroleum Part 3: Operation and Maintenance, Section 6: Pipeline Structural Integrity, including but not limited to operational control, corrosion protection, pipe wall integrity and inspection

AS2885.3 mandates that pipeline integrity and condition be assessed to confirm the pipeline is able to continue safe operation at the nominated MAOP. The Pipeline has historically met this regulatory obligation by performing DCVG surveys followed up with integrity digs. This method has been acceptable in the past because we have relied on the design of the pipeline to provide the assurance that any corrosion that occurs is manageable.

However, the Pipeline is aging, with commissioning occurring in 1981. As the pipeline has been in operation for over 40 years, it is imperative to fully understand the pipe wall's condition to confirm its ability to continue safe and reliable operations. This can be efficiently confirmed by measuring the pipe wall thickness, best provided by performing ILI.

2.2 IDENTIFIED NEED

The 2020 Licence 8 Five yearly Safety Management Study (SMS)[10] , asset operational reports and recent pipeline's APAIR[11] have identified the threat of corrosion at the field applied disbonded HSS on the entire Northern Trunk Pipeline. Modern high-pressure gas mains are designed to enable a pig tool to run through the pipe which inspects the thickness of the pipe wall from the inside that can identify all corrosion. This inspection method is an industry wide practice as it is the most cost effective and efficient way of inspection.

The Licence 8c Pipeline does not have this capability and we historically verify the condition by conducting DCVG surveys and digging holes to inspect the condition of the pipe and coating. As mentioned above a DCVG survey is not an effective method of detecting the identified threat of disbonded HSS.

There is also a safety risk in conducting these spot checks as we do not know the full condition of the pipeline. By reconfiguring the pipeline to inspect the pipeline more thoroughly, using a pigging tool provides a cost-effective method to show a complete picture of the condition of the pipeline allowing us to identify and correct material defects.

If integrity management works are not carried out on the Licence 8c pipeline, potential outcomes may include a gas leak due to external corrosion, this risk is amplified by CP shielding which occurs as disbonded HSS locations and renders the CP ineffective. Such a leak could release flammable gas, leading to possible ignition and catastrophic consequences, including the risk of fatalities for workers and the public within the pipelines vicinity.

[10] Refer to GAS-1295-RP-RM-001 Licence 8 Pipeline - Five (5) Yearly Safety Management Study (SMS): http://ecms/otcs/cs.exe/open/303092143

[11] GAS-999-RP-IN-003 JGN Pipelines Asset Performance and Integrity Review (APAIR) - July 2021 to June 2022": http://ecms/otcs/cs.exe/open/321230339

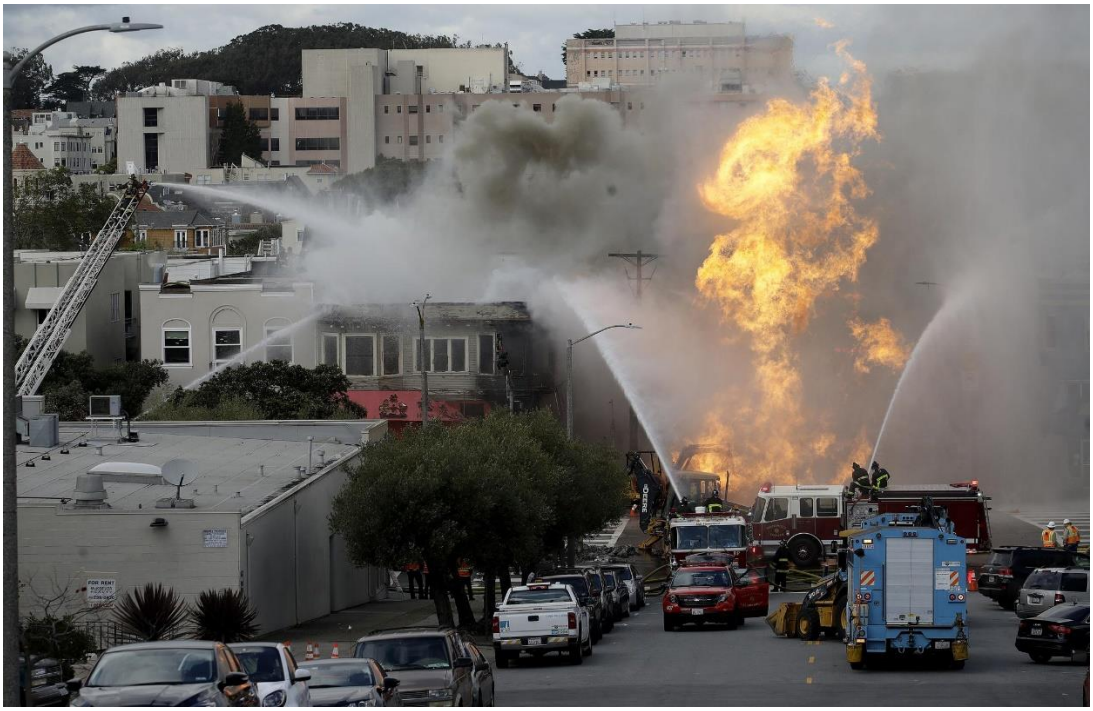

Figure 2 Wednesday, Feb. 6, 2019. A 4-inch plastic gas pipe explosion in San Francisco.

The risk of gas escape resulting in either; a sinkhole substantially impacting road or rail infrastructure or leading to jet fire affecting public safety is rated as *HIGH* which is above the broadly accepted level defined in the Jemena Risk Manual[12] and AS 2885 and requires further risk reduction, if the risk cannot be shown as low as reasonably practicable (**ALARP**).

2.3 PROJECT DRIVERS AND OBLIGATIONS

Based on the identified risk, a solution is required to assess the integrity to ensure the assets are compliant with the obligations and requirements of the Gas Supply Act 1996 No. 38[13] and by extension the Gas Supply (Safety and Network Management) Regulation 2022[14] and Australian Standard AS 2885.3[15].

- *Jemena will not be able to meet its obligations under the Gas Supply Act 1996 No.38 - Facilitate the continuity of supply of natural gas to customers and Consider the development of efficient and safe gas distribution systems*

The current approved safety and operating plan accepted by the **NSW** regulator is Jemena's Safety Case (**SAOP**) of New South Wales (**NSW**) gas assets. The **SAOP** calls on the **JGN ACS**[16] as the principal document which defines the approach and principal methods by which each asset class contributes to delivering Jemena's

12 Refer to: JAA MA 0050 – Group Risk Management Manual – Figure 9: Risk Evaluation, Escalation and Reporting Table

13 Gas Supply Act 1996 No. 38 – Part 1 Section 3 clause (1) subclause (b1), clause (3), and clause (3A)

14 Gas Supply (Safety and Network Management) Regulation 2022 Link

15 AS2885.3 – 2022 – Pipeline – Gas and Liquid Petroleum Part 3: Operation and Maintenance, Section 6: Pipeline Structural Integrity, including but not limited to operational control, corrosion protection, pipe wall integrity and inspection

16 Refer to GAS-999-PA-PL-002 – JGN - Pipelines Asset Class Strategy - http://ecms/otcs/cs.exe/open/322879221

Asset Management and Health and Safety objectives as defined in the **JGN** Asset Business Strategy (**ABS**). These are to:

- *Non-compliance with Australian Standards AS 2885.1 and AS 2885.3*
- Operate and maintain Jemena assets in a way that protects or enhances community safety; and
- Be the customers' first choice for world leading, reliable and sustainable energy solutions.

Jemena as a prudent gas operator, takes into account and complies with relevant standards (such as codes, Australian Standards, guidelines or other requirements) when operating a gas network.

The external corrosion threats which have been identified on the Licence 8c Pipeline cannot be mitigated with current measures and if not checked can affect the pipeline's integrity resulting in a risk of loss of containment, loss of supply or financial loss.

Summary of identified threats and associated risk ratings (as per Group risk management manual and AS2885.1 Risk Matrix) are provided below. The untreated risk levels as determined by the Jemena and AS2885 risk assessment matrices is shown in Table 2. Refer to Appendix A for the detailed risk assessment.

Table 2 – Untreated Risk Ratings

Threat Type	Threat Cause	Threat Consequence	Untreated Jemena Risk Rating	Untreated AS 2885 Risk Rating
People (safety)	Through wall corrosion leading to loss of containment resulting from corrosion under disbonded HSS aided by CP shielding (Pin hole gas leak assuming 20 mm hole results in unacceptable heat contours at 12.6kW/m^2 = 12 m & 4.7 kW/m^2 = 20 m)	Through wall corrosion will result in gas escape leading to a massive sinkhole which would potentially shutdown traffic, and would sink surrounding properties and infrastructure, affecting public safety. If the gas leak were to ignite, fatalities would occur within a radius of 12m to 15m and buildings would be destroyed.	High	High
Supply		Potential interruption of supply to JGN largest customer by volume due to reduction in pressure during repair process.	Significant	Intermediate
Environmental		Crater formation close to source of leak. Damage to buildings and infrastructure Release of significant amounts of unburnt natural gas to atmosphere.	Moderate	Intermediate
Financial		Necessary permanent repair at location of pipe wall defect. Requiring unplanned or unbudgeted expenditure for repair works (> $1M < $10M)	Moderate	N/A

2.4 CURRENT STATUS OF ASSET

From 2004 to 2023, three (3) integrity digs have been conducted along the Licence 8c pipeline, showing no evidence of deterioration. However, over 80 integrity digs have been performed on upstream pipelines (Licence 3, 7, 8a & 8b), revealing common issues such as disbondment and poor adhesion of heat shrink sleeves (HSS). In the past 5 years, eight (8) inspections have uncovered severe corrosion under these disbonded sleeves, necessitating repairs.

To date all anomalies were repaired either by installing composite wraps, welded sleeve or by replacing the damaged coating. Based on the existing integrity dig data, a wholistic assessment of the integrity of the entire pipeline indicates that corrosion under HSS is a credible threat for the entire length of the pipeline including the License 8c section.

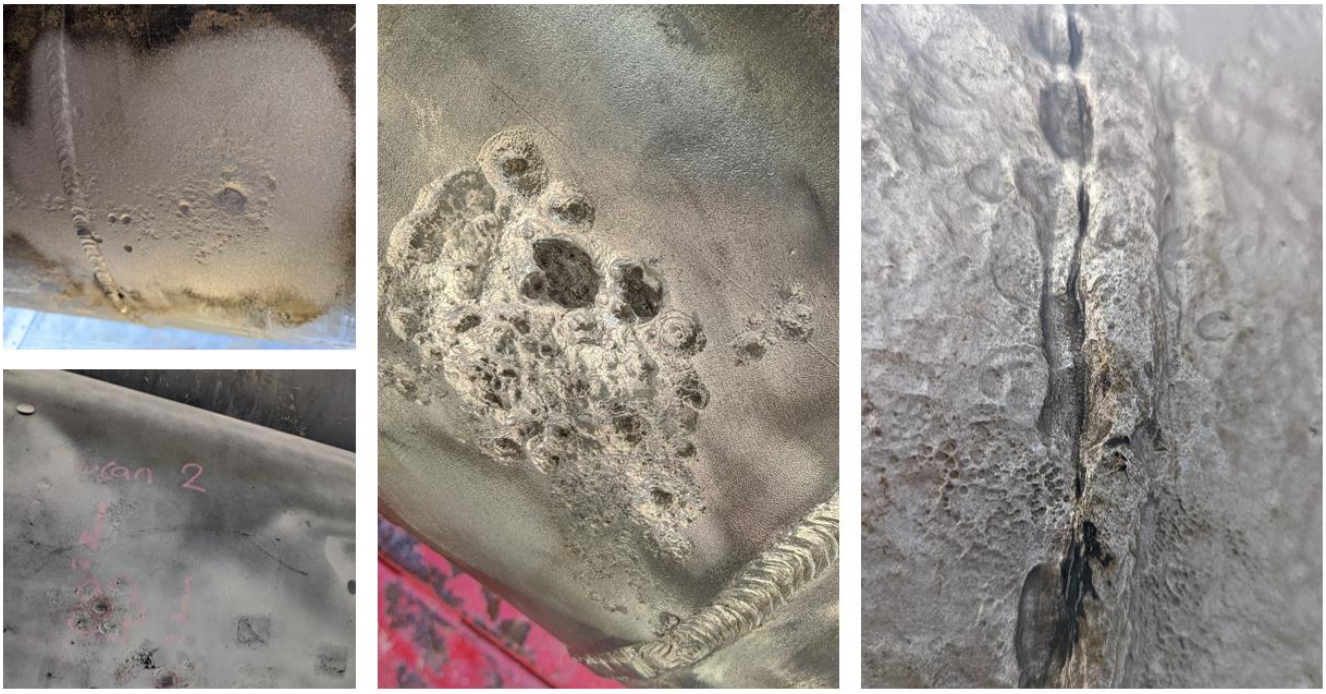

Figure 3: Corrosion Anomalies found on Licence 3, 7, 8a & 8b - ILI

2.5 ASSUMPTIONS

Table 3 lists the assumptions that are applicable to this Options Analysis.

Table 3: General assumptions and implications

S.No.	Assumptions	Implication
1.	All sections of the Northern Trunk Pipeline including License 8c are subject to corrosion under HSS similar to recent findings on the balance of the pipeline	Some sections may be worse or better than the assumed and may/ or may not require significant repairs.

2.	Pipeline operation risk during pigging is tolerable.	The schedule of the pigging activity will need to be planned outside the winter period to avoid any capacity / supply risks.
3.	A small foot print will be required for pipe modification and installation of temporary launcher and receiver system, and no land will need to be acquired or leased.	If land for pig launcher and receiver facility needs to be acquired or leased costs will increase.
4.	Hydrostatic testing of the section is not a credible option	Hydrostatic testing would require a shutdown of the main for up to two weeks, resulting in loss of supply to JGN's largest customer

2.6 STRATEGY

Jemena is mandated to demonstrate that pipeline integrity is monitored, assessed and maintained in accordance with AS2885.3 to ensure continuous safe operation. This project is a continuation of works to improve the safety and integrity of the Northern Trunk asset by facilitating in-line inspection and addressing the associated risks related to external corrosion under disbonded HSS.

As part of Jemena Asset Management System (AMS)[17], we conduct annual asset condition assessments for all our assets. These assessments provide critical insights into an asset's remaining life expectancy and when preventive actions are warranted[18]. Based on findings discovered on pipelines of similar vintage, the threat related to undetected corrosion under disbonded HSS on Licence 8 pipeline have been identified through an asset condition assessment, notably the **JGN** Pipeline Asset Performance and Integrity Report (**APAIR**)[19]. These findings are incorporated into the **Licence 8** Integrity Risk Register[20], which both then feed in to the **JGN ACS**[21].

Historically, the integrity of the entire Licence 8c Pipeline was managed through sporadic integrity digs to inspect the pipe wall condition. Data collected from these checks was used to infer the pipe's condition and operational safety in similar locations. This approach was suitable, given the pipeline's age and the reasonable cost of such spot checks.

However, Jemena's strategy underwent a transformation in 2018 for two main reasons:

1. The pipeline's condition is deteriorating with age.
2. The cost of integrity digs has escalated, diminishing the efficiency of spot checks.

Consequently, our new strategy is focused around de-rating the main wherever possible. In instances where de-rating is not feasible, we are actively pursuing pipeline reconfiguration to enable in-line inspection (ILI), also known as pigging, as a more efficient and cost-effective approach.

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17 JEM AM MA 0001 Jemena Asset Management System Manual http://ecms/otcs/livelink.exe/open/301179363

18 JEM AM MA 0001 Jemena Asset Management System Manual http://ecms/otcs/livelink.exe/open/301179363– Section 10.5 and 10.5.1

19 GAS-999-RP-IN-003 JGN Pipelines Asset Performance and Integrity Review (APAIR) - July 2021 to June 2022": http://ecms/otcs/cs.exe/open/321230339

20 GAS-1295-RG-RM-002 ASG Pipelines Risk Register - Lic 3,7,8 http://ecms/otcs/cs.exe/Open/310268187

21 Refer to GAS-999-PA-PL-002 – JGN - Pipelines Asset Class Strategy - http://ecms/otcs/cs.exe/open/322879221

3. CREDIBLE OPTIONS

The following options were identified to address the threat of external corrosion on Licence 8c:

• Option 1: Maintain Status Quo (continue with DCVG every 5 years and integrity digs as required)

• Option 2: Reconfigure the pipeline section to enable in-line inspection

• Option 3: Replace Pipeline

• Option 4: Direct inspection of Pipeline.

All options are explained in detail below.

3.1 OPTION 1 – MAINTAIN STATUS QUO (INTEGRITY DIG PROGRAM)

This option is no longer considered to be an acceptable method of validating the ongoing safe and reliable operation of this pipeline. Knowledge of the pipelines condition and specific threat that cannot be mitigated, requires a more complete understanding of the condition of this asset.

Under this option, JGN would continue undertaking integrity digs in areas where corrosion is inferred to be more susceptible. This can include locations where the pipeline has historically had poor coating, issues with CP and where the pipe is subject to changing wet and dry conditions.

These locations would then be inspected by digging up the main and physically removing the HSS and inspecting the pipeline for any metal loss. The data gained can then be extrapolated across other areas of Licence 8c pipeline. However, this does not give the same level of confidence as undertaking direct inspection of the pipe wall along the full pipeline length. This option would require three integrity digs performed each year on this section of the pipeline and a DCVG survey performed every five years.

3.1.1 CONSTRAINTS

The following constraints provided in Table 4 are applicable to Option - 1

Table 4: Constraints for Option - 1

Description	Implication
Some sections of pipeline are inaccessible as they are under major road.	The condition of the pipeline at these locations will remain unknown, and will be at risk of failure. If dig ups are performed it will require a significant capital cost, in the range of ($400k to $600k for one dig up).
Disbonded HSS cannot be detected through above ground inspection techniques such as DCVG.	Random locations will be selected for dig ups which reduces the probability of finding the actual defect. More length of pipeline would need to be exposed to search for girth welds with disbonded HSS which substantially increase the cost of dig ups.

3.1.2 BENEFITS & DRAWBACKS:

The expected benefits and drawbacks of this option are provided in the Table 5 below:

Table 5 : Benefits and Drawbacks of Option 1

Benefits	Drawbacks	Risk Reduction	
		Jemena	AS2885
• Validate identified threats, pipeline condition and confirm MAOP of the pipeline localised to locations where integrity digs have been performed • Allows the repair of any identified defect immediately during dig up such as coating or metal loss anomalies as these can be repaired prior to the occurrence of through wall corrosion at the targeted location. • Avoid initial capital outlay by spreading the cost overtime • Allows finding other integrity issues which are currently unidentified and provides data for trending purposes	• Public safety and security of supply will be at “High” risk due to pipeline failure • No guarantee against high consequence events • Does not address the pipeline overall safety, supply and integrity concerns as the rate of anomaly deterioration / corrosion rate cannot be determined to adequately evaluate pipeline remaining life, thus the pipeline refurbishment activities cannot be efficiently planned. • Integrity dig at a specific location does not represent statistically the entire pipeline condition, thus the overall pipeline condition remains unknown. • The chances of finding a defect in the exact location where an integrity dig takes place is low, can give false indication of condition of the coating and pipeline. • JGN reputation and gas distribution business would be at stake. • The cost of dig ups will continue to rise due to the continuous growth of industries and infrastructure, thus in long term the cost will be disproportionate to the benefit achieved. • Unbudgeted OPEX expenditure would be required to undertake ad-hoc repairs. • This option will cause more frequent disturbance to environment and community.	High	High

3.2 OPTION 2: RECONFIGURE THE PIPELINE TO ENABLE IN-LINE INSPECTION – CONSTRUCTING PIGGING FACILITIES

In-Line Inspection (pigging) involves the use of devices known as pigs which clean the pipeline and are capable of checking pipeline condition. It requires a pig trap to insert a pig into the pipeline and a receiver at the end of the pipeline to receive the pig once it has travelled the length of the pipeline.

The ILI of the Pipeline would be used to identify areas where pipe wall integrity has deteriorated, informing where repair works would take place[22]. Once the initial ILI has been performed, ongoing integrity of the pipeline will be maintained by operating in accordance with the **JGN ACS.**

ILI is the pipeline industry preferred integrity assessment technique to validate the structural integrity of high pressure pipelines. This method assesses pipeline wall conditions along its length, identifying and characterizing any anomalies encountered. ILI proves cost-effective for detecting integrity issues like corrosion (including detection under Heat Shrink Sleeves), manufacturing defects, and mechanical damage. Moreover, the pigging facility enables future fuel compatibility inspection of the pipeline, a task currently unfeasible without excavating the entire pipeline.

This option includes all necessary pre-work for performing the **ILI**, which involves digging up and validating that existing bends / tees would allow passage of modern ILI pigs, modifying existing pipework, installing ILI launcher/receiver infrastructure, detailed selection of an inspection tool, and finally undertaking the ILI inspection. This project will only involve the construction of the pigging facilities, while the actual pigging will be carried out by a subsequent project.

3.2.1 CONSTRAINTS

The following constraints provided in Table 6 are applicable to Option 2

Table 6: Constraints for Option 2

Description	Implication
Pipeline construction details are not adequately available to confirm that the pipeline is piggable	To determine the piggability of pipeline, feasibility assessment will be required to confirm the characteristics and geometry of the existing bends. The results of the investigation will determine if any pipeline modification are required for the pigging.
There are no pig launcher or receiver facility on existing Licence 8c pipeline to allow ILI activity.	Pipeline modification will be required to install temporary launcher and receiver facility.

[22] The cost of any major pipeline cut out repairs has not been considered in this Options Analysis, only the cost of validation digs, sleeve or composite repairs and coating reinstatement are included post pigging based on experience with pigging of pipelines of similar vintage

3.2.2 BENEFITS & DRAWBACKS:

The expected benefits and drawbacks of this option are provided in the Table 7 below:

Table 7: Benefits and Drawbacks of Option 2

Benefits	Drawbacks	Risk Reduction	
		Jemena	AS2885
• Provides quantitative data to accurately assess any anomalies found on the pipe wall and allows targeted repairs to be undertaken to ensure safety and security of supply, including minor repairs prior to worsening of any identified anomaly • Reduces number of random dig ups, frequent disturbance to environment and community, and long term cost o by minimising dig up footprints • The ILI will determine the presence of corrosion under disbonded HSS, thus the actual data of the entire pipeline and ability to target problematic areas minimises the likelihood of through wall corrosion occurring. • Ability to conduct ILI without removing the line from service thus maintaining supply. • Determine threats along the pipeline which may have been unidentified prior to ILI and assess the associated risk. • Confirm the ability to continue operating at MAOP as required for a ten-yearly AS2885.3 Fitness for Service assessment. • Ability to establish appropriate intervals to monitor for changes in existing anomalies or newly identified anomalies and determine an effective corrosion rate for all identified anomalies; and • Provides a reliable and comprehensive dataset for continued management of long term integrity of the Pipeline and ensure security of supply	• Modification to pipework will be required to implement pigging activity • Validation digs will be required to validate pigging results • Not all ILI tools from various vendors have the same detection and characterization capabilities	Moderate	Low

3.3 OPTION 3: REPLACE PIPELINE

This option is to replace the entire Licence 8c pipeline with a new build pipeline using modern materials, coatings and a higher safety factor along with new pigging facilities. This would require a new design, regulatory approvals and significant consultation with the various stakeholders impacted to complete.

Installing a new pipeline will allow Jemena the opportunity to design a pipeline that is hydrogen-ready, which could be used for the transportation or storage of hydrogen and is also compatible with future fuels. Although this will come at a significant cost, Jemena would need to engage with potential project partners to utilize the pipeline in future.

3.3.1 CONSTRAINTS

The following constraints provided in Table 8 are applicable to Option 3

Table 8: Constraints for Option 3

Description	Implication
Cost of replacing the assets is significant	The implication of the cost of replacing the entire pipeline with a hydrogen-ready pipeline is significant financial investment. This includes expenses associated with designing, constructing, and commissioning the new pipeline to meet hydrogen transportation or storage standards. Additionally, there may be costs related to regulatory compliance, stakeholder engagement, and potential project partnerships. While the upfront cost is substantial, it offers the opportunity to future-proof the pipeline for hydrogen use and align with evolving energy trends and regulations
Construction work in the industrial area, permitting, land access and stakeholders	The location of the works in the industrial zone on Kooragang Island means working time may be restricted. There may also be restrictions on working space close to large industrial facilities.

3.3.2 BENEFITS & DRAWBACKS:

The expected benefits and drawbacks of this option are provided in the Table 9 below:

Table 9: Benefits and Drawbacks of Option 3

Benefits	Drawbacks	Risk Reduction	
		Jemena	AS2885
• A new pipeline will make catastrophic failure (ignition resulting in fatality) to remote. • Reduces overall risk ranking from High to Low (AS2885) • A new pipeline will not require the levels of corrective maintenance seen in vintage network assets.	• Significant Capital Investment. • Extensive resource and time required to design and build the pipeline	Moderate	Low

Benefits	Drawbacks	Risk Reduction	
		Jemena	AS2885
• The pipeline will be compatible with future fuels.			

3.4 OPTION 4: DIRECT INSPECTION OF PIPELINE.

This option involves direct inspection of all welded joints along the Licence 8c pipeline. This would involve the excavation of the ~110 weld joint locations along pipeline, or essentially the systematic exposing of the entire line for the purpose of inspecting the coating and repairing any damage discovered.

This approach will reduce the risk of failure with ignition, due to a reduced probability of failure (reducing the overall risk rating). The cost of this option will be very similar to laying a new pipeline but as with the other options there are limitations. While performing these inspections and repairs will extend the life of the pipeline, the pipeline would still not be inspectable which does limit the future usability of the asset in terms of future fuel compatibility.

3.4.1 CONSTRAINTS

The following constraints provided in Table 8 are applicable to Option 4

Table 10: Constraints for Option 4

Description	Implication
Cost of work is variable, depending on what is discovered.	The cost of excavating and inspecting the pipeline can be estimated and is fixed, depending on what and how much damage is discovered, the cost of repair may inflate the cost of the project
Construction work in the industrial area, permitting, land access and stakeholders	The location of the works in the industrial zone on Kooragang Island means working time may be restricted. There may also be restrictions on working space close to large industrial facilities.

3.4.2 BENEFITS & DRAWBACKS:

The expected benefits and drawbacks of this option are provided in the Table 9 below:

Table 11: Benefits and Drawbacks of Option 3

Benefits	Drawbacks	Risk Reduction	
		Jemena	AS2885
• Inspecting and repairing all pipe and coating damage will make catastrophic failure (ignition resulting in fatality) to remote. • Reduces overall risk ranking from High to Low (AS2885) • Inspecting and repairing all pipe and coating damage will reduce the levels of corrective maintenance compared to vintage network assets.	• Relatively short term solution, ensure pipeline is fit for service but wound still not be inspectable or proven compatible with future fuels.	Moderate	Low

3.5 COMPARISON OF OPTIONS

A summary of the options analysis is provided in **Table 12** below

Table 12: Options summary including risk, benefits and cost

Criteria	Option 1	Option 2	Option 3	Option 4
Option description	Maintain Status Quo	Reconfigure for ILI – Install Pigging Facilities	Replace Pipeline	Direct Inspection of Pipeline
Safety	Fatality risk exists	Majority of defects will be detected prior to failure	Failure rate and consequence will be reduced	Failure rate and consequence will be reduced
Integrity	Limited applicability	Majority of defects will be detected prior to failure	Failure rate and consequence will be reduced	Failure rate and consequence will be reduced
Supply Reliability	Un-planned repairs due to pipe failure	No impact to supply	No impact to supply	No impact to supply
Regulatory Compliance (AS2885)	Limited compliance	Meets compliance	Meets compliance	Meets compliance
Strategic Benefit	Limitation in forecasting future asset integrity planning works	Allows long term capital & operational works planning & expenditure	Allows long term capital & operational works planning & expenditure	Limitation in forecasting future asset integrity planning works
Delivery Constraints	• Restrictions exist on the location of integrity dig (busy arterial road or railway corridor). • Require traffic management.	• Availability and approval for suitable land in road reserve • Investigation digs to confirm piggability. • Design of launching receiver	• Delays to construction due to other utilities and council approvals. • Disturbance to community and environment during construction. • Requires traffic management.	• Delays to construction due to other utilities and council approvals. • Disturbance to community and environment during construction.

Criteria	Option 1		Option 2		Option 3		Option 4	
			system to perform pigging • Modification to existing pipeline will be required.				• Requires traffic management	
Treated Risk Ranking	Jemena		High		Moderate		Moderate	
	AS2885		High		Low		Low	
Cost Estimate (10 year period – excluding risk)	CAPEX	Nil	CAPEX	A$ 6.91M	CAPEX	A$ 30[23] M	CAPEX	Nil
	OPEX	A$ 10[24]M	OPEX	$1.42M[25] (ILI) $1.75M[26] (digs)	OPEX	Nil	OPEX	A$ 16.5[27]M
Options Analysis	○ Does not address the issue		● Fully addresses the issue		● Fully addresses the issue		● Fully addresses the issue	
Recommended order of preference for options	**Not Recommended**		**1**		**2**		**3**	

[23] Cost estimate based on Kurri Kurri Lateral pipeline price, 450m of DN350 for $8M ($17,000/m)

[24] 3 digs per year at a cost of $300k per dig, along with 1 DCVG at 5 years interval @ $50k. The cost of $10M is based over 10 year period

[25] Northern Trunk (Lic 8c) – ILI will be carried out after the construction of the pigging facilities, under OPEX project BAB-RAK-000137 (refer to PEM BAB-RAK-000137 - Northern Trunk (Lic 8C) - ILI v1.97R-1.xlsm)

[26] Northern Trunk (Lic 8c) – Validation digs will be carried out after the ILI, under OPEX project BAB-RAK-000135 (refer to PEM BAB-RAK-000135 - Northern Trunk (Lic 8c) - Validation Digs v1.97R-2.xlsm)

[27] Cost estimate based on exposing 2 welds per integrity dig at a cost of $300k per dig (total number of welds is expected to be 110).

4. RECOMMENDATION

4.1 RECOMMENDED SOLUTION

Four options were analysed to mitigate the identified risk on the Licence 8c section of the Northern Trunk Pipeline..

Option 2 (Reconfigure for ILI – Install Pigging Facilities) is **recommended** as it ensures the pipeline safe, repairing any damage found and is the most cost efficient option.

At present, the ILI method offers the only way to positively identify all external metal loss in the pipeline in a non-destructive manner. This option will provide a wholistic data set to assess the entire pipeline condition and confirm MAOP, and will allow JGN to ascertain critical pipeline asset integrity information that will assist in defining the prudent and efficient long term capital and operational works planning and expenditure.

Accurately validating the pipeline integrity using In-line inspection will mitigate the safety, supply, compliance and integrity risk to Low as per AS2885 risk matrix and Moderate in terms of Jemena Risk Management Manual. This option is also the most economical (long term) and efficient option as it meets the requirements of AS2885.3 and Jemena obligations under the Act.

The remaining 3 options are not recommended for the following reasons for this section of the Northern Trunk:

Option 1 (Maintain Status Quo) is **not recommended** as integrity digs based on DCVG do not provide a comprehensive data set of pipeline condition, especially given disbonded HHS will shield CP and prevent the detection of the damage, as a result this option will not reduce the risks to acceptable levels.

Option 3 (Replace Pipeline) is **not recommended** as this option is not financially efficient, the increased cost over other options does not provide any currently realisable benefits.

Option 4 (Direct Inspection of Pipeline) is **not recommended** as this option is not financially efficient, it is only applicable for a one-time inspection, is not repeatable, and does not provide any benefit for future inspections that will be required.

4.2 SCOPE

Based on the options analysis, Option 2 is the recommended approach for mitigating threats related to undetected external corrosion caused by CP shielding at disbonded coatings, which could lead to pipeline failure in High Consequence Areas. The pipeline will require the installation of a set of pig launcher and receiver to facilitate pigging in this section. The pig launcher will need to be installed at Kooragang Island TRS and the corresponding pig receiver will be installed downstream at the Orica facility. These requirements will be further assessed as part of the feasibility assessment.

The necessary activities for implementing the recommended option are outlined below:

1. Engage pigging vendor during FEED design:
   - Collaborate with pigging vendor during Front End Engineering Design (FEED) phase.
   - Conduct feasibility assessment using available alignment plans, valve drawings, past dig up data, and bend investigation results.
2. Evaluate and finalize temporary launcher and receiver locations:
   - Identify suitable locations for the temporary launcher and receiver systems.
3. Undertake BYDA (Before You Dig Australia), potholing and site survey:
   - Perform BYDA checks, and conduct potholing to locate underground services.
   - Conduct site surveys to assess the environment.
   - Carry out geotechnical investigation to determine the water table, soil properties, and other relevant factors.
4. Design, fabricate, and pressure test the customized temporary launcher and receiver system:
   - Develop detailed designs for the temporary launcher and receiver system.
   - Fabricate the necessary components.
   - Perform pressure tests to ensure the system's integrity.
5. Civil construction:

- Prepare the construction site, including:
  - Site clearing.
  - Excavation and leveling.
  - Construction of access roads.
  - Foundation and base preparation for launcher and receiver.
  - Installation of site fencing and security measures.

6. Excavate a trench for hot tap installation:

- Dig a trench to expose the pipeline for hot tap installation and pipe work modification.

7. Modify existing pipework:
   - Replace any un-piggable pipework, bends, or tees as necessary.
   - Modify existing pipework to accommodate the temporary launcher and receiver barrels and supporting equipment.
8. Install Double block and bleed isolation valves:
   - Install DN250 (CL600#) ball valves for double block and bleed isolation.
9. Perform pre-commissioning activities:
   - Conduct all mandatory testing as per AS2885 standards.
   - Ensure that the system meets safety and performance requirements.
10. Commission the facilities:
    - Commission the newly constructed facilities to allow for in-line inspection (pigging).
    - Ensure that all systems and equipment are operational and safe for use.

These activities are essential to implement the recommended option and enhance the integrity of the pipeline.

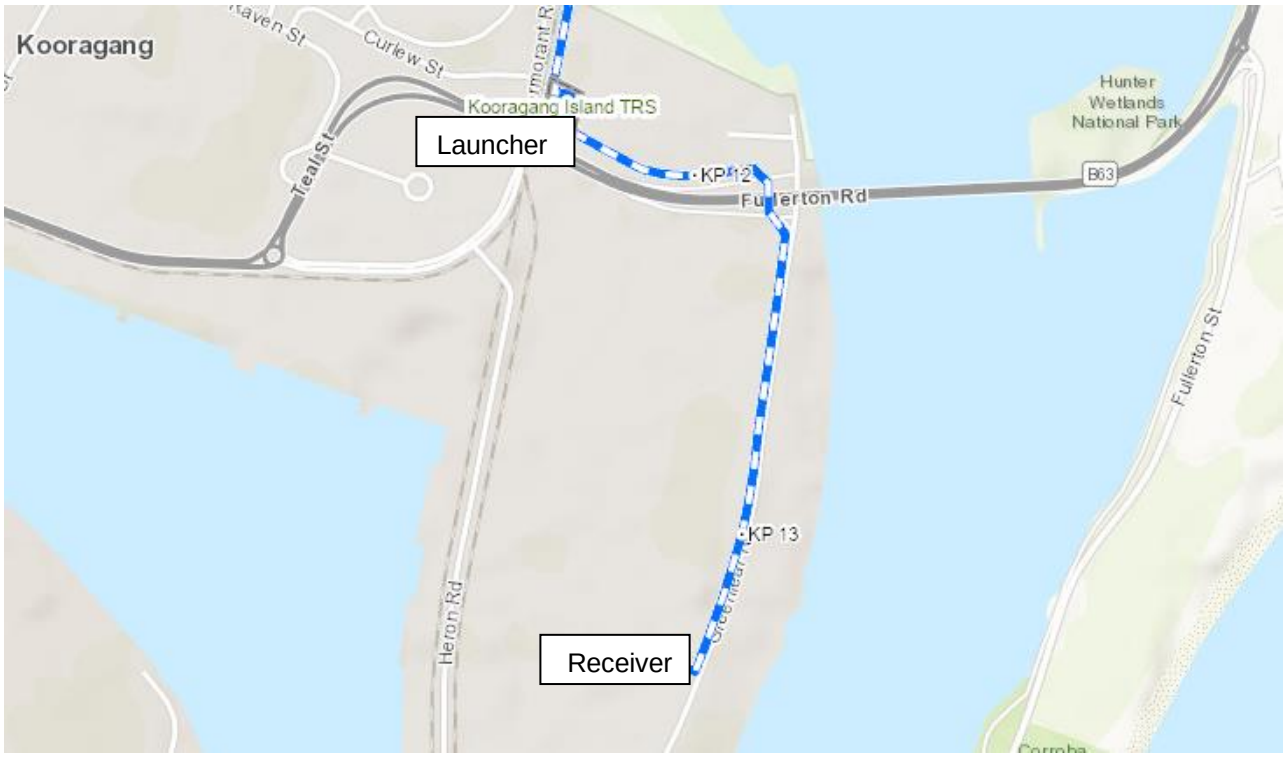

Figure 4: Proposed Launcher and Receiver Locations

4.3 COST DETAILS

4.3.1 COST METHODOLOGY

The cost estimate is based on the received quotations from the approved Jemena pigging vendor and actual costs of similar projects that underwent a competitive tendering process, which is all incorporated into Jemena's Project Estimation Model (PEM) developed by the FEED Project Manager.

4.3.2 SUMMARY OF COSTS

The summary of the cost estimate for Lic 8c pigging facilities is provided in **Table 13**:

Table 13: Project Estimation – Pigging Facilities (CAPEX)

Activities	Item	Project Estimate ($000,2024)
Lic 8c – Kooragang Island to Incitec		
Pigging Facilities (CAPEX) **Delivery Year (RY27)**	Materials	$ 707 k
	Contractor Costs	$ 2,381 k
	Jemena / Zinfra Labour	$ 814 k
	Risk (excl overhead)	$ 1,002 k
	Total Direct Costs	**$ 4,904 k**
	Indirect & Overheads	$ **2,015 k**
	Total Direct costs + Overheads	$6,919 k

Refer to JGN - RIN - 4.3 - 10068009 - Northern Trunk - Lic 8c - Pigging Facilities - PEMO - 20240628 - Public

The summary of the cost estimate for Lic 8c In-Line inspection (Opex) is provided in **Table 14**

Table 14: Project Estimation – ILI (OPEX)

Activities	Item	Project Estimate ($000,2024)
Lic 8c – Kooragang Island to Incitec		
In-Line Inspection (ILI) (OPEX) **Delivery Year (RY28)**	Contractor Costs	$ 525 k
	Jemena / Zinfra Labour	$ 298 k
	Risk (excl overhead)	$ 183 k
	Total Direct Costs	**$ 1,006 k**
	Indirect & Overheads	$ **413 k**
	Total Direct costs + Overheads	$1,419 k

Refer to JGN - RIN - 4.4 - 10068010 - Licence 8C ILI - PEMO - 20240628 - Public

The summary of the cost estimate for Lic 8c – validation digs is provided in **Table 15**

Table 15: Project Estimation – Validation Digs (OPEX)

Activities	Item	Project Estimate ($000,2024)
Lic 8c – Kooragang Island to Incitec		
Validation Digs (OPEX) **Delivery Year (RY30)**	Materials	$ 23 k
	Contractor Costs	$ 611 k
	Jemena / Zinfra Labour	$ 384 k
	Risk (excl overhead)	$ 225 k
	Total Direct Costs	**$ 1,242 k**
	Indirect & Overheads	$ **510 k**
	Total Direct costs + Overheads	$1,752 k

Refer to JGN - RIN - 4.4 - 10068011 - Licence 8C Validation Digs - PEMO - 20240628 - Public

5. TERMS AND DEFINITIONS

Term	Definition
AA	Access Arrangement
ACS	Asset Class Strategy
ALARP	As Low As Reasonably Practicable
ALBV	Automatic Line Break Valve
APAIR	Asset Performance and Integrity Report
AS	Australian Standards
CP	Cathodic Protection
DBYD	Dial Before You Dig
DCVG	Direct Current Voltage Gradient
DN	Diameter Nominal
HCA	High Consequence Area
ILI	In Line Inspection
JCARS	Jemena Compliance and Risk System
JGN	Jemena Gas Network
km	Kilometre
m	Metre
M	Million
M-W	Mortlake to Willoughby
M-LC	Mortlake to Lane Cove
MAOP	Maximum Allowable Operating Pressure
MFL	Magnetic Flux Leakage
MLV	Main Line Valve
NSW	New South Wales
PEM	Project Estimating Model
PIMP	Pipeline Integrity Management Plan
PRS	Pressure Regulating Station
RFE	Request For Estimate
SMS	Safety Management Study

SMYS	Simplified Minimum Yield Strength
SPM	Sydney Primary Main
SPL	Sydney Primary Loop
T1	Residential
T2	High Density
TRS	Trunk Receiving Station
WT	Wall Thickness

6. REFERENCES

6.1 INTERNAL

1. Refer to GAS-999-PA-PL-002 – JGN - Pipelines Asset Class Strategy - http://ecms/otcs/cs.exe/open/322879221
2. GAS-1295-RP-RM-001 Licence 8 Pipeline - Five (5) Yearly Safety Management Study (SMS) http://ecms/otcs/cs.exe/Open/303092143
3. GAS-1295-RG-RM-002 ASG Pipelines Risk Register - Lic 3,7,8 http://ecms/otcs/cs.exe/Open/310268187
4. GAS-999-RP-IN-003 JGN Pipelines Asset Performance and Integrity Review (APAIR) - July 2021 to June 2022": http://ecms/otcs/cs.exe/open/321230339

6.2 EXTERNAL

1. Australian Standard AS2885.3-2022, Pipelines – Gas and Liquid Petroleum Part 3 Operation and Maintenance
2. Australian Standard AS2885.1-2018 Pipelines – Gas and Liquid Petroleum Part 1 Design and Construction
3. ASME B31.8S Managing System Integrity of Gas Pipelines
4. 2022 Gas Supply (Safety and Network Management) Regulations
5. National Gas Rules Version 38
6. Gas Supply Act 1996

Appendix A Network Risk Assessment Summary

A risk assessment was conducted to determine the level of risk severity of the untreated risk. The table below shows the summary of results and then the treated risk summary for each option. The risk assessment was undertaken in accordance with the Jemena Risk Manual JAA MA 0050 Revision 10 (22/05/2023).

UNTREATED IMPACT/CONSEQUENCES								UNTREATED RISK SUMMARY		
Contributing Factors/ Scenario	**Strategic**	**Financial**	**Safety**	**Operational**	**Regulatory & Compliance**	**Reputation**	**Comments**	**Consequence (Highest Impact)**	**Likelihood**	**Risk Level**
(People – Safety) Pipeline integrity issue i.e. metal loss corrosion failure due to CP shielding or metal loss combined with third party damage resulting in Loss of containment with ignition causing jet fire	N/A	Major (Jemena)	Catastrophic (Jemena) Catastrophic (AS2885)	Major (Jemena) Severe (AS2885)	Major (Jemena)	Major (Jemena)	○ SAFETY: CATASTROPHIC – Potential fatality (1 to 5) associated with Loss of Containment anywhere on line ○ REGULATORY: MAJOR – Government/regulator review results in fines and/or litigation/ or loss of license ○ REPUTATIONAL: MAJOR - Reputation impacted in pipeline industry, government and community stakeholders. Significant stakeholders criticism / negativity ○ OPERATIONAL: MAJOR – Loss of Supply to JGN largest industrial customer	Catastrophic (Jemena)	Unlikely (Jemena)	High (Jemena)
								Catastrophic (AS2885)	Unlikely (AS2885)	High (AS2885)
(Supply) Inability to maintain supply to all customers during emergency or planned repairs as a result of pipeline failure causing loss of supply to customers downstream	N/A	Severe (Jemena)	N/A	Major (Jemena) Severe (AS2885)	Major (Jemena)	Severe (Jemena)	○ FINANCIAL: SEVERE – Loss of supply during repair works of SPM (minimum 3 days to maximum 21 days). Financial consequence includes lost transmission and distribution profits, claims for lost profits by customers, breach of supply contracts, etc ○ OPERATIONAL: MAJOR – Loss of supply (minimum 3 days to maximum 21 days), ○ REGULATORY & COMPLIANCE: MAJOR – Violation of Gas Supply Act requirement to ensure the continuity supply of natural gas to customers requiring formal explanation by senior management and regulatory review ○ REPUTATION: SEVERE – Persistent public scrutiny for loss supply for large scale loss of supply to large customers including airport and major customers.	Major (Jemena)	Unlikely (Jemena)	Significant (Jemena)
								Severe (AS2885)	Unlikely (AS2885)	Intermediate (AS2885)

(Environmental) Through wall corrosion resulting from CP shielding under disbonded HSS result in a gas leak leading to either a crater formation, damage to nearby buildings and/or release of CO_2 to atmosphere	N/A	Serious (Jemena)	Severe (Jemena) Severe (AS2885)	N/A	Severe (Jemena)	Severe (Jemena)	○ FINANCIAL: SERIOUS – ($1M - $10M) impact absorbed under normal operating condition. ○ ENVIRONMENT: SEVERE – Harm to natural environment that can be remediated (<1 year management). ○ REGULATORY & COMPLIANCE: SEVERE –Regulator requires formal explanation and remedial plans, fines or penalties. ○ REPUTATION: SEVERE – Reputational impacted with some stakeholders.	Severe (Jemena) Severe (AS2885)	Unlikely (Jemena) Unlikely (AS2885)	**Moderate** **(Jemena)** Intermediate (AS2885)
(Financial) Necessary permanent repair of pipe wall defect DUE TO metal loss / external corrosion (<200mm in length, pin hole 50mm) resulting from CP shielding or CP under protection at coating defects or metal loss combined with third damage	N/A	Serious (Jemena)	N/A	Severe (Jemena)	N/A	N/A	○ Financial: SERIOUS - unplanned or unbudgeted expenditure for dig up, hot-tap, repair, and remediation of site (cost between $1M to $10M) ○ OPERATIONAL: SEVERE – Potential restriction of supply for < 3000 customers. Business interruption 1 to 7 days.	Severe (Jemena) N/A	Unlikely (Jemena) N/A	**Moderate** **(Jemena)** **N/A**

PREFERRED OPTION – Risk assessment summary				TREATED RISK SUMMARY		
Preferred Option/Treated risk	Cost	Benefit	Key Mitigations	Consequence	Likelihood	Risk Level
Option 1 – Maintain Status Quo (Integrity Dig Program)	A$ 10M (over 10 year period)	- Validate pipeline condition only at the areas targeted; - Determine threats, rate of change of pipeline condition and confirm continued MAOP at the locations targeted only; provides data for future trending purposes. - Avoid initial capital expenditure by spreading cost overtime. - Overall pipeline condition remains unknown and can also give false indication of coating and pipeline.	People (Safety) ○ Targeted confirmation of the Pipeline's ability to continue operating at MAOP, localised to locations where integrity digs have been performed and confirmation of control effectiveness through trending of integrity data. ○ Defects can be easily identified and immediately repaired and recoated. ○ No guarantee against all unknown anomalies causing pipe failure or loss of supply which do not fit trend	Catastrophic (Jemena)	Unlikely (Jemena)	High (Jemena)
				Catastrophic (AS2885)	Unlikely (AS2885)	High (AS2885)
			(Supply) ○ Targeted confirmation of the Pipeline's ability to continue operating at MAOP, localised to locations where integrity digs have been performed and confirmation of control effectiveness through trending of integrity data. ○ Defects can be easily identified and immediately repaired and recoated. ○ No guarantee against all unknown anomalies causing pipe failure or loss of supply which do not fit trend.	Major (Jemena)	Unlikely (Jemena)	Significant (Jemena)
				Severe (AS2885)	Unlikely (AS2885)	Intermediate (AS2885)
			(Environmental) ○ Defects can be easily identified and immediately repaired and recoated. ○ No guarantee against all unknown anomalies causing pipe failure or loss of supply which do not fit trend.	Severe (Jemena)	Unlikely (Jemena)	**Moderate (Jemena)**
				Severe (AS2885)	Unlikely (AS2885)	Intermediate (AS2885)
			(Financial) ○ Reduction of likelihood by rectification of potential problem areas by targeted investigation and repair of HSS with known adhesion issues and at coating defects with CP under-protection. ○ No guarantee against all unknown anomalies causing pipe failure or loss of supply which do not fit trend...	Severe (Jemena)	Unlikely (Jemena)	Moderate (Jemena)
				N/A (AS2885)	N/A (AS2885)	N/A (AS2885)
Option 2 – Reconfigure pipeline	A$ 6.91M (Capex)	- Pigging the pipeline will provide data to accurately assess any anomalies found and if required undertake repairs to ensure safety	People (Safety) ○ Confirmation of the Pipeline's ability to continue	Major (Jemena)	Rare (Jemena)	Moderate (Jemena

to enable In-Line inspection Pigging Facilities	ILI - $1.42M (Opex) Digs - $1.75M (Opex)	and security of supply - Pigging can be conducted without removing the line from service thus maintaining supply. - This option will validate the pipeline condition along the pipe wall. - Assist in targeting locations and reduce ongoing cost for the validation dig program; - Once an ILI base line is established, it is feasible to rerun inspection tools at appropriate intervals to monitor for changes in anomalies or new anomalies. - Provide a reliable and comprehensive dataset for continuing management of long term integrity and ensure security of supply;	operating at MAOP in its entirety. ○ Identify pipe wall defects in need of further investigation and possible repair to ensure continued operability of the Pipeline at MAOP in its entirety. ○ Identify areas on the pipe wall potentially subject to active corrosion and undertake further investigation, initiating digs and perform repairs where necessary to prevent loss of containment events. ○ Satisfy the requirements of AS2885.3 Section 6 “Pipeline Structural Integrity”.	Major (AS2885)	Hypothetical (AS2885)	Low (AS2885)
			(Supply) ○ Identify areas on the pipe wall potentially subject to active corrosion and undertake further investigation, initiating digs and perform repairs where necessary to prevent loss of containment or loss of supply events.	Major (Jemena)	Rare (Jemena)	Moderate (Jemena)
				Severe (AS2885)	Remote (AS2885)	Low (AS2885)
			(Environmental) ○ Identify anomalies on the pipe wall prior to pipe failure resulting in gas escape.	Severe (Jemena)	Rare (Jemena)	Moderate (Jemena)
				Severe (AS2885)	Remote (AS2885)	Low (AS2885)
			(Financial) ○ Identify anomalies on the pipe wall which may be subject to active corrosion and perform preventative integrity digs to remove CP shielding or coating defect before permanent repair is required.	Serious (Jemena)	Rare (Jemena)	Low (Jemena)
				N/A (AS2885)	N/A (AS2885)	N/A (AS2885)
Option 3 – Replace Pipeline	A$ 30M	- New pipeline will have known integrity and can be designed with a higher factor of safety to mitigate future concerns - Reduces overall risk ranking from High to Low (AS2885)	People (Safety) ○ A new pipeline operating at a lower stress level providing more safety margin before pipeline failure occurs due to corrosion. ○ Pressure reduction will reduce the consequence of leak failure with ignition due to less pressure in the pipeline	Severe (Jemena)	Unlikely (Jemena)	Moderate (Jemena)
				Severe (AS2885)	Remote (AS2885)	Low (AS2885)
			(Supply) ○ A new pipeline operating at a lower stress level providing more safety margin before pipeline failure occurs due to corrosion.	Severe (Jemena)	Unlikely (Jemena)	Moderate (Jemena)
				Severe	Remote	Low

				(AS2885)	(AS2885)	(AS2885)
			(Environmental) ○ A new pipeline will provide more safety margin before pipeline failure occurs due to corrosion.	Serious (Jemena)	Unlikely (Jemena)	Low (Jemena)
				Minor (AS2885)	Remote (AS2885)	Negligible (AS2885)
			(Financial) ○ A new pipeline will provide more safety margin before pipeline failure occurs due to corrosion.	Serious (Jemena)	Unlikely (Jemena)	Low (Jemena)
				N/A (AS2885)	N/A (AS2885)	N/A (AS2885)
Option 4 – Direct Inspection of Pipeline	A$ 16.5M	- New pipeline will have known integrity and can be designed with a higher factor of safety to mitigate future concerns - Reduces overall risk ranking from High to Low (AS2885)	People (Safety) ○ A new pipeline operating at a lower stress level providing more safety margin before pipeline failure occurs due to corrosion. Pressure reduction will reduce the consequence of leak failure with ignition due to less pressure in the pipeline	Severe (Jemena)	Unlikely (Jemena)	Moderate (Jemena)
				Severe (AS2885)	Remote (AS2885)	Low (AS2885)
			(Supply) A new pipeline operating at a lower stress level providing more safety margin before pipeline failure occurs due to corrosion.	Severe (Jemena)	Unlikely (Jemena)	Moderate (Jemena)
				Severe (AS2885)	Remote (AS2885)	Low (AS2885)
			(Environmental) A new pipeline will provide more safety margin before pipeline failure occurs due to corrosion.	Serious (Jemena)	Unlikely (Jemena)	Low (Jemena)
				Minor (AS2885)	Remote (AS2885)	Negligible (AS2885)
			(Financial) A new pipeline will provide more safety margin before pipeline failure occurs due to corrosion.	Serious (Jemena)	Unlikely (Jemena)	Low (Jemena)
				N/A (AS2885)	N/A (AS2885)	N/A (AS2885)