Attachment 8.10

Response to Draft Decision: Mains Replacement Program

2016/17 to 2020/21 Access Arrangement Information Response to Draft Decision

Australian Gas Networks

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1 Response to Draft Decision on Mains Replacement

1.1 Introduction

At 30 June 2016 it is forecast that there will be 2,619 kilometres of at risk[1] mains in the South Australian natural gas distribution network (the Network). These mains comprise a mixture of cast iron (CI) and unprotected steel (UPS) pipe and related services that are in poor condition and have reached the end of their useful lives, and high-density polyethylene (HDPE) pipe that has become brittle and susceptible to cracking.

A number of serious safety incidents on the Network in recent years highlight the need to mitigate the risk posed by these assets. The mitigation of risk includes removing the 'Extreme' and 'High' risk mains from the Network and replacing them with new material that is less prone to failure. In its Initial Access Arrangement (AA) Proposal (1 July 2015), AGN submitted a mains replacement program for the next (2016/17 to 2020/21) AA period designed to:

- eliminate the safety risk associated with the remaining low pressure (CI/UPS) mains and service inlets in the Network, which is a continuation of the program commenced in the current (2011/12 to 2015/16) AA period;
- eliminate the safety risk associated with the medium pressure 'Class 250' HDPE mains, which are at the end of their useful life and becoming increasingly brittle; and
- eliminate the safety risk associated with the high and medium pressure 'Class 575' HDPE mains located in areas that pose the greatest safety risk to the public.

AGN's Initial AA Proposal sought to address these risks by replacing 1,273 kilometres (250 to 260 kilometres per year) of these 'at risk' mains with new polyethylene (PE) pipe during the next AA period, with the balance to be replaced during subsequent AA periods. The required capital expenditure (capex) forecast of $370 million for the mains replacement program reflected the volume of mains that could be replaced during the five-year program and consisted of a mixture of CI/UPS and HDPE mains.

In response to the AER's Draft Decision, and in the light of new and more up-to-date information on asset condition and the inherent risk posed by CI/UPS and HDPE mains, we have taken the opportunity to review the mains replacement program. We have also supplied further analysis as requested by the AER to demonstrate the prudency and efficiency of mains replacement during the next AA period and beyond.

We remain of the view that removing all the CI/UPS and HDPE mains from the Network is necessary to mitigate against incidents such as the gas incidents that occurred in the Adelaide metropolitan gas network in 2004, 2007, 2011 and 2014. We also maintain that removing around 250 kilometres per year of at risk mains from the Network is consistent with AGN's delivery capability, and represents a prudent and efficient delivery volume. Replacing as much of these mains as possible within current delivery capability is consistent with mitigating risk to 'Low'[2] and, if not, to as low as reasonably practicable (ALARP) during the period.

However, further analysis of the risk associated with HDPE mains' propensity for cracking and sudden failure has led us to modify the composition of mains to be replaced. We have undertaken a rigorous risk assessment, which is now presented in this response to the Draft Decision, which underpins the necessity to replace the 2,619 kilometres of at risk mains. We have also developed a 'risk prioritisation model' (based

[1] 'At risk' mains comprise all 2,619 kilometres of CI/UPS, HDPE Class 250 and HDPE Class 575 mains in the network, whose risk rating under Australian Standard/New Zealand Standard (AS/NZS) 4645 ranges from 'High' to 'Extreme'.

[2] As defined in AS/NZS 4645.

on a similar model used by the United Kingdom's (UK's) Health & Safety Executive (HSE) and economic regulator Ofgem), which uses historical data on pipe cracking and other characteristics to rank the risk associated with CI/UPS and HDPE mains. This model has been used to prioritise the circa 250 kilometres per year of 'High' risk mains that are earmarked for replacement during the next AA period.

Based on this updated assessment, in this Revised AA Proposal we aim to replace 1,265 kilometres of mains during the next AA period, at a capital cost of $326 million. As per our Initial AA Proposal, this includes continuing our current program to replace CI/UPS mains in the Adelaide Central Business District (CBD) and medium pressure trunk mains. However, rather than maintaining the Initial AA Proposal of replacing *all* CI/UPS mains during the next AA period, priority will be given to replacing mains identified by the risk prioritisation model as presenting the greatest risk to public safety, whether the mains are HDPE or CI/UPS. This has the effect of increasing the amount of HDPE mains to be replaced during the next AA period compared to the Initial AA Proposal, which is offset by a decrease in CI/UPS mains replacement.

The 1,354 kilometres of 'at risk' mains that cannot be replaced during the next AA period (due to delivery constraints) will be scheduled to be replaced in subsequent years, subject to ongoing review and prioritisation according to risk. This means the timeframe for full CI/UPS replacement has extended to 10 years rather than five years as initially proposed in July 2015.

While the revised mains replacement program adopts the same risk principles and similar delivery volumes as the Initial AA Proposal, AGN considers the modified mains replacement composition will reduce the inherent network risk to 'Low' and, if not, to ALARP more quickly. This is because the risk prioritisation model offers a method of ranking the risk associated with gas mains across asset classes. Complemented by qualitative risk assessment, new data, and ongoing refinement, the model allows for a more robust risk-based approach to replacement.

With regard to cost, we maintain that 1,265 kilometres of replacement (circa 250 kilometres per year) is a realistic and prudent replacement volume, which would allow AGN to meet its obligations to reduce the inherent network risk to ALARP. The revised capex of $326 million (compared to $370 million in our Initial AA Proposal) is the result of updated unit rates and competitive tendering conducted since July 2015. Notably, the unit rates relating to replacement of HDPE mains have decreased materially since the Initial AA Proposal.

We consider that our revised mains replacement program is consistent with the actions of a prudent and efficient service provider, acting in accordance with accepted good industry practice to maintain and improve the safety of gas distribution services. Replacing these assets satisfies the criteria under Section 79(2)(c) of the National Gas Rules (NGR), which states capex is justifiable if:

> *"(c) the capital expenditure is necessary:*
>
> *(i) to maintain and improve the safety of services; or*
>
> *(ii) to maintain the integrity of services; or*
>
> *(iii) to comply with a regulatory obligation or requirement; …"*

To summarise, we consider that:

- the 2,619 kilometres of CI/UPS and HDPE mains currently in the Network have an inherent risk that must be addressed;
- AGN has an obligation under its Gas Distribution Licence, Section 55 of the *Gas Act* 1997 and Section 37(1)(a) of the *Gas Regulations (SA) 2012*, the *Work Health and Safety Act 2012* and Australian/New Zealand Standard 4645 (AS/NZS 4645) to eliminate this risk or reduce it to 'Low' or ALARP;

- a mains replacement program in the order of 1,265 kilometres represents a prudent and efficient delivery volume for the next AA period that would allow AGN to meet its obligations;
- in light of new information and analysis, AGN has revised the composition of the mains replacement program to better target the highest risk mains across CI/UPS and HDPE 250 and HDPE 575;
- the balance of at risk mains (1,354 kilometres) should be replaced during subsequent periods, prioritised according to safety risk; and
- AGN's plan to address the risk is prudent, efficient, and in accordance with accepted good industry practice, consistent with the NGR 79 criteria and with the National Gas Objective (NGO).

To support this, we submit this response to the AER's Draft Decision, which describes:

- AGN's approach to identifying and rating 'Extreme' and 'High' risk mains;
- AGN's approach to ranking the risk on 'High' risk mains;
- AGN's consideration of the activities available to mitigate the risk, including the mains replacement program;
- that AGN's proposed mains replacement program reduces the risk to 'Low' and, if not, to ALARP as quickly as delivery capability will reasonably allow, in the most prudent and efficient way and in accordance with accepted good industry practice;
- AGN's efficient cost of delivering the mains replacement program; and
- AGN's revised mains replacement program for the next AA period.

In addition to the supporting evidence provided in its Initial AA Proposal, AGN provides the following evidence in this response to the Draft Decision for consideration by the AER:

- AGN's Safety, Reliability, Maintenance and Technical Management Plan (Safety Plan), approved by the Essential Services Commission of South Australia (ESCOSA) in November 2015 (Attachment 8.13);
- AGN's risk prioritisation model (Attachment 8.14);
- AGN's cost impact analysis model (Attachment 8.15);
- Affidavit from APA Group Executive Networks John Ferguson in the Matter of the AER Gas Access Arrangement Review 2016-2021 (Attachment 8.16);
- *Mains Replacement Program Review*, Jacobs, January 2016 (Attachment 8.11);
- *HSE/Ofgem: 10 year review of the Iron Mains Replacement Programme*, Prepared by Cambridge Economic Policy Associates Ltd for the Health and Safety Executive and Office of Gas and Electricity Markets 2011 (Attachment 8.17); and
- various emails relating to assumptions underpinning the revised unit rates (Attachment 8.18).

1.2 AER Draft Decision

The AER's Draft Decision proposes an alternative mains replacement program, which more than halves the amount of 'High' risk gas mains to be replaced during the next AA period compared to AGN's Initial AA Proposal. The AER recognises the hazard associated with the mains currently in the Network, however it questions the likelihood and impact of a major hazard occurring. In its Draft Decision, the AER states:

> *"The information that AGN has provided us does not support or demonstrate that its proposal is prudent or efficient. In particular, AGN did not provide a rigorous (quantitative) risk assessment to establish that its proposed rate of mains replacement over the 2016–21 period is prudent and efficient. Rather, its assessment identifies what it terms 'hazards' and proceeds on the basis that they will occur and have significant impacts. We consider a rigorous risk assessment that measures the likelihood and impact of a hazard occurring is necessary in determining whether proposed investment is prudent and efficient. This is especially the case where, as here, there are no regulatory or legislative obligations that require AGN to replace mains at the rate it has proposed over the 2016–21 period."*[3]

And:

> *"We consider a rigorous risk assessment that measures the likelihood and impact of a hazard occurring is necessary in determining whether proposed investment is prudent and efficient."*[4]

The AER has, however, invited AGN to provide additional information to support its mains replacement proposal. Specifically, the AER states:

> *"We invite AGN in its revised proposal to … include the necessary material, particularly a rigorous risk assessment, to demonstrate and justify the extent to which its proposed capex for mains replacement is conforming capex that complies with rule 79"*[5]

Further, the AER also considers:

> *"…ideally, we would derive an alternative estimate based on a cost benefit analysis. This information is not available to us, and we accept that this kind of analysis may be difficult to undertake. Given the limited information available to us, we have drawn on historical leakage reduction rates."* [6]

Without a clearly expressed risk assessment and cost benefit analysis, the AER considered that its ability to develop an alternative replacement program was limited. As a substitute for these analyses, the AER has scaled AGN's proposed volume of mains replacement down based on an assumed leak reduction target. More specifically, the AER:

- calculated the rate of leaks per kilometre of main by suburb over the period 2005 to 2014, and used this to assume the 1,273 kilometre mains replacement program proposed by AGN will deliver a 47% reduction in leaks over the next AA period;
- considered that a 47% reduction in leaks was not justified, and assumed a 25% reduction in leaks is a more prudent target; and therefore
- calculated the volume of mains it considered will deliver a 25% leak reduction, resulting in a revised mains replacement program consisting of 577 kilometres of mains.

The AER then reduced AGN's proposed mains replacement capex ($370 million) by the same percentage reduction in kilometres to arrive at its alternative capex estimate of $168 million.

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3 AER 2015, "*Confidential Appendix A – Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6A-6.

4 AER 2015, "*Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6-29.

5 bid, pg. 6-37.

6 bid.

In summary, the AER Draft Decision allowance of $168 million capex and 577 kilometres mains replacement over the next AA period is a:

- 55% cut to the volume of mains AGN proposed must be replaced in its Initial AA Proposal; and
- 50% cut to the volume of mains replaced compared to the 'High' risk mains replaced over the current (2011/12 to 2015/16) AA period.

As discussed in Section 1.5, we have not been able to reconcile the AER's modelling and conclusions in this alternative proposal with the data AGN provided. However, we recognise that the AER does not necessarily claim its alternative proposal is the most prudent option, and highlights the emerging risk associated with HDPE stating:

> *"On balance, we consider there is case to adopt a more cautious approach and accommodate a higher level of mains replacement. There are two reasons for this.*
>
> *Firstly, leakage associated with HDPE is emerging as a new issue. HDPE pipes typically run at higher pressure than CI and UPS pipes and are more prone to sudden failure. This combination increases the probability that leakage events will cause harm compared to CI and UPS main pipes.*
>
> *Secondly, the main pipes will continue to deteriorate over the period as they age. There is some uncertainty about the rate of deterioration going forward. The pipes could deteriorate faster than historically with corresponding increases in leakage rates. In this scenario, additional investment would be required to achieve a given reduction in leakage rates."*[7]

Therefore, in this response to the Draft Decision, AGN has considered the AER's recommendations and provided further information that evaluates the consequences and likelihood of mains failure. This identifies the level of risk that should be addressed during the next AA period, particularly with regard to HDPE mains and prioritising CI/UPS mains replacement going forward. Our response is presented in Section 1.3 below.

In its Draft Decision, the AER also identifies concerns relating to the unit rates used in AGN's proposed mains replacement program. Primary concerns (identified in Confidential Appendix A) are that some unit rates:

- were based on tender submissions rather than awarded contracts;
- included a premium for night time work and other costs associated with work to be carried out in higher congestion zones, that were not adequately supported; and
- appeared inconsistent with historical rates experienced, so a revealed historical unit rate was a better estimate.

We have reviewed the unit rates and updated them where relevant to reflect latest information and tender processes that have been conducted since the Initial AA Proposal. The revised unit rates are discussed in Section 1.4.1.

We have also assessed the AER's alternative mains replacement proposal and explained why it would not represent a course of action that would be undertaken by "*a prudent service provider, acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of providing services",*[8] and is not consistent with the NGR or materially preferable. This is discussed in Section 1.5.

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7 AER 2015, "*Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6-37.

8 National Gas Rules 79(1)(a).

1.3 Response to AER Draft Decision

AGN has reviewed its mains replacement program in light of the AER's Draft Decision. We maintain that our proposal to replace around 250 kilometres of mains per year is prudent and can be delivered efficiently during the next AA period. We have, however, taken this opportunity to review unit rates and the composition of mains to be replaced, and propose an updated program that will target the inherent network risk during the next AA period given current delivery capability.

In summary, we submit that:

- It is prudent, efficient and accepted good gas industry practice, and compliant with NGR 79 for AGN to undertake capex of $326 million to replace 1,265 kilometres of mains rated as 'Extreme' and 'High' risk over the next AA period. This revised capex is $44 million less than our Initial AA Proposal.

- The *Gas Act 1997* and *Gas Regulations 2012* through their incorporation of AS/NZS 4645 and the Work *Health and Safety Act 2012* place a regulatory obligation and requirement on AGN to reduce 'High' and 'Extreme' Network risk as soon as possible (if 'High) or immediately (if 'Extreme') to 'Low' or Negligible and if this is not possible to as low as reasonably practicable (ALARP).

- AGN has assessed network risk under the requirements of AS/NZS 4645 Gas Distribution Network Management. This includes an assessment of severity and likelihood of risk associated with each type of mains.

- Of the 2,619 kilometres of CI/UPS and HDPE mains identified for replacement the AS/NZS 4645 risk assessment shows that 106 kilometres of mains are rated as 'Extreme', with the remaining 2,513 kilometres rated 'High'.

- Current resourcing levels will enable AGN to replace 1,265 kilometres of these 'Extreme' and 'High' risk mains during the next AA period. All 'Extreme' risk mains will be addressed first, with the 2,513 kilometres of 'High' risk mains scheduled for replacement using AGN's risk prioritisation model.

- The 1,265 kilometres of mains AGN proposes to replace during the next AA period is composed of:

    - 106 kilometres of 'Extreme' risk CI/UPS mains in the Adelaide CBD and medium pressure trunk (100% of the total volume of these mains);

    - 393 kilometres of 'High' risk CI/UPS mains identified to have the highest safety risk using AGN's risk prioritisation model (48% of the total volume of 'High' risk CI/UPS mains);

    - 766 kilometres of 'High' risk HDPE 250 and HDPE 575 mains identified to have the highest safety risk using AGN's risk prioritisation model (45% of the volume of 'High' risk HDPE 250 and HDPE 575 mains); and

    - all 1,328 CI/UPS multi-user service inlets rated 'High' risk.

- The replacement program will be complemented with mitigation activities to manage the residual risk. The remaining 418 kilometres of CI/UPS mains and 936 kilometres of HDPE 250 and HDPE 575 mains will be replaced during subsequent AA periods and prioritised accordingly.

- The higher volume of HDPE mains replacement (766 kilometres) compared to AGN's Initial AA Proposal (411 kilometres) is based on a quantitative risk ranking to prioritise the replacement across all mains types, and reflects the greater risk associated with HDPE mains failure. This increase in HDPE is offset by a 363 kilometre decrease in CI/UPS replacement during the period.

- Of the CI/UPS mains that have been deferred to subsequent years, 260 kilometres are identified as being located in suburbs with a history of mains cracking and are likely to be prioritised for replacement in the early years of the subsequent (2021/22 to 2025/26) AA period. The remaining 158 kilometres of CI/UPS mains are in suburbs where there has been no cracking recorded to date.

- AGN has reviewed unit rates to take into account further information and address the AER's concerns. Unit rates have been updated to reflect the most recent view of efficient delivery costs.

- AGN has analysed several scenarios for replacing the 2,619 kilometres of 'Extreme' and 'High' risk mains over the coming AA periods. The analysis shows:

    - The net present cost (NPC) per customer of the AER's alternative mains replacement proposal would be around $3.45 per year lower than AGN's mains replacement proposal, but around 2,058 kilometres (78%) of the CI/UPS, and HDPE mains identified as 'High' risk would remain in the Network at the end of the next AA period.

    - AGN's revised mains replacement proposal would result in average prices to customers being $3.45 higher per customer per year than AER's alternative proposal, however, AGN's proposal would remove 46% of the 'High' risk mains and provide for mitigation activities that would allow the risk associated with the residual 1,354 kilometres of mains to be monitored and managed.

    - Replacing all 2,619 kilometres in five years would address 100% of the 'Extreme' and 'High' risk mains in the next AA period. However, this rate of replacement would require significantly more resources and we do not believe this is a realistic proposition. The constraints on delivery capability are driven by the availability of resources, the ability to ramp up delivery quickly, and the expected additional cost of securing sufficient resources.

We consider that the revised mains replacement proposal is materially preferable to the AER's alternative and delivers an outcome that achieves the NGO. The above points and the regulatory compliance framework that relates to AGN's mains replacement program are discussed in detail in the following sections.

1.3.1 Regulatory Compliance Framework

This section describes the key legislative framework governing AGN's obligation to undertake mains replacement, which includes the NGO, the revenue and pricing principles (RPP) under the National Gas Law (NGL), relevant criteria set out in the NGR, AGN's Gas Distribution Licence, and the risk assessment framework set out in AS/NZS 4645 Gas Distribution Network Management (which is given statutory force by Section 55 of the *Gas Act 1997* and the *Gas Regulations 2012 (SA))* and the *Work Health and Safety Act 2012*.

1.3.1.1 National Gas Law

Section 23 of the NGL provides:

> *"The objective of this [National Gas] Law is to promote efficient investment in, and efficient operation and use of, natural gas services for the long term interests of consumers of natural gas with respect to price, quality, safety, reliability and security of supply of natural gas."*

The focus of Section 23 is on the long-term interests of consumers with respect to price, quality, safety, reliability and security of supply. While price comes first in the list there is nothing to suggest it is more important than the other factors. Indeed, in AGN's submission when viewed over the long-term safety, reliability and security of supply are more important to the long-term interests of consumers than price as a network which does not provide safety, reliability and security of supply is of no use to consumers.

The mains replacement program focuses on ensuring the safe, reliable and secure supply of natural gas. It aims to replace mains that are at risk of fracturing or cracking in the interests of ensuring the safe operation of the distribution network. Equally any such fracture impacts reliability of supply. The program is directly relevant to promotion of the NGO, as a distribution network with mains at risk of fracture cannot operate in a way that ensures a safe and reliable supply.

Under Section 28(1) of the NGL the AER must, in performing or exercising an AER economic regulatory function or power, do so in a manner that will or is likely to contribute to the achievement of the NGO.

Under Section 28(2) the AER must take into account the RPP when exercising a discretion in approving or making those parts of an AA relating to a reference tariff.

The phrase "*must take into account"* requires the AER to take each of the RPP into account and give them weight as fundamental elements.[9]

In the current context the most relevant RPP is Section 24(2) of the NGL which provides:

> *"A service provider should be provided with a reasonable opportunity to recover at least the efficient costs the service provider incurs in—*
>
> *(a) providing reference services; and*
>
> *(b) complying with a regulatory obligation or requirement or making a regulatory payment."*

AGN notes there is no conflict between this principle and the NGO because a service provider that cannot meet its efficient costs or regulatory obligations will not be able to ensure a safe, reliable and secure supply.

A regulatory obligation or requirement is defined in section 6 of the NGL. It includes a "*pipeline safety duty*" which is in turn defined in Section 2 of the NGL as:

> *"pipeline safety duty means a duty or requirement under an Act of a participating jurisdiction, or any instrument made or issued under or for the purposes of that Act, relating to—*
>
> *(a) the safe haulage of natural gas in that jurisdiction; or*
>
> *(b) the safe operation of a pipeline in that jurisdiction;"*

There are several concurrent pipeline safety duties requiring AGN to implement the mains replacement program. They are:

- Clause 8 of AGN's distribution licence under the *Gas Act 1997* which clause requires that AGN implement the mains replacement plan in the form approved by the ESCOSA in November 2015;
- Clause 5 of AGN's distribution licence which relates to safe operation of the Network;
- Section 55 of the *Gas Act 1997* and regulation 37 of the *Gas Regulations 2012* which require gas infrastructure to be operated safely and requires compliance with AS/NZS 4645, AS/NZS 1596 and AS 2885;
- The *Work Health and Safety Act 2012* which requires AGN to ensure so far as is reasonably practicable that the health of workers, and any other person who may be affected by AGN's business undertaking, is not put at risk.

These pipeline safety duties are discussed further below.

The effect of Sections 28 and 24(2) of the NGL is that the AER must take into account as a fundamental element in its decision that it must provide AGN with a reasonable opportunity to recover the efficient costs of complying with these duties.

None of the remaining RPPs operate so as to contradict this conclusion.

1.3.1.2 National Gas Rules

Under Rule 78 of the NGR the projected capital base for a period is to be increased by the forecast conforming capex for that period.

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[9] *Re Dr Ken Michael AM: Ex parte Epic Energy (WA) Nominees Pty Ltd [2002] WASCA 231.*

Rule 79(1) provides:

> *"Conforming capital expenditure is capital expenditure that conforms with the following criteria:*
>
> *(a) the capital expenditure must be such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of providing services;*
>
> *(b) the capital expenditure must be justifiable on a ground stated in subrule (2)."*

For the reasons explained below the mains replacement program falls within Rule 79(1)(a). It is undertaken to comply with AGN's pipeline safety duties and therefore reflects expenditure which would be undertaken by a prudent service provider. Because it is prudent it is also efficient (absent some direct contrary indication, which is not the position here), those duties require AGN to comply with the mains replacement plan approved by ESCOSA and also require it to eliminate (or if not practicable minimise) the risks posed by ageing and/or at risk mains by replacing those mains as soon as is practicable. A service provider acting in accordance with good industry practice would comply with its pipeline safety duties and vice versa.

Section 1.4 of this Attachment shows how the costs of mains replacement have been built up and why these costs reflect an efficient cost. The costs are derived from either competitive tenders or revealed historical cost.

Rule 79(2) provides:

> *"Capital expenditure is justifiable if:*
>
> *(a) the overall economic value of the expenditure is positive; or*
>
> *(b) the present value of the expected incremental revenue to be generated as a result of the expenditure exceeds the present value of the capital expenditure; or*
>
> *(c) the capital expenditure is necessary:*
>
> *(i) to maintain and improve the safety of services; or*
>
> *(ii) to maintain the integrity of services; or*
>
> *(iii) to comply with a regulatory obligation or requirement; or*
>
> *(iv) to maintain the service provider's capacity to meet levels of demand for services existing at the time the capital expenditure is incurred (as distinct from projected demand that is dependent on an expansion of pipeline capacity); or*
>
> *(d) the capital expenditure is an aggregate amount divisible into 2 parts, one referable to incremental services and the other referable to a purpose referred to in paragraph (c), and the former is justifiable under paragraph (b) and the latter under paragraph (c)."*

The expenditure that is the subject of the mains replacement program falls within each of Sub-rule 79(2)(c)(i), (ii) and (iii).

The relevant regulatory obligations and requirements are the pipeline safety duties noted above as defined in the National Gas Law[10]. The mains replacement expenditure therefore satisfies the criteria in Rule 79.

In addition, the mains replacement expenditure independently falls within each of Sub-rule 79(2)(c)(i) and 79(2)(c)(ii). For the reasons set out in this attachment and the accompanying evidence the existing CI, UPS

[10] Regulatory obligation or requirement is not separately defined in the National Gas Rules. It therefore has the meaning set out in the National Gas Law. Under clause 13 of *Schedule* 2 of the National Gas Law: "Words and expressions used in a statutory instrument have the same meanings as they have, from time to time, in this Law, or relevant provisions of this Law, under or for the purposes of which the instrument is made or in force." (The statutory instrument being the National Gas Rules – statutory instrument is defined in Schedule 2 as including an instrument made or in force under the National Gas Law). Section 20 of the National Gas Law makes clear Schedule 2 applies to both the National Gas Law and National Gas Rules.

and HDPE mains represent a risk to safety. The mains replacement plan is therefore necessary to maintain and improve the safety of services. Without the plan, safety risks will not be addressed and, indeed, will continue to grow.

The mains replacement plan also falls within sub-rule 79(c)(ii). It is necessary to maintain the integrity of services because if the risks presented by the current mains are not addressed and the Network cannot operate safety then the reliability and integrity of services is jeopardised.

Also of note in assessing forecasts of expenditure is Section 74(2) of the NGR which provides:

> *"A forecast or estimate:*
>
> *(a) must be arrived at on a reasonable basis; and*
>
> *(b) must represent the best forecast or estimate possible in the circumstances."*

AGN's mains replacement proposal is based on the best estimate possible in the circumstances. This is because the volume of mains identified for replacement is informed by a rigorous risk assessment, which prioritises mains by location, crack rates and potential events. Unit rates are based on competitive tender processes for the particular work required, and adopt AGN's historical rates where appropriate.

1.3.1.3 Gas Distribution Licence – Clause 8

Clause 8 of AGN's gas distribution licence requires AGN to prepare a safety, maintenance and technical management plan. This is to include an Unaccounted for Gas (UAFG) Plan in turn comprised of (without limitation) a leakage management plan, asset management plan and mains replacement plan. These plans must be submitted to the ESCOSA for approval.

Clause 8 reflects Section 26(1)(b) of the *Gas Act 1997* which requires a gas distribution licence to include a condition requiring the holder to prepare a safety, reliability, maintenance and technical management plan dealing with matters prescribed by regulation. The plan must be submitted to the ESCOSA for approval, who may only give approval on the recommendation of the Technical Regulator (Section 26(1)(c)).

Under Clause 8(c) of its gas distribution licence AGN must comply with the approved plan.

The mains replacement plan was approved by the ESCOSA on 9 November 2015. AGN therefore has a regulatory obligation/requirement (by virtue of its licence) to comply with the plan. This obligation is a pipeline safety duty under the NGL.

It is an offence for AGN to fail to comply with the conditions of its licence (*Gas Act 1997* section 27). The maximum penalty for such an offence is $1,000,000. In addition, under Section 38(1)(b) of the *Gas Act 1997* the ESCOSA may suspend or cancel AGN's licence if AGN commits a material contravention of a requirement imposed by or under the *Gas Act 1997*.

1.3.1.4 Gas Act –Section 55

Section 55 of the *Gas Act 1997* provides:

> *"A person who owns or operates gas infrastructure or a gas installation must take reasonable steps to ensure that—*
>
> *(a) the infrastructure or installation complies with, and is operated in accordance with, technical and safety requirements imposed under the regulations; and*
>
> *(b) the infrastructure or installation is safe and safely operated."*

The relevant regulation is Regulation 37, which provides:

> *"For the purposes of section 55 of the Act—*
>
> *(a) gas infrastructure must be designed, installed, operated and maintained to be safe for the gas service conditions and the physical environment in which it will operate and so as to comply with any applicable requirements of AS/NZS 4645, AS/NZS 1596 and AS 2885 or achieve, to the satisfaction of the Technical Regulator, the same or better safety and technical outcomes; and*
>
> *(b) a gas installation must be designed, installed, operated and maintained to be safe for the gas service conditions and the physical environment in which it will operate and so as to comply with any applicable requirements of—*
>
> *(i) in the case of a liquefied petroleum gas installation—AS/NZS 5601 and AS/NZS 1596;*
>
> *(ii) in any other case—AS/NZS 5601."*

Read together Section 55 and Regulation 37 require, amongst other matters, compliance with AS/NZS 4645.

AS/NZS 4645 requires risks from a network which are 'High' or 'Extreme' to be reduced as soon as possible (if 'High') or immediately (if 'Extreme') to 'Low' or 'Negligible' and if this is not possible to ALARP.[11]

Section C4 of AS/NZS 4645 provides: "*risks determined to be low or negligible or demonstrated to be as low as reasonably practicable (ALARP) are accepted risks*"

Page 3 of the standard provides: "*Risks associated with the network shall be at acceptable levels with respect to loss of any of supply of gas and any threats from escaping gas, throughout the life of the network*."

Clause 2.2 requires that all actions and activities shall not unduly expose personnel, the public or the environment to "unacceptable risks." Clause 2.3.1 provides: the primary principle in managing risk is to achieve an acceptable risk level.

Section C5 of Appendix C of the standard (reproduced in Appendix A) specifies treatment for addressing network risk and places an obligation on network operators to act immediately to reduce 'Extreme', 'High' and intermediate risks to ALARP.

As required by the *Gas Act 1997 (*and consistently with accepted good industry practice which would require compliance with applicable Australian Standards in the absence of any direction by safety legislation or a safety regulator to the contrary) AGN has applied the AS/NZS 4645 standard to assessing the risk associated with the CI/UPS and HDPE mains. It has also adopted risk mitigation activities such as pressure reduction and increased inspections to reduce the risk as required under the standard. Further, the mains replacement program has been designed to achieve the maximum risk reduction possible given delivery capability, without imposing costs that are disproportionate to the risk reduction on customers.

Relevant excerpts from the standard that relate to rigorous risk assessment are provided in Appendix A to this Attachment.

1.3.1.5 Gas Distribution Licence Clause 5

Under Clause 5.1 of AGN's gas distribution licence, AGN must:

> *"… use its best endeavours to conduct the operations authorised by this licence in accordance with good gas industry practice including, but not limited to, conducting the operations so as to:*

[11] See Table C4 (Risk *Treatment* Actions) AS 4645.

(a) prevent death or injury to, persons or damage to property;

(b) minimise leakage of gas; and

(c) account for the total amount of gas lost from the distribution system as a result of leakage or an activity referred to in section 82{1) of the Act."

1.3.1.6 Work Health and Safety Act 2012

As an entity carrying on a business or undertaking AGN is required to comply with the *Work Health and Safety Act 2012* (WHS Act).

The provisions of the WHS Act are in addition to and do not derogate from the provisions of any other Act (Section 12(1)). Therefore, its requirements apply in addition to those of the *Gas Act 1997*.

Section 19(1) of the WHS Act provides:

"A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the health and safety of—

(a) workers engaged, or caused to be engaged by the person; and

(b) workers whose activities in carrying out work are influenced or directed by the person, while the workers are at work in the business or undertaking."

This Section creates a duty towards AGN's workers (and those of APA – persons caused to be engaged by AGN). Such workers are exposed to potentially significant risks through the fracturing of mains. When leaks are investigated the investigation team does not know until such time as the main is excavated the nature or extent of degradation to the main – whether the main has cracked, corroded or is subject to graphitisation. In the case of a main with major degradation, there is potential for sudden failure, exposing the investigation and repair team to significant risks to their personal safety.

While Section 19(1) is limited in its scope to workers, Section 19(2) of the WHS Act imposes a general duty on persons conducting a business or undertaking to ensure, so far as reasonably practicable, no other persons are exposed to risks. In the case of a distribution network persons who may be exposed to such risks include customers as well as members of the public generally.

Section 19(2) provides:

"A person conducting a business or undertaking must ensure, so far as is reasonably practicable, that the health and safety of other persons is not put at risk from work carried out as part of the conduct of the business or undertaking."

Section 17(1) of the Act provides:

"A duty imposed on a person to ensure health and safety requires the person—

(a) to eliminate risks to health and safety, so far as is reasonably practicable; and

(b) if it is not reasonably practicable to eliminate risks to health and safety, to minimise those risks so far as is reasonably practicable."

Section 18 defines the concept of reasonably practicable:

"reasonably practicable, in relation to a duty to ensure health and safety, means that which is, or was at a particular time, reasonably able to be done in relation to ensuring health and safety, taking into account and weighing up all relevant matters including—

(a) the likelihood of the hazard or the risk concerned occurring; and

(b) the degree of harm that might result from the hazard or the risk; and

(c) what the person concerned knows, or ought reasonably to know, about—

(i) the hazard or the risk; and

(ii) ways of eliminating or minimising the risk; and

(d) the availability and suitability of ways to eliminate or minimise the risk; and

(e) after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk."

Of note is that under Section 18(e) cost is only taken into account once an assessment of the extent of the risk and ways of eliminating or minimizing it has first been made. Further, cost is only a basis for not addressing a risk where grossly disproportionate to the risk.

1.3.1.7 Summary of the Pipeline Safety Duties

AGN is required by its licence to comply with the mains replacement plan as approved by the ESCOSA. Failure to do so would constitute breach of a pipeline safety duty.

Section 55 of the *Gas Act 1997* (through its incorporation of AS/NZS 4645) requires AGN to reduce the risk arising from its gas distribution network to 'Low' or 'Negligible' as soon as possible (if 'High') and immediately (if 'Extreme') and if not possible then to a level which is ALARP. The *Work Health and Safety Act 1997* requires AGN to ensure the safety of its workers and others as far as is reasonably practicable. AGN's mains replacement program has been designed to meet these standards of safety. The CI, UPS and HDPE mains are prone to fracture, with the 'High' or 'Extreme' risk of a significant escape of gas and the consequent potential for that gas to ignite.

Managing this risk is difficult because of the unpredictability of when fractures will occur. To minimise the risk to a level that is 'Low' or 'Negligible' or, if this is not possible, to ALARP, all of the CI, UPS and HDPE mains must be replaced as quickly as the resources available to AGN allow replacement to be undertaken in a safe and reliable manner.

1.3.2 Inherent Network Risk

In its 2011 AA Final Decision for the South Australia Gas Distribution Network, the AER recognised the safety risk CI/UPS mains pose to maintenance personnel and the public, approving a 1,072 kilometres replacement program for the current (2011/12 to 2015/16) AA period. This decision was based on the fact that the CI/UPS network is up to 70 years old and has reached the end of its useful life. The material is prone to leakage, corrosion and fracture, increasing the likelihood of explosion in a property and the potential loss of life or serious harm. AGN is committed to removing this aged asset from the Network, particularly from areas that are heavily populated or located near to buildings where escaped gas has the potential to collect.

By the end of 2015/16, around 917 kilometres of this high-risk asset will remain in the Network, including 106 kilometres located in the CBD and medium pressure trunk mains. As referred to in Section 1.4.1.2, replacement work is currently being completed in the southern section of the CBD and progressing in a systematic manner towards the centre of the CBD. The replacement of mains in the Adelaide CBD requires significant preparatory design and consultation work which delayed the commencement of the replacement of CBD mains in the current AA period. This program will now be completed in the next AA period.

In recent years, a new safety issue associated with cracking and sudden failure of HDPE mains has emerged in the Network. Three gas incidents since 2007 as a result of brittle crack failures of HDPE mains have sharpened our focus on understanding the behaviour of this material. We are conducting ongoing research into the threat of HDPE cracking and have begun HDPE mains replacement to minimise the likelihood that similar events will occur in the future. The research is expected to provide a better understanding of time-to-failure and enable optimum prioritisation of replacement.

Technical experts Jacobs were engaged by AGN to provide a review of the proposed mains replacement program as well as advice on risk associated with CI/UPS and HDPE mains in other jurisdictions, drawing on its experience in the US and UK gas sectors. With regard to cast iron mains, in its expert report Jacobs states:

> *"Various risk-based cast iron replacement schemes have been adopted in the UK since the 1970s. However, over 30 years later the UK was still experiencing failures leading to about four serious fires and explosion incidents each year. Based on a number of studies into these incidents, the UK Health Safety Executives (HSE) determined that the risk posed by cast and ductile iron, including the unpredictable nature of that risk and inability of well-intentioned risk management programs to effectively reduce that risk, could no longer be accepted. The UK Iron Main Replacement Program (IMRP) was introduced in 2002 to address societal concerns by dealing directly with the inherent risk posed by iron mains (both cast and ductile iron)."*[12]

And:

> *"US regulators have justified accelerated cast iron replacement based on a safety case. In the UK, policy makers determined that cast iron mains posed a 'societal risk' meaning a hazard that impacts society at large, such as a risk of multiple fatalities from a gas explosion. In both the US and the UK, the qualitative case was built from a detailed review of a series of incidents that have occurred on iron mains and from a review of frequency and nature of breaks, leaks, and corrosion (failure modes) found on iron networks that can, under the certain conditions, result in an incident. This was coupled in both cases with an unwillingness of policy makers and regulators to tolerate a known risk associated with obsolete materials.*
>
> *In both the US and the UK the risk to be avoided is not limited to the risk of multiple fatalities but also the risk of significant property damage such as, if an incident occurs when a building is empty, had the building been occupied it would have potentially resulted in loss of life.*
>
> *It is cast iron's failure mode that has caused regulators in the US and UK to support accelerated replacement. This failure mode has proven to be unpredictable and catastrophic. Ground movement is the primary trigger for failure."* [13]

The Jacobs report contains examples of incidents in US and UK gas distribution networks that resulted in death or serious injury. It is worth noting that the rate of cracking in the South Australian CI network is around two-and-a-half times that of UK cast iron mains, experiencing 0.27 CI cracks per kilometre per year compared with 0.11 in the UK.

Further, Jacobs notes that:

> *"Cast iron pipes with diameters of 12 inches or less are more susceptible to these unpredictable breaks, and we understand that over 98% of AGN's cast iron pipe is smaller than 12 inch. Further, surface pressures that exist today were most often not known understood or anticipated when the pipe was installed."* [14]

In its report, Jacobs also highlights the catastrophic risk posed by aged CI mains. Data on gas distribution incidents in the US between 2005 and 2014 show that:

- 10.2% of the incidents occurring on gas distribution mains involved cast iron mains. However, only 2.3% of distribution mains are cast iron.

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12 Jacobs 2016, "*Mains Replacement Program Review*", January 2016, pg. 9. Provided as Attachment 8.11 to this Revised AA Proposal.

13 bid.

14 bid, pg. 11.

- In proportion to overall cast iron main mileage, the frequency of incidents on mains made of cast iron is more than four times that of mains made of other materials.
- 40% of the cast/wrought iron main incidents caused a fatality or injury, compared to only 18 percent of the incidents on other types of mains.
- 10% of all fatalities and 7% of all injuries on gas distribution facilities involved cast or wrought iron pipelines. [15]

AGN considers that the advice from Jacobs confirms the inherent and 'High' to 'Extreme' risk (as assessed under AS/NZS 4645) associated with CI/UPS and particularly the safety risk to people in certain circumstances. On the basis of the advice and AGN's assessment, a prudent network operator would prioritise replacement of the highest risk CI/UPS mains that are located in areas where there is likely to be a concentration of people.

The Jacobs report also provides insight into severity of the risk associated with old (vintage) PE pipe in the US:

> *"The primary problem encountered with vintage plastic pipe in the US is that some of the early products found in systems have an oxidized inner surface that predisposes the inner surface to experience cracks faster when certain stresses are applied. The resulting shortened crack initiation time leads to dramatically reduced overall pipeline longevity through a predominant failure mechanism known as slow crack growth.*
>
> *This failure mode can have catastrophic consequences and was the cause of a large incident involving multiple fatalities in Puerto Rico in 1996, and incidents in California leading to the California Public Utilities Commission (CPUC) identifying Aldyl A PE pipes as a major potential hazard that will not be manageable by leak surveying.* [16]

While the Aldyl A PE pipe used in the US is not identical to the HDPE used in the South Australia network, the failure mode is the same, with the pipes cracking much more abruptly than CI and resulting in a potentially greater volume of escaped gas.

Our experience shows that HDPE mains are prone to brittle crack failures under certain conditions, resulting in a sudden release of gas. As the AER correctly identifies in its recent Draft Decision *"The higher pressure on HDPE mains means that, while they have better leakage rates than CI & UPS, they carry more risk."*[17]

We consider, consistent with the advice of Jacobs and AS/NZS 4645, this high risk material must be removed from the Network as quickly as possible. We believe this course of action, along with complementary activities to mitigate the risk of HDPE mains that cannot be replaced during the next AA period, is necessary to reduce the inherent network risk to 'Low' or 'Negligible' and if not possible, to ALARP. We have therefore revisited the risk assessment and prioritisation of CI/UPS and HDPE mains for the next AA period.

1.3.3 AGN's Risk Assessment Approach

AGN's risk management framework is based on AS/NZS ISO 31000 Risk Management – Principles and Guidelines, and the requirements of AS 2885 Pipelines-Gas and Liquid Petroleum and AS/NZS 4645 Gas Distribution Network Management. As noted above AGN is required to comply with AS 2885 and AS/NZS 4645 by section 55 of the *Gas Act 1997*.

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15 Jacobs 2016, "*Mains Replacement Program Review*", January 2016, pg. 7. Provided as Attachment 8.11 to this Revised AA Proposal.

16 bid, pg. 24.

17 AER 2015, "*Confidential Appendix A – Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6A-15.

We assess the risk of mains failure events in the distribution network in accordance with AS/NZS 4645. For each failure event, we consider the consequence and likelihood of that event occurring. Combining these produces the level of risk assessed (risk rating). Once the level of risk has been defined, we identify the necessary risk treatment (guided by AS/NSZ 4645) and calculate the cost of remediating the risk.

Cost impact is considered against the inherent risk, the level of risk reduction and the residual risk, to determine a prudent and efficient course of action. Where risk mitigation activities alone cannot reduce the risk to 'Low' or 'Negligible' or ALARP, we seek to replace the asset so that 'Low' or 'Negligible' or ALARP can be achieved as quickly as possible.

1.3.4 Risk Assessment of Mains in the South Australian Gas Distribution Network

As previously discussed, CI/UPS mains failure and HDPE cracking poses a significant safety risk to maintenance personnel and the general public. As such, AGN's risk assessment approach focuses on understanding the potential severity of failure events associated with each asset and the likelihood that the event will occur.

In its Draft Decision the AER states:

> *"… the level of risk can vary across the different pipe types depending on several factors such as pressure of the pipes, and location of the pipes which has nothing to do with the pipe type. For instance, we recognise that:*
>
> - *The higher pressure on HDPE mains means that, while they have better leakage rates than CI and UPS, they carry more risk*
> - *CI and UPS mains for block replacement are mostly low pressure and carry less risk, especially of a major consequence. This is because the manner of the leak is likely to result in a slow release of gas*
> - *CI and UPS mains located in the CBD are likely to be deemed high risk given the high population density that exists there. However, the leakage rates in these areas are low, as the CI is of a high grade, with most leaks coming from the joints.*[18]

The level of risk does vary between assets, and other than the assumption that CI mains in the CBD are of a high grade[19], the AER's view on relative asset risk is reasonable. The main type, location and pressure all contribute to risk. For example, an asset that:

- is made from a material that has a propensity to crack;
- is located in a built-up area; and
- operates at high or medium pressure,

would carry the highest risk and should be prioritised for replacement. All mains carry an inherent risk of causing fatality or serious harm, simply due to the hazard associated with distributing natural gas. Taking into account the above factors allows us to understand the likelihood of asset failure resulting in a major (or potentially catastrophic) event.

To ensure proper consideration of the variables that affect the risk associated with mains, we have grouped our network mains into 11 categories based on asset material, location and pressure. This allows for a more

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[18] AER 2015, "*Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6-36.

[19] CBD mains are of no higher grade than other areas of the network and the AGN has not provided the AER any information that would support this conclusion. We note the AER comment that in the CBD, most leaks originate from joints, but this is the case in all cast iron networks, regardless of location.

rigorous assessment of risk, particularly the likelihood of harm occurring, than assessing mains as a single asset class.

The mains categories are as follows:

1. CI/UPS CBD program – this category refers to all CI/UPS mains located within the Adelaide CBD.
2. CI/UPS trunk mains – this category refers to all medium pressure larger diameter CI/UPS trunk mains. These mains are typically located along major carriageways and in older suburbs that contain older-style residential buildings with underfloor spaces, where escaped gas has the potential to collect.
3. CI/UPS higher risk areas – this category refers to all low pressure CI/UPS mains in areas with a history of crack failure.[20] These mains are typically located in older suburbs that contain older-style residential buildings with underfloor spaces, where escaped gas has the potential to collect.
4. CI/UPS remaining – this category refers to the remaining CI/UPS mains in areas where there have been no recorded cracks to date.
5. HDPE 250 higher risk areas – this category refers to Class 250 (SDR 17.6) PE mains, which operate at medium pressure and are located in areas with a history of crack failure.[21] These mains were installed during the 1970s and 1980s and have become brittle and susceptible to cracking, and many are located in populated areas near buildings where escaped gas has the potential to collect.
6. HDPE 250 remaining – this category refers to the remaining Class 250 (SDR 17.6) PE mains, which operate at medium pressure, have become brittle and susceptible to cracking and are located in areas where there have been no recorded cracks to date. As with other HDPE mains, these mains have also sustained squeeze off damage and as a result are considered likely to exhibit slow crack growth failures in the future.
7. HDPE 575 higher risk areas – this category refers to Class 575 (SDR 9.9) PE mains that operate at high or medium pressure, and are located in areas with a history of cracking. Many of these mains are located in populated areas near buildings where escaped gas has the potential to collect.
8. HDPE 575 remaining – this refers to the remaining Class 575 (SDR 9.9) PE mains that operate at high or medium pressure, and are located in areas where there have been no recorded cracks to date. However, as these mains have also sustained squeeze off damage, they are considered likely to exhibit slow crack growth failures in the future.
9. Multi-user inlet services (CI/UPS) – this category refers to 1,328 predominantly UPS services running through unit developments and commercial premises. These assets are located across the Network.
10. New PE – this refers to the new polyethylene pipe that has been installed in the Network in more recent times and is not considered susceptible to cracking.
11. Protected steel – this refers to steel pipe with a PE coating that is typically now used only in high pressure applications, and cathodically protected to maintain integrity and longevity. These mains are not susceptible to the type of cracking and integrity issues that affect other pipe materials.

Table 1.1 summarises the characteristics of each sub-category of main.

[20] These mains have a crack frequency rate almost 2.5 times that of CI mains in the UK.

[21] These mains have a crack frequency rate almost three times higher than CI/UPS mains.

TABLE 1.1: ASSET ATTRIBUTES BY MAINS REPLACEMENT PROGRAM CATEGORY

	Program Category	Leak Rate per Kilometre	Crack-Related Leak Rate per Kilometre	Low Pressure (1.75 kPa)	Medium Pressure (100 kPa)	High Pressure (250-350 kPa)
1	CI/UPS CBD program	1.12	0.25	X	X	
2	CI/UPS trunk mains	1.12	0.27		X	
3	CI/UPS higher risk areas	1.12	0.27	X		
4	CI/UPS remaining	1.12	Not applicable	X		
5	HDPE 250 higher risk areas	0.33	0.165		X	
6	HDPE 250 remaining	0.33	Not applicable		X	
7	HDPE 575 higher risk areas	0.33	0.054		X	X
8	HDPE 575 remaining	0.33	Not applicable		X	X
9	Multi-user inlet services (CI/UPS)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
10	New PE	Negligible	Negligible			X
11	Protected steel	Negligible	Negligible			=>350kPa

An estimate of the number of kilometres of each category of mains remaining in the Network at 30 June 2016 is calculated using the model described in Section 1.3.4.6.

The next step in the risk assessment is to identify the severity (or consequence) of a failure event for each category of pipe. The consequence of the potential event is then mapped against the AS/NZS 4645 severity classes.

1.3.4.1 Severity of the Consequence of the Event

The AS/NZS 4645 framework considers the consequences of a mains failure event on people, gas supply and the environment. The framework ranks the severity of the failure event from 'Catastrophic' (multiple fatalities) to 'Trivial' (minimal impact on health and safety).

As previously discussed, and supported by the Jacobs report, the most significant threat posed by the natural gas distribution network is that escaped gas gathers in a building and causes explosion. AGN has therefore used the AS/NZ 4645 consequence analysis to assess the following:

> *The consequences of a crack or leak in the gas mains that results in gas collecting in a building and causing explosion.*

Figure 1.1 presents AGN's assessment of the severity of consequences of mains failure on people, supply and environment as set out in AS/NZS 4645.

FIGURE 1.1: SEVERITY OF CONSEQUENCES OF MAINS FAILURE UNDER AS/NZS 4645 GUIDELINES (NO MITIGATION MEASURES)

	Catastrophic	Major	Severe	Minor	Trivial
People	Multiple fatalities result 1 2	Few fatalities or several people with life-threatening injuries 3 4 5 6 7 8 9 10 11	Injury or illness requiring hospital treatment	Injuries requiring first aid treatment	Minimal impact on health and safety
Supply	Long term interruption of the supply	Prolonged interruption or long-term restriction of supply	Short term interruption or prolonged restriction of supply 2	Short term interruption or restriction of supply but shortfall met from other sources 1 3 4 5 6 7 8 9 10 11	No impact; no restriction of gas distribution network supply
Environment	Effects widespread, viability of ecosystems or species affected, permanent major changes	Major off-site impact or long-term severe effects or rectification difficult	Localised (<1ha) and short-term (<2 yr) effects, easily rectified	Effect very localised (<0.1 ha) and very short term (weeks), minimal rectification	No effect, or minor on-site effects rectified rapidly with negligible residual effect 1 2 3 4 5 6 7 8 9 10 11

Key:

1. CI/UPS CBD program
2. CI/UPS trunk mains
3. CI/UPS higher risk areas
4. CI/UPS remaining
5. HDPE 250 higher risk areas
6. HDPE 250 remaining
7. HDPE 575 higher risk areas
8. HDPE 575 remaining
9. Multi-user inlet services (CI/UPS)
10. New PE
11. Protected steel

AGN considers it prudent to mitigate the most severe consequences (as per the Standard) of a mains failure event, therefore the severity ratings in the 'People' category of AS/NZS 4645 take precedence for the purpose of assessing the risk associated with each category of mains.

The key drivers of consequence severity on people are the location of the pipe (proximity to population centres and buildings where escaped gas has the potential to collect and result in an explosion), and the pressure of the gas in the pipe. The inherent risk associated with pressurised natural gas means any substantial release of gas (regardless of the asset that fails) gives rise to the potential for explosion and *fatalities or several people with life-threatening injuries*[22]. Therefore, we consider the lowest plausible severity ranking for any gas main is 'Major', with the severity rating of asset failure in densely populated areas such as the Adelaide CBD being 'Catastrophic.'

With regard to the impact on gas supply and environment, the consequences of a mains failure are far less severe. Only a failure in the trunk mains would have the potential for a prolonged restriction of supply, with failure elsewhere only likely to result in a short term or very isolated interruption. Environmental impact of mains failure is minor and very isolated, as in most cases natural gas will dissipate into the atmosphere and leave negligible residual effect.

22 AS/NZS 4645 Risk Severity Matrix, 'Major' rating.

AGN considers that the risk severity of CI/UPS mains failure in the CBD (Category 1 in the above matrix) is 'Catastrophic'. This is because these mains are located in a heavily populated area and near high occupancy buildings where escaped gas could collect. The Adelaide CBD has predominantly sealed ground services, which promotes gas migration through below ground ductworks into buildings.

Despite the CI/UPS being low pressure, the Network experienced a gas in building (GIB) incident event in 2004 [redacted] In addition, a number of GIB events not resulting in an incident have also been reported. These events indicate that even at low pressure, escaped gas can migrate into buildings in sufficient quantities and in some instances result in an incident. [redacted]

This rating is consistent with the AER's recognition that:

> *"CI and UPS mains located in the CBD are likely to be deemed high risk given the high population density that exists there."* [23]

Similarly, CI/UPS trunk mains (Category 2) are rated 'Catastrophic' as these mains are predominantly located in major carriageways in older suburbs with a mixture of commercial and residential buildings that have underfloor spaces. In addition, there have been a number of incidents involving maintenance personnel where sections of the main have "blown out" while endeavouring to fix a leak. The sudden and unpredictable release of gas not only impacts the safety of the public but also the safety of several maintenance personnel in the immediate vicinity. Trunk mains are typically large diameter (DN150mm and greater) and operate at medium pressure, meaning the amount of gas released in the event of failure is likely to be significant. As a result, we consider there is a plausible risk of multiple fatalities resulting from trunk mains failure.

AGN has rated all remaining CI/UPS mains as 'Major' as these mains are less likely to be generally located in densely populated areas.

AGN's rating of severity for CI and UPS CBD and trunk mains as 'Catastrophic' is supported by Jacobs. However, Jacobs considers that to not apply 'Catastrophic' to more of the CI/UPS and HDPE mains understates the risk. More specifically, Jacobs state:

> *"One point we would make here in describing our view that the approach is conservative is to apply some caution to the allocation of "CI & UPS higher risk areas" and "CI/UPA remaining" family to the major and not catastrophic risk class. Within this class there are likely to be numerous cast iron and UPS assets in close proximity (30m) of high occupancy buildings within suburban areas such as schools, hospitals, shopping malls, aged care homes and office buildings. Any one of these buildings could fit within the AS 4645 category "Catastrophic" as a severity class as the consequence of an event may be multiple fatalities. In addition, we believe the HDPE high-risk areas family should be included in the catastrophic category as directly from AGN's own experience these pipes can crack with catastrophic consequences."*[24]

AGN has adopted a more conservative approach for HDPE 250 and 575 mains by assuming that the consequence severity of mains failure outside the CBD and concentrated population areas is 'Major' rather than 'Catastrophic'. [25] However, for mains in higher risk areas (those in suburbs with a history of cracking) the *likelihood* of the threat occurring is given the same rating under the AS/NZS 4645 framework as for the CI/UPS CBD and trunk mains. The likelihood assessment is discussed further in the following section.

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23 AER 2015, "*Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6-36.

24 Jacobs 2016, "*Mains Replacement Program Review*", January 2016, pg. 27. Provided as Attachment 8.11 to this Revised AA Proposal.

25 [redacted]

1.3.4.2 Likelihood of Catastrophic/Major Failure Event

The next stage of the risk assessment considers the likelihood (frequency) that the failure event will occur and cause harm to people. AS/NZS 4645 has five frequency classes, ranging from 'Frequent' (expected to occur once per year or more) down to 'Hypothetical' (theoretically possible but has never occurred on a similar gas distribution network).

Though the AS/NSZ 4645 risk matrix considers impact on people, supply and the environment, standard risk management practice is to assess the likelihood of the highest consequence risk occurring when rating the risk event. This approach is supported by Jacobs:

> *"We are specifically focussed on the first ranking under the heading "People" as this is where the fundamental safety risk is. This should not in any way be taken as a diminution of the importance of reliability of supply or the environment, but is a direct acknowledgement that the risk of a gas escape leading to an explosion causing significant loss of life and/or property damage is, and should be, the principal concern."*[26]

Therefore, AGN has used the AS/NZS 4645 frequency analysis to assess the following risk event:

> *The frequency that a crack or leak in the gas main results in gas collecting in a building and causes an explosion that results in fatalities or several people with life-threatening injuries.*

Figure 1.2 shows AGN's assessment of the risk frequency associated with gas mains.

FIGURE 1.2: FREQUENCY OF FAILURE EVENT UNDER AS/NZS 4645 GUIDELINES (NO MITIGATION MEASURES)

Frequency Class	Frequency Description	AGN Asset Classification
Frequent	Expected to occur once per year or more	
Occasional	May occur occasionally in the life of the gas distribution network	1 2 3 5 7
Unlikely	Unlikely to occur within the life of the gas distribution network, but possible	4 6 8 9
Remote	Not anticipated for this gas distribution network at this location	
Hypothetical	Theoretically possible but has never occurred on a similar gas distribution network	10 11

Key:

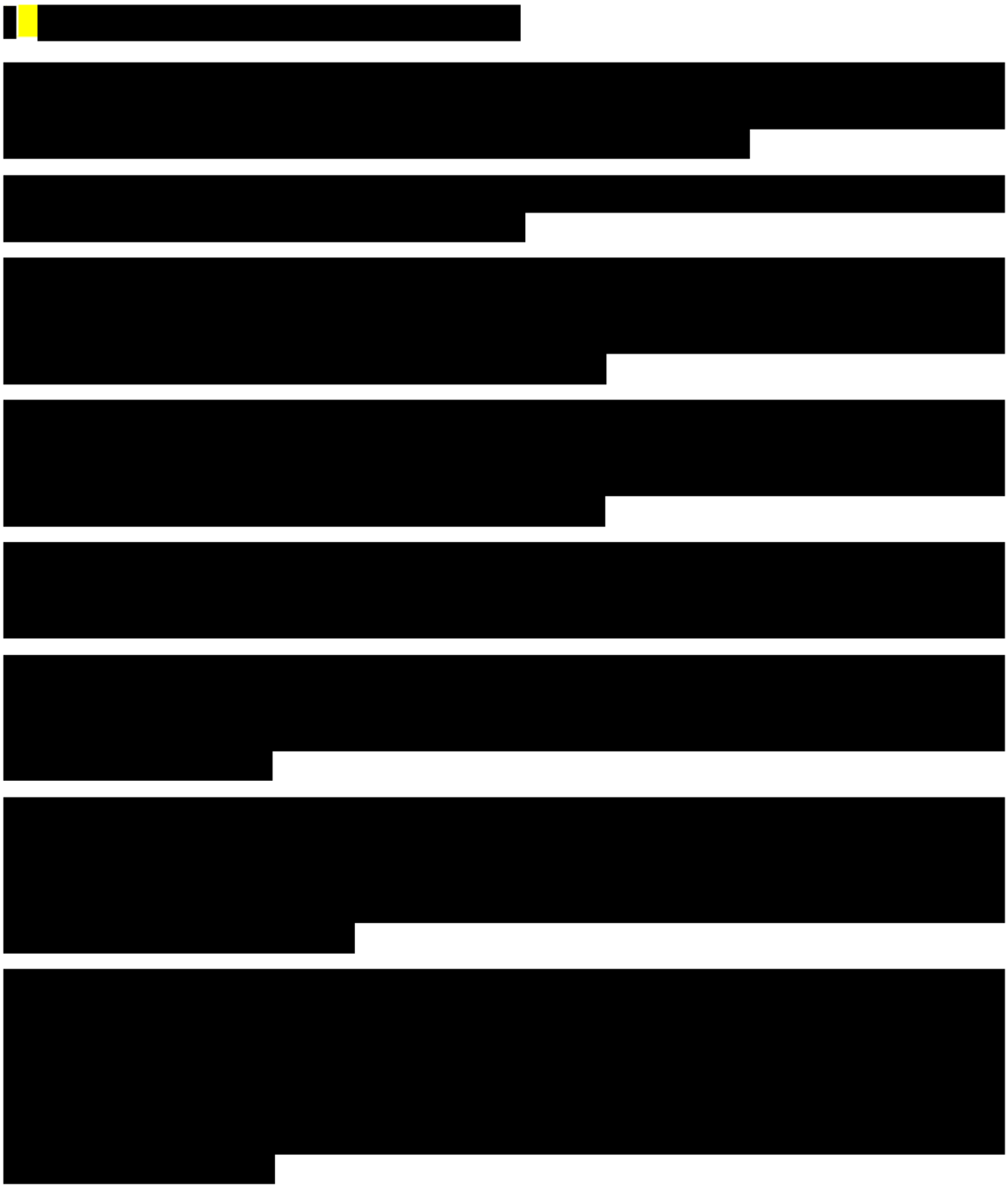
1. CI/UPS CBD program
2. CI/UPS trunk mains
3. CI/UPS higher risk areas
4. CI/UPS remaining
5. HDPE 250 higher risk areas
6. HDPE 250 remaining
7. HDPE 575 higher risk areas
8. HDPE 575 remaining
9. Multi-user inlet services (CI/UPS)
10. New PE
11. Protected steel

The key drivers of risk frequency are the pipe material and condition (propensity to crack) and the mains pressure. When assessing frequency, it is also important to consider proximity of the mains to the general population and/or buildings, and the historical occurrence of incidents that either resulted in or had the potential to result in a catastrophic or major event. [redacted]

[redacted]

[redacted]

[26] Jacobs 2016, "*Mains Replacement Program Review*", January 2016, pg. 26. Provided as Attachment 8.11 to this Revised AA Proposal.



We consider a failure event of major severity is less likely on HDPE 250 and 575 mains located outside of higher risk areas (Categories 6 and 8 on the above matrix). Therefore, the risk frequency for these mains is rated 'Unlikely'.

We have also rated the risk frequency of CI/UPS mains located outside of higher risk areas (Category 4) and multi-user service inlets (Category 9) as 'Unlikely'. Though these assets are in poor condition and at the end of their useful lives, their lack of crack failure history suggests the likelihood of serious harm resulting from failure is lower.

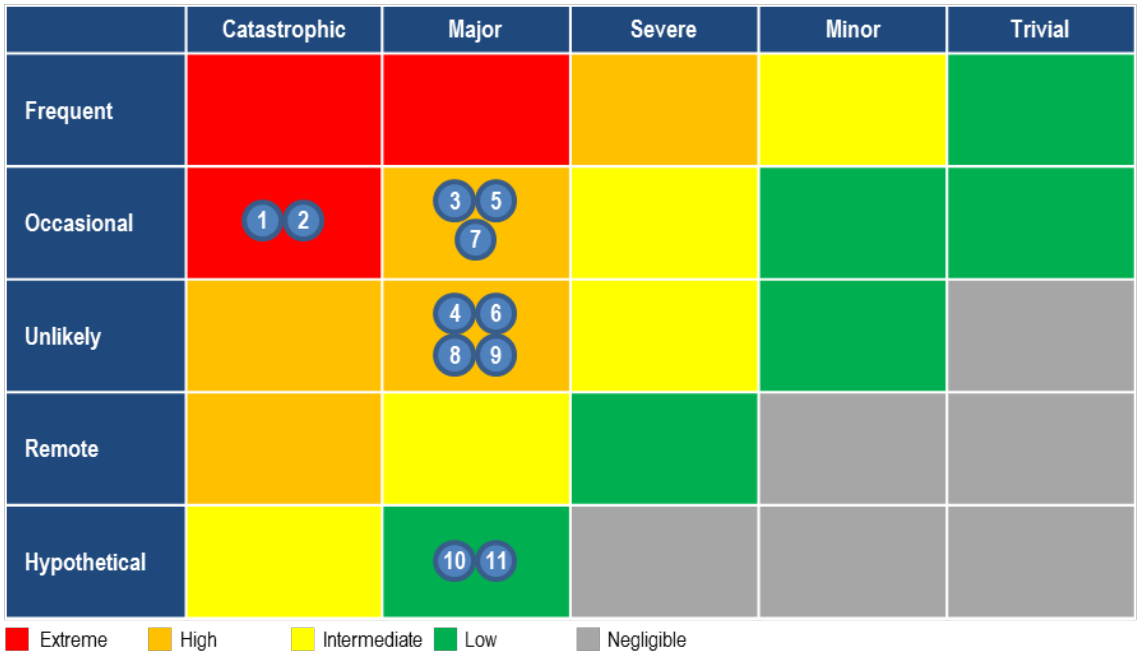
The risk likelihood associated with new PE and protected steel mains (Categories 10 and 11), is considered 'Hypothetical' as these mains are in good condition, with negligible leakage rates.

1.3.4.3 Overall Risk Rating

The AS/NZS 4645 risk framework then provides for the consequence and frequency analysis to determine an overall risk rating. The ratings range from 'Extreme' to Negligible', and correspond to a recommended

risk treatment action (presented in Section 1.3.4.4). Based on the above severity and frequency analysis, Figure 1.3 shows the overall risk rating for the different categories of mains in the Network.

FIGURE 1.3: MAINS INHERENT RISK RATING UNDER AS/NZS 4645 GUIDELINES (NO MITIGATION MEASURES)



Key:

1.	CI/UPS CBD program	5.	HDPE 250 higher risk areas	9.	Multi-user inlet services (CI/UPS)
2.	CI/UPS trunk mains	6.	HDPE 250 remaining		
3.	CI/UPS higher risk areas	7.	HDPE 575 higher risk areas	10.	New PE
4.	CI/UPS remaining	8.	HDPE 575 remaining	11.	Protected steel

AGN considers that the inherent risk associated with CI/UPS mains located in the CBD, and the CI/UPS medium pressure trunk mains is 'Extreme'. As such, continuation of the CI/UPS program to remove these mains as quickly as possible is the most prudent course of treatment.[27]

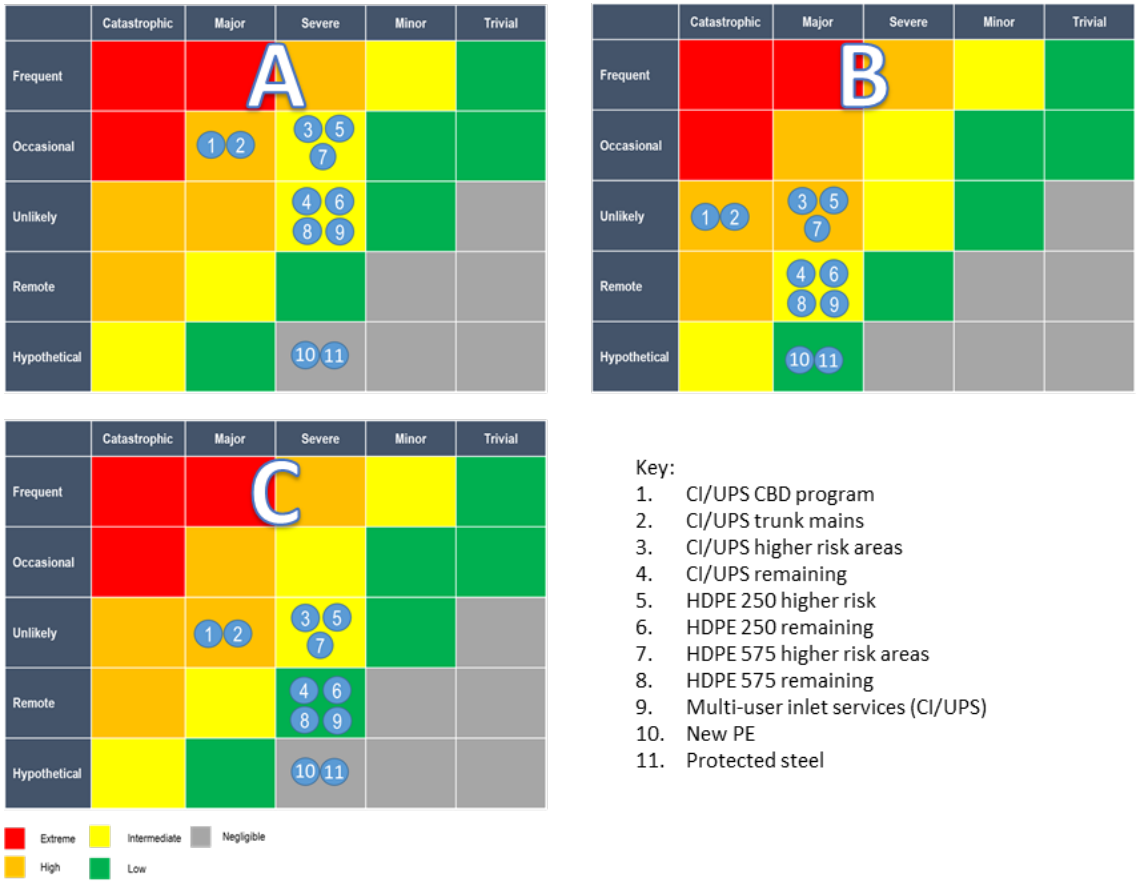
All other mains (with the exception of new PE and protected steel) are considered 'High' risk. We consider a prudent network operator would replace these assets as quickly as possible, reducing the risk to 'Low' or 'Negligible' and if not possible then to ALARP. The specific risk treatments required by AS/NSZ 4645, and AGN's proposed mains replacement program, are discussed in Section 1.3.4.4.

Sensitivity Analysis

To challenge the rigour of the results, we considered the outcome of risk scenarios that assume a lower severity and frequency of risk associated with each category of mains. The purpose of this exercise was to understand how a shift in risk assessment might impact AGN's obligation to replace the mains or change the recommended risk treatment. Figure 1.4 shows the revised AS/NZS 4645 matrices if the risk severity or frequency assessment (or both) is lowered by one degree.

[27] In recognition of the inherent 'Extreme' risk associated with these assets, AGN is currently undertaking replacement in the Adelaide CBD, with significant preparatory design and consultation work having been undertaken at the commencement of the current AA period.

FIGURE 1.4: ALTERNATIVE RISK SEVERITY AND FREQUENCY ASSESSMENT



Matrix A in Figure 1.4 contemplates lowering the severity assessment, placing mains Categories 3 to 9 in the 'Severe' rating. Under AS/NZS 4645 a severe event results in *injury or illness requiring hospital treatment*, and excludes the possibility of a fatality. Categories 1 and 2 move into the 'Major' severity category.

Under this scenario, the CI/UPS CBD and trunk mains are rated 'High' risk. The obligation to reduce the risk is the same for 'High' and 'Extreme' risks. This means that the risk treatment for these mains specified under AS/NZS 4645 requires AGN to reduce the risk to 'Low' or 'Negligible' as soon as possible and if not possible, to ALARP. Therefore, AGN's obligation to replace these mains during the next AA period would not be diminished.

Mains Categories 3 to 9 become rated 'Intermediate' risk. Under AS/NZS 4645, AGN would be required to reduce the risk level associated with these assets to 'Low' or 'Negligible' as soon as possible. If AGN cannot reduce the risk within a few months, it must demonstrate it is doing everything in its power to reduce the risk to ALARP. This scenario is also consistent with AGN's proposal to replace the highest risk mains during the next AA period to reduce the risk to 'Low', with the remainder reduced to ALARP until such a time they can be replaced.

Therefore, under the scenario in Matrix A, AGN would still be required to deliver its mains replacement program as proposed.

Matrix B contemplates maintaining AGN's severity assessment, but lowering the frequency of these events occurring. This moves Categories 1 and 2 from 'Extreme' to 'High 'risk. As per the scenario presented in Matrix A, a 'High' risk ranking still places an obligation on AGN to replace these assets as soon as possible. Note the 'High' risk rating of CI/UPS and HDPE mains in higher risk areas (Categories 3, 5 and 7) remain unchanged.

Similarly, ranking categories 4, 6, 8, and 9 as 'Intermediate' risk decreases the urgency to replace these assets, however, AGN would still be obligated under AS/NZS 4645 (and the *Gas Act* 1997 which gives statutory force to AS/NZS 4645) to reduce the risk to 'Low' or 'Negligible' and if that is not possible then to

ALARP. We consider reducing the risk to 'Low' involves replacing all the assets, therefore to reduce the risk to ALARP requires replacing as many of these assets as timing and resources will efficiently allow during the next AA period, and undertaking mitigation activities (such as monitoring and reducing pressure) as an interim solution.

Therefore, under the scenario in Matrix B, AGN considers its proposed mains replacement program would need to be delivered in full in order to satisfy its obligations.

Matrix C contemplates reducing the risk severity *and* likelihood such that the risk associated with the assets in category 4, 6, 8 and 9 is 'Low'. This scenario would only require AGN to develop a risk management plan and to monitor these assets until such a time their risk classification changed.

Therefore, under this scenario AGN would only be obligated to replace mains Categories 1, 2, 3, 5 and 7 during the next AA period. This is not entirely inconsistent with AGN's proposed replacement program, which focuses on replacing mains in Categories 1, 2, 3, 5, 7 and 9 during the next AA period, and replacing the balance in subsequent years.

However, this risk assessment would also imply replacement of CI/UPS multi-user services (Category 9) could be deferred into future periods. The scenario in Matrix C also implies replacing the 'remaining' CI/UPS and HDPE could be deferred indefinitely.

AGN notes that decreasing the risk severity and frequency rating of assets that are known to have failed and caused explosion to 'Severe' and 'Remote' respectively, is not consistent with recent experience. AGN also notes that Jacobs formed the view that AGN's risk assessment rating was conservative (i.e. potentially understates the risk) for both severity and frequency stating:

> *"The risk ratings that result from the application of the severity class and the frequency class are in our opinion overly conservative. We say they are conservative because of the concern expressed above that some pipes within the "CI & UPS higher risk" family, and HDPE higher risk families can reasonably be seen from the discussion above as falling within the "catastrophic" class."*[28]

Conclusion

For the reasons discussed in the severity and frequency analysis above, we consider the overall inherent risk ratings of 'Extreme' for CBD and trunk mains and 'High' for all other at risk assets to be appropriate.

Our risk assessment also sets a realistic target of reducing this inherent risk to 'Low' by replacing these mains with new PE. As shown by the 'New PE' risk assessment, the risk ranking in the gas distribution network can never be 'Negligible', due to the hazards posed by transporting natural gas. Indeed, we have been taking action to manage this 'Extreme' risk to 'Low', or if not, ALARP during the current AA period through the existing mains replacement program. AGN is currently replacing the 'Extreme' risk CI/UPS mains in the CBD and commenced block replacement of HDPE during 2014/15. In any event, the obligations on AGN in relation to replacing at risk mains are reasonably indifferent to the changes in severity and frequency ratings.

The risk treatment actions required by AS/NZS 4645 and those proposed by AGN are discussed in the following Section.

1.3.4.4 Risk Treatment Actions

AS/NZS 4645 provides direction on how the risks in a gas distribution network should be treated and places an obligation on network operators to take action. Figure 1.5 shows the relevant risk treatments required by AGN's obligation under AS/NZS 4645 and the categories of main that require each treatment.

[28] Jacobs 2016, "*Mains Replacement Program Review*", January 2016, pg. 28. Provided as Attachment 8.11 to this Revised AA Proposal.

FIGURE 1.5: INHERENT RISK RANK & RISK TREATMENT ACTIONS UNDER AS/NZS 4645 GUIDELINES

Risk Rank	Required Action	AGN Asset Classification
Extreme	Modify the threat, the frequency or the consequences to ensure that the risk rank is reduced to Intermediate or lower. For a gas distribution network in operation the risk must be reduced immediately.	1 2
High	Modify the threat, the frequency or the consequences to ensure that the risk rank is reduced to Intermediate or lower. For a gas distribution network in operation the risk must be reduced as soon as possible, typically within a timescale of not more than a few weeks.	3 4 5 6 7 8 9
Intermediate	Repeat threat identification and risk evaluation process to verify and, where possible, quantify the risk estimation; determine the accuracy and uncertainty of the estimation. Where the risk rank is confirmed to be Intermediate, if possible modify the threat, the frequency or the consequence to reduce the risk rank to Low or Negligible. Where the risk rank cannot be reduced to Low or Negligible action shall be taken to: a) remove threats, reduce frequencies and/or reduce severity of consequences to the extent practicable; and b) demonstrate as low as reasonably practicable (ALARP). For a gas distribution network that is in operation, the reduction to Low or Negligible or demonstration of ALARP must be complete as soon as possible, typically within a timescale of not more than a few months.	
Low	Determine the management plan for the threat to prevent occurrence and to monitor changes which could affect the classification.	10 11
Negligible	Review at the next review interval.	

Key:

1. CI/UPS CBD program
2. CI/UPS trunk mains
3. CI/UPS higher risk areas
4. CI/UPS remaining
5. HDPE 250 higher risk areas
6. HDPE 250 remaining
7. HDPE 575 higher risk areas
8. HDPE 575 remaining
9. Multi-user inlet services (CI/UPS)
10. New PE
11. Protected steel

AGN's obligation under the *Gas Act* 1997 to comply with AS/NZS 4645 requires that AGN must reduce any risks rated as 'Extreme' immediately and those ranked 'High' as soon as possible, typically within a timescale of not more than a few weeks. This has led AGN to develop the following risk mitigation strategies:

- increase frequency of leak surveys in areas identified as higher risk (proximity of mains to buildings, type of premises and ground conditions);
- pressure reduction in areas with a history of crack failure;
- increase the level of gas odorisation;
- replacement of all CI/UPS mains in the CBD and medium pressure trunk mains, with completion in the next AA period;
- replace as much of the 'High' risk CI/UPS, HDPE 250 and HDPE 575 mains as possible within delivery capability during the next AA period;
- replace all remaining 'High' risk CI/UPS, HDPE 250, and HDPE 575 mains as soon as reasonably practicable;
- replace all CI/UPS multi-user inlet services during the next AA period;
- research and utilise inline camera technology to identify defects and effect temporary repair in HDPE pipe that has not been prioritised for replacement during the next AA period;

- continue installation of ground vents over HDPE mains in locations where ground conditions could seal in gas leaks, making them difficult to detect; and

- develop a reliability forecast model for predicting the remaining life of HDPE 575, so that risk mitigation strategies (including replacement) can be optimised.

We have already begun implementing a number of the above strategies, including commencing replacement of the highest risk mains, utilising cameras and installing vents. The current mains replacement program and various risk mitigation activities have been underway since 2011 and are working towards lowering the overall network risk. However, it is not practicable to replace all 2,619 kilometres of the remaining 'Extreme' and 'High' risk mains immediately.

Table 1.2 presents the actual and forecast volume of mains that have been replaced under the mains replacement program over the current AA period.

TABLE 1.2: MAINS REPLACEMENT DURING CURRENT AA PERIOD

Mains Replaced (kilometres)	2011/12	2012/13	2013/14	2014/15	2015/16 (estimate)	Total
CI/UPS	166	201	264	240	200	**1,071**
HDPE 250	0	5	0	26	50	**81**
Total Replaced	**166**	**206**	**264**	**266**	**250**	**1,152**

As noted earlier in this Attachment, the pipeline safety duties on AGN require it to eliminate risks to health and safety from its operations or where this is not achievable reduce those risks to ALARP. In order to demonstrate the inherent network risk during the next AA period is being reduced to ALARP, AGN must replace the volume of mains during the next AA period that skill and resources will allow.

Based on performance over the current AA period, we have developed the capability to efficiently replace around 250 kilometres of mains per year, or 1,245 kilometres of planned replacement during the next AA period, with the potential to deliver an additional 20 kilometres of reactive (piecemeal) works.

Given the nature of the risk and guidance provided under AS/NZS 4645, we have considered options to replace all 2,619 kilometres of mains rated 'High' or 'Extreme' within five years and within AGN's current delivery capability.

A five-year program would require AGN to double its delivery capability to more than 500 kilometres per year. It is unlikely that this delivery capability would be achievable. The business would need to:

- source additional contractors and staff, and ensure any new resources are trained and fully inducted to AGN's safety and work practice requirements;

- co-ordinate a substantial increase in access schedules with the other utilities providers, councils and the community (and in various cases obtain their approval to undertake the mains replacement) and

- minimise a potentially larger volume of disruptions to gas users and the general public, for example by staggering required road closures and service outages.

The increased time and resources required to undertake these activities would make achieving full replacement within five years extremely challenging.

Further, if it were possible to increase resources to replace all 2,619 kilometres of mains in five years, the delivery scenarios presented in Section 1.3.5 indicate that there would a 12% increase in the cost per customer compared to replacing the mains within current delivery capability. However, AGN would likely have to pay a premium to attract sufficient resources to replace all 2,619 kilometres of mains in five years, which means the unit rate of replacement would increase significantly from current estimates adopted in the cost impact analysis. As a result, the cost per customer is likely to be significantly greater than 12% per customer.

Therefore AGN considers that, even if such a program were feasible, the additional cost would be disproportionate to the risk reduction.

Given our delivery capability will not result in the replacement of all 'High' risk mains over the five-year period, we have undertaken a risk prioritisation process to rank the risk of particular mains. This process involves modelling the risk rating based on characteristics such as location, crack rate and event history. The risk prioritisation model enables a risk ranking to be applied to mains in each suburb.

We have used the risk prioritisation model to help ensure that the right mains will be replaced at the right time (and at the right cost), within AGN's current delivery capability. Utilising this model, we have identified which class of main and how many kilometres of each main should form part of the 1,265 kilometres replacement program that is within AGN's delivery capability. The risk prioritisation model is discussed below.

1.3.4.5 Prioritising Mains for Replacement

The AS/NZS 4645 risk assessment demonstrates that the risk associated with failure of CI/UPS and HDPE mains needs to be addressed. The most effective method of eliminating this risk is to replace all these mains with new PE. However, as explained above, AGN does not have the resources available to replace 2,619 kilometres of 'Extreme' and 'High' risk mains in five years. Even if it were possible to safely source and train sufficient replacement crews to replace all mains within this period, the expected increase in unit rates would make the cost of doing so disproportionate to the risk that will be mitigated.

The employment of the resources available to AGN, using best endeavours, would result in around 1,265 kilometres of mains replacement over the next AA period.[29] The challenge is to prioritise the mains that make up this 1,265 kilometres program. Table 1.3 shows the volume of the 'High' and 'Extreme' risk mains forecast to remain in the Network at the end of the current AA period (30 June 2016).

TABLE 1.3: NETWORK INHERENT RISK RATING AT 30 JUNE 2016

	Program Category	Risk Rating	Kilometres in Network
1	CI/UPS CBD program	Extreme	44
2	CI/UPS trunk mains	Extreme	62
3	CI/UPS higher risk areas	High	811
4	CI/UPS remaining	High	
5	HDPE 250 higher risk areas	High	286
6	HDPE 250 remaining	High	
7	HDPE 575 higher risk areas	High	1,416
8	HDPE 575 remaining	High	
Total Kilometres			**2,619**

Identifying the kilometres of CI/UPS mains in the CBD and CI/UPS trunk mains is relatively simple, as these are distinct asset families with relatively low volumes (44 kilometres and 62 kilometres respectively). All of these assets are rated an 'Extreme' risk, so the need to replace these mains immediately is clear.

However, the other mains categories need to be prioritised as the volume is greater than AGN's sustainable delivery capability over the next five years. There are 286 kilometres of 'High' risk HDPE 250 mains, 811 kilometres of 'High' risk CI/UPS mains, and 1,416 kilometres of 'High' risk HDPE 575 mains in the Network. This means 2,456 kilometres of 'High' risk mains that must be prioritised within a delivery capability of 1,159 kilometres[30] for the next AA period.

[29] Constraints on mains replacement speed are discussed in the Affidavit from APA Group Executive Networks John Ferguson in the Matter of the AER Gas Access Arrangement Review 2016-2021.

[30] 1,265 kilometres minus the 106 kilometres of CDB and trunk mains that are highest priority.

Logically, assets that carry the greatest risk should be prioritised for replacement, therefore AGN has developed a model that uses pipe cracking history to identify which mains in an asset class are located in higher risk areas. This allows us to work out the kilometres of mains that fit into each category in the above Table (for example splitting the 811 kilometres of CI/UPS mains in program categories 3 and 4), which we can use to determine the make-up of the 1,265 kilometres mains replacement program.

AGN's risk prioritisation model draws information from AGN's Geospatial Information System (GIS) and Works Management System (WMS), which identifies the number of leaks and cracks that have occurred on CI/UPS and HDPE mains by suburb since 2007. The information allows us to identify the suburbs that have a history of cracking. The steps to calculate the prioritised mains are described below.

Mains Prioritisation Process

Step 1 – Exclude mains rated 'Extreme' risk from the model

The risk assessment under AS/NZS 4645 has identified the 106 kilometres of CI/UPS mains in the CBD and medium pressure trunk as 'Extreme' risk. As a result, these mains will be prioritised for replacement and therefore do not need to be ranked using the risk prioritisation model.

Step 2 – Exclude mains in suburbs with no history of cracking from the model

Next, we have determined that mains located in suburbs where there has been no record of cracking to date can be deferred for replacement. We consider these mains carry a lower likelihood of failure than mains in suburbs with a history of cracking. While mains in suburbs with no record of cracking must be replaced at some point, a temporary solution is to manage the risk through monitoring and risk mitigation activities, such as utilising inline camera technology to identify defects and temporarily repair HDPE pipe, until such a time that they can be replaced. Therefore, these mains are not included in the risk prioritisation model.

Removing the mains located in suburbs with no crack history leaves 2,087 kilometres of 'High' risk mains to be assessed utilising the risk prioritisation model as is shown in Table 1.4.

TABLE 1.4: SPLIT OF 'AT RISK' MAINS BY CRACKING HISTORY

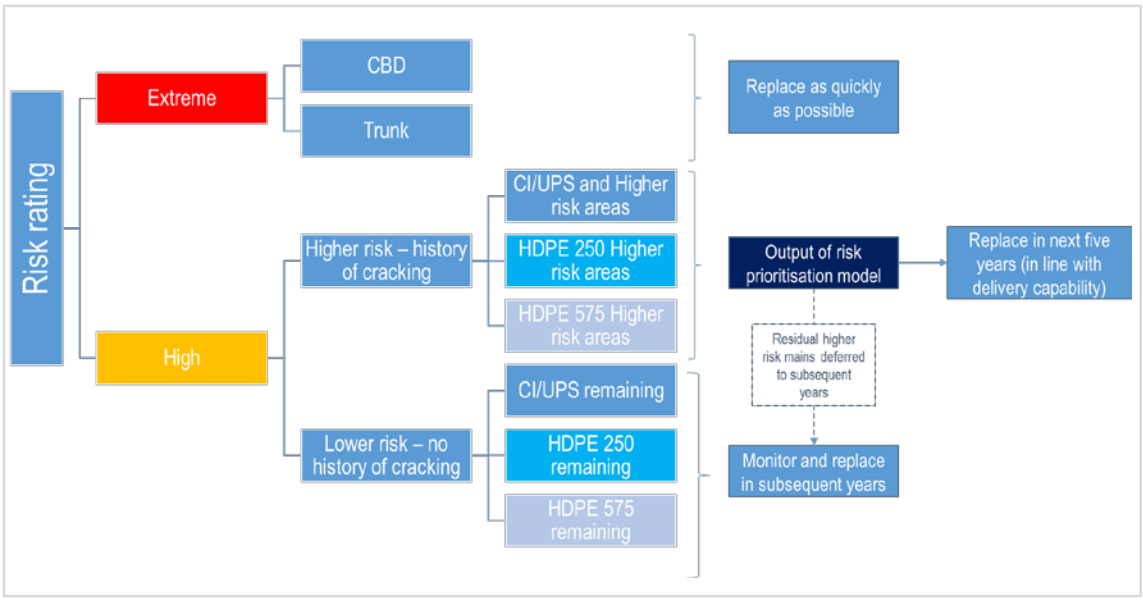
Program Category	Risk Rating	Kilometres in Network	Mains in Suburbs with no Record of Crack History (not included in prioritisation model) (kilometres)	Mains in Suburbs with Record of Crack History (included in prioritisation model) (kilometres)
1 CI/UPS CBD program	Extreme	44	Not applicable – mains prioritised for replacement	Not applicable – mains prioritised for replacement
2 CI/UPS trunk mains	Extreme	62		
3 CI/UPS higher risk areas	High	811	158	653
4 CI/UPS remaining	High			
5 HDPE 250 higher risk areas	High	286	20	266
6 HDPE 250 remaining	High			
7 HDPE 575 higher risk areas	High	1,416	248	1,168
8 HDPE 575 remaining	High			
Total Kilometres		**2,619**	**426**	**2,087**

Step 3 – Prioritise against delivery capability

Once the mains located in suburbs with a record of cracking have been identified, the next step is to prioritise these mains in line with our delivery capability. As shown in Table 1.4, there are 2,087 kilometres of mains located in suburbs with a history of cracking, which is greater than our delivery capability for the next AA period. The risk prioritisation model allows us to identify the mains, whether CI/UPS or HDPE that are located in suburbs where cracking occurred. These suburbs are then ranked, meaning we can work down the priority list until we reach a volume of mains that matches our delivery capability.

This model enables us to derive the kilometres of mains that fit into the 'higher risk area' category (Categories 3, 5 and 7) and can be replaced in the next AA period. The mains in suburbs with a history of cracking that cannot be replaced during the next AA period and the mains in suburbs without a history of cracking will be scheduled for replacement in future periods subject to ongoing review and the risk prioritisation model. Figure 1.6 illustrates the prioritisation process.

FIGURE 1.6: RISK PRIORITISATION PROCESS



1.3.4.6 AGN's Risk Prioritisation Model

AGN's risk prioritisation model adopts an approach to risk tolerance that is based on the principles used by the UK's HSE and regulator Ofgem. The HSE/Ofgem method identifies thresholds for the risk of fatality, which assists the Network operator to make a judgement call on whether the risk is tolerable or not. We have used the HSE's 'tolerability of risk' framework, to provide guidance on various asset class risks. In summary the framework identifies three 'risk regions':

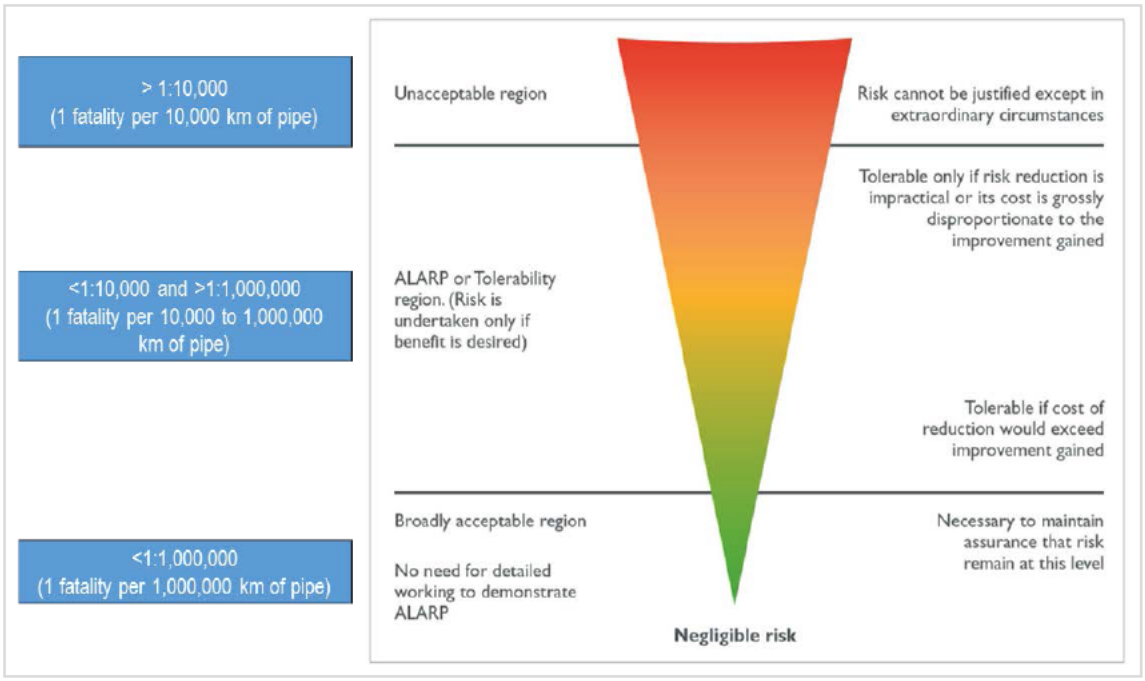
1. *Broadly Acceptable Region* – No immediate action is required to reduce risk. Monitoring is required to ensure risk remains at this level;

2. *Unacceptable Region* – Risk cannot be justified and should be eliminated as soon as possible; and

3. *ALARP Region* – Reduce risk to as low as reasonably practicable (ALARP); that is, where costs are not disproportionate to risk reduction.

Figure 1.7 illustrates the tolerability thresholds.

FIGURE 1.7: HSE/OFGEM TOLERABILITY OF RISK



As outlined earlier in this Attachment, it is recognised in the gas distribution industry that the most significant risk of an explosion is from mains that are susceptible to sudden fracture where large volumes of gas can be released and migrate to basements and underfloor locations. If an ignition source is present, the accumulated gas could cause a major explosion and, depending on occupancy at the time, may result in life threatening injuries and/or fatalities.

All gas network operators with gas main networks that are prone to failure have the challenge of determining how to prioritise mains replacement of 'at risk' mains" as part of wider risk management strategies. Many countries, including the UK, have developed risk prioritisation models which attempt to provide relative rankings for different mains assets through the derivation of modelled risk scores. Assets with the highest modelled risk represent priorities for replacement.

The output of HSE/Ofgem's mains risk prioritisation system (MRPS) is used as a tool to help inform the replacement strategy of the gas distribution networks. It enables the Network operators to make an economic assessment of whether to include all the at risk pipes in a single program, or to balance a top-down replacement of the riskiest mains with the costs involved. In addition, the MRPS can be used to compare the level of risk posed by the different pipe diameters and materials, and whether different geographic locations have an above average exposure to risk.[31]

[redacted]

[31] HSE 2011, *HSE/Ofgem: 10-year review of the Iron Mains Replacement Programme*, prepared by Cambridge Economic Policy Associates Ltd for the Health and Safety Executive and Office of Gas and Electricity Markets 2011, pg. 25. Provided as Attachment 8.17.

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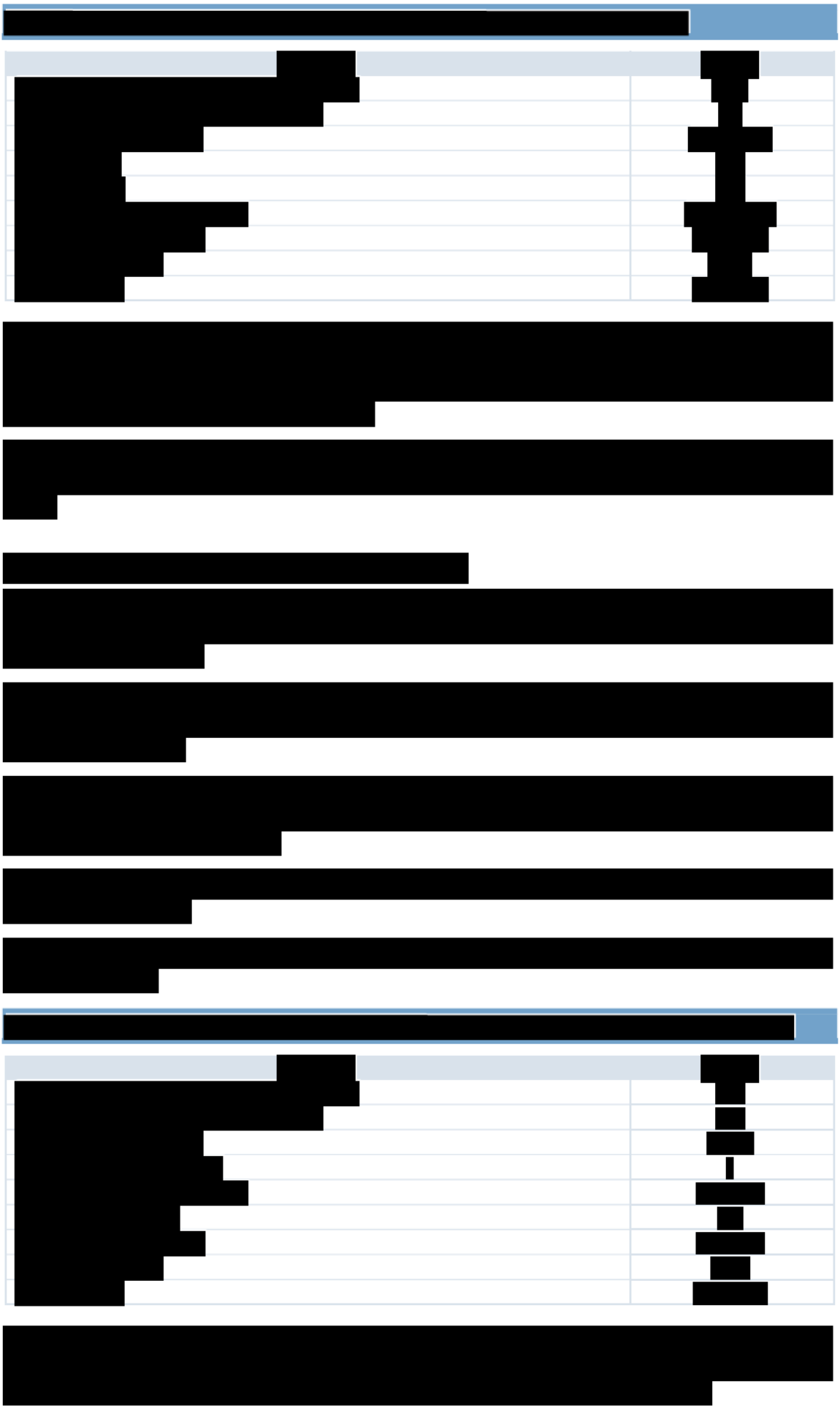
32 Note the mains prioritisation model uses 30 June 2015 inventory data, and does not consider the approximately 50 kilometres of HDPE mains expected to be replaced during 2015/16.



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1.3.4.7 Risk Prioritisation Results

Using the risk prioritisation model, AS/NZS 4645 risk assessment, and expert advice, we have identified that in addition to the 106 kilometres of 'Extreme' risk CDB and medium pressure trunk mains that will be replaced, the following 'High' risk mains should also be replaced during the next AA period:

- 393 kilometres of the 811 kilometres of CI/UPS mains located outside the CBD and trunk, with the balance to be replaced in future periods;
- 192 kilometres of the 286 kilometres of HDPE 250 mains, with the balance to be replaced in future periods; and
- 574 kilometres of the 1,416 kilometres of HDPE 575 mains, with the balance to be replaced in future periods.

Table 1.8 presents the results in more detail.

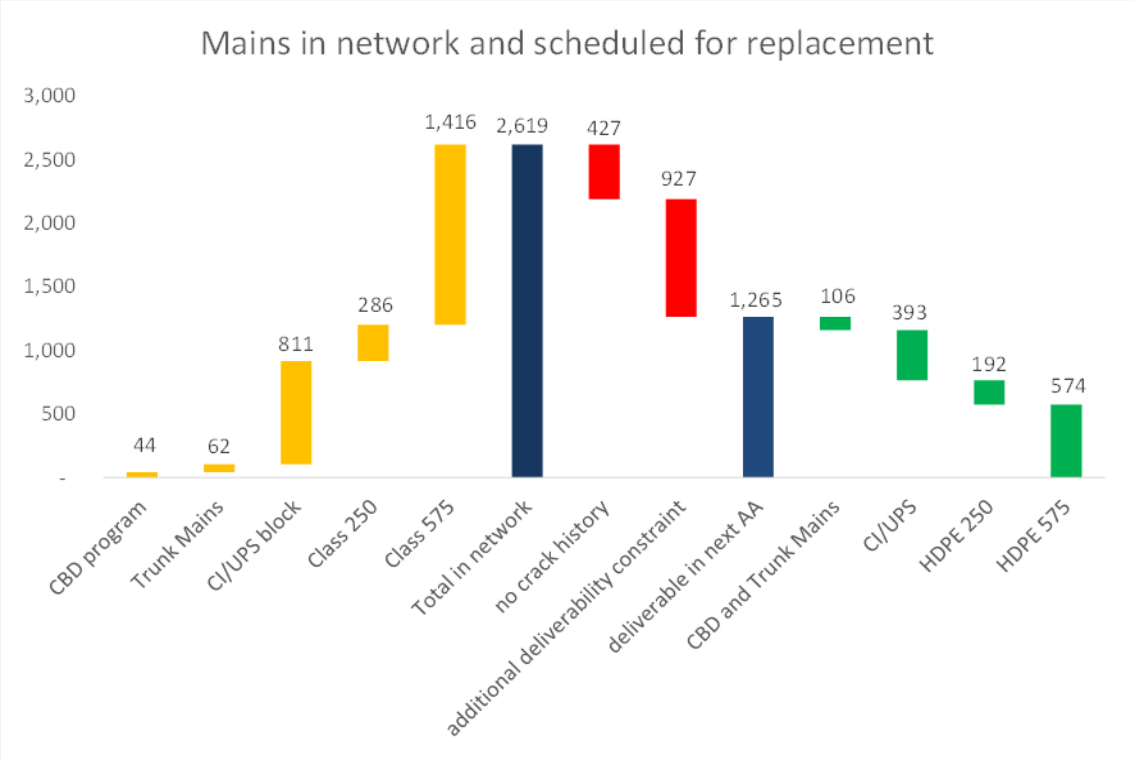
TABLE 1.8: OUTPUT OF MAINS PRIORITISATION MODEL – MAINS TO BE REPLACED IN THE NEXT AA PERIOD

	Program Category	Risk Rating	Kilometres in Network	Length in Suburbs with no Record of Crack History (km)[1]	Length in Suburbs with Record of Crack History (km)[2]	Delivery Capability During Next AA Period	Length to be Replaced during Next AA Period (km)[3]
1	CI/UPS CBD program	Extreme	44	Not applicable – mains prioritised for replacement due to Risk Rating and not part of the prioritisation model		1,265	106
2	CI/UPS trunk mains	Extreme	62				
3	CI/UPS higher risk areas	High	811	158	653		393
4	CI/UPS remaining	High					-
5	HDPE 250 higher risk areas	High	286	20	266		192
6	HDPE 250 remaining	High					-
7	HDPE 575 higher risk areas	High	1,416	248	1,168		574
8	HDPE 575 remaining	High					-
Total Kilometres			**2,619**	**426**	**2,087**	**1,265**	**1,265**

[1] Excluded from prioritisation model.
[2] Included in prioritisation model.
[3] Those kilometres with an "Extreme" risk rating and the output of the prioritisation model.

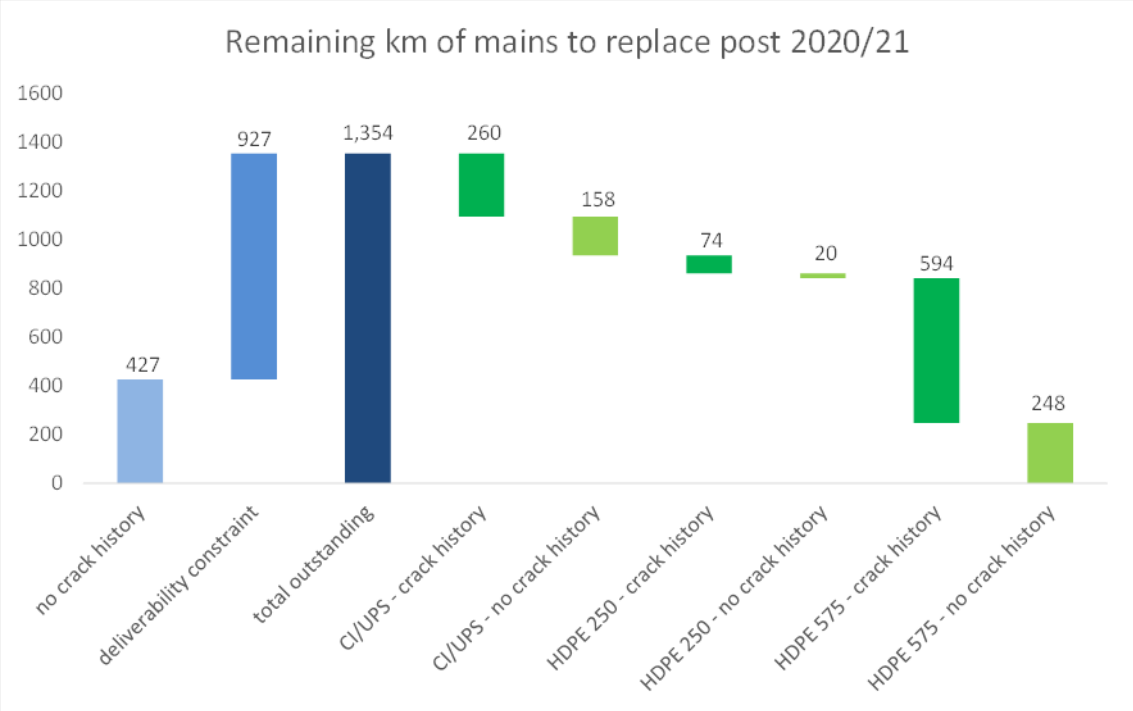
As previously discussed, the purpose of the risk prioritisation model is to help the business work out which of the 2,619 kilometres of at risk mains should be included in the 1,265 kilometres delivery capability over the next AA period, and which can be prudently deferred to subsequent years. Figure 1.10 shows the progression of how we calculated the efficient delivery volumes.

FIGURE 1.10: CALCULATION OF MAINS IN NETWORK AND DELIVERY VOUMES FOR THE NEXT AA PERIOD



The outstanding 1,354 kilometres of 'High' risk mains will be carefully monitored during the next AA period, with risk mitigation activities (such as reducing pressure) being a temporary solution until these mains can be replaced in subsequent years. The 1,354 kilometres of mains will also be subject to further analysis and prioritisation to ensure the highest risk mains are replaced first. This means mains in suburbs with a crack history are likely to be replaced earlier in the subsequent AA period than those with no crack history. Figure 1.11 presents the make-up of the mains that will need to be prioritised for future AA periods.

FIGURE 1.11: MAINS TO BE PRIOTISED AND REPLACED IN FUTURE AA PERIODS



We note that the risk prioritisation model relies on historical data and the results at any point in time may differ as new information is uploaded in to AGN's GIS and WMS. However, consistent with NGR 74, we consider the results from the current model have been arrived at on a reasonable basis and represent the best estimate possible in the circumstances.

We intend to monitor the data and re-visit the prioritisation on an ongoing basis to ensure any new information that may impact on the risk rating for a suburb can be considered. We recognise that at the end of the any regulatory AA period, AGN will need to justify to the AER that the expenditure planned for the subsequent regulatory AA period meets the requirement of the NGR.

1.3.5 Cost Impact Analysis

The AS/NZS 4645 risk assessment and AGN's risk prioritisation model provides a qualitative and quantitative assessment of the inherent risk in the Network.

AS 4645.1: 2008 states (at paragraph 2.3.4) that "*risk assessment of threats shall be undertaken in accordance with AS/NZS 4360*".

Under AS/NZS 4360 (which was superseded by AS/NZS ISO 31000: 2009 with effect from 6 November 2009) risk assessment involves both certain quantitative, and qualitative assessments.

The two standards (AS 4645.1: 2008 and AS/NZS ISO 31000: 2009) accordingly operate together in the following way in respect of gas distribution networks:

- certain quantitative assessments are prescribed in AS/NZS ISO 31000: 2009 itself;
- qualitative risk assessments for gas distribution networks are as prescribed by AS 4645.1: 2008 (per paragraph 2.3.4 of that Standard).

AS/NZS ISO 31000: 2009 requires a certain level of quantitative assessment but not a full cost benefit analysis. In particular, Section 5.5.2 states:

> "*Selecting the most appropriate risk treatment option involves balancing the costs and efforts of implementation against the benefits derived, with regard to legal, regulatory, and other requirements such as social responsibility and the protection of the environment. Decisions should also take into account risks which can warrant risk treatment that is not justifiable on economic grounds, eg severe (high negative consequence) but rare (low likelihood) risks.*"

Accordingly, the quantitative prescription itself involves certain elements of qualitative judgement (such as social responsibility such as for safety).

Overall, AS/NZS ISO 31000: 2009 does not require a cost benefit analysis per se of a particular risk and the risk treatment options. The Standard merely requires that certain costings and other assessments be made as part of assessing risk treatment options.

The qualitative risk assessment requirements are outlined in AS 4645.1: 2008 and have been dealt with in detail in this Attachment.

We have identified the amount of mains that need to be replaced (2,619 kilometres) and the volume we consider we can deliver during the next AA period (1,265 kilometres). The next challenge is to understand the cost associated with addressing the Network risk, price impact on customers, and the outcome under a range of delivery options.

To this end we have analysed the cost impact of several indicative delivery scenarios for addressing network risk. The analysis identifies the NPC to customers of each mains replacement scenario, as well as the average cost per customer per year compared to the AER's alternative proposal. The NPC over the economic life of the assets provides an indication of the impact on customers over the longer term, rather than just considering the impact in the current AA period when costs are deferred to future periods.

The purpose of the cost impact analysis is to help AGN assess whether the mains replacement program is proportionate to the level of risk involved, and to evaluate the potential impact of changes to the composition and rate of replacement.

A similar analysis was adopted by Ofgem in assessing the iron mains replacement program (IMRP) in the UK. Ofgem used the cost benefit analysis to:

> *"…determine that if duty holder (responsible for managing the risk) has achieved ALARP the potential impact of the risk and the costs involved in trying to mitigate the risks needs to be considered. Unless there is a gross disproportion between them the duty holder has to undertake the risk reduction measure. Thus, the process is not one of simply balancing the costs and benefits of measures but, rather, of adopting measures except where they are ruled out because they involve grossly disproportionate sacrifices."* [33]

AGN agrees with the above statement from Ofgem regarding the role cost analysis plays in mitigating risk. Specifically, that safety considerations are the primary driver and financial considerations are a secondary driver in developing a mains replacement program.

Given the risk assessment has identified a total of 2,619 kilometres of mains rated 'High' or 'Extreme' inherent risk (Categories 1 to 8 listed above), the cost impact analysis considers various options and timeframes for replacing these mains. Each scenario presents the cost of the program, the residual risk achieved at the conclusion of each AA period and the average cost to each customer. AGN has also incorporated a scenario representing the AER's draft decision. Specifically, the indicative scenarios considered are:

- Scenario A (AGN's proposal) – Replacing 1,265 kilometres of the highest risk mains during the next AA period and replacing the outstanding 'High' risk mains during the subsequent AA period. All 1,328 multi-user service inlets will also be replaced in the next AA period. This scenario limits the replacement of 'High' risk rated mains to AGN's delivery capability.

- Scenario B – Replacing all 2,619 kilometres of at risk mains during the next AA period (a five-year program). All 1,328 multi-user service inlets will also be replaced in the next AA period. This scenario replaces all 'High' risk mains over the next AA period and assumes no deliver constraints or premium unit rates associated with securing sufficient resources.

- Scenario C – Replacing all 2,619 kilometres of at risk mains during the next 20 years in a piecemeal fashion. This scenario incorporates a higher unit rate for replacement as a result of the less efficiently bundled replacement program.

- Scenario D (AER Aligned) – Replacing as many kilometres as possible within the expenditure provided for in the AER's Draft Decision. Given the adjustment to unit rates and matching the kilometres to the risk prioritisation model, this will allow 561 kilometres of the highest risk mains to be replaced during the next AA period, and replacing the balance (2,058 kilometres) over the following four AA periods. No multi-user service inlets will be replaced during the next AA period. This scenario assumes an annual rate of replacement of 'High' risk mains in every year, which is consistent with the cost (rather than kilometres) allowed for in the AER's Draft Decision for the next AA period. This will take longer than 20 years.

We have assessed the outcome of the cost impact analysis for each scenario over a 60-year period consistent with the economic life of mains. In all scenarios, AGN has adopted its revised unit rates and the underlying financial assumptions presented in Table 1.9.

[33] HSE 2011, "*HSE/Ofgem: 10 year* review *of the Iron Mains Replacement Programme*, prepared by Cambridge Economic Policy Associates Ltd for the Health and Safety Executive and Office of Gas and Electricity Markets 2011", pg.27.

TABLE 1.9: UNDERLYING ASSUMPTIONS FOR COST IMPACT ANALYSIS

Financial Assumptions	
Post Tax Real Return on Equity	4.68%
Debt	60%
Interest Rate	5.16%
Debt Repayment	60 years
Project Assessment Period	60 years

It should be noted that the assessment for the four scenarios has been done based on the AER's Draft Decision Post Tax Real Return on Equity and Interest Rate. These financial assumptions were adopted for illustrative purposes only. The outcome from the model in terms of ranking and risk profile do not change when modelled with alternative financial assumptions such as those embedded in AGN's Revised AA Proposal.

It should also be noted that while the assessment period being used for this analysis is 60 years, which reflects the useful economic life of the underlying asset, all scenarios will generate costs for the customer beyond past this 60-year period. These costs relate to the depreciation and return on Regulated Asset Base for assets with a useful life that has not been fully depreciated by the end of year 60 due to the timing of their construction. Scenario A generates costs of $51 million, Scenario B $22 million, Scenario C $208 million and Scenario D $143 million.

Table 1.10 presents the results of the cost impact analysis.

TABLE 1.10: COST IMPACT ANALYSIS OF MAINS REPLACEMENT SCENARIOS

Scenario	Parameter	At end of: Current AA Period (30 June 2016)	Next AA Period (30 June 2021)	Subse-quent AA Period (30 June 2026)	Future AA Period (30 June 2031)	Future AA Period (30 June 2036)	Net Present Cost per Customer per Year	Incre-mental Impact on Price
A	Capex ($ million)	326.0	273.3	-	-	-	$18.65	Base
	Km of pipe replaced	1,265	1,354	-	-	-		
	Services replaced (sites)	1,328	-	-	-	-		
	Opex ($ million)	11.4	2.4	-	-	-		
	Total cost ($ million)	**337.4**	**275.7**	**0**	**0**	**0**		
	Residual network risk	High	Low	Low	Low	Low		
B	Capex ($ million)	599.3	-	-	-	-	$20.36	$1.71 increase
	Km replaced	2,619	-	-	-	-		
	Services replaced (sites)	1,328	-	-	-	-		
	Opex ($ million)	6.6	-	-	-	-		
	Total cost ($ million)	**605.9**	**0**	**0**	**0**	**0**		
	Residual network risk	Low	Low	Low	Low	Low		
C	Capex ($ million)	243.2	243.2	243.2	243.2	-	$24.52	$5.86 increase
	Km replaced	655	655	655	655	-		
	Services replaced (sites)	332	332	332	332	-		
	Opex ($ million)	14.8	11.1	6.5	1.9	-		
	Total cost ($ million)	**258.0**	**254.3**	**249.7**	**245.1**	**0**		
	Residual network risk	High	High	High	Low	Low		
D	Capex ($ million)	168.1	120.2	120.2	119.7	71.0	$15.20	$3.45 decrease
	Km replaced	561	570	570	566	353		
	Services replaced (sites)	-	443	443	443	-		
	Opex ($ million)	14.2	10.9	7.1	3.3	0.4		
	Total cost ($ million)	**182.3**	**131.1**	**127.3**	**123.0**	**71.4**		
	Residual network risk	High	High	High	High	Low		

The cost impact analysis indicates that Scenario A, which is the delivery scenario proposed by AGN, would increase the net present cost per customer by $3.45 per year more than a mains replacement program consistent with the AER's Draft Decision. However, AGN's proposal would eliminate 48% of the 'Extreme'

and 'High' risk mains in the Network by the end of the next AA period, and the remaining 'High' risk mains within 10 years. This is consistent with a strategy to reduce the risk to 'Low', and if not, to ALARP.

While the AER's alternative proposal (Scenario D) would result in an additional $3.45 net present cost saving to each customer per year, more than 2,000 kilometres (around 78%) of the 'High' risk mains would remain in the Network at the end of the next AA period, as well as all 1,328 multi-user inlet services, which are also rated as 'High' risk. The residual network risk would not be reduced to 'Low' until the end of 2040/41. To this extent, Scenario D would not be consistent with AGN's obligation under AS/NZS 4645 (given statutory force by the *Gas Act 1997*) to reduce network risk to 'Low' and if not, to ALARP, nor its equivalent obligation to reduce risk to ALARP under the *Work, Health and Safety Act 2012*.

Though Scenario B (a five-year replacement program) reduces the inherent network risk more quickly than AGN's proposal, we consider that this scenario would not be achievable. Although the net present cost per customer is identified to be $1.71 per year, this cost assumes that there is no delivery constraint and that additional resources will be available at the same unit rates. Securing sufficient resources to achieve this delivery capability, if possible, would be at significantly higher unit rates. In addition, this scenario would result in considerably more disruption to supply.

Scenario C is a piecemeal replacement option, and does not reduce the risk to 'Low' until the 2031 AA period.

Table 1.11 presents the total expenditure for each scenario.

TABLE 1.11: TOTAL EXPENDITURE FORECASTS – MAINS REPLACEMENT SCENARIOS ($ REAL MILLIONS)

	Scenario	Opex	Capex	Total Expenditure
A	AGN Revised AA Proposal	13.9	599.3	613.2
B	Full Replacement	6.6	599.3	605.9
C	Piecemeal	34.2	972.7	1,007
D	AER Aligned	35.9	599.3	635.2

The variation in opex reflects the variation in UAFG over time as mains are replaced. The longer it takes to replace CI and UPS, the greater the UAFG costs. The higher capex for the Piecemeal replacement option (Option C) reflect the higher unit rate for replacement as a result of lost efficiencies associated with not undertaking managed block replacement.

AGN's revised mains replacement proposal has the lowest total expenditure[34] given an efficient and realistic delivery capability and delivers a better risk reduction outcome than Option C (Piecemeal) or Option D (AER aligned).

1.3.6 Revised Mains Replacement Proposal

Based on the risk assessment, results of the risk prioritisation model and cost impact analysis, AGN submits a revised proposal that plans to replace 1,265 kilometres of the highest risk mains with new PE over the next AA period.

As shown in Table 1.12, AGN's proposal will replace all 'Extreme' risk assets within the next AA period, along with around 1,159 kilometres of 'High' risk mains. The risk associated with all 1,382 kilometres of CI/UPS multi-user inlet services will also be eliminated during the next AA period.

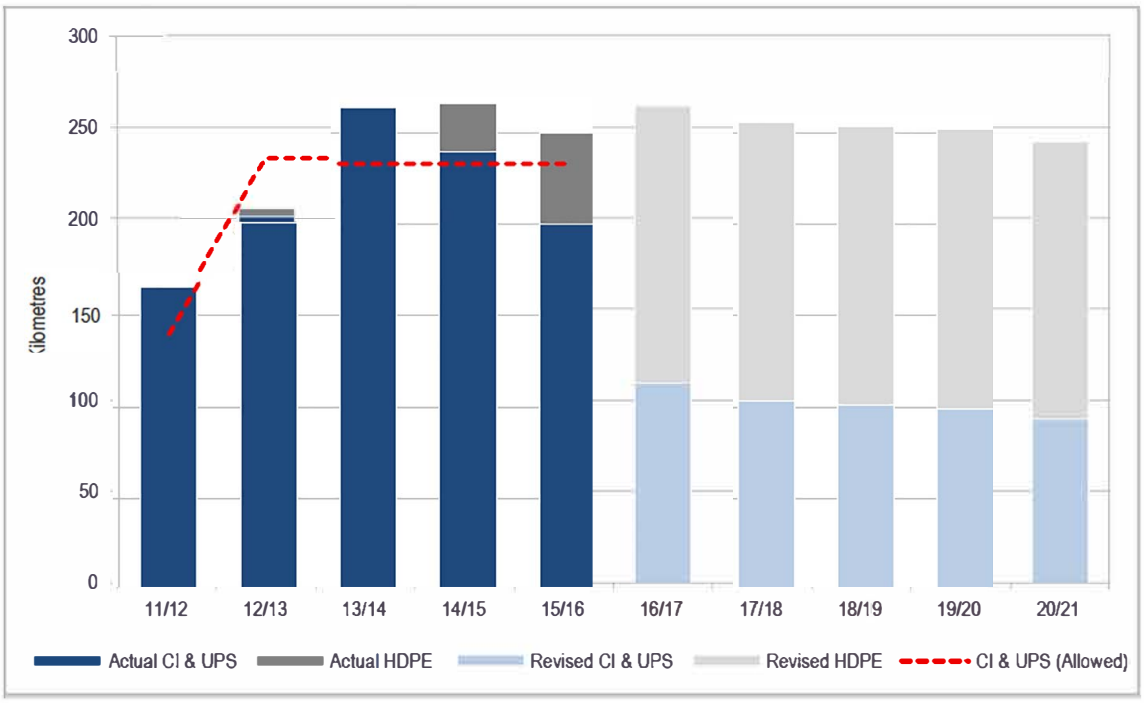
[34] The higher NPC for AGN's proposal (Option A) despite a lower total expenditure when compared to the AER's DD (Option D) is because the assets are replaced sooner in the 60-year period resulting in higher capital costs (depreciation and return) recovered in that period. For the capital costs to be the same, the assessment would have to be extended to cover the economic life of the last main replaced under the program.

TABLE 1.12: COMPOSITION OF PROPOSED MAINS REPLACEMENT 2016/17 TO 2021/22

	Program Category	Risk Rating	Length in Network (km)	Length Replaced in Next AA Period (km)	Residual Risk (2021)	Length Replaced in Subsequent AA Periods (km)	Residual Risk (2026)
1	CI/UPS CBD program	Extreme	44	44	Low	-	Low
2	CI/UPS trunk mains		62	62		-	
3	CI/UPS higher risk areas	High	811	393	High	260	Low
4	CI/UPS remaining	High		-	High	158	
5	HDPE 250 higher risk area	High	286	192	High	74	Low
	HDPE 250 remaining	High			High	20	Low
6	HDPE 575 higher risk areas	High	1,416	574	High	594	Low
7	HDPE 575 remaining	High		-	High	248	Low
Total Kilometres			**2,619**	**1,265**		**1,354**	
8	Multi-user inlet services (CI/UPS)	High	1,328 sites	1,328	Low	-	Low

Figure 1.12 illustrates our revised mains replacement program for the next AA period, compared with the replacement rates over the current AA period.

FIGURE 1.12: HISTORICAL AND FORECAST MAINS REPLACMENT, 2011/12 TO 2020/21



AGN's revised proposal puts greater focus on replacing the HDPE 250 and 575 mains, which are an emerging and higher network risk. We remain of the view that removing all the CI/UPS mains from the Network is necessary to mitigate against serious incidents. However, the gas incidents that occurred in the Adelaide metropolitan gas network in 2007, 2011 and 2014 were all the result of HDPE failure. Further

analysis of the risk associated with the HDPE mains' propensity for cracking and sudden failure has led us to modify the composition of the mains to be replaced.

The risk prioritisation model allows us to better prioritise replacement according to asset risk regardless of the material type, with mains located in suburbs with a history of cracking scheduled for replacement before those mains deemed to carry a slightly lower likelihood of failure. The results are that a greater volume of HDPE mains will be replaced during the next AA period than initially proposed. We consider this change in composition is a prudent update to our mains replacement program and will better enable AGN to reduce the inherent network risk to ALARP.

We also consider that although the composition of mains has changed, because the volumes remain consistent with those in our approved Mains Replacement Plan (MRP), and the level of risk being addressed is the same (if not greater), the revised program will satisfy our obligation to replace the mains in line with the approved MRP. We will discuss the revised program with the ESCOCA and South Australian Office of the Technical Regulator (OTR) as soon as is practicable and submit a modified MRP to them for approval following the conclusion of this AA review process.

1.3.6.1 Risk Mitigation and ALARP

When delivered in full, the mains replacement program will reduce the risk rating for nearly half of the 'at risk' gas mains in the Network from 'Extreme/High' to 'Low' by the end of the next AA period. Replacing 1,265 kilometres of mains represents the highest replacement rate AGN can sustain during the period without increasing potential workforce safety issues and without incurring costs disproportionate to the risk being addressed. Therefore, AGN considers its proposed mains replacement program is reducing the Network risk as quickly as possible to 'Low' and/or is demonstrating ALARP, consistent with its obligation under AS/NZS 4645.

As it is not practicable to replace all 2,619 kilometres of at risk mains during the next AA period, AGN proposes a number of risk mitigation activities, in addition to those already in place, that will complement mains replacement and monitor the residual risk in the Network. Mitigation activities will facilitate improved monitoring of the mains to ensure any changes that might affect the prioritisation of the mains are identified, and where necessary are incorporated in to the risk prioritisation model.

However, it is important to note that risk mitigation activities are a second-best solution to mains replacement. While the 'at risk' assets remain in the Network, the risk of mains failure causing fatality or serious injury remains high. Mitigation activities such as pressure reduction, venting and inline mains inspection complement mains replacement and only offer a temporary solution until the risky mains can be removed from the Network entirely.

These mitigation activities proposed for the next AA period are summarised in the following sections.

In-line HDPE Camera Inspection and Repair of High Risk Sites (Business Case SA52)

This project provides for the continuing use of a camera to be inserted into HDPE mains to mitigate risk on the HDPE 575 that has not currently been identified for replacement during the next AA period. The camera increases the effectiveness of monitoring as it provides visual information on the interior of the pipe, which cannot be achieved by leak surveys alone. It allows squeeze-off points to be identified and where required temporary repair, or, piecemeal (reactive) replacement if a site is identified as a significant risk. However, this is an innovation-stage technology with the reliability of results and the scalability of the method still to be proven.

The continuation of the inline camera project is an important accompaniment to the mains replacement program, as it will help AGN effectively address risk where replacement is not being considered in the short term. The inline camera inspections are a key component of managing the risk so that it is ALARP, consistent with AGN's obligations for those mains that will not be replaced during the next AA period.

In its Draft Decision, the AER did not approve this project so AGN has reproposed the initiative in its Revised AA Proposal (see Attachment 8.9), updated to reflect the amended mains replacement program. As a result,

the costs associated with this project have been reduced from $12 million to $10 million over the next AA period.

Installation of Ground Vents (Business Case SA56)

This opex project provides for installation of vents on HDPE 575 mains where ground conditions could prevent escaped gas from dissipating into the atmosphere. Gas that collects underground poses a safety risk to the public, while also making leak detection difficult. The vents improve the probability that escaped gas will dissipate rather than travelling in to buildings and improves the effectiveness of leak surveys by making detection easier.

Like the inline camera project, this project is a risk mitigation activity targeting those HDPE mains that are not scheduled for replacement during the next AA period. While not a substitute for replacement, installing gas vents is a prudent and efficient method of mitigating the risk associated with these assets in the short term until such time that the at risk pipes can be removed from the Network completely.

AGN notes that the AER did not approve an opex step change in its Draft Decision for this initiative. Although AGN has withdrawn its proposal for additional expenditure for this project, AGN considers it is a prudent and efficient approach to manage the risk. AGN expects to have to absorb the costs of continuing this project over the next AA period which will be minimised as a result of pursuing other capex initiatives (such as SA60 Business Intelligence).

HDPE Integrity Management Program (Business Case SA54)

This opex project provides for employment of three additional resources to develop a reliability forecast model (integrating pipe age, repair data, material analysis and applying statistical modelling) to produce expected failure rates of HDPE. This work will help determine the useful life of the HDPE mains that are not scheduled for replacement until after the next AA period. It will also improve the effectiveness of the longer term management of HDPE through optimised maintenance and replacement strategies that take into account expected failure rates.

Consistent with SA56, Although AGN has withdrawn its proposal for additional expenditure for this project, AGN considers it is a prudent and efficient approach to manage the risk. AGN expects to have to absorb the costs of this program over the next AA period which will be minimised as a result of pursuing other capex initiatives (such as SA60 Business Intelligence).

1.3.7 Conclusion

AGN submits that its mains replacement proposal is prudent, efficient and satisfies its obligations to reduce the inherent network risk to 'Low' or to ALARP if a 'Low' rating is not achievable, during the next AA period. The program is based on a rigorous risk assessment founded on an industry-specific Australian Standard and a reasonable application of a proven risk assessment framework.

In its report on the mains replacement program, engineering experts Jacobs states:

> *"It is our opinion that AGN's recognition of the need for the MRP and its proposed timing is consistent with a prudent service provider acting "in accordance with accepted good industry practice" based on our direct experience with similar overseas programs (UK and US) for accelerated main replacement for Cast Iron, UPS and vintage plastic."* [35]

And:

> *"Even though the required action in the extreme class is stated to be immediate reduction in risk, we believe that a planned removal program within the shortest feasible time is entirely*

[35] Jacobs 2016, "*Mains Replacement Program Review*", January 2016, pg. 3. Provided as Attachment 8.11 to this Revised AA Proposal.

> *consistent with the requirement. Again, with reservations around some of the pipe within the "CI &UPS higher risk" family, we believe the Risk Treatment Actions as allocated are entirely appropriate."*[36]

With regard to AGN's approach of developing a mains replacement program based on a reasonable and sustainable rate of replacement designed to achieve low risk or alternatively risk which is ALARP, the Jacob's report draws parallels between AGN's proposal and experience in the UK.

> *"In the UK the low pressure small diameter mains (less than 12 inches) accounted for 77% of the 'at risk' mains population in 2003, and this category was targeted specifically for replacement. Prior to 2002 the historic (1977 to 2002) rate of replacement of the iron mains averaged around 2,650km per annum, at which rate the remaining 'at risk' mains would have been removed in 35 years.*
>
> *It was determined that the 35 year option was the minimum rate of replacement that would enable Transco (now National Grid) to comply with its legal requirements, however it was not the fastest rate practicable. The 25-year option was discounted on the grounds that a replacement rate of 4,300km per annum had never been achieved, and had the potential to lead to a level of disruption too high for the public to tolerate. The 30 year option would require a maximum replacement rate of 3,580km per annum; this was judged to represent an achievable level of replacement that would not cause excessive disruption for the public. The 30-year replacement option was determined to be consistent with As Low as Reasonably Practicable (ALARP) principles. Thus, the objective of the IMRP in 2002 was for the GDNs to increase the rate of replacement to be in a position to replace the 'at risk' pipes within a total of 30 years. The number of years to remove was a direct function of the miles of main in the system and an achievable rate of acceleration. The intention was to remove at risk pipe as soon as reasonably practicable (ALARP), with acceleration as the driver.*
>
> *The principle used to determine this schedule is the same as proposed by AGN. That is, AGN has determined the most prudent and efficient rate of replacement, given its resources and the cost of achieving a reduction in risk, in accordance with relevant standard to which it is subject (AS4645)."* [37]

The mains replacement program proposed for the next AA period is also consistent with AGN's Safety, Reliability, Maintenance and Technical Plan (Safety Plan). As discussed in Section 1.3.1.3 under Clause 8 of its Gas Distribution Licence, it is a regulatory obligation/requirement on AGN to produce a Safety Plan for annual approval by the ESCOSA and the OTR.

Clause 8 reflects Section 26(1)(b) of the *Gas Act 1997* which requires a gas distribution licence to include a condition requiring the holder to prepare a safety, reliability, maintenance and technical management plan dealing with matters prescribed by regulation. The plan must be submitted to the ESCOSA for approval, who may only give approval on the recommendation of the Technical Regulator (Section 26(1)(c)). Under Clause 8(c) of its gas distribution licence AGN must comply with the approved plan.

The current Safety Plan (comprising the Mains Replacement Plan, Asset Management Plan and Leakage Management Plan) was submitted to the OTR in August 2015, and subsequently approved in November 2015. ESCOSA's approval notice states:

> *"…AGN, under the current distribution licence, must at least once in a 12-month period, review its SRMTMP, including UAFG Plan (comprising the Mains Replacement Plan, Asset Management Plan and Leakage Management Plan), and GMMP [Gas Measurement Management Plan], and provide the Commission and the OTR with a copy of that review by*

[36] bid, pg. 28.

[37] bid, pg. 20.

31 August 2016. AGN must not amend the Plan without the Commission's approval, which is granted on the recommendation of the OTR."

AGN therefore has a regulatory obligation/requirement (by virtue of its licence) to comply with the plan. This obligation is a pipeline safety duty under the NGL. This obligation is a pipeline safety duty under the NGL and therefore falls within Sub-rule 79(2)(c)(iii). (The mains replacement plan also falls within Sub-rule 79(2)(c)(i) (being expenditure necessary to maintain and improved the safety of services) and Sub-rule 79(2)(c)(ii) (being expenditure necessary to maintain the integrity of services).

AGN's revised mains replacement program proposes replacement volumes and risk mitigation that is consistent with the plan endorsed by the OTR on 9 November 2015 and therefore represents a prudent course of action that AGN is obligated to deliver.

Though we are currently obligated to deliver the mains replacement program approved by the ESCOSA, we will present the revised plan to the OTR and the ESCOSA at the earliest opportunity following the provision of this Revised AA Proposal.

We expect the OTR to endorse the revised proposal as it currently stands, as it addresses the same key concerns as the currently approved plan, and provides for mains replacement to occur at a rate that is high enough to be commensurate with the resources available to AGN and in line with the current approved plan.

We do not, however, expect the OTR to endorse changes that materially decrease the mains volumes from those currently approved in the Safety Plan.

1.4 Forecast Mains Replacement Capital Expenditure

The forecast expenditure and the cost impact analysis is underpinned by the forecast unit rates. We have reviewed the unit rates in our Initial AA Proposal, and updated them to reflect the latest information. We have also considered the issues raised by AER in its Draft Decision, and responded accordingly.

The proposed mains replacement program will cost $326 million of capex during the next AA period. Table 1.13 shows the replacement program and associated capex by year during the next AA period.

TABLE 1.13: MAINS REPLACEMENT DURING THE NEXT AA PERIOD

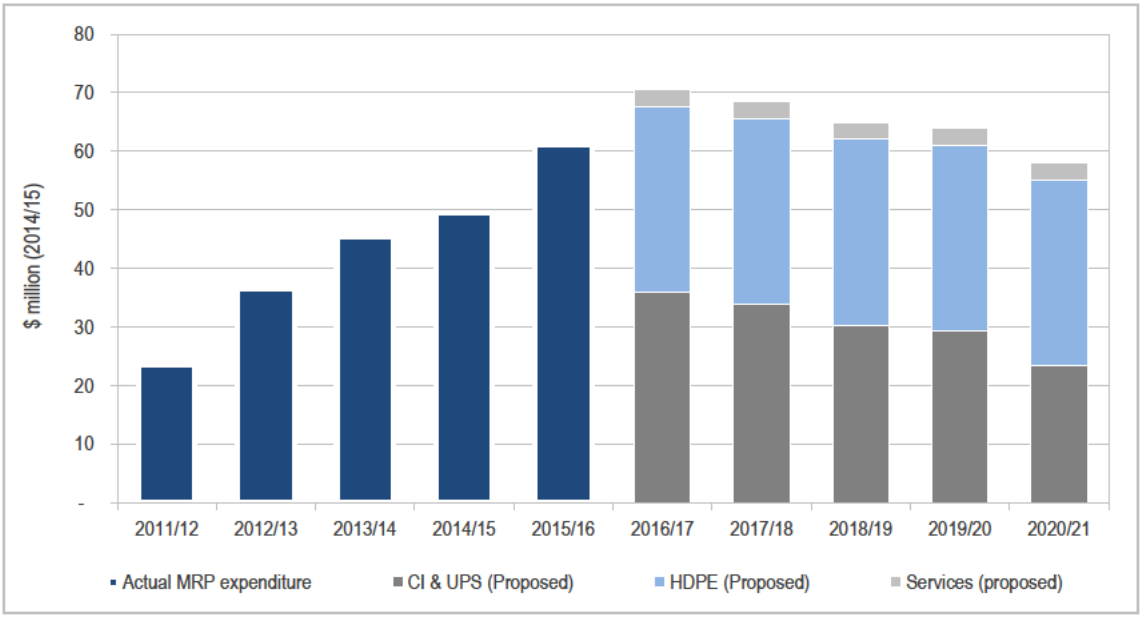
	2016/17	2017/18	2018/19	2019/20	2020/21	Total
Mains						
Replacement Profile (km)						
CI/UPS CBD	14	11	10	9	0	**44**
CI/UPS trunk mains	14	12	12	12	12	**62**
CI/UPS higher risk areas	81	80	79	78	77	**393**
HDPE 250 higher risk areas	38	38	38	38	38	**192**
HDPE 575 higher risk areas	115	115	115	115	115	**574**
Total Replaced (km)	**262**	**256**	**254**	**251**	**242**	**1,265**
Remaining to be Replaced (km)	**2,357**	**2,101**	**1,848**	**1,596**	**1,354**	**-**
Total Expenditure ($m)	**67.6**	**65.5**	**62**	**61**	**55.1**	**311.2**
CI/UPS Multi-User Inlet Services						
Replacement Profile (sites)	**266**	**226**	**226**	**226**	**266**	**1,328**
Total Expenditure ($m)	**2.9**	**2.9**	**2.9**	**2.9**	**2.9**	**14.7**
Total Mains Replacement Expenditure (Mains and Services) ($m)	**70.6**	**68.4**	**65.0**	**63.9**	**58.1**	**326.0**

Forecast mains replacement capex is circa $110 million (51%) higher than the current AA period ($326 million compared to $216 million). However, the kilometres to be replaced in each year during the next AA period are similar to the kilometres approved by the AER for the later years of the current AA period.

The $326 million capex program for the next AA period is a $44 million decrease compared to AGN's Initial AA Proposal. This lower capex amount is the result of materially lower unit rates, particularly for HDPE mains, and a revised mix of materials being replaced during the period.

Figure 1.13 illustrates the actual and forecast mains replacement capex over the current and next AA period

FIGURE 1.13: HISTORICAL AND FORECAST MAINS REPLACMENT CAPITAL EXPENDITURE, 20011/12 TO 2020/21



We consider the capex profile represents a prudent and efficient program that will enable AGN to continue to meet its safety obligations during the next AA period. More importantly, it provides the platform for eliminating the risk associated with all the old and poor condition mains assets in the Network and concluding this essential mains replacement as quickly as possible.

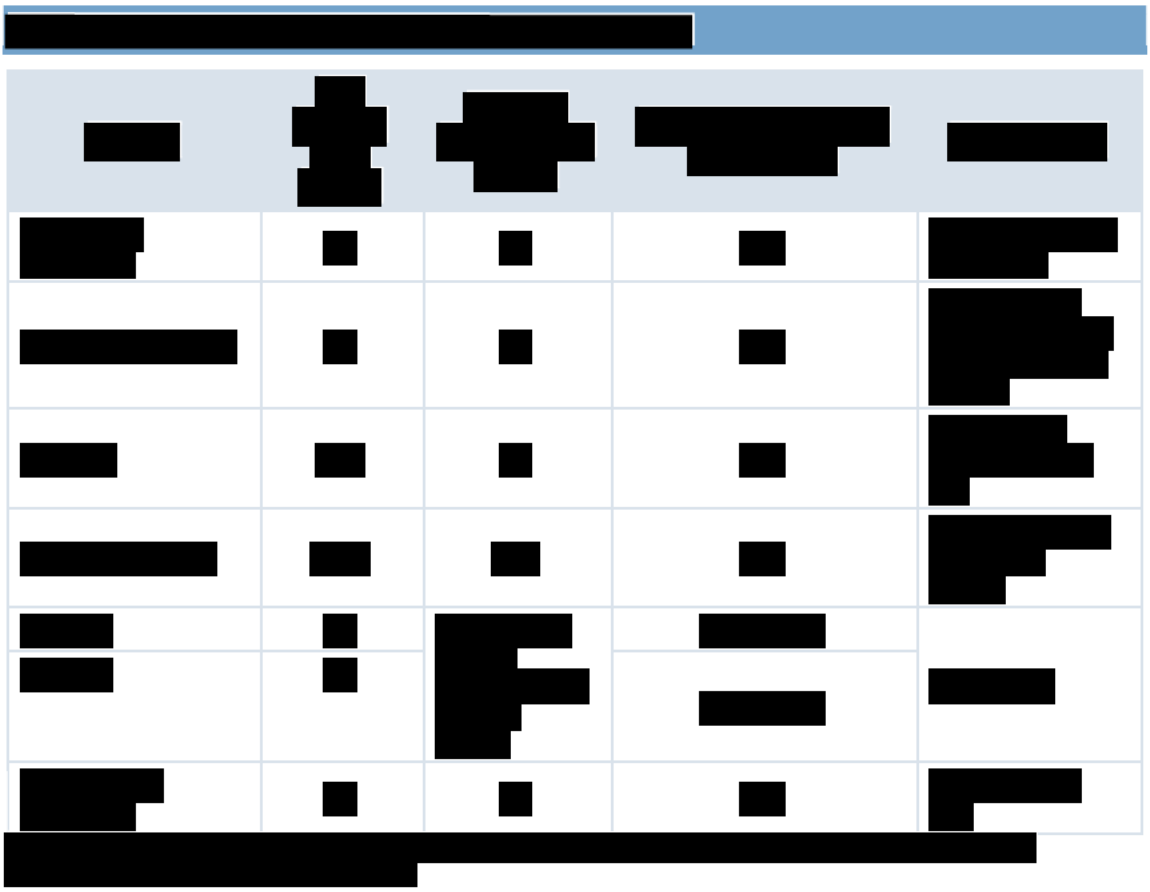
The changes in unit rates are discussed in the following section.

1.4.1 Unit Rates

In its Draft Decision, the AER identified concerns relating to the unit rates used in AGN's proposed mains replacement program. Primary concerns (identified in Confidential Appendix A) are that some unit rates:

- were based on tender submissions rather than awarded contracts;
- included a premium for night time work and other costs associated with work to be carried out in higher congestion zones, that were not adequately supported; and
- appeared inconsistent with historical rates experienced, so a revealed historical unit rate was a better estimate.

Table 1.14 summarises the AER's alternative calculation of unit rates.



The AER did not directly use these unit rates to develop its alternative forecast for the mains replacement program, instead calculating a capex reduction proportionate to its recommend reduction in mains replacement volumes. However, the AER did invite AGN to provide further information to support the unit rates in its Revised AA Proposal.

We have reviewed the rates for all historical, current and potential operational delivery options. There are several drivers for the forecast unit rates for the mains replacement program. These are:

- historical expenditure;
- awarded contracted rates;
- variations to awarded rates due to scope changes (which reflect the actual unit rates);
- forecast variations to awarded rates due to contract expiry in the next AA period;
- variations to awarded rates due to external factors, i.e. night time work requirements to minimise disruption; and
- tendered contracted rates not yet awarded.

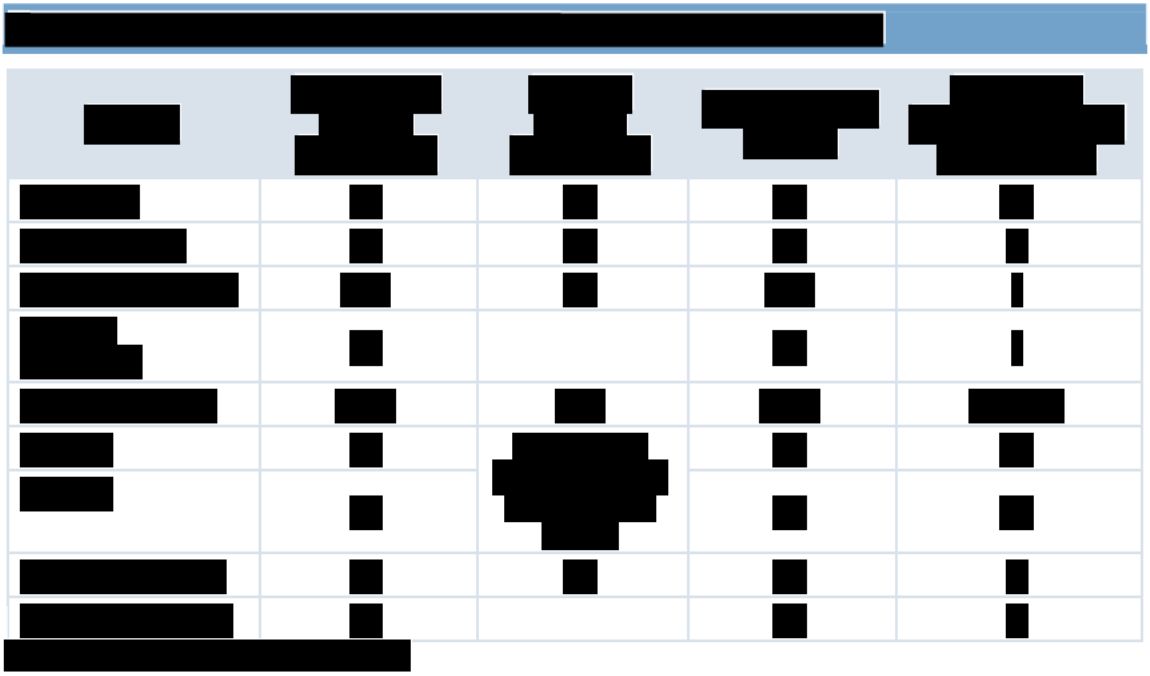
We have selected the most appropriate rate by considering scope, location and volume of work. Where work in future AA periods is of similar scope, location or volume to work undertaken in the current period, we base the unit rate on a weighted average of historical actuals. If the scope, location or volume varies substantially (for example work in the 7kpa area of the CBD is materially different to elsewhere), a specific unit rate is applied.

Since our Initial AA Proposal, new information is available on unit rates for the mains replacement program. Panel contractors have recently submitted tenders for both HDPE and multi service sites, therefore the unit rates provided in this response to the Draft Decision reflect the most up-to-date information.

We have completed further analysis of the CBD program of work (CI/UPS and trunk mains replacement), particularly for the area of the CBD that operates at 7kpa, and have refined our forecasts accordingly. We have also provided further evidence to support our forecast unit rates for general CI/UPS block replacement.

Based on the updated analysis, AGN submits the revised unit rates presented below represent the efficient cost of delivering the mains replacement program during the next AA period. As required by NGR 74, these forecast unit rates have been *arrived at on a reasonable basis* and *represent the best estimate possible in the circumstances*.

Table 1.15 shows the unit rates adopted in AGN's Initial AA proposal, the AER's Draft Decision, and the revised unit rates adopted in this Revised AA Proposal.



AGN's revised unit rates are based on its proposed volume of activity across the AA period. Any material shift in volumes may impact unit rates. For example, a reduction in volume could result in an increase in the unit rates if a lower number of contractors remain in Adelaide. Given the uncertainty regarding volume changes and the subsequent need for contractors to re-tender, AGN has not factored this impact in the expenditure forecast or cost impact analysis.

The following sections explain why the revised unit rates are the best estimate possible in the circumstances (NGR 74) and why they are efficient (NGR 79).

[38] AER 2015, "*Confidential Appendix A – Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6A-20.

39 AER 2015, "*Confidential Appendix A – Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6A-20.

40 At the time of this submission, AGN was seeking clarification from the AER as to the derivation of their unit rate.

41 AER 2015, "*Confidential Appendix A – Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6A-20.

42 We excluded the rates from the fourth contractor because the price was more than 20% higher than that tendered by the other three contractors, and the fifth contractor's rates were not available as it had only recently been added to the panel.

43 AGN 2015, "*Attachment 8.6 Unit Rates*", July 2015, pg. 28.

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[44] AGN 2015, "*Attachment 8.5 Network Materials & Services Contracting Regime*", July 2015, pg. 10.

[redacted]

[45] AER 2015, *"Confidential Appendix A – Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21"*, November 2015, pg. 6A-22.

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The work awarded in Rosewater, Beaumont and Woodville was not trunk mains replacement, rather the installation of new trunk mains. They were augmentation projects associated with the mains replacement program. This difference in scope of work results in a materially different unit rate.

An existing trunk main that is part of the existing network is replaced either by insertion or open cut method or a combination of both. The method selected is dependent on gas flows and pressures that are needed to maintain gas supply to the Network. The trunk mains replacement included in the forecast for the next AA period relates to removing existing mains and replacing them with new material, and not simply installing new pipes as was the case for Rosewater, Beaumont and Woodville.

Unlike laying a new trunk main, replacement of an existing trunk main includes:

- replacement of all services connected to the existing trunk main;
- replacement of any number of interconnections to the smaller local supply mains;
- multiple pressure controls and/or construction of temporary or permanent regulator sets; and
- operational planning of works to maintain adequate flows and pressures.

Existing trunk mains are also frequently located in major trunk arterial roads, which further adds to the complexity (and associated cost) of the work. Work duration is often restricted or requires night works. Safety measures for traffic and pedestrians are significant. Reinstatement costs are often increased due to the requirement to re-sheet traffic-lane widths.

Table 1.19 shows how AGN's revised unit rate is calculated.

[redacted]

1.4.1.4 Services Replacement

[redacted]

The services replacement capex forecast represents the standalone multi-user service replacements required in the period, which are not part of the broader block program of work. These standalone

[46] AER 2015, "*Confidential Appendix A – Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6A-24.

[47] At the time of this submission, AGN was seeking clarification from the AER as to the derivation of this rate.

replacements are for areas where the mains have already been replaced, but the work was done at a time (pre-2012) when the service replacement did not fall within the scope of work for the contractors delivering the mains replacement program.

In our Initial AA Proposal, the unit rate for services replacement was based on the rates provided for services replacement in previous block replacement tenders. Replacing multi-user inlet services together with pipe mains achieves some savings as a result of lower crew mobilisation costs. As such, savings are not available when services replacement is delivered outside of block replacement work, and the cost of stand-alone multi-user services replacements is higher than previously envisaged.

Since our Initial AA Proposal, we have received tenders from two contractors for replacement of multi-user inlet services. These tenders identify individual rates depending on the location of the work, and the number of units per development. We believe that using these rates is the best estimate of expenditure in the circumstances. A weighted average of the lowest unit rates received for the services replacement has been used in the calculation. This is shown in Table 1.20.

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1.4.1.5 HDPE Replacement

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1.4.1.6 Medium Pressure Trunk Mains Replacement

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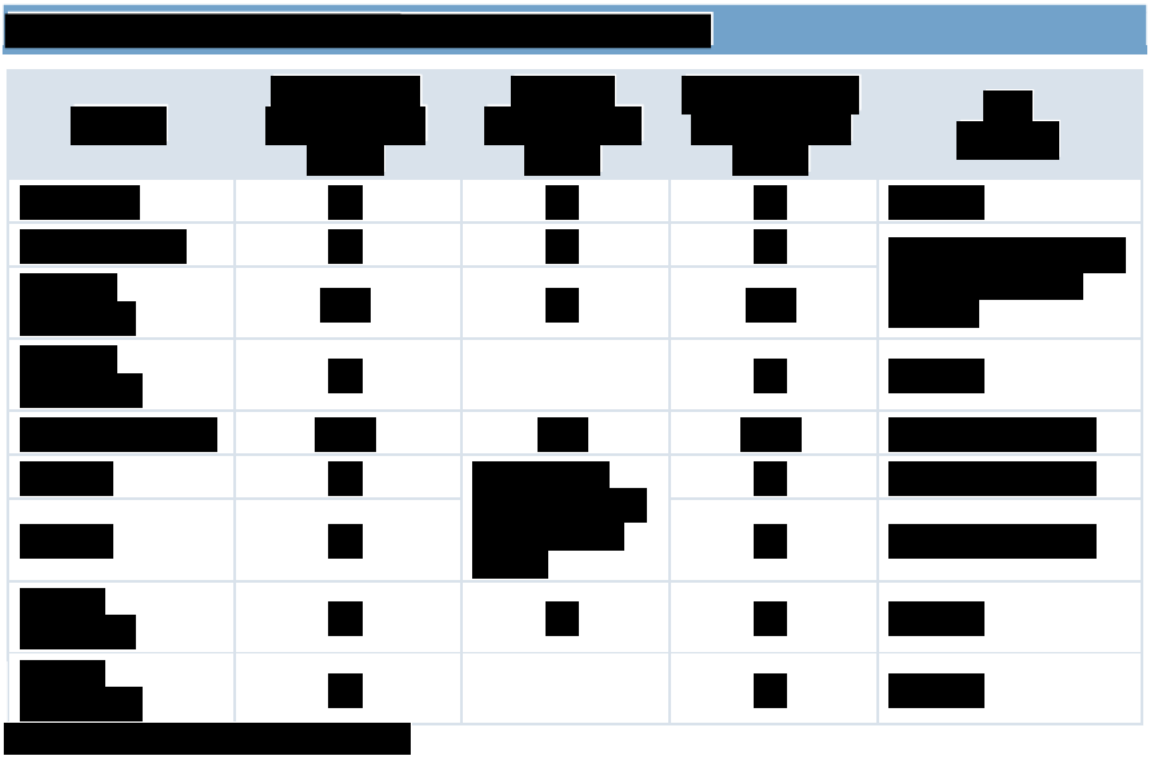
1.4.1.7 Conclusion

AGN proposes unit rates which reflect either historical actuals experienced, historical actuals experienced adjusted for new location specific premiums or market tested tendered rates that are in the process of being awarded. As required by NGR 74, these forecast unit rates have been *arrived at on a reasonable basis* and *represent the best estimate possible in the circumstances.*

48 AER 2015, "*Confidential Appendix A – Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6A-25.

AGN submits the revised unit rates in Table 1.22 represent the efficient cost of delivering the mains replacement program during the next AA period.



1.5 Assessment of the AER's Alternative Mains Replacement Program

The AER Draft Decision provides for replacement of 577 kilometres of mains over the next AA period, at a cost of $168 million. This decision allows for replacement of less than half of the 1,265 kilometres of the 'Extreme' and 'High' risk mains AGN has the capability to replace during the next AA period. It also represents a 50% reduction compared to volumes replaced during the current AA period.

While we understand the AER's ability to develop an alternative replacement program was limited by the data available to it, we consider the AER has misinterpreted that data and its alternative proposal therefore does not satisfy the requirement of NGR 74(2), in that:

> *"2) A forecast or estimate:*
>
> *(a) must be arrived at on a reasonable basis; and*
>
> *(b) must represent the best forecast or estimate possible in the circumstances."*

Further, we submit that the amount of mains replacement capital expenditure provided for in the AER Draft Decision is not consistent with the requirements of NGR 79 (a) that:

> *"(a) the capital expenditure must be such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted industry good practice, to achieve the lowest sustainable cost of providing services."*

We consider a program that only provides for replacement of 577 kilometres of the 1,265 kilometres of 'Extreme' and 'High' risk mains capable of being replaced in the next AA period would not reduce the risk in the Network to 'Low' and, if not, ALARP, as is required under AS/NZS 4645.

We believe a mains replacement program that only provides for replacing 577 kilometres of 'Extreme' and 'High' risk mains when the Network operator has developed the resources to replace more than 1,200 kilometres at an efficient cost is not consistent with good gas industry practice. Nor would it result in

risk from the operation of the Network being reduced to a level which is 'Low' and, if not, ALARP as is required by the pipeline safety duties binding upon AGN.

AGN has the capability to replace all mains and services rated as 'Extreme' or 'High' risk of causing death or serious injury within 10 years, eliminating all 'Extreme' risk assets within five years. We consider a mains replacement program that delivers a lesser outcome does not reflect the requirements of pipeline safety duties, does not enable AGN to recover its efficient costs as required by Section 24(2) of the NGL, is not consistent with the NGO because it does not give sufficient weight to consumers need for a safe, secure and reliable supply and would not be a materially preferable decision.

The issues with the AER's methodology for calculating its alternative mains replacement program, and AGN's concerns with the outcomes that would arise from that program, are discussed in the following Sections.

1.5.1 Issues with the AER's Alternative Proposal

As discussed above, the AER's alternative proposal has been derived by using AGN's historical leakage data over 2005 to 2014 to generate an assumption of the expected leak reduction for the next AA period. The AER concludes that:

> *"AGN's proposed 1,273 kilometres of mains replacement assumes a 47 per cent reduction in leaks over the 2016-21 access arrangement period."*[49]

The AER has then reduced this assumed 47% target to 25%, and approved a capex amount commensurate with replacing the 577 kilometres of mains it concludes must be replaced to reach this target.

We have identified several fundamental errors in the AER's methodology, which indicate the AER's alterative proposal is not a reasonable estimate nor the best estimate possible in the circumstances as required by NGR 74. These errors are:

- the AER has interpreted the data provided by AGN incorrectly, in that:
  - the AER's analysis of leak history includes assets that are reticulated with Liquid Petroleum Gas rather than natural gas;
  - the AER's analysis includes assets that are located in regional towns and suburbs not covered by the mains replacement program;
  - the AER's leak analysis considers all leaks on all materials, including leaks recorded on assets already replaced (e.g. on new PE);
  - the AER's modelling of 20,069 total leaks from 2005 to 2014 is around 35% lower than AGN's actual data;
  - the AER analysis assumes mains replacement has not taken place and asset population per suburb has not changed;
- the AER's analysis treats cracks and leaks the same, with no consideration of the typically larger and more unpredictable release of gas caused by a crack than by a leak;
- the AER's model does not consider HDPE risk; and
- the AER does not recognise AGN's safety obligations.

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[49] AER 2015, "*Confidential Appendix A – Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6A-20.

Further, we have not been able to reconcile the AER's modelling of the data provided by AGN, and consider the AER's 25% leak reduction target is arbitrary and does not constitute a reasonable estimate or an approach that would be adopted by a prudent operator.

The AER's 25% target appears to have been derived by adopting an approximate midpoint between the AER's calculation of the proposed reduction in leaks over the next AA period (47%) resulting from AGN's mains replacement program, and the 8% reduction in leakage rates the AER calculated between 2007 and 2014. Although we understand the AER has adopted the 25% target on this basis, we have not been able to reconcile the 47% leak reduction forecast or the 8% historical leakage reduction with the leak history data we provided to the AER. Therefore, we consider the 25% leak reduction target is arbitrary and not based a reasonable interpretation of evidence.

The AER's analysis appears to assume that a percentage reduction in leaks is sufficient to address the issues posed by the current mains in the Network. This is not the case. The issue with the mains is their age and consequent propensity to fracture or crack, in turn resulting in escapes of large levels of gas and potential explosions. This creates a risk of property damage but more significantly it creates a risk to human life and welfare for both members of the public, customers and workers on gas infrastructure. For example, if only 22% of 'High' risk mains were replaced, then the risk remains unaltered in respect of the remaining 78% of mains.

A program that only provides for replacement of 577 kilometres of 'Extreme' and 'High' risk mains would not reduce the risk in the Network to ALARP, as is required under AS/NZS 4645, the *Gas Act 1997* and regulations, or the *Work, Health and Safety Act 2012*. The AER's alternative proposal does not represent a replacement program that would be undertaken by *a prudent service provider, acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of providing services*[50]*,* and is not consistent with the NGL or materially preferable.

These matters are discussed further below.

1.5.1.1 The AER's Model Includes Mains Already Replaced

The AER's model also appears to assume mains replacement has not taken place and asset populations by suburb have not changed. For example, the AER states that:

> *"The 'Suburb Model' worksheet data has been sorted on 'Leakage rate' (Column n) from highest to lowest for the reasons discussed in point 3 above (efficient order)."*[51]

The suburb of Sturt is top of the AER's list of suburbs prioritised by 'efficient order', however the CI & UPS mains have already been replaced in that area. The AER's complete analysis on 'knee point' (*a point which shows 'Extended replacement timing (25 per cent), and 'AGN Proposed' replacement point*[52]) and optimal reduction in leaks is therefore not correct. Suburbs that have already had assets replaced will behave differently to those that are awaiting mains replacement, and should be lower on the list. This would change the knee point.

1.5.1.2 The AER has Interpreted Data Incorrectly

The AER has based its modelling on historical leakage incident data provided by AGN. However, AGN has several concerns with the AER's interpretation of that data.

First of all, the AER's analysis considers leakage history across AGN's entire inventory of assets and then uses this to assume a leakage reduction rate for the next AA period. This is an error. The AER's analysis

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50 National Gas Rule 79(1)(a).

51 AER 2015, "*Confidential Appendix A – Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6A-19.

52 bid.

includes assets that are not part of the Network and/or are not located in areas covered by the mains replacement program. The following suburbs should have been excluded from the AER's analysis:

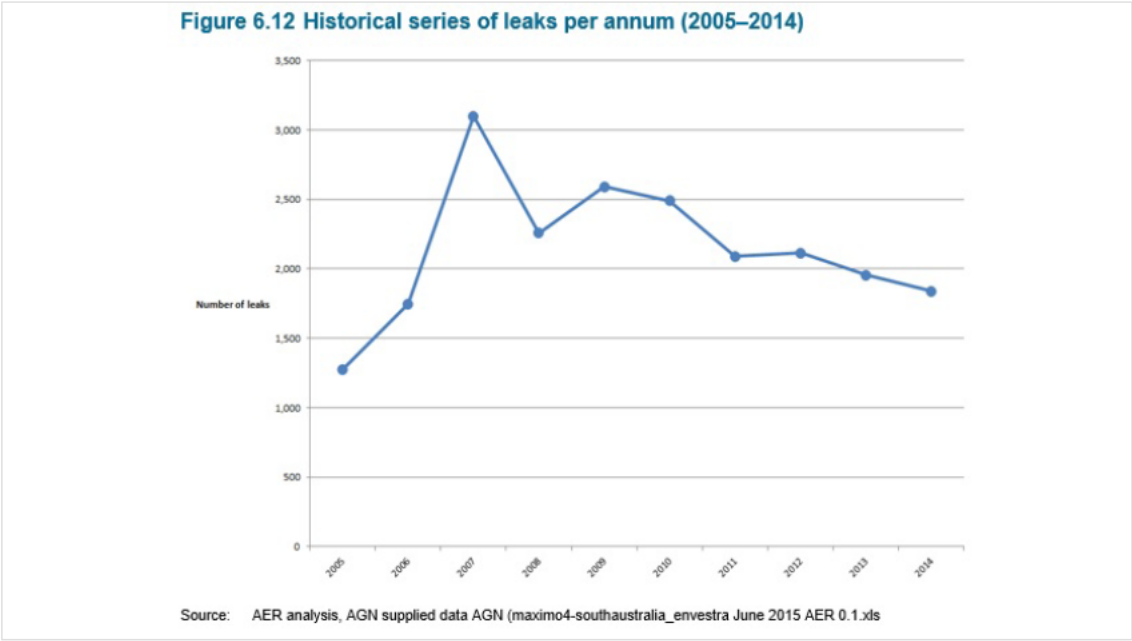
- Mildura;
- Red Cliffs;
- Irymple;
- Berri Mildura Pipeline;
- Renmark;
- Encounter Bay;
- Wallaroo;
- Victor Harbour;
- Koorlong;
- Korunye;
- Glossop;
- Maggea;
- Brinkley; and
- Cape Jaffa.

As a result, the asset length used in the AER's analysis has been overstated by 321 kilometres.

A further issue is that the AER's analysis considers historical leaks across all materials, including leaks recorded on assets already replaced. This means the AER's analysis does not reflect the leakage rates on the assets that are going to be replaced. As a result, the AER's analysis is not relevant in determining the volume of CI/UPS and HDPE mains that should be replaced during the next AA period.

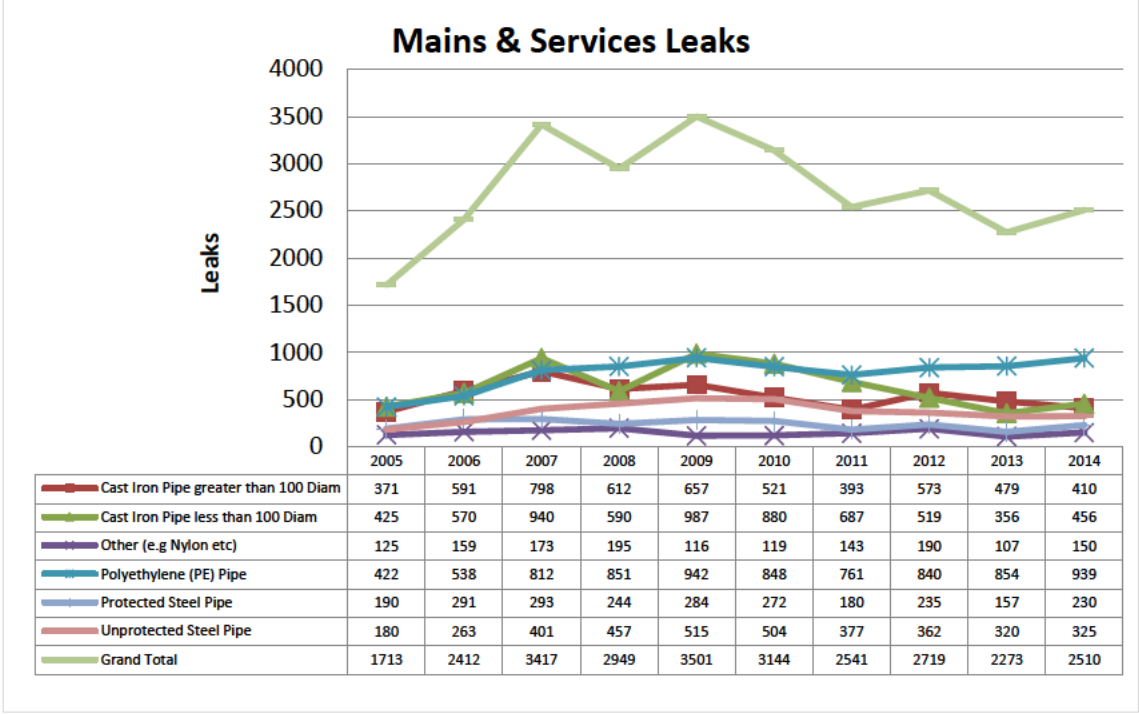
We have also identified that the AER's modelling, which it states is based on data provided by AGN, shows 20,069 leaks were recorded from 2005 to 2014. This is represented by Figure 6.12 of the AER's Confidential Appendix A to Attachment 6 of the Draft Decision, which is reproduced below as Figure 1.14.

FIGURE 1.14: AER ANALYSIS OF AGN LEAK HISTORY DATA



We have modelled the same data provided to the AER and cannot reconcile the above chart. Our analysis, summarised in Figure 1.15 shows 27,179 leaks over the period, which is 35% higher than the AER's estimate.

FIGURE 1.15: AGN ANALYSIS OF LEAK HISTORY DATA



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Cast Iron Pipe greater than 100 Diam	371	591	798	612	657	521	393	573	479	410
Cast Iron Pipe less than 100 Diam	425	570	940	590	987	880	687	519	356	456
Other (e.g Nylon etc)	125	159	173	195	116	119	143	190	107	150
Polyethylene (PE) Pipe	422	538	812	851	942	848	761	840	854	939
Protected Steel Pipe	190	291	293	244	284	272	180	235	157	230
Unprotected Steel Pipe	180	263	401	457	515	504	377	362	320	325
Grand Total	1713	2412	3417	2949	3501	3144	2541	2719	2273	2510

In any event, leaks by themselves are not relevant. It is the leak and crack rate of CI/UPS and HDPE that gives rise to the risk and must be addressed.

There is also inconsistency between the AER's modelling and its discussion in Confidential Appendix A, which states:

> *"The leakage historical data provided by AGN indicates from 2005 to 2014 a total of 23,809 leaks occurred in mains and services of all material type (CI, UPS and HDPE)"*[53]

The AER's model shows 20,069 leaks and does not reconcile with the 23,809 leaks stated above. This inconsistency suggests the AER has misinterpreted the data provided to it, and has therefore formed an alternative mains replacement proposal that is based on an erroneous interpretation of data.

The AER has also arrived at incorrect conclusions when assessing its own data analysis, which showed a decreasing trend of number of leaks since 2009:

> *"There is also a significant ongoing decline in the annual leakage rate from 2009 to 2014, especially since 2010. Across this same period the leakages per kilometre of pipe have been declining at a rate of about 200 leaks per year. Part of this decline may be attributed to AGN's increased frequency of leakage surveys (resulting in increased leak identification and repair), and to the CI and UPS mains replacement undertaken in the 2010–15 access arrangement period."*[54]

First, AGN advises that the frequency of leak surveys on most of the Network has remained unchanged over this period. Second, the conclusion that increased surveys has resulted in an increased number of leaks is contradictory to the previous statement that there has been a significant ongoing decline in annual leakage rate.

Given that data has been interpreted incorrectly, the AER's assumption that AGN's initially proposed replacement of 1,273 kilometres would reduce leaks by 47% is incorrect. Therefore, any subsequent adjustments to mains volumes and capex in relation to this erroneous assumption are also incorrect, and do not represent an estimate arrived at on a reasonable basis as required by NGR 74. Nor are such volumes consistent with Section 24(2) of the NGL as such volumes do not allow AGN sufficient expenditure to meet its pipeline safety duties. Nor would such volumes appear consistent with the NGO because the requirements of network safety, security and reliability are not met.

1.5.1.3 The AER's Model Treats Cracks and Leaks the Same

A further issue with the AER's leakage data analysis is that it does not differentiate between cracks in the pipe and leaks. The most significant issue associated with CI and HDPE mains is their propensity to crack suddenly and unpredictably (particularly as they age). A crack typically releases larger volumes of gas than a leak at a pipe joint, and therefore carries a greater likelihood of resulting in an event that causes serious harm. This is an important distinction and must be factored into any risk-based prioritisation of suburbs for replacement.

The AER's model is based entirely upon its interpretation of leakage data, and does not consider crack-related leak rates nor reflect the greater risk posed by cracking CI and HDPE mains. While leakage data is an important indicator of pipe condition, AGN considers it is not good gas industry practice to develop a mains replacement program based on leakage data alone.

1.5.1.4 No Consideration of HDPE Risk

A key omission in the AER analysis and decision is that it does not address the risk associated with HDPE. There is no consideration of the level of replacement necessary to mitigate the risk of further incidents in the Network due to this class of asset. This omission runs contrary to the AER's statement that:

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[53] AER 2015, "*Confidential Appendix A – Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6A-12.

[54] bid, pg. 6A-11.

> *"We consider a rigorous risk assessment that measures the likelihood and impact of a hazard occurring is necessary in determining whether proposed investment is prudent and efficient."*[55]

As the AER has not undertaken such analysis, then the mains replacement program set out by the AER in its decision cannot be considered to be materially preferable to that proposed by AGN.

1.5.1.5 No Consideration of Regulatory Obligations

In its Draft Decision, the AER states:

> *"… there are no regulatory or legislative obligations that require AGN to replace mains at the rate it has proposed over the 2016–21 period."*[56]

The AER is incorrect in its assumption that AGN has no regulatory or legal obligations to undertake the mains replacement program as proposed. As discussed at length in Section 1.3.1, AGN is obliged under the NGL and associated instruments to ensure network safety. We consider delivering the mains replacement program at the proposed rate is the minimum requirement in order to satisfy this obligation.

A regulatory obligation or requirement is defined in Section 6 of the NGL. It includes a *"pipeline safety duty"* which is in turn defined in Section 2 of the NGL as:

> *"pipeline safety duty means a duty or requirement under an Act of a participating jurisdiction, or any instrument made or issued under or for the purposes of that Act, relating to—*
>
> *(a) the safe haulage of natural gas in that jurisdiction; or*
>
> *(b) the safe operation of a pipeline in that jurisdiction;"*

There are several concurrent pipeline safety duties requiring AGN to implement the mains replacement program. They are:

- Clause 8 of AGN's distribution licence under the *Gas Act 1997* which clause requires that AGN implement the mains replacement program in the form approved by the ESCOSA in November 2015;
- Clause 5 of AGN's distribution licence which relates to safe operation of the Network;
- Section 55 of the *Gas Act 1997* and regulation 37 of the *Gas Regulations 2012* which require gas infrastructure to be operated safely and require compliance with AS/NZS 4645, AS/NZS 1596 and AS 2885;
- the *Work Health and Safety Act 2012* which requires AGN to ensure so far as is reasonably practicable that the health of workers, and any other person who may be affected by AGN's business undertaking, is not put at risk.

The effect of Sections 28 and 24(2) of the NGL is that the AER must take into account as a fundamental element in its decision that it must provide AGN with a reasonable opportunity to recover the efficient costs of complying with these duties.

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[55] AER 2015, "*Confidential Appendix A – Attachment 6 – Capital expenditure | Draft decision: Australian Gas Networks Access Arrangement 2016–21*", November 2015, pg. 6A-6.

[56] bid.

1.5.2 Outcome of the AER's Alternative Program

AGN has assessed the AER's alternative proposal in its risk assessment and cost impact analysis. Under the AER's alternative mains replacement, the average net present cost per customer per year is $3.45 lower than AGN's proposal. However, at the end of the next AA period, around 78% of mains rated as 'High' risk will remain and more than 50% of mains could remain at 'High' risk at the end of the subsequent AA period.

We do not consider that this program is prudent and efficient or consistent with AGN's obligations under the *Gas Act 1997* or the *Work Health and Safety Act 2012* (AGN's pipeline safety duties). We believe our proposal, which is concordant with AS 4645 risk treatment, of eliminating the risk associated with almost 50% of mains rated as 'Extreme' or 'High' risk is, materially preferable.

Though the cost of AGN's revised proposal is higher than the AER's alternative program, AGN's customers will still pay considerably less than they currently pay, and the risk associated with the 'Extreme' and 'High' risk mains will be reduced more quickly. Under the AER's Draft Decision, the initial reduction in prices is estimated to be $123.80. If AGN's mains replacement program is adopted, holding all else the same, customers would still receive a price reduction in the first year of $115.90. AGN notes that:

- the $7.90 price difference reflects an indicative price impact of AGN's mains replacement program relative to the AER Draft Decision over the next AA period (calculated by simply substituting AGN's proposed mains replacement capex for the AER Draft Decision mains replacement capex in the AER Post Tax Revenue Model); and

- the $3.45 cost per customer difference between an AGN replacement scenario and indicative AER replacement scenario reflects the cost difference to customers when taken over the 60 year useful life of the assets.

Table 1.23 presents the AER's alternative proposal compared to AGN's proposal.

TABLE 1.23: COMPARISON OF AGN AND AER MAINS REPLACEMENT PROPOSALS FOR THE NEXT AA PERIOD

Mains Replacement Program	Capex ($ million)	Length of Mains Replaced (km)	Net Present Cost per Customer per Year	Price reduction in first year (2016/17)*	Risk at the End of the Next AA Period
AGN Revised AA Proposal	$326	1,265	$18.65	$115.90	52% of mains remain high risk
AER Draft Decision	$168	561	$15.20	$123.80	79% of mains remain high risk

*Note: The AER Draft Decision price reduction in 2016/17 reflects that calculated under the AER's Draft Decision, which includes the AER Draft Decision mains replacement program. The AGN Revised AA Proposal price reduction has been calculated by adjusting the AER Draft Decision for AGN's mains replacement capex only.

AGN remains of the view that, given it has the capability to efficiently replace 1,265 kilometres of mains during the next AA period, to limit the replacement of mains that have been identified as having 'Extreme' or 'High' risk is not consistent with achieving a 'Low', and if not, ALARP risk rating, and as such, is not what a prudent and efficient operator would choose. AGN therefore submits that its proposed mains replacement program is materially preferable to the AER's Draft Decision.

Appendix A – Excerpts from AS/NZS 4645

C2 CONSEQUENCE ANALYSIS

The severity of the consequences of each failure event shall be assessed. Consequences to be assessed shall include the potential for the following:

(a) Human injury or fatality.

(b) Interruption to continuity of supply with economic impact.

(c) Environmental damage.

NOTES:

1 Other factors such as property damage and loss of reputation may also be considered.

2 Gas distribution networks and some liquid petroleum gas distribution networks may be identified as 'essential infrastructure' where the consequence of a loss of supply is significant. This may be in terms of the potential for economic impact, and in some cases significant fatalities may result from the cascading consequence of loss of the energy supply.

A severity class shall be assigned to each failure event based on the consequences at the location of the failure. The severity class may be selected from Table C1.

Where necessary to make the severity classes applicable to the gas distribution network under study the measures of severity in Table C1 may be modified with the agreement of the stakeholders. Modification should be minimized. Any modification of the severity classes shall be undertaken so that consistency with Table C3 is maintained.

The reasons for any changes to the measures of severity shall be documented and approved.

TABLE C1

SEVERITY CLASSES

Dimension	Severity class				
	Catastrophic	Major	Severe	Minor	Trivial
	Measures of severity				
People	Multiple fatalities result.	Few fatalities, or several people with life-threatening injuries	Injury or illness requiring hospital treatment	Injuries requiring first aid treatment	Minimal impact on health and safety
Supply	Long term interruption of supply	Prolonged interruption or long-term restriction of supply	Short term interruption or prolonged restriction of supply	Short term interruption or restriction of supply but shortfall met from other sources	No impact; no restriction of gas distribution network supply
Environment (See Note)	Effects widespread, viability of ecosystems or species affected, permanent major changes	Major off-site impact or long-term severe effects or rectification difficult	Localized (<1 ha) and short-term (<2 yr) effects, easily rectified	Effect very localized (<0.1 ha) and very short term (weeks), minimal rectification	No effect, or minor on-site effects rectified rapidly with negligible residual effect

NOTE: Significant environmental consequences may occur in locations which are relatively small and isolated.

C3 FREQUENCY ANALYSIS

A frequency of occurrence of each threat shall be assigned for each location where risk estimation is required. The frequency of occurrence shall be selected from Table ~~A~~C1.3(a).

The contribution of operations and maintenance practices and procedures to the occurrence or prevention of failure events shall be considered in assigning the frequency of occurrence.

TABLE C2

FREQUENCY CLASSES

Frequency class	Frequency description
Frequent	Expected to occur once per year or more
Occasional	May occur occasionally in the life of the gas distribution network
Unlikely	Unlikely to occur within the life of the gas distribution network, but possible
Remote	Not anticipated for this gas distribution network at this location
Hypothetical	Theoretically possible but has never occurred on a similar gas distribution network

For a threat which exists for a limited period the frequency class should be assessed against the exposure period rather than the life of the gas distribution network.

C4 RISK RANKING

Table C3 shall be used to combine the results of frequency analysis and consequence analysis and determine the risk rank.

Risks determined to be low or negligible or demonstrated to be as low as reasonably practicable (ALARP) are accepted risks.

TABLE C3

RISK MATRIX

	Catastrophic	Major	Severe	Minor	Trivial
Frequent	Extreme	Extreme	High	Intermediate	Low
Occasional	Extreme	High	Intermediate	Low	Low
Unlikely	High	High	Intermediate	Low	Negligible
Remote	High	Intermediate	Low	Negligible	Negligible
Hypothetical	Intermediate	Low	Negligible	Negligible	Negligible

C5 RISK TREATMENT

C5.1 General

Action to reduce risk shall be taken in accordance with Table C4 based on the risk rank determined from Table C3.

The action(s) taken and their effect on safety management shall be documented and approved.

TABLE C4

RISK TREATMENT ACTIONS

Risk rank	Required Action
Extreme	Modify the threat, the frequency or the consequences to ensure that the risk rank is reduced to Intermediate or lower. For a gas distribution network in operation the risk must be reduced immediately.
High	Modify the threat, the frequency or the consequences to ensure that the risk rank is reduced to Intermediate or lower. For a gas distribution network in operation the risk must be reduced as soon as possible, typically within a timescale of not more than a few weeks.
Intermediate	Repeat threat identification and risk evaluation processes to verify and, where possible, quantify the risk estimation; determine the accuracy and uncertainty of the estimation. Where the risk rank is confirmed to be Intermediate, if possible modify the threat, the frequency or the consequence to reduce the risk rank to Low or Negligible. Where the risk rank cannot be reduced to Low or Negligible action shall be taken to— (a) remove threats, reduce frequencies and/or reduce severity of consequences to the extent practicable, and (b) demonstrate ALARP. For a gas distribution network that is in operation, the reduction to Low or Negligible or demonstration of ALARP must be completed as soon as possible, typically within a timescale of not more than a few months.
Low	Determine the management plan for the threat to prevent occurrence and to monitor changes which could affect the classification.
Negligible	Review at the next review interval.

C5.2 ALARP

A risk cannot be designated as ALARP until the following has been completed:

(a) Analysis of the means of further reducing the risk, including an analysis of various options.

(b) Review as to the reasons why these further means have not been adopted.

(c) Substantiation that the cost of further risk reduction measures is grossly disproportionate to the benefit gained from the reduced risk that would result.

Options that shall be considered include—

(i) relocation of the network components;

(ii) modification of the design of network components;

(iii) review of pressure levels;

(iv) modification or enhancement of specific operations or maintenance procedures;

(v) modification to gas distribution network marking; and

(vi) threat treatment for operating gas distribution networks shall consider interim control measures (e.g. reduction in operating pressure, access restrictions) to allow time for the implementation of permanent control measures (e.g. repair).

The further risk reduction measures considered and the reasons they have not been adopted shall be documented.