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Summary Report

Network Analysis for State-Wide Feasibility Studies

Australian Gas Infrastructure Group

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1 INTRODUCTION

GPA Engineering, on behalf of Australian Gas Infrastructure Group (AGIG), have investigated a number of factors relating to the feasibility of injecting hydrogen into AGIG's natural gas distribution networks in South Australia and Victoria. The networks are:

- Australian Gas Networks South Australia (AGN SA)
- Australian Gas Networks Victoria (AGN Vic)
- Multinet Gas Networks

The assessment was focused on two scenarios: the injection into the gas networks of a 10% hydrogen / 90% natural gas blend, and the injection of 100% hydrogen gas.

The scope of this assessment included four parts, each covered by its own report, as listed in Table 1.

Table 1: Project documents

Document no.	Document title	Scope
220804-REP-001	Piping Compatibility Report	The suitability of **pipe materials** and **jointing methods** for **pipelines** and **network piping** in hydrogen service
220804-REP-002	Component Compatibility Report	The compatibility of materials used in network **components** (such as valves, regulators, meters, etc.) in hydrogen service
220804-REP-003	Operational Issues Report	The effects on **operational procedures** and safety in **design considerations** as a result of pipeline conversion to hydrogen service
220804-REP-004	Downstream considerations report	The compatibility of materials and impacts on pipe sizing of **customer "downstream" gas fittings** in hydrogen service

1.1 EXCLUSIONS

The following items existing in the distribution networks were excluded from this assessment, and should be explored in greater detail in future studies:

- Licensed transmission pipelines with MAOP above 2,800 kPag, or design factor above 0.4 (the cost to assess these pipelines is estimated in 4.1).
- Pipelines within the network area that are owned by an entity other than AGIG.
- Components for which materials could not be identified (e.g. older makes and models) – as identified in 220804-REP-002 and summarised in Table 7.
- Components used at pressures above 2,800 kPag, or installed upstream of city gates, such as compressors or water bath heaters.
- Higher pressure consumer piping (e.g. industrial fitting lines) operating at a pressure between 7 and 200 kPag.
- Appliances, flues, and any piping downstream of the appliance.
- Performance of components (e.g. the ability of regulators and meters to achieve the correct pressure and flow-rate).
- Items that relate to network flow capacity/the ability of the system to deliver energy.

2 SUMMARY OF RESULTS

2.1 LICENCED PIPELINES

Most licensed pipelines in the assessed networks can safely be used to transport hydrogen blends or pure hydrogen. They have effective resistance to fracture and fatigue at the relevant operating conditions, and the original hydrotest still provides a margin of safety after hydrogen embrittlement.

The following exceptions apply:

- Three pipelines were manufactured to superseded Australian Standards, which permitted "dirtier" steels than are allowed under current standards. It is expected that two pipelines can be used safely in hydrogen service due to low design factor and operating stress, though the material composition of AGN Vic PL215 (Morwell to Tramway Rd) requires confirmation before use in 100% hydrogen. The third pipeline, AGN SA M5 Prospect to Brompton, manufactured with AS A149 steel, has a design factor of 0.3 and is not recommended for hydrogen service unless toughness tested (Table 2).
- Six of the licenced pipelines have a design factor higher than 0.3 (Table 3). For these pipelines, the reduction of critical defect length due to hydrogen embrittlement will require review in the pipeline safety management study (SMS), especially if these pipelines are currently classified as "no rupture". A conservative critical defect length (CDL) has been estimated and reported in 220804-REP-001 that can be used for the assessment.

Table 2: Pipelines which require further testing

Network	*Pipeline License*	*Pipeline Name*	*Material*
AGN Vic	PL215	Morwell to Tramway Rd	A23-1937 / ASB.65C
AGN SA	M5	Prospect to Brompton	AS A149

Table 3: Pipelines which require review of SMS because of DF > 0.3

Network	Pipeline	Material	MAOP (kPa)	Hydro P (kPag)	DN	Wall thickness (mm)	Hoop Stress (MPa)	Design Factor
Multinet	PL40 Dandenong - West Melbourne (Ring Main) (Dandenong to Templestowe)	API 5L A	2760	6,930	450	7.92	79.66	0.38
	PL56 Murrumbeena - Highett	API 5L A	2760	7,700	300	6.35	70.39	0.34
	PL82 Sunshine to Sunshine North	API 5L B	2760	3,860	300	4.78	93.51	0.39
AGN Vic	PL201 Ring Main – Templestowe to Keon Park	API 5L A	2760	5,378	450	7.92	79.66	0.38
	PL208 Ring Main – North Melbourne to West Melbourne	API 5L A	2760	6,174	450	7.92	79.66	0.38
	PL208 Ring Main – North Melbourne to West Melbourne	API 5L X42	2760	4,200	450	6.4	98.58	0.34
AGN SA	M5 Prospect to Brompton	AS A149	1896	2,414	450	6.0	72.24	0.30

2.2 DISTRIBUTION PIPELINES

The review of the distribution piping identified that steel, copper and plastic pipe materials can be retained in hydrogen service at 10% and 100%. Cast iron, however, may not be suitable for hydrogen service. From the little data available, this assessment concluded that low-pressure cast iron (<7 kPag) can be retained in 10% and 100% hydrogen service, but that it cannot be used at pressures higher than 7 kPag without conducting specific assessment through calculation or obtaining material data.

2.3 JOINT TYPES

The review concluded that all joint types in the system are suitable for use with 10% hydrogen blends, and that most connection types are suitable for 100% hydrogen also, including welded, flanged and threaded steel connections, and welded and glued plastic pipe connections.

Though flared-type tubing connections (e.g. Swagelok and similar copper pipe connection types) are acceptable and are in fact common in hydrogen systems, ongoing research at Deakin University has flagged that other mechanical joint types that have a narrow leak path may have unacceptable leak rates at 100% hydrogen; these include Gibault and PERFECTION joints, which are primarily designed for the water industry, and also single-ferrule compression fittings. These joints require closer review, and may require testing to confirm effectiveness in pure hydrogen.

Caulked connections and bell and spigot connections are not permitted under ASME B31.12. Due to their design, it is expected that these connections would have no additional vulnerability to mechanical failure, but that Bell and Spigot connections may have higher leak rates at 100% hydrogen. Caulked joints are likely to be used only with cast iron, which is not permitted at higher pressures, as noted above.

2.4 METAL COMPONENTS

It was identified that components with parts made from copper alloys, most aluminium alloys, and stable austenitic stainless steels are suitable for 10% and 100% hydrogen service. Other metals, with poor performance, such as cast irons, high strength carbon steels (e.g. chrome-moly), martensitic stainless steels and nickel alloys, may not be suitable and the following recommendations apply:

- Components with bodies or pressure containing parts made from martensitic stainless steel or nickel alloys are not suitable for any level of hydrogen service (Table 4).
- Components with cast iron bodies should only be used up to a maximum pressure of 7 kPag in 10% and 100% hydrogen service, in the absence of any other supporting data (Table 5).

Components with internal parts made from poor performing materials, or used at low pressures (i.e. domestic gas fittings) may be accepted for hydrogen service, provided testing and a risk assessment are performed (

- Table 6).
- Components that contain materials for which no data has been identified should be replaced unless the manufacturer can endorse its performance in hydrogen (Table 7).
- Any component retained under risk assessment should be closely monitored for leak performance and failure frequency.
- Where material compatibility with hydrogen cannot be confirmed from available data, material testing is recommended (Table 8).

Note: several components (listed in Table 9) have the option of a selection of materials for certain parts.

The selected material could not be confirmed at the current level of analysis, so it is possible these components contain hydrogen-incompatible materials. It is recommended that the selected material is confirmed; the recommended action (replacement/ monitoring) depends on the material selection.

The cost of replacing incompatible valves and regulators is estimated in section 4.2.

Table 4: Components to be replaced

Component type	*Make*	*Models*	*Issue*
Large bore valves	Brook	B600E	Cast iron body and SS410 stem
	Keystone	AR2 butterfly	Cast iron body with 17-4PH SS stem

Table 5: Cast iron components

Component type	*Make*	*Models*	*Action*
Large bore valves	Audco	M series Class 125	Replace if used above 7 kPag OR Perform material testing to prove material compatibility with hydrogen at higher pressures
	John Valves	FIG 600	
Regulators	Fisher	298T, 99, 61	
	Mooney	Flowmax	
	AMC	Reliance 1800,3000, 3010, 1203	
	Elster	J125	
	Sensus	243RPC	
	Donkins	BD240R-290	
Filters/strainers	ME MACK	Y strainer	
	CLAM	-	
	-	Proprietary item: right angled filter	

Table 6: Components with incompatible materials to be risk assessed for their application

Component type	*Make*	*Models*	*Action*
Large bore valves	Richards	R43, R723, R733	Risk assess use of Inconel
	PBV	5800/6800	Risk assess use of Inconel
	Sferova	TM2/TM3	Risk assess use of Inconel
Small bore valves	Swagelok	SS-EGUF8	S17400SS needle
Regulators	AMC	Axial Flow Valve, Radial Flow Valve	Risk assess use of 17-4(PH) SS
	Pietro Fiorentini	PF Reflux 819 FO	Risk assess use of 416 SS
	Crosby	951 series	Risk assess use of 416SS and 17-7PH or Monel or Hastelloy C

Table 7: Components for which material information is not known

Component type	*Make*	*Models*	*Material information required*
Large bore valves	Cameron	WKM R603 NH	ALL
	Richards	R346, R46	ALL
		93300A RP6B MK3	ALL
Regulators	Gorter	Cocon 13, 26	Confirm type of steel and any plastics
	Fisher	64 HPR, 67F	ALL

	Fisher	161, 168, EZH	Confirm type of steels used, and in what application
	Mooney	15H01G	ALL
	AMC	Reliance 2000	ALL
	AMPY Email 300	Spec 23, 59, 68, 78	Confirm any metals used
	Grove	Model 80, 81, 83	ALL
	Reynolds	670, 678, 682	ALL
	Donkins	688, 999	ALL
	Pietro Fiorentini	FEX, VS/AM	Confirm any plastics used
		Dival 300 & 512 LTR, Reval	ALL
	RMG	650, 850	ALL
	Welker	Welker Jet	Confirm application of 1045 CS
	Honeywell	HON 5020	Confirm type of SS used
	EDMI / Atlas	TR200B, TR143	Confirm type of SS used
Meters	Dresser	Roots	Confirm type of steel and any plastics
	Actaris	1000A	Confirm any metals used
	L&G / AMPY	Model 750, 1010, 602, 610	Confirm type of steel
	EDMI / Atlas	RK MR8, U8, U10	Confirm type of steel
Filters/ strainers	ME MACK	6761A-050	ALL
	Grove	104-00019	ALL
	NUPRO	55	ALL
	Fisher P252	Type P252	ALL
Insulated Joints	Zunt	-	ALL
	Swagelok	-	ALL
	ElectroStop		ALL
Any components which are not included in 220804-CALC-002			ALL

Table 8: Components that require material testing

Component type	***Make***	***Models***	***Material information required***
Regulators	Pietro Fiorentini	FE10 / FE25	Investigate hydrogen compatibility of Zamak (and approve component use at 100% hydrogen)
Domestic gas meter fittings	-	-	Investigate hydrogen compatibility of zinc
Various	Various	Various	Investigate hydrogen compatibility of cast iron at pressures above 7 kPag

Table 9: Components with cast iron, nickel alloy or martensitic stainless steel options - material selection to be confirmed

Component type	***Make***	***Models***	***Material information required***
Large bore valves	Nordstrom	-	Confirm plug material (SS or Monel). Replace if Monel or martensitic SS.
	Audco	Standard M series and Super H series	Confirm plug material. Replace if cast iron at pressure above 7 kPag
	Keystone	F2 butterfly	Confirm whether body is cast iron or carbon steel. Replace if cast iron at pressure above 7 kPag

	Bray	S31-713	Confirm body material. If cast/ductile iron, and used at pressure above 7 kPag, replace. If not, risk assess, considering Monel or 17-4PH SS stem
Small bore valves	Fisher	OSE	Confirm body material. Replace if cast iron at pressure above 7 kPag
Regulators	Gorter	Cocon 1-12	Confirm body material. Replace if cast iron at pressure above 7 kPag
	Fisher	620, 627, 289H, 299, 166, EZR, 66	Confirm body material. Replace if cast iron at pressure above 7 kPag
		98H PRV	Confirm body material. If cast/ductile iron at pressure above 7 kPag, replace. Otherwise, confirm seat option. If 416SS metal/metal seat, risk assess.
	Mooney	Flowgrid FG/SG	Confirm body material. If cast iron at pressure above 7 kPag, replace. Otherwise, risk assess, considering 17-4PH SS throttle plate
	AMC	Reliance Z 138	Confirm body material. Replace if cast iron at pressure above 7 kPag
	Donkins	226 MK2 / MK3	Confirm body material. Replace if cast iron at pressure above 7 kPag
	Pietro Fiorentini	Dival 100/160/250/ 600, Norval, Aperval	Confirm body material. Replace if cast iron at pressure above 7 kPag
		Reval 182	Confirm whether body is cast iron/ductile iron. If yes, and used at pressure above 7 kPag, replace. Otherwise, risk assess, considering 416 SS stem
Meters	Actaris	Fluxi Turbine Meter	Confirm body material. Replace if ductile iron at pressure above 7 kPag
	Sensus / Rockwell	RK T18 Turbine	Confirm body material (is not cast iron option) Replace if cast iron at pressure above 7 kPag
		RK MKII and IIE Turbine	Confirm body material. Replace if ductile iron at pressure above 7 kPag
	Elster Instromet	TRZ2 (turbine) and RVG (rotary)	Confirm body material. Replace if cast iron at pressure above 7 kPag

2.5 PLASTIC COMPONENT PARTS

The hydrogen effect on properties for many plastic materials could not be quantified or reliably predicted. While commonly-used Viton and PTFE are hydrogen compatible, very widely-used NBR (Buna-N) often underperforms in hydrogen (depending on the brand). There are also many instances of Acetal, EPDM and some other elastomers that may have reduced performance in hydrogen. Across all of these materials, however, the reduced performance is not expected to result in spontaneous failure of the component. The materials are generally used internally in valves and regulators as seals, gaskets, diaphragms and occasionally bearing materials. As a result, replacing the components containing these materials is not considered essential; instead, risk assessment of seal leakage and close monitoring of performance and failure rates are advised.

It is important to note that permeation through certain elastomers may affect the metering or volumetric performance of diaphragm meters. This effect has not been assessed in this project but is anticipated to result in a need to replace all such components at 100% hydrogen; the cost of replacing all diaphragm meters is estimated in section 4.3.

2.6 OTHER COMPONENTS

Specific pressure transmitter makes and models, as well as particular sealants and lubricants, should be assessed in consultation with the manufacturers. It is also recommended that all pipeline repairs going forward are performed with materials that are 100% hydrogen compatible, from the perspectives of both material compatibility and tendency for leaking; this may also require consultation with manufacturers.

2.7 FACILITY PIPING

Review of the requirements of ASME B31.12 identified that the design of piping in gas facilities should account for increased susceptibility to fatigue, particularly from thermal expansion. This would affect, in particular, city gate stations and field regulators. This issue has not been addressed in the other reports for this project.

The requirements of ASME B31.12 address the issue of fatigue in two ways: Firstly, the number of cycles used in thermal expansion assessments is increased by a factor of 10x. Secondly, the tolerances applied on permissible facility weld defects are reduced by a significant margin. These two requirements are linked in the standard because, if the stress due to expansion is low enough (less than 80% allowable), the extent of weld inspections can be decreased.

A stress analysis should be completed for the piping layouts at each facility before they are converted to hydrogen service. In some instances this could involve a desktop assessment by inspection, rather than a detailed simulation. Also, it is noted that many facilities have a common layout, so one analysis may be representative of several facilities.

The following outcomes are possible:

- Stress levels are below 80% allowable – design is accepted. Most piping designs maximise flexibility, and result in stress levels that are far below allowable stress limits.
- Stress levels are above 80% allowable
    - Simple design modifications may rectify the stress and reduce it; typically this will involve adjustment of pipe supports.
    - If it cannot be adjusted, then any girth welds at high stress locations should be subject to non-destructive testing to confirm that they do not have injurious defects.
- Stress levels are above 100% allowable. In this case the design must be modified to rectify the issue; weld NDT at high stress locations is recommended.

Note that often the highest stress is not on a weld; conducting NDT would only be recommended where there is high axial (bending) stress *at a weld*, which *cannot be rectified* through modification of the pipe supports.

From a review of the AGIG Murray Valley network, it is expected that most field regulators will not require modification, because they apply a common layout that is well-designed to minimise expansion stress. For some connections, however – typically industrial connections with above-ground regulator stations – there is a greater likelihood that modification of pipe supports may be required. Requirement to conduct NDT is expected to be a rare outcome of analysis.

2.8 OPERATIONAL ISSUES

Differences between natural gas and hydrogen were identified to affect network operation in a number of ways, particularly in the case of 100% hydrogen service. These effects include:

- Reduced energy density, requiring higher volumetric flowrates throughout the distribution network to match the current energy capacity (capacity review excluded)
- Increased likelihood of erosion, vibration and noise as a result of increased velocity
- Increased size of leak clouds due to higher volumetric flow rates
- Increased probability of ignition due to reduced ignition energy
- Higher explosive forces than natural gas due to increased flame speed
- Faster dispersion in open areas due to buoyancy
- Differences in thermal behaviour due to pure hydrogen having a negative Joule-Thomson coefficient

These effects impact a range of operational issues such as:

- Hazardous area extents and exclusion zones
- Ventilation requirements
- Flame detectors, gas detectors and burner equipment technology
- HA-ratings of electrical devices (cost of upgrade of equipment to Class IIC is estimated in 4.4)
- Leak detection protocols, confined space entry procedures and PPE requirements
- Venting designs and purging procedures
- Pipeline integrity management, defect assessment and repair processes
- Control systems to prevent over-injection of hydrogen in blended service

Most of these issues have a significant impact for 100% hydrogen, but are less severe or even negligible for 10% hydrogen blends in natural gas. Historic operation of systems with Towns Gas (which contained hydrogen) demonstrate that a system can be safely operated with a lean hydrogen blend, with minimal fuss, despite the change in gas properties.

2.9 DOWNSTREAM CONSIDERATIONS

The requirements of AS 5601.1, which guides the design of consumer piping downstream of customer meter sets, were reviewed. The review did not identify any concerns relating to the materials of construction. However, some jointing types that are permitted by the Standard may lead to higher leak rates with pure hydrogen. It is recommended that leak potential is investigated further before converting to 100% hydrogen, and it may be necessary to conduct leak tests when commissioning a domestic system with pure hydrogen. This can conveniently be done at the same time that the appliances are necessarily replaced.

Systems designed to AS 5601.1 will normally have significant excess flow capacity, especially if the graphical or tabulated design methods are used to size them initially. In these cases, the piping can safely be used for 10 mol% hydrogen blends. However, if any systems have been designed differently (the standard allows for sizing to be determined “using recognised systems or formulae”), and they have low or negligible excess capacity, it is hypothetically possible that there would be insufficient flow capacity to meet the minimum inlet pressure requirements for appliances. The likelihood of this has not been quantified in this assessment. It is recommended that this possibility be subject to risk assessment.

In the case of pure hydrogen, the likelihood of capacity constraint is higher, and the flow capacity should also be reviewed when the appliances are replaced.

In addition, design requirements for natural and mechanical ventilation systems in 100% hydrogen will require assessment, because hydrogen will require a higher air change-out rate compared to natural gas. Secondly, flue designs downstream of appliances should consider the changed properties of hydrogen exhaust gas and the potential for different water condensation.

3 ACTIONS

The recommended actions from the four reports have been compiled and are attached as an Actions Register in Appendix 1.

As research regarding compatibility of various materials is still developing, there is some uncertainty around the compatibility of particular materials and so conclusions were drawn according to the level of current knowledge.

It is expected that operational experience in service will further refine industry knowledge about hydrogen compatibility and may reduce conservatism—this is particularly applicable for cast iron, which has not been approved for use above 7 kPag based on current knowledge. Cast iron is prohibited or not recommended by all hydrogen codes and references that were identified; despite this, it is likely that the safe operating envelope for cast iron could be expanded if the actual hydrogen-related failure modes and their severity were quantified.

4 COST ESTIMATE

Costs to implement four aspects of the hydrogen transition have been estimated:

1. Assessment of excluded transmission pipelines
2. Replacement of valves and regulators with hydrogen-incompatible or unknown materials
3. Replacement of diaphragm meters (for 100% hydrogen service)
4. Replacement of hazardous area rated electrical equipment

Note all costs have been estimated based on equipment factoring and some application of personal judgement; at best the cost estimate is AACE Class 4, with an expected accuracy range around ±50%.

4.1 ASSESSMENT OF EXCLUDED TRANSMISSION PIPELINES

Several licensed transmission pipelines with MAOP above 2800 kPag or high design factor (as listed in Table 10) were excluded from the assessment in this project. High pressure and high design factor pipe requires a more detailed review on a case-by-case basis.

Methods of assessment recommended for each pipeline are discussed in Table 11. Estimated costs to perform these assessments are summarised in Table 12, and the cost per network is shown in Table 13.

Costs for in-line inspection (ILI) of pipelines have not been included, but may be recommended in practice.

These costs are for activities that are recommended for action before any level of hydrogen is introduced (including before 10%).

Table 10: Excluded pipelines, to be assessed

Network	*Pipeline License*	*Pipeline Name*	*Material*	*MAOP (kPa)*	*DN*	*WT (mm)*	*Length (km)*	*Year*	*SMYS (MPa)*	*Hoop Stress (MPa)*	*DF*	*HT P (kPa)*	*Req. CVN (J)*
Multinet	PL210	Pakenham-Wollert Offtake	API 5L B	6890	100	8.56	3	1999	241	46.00	0.19		0.10
			X42	10200	100	8.56	3	2006	290	68.10	0.23		0.22
	PL261	South Gippsland Pipeline	X42	10200	150	4.8	65.7	2007	290	178.82	0.62		2.32
	PL265	Lang Lang CG Connection	API 5L B	10200	50	5.54	0.115	1981	241	55.51	0.23		0.06
	PL276	Lilydale Pipeline - Yarra Glen to LCG	X56	6980	300	7.0	7.5	2012	390	161.49	0.41		4.09
AGN Vic	VIC11	Dandenong to Crib Point	API 5L A	2760	300	6.35	39.12	1966/68	207	70.39	0.34		0.78
		Dandenong to Crib point (Abbotts Road to Hall Road)	X42	7000	450	8.4	3.8	2008/9	290	190.5	0.66		9.65
		Dandenong to Crib point (Ballarto Road)	X42	7000	450	8.4	5.8	2010	290	190.5	0.66		9.65
		Dandenong to Crib point (Robinsons Road)	X42	7000	450	8.4	7.1	2012	290	190.5	0.66		9.65
	VIC43	Longford to Sale	API 5L A	4800	100	6.02	15	1969	207	45.57	0.22		0.10
			X42	4800	100	6.02	1.2	2010	290	45.57	0.16		0.10
	VIC137	Bittern to Dromana	API 5L B	2900	200	6.35	19	1983	241	50.03	0.21		0.25
	VIC139	Langwarrin to Frankston	API 5L B	2900	200	6.35	8	1983	241	50.03	0.21		0.25
	VIC208 (section)	Ring Main – North Melbourne to West Melbourne - **section**	API 5L B	2760	450	6.4	?	?	241	98.58	0.41	4200	2.58
	VIC226	Berri to Mildura Pipeline	X42	9525	100	4.8	148	1999	290	113.41	0.39		0.60
AGN SA	PL11		X42	9525	100	3.2		1999	290	170.11	0.59		1.35
	PL 6	Riverland Pipeline	X42	9525	100	3.0	160	1994	290	181.45	0.63		1.54
			X42	9525	100	4.8		1994	290	113.41	0.39		0.60
	-	Murray Bridge lateral	X42	9525	100	3	64	1994	290	181.45	0.63		1.54

Table 11: Assessment types for each pipelines

	License	Name	Dig-up	Hot-tap	Stopple	Test - air	Test – H2	Assumed outcome	Scope	Fatigue
Multinet	PL210	Pakenham-Wollert						Despite high pressure, low design factor (~0.2) and stress. Generally low diameter also. Accepted for 10 mol% hydrogen based on desktop exercise.	Desktop assessment only.	Low stress hence unlikely to be an issue.
Multinet	PL265	Lang-Lang CG Connection								
AGN Vic	VIC43	Longford to Sale	2							
AGN Vic	VIC137	Bittern to Dromana								
AGN Vic	VIC139	Langwarrin to Frankston								
AGN Vic	VIC208	Melbourne Ring Main Section		1		1		*Unclear how long this section is.* Design factor close to 0.4, and hydrotest factor of 1.5x. Large diameter (DN450), hence available energy is significant and toughness demand is at a moderate level. Recommend characterising material.	Sample retrieval (hot-tap) and material testing in air.	Low stress hence unlikely to be an issue.
AGN Vic/SA	VIC226 / PL11	Berri-Mildura Pipeline				4	1	These DN100 pipelines are zaplock. Fractures cannot propagate through joints, and brittle behaviour is reduced risk at less than 5 mm thickness. Despite thin wall and hence high design factor, *incremental* risk related to hydrogen not expected to be significant. However, one hydrogen-related concern for these pipelines is joint leakage at 100% H2.	Desktop assessment only. Test properties in air for 2x 3mm and 2x 4.8mm samples.	Assess fatigue. Cycling control may be required. **Difficult to predict outcome due to thin wall.**
AGN SA	PL 6	Riverland Pipeline								
AGN SA	-	Murray Bridge Lateral								
Multinet	PL261	South Gippsland			1	1		High design factor (0.62). Thin-wall (4.8mm). Diameter (DN150). Fatigue is main concern. Pipeline cannot readily be assessed using ILI due to diameter, would require water-fill for ultrasonic. Assume hydrotest pressure available.	Sample retrieval and material testing in air.	Cycling control or MOP reduction or if economical: ILI or hydrotest may be required.

	License	Name	Dig-up	Hot-tap	Stopple	Test - air	Test – H2	Assumed outcome	Scope	Fatigue
Multinet	PL276	Lilydale Pipeline	2	2		2	1	Mid. design factor (0.4). Med-wall (7mm). Diameter (DN300). Despite low design factor, the strength is high (X56) and hence stress is still high. Fatigue risk is significant concern.	Sample retrieval and material testing in air and hydrogen.	Cycling control or MOP reduction or if economical: ILI or hydrotest may be required.
AGN Vic	VIC11	Dandenong to Crib Point – 2008-2012 sections		2		2	1	High design factor (0.66). Med-wall (8.4mm). Large diameter (DN450). Pipeline has relatively high toughness demand, primarily due to high diameter. Fatigue risk is significant concern.	Sample retrieval and material testing in air and hydrogen.	Cycling control or MOP reduction or if economical: ILI or hydrotest may be required.
AGN Vic	VIC11	Dandenong to Crib Point – 1966 section	2					Material identity is uncertain, though design factor and stress are relatively low.	Candidate for dig-up and scraping to characterise the material.	N/A

[1] Definitions as follows:

- **Dig-up** – A small excavation to expose the buried pipeline, and remove a section of coating for the purposes of inspecting the pipe surface and potentially taking samples (scrapings) for characterisation of the material. Afterwards the pipeline is re-coated and re-buried.
- **Hot-tap** – Hot tapping equipment is used to cut out a circle of material from the pipe, to use for material testing.
- **Stopple** – Where one hot-tap would not retrieve enough material, two hot-taps, stopples and a temporary bypass are used to isolate a section of pipeline which can be cut out, and replaced with a new piece.
- **Test – air** – Testing of material properties in air, focussing on actual yield strength, tensile strength and ductility determined through tensile testing, and then fracture properties determined through fracture testing. Fracture testing would use *both* Charpy and a J-R curve testing. Fatigue crack growth rate testing may also be completed.
- **Test – H2** – Testing of material properties in hydrogen, focussing on the fracture properties as measured using J-R curve testing in a hydrogen chamber. Fatigue crack growth testing and tensile property testing may also be completed. Charpy is not feasible in a hydrogen environment.

Table 12: Estimated unit costs for each type of pipeline assessment

Item	Estimated Cost
Engineering assessments	$50,000
Dig-up and scraping for material characterisation and hardness spot-tests	$50,000
Sample retrieval using:	
• Simple hot-tap	$250,000
• Stopple and bypass to remove section	$1,000,000
Testing material in air	$10,000
Testing in hydrogen	$200,000

Table 13: Estimated costs for pipeline assessment in each network

Item	AGN SA		AGN Vic		Multinet	
	Qty	Cost	Qty	Cost	Qty	Cost
Total engineering assessments	1	$12,500	1	$12,500	1	$12,500
Dig-up and scraping for material characterisation and hardness spot-tests			4	$200,000	2	$100,000
Sample retrieval[1] using:						
• Simple hot-tap			3	$750,000	2	$500,000
• Stopple and bypass to remove section					1	$1,000,000
Testing material in air	3	$30,000	4	$40,000	3	$30,000
Testing in hydrogen	1	$200,000	1	$200,000	1	$200,000
Contingency – additional hot taps network-wide	2	$500,000	3	$750,000	2	$500,000
TOTAL		**$742,500**		**$1,202,500**		**$2,342,500**

[1] It has been assumed that there are no original spares of installed pipe available, except for Zaplock pipe.

4.2 REPLACEMENT OF VALVES AND REGULATORS WITH INCOMPATIBLE MATERIALS

As summarised in sections 2.4 and 2.5, the Component Compatibility Report 220804-REP-002 recommended replacement, risk assessment, or further investigation for a number of components containing materials that are not suitable for hydrogen service. Costs for replacement of the incompatible valves and regulators have been estimated and are summarised in Table 16. Appendix 2 provides a detailed breakdown.

In order to estimate costs, the following assumptions have been made:

1. Costs have been estimated for replacement of 100% of valves and regulators listed in Table 4 to Table 9. Note this is a conservative assumption because 100% replacement is only necessary if further research and/or risk assessment deem replacement is required.
2. Costs to replace filters, strainers, meters and other components have been excluded.
3. Quantities of regulators and valves in the AGN networks were based on spreadsheets (*AGN Vic-SA Regulator make and model data.xlsx* and *Valve make and model data AGN Vic SA.xlsx*) provided by AGIG in August 2021 that list quantities and types of valves and regulators across the two AGN networks. The lists did not differentiate the components in each network, so an assumption has been made that AGN Vic has 60% of the total quantity of each valve, and AGN SA has the remaining 40%.
4. Quantities of regulators and valves in the Multinet network were estimated based on quantities in the AGN Vic and SA networks as a guide.
5. Sizes of each valve and regulator are not known. An average cost for each component has been assumed as per Table 15, which roughly aligns to the cost for a DN100 component.
6. Components for which makes and models could not be identified have not been included.
7. Demolition, installation and commissioning costs were assumed to be required for every component. Direct replacement of each component was assumed to require 2 operators for 4 hours, at a cost of $50 per person per hour. Note this is a conservative assumption as upgrades to multiple components at the same facility would enable reduction in costs for mobilisation/demobilisation/isolation, etc.; however, no allowance was made for re-design required if replacements are not an exact fit.

Table 14: Number of facilities per network

Item	AGN SA	AGN Vic	Multinet
Gate Stations	17	54	7
Regulating Stations	257	142	236
Custody transfer meter stations		58	20

Table 15: Estimated unit costs for each type of replacement component

Item	Estimated Cost
Large bore valve	$1000
Small bore valve	$200
Customer regulator	$10,000
Network regulator	$20,000
City Gate regulator	$50,000
Pilot regulator	Included in city gate/network regulator price

Table 16: Estimated costs for component replacement in each network

Item	AGN SA		AGN Vic		Multinet	
	Qty	Cost	Qty	Cost	Qty	Cost
Components with cast iron and martensitic stainless steels	2	$1,658	2	$2,486	5	$5,180
Components with cast iron bodies	2268	$16,715,662	3403	$25,073,494	3921	$27,781,120
Components with nickel alloys or unsuitable stainless steels	231	$4,340,309	346	$6,510,463	291	$5,890,476
Components with unsuitable material options (selection to be confirmed)	1723	$24,451,461	2584	$36,677,191	3462	$43,874,632
Components without known material information	502	$6,032,472	753	$9,048,708	755	$9,827,180
TOTAL PARTS COST		**$51,541,562**		**$77,312,342**		**$87,378,588**
Part delivery (10% of total parts cost)		$5,154,156		$7,731,234		$8,737,859
Site works to perform replacement (calculated per component)	4726	$1,890,240	7088	$2,835,360	8434	$3,373,600
GRAND TOTAL		**$58,585,958**		**$87,878,937**		**$99,490,047**

4.3 REPLACEMENT OF DIAPHRAGM METERS

Permeation through elastomeric diaphragms is anticipated to affect the performance of diaphragm meters to such an extent that there is a need to replace all such components at 100% hydrogen. Estimated costs of replacing the diaphragm meters is estimated in Table 17, with quantities of diaphragm meters per network shown in Table 18 and a cost estimate for each network in Table 19.

Table 17: Estimated unit costs for each type of meter and their respective installation costs

Item	Estimated Cost
Replacement domestic meter (ultrasonic)	$200
Replacement industrial/commercial meter	$1,200
Installation of domestic meter	$50
Installation of industrial/commercial meter	$200

Table 18: Quantity of diaphragm meters per network

Item	AGN SA	AGN Vic	Multinet
Domestic meters	420410	678790	691524
Industrial/commercial meters	33030	3993	29639

Table 19: Estimated costs for diaphragm meter replacement in each network

Item	AGN SA	AGN Vic	Multinet
Domestic meter	$84,082,000	$135,758,000	$138,304,800
Domestic meter installation	$21,020,500	$33,939,500	$34,576,200
Industrial/commercial meter	$39,636,000	$4,791,600	$35,566,800
Industrial meter installation	$6,606,000	$798,600	$5,927,800
TOTAL	**$151,344,500**	**$175,287,700**	**$214,375,600**

4.4 REPLACEMENT OF HAZARDOUS AREA RATED ELECTRICAL EQUIPMENT

Hydrogen as a process fluid can change the Hazardous Area (HA) compliance of electrical equipment due to a change both Gas Group and Temperature Class. Hydrogen is in Gas Group IIC and Temperature Class T1; this is the most volatile Gas group, and therefore it requires the most onerous safeguarding. Therefore, any equipment already installed and operating, but rated for a Gas Group IIA or IIB must be replaced with a gas group IIC equivalent instrument. For the three type of facilities ***City Gate, Field Regulator*** and ***Customer Meter Set*** there are 6 (six) instrument types that require hazardous area rating and hence will be non-compliant with respect to hydrogen use:

1. Flow / Volume Correctors
2. Limit Switches
3. Junction Boxes
4. Temperature Transmitters
5. Solenoids
6. Isolator switch

Estimated costs (+/-50%) of replacing all of non-compliant instruments of each type are summarised in Table 20 to Table 22 below. Three scenarios are provided for consideration:

1. Replace all instruments that are rated for Gas Group IIA and IIB, *and* replace all items with missing information
2. Replace all instruments that are rated for Gas Group IIA and IIB
3. Replace all instruments that are rated for Gas Group IIA and IIB, *and* replace all items with missing information *and* relocate RTU / DBs at 50% of outdoor locations

For all three scenarios, time has been allocated for engineering which includes:

- Creation of datasheets for new Hazardous Area equipment
- Design/Review for new junction box(es)
- Installation Scope(s) of Work for all sites with equipment installations
- Cable Calculations / Review for new relocated distribution board locations
- Review / Selection of New relocated Remote Telemetry Unit and distribution board locations.

All of the new (replacement) instrumentation pricing has been based on equipment that is compliant for gas group IIC, temperature class T1 and are appropriate for use in the indicated zone identified in the provided information. Where zoning information was not provided/available, HA Zone 1 was assumed for the specification of equipment. If required, GPA can provide the datasheet and IECEx certificate for all new specified equipment.

The estimates apply to the three networks (AGN SA, AGN Vic and Multinet). The estimates are based upon there being **50 "City Gate"** Sites Across Victoria and South Australia, **589 "Field Regulator"** Sites Across Victoria and South Australia and **838 "Customer Meter Set"** Sites Across Victoria and South Australia.

Refer to Appendix 3 for a detailed cost estimate and list of assumptions for the upgrade of all HA rated electrical equipment that is not already HA rated for Gas Group IIC.

Table 20: Number of Facilities

Type of Facility	AGN SA	AGN Vic	Multinet	Total
City Gate	3	40	7	**50**
Field Regulators	257	103	229	**589**
Customer Meter Set	253	271	314	**838**

Table 21: Estimated price per unit of each hazardous area rated replacement instrument

Type of Instrument	Manufacturer	Model	Cost	IECEx Certificate
Flow / Volume Correctors	Honeywell	EK 220	$3000	IECEx LCIE 16.0003X
Limit Switches	Honeywell	LS4A1A	$350	Simple Device
Junction Boxes	Pepperl and Fuchs (Govan)	GUB*	$2000	IECEx INE 14.0042X
Temperature Transmitters	Yokogawa	YTA610	$1500	IECEx FMG 16.0014X
Solenoids	Norgren-IMI-Herion	80207 65	$650	IECEx KEM 09.0068X
Isolator switch	Crouse-Hinds	GHG 263	$1325	IECEx BKI 07.0012

Table 22: Cost breakdown for each scenario of hazardous area equipment replacement

Scenario	Equipment and Materials	Installation cost	Engineering and Owners Cost	Uncertainty/ Contingency	Total	% of Total Cost
1 – Total	**$6,467,182**	**$2,510,000**	**$2,064,752**	**$1,987,548**	**$13,029,482**	**100%**
AGN Vic	$2,069,498	$803,200	$660,721	$636,015	$4,169,434	32%
AGN SA	$2,134,170	$828,300	$681,368	$655,891	$4,299,729	33%
Multinet	$2,263,514	$878,500	$722,663	$695,642	$4,560,319	35%
2 –Total	**$5,936,660**	**$2,150,000**	**$1,859,932**	**$1,790,387**	**$11,736,978**	**100%**
AGN Vic	$1,662,265	$602,000	$520,781	$501,308	$3,286,354	28%
AGN SA	$2,077,831	$752,500	$650,976	$626,635	$4,107,942	35%
Multinet	$2,196,564	$795,500	$688,175	$662,443	$4,342,682	37%
3 – Total	**$8,090,720**	**$4,590,000**	**$2,916,566**	**$2,807,511**	**$18,404,797**	**100%**
AGN Vic	$2,427,216	$1,377,000	$874,970	$842,253	$5,521,439	30%
AGN SA	$2,750,845	$1,560,600	$991,632	$954,554	$6,257,631	34%
Multinet	$2,912,659	$1,652,400	$1,049,964	$1,010,704	$6,625,727	36%

APPENDIX 1 220804-LIS-002 ACTIONS REGISTER

Client	Australian Gas Infrastructure Group			Document Title	Document No. (Client / GPA)	Date	1/11/2022	By	MG
Client		GPA	220804	Actions Register	220804-REP-005 - Appendix 1	Rev/ Status	0	Chkd	RC
Project	Network Analysis for State-Wide Feasibility Studies				220804-LIS-002		IFU	QA	DP

Report #	Action or Issue	Item number	Category	Issue / Description / Action	Recommendation	Hydrogen percentage
Exclusions	Action	1	Pipelines	Assess licensed transmission pipelines with MAOP above 2,800 kPag or design factor above 0.4	Further investigation	Any
1	Action	2	Pipelines	Refine the critical defect length estimate for all pipelines with a design factor 0.3, and perform SMS if required	SMS	100%
1	Action	3	Pipelines	Confirm material composition of unknown section of AGN Vic PL215 Morwell to Tramway Rd to show material suitability for hydrogen use	Testing	100%
1	Action	4	Pipelines	Perform toughness testing on pipeline material from AGN SA M5 Prospect to Brompton to show material suitability for hydrogen use	Testing	Any
1	Action	5	Pipelines	Confirm pressure cycling regime for each pipeline satisfies fatigue screening criteria provided in 220804-REP-001	Further investigation	Any
Exclusions	Action	6	Pipelines	Collaborate with owners of any other pipelines within the network area to complete the assessment	Further investigation	Any
1	Action	7	Piping	Perform testing on distribution piping to assess mechanical joint leakage with 100% hydrogen	Testing	100%
2 & 3	Action	8	Components; Pipelines	Ensure all future pipeline repairs are performed using hydrogen compatible materials and methods – consult with manufacturers to confirm. For instance, obtain superior seal materials than Buna-N for improved compatibility of pipeline repair fittings, and use welded connections (electrofusion couplings) for all repairs.	Consult manufacturers; update procedures	Any
1 & 2	Action	9	Components; Piping	Replace all cast iron piping and components (e.g. valves and regulators) used at pressures above 7 kPag unless further testing is performed, or data/advice can be obtained from other jurisdictions supporting the use of cast iron at higher pressures.	Testing	Any
Exclusions	Action	10	Components	Investigate hydrogen suitability of any large or high pressure components, such as components used at pressures above 2,800 kPag, or components installed up stream of city gates (e.g. compressors or water bath heaters).	Further investigation	Any
2	Action	11	Components	Perform literature review (and testing if required) on materials for which there is little data (e.g. Zamak and some aluminium alloys) to better understand their performance in hydrogen service. Replace components containing those materials if hydrogen suitability is not confirmed.	Further investigation	Any
2 & 3	Action	12	Components	Consult manufacturers for specific recommendations regarding lubricants, sealants and adhesives.	Consult manufacturers	Any
2	Action	13	Components	Obtain records for components for which material specifications were not found. If no records are found, these components may not be suitable for hydrogen service and should be replaced.	Further investigation	Any
2	Action	14	Components	Consult manufacturers for specific recommendations regarding metering components and instrumentation such as pressure/temperature gauges.	Consult manufacturers	Any
2	Action	15	Components	Closely monitor the performance in hydrogen of regulators and meters with diaphragms made from permeable elastomers such as EPDM, Buna-N and any unspecified rubbers. Investigate the potential for deterioration of performance of the elastomers, including ability to achieve correct pressure/flowrate.	Monitoring; further investigation	Any
2	Action	16	Components	Increase the leak and performance monitoring and observation of failure frequencies of filters and strainers	Monitoring	Any
2	Action	17	Components	Risk assess or test zinc components used in domestic gas meter fittings and monitor for leaks after the initial conversion.	Risk assessment / further investigation; monitoring	Any
2	Action	18	Components	Examine the application of any components that use precipitation hardened and martensitic stainless steels and replace if a risk of failure is unacceptable	Risk assessment; replacement	Any
2	Action	19	Components	Perform risk assessments on possible loss of isolation for all components that have pressure-containing parts made of nickel alloys or any untested aluminium alloys. Replace if risk is unacceptable.	Risk assessment; replacement	Any
2	Action	20	Components	Perform risk assessments on possible loss of isolation for all components containing elastomers that are listed as “C: Confirm” in the Material Compatibility table (220804-REP-002 Table 2), including EPDM, Buna-N, PEEK, Acetal, Polyurethane, Hydrin, natural rubber, fluorosilicone, and any unspecified elastomers (e.g. “synthetic rubber”). Replace if risk is unacceptable.	Risk assessment; replacement	Any
2	Action	21	Components	Confirm materials used in isolation joints and assess their hydrogen suitability	Further investigation	Any
2	Action	22	Components	Replace diaphragm meters	Replacement	100%
2	Action	23	Components	Investigate the use of 1045 Carbon Steel in the Welker Jet regulators to confirm it is not used in a pressure containing part; if it is, further categorisation of this steel is warranted.	Further investigation	Any
3	Action	24	Design of system for safe operation	Ensure total odorant levels are adequate, if not odorising the hydrogen injection stream.	Further investigation	10%
3	Action	25	Design of system for safe operation	Review heater controls at city gate stations, if hard-coded for specific J-T coefficient	Further investigation	10%
3	Action	26	Design of system for safe operation	Review potential impact of carbon-monoxide detector co-sensitivity to hydrogen and replace gas detectors if required.	Further investigation	10%
3	Action	27	Design of system for safe operation	Review the risk of erosion at high velocities, based on potential for inclusion of solid particulates	Further investigation	100%
3	Action	28	Design of system for safe operation	Review the value of colourant for safe detection of ignited leaks	Further investigation	100%
3	Action	29	Design of system for safe operation	Review sizing of natural ventilation systems	Further investigation	100%

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Client		GPA	220804	Actions Register	220804-REP-005 - Appendix 1	Rev/ Status	0	Chkd	RC
Project	Network Analysis for State-Wide Feasibility Studies				220804-LIS-002		IFU	QA	DP

Report #	Action or Issue	Item number	Category	Issue / Description / Action	Recommendation	Hydrogen percentage
3	Action	30	Design of system for safe operation	Review confined spaces procedures to avoid ignition potential, as well as the confined spaces themselves to provide a high-point vent where possible	Further investigation	100%
3	Action	31	Design of system for safe operation	Review the suitability of existing flame detection systems (replace if necessary)	Further investigation	100%
3	Action	32	Design of system for safe operation	Review sizing of pressure relief devices where existing regulators are retained.	Further investigation	100%
3	Action	33	Design of system for safe operation	Determine flow velocities and review thermowell vibration risk	Further investigation	Any
3	Action	34	Design of system for safe operation	Completely audit all HA equipment, and examine changes to HA equipment group ratings (this may result in a need for recertification, replacement or risk-based dispensation for certain electrical devices).	Further investigation	Any
3	Action	35	Design of system for safe operation	Perform a location-specific review of Hazardous Area extents for all HA-rated facilities (Note: at 10% H2 this is unlikely to have a significant impact, but at 100% H2 the impact may be significant)	Further investigation	Any
3	Action	36	Design of system for safe operation	Perform a HAZOP to: 1. Review composition control at the injection points against established limits (include the risk of reverse flow, injecting hydrogen downstream of another existing injection point, and variability of composition of the incoming gas), 2. Assess over-pressure at injection sites.	HAZOP	10%
3	Action	37	Design of system for safe operation	Review changes in AIV/FIV risk with reference to the Energy Institute guidelines. This will likely result in: 1. Monitor noise for regulators that are already marginal with respect to permissible noise levels. 2. Review design of thermowells for revised maximum flow velocity.	Monitoring	Any
3	Action	38	Design of system for safe operation	Monitor piping for any locations that may have developed structural resonance at the revised highest flow velocity.	Monitoring	100%
3	Action	39	Design of system for safe operation	Monitor developments arising from ongoing research; in particular, those establishing standards for hydrogen delivery condition and purity, and customer meter offsets.	Monitoring	Any
3	Action	40	Design of system for safe operation	Decommission gas heaters at city gate stations, if relevant.	Removal/Decommissioning	100%
3	Action	41	Design of system for safe operation	Replace all gas detectors with hydrogen detectors.	Replacement	100%
3	Action	42	Design of system for safe operation	Consider a revision of any leak detection concentration thresholds, (such as 5%LEL for entering confined spaces) though it is expected that 10% accuracy impact will be immaterial.	Update Operating Procedures	10%
3	Action	43	Design of system for safe operation	Consider placing a higher priority on low-energy ignition sources, particularly avoiding static build-up, for example by enforced earthing practices and anti-static clothing (if not already required).	Update Operating Procedures	100%
3	Action	44	Design of system for safe operation	Identify best-practice for confined space entry in hydrogen environments.	Update Operating Procedures	100%
3	Action	45	Design of system for safe operation	Increase proactive leak control measures and consider design alteration options for leak control (e.g. flow-limiting device at meter sets). (Important for 100%, but consider for 10% also)	Update Operating Procedures	100%
3	Action	46	Design of system for safe operation	Modify odorisation control systems as required.	Update Operating Procedures	100%
3	Action	47	Design of system for safe operation	Place less value on the absence of ignition sources during reactive leak response procedures.	Update Operating Procedures	100%
4	Action	48	Downstream Considerations	Assess risk of insufficient consumer piping capacity at 10 mol%. This is a hypothetical issue for piping designed with marginal capacity currently; it will not be the case for piping correctly designed to the graphical or tabulated methods. More detailed modelling could be used to further quantify the risk.	Further investigation	10%
4	Action	49	Downstream Considerations	At the time when 100% hydrogen appliances are installed in a residence, review: 1. Line sizing 2. Consumer piping joint types and any unusual joint materials or compounds, and perform leak detection when commissioning appliances 3. Sizing of natural and mechanical ventilation, where used 4. Clearances around appliances, as required 5. Flue design	Further investigation	100%
4	Action	50	Downstream Considerations	Assess any gaps relating to higher pressure downstream piping (between 7-200 kPag), e.g. industrial fitting lines, which have not been reviewed to the same detail.	Further investigation	Any
Exclusions	Action	51	Downstream Considerations	Investigate hydrogen effects on appliances, flues and any piping downstream of the appliance	Further investigation	Any
4	Action	52	Downstream Considerations	Study PE/AL/PE, PE-X/AL/PE-X multilayer, and PE-Xb pipe materials and joint types for suitability in hydrogen service.	Testing	Any

Client	Australian Gas Infrastructure Group			Document Title	Document No. (Client / GPA)	Date	1/11/2022	By	MG
Client		GPA	220804	Actions Register	220804-REP-005 - Appendix 1	Rev/ Status	0	Chkd	RC
Project	Network Analysis for State-Wide Feasibility Studies				220804-LIS-002		IFU	QA	DP

Report #	Action or Issue	Item number	Category	Issue / Description / Action	Recommendation	Hydrogen percentage
3	Action	53	Ongoing operation and maintenance	Avoid purging with a flammable interface (if practised at all), instead always use an inert gas as a buffer unless the risk of ignition has been accepted.	Further investigation	100%
3	Action	54	Ongoing operation and maintenance	Perform leak survey to locate any existing plastic pipe repairs that may have leakage issues due to using compression fittings.	Further investigation	100%
3	Action	55	Ongoing operation and maintenance	Review cold vent design (e.g. earthing / radius outlets) and noise limits for high-pressure pipelines.	Further investigation	100%
3	Action	56	Ongoing operation and maintenance	Closely monitor a selection of facilities after introducing hydrogen to establish a failure rate benchmark.	Monitoring	Any
3	Action	57	Ongoing operation and maintenance	Confirm that isolation by squeeze-off is sufficiently effective to continue the practice in hydrogen service.	Testing	100%
3	Action	58	Ongoing operation and maintenance	Review burner equipment (as used for flaring) for different fluid properties.	Testing	100%
3	Action	59	Ongoing operation and maintenance	After inerting, avoid introducing air until H2 concentration in N2 is 5% or less. This is a lower target than used in natural gas.	Update Operating Procedures	100%
3	Action	60	Ongoing operation and maintenance	Ensure all leak tests include in-service leak test with hydrogen medium, even if an air leak test has already been conducted.	Update Operating Procedures	100%
3	Action	61	Ongoing operation and maintenance	Only live weld to new approved procedures applicable to hydrogen service of the relevant mol%.	Update Operating Procedures	Any
3	Action	62	Ongoing operation and maintenance	Review approval framework for non-piggable pipelines to ensure they meet the integrity management requirements of ASME B31.12.	Update Operating Procedures	Any
3	Action	63	Ongoing operation and maintenance	Review pipeline condition, particularly for cracks, before introducing hydrogen.	Update Operating Procedures	Any
3	Action	64	Ongoing operation and maintenance	Revise pipeline defect assessment procedures as outlined in ASME B31.12.	Update Operating Procedures	Any
Exclusions	Action	65	Ongoing operation and maintenance	Assess network flow capacity and the ability of the system to deliver energy	Further investigation	Any
5	Action	66	Facilities; Piping	Perform a stress analysis for the piping layouts at each facility to ensure the designs account for increased susceptibility to fatigue in hydrogen service	Stress analysis / further investigation	Any

APPENDIX 2 220804-OTH-001 VALVE AND REGULATOR REPLACEMENT COST ESTIMATE

GPA

Client	Australian Gas Infrastructure Group			Document Title	Document Subtitle	Document No.	Date	1/11/22	By	MG
Client		GPA	220804	Total Installed Cost Estimate	Replacement of hydrogen-incompatible regulators and valves	220804-REP-005 - Appendix 2	Rev/ Status	0	Chkd	RC
Project	Network Analysis for State-Wide Feasibility Studies					220804-OTH-001		IFU	QA	DP

Item	Description	Vendor/ Contractor	Size/People	AGN SA	AGN Vic	MULTINET	Unit	Rate/Lump Sum	Assumptions	Amount AGN SA	Amount AGN Vic	Amount Multinet
A.Equipment and Materials												
1	**Valves with cast iron and martensitic stainless steel**											
1.1	**Components**											
1.1.1	Brook B600E Gate valve		1	0	0	0		$ 1,000.00		$ -	$ -	$ -
1.1.2	Keystone AR2 Butterfly valve		1	1.6	2.4	5		$ 1,000.00		$ 1,600.00	$ 2,400.00	$ 5,000.00
1.1.3								$ -				
1.2	**Related parts [NOTE 6]**											
1.2.1	Gaskets		2	1.6	2.4	5		$ 10.00	Assume 2 per component	$ 32.00	$ 48.00	$ 100.00
1.2.2	Stud bolts		16	1.6	2.4	5		$ 1.00	Assume 16 per component	$ 25.60	$ 38.40	$ 80.00
1.2.3			0			0		$ -				$ -
									Total	$ 1,657.60	$ 2,486.40	$ 5,180.00
2	**Cast iron components**											
2.1	**Components**											
2.1.1	Audco CL125 Cast iron series plug valve		1	514	771	1000		$ 1,000.00		$ 514,000.00	$ 771,000.00	$ 1,000,000.00
2.1.2	John Valves FIG 600 ball valve		1	0	0	40		$ 1,000.00		$ -	$ -	$ 40,000.00
2.1.3	Fisher 298T Regulator		1	24	37	30		$ 20,000.00		$ 488,000.00	$ 732,000.00	$ 600,000.00
2.1.4	Fisher 99 Pilot Regulator		1	18	28	50		$ -		$ -	$ -	$ -
2.1.5	Fisher 61 Pilot Regulator		1	152	229	200		$ -		$ -	$ -	$ -
2.1.6	Mooney Flowmax Regulator		1	4	7	0		$ 20,000.00		$ 88,000.00	$ 132,000.00	$ -
2.1.7	AMC Reliance 1800 with pilot Regulator		1	1399	2098	2500		$ 10,000.00		$ 13,988,000.00	$ 20,982,000.00	$ 25,000,000.00
2.1.8	AMC Reliance 3000 Regulator		1	119	178	100		$ 10,000.00		$ 1,188,000.00	$ 1,782,000.00	$ 1,000,000.00
2.1.9	AMC Reliance 3010 Regulator		1	0	0	0		$ 10,000.00		$ -	$ -	$ -
2.1.10	AMC Reliance 1203 Pilot Regulator		1	0	1	0		$ -		$ -	$ -	$ -
2.1.11	Elster Jeavons J125 Regulator		1	10	14	0		$ 10,000.00		$ 96,000.00	$ 144,000.00	$ -
2.1.12	Sensus 243 RPC Regulator		1	27	41	0		$ 10,000.00		$ 272,000.00	$ 408,000.00	$ -
2.1.13	Donkins BD240R-290 Regulator		1	0	0	0		$ 10,000.00		$ -	$ -	$ -
2.1.14								$ -				
2.2	**Related parts**											
2.2.1	Gaskets		2	2268	3403	3920		$ 10.00	Assume 2 per component	$ 45,368.00	$ 68,052.00	$ 78,400.00
2.2.2	Stud bolts		16	1754	2632	3920		$ 1.00	Assume 16 per component	$ 36,294.40	$ 54,441.60	$ 62,720.00
2.2.3			0			0		$ -				$ -
									Total	$ 16,715,662.40	$ 25,073,493.60	$ 27,781,120.00
3	**Components to be risk assessed (nickel alloys or unsuitable stainless steels)**											
3.1	**Components**											
3.1.1	Richards R43, R723, R733		1	10	14	0		$ 1,000.00		$ 9,600.00	$ 14,400.00	$ -
3.1.2	PBV 5800, 6800		1	0	0	0		$ 1,000.00		$ -	$ -	$ -
3.1.3	Sferova TM2/TM3		1	6	10	0		$ 1,000.00		$ 6,400.00	$ 9,600.00	$ -
3.1.4	AMC Axial Flow Valve/Radial Flow Valve		1	208	311	289		$ 20,000.00		$ 4,152,000.00	$ 6,228,000.00	$ 5,780,000.00
3.1.5	Pietro Fiorentini Reflux 819 FO		1	3	5	2		$ 50,000.00		$ 160,000.00	$ 240,000.00	$ 100,000.00
3.1.6	Crosby 951 PRV		1	4	6	0		$ 1,000.00		$ 4,000.00	$ 6,000.00	$ -
3.1.7	Swagelok Needle valve		1	0	0	0		$ 100.00	[NOTE 4]	$ -	$ -	$ -
3.2	**Related parts**											
3.2.1	Gaskets		2	231	346	291		$ 10.00	Assume 2 per component	$ 4,616.00	$ 6,924.00	$ 5,820.00
3.2.2	Stud bolts		16	221	332	291		$ 1.00	Assume 16 per component	$ 3,692.80	$ 5,539.20	$ 4,656.00
3.2.3			0					$ -				$ -
									Total	$ 4,340,308.80	$ 6,510,463.20	$ 5,890,476.00

GPA

Client	Australian Gas Infrastructure Group		Document Title	Document Subtitle	Document No.	Date	1/11/22	By	MG
Client		GPA 220804	Total Installed Cost Estimate	Replacement of hydrogen-incompatible regulators and valves	220804-REP-005 - Appendix 2	Rev/ Status	0	Chkd	RC
Project	Network Analysis for State-Wide Feasibility Studies				220804-OTH-001		IFU	QA	DP

Item	Description	Vendor/ Contractor	Size/People	AGN SA	AGN Vic	MULTINET	Unit	Rate/Lump Sum	Assumptions	Amount		
										AGN SA	AGN Vic	Multinet
4	**Components that need material selection confirmed**											
4.1	**Components**											
4.1.1	Nordstrom plug valve		1	0	0	0		$ 1,000.00		$ -	$ -	$ -
4.1.2	Audco M Series plug valve (steel)		1	120	179	1000		$ 1,000.00		$ 119,600.00	$ 179,400.00	$ 1,000,000.00
4.1.3	Audco Super H plug valve		1	146	219			$ 1,000.00		$ 146,000.00	$ 219,000.00	
4.1.4	Keystone F2 Butterfly valve		1	5	7	0		$ 1,000.00		$ 4,800.00	$ 7,200.00	$ -
4.1.5	Bray S31-713 Butterfly valve		1	0	0	10		$ 1,000.00		$ -	$ -	$ 10,000.00
4.1.6	Fisher OSE small bore valve		1	7	11	0		$ 200.00		$ 1,440.00	$ 2,160.00	$ -
4.1.7	Gorter Cocon 1-12 Regulator		1	9	14	10		$ 50,000.00		$ 460,000.00	$ 690,000.00	$ 500,000.00
4.1.8	Fisher 620 Regulator		1	7	10	0		$ 20,000.00		$ 136,000.00	$ 204,000.00	$ -
4.1.9	Fisher 627 Regulator		1	482	724	1000		$ 20,000.00		$ 9,648,000.00	$ 14,472,000.00	$ 20,000,000.00
4.1.10	Fisher 289 Regulator		1	342	514	500		$ 20,000.00		$ 6,848,000.00	$ 10,272,000.00	$ 10,000,000.00
4.1.11	Fisher 299 Regulator		1	157	236	500		$ 20,000.00		$ 3,144,000.00	$ 4,716,000.00	$ 10,000,000.00
4.1.12	Fisher 166 Regulator		1	0	0	0		$ -		$ -	$ -	$ -
4.1.13	Fisher EZR Pilot Regulator		1	88	133	100		$ -		$ -	$ -	$ -
4.1.14	Fisher 66 Pilot Regulator		1	0	0	30		$ -		$ -	$ -	$ -
4.1.15	Fisher 98H PRV		1	2	2	0		$ 1,000.00		$ 1,600.00	$ 2,400.00	$ -
4.1.16	Mooney Flowgrid FG/SG Regulator		1	103	154	0		$ 20,000.00		$ 2,056,000.00	$ 3,084,000.00	$ -
4.1.17	AMC Reliance Pilot Z138 / Z&ZSC Regulator		1	163	245	200		$ -		$ -	$ -	$ -
4.1.18	Donkins 226 MK2 / MK3 Regulator		1	37	56	40		$ 20,000.00		$ 744,000.00	$ 1,116,000.00	$ 800,000.00
4.1.19	Pietro Fiorentini Dival 100/160/250/600 Regulator		1	44	66	50		$ 20,000.00		$ 880,000.00	$ 1,320,000.00	$ 1,000,000.00
4.1.20	Pietro Fiorentini Norval Regulator		1	3	5	5		$ 20,000.00		$ 64,000.00	$ 96,000.00	$ 100,000.00
4.1.21	Pietro Fiorentini Aperval Regulator		1	7	10	15		$ 20,000.00		$ 136,000.00	$ 204,000.00	$ 300,000.00
4.1.22	Pietro Fiorentini Reval 182 Regulator		1	0	0	2		$ 20,000.00		$ -	$ -	$ 40,000.00
4.2	**Related parts**											
4.2.1	Gaskets		2	1723	2584	3462		$ 10.00	Assume 2 per component	$ 34,456.00	$ 51,684.00	$ 69,240.00
4.2.2	Stud bolts		16	1723	2584	3462		$ 1.00	Assume 16 per component	$ 27,564.80	$ 41,347.20	$ 55,392.00
4.2.3			0					$ -				$ -
									Total	$ 24,451,460.80	$ 36,677,191.20	$ 43,874,632.00
5	**Components without known material information**											
5.1.	**Components**											
5.1.1	Cameron WKM R603 NH valve		1	2	4	0		$ 1,000.00		$ 2,400.00	$ 3,600.00	$ -
5.1.2	Richards R346 valve		1	0	0	0		$ 1,000.00		$ -	$ -	$ -
5.1.3	Richards R46 valve		1	0	0	0		$ 1,000.00		$ -	$ -	$ -
5.1.4	Richards 93300A RP6B MK3 valve		1	0	0	0		$ 1,000.00		$ -	$ -	$ -
5.1.5	Gorter Cocon 13, 26 regulators		1	16	24	40		$ 50,000.00		$ 800,000.00	$ 1,200,000.00	$ 2,000,000.00
5.1.6	Fisher 64 HPR Pilot regulator		1	13	19	0		$ -		$ -	$ -	$ -
5.1.7	Fisher 67F Pilot Regulator		1	26	38	0		$ -		$ -	$ -	$ -
5.1.8	Mooney 15H01G Regulator		1	1	1	0		$ 20,000.00		$ 16,000.00	$ 24,000.00	$ -
5.1.9	AMC Reliance 2000 Regulator		1	110	164	200		$ 10,000.00		$ 1,096,000.00	$ 1,644,000.00	$ 2,000,000.00
5.1.10	AMPY Email 300 Spec 23, 59, 68 and 78 Regulators		1	276	413	400		$ 10,000.00		$ 2,756,000.00	$ 4,134,000.00	$ 4,000,000.00
5.1.11	Grove Model 80, 81 and 83 Regulators		1	21	32	50		$ 20,000.00		$ 424,000.00	$ 636,000.00	$ 1,000,000.00
5.1.12	Reynolds 670, 678 and 682 Regulators		1	0	0	5		$ 10,000.00		$ -	$ -	$ 50,000.00
5.1.13	Donkins 688 and 999 Regulators		1	3	4	0		$ 10,000.00		$ 28,000.00	$ 42,000.00	$ -
5.1.14	Pietro Fiorentini FEX, VS/AM		1	7	11	0		$ 10,000.00		$ 72,000.00	$ 108,000.00	$ -
5.1.15	Pietro Fiorentini Dival 300 & 512 LTR and Reval Regulators		1	0	0	10		$ 10,000.00		$ -	$ -	$ 100,000.00
5.1.16	RMG 650 and 850 Regulators		1	0	0	0		$ 20,000.00		$ -	$ -	$ -
5.1.17	Welker Jet Regulator		1	16	25	10		$ 50,000.00		$ 820,000.00	$ 1,230,000.00	$ 500,000.00
5.1.18	Fisher 161 Pilot Regulator		1	2	2	5		$ -		$ -	$ -	$ -
5.1.19	Fisher 168 Pilot Regulator		1	7	10	15		$ -		$ -	$ -	$ -
5.1.20	Fisher EZH Pilot Regulator		1	3	5	5		$ -		$ -	$ -	$ -
5.1.21	Honeywell HON 5020 Regulator		1	0	0	0		$ 20,000.00		$ -	$ -	$ -
5.1.22	EDMI / Atlas TR200B, TR143 Regulators		1	0	0	15		$ 10,000.00		$ -	$ -	$ 150,000.00
5.2	**Related parts**											
5.2.1	Gaskets		2	502	753	755		$ 10.00	Assume 2 per component	$ 10,040.00	$ 15,060.00	$ 15,100.00
5.2.2	Stud bolts		16	502	753	755		$ 1.00	Assume 16 per component	$ 8,032.00	$ 12,048.00	$ 12,080.00
5.2.3			0					$ -				$ -
									Total	$ 6,032,472.00	$ 9,048,708.00	$ 9,827,180.00
									Sum of Direct Cost (A. Equipment)	$ 51,541,561.60	$ 77,312,342.40	$ 87,378,588.00

GPA

Client	Australian Gas Infrastructure Group			Document Title	Document Subtitle	Document No.	Date	1/11/22	By	MG
Client		GPA	220804	Total Installed Cost Estimate	Replacement of hydrogen-incompatible regulators and valves	220804-REP-005 - Appendix 2	Rev/ Status	0	Chkd	RC
Project	Network Analysis for State-Wide Feasibility Studies					220804-OTH-001		IFU	QA	DP

Item	Description	Vendor/ Contractor	Size/People	AGN SA	AGN Vic	MULTINET	Unit	Rate/Lump Sum	Assumptions	Amount		
										AGN SA	AGN Vic	Multinet
B.Installation												
1	**Procurement**											
1.1	**Transport**											
1.1.1	Delivery Cost		1	1	1	1		$ -	Assume 10% equipment cost	$ 5,154,156.16	$ 7,731,234.24	$ 8,737,858.80
1.1.2			0			0		$ -		$ -	$ -	$ -
1.1.3			0			0		$ -				$ -
									Total	$ 5,154,156.16	$ 7,731,234.24	$ 8,737,858.80
2	**Site Work**											
2.1	**Mobilisation / Demobilisation**											
2.1.1	Travel to/from site		0	0	0	0		$ -	Included in works cost			$ -
2.1.2								$ -				
2.1.3								$ -				
2.2	**Works**											
2.2.1	Demolition/Installation/Commissioning		2	4726	7088	8434		$ 200.00	Assume 2 people @ $50/hr for 4 hrs per	$ 1,890,240.00	$ 2,835,360.00	$ 3,373,600.00
2.2.2			0					$ -	component [NOTE 3]	$ -	$ -	$ -
2.2.3			0					$ -				$ -
									Total	$ 1,890,240.00	$ 2,835,360.00	$ 3,373,600.00
									Sum of Direct Cost (B. Installation)	$ 7,044,396.16	$ 10,566,594.24	$ 12,111,458.80
									GRAND TOTAL	$ 58,585,957.76	$ 87,878,936.64	$ 99,490,046.80

NOTES

1. Numbers highlighted in yellow refer to components which are believed to exist in the relevant network, but no quantities for that component are available
2. Quantities for AGN SA and AGN Vic have been taken from a database covering both networks. It has been assumed that the components are split evenly across the two networks, in the proportion of 60% in the AGN Vic network and 40% in the AGN SA network
3. Site work costs are based on the assumption of 2 people at $50/hr for 4 hours per component. 4 hours is thought to be adequate for mobilisation, demolition, installation, commissioning and demobilisation for one component, with the expectation that this is a conservative scenario, as mobilisation and demobilisation will be common for multiple components at the same facility.
4. Swagelok needle valve was estimated at $100 each
5. Costs for individual components except the Swagelok needle valve (Note 3) are based on the following prices:

Large bore valve	$1,000
Small bore valve	$200
Customer regulator	$10,000
Network regulator	$20,000
City Gate regulator	$50,000
Pilot regulator	0

6. Costs for loose items are based on the following prices:

Gaskets	$10
Stud bolts	$1

APPENDIX 3 210620-OTH-002 HA EQUIPMENT REPLACEMENT COST ESTIMATE

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Total Installed Cost Estimate (Electrical)

AHC - Network Analysis for State-Wide Feasibility

Australian Gas Infrastructure Group

GPA Document No: 210620-OTH-002

Client Document Number: TBA

Client Project No: TBA

Rev	Date	By	Checked	QA	Description
A	3/12/2021	TJM	DBJ	DBJ	Issued for Client Review
0	13/12/2021	TJM	DBJ	DBJ	Issued for Use

	Document Title	Document Subtitle
	Total Installed Cost Estimate	Executive Summary

Client	Australian Gas Infrastructure Group			Document No. (Client / GPA)
Client	TBA	GPA	210620	TBA
Project	AHC - Network Analysis for State-Wide Feasibility Studies			210620-OTH-002

Basis of Estimate	
Estimate Type	Class 2
Cost Basis	AUD 2021
Accuracy Range	+/- 50%
Contingency	Allowance for Variation in Cost of Goods due to shortages and/or yearly price increases
Uncertainty	TBD - Uncertainty is around H2 % and whether the Zoning and Extents remain the same

Scope Information	
Option	**Description of Scope**
1	Change of Gas to Hydrogen: Gas Group changes to IIC, Temp Class Changes to T1.
2	Any Hazardous Area equipment that is not suitable for Gas Group IIC And/OR Temp Class T1 is required to be replaced with compliant equilivant.
3	
4	
5	
6	
7	
8	

Methodology Statement	
Methodology	
1	
2	
3	
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8	

GPA	Document Title	Document Subtitle
	Total Installed Cost Estimate	**Executive Summary**

Client	**Australian Gas Infrastructure Group**			**Document No. (Client / GPA)**
Client	**TBA**	**GPA**	**210620**	**TBA**
Project	**AHC - Network Analysis for State-Wide Feasibility Studies**			**210620-OTH-002**

Cost Summary

Option	Equipment and Materials	Installation Costs	Engineering and Owners Costs	Uncertainty/ Contingency/Escalation	Total Installed Cost	% of Total Cost
1 - Total	**$ 6,467,182**	**$ 2,510,000**	**$ 2,064,752**	**$ 1,987,548**	**$ 13,029,482**	**100%**
AGN Vic	$ 2,069,498	$ 803,200	$ 660,721	$ 636,015	$ 4,169,434	32%
AGN SA	$ 2,134,170	$ 828,300	$ 681,368	$ 655,891	$ 4,299,729	33%
Multinet	$ 2,263,514	$ 878,500	$ 722,663	$ 695,642	$ 4,560,319	35%
2 -Total	**$ 5,936,660**	**$ 2,150,000**	**$ 1,859,932**	**$ 1,790,387**	**$ 11,736,978**	**100%**
AGN Vic	$ 1,662,265	$ 602,000	$ 520,781	$ 501,308	$ 3,286,354	28%
AGN SA	$ 2,077,831	$ 752,500	$ 650,976	$ 626,635	$ 4,107,942	35%
Multinet	$ 2,196,564	$ 795,500	$ 688,175	$ 662,443	$ 4,342,682	37%
3 - Total	**$ 8,090,720**	**$ 4,590,000**	**$ 2,916,566**	**$ 2,807,511**	**$ 18,404,797**	**100%**
AGN Vic	$ 2,427,216	$ 1,377,000	$ 874,970	$ 842,253	$ 5,521,439	30%
AGN SA	$ 2,750,845	$ 1,560,600	$ 991,632	$ 954,554	$ 6,257,631	34%
Multinet	$ 2,912,659	$ 1,652,400	$ 1,049,964	$ 1,010,704	$ 6,625,727	36%

GPA	Document Title	Document Subtitle
	Total Installed Cost Estimate	**Assumptions & Exclusions**

Client	Australian Gas Infrastructure Group			Document No. (Client / GPA)
Client	TBA	GPA	210620	**TBA**
Project	AHC - Network Analysis for State-Wide Feasibility Studies			**210620-OTH-002**

Assumptions	
REF	**Description**
1	That the gas network is to be used at 100% Hydrogen.
2	For Options 1 and 2 the Current Hazardous Area Zoning extents are not affected by Hydrogen introduction. However Option 3 allows for an RTU and Power Distribution board to be relocated on the basis of the increase in zoning size
3	Information provided in the spreadsheets: **"Gas Station"** and **"Meter Set" are** representative of a typical ***City Gate*** **,** ***Field Regulator*** and ***Customer Meter Set*** facilities.
4	That there are **50 "City Gate"** Sites Across Victoria and South Australia
5	That there are **589 "Field Regulator"** Sites Across Victoria and South Australia
6	That there are **838 "Customer Meter Set"** Sites Across Victoria and South Australia
7	Remote Telemetry Units and Distribution Boards that are to be relocated will move at least 20m
8	That underground stations will not have an increased Hazardous Area zoning with the introduction of Hydrogen.
9	That all AGN, Multinet sites are similar in design and therefore efficiencies of specification can be made.
10	

Exclusions	
REF	**Description**
1	Demolition and other decomissioning costs
2	Spare parts
3	Hazardour Area Dossier and Inspection sheets
4	Intrinsically safe Calculations
5	Engineering Design and/or review of Hazardous Area Classification
6	Any Ancillary costs associated with electrical installation that is not labour, i.e Cabling, Glands and Consumables
7	

GPA	Document Title	Document Subtitle
	Total Installed Cost Estimate (Electrical)	**Option 1: Replace All NC Equipment**

Client Name	**Australian Gas Infrastructure Group**			**Document No. (Client / GPA)**
Client Project No.	**TBA**	**GPA Project No.**	**210620**	**TBA**
Project Name	**AHC - Network Analysis for State-Wide Feasibility Studies**			**210620-OTH-002**

Equipment and Materials			
Item	**Description**	**Estimate**	**Notes**
1	Non-Compliant Instruments : All intruments that rated for Gas Group IIA and IIB Replaced, As Well As Items that Items With Missing Information Replaced	$ 5,727,400.00	**TOTAL**
2	Engineering Design and Deliverables	$ 739,782.00	**TOTAL**
3	AGN Victoria	$ 2,011,383.00	**31%**
4	AGN South Australia	$ 2,160,153.00	**33%**
5	Multinet Victoria	$ 2,288,249.00	**35%**
6	-	-	
	Total	**$ 6,467,182**	**100%**

Installation			
Item	**Description**	**Estimate**	**Notes**
1	Installation Works	$ 2,510,000	**TOTAL**
2	AGN Victoria	$ 780,644.70	**31%**
3	AGN South Australia	$ 838,384.33	**33%**
4	Multinet Victoria	$ 888,100.10	**35%**
5	-	$ -	
	Total	**$ 2,510,000**	**100%**

Engineering and Owners Costs				
Item	**Description**	**Factor**	**Factored Estimate**	**Notes**
1	Project Management / Administration (Owner's Cost)	5%	$ 448,859	
2	Engineering	5%	$ 448,859	
3	Procurement (Owner's Cost)	2%	$ 179,544	
4	Fabrication/Construction Management (Owner's Cost)	6%	$ 538,631	
5	Commissioning (Owner's Cost)	5%	$ 448,859	
	Total		$ 2,064,752	

Uncertainty	10%	$ 1,104,193	
Contingency	5%	$ 552,097	
Escalation	3%	$ 331,258	

Grand Total	**$ 13,029,482**	

Notes	
1	Assumumption that Equipment where insufficient information is available (Model Number, HA certification, Funtion, Zone) are all Non-Compliant and need to be replaced.
2	Installation Contractors work a 10 (ten) Hour Day at $100/Hour
3	GPA Engineers work a 8 (eight) Hour Day at $146/Hour

GPA	Document Title	Document Subtitle
	Total Installed Cost Estimate (Electrical)	**Option 2: Replace ONLY Gas Group IIA and IIB Equipment**

Client Name	**Australian Gas Infrastructure Group**			**Document No. (Client / GPA)**
Client Project No.	**TBA**	**GPA Project No.**	**210620**	**TBA**
Project Name	**AHC - Network Analysis for State-Wide Feasibility Studies**			**210620-OTH-002**

Equipment and Materials

Item	Description	Estimate	Notes
1	Non-Compliant Instruments : Replace All intruments that are rated for Gas Group IIA and IIB Replaced	$ 5,307,400.00	**TOTAL**
2	Engineering Design and Deliverables	$ 629,260.00	**TOTAL**
3	AGN Victoria	$ 1,616,048.00	27%
4	AGN South Australia	$ 2,057,192.00	35%
5	Multinet Victoria	$ 2,203,485.00	37%
6	-	-	
	Total	**$ 5,936,660**	**100%**

Installation

Item	Description	Estimate	Notes
1	Installation Works	$ 2,150,000	**TOTAL**
2	AGN Victoria	$ 580,500	27%
3	AGN South Australia	$ 752,500	35%
4	Multinet Victoria	$ 795,500	37%
5	-	$ -	
	Total	**$ 2,150,000**	**100%**

Engineering and Owners Costs

Item	Description	Factor	Factored Estimate	Notes
1	Project Management / Administration (Owner's Cost)	5%	$ 404,333	
2	Engineering	5%	$ 404,333	
3	Procurement (Owner's Cost)	2%	$ 161,733	
4	Fabrication/Construction Management (Owner's Cost)	6%	$ 485,200	
5	Commissioning (Owner's Cost)	5%	$ 404,333	
	Total		$ 1,859,932	

Uncertainty	10%	$ 994,659	
Contingency	5%	$ 497,330	
Escalation	3%	$ 298,398	

Grand Total	**$ 11,736,978**	

Notes

1	Installation Contractors work a 10 (ten) Hour Day at $100/Hour
2	GPA Engineers work a 8 (eight) Hour Day at $146/Hour
3	Only Instruments that are identified as gas group IIA or IIB are to be replaced

Document Title	Document Subtitle
Total Installed Cost Estimate (Electrical)	**Option 3: Replace All NC Equipment and 50% of RTU/DB**

Client Name	**Australian Gas Infrastructure Group**			**Document No. (Client / GPA)**
Client Project No.	**TBA**	**GPA Project No.**	**210620**	**TBA**
Project Name	**AHC - Network Analysis for State-Wide Feasibility Studies**			**210620-OTH-002**

Equipment and Materials

Item	Description	Estimate	Notes
1	Non-Compliant Instruments : All intruments that rated for Gas Group IIA and IIB Replaced, As Well As Items that Items With Missing Information Replaced And RTU / DB's to be relocated at 50% of outdoor locations	$ 7,007,400.00	TOTAL
2	Engineering Design and Deliverables	$ 1,083,320.00	TOTAL
3	AGN Victoria	$ 2,380,213.00	29%
4	AGN South Australia	$ 2,748,354.00	34%
5	Multinet Victoria	$ 2,893,321.00	36%
6	-	-	
	Total	**$ 8,090,720**	**100%**

Installation

Item	Description	Estimate	Notes
1	Installation Works	$ 4,590,000	TOTAL
2	AGN Victoria	$ 1,377,000	30%
3	AGN South Australia	$ 1,560,600	34%
4	Multinet Victoria	$ 1,652,400	36%
5	-	$ -	
	Total	**$ 4,590,000**	**100%**

Engineering and Owners Costs

Item	Description	Factor	Factored Estimate	Notes
1	Project Management / Administration (Owner's Cost)	5%	$ 634,036	
2	Engineering	5%	$ 634,036	
3	Procurement (Owner's Cost)	2%	$ 253,614	
4	Fabrication/Construction Management (Owner's Cost)	6%	$ 760,843	
5	Commissioning (Owner's Cost)	5%	$ 634,036	
	Total		$ 2,916,566	

Uncertainty	10%	$ 1,559,729	
Contingency	5%	$ 779,864	
Escalation	3%	$ 467,919	

Grand Total	**$ 18,404,797**	

Notes

1	Assumumption that Equipment where insufficient information is available (Model Number, HA certification, Funtion, Zone) are all Non-Compliant and need to be replaced.
2	Installation Contractors work a 10 (ten) Hour Day at $100/Hour
3	GPA Engineers work a 8 (eight) Hour Day at $146/Hour
4	50% of Outdoor, Above ground sites RTU and 240VAC DB are to be moved at least 10m from their current location to be outside of the Hazardous Area

Client	Australian Gas Infrastructure Group			Document Title	Document Subtitle	Document No. (Client / GPA)
Client	TBA	GPA	210620	Total Installed Cost Estimate (Electrical)	Option 1	TBA
Project Name	AHC - Network Analysis for State-Wide Feasibility Studies					210620-OTH-002

Calculated
User Input

Item	Description	Vendor/ Contractor	Size/Men	Quantity/Days	Unit	Rate/Lump Sum	Assumptions	Quantity Ranges		Rate/Sum Ranges		Quantity			Rate			Amount		
								Low	High	Low	High	Low	Most Likely	High	Low	Most Likely	High	Low	Most Likely	High
A.Equipment and Materials																				
1	**Non-Compliant Instruments : All intruments that rated for Gas Group IIA and IIB Replaced, As Well As Items that Items With Missing Information Replaced**																			
	Customer Meter Sets																			
1.1	CULC-FQT-001 - Flow / Volume Corrector **GSP, 5250019446**	Honeywell	1	838	EK 220	$ 3,000.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	838	838	838	$ 2,100.00	$ 3,000.00	$ 3,900.00	$ 1,759,800.00	$ 2,514,000.00	$ 3,268,200.00
	Field Regulators																			
1.2	NORTH-ZS-003 - Limit Switch **City Gate Station, P4-294, NORTH STREET ALBURY**	Honeywell	1	589	LS4A1A	$ 350.00	Current model Non Compliant for Gas Group IIC	0%	0%	-30%	30%	589	589	589	$ 245.00	$ 350.00	$ 455.00	$ 144,305.00	$ 206,150.00	$ 267,995.00
1.3	NORTH-JB-001 - Junction Box **City Gate Station, P4-294, NORTH STREET ALBURY**	Pepperl and Fuchs (Govan)	1	589	GUB*	$ 2,000.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	589	589	589	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 824,600.00	$ 1,178,000.00	$ 1,531,400.00
1.4	NORTH-JB-003 - Junction Box **City Gate Station, P4-294, NORTH STREET ALBURY**	Pepperl and Fuchs (Govan)	1	589	GUB*	$ 2,000.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	589	589	589	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 824,600.00	$ 1,178,000.00	$ 1,531,400.00
	City Gate Stations																			
1.5	OBR-TT-002 - Temperature Transmitter **City Gate, P8-002, WODONGA CITY GATE**	Yokogawa	1	50	YTA610	$ 1,500.00	Model Number for current model not available: Assumed Non-Compliance	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ 52,500.00	$ 75,000.00	$ 97,500.00
1.6	ORB-SV-001 - Solenoid **City Gate, P8-002, WODONGA CITY GATE**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.7	ORB-SV-002 - Solenoid **City Gate, P8-002, WODONGA CITY GATE**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.8	ORB-SV-003- Solenoid **City Gate, P8-002, WODONGA CITY GATE**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.9	CULC-UV-0028 - Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.10'	CULC-TCV-0025 - Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.11	CULC-FE-002 - Flow Meter **GSP, 5250019446**	Motion Sensors	0	0	DMX-001-2	$ -	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	0	0	0	$ -	$ -	$ -	$ -	$ -	$ -
1.12	CULC-FE-003 - Flow Meter **GSP, 5250019446**	Motion Sensors	0	0	DMX-001-2	$ -	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	0	0	0	$ -	$ -	$ -	$ -	$ -	$ -
1.13	CULC-FE-001 - Flow Meter **GSP, 5250019446**	Motion Sensors	0	0	DMX-001-2	$ -	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	0	0	0	$ -	$ -	$ -	$ -	$ -	$ -
1.14	CULC-TT-001 - Temperature Transmitter **GSP, 5250019446**	Yokagowa	1	50	YTA610	$ 1,500.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ 52,500.00	$ 75,000.00	$ 97,500.00
1.15	CULC-XV-001 Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.16	CULC-XV-002 Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.17	CULC-XV-003 Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.18	CULC-JB-004 - Junction Box **GSP, 5250019446**	Pepperl and Fuchs (Govan)	1	50	GUB*	$ 2,000.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 70,000.00	$ 100,000.00	$ 130,000.00
1.19	CULC-TT-002 - Temperature Tranmitter **GSP, 5250019446**	Yokagowa	1	50	YTA610	$ 1,500.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ 52,500.00	$ 75,000.00	$ 97,500.00
1.2	CULC-ZS-003 - Isolator switch **GSP, 5250019446**	Crouse-Hinds	1	50	GHG 263	$ 1,325.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 927.50	$ 1,325.00	$ 1,722.50	$ 46,375.00	$ 66,250.00	$ 86,125.00
																	Total	$ 4,009,180.00	$ 5,727,400.00	$ 7,445,620.00
																	Sum of Direct Cost	**$ 4,009,180.00**	**$ 5,727,400.00**	**$ 7,445,620.00**
2	**Engineering Design and Deliverables**																			
2.1	**Deliverables**																			
2.1.1	Production of 3255 Unique Datasheets for new equipment		1	206		$ 240,170.00		0%	0%	-5%	5%	1	1	1	$ 228,161.50	$ 240,170.00	$ 252,178.50	$ 228,161.50	$ 240,170.00	$ 252,178.50
2.1.2	Design/Review of 1228 New Junction box(s)		1	308		$ 359,452.00		0%	0%	-5%	5%	1	1	1	$ 341,479.40	$ 359,452.00	$ 377,424.60	$ 341,479.40	$ 359,452.00	$ 377,424.60
2.1.3	Installation Scope of Work for 1477 Unique Sites		1	120		$ 140,160.00		0%	0%	-5%	5%	1	1	1	$ 133,152.00	$ 140,160.00	$ 147,168.00	$ 133,152.00	$ 140,160.00	$ 147,168.00
																	Total	$ 702,792.90	$ 739,782.00	$ 776,771.10
																	Sum of Direct Cost	**$ 702,792.90**	**$ 739,782.00**	**$ 776,771.10**
B.Installation																				
1	**Installation Works**																			
1.1	**Installation of New Field Equipment**																			
	Installation Customer Meter Sets																			
1.1.1	Installation Flow / Volume Corrector		1	502		$ 502,000.00		0%	0%	-30%	30%	1	1	1	$ 351,400.00	$ 502,000.00	$ 652,600.00	$ 351,400.00	$ 502,000.00	$ 652,600.00
	Installation Field Regulators																			
1.1.2	Installation Limit Switch		1	300		$ 300,000.00		0%	0%	-30%	30%	1	1	1	$ 210,000.00	$ 300,000.00	$ 390,000.00	$ 210,000.00	$ 300,000.00	$ 390,000.00
1.1.3	Installation Junction Box		1	589		$ 589,000.00		0%	0%	-30%	30%	1	1	1	$ 412,300.00	$ 589,000.00	$ 765,700.00	$ 412,300.00	$ 589,000.00	$ 765,700.00
1.1.4	Installation Junction Box		1	589		$ 589,000.00		0%	0%	-30%	30%	1	1	1	$ 412,300.00	$ 589,000.00	$ 765,700.00	$ 412,300.00	$ 589,000.00	$ 765,700.00
	City Gate Stations																			
1.1.5	Installation Temperature Transmitter		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.6	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.7	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.8	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.9	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.10	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.11	Installation Flow Meter		0	0		$ -		0%	0%	-30%	30%	1	1	1	$ -	$ -	$ -	$ -	$ -	$ -
1.1.12	Installation Flow Meter		0	0		$ -		0%	0%	-30%	30%	1	1	1	$ -	$ -	$ -	$ -	$ -	$ -
1.1.13	Installation Flow Meter		0	0		$ -		0%	0%	-30%	30%	1	1	1	$ -	$ -	$ -	$ -	$ -	$ -
1.1.14	Installation Temperature Transmitter		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.15	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.16	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.17	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.18	Installation Junction Box		1	50		$ 50,000.00		0%	0%	-30%	30%	1	1	1	$ 35,000.00	$ 50,000.00	$ 65,000.00	$ 35,000.00	$ 50,000.00	$ 65,000.00
1.1.19	Installation Temperature Transmitter		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.20	Installation Isolator switch		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
																	Total	**$ 1,757,000.00**	**$ 2,510,000.00**	**$ 3,263,000.00**

GPA

Client	Australian Gas Infrastructure Group			Document Title	Document Subtitle	Document No. (Client / GPA)
Client	TBA	GPA	210620	Total Installed Cost Estimate (Electrical)	Option 2	TBA
Project Name	AHC - Network Analysis for State-Wide Feasibility Studies					210620-OTH-002

Calculated
User Input

Item	Description	Vendor/ Contractor	Size/Men	Quantity/Days	Unit	Rate/Lump Sum	Assumptions	Quantity Ranges		Rate/Sum Ranges		Quantity			Rate			Amount		
								Low	High	Low	High	Low	Most Likely	High	Low	Most Likely	High	Low	Most Likely	High
A.Equipment and Materials																				
1	Non-Compliant Instruments : Replace All intruments that are rated for Gas Group IIA and IIB Replaced																			
	Customer Meter Sets																			
1.1	CULC-FQT-001 - Flow / Volume Corrector **GSP, 5250019446**	Honeywell	1	838	EK 220	$ 3,000.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	838	838	838	$ 2,100.00	$ 3,000.00	$ 3,900.00	$ 1,759,800.00	$ 2,514,000.00	$ 3,268,200.00
	Field Regulators																			
1.2	NORTH-ZS-003 - Limit Switch **City Gate Station, P4-294, NORTH STREET ALBURY**	Honeywell	1	589	LS4A1A	$ 350.00	Current model Non Compliant for Gas Group IIC	0%	0%	-30%	30%	589	589	589	$ 245.00	$ 350.00	$ 455.00	$ 144,305.00	$ 206,150.00	$ 267,995.00
1.3	NORTH-JB-001 - Junction Box **City Gate Station, P4-294, NORTH STREET ALBURY**	Pepperl and Fuchs (Govan)	1	589	GUB*	$ 2,000.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	589	589	589	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 824,600.00	$ 1,178,000.00	$ 1,531,400.00
1.4	NORTH-JB-003 - Junction Box **City Gate Station, P4-294, NORTH STREET ALBURY**	Pepperl and Fuchs (Govan)	1	589	GUB*	$ 2,000.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	589	589	589	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 824,600.00	$ 1,178,000.00	$ 1,531,400.00
	City Gate Stations																			
1.5	OBR-TT-002 - Temperature Transmitter **City Gate, P8-002, WODONGA CITY GATE**	Yokogawa	0	50	YTA610	$ 1,500.00	Model Number for current model not available: Assumed Non-Compliance	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ -	$ -	$ -
1.6	ORB-SV-001 - Solenoid **City Gate, P8-002, WODONGA CITY GATE**	Norgren-IMI-Herion	0	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ -	$ -	$ -
1.7	ORB-SV-002 - Solenoid **City Gate, P8-002, WODONGA CITY GATE**	Norgren-IMI-Herion	0	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ -	$ -	$ -
1.8	ORB-SV-003- Solenoid **City Gate, P8-002, WODONGA CITY GATE**	Norgren-IMI-Herion	0	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ -	$ -	$ -
1.9	CULC-UV-0028 - Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.10'	CULC-TCV-0025 - Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.11	CULC-FE-002 - Flow Meter **GSP, 5250019446**	Motion Sensors	0	50	DMX-001-2	$ 1,500.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ -	$ -	$ -
1.12	CULC-FE-003 - Flow Meter **GSP, 5250019446**	Motion Sensors	0	50	DMX-001-2	$ 1,500.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ -	$ -	$ -
1.13	CULC-FE-001 - Flow Meter **GSP, 5250019446**	Motion Sensors	0	50	DMX-001-2	$ 1,500.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ -	$ -	$ -
1.14	CULC-TT-001 - Temperature Transmitter **GSP, 5250019446**	Yokagowa	0	50	YTA610	$ 1,500.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ -	$ -	$ -
1.15	CULC-XV-001 Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	0	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ -	$ -	$ -
1.16	CULC-XV-002 Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	0	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ -	$ -	$ -
1.17	CULC-XV-003 Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	0	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ -	$ -	$ -
1.18	CULC-JB-004 - Junction Box **GSP, 5250019446**	Pepperl and Fuchs (Govan)	1	50	GUB*	$ 2,000.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 70,000.00	$ 100,000.00	$ 130,000.00
1.19	CULC-TT-002 - Temperature Tranmitter **GSP, 5250019446**	Yokagowa	0	50	YTA610	$ 1,500.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ -	$ -	$ -
1.2	CULC-ZS-003 - Isolator switch **GSP, 5250019446**	Crouse-Hinds	1	50	GHG 263	$ 1,325.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 927.50	$ 1,325.00	$ 1,722.50	$ 46,375.00	$ 66,250.00	$ 86,125.00
																	Total	$ 3,715,180.00	$ 5,307,400.00	$ 6,899,620.00
																	Sum of Direct Cost	**$ 3,715,180.00**	**$ 5,307,400.00**	**$ 6,899,620.00**

Item	Description	Vendor/ Contractor	Size/Men	Quantity/Days	Unit	Rate/Lump Sum	Assumptions	QR Low	QR High	RSR Low	RSR High	Qty Low	Qty Most Likely	Qty High	Rate Low	Rate Most Likely	Rate High	Amount Low	Amount Most Likely	Amount High
2	**Engineering Design and Deliverables**																			
2.1	**Deliverables**																			
2.1.1	Production of 2186 Unique Datasheets for new equipment		1	140		$ 163,520.00		0%	0%	-5%	5%	1	1	1	$ 155,344.00	$ 163,520.00	$ 171,696.00	$ 155,344.00	$ 163,520.00	$ 171,696.00
2.1.2	Design/Review of 1228 New Junction box(s)		1	308		$ 359,452.00		0%	0%	-5%	5%	1	1	1	$ 341,479.40	$ 359,452.00	$ 377,424.60	$ 341,479.40	$ 359,452.00	$ 377,424.60
2.1.3	Installation Scope of Work for 1477 Unique Sites/Stations		1	91		$ 106,288.00		0%	0%	-5%	5%	1	1	1	$ 100,973.60	$ 106,288.00	$ 111,602.40	$ 100,973.60	$ 106,288.00	$ 111,602.40
																	Total	$ 597,797.00	$ 629,260.00	$ 660,723.00
																	Sum of Direct Cost	**$ 597,797.00**	**$ 629,260.00**	**$ 660,723.00**

Item	Description	Vendor/ Contractor	Size/Men	Quantity/Days	Unit	Rate/Lump Sum	Assumptions	QR Low	QR High	RSR Low	RSR High	Qty Low	Qty Most Likely	Qty High	Rate Low	Rate Most Likely	Rate High	Amount Low	Amount Most Likely	Amount High
B.Installation																				
1	**Installation Works**																			
1.1	**Installation of New Field Equipment**																			
	Installation Customer Meter Sets																			
1.1.1	Installation Flow / Volume Corrector		1	502		$ 502,000.00		0%	0%	-30%	30%	1	1	1	$ 351,400.00	$ 502,000.00	$ 652,600.00	$ 351,400.00	$ 502,000.00	$ 652,600.00
	Installation Field Regulators																			
1.1.2	Installation Limit Switch		1	300		$ 300,000.00		0%	0%	-30%	30%	1	1	1	$ 210,000.00	$ 300,000.00	$ 390,000.00	$ 210,000.00	$ 300,000.00	$ 390,000.00
1.1.3	Installation Junction Box		1	589		$ 589,000.00		0%	0%	-30%	30%	1	1	1	$ 412,300.00	$ 589,000.00	$ 765,700.00	$ 412,300.00	$ 589,000.00	$ 765,700.00
1.1.4	Installation Junction Box		1	589		$ 589,000.00		0%	0%	-30%	30%	1	1	1	$ 412,300.00	$ 589,000.00	$ 765,700.00	$ 412,300.00	$ 589,000.00	$ 765,700.00
	City Gate Stations																			
1.1.5	Installation Temperature Transmitter		0	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ -	$ -	$ -
1.1.6	Installation Solenoid		0	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ -	$ -	$ -
1.1.7	Installation Solenoid		0	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ -	$ -	$ -
1.1.8	Installation Solenoid		0	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ -	$ -	$ -
1.1.9	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.10	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.11	Installation Flow Meter		0	50		$ 50,000.00		0%	0%	-30%	30%	1	1	1	$ 35,000.00	$ 50,000.00	$ 65,000.00	$ -	$ -	$ -
1.1.12	Installation Flow Meter		0	50		$ 50,000.00		0%	0%	-30%	30%	1	1	1	$ 35,000.00	$ 50,000.00	$ 65,000.00	$ -	$ -	$ -
1.1.13	Installation Flow Meter		0	50		$ 50,000.00		0%	0%	-30%	30%	1	1	1	$ 35,000.00	$ 50,000.00	$ 65,000.00	$ -	$ -	$ -
1.1.14	Installation Temperature Transmitter		0	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ -	$ -	$ -
1.1.15	Installation Solenoid		0	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ -	$ -	$ -
1.1.16	Installation Solenoid		0	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ -	$ -	$ -
1.1.17	Installation Solenoid		0	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ -	$ -	$ -
1.1.18	Installation Junction Box		1	50		$ 50,000.00		0%	0%	-30%	30%	1	1	1	$ 35,000.00	$ 50,000.00	$ 65,000.00	$ 35,000.00	$ 50,000.00	$ 65,000.00
1.1.19	Installation Temperature Transmitter		0	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ -	$ -	$ -
1.1.20	Installation Isolator switch		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
																	Total	**$ 1,505,000.00**	**$ 2,150,000.00**	**$ 2,795,000.00**

Client	Australian Gas Infrastructure Group			Document Title	Document Subtitle	Document No. (Client / GPA)
Client	TBA	GPA	210620	Total Installed Cost Estimate (Electrical)	Option 3	TBA
Project Name	AHC - Network Analysis for State-Wide Feasibility Studies					210620-OTH-002

Calculated
User Input

Item	Description	Vendor/ Contractor	Size/Men	Quantity/Days	Unit	Rate/Lump Sum	Assumptions	Quantity Ranges		Rate/Sum Ranges		Quantity			Rate			Amount		
								Low	High	Low	High	Low	Most Likely	High	Low	Most Likely	High	Low	Most Likely	High
A.Equipment and Materials																				
1	**Non-Compliant Instruments : All intruments that rated for Gas Group IIA and IIB Replaced, As Well As Items that Items With Missing Information Replaced And RTU / DB's to be relocated at 50% of outdoor locations**																			
	Customer Meter Sets																			
1.1	CULC-FQT-001 - Flow / Volume Corrector **GSP, 5250019446**	Honeywell	1	838	EK 220	$ 3,000.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	838	838	838	$ 2,100.00	$ 3,000.00	$ 3,900.00	$ 1,759,800.00	$ 2,514,000.00	$ 3,268,200.00
	Field Regulators																			
1.2	NORTH-ZS-003 - Limit Switch **City Gate Station, P4-294, NORTH STREET ALBURY**	Honeywell	1	589	LS4A1A	$ 350.00	Current model Non Compliant for Gas Group IIC	0%	0%	-30%	30%	589	589	589	$ 245.00	$ 350.00	$ 455.00	$ 144,305.00	$ 206,150.00	$ 267,995.00
1.3	NORTH-JB-001 - Junction Box **City Gate Station, P4-294, NORTH STREET ALBURY**	Pepperl and Fuchs (Govan)	1	589	GUB*	$ 2,000.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	589	589	589	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 824,600.00	$ 1,178,000.00	$ 1,531,400.00
1.4	NORTH-JB-003 - Junction Box **City Gate Station, P4-294, NORTH STREET ALBURY**	Pepperl and Fuchs (Govan)	1	589	GUB*	$ 2,000.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	589	589	589	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 824,600.00	$ 1,178,000.00	$ 1,531,400.00
1.5	XXX-JB-XXX - Junction Box **New Junction Box for Field Terminations to RTU**	Pepperl and Fuchs (Govan)	1	295	GUB*	$ 2,000.00	Similar size to current field JB's is applicable	0%	0%	-30%	30%	295	295	295	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 413,000.00	$ 590,000.00	$ 767,000.00
1.6	XXX-JB-XXX - Junction Box **New Junction Box for Field Terminations to DB**	Pepperl and Fuchs (Govan)	1	295	GUB*	$ 2,000.00	Similar size to current field JB's is applicable	0%	0%	-30%	30%	295	295	295	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 413,000.00	$ 590,000.00	$ 767,000.00
	City Gate Stations																			
1.7	OBR-TT-002 - Temperature Transmitter **City Gate, P8-002, WODONGA CITY GATE**	Yokogawa	1	50	YTA610	$ 1,500.00	Model Number for current model not available: Assumed Non-Compliance	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ 52,500.00	$ 75,000.00	$ 97,500.00
1.8	ORB-SV-001 - Solenoid **City Gate, P8-002, WODONGA CITY GATE**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.9	ORB-SV-002 - Solenoid **City Gate, P8-002, WODONGA CITY GATE**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.10'	ORB-SV-003- Solenoid **City Gate, P8-002, WODONGA CITY GATE**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.11	CULC-UV-0028 - Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.12	CULC-TCV-0025 - Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.13	CULC-FE-002 - Flow Meter **GSP, 5250019446**	Motion Sensors	0	50	DMX-001-2	$ 1,500.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ -	$ -	$ -
1.14	CULC-FE-003 - Flow Meter **GSP, 5250019446**	Motion Sensors	0	50	DMX-001-2	$ 1,500.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ -	$ -	$ -
1.15	CULC-FE-001 - Flow Meter **GSP, 5250019446**	Motion Sensors	0	50	DMX-001-2	$ 1,500.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ -	$ -	$ -
1.16	CULC-TT-001 - Temperature Transmitter **GSP, 5250019446**	Yokagowa	1	50	YTA610	$ 1,500.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ 52,500.00	$ 75,000.00	$ 97,500.00
1.17	CULC-XV-001 Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.18	CULC-XV-002 Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.19	CULC-XV-003 Solenoid **GSP, 5250019446**	Norgren-IMI-Herion	1	50	80207 65	$ 650.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 455.00	$ 650.00	$ 845.00	$ 22,750.00	$ 32,500.00	$ 42,250.00
1.2	CULC-JB-004 - Junction Box **GSP, 5250019446**	Pepperl and Fuchs (Govan)	1	50	GUB*	$ 2,000.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 70,000.00	$ 100,000.00	$ 130,000.00
1.21	CULC-TT-002 - Temperature Tranmitter **GSP, 5250019446**	Yokagowa	1	50	YTA610	$ 1,500.00	Certificate for Current model not found, Assumed Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 1,050.00	$ 1,500.00	$ 1,950.00	$ 52,500.00	$ 75,000.00	$ 97,500.00
1.22	CULC-ZS-003 - Isolator switch **GSP, 5250019446**	Crouse-Hinds	1	50	GHG 263	$ 1,325.00	Current model Non-Compliant for Gas Group IIC	0%	0%	-30%	30%	50	50	50	$ 927.50	$ 1,325.00	$ 1,722.50	$ 46,375.00	$ 66,250.00	$ 86,125.00
1.23	XXX-JB-XXX - Junction Box **New Junction Box for Field Terminations to RTU**	Pepperl and Fuchs (Govan)	1	25	GUB*	$ 2,000.00	Similar size to current field JB's is applicable	0%	0%	-30%	30%	25	25	25	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 35,000.00	$ 50,000.00	$ 65,000.00
1.24	XXX-JB-XXX - Junction Box **New Junction Box for Field Terminations to DB**	Pepperl and Fuchs (Govan)	1	25	GUB*	$ 2,000.00	Similar size to current field JB's is applicable	0%	0%	-30%	30%	25	25	25	$ 1,400.00	$ 2,000.00	$ 2,600.00	$ 35,000.00	$ 50,000.00	$ 65,000.00
																	Total	**$ 4,905,180.00**	**$ 7,007,400.00**	**$ 9,109,620.00**
2	**Engineering Design and Deliverables**																			
2.1	**Deliverables**																			
2.1.1	Production of 3575 Unique Datasheets for new equipment		1	225		$ 262,800.00		0%	0%	-10%	10%	1	1	1	$ 236,520.00	$ 262,800.00	$ 289,080.00	$ 236,520.00	$ 262,800.00	$ 289,080.00
2.1.2	Design/Review of 1573 New Junction box(s)		1	375		$ 438,000.00		0%	0%	-10%	10%	1	1	1	$ 394,200.00	$ 438,000.00	$ 481,800.00	$ 394,200.00	$ 438,000.00	$ 481,800.00
2.1.3	Installation Scope of Work for 1477 Unique Sites		1	187.5		$ 219,000.00		0%	0%	-10%	10%	1	1	1	$ 197,100.00	$ 219,000.00	$ 240,900.00	$ 197,100.00	$ 219,000.00	$ 240,900.00
2.1.4	Cable Calculation for 320 Unique New DB Location s		1	50		$ 58,400.00		0%	0%	-10%	10%	1	1	1	$ 52,560.00	$ 58,400.00	$ 64,240.00	$ 52,560.00	$ 58,400.00	$ 64,240.00
2.1.5	Review/ Selection of 320 New RTU and DB Locations		1	90		$ 105,120.00		0%	0%	-10%	10%	1	1	1	$ 94,608.00	$ 105,120.00	$ 115,632.00	$ 94,608.00	$ 105,120.00	$ 115,632.00
																	Total	$ 974,988.00	$ 1,083,320.00	$ 1,191,652.00
																	Sum of Direct Cost	**$ 974,988.00**	**$ 1,083,320.00**	**$ 1,191,652.00**

Item	Description	Vendor/ Contractor	Size/Men	Quantity/Days	Unit	Rate/Lump Sum	Assumptions	Quantity Ranges Low	Quantity Ranges High	Rate/Sum Ranges Low	Rate/Sum Ranges High	Quantity Low	Quantity Most Likely	Quantity High	Rate Low	Rate Most Likely	Rate High	Amount Low	Amount Most Likely	Amount High
B.Installation																				
1	**Installation Works**																			
1.1	**Installation of New Field Equipment**																			
	Installation Customer Meter Sets																			
1.1.1	Installation Flow / Volume Corrector		1	502		$ 502,000.00		0%	0%	-30%	30%	1	1	1	$ 351,400.00	$ 502,000.00	$ 652,600.00	$ 351,400.00	$ 502,000.00	$ 652,600.00
	Installation Field Regulators																			
1.1.2	Installation Limit Switch		1	300		$ 300,000.00		0%	0%	-30%	30%	1	1	1	$ 210,000.00	$ 300,000.00	$ 390,000.00	$ 210,000.00	$ 300,000.00	$ 390,000.00
1.1.3	Installation Junction Box		1	589		$ 589,000.00		0%	0%	-30%	30%	1	1	1	$ 412,300.00	$ 589,000.00	$ 765,700.00	$ 412,300.00	$ 589,000.00	$ 765,700.00
1.1.4	Installation Junction Box		1	589		$ 589,000.00		0%	0%	-30%	30%	1	1	1	$ 412,300.00	$ 589,000.00	$ 765,700.00	$ 412,300.00	$ 589,000.00	$ 765,700.00
	City Gate Stations																			
1.1.5	Installation Temperature Transmitter		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.6	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.7	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.8	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.9	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.10	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.11	Installation Flow Meter		0	50		$ 50,000.00		0%	0%	-30%	30%	1	1	1	$ 35,000.00	$ 50,000.00	$ 65,000.00	$ -	$ -	$ -
1.1.12	Installation Flow Meter		0	50		$ 50,000.00		0%	0%	-30%	30%	1	1	1	$ 35,000.00	$ 50,000.00	$ 65,000.00	$ -	$ -	$ -
1.1.13	Installation Flow Meter		0	50		$ 50,000.00		0%	0%	-30%	30%	1	1	1	$ 35,000.00	$ 50,000.00	$ 65,000.00	$ -	$ -	$ -
1.1.14	Installation Temperature Transmitter		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.15	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.16	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.17	Installation Solenoid		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.18	Installation Junction Box		1	50		$ 50,000.00		0%	0%	-30%	30%	1	1	1	$ 35,000.00	$ 50,000.00	$ 65,000.00	$ 35,000.00	$ 50,000.00	$ 65,000.00
1.1.19	Installation Temperature Transmitter		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
1.1.20	Installation Isolator switch		1	40		$ 40,000.00		0%	0%	-30%	30%	1	1	1	$ 28,000.00	$ 40,000.00	$ 52,000.00	$ 28,000.00	$ 40,000.00	$ 52,000.00
	Relocation of RTU and DB's Installation and Commissioning of New Power and RTU Junction Boxes																			
1.1.21	Installation Junction Box RTU		1	320		$ 320,000.00		0%	0%	-30%	30%	1	1	1	$ 224,000.00	$ 320,000.00	$ 416,000.00	$ 224,000.00	$ 320,000.00	$ 416,000.00
1.1.22	Installation Junction Box DB		1	320		$ 320,000.00		0%	0%	-30%	30%	1	1	1	$ 224,000.00	$ 320,000.00	$ 416,000.00	$ 224,000.00	$ 320,000.00	$ 416,000.00
1.1.23	Install / Run new cabling between RTU and New JB		1	400		$ 400,000.00		0%	0%	-30%	30%	1	1	1	$ 280,000.00	$ 400,000.00	$ 520,000.00	$ 280,000.00	$ 400,000.00	$ 520,000.00
1.1.24	Install / Run new cabling between DB and New JB (and new Supports/ Ladder where required)		1	400		$ 400,000.00		0%	0%	-30%	30%	1	1	1	$ 280,000.00	$ 400,000.00	$ 520,000.00	$ 280,000.00	$ 400,000.00	$ 520,000.00
1.1.25	Move / Terminate RTU to new Location		1	320		$ 320,000.00		0%	0%	-30%	30%	1	1	1	$ 224,000.00	$ 320,000.00	$ 416,000.00	$ 224,000.00	$ 320,000.00	$ 416,000.00
1.1.26	Move / Terminate DB to new Location		1	320		$ 320,000.00		0%	0%	-30%	30%	1	1	1	$ 224,000.00	$ 320,000.00	$ 416,000.00	$ 224,000.00	$ 320,000.00	$ 416,000.00
																	Total	**$ 3,213,000.00**	**$ 4,590,000.00**	**$ 5,967,000.00**