Australia Pacific LNG Project

Volume 5: Attachments

Attachment 49: Main Pipeline System - Preliminary Safety Management Study

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1. Introduction

The Australia Pacific LNG project is currently preparing an EIS submission in accordance with Terms of Reference issued by the Co-ordinator Generals Department.

Section 6.1.1 of those Terms states in part:

> *"A risk assessment in accordance with Australia/New Zealand Standard AS/NZS 2885 Gas and Liquid Petroleum Pipelines should be conducted on the gas transmission pipeline from the gas processing plant(s) to the LNG plant on Curtis Island. The results of the Location Analysis and Threat Analysis and calculation of 'measurement lengths' should be presented together with management strategies which will be employed to deliver the safety principles of the Standard that require risks to be reduced to as low as reasonably practical, low or negligible."*

Although not stated explicitly in the paragraph above, it is clear that the "risk assessment" mentioned is in fact a Safety Management Study as detailed in AS2885.1 (Section 2 and various Appendices).

This document records the outcomes of the preliminary Safety Management Study of the APLNG high pressure transmission pipelines (called the Main APLNG Pipeline System) that connect the Walloons Gas Fields to the Curtis Island LNG Plant.

The Upstream portion of the Australia Pacific LNG project also includes a High Pressure network which is the subject of a separate Preliminary Safety Management Study and Report.

2. Description of pipelines

This section describes the proposed APLNG Main Pipeline System to connect the Walloons Gas Field to the Liquefied Natural Gas (LNG) plant on Curtis Island near Gladstone. The overall Australia Pacific LNG project also includes development of the Walloons Gas Field and construction and operation of an LNG plant on Curtis Island.

The approximately 450 kilometre (km) Main Pipeline System is required to transport dehydrated and compressed coal seam gas from the Walloons Gas Field to the LNG plant at Laird Point, Curtis Island near Gladstone. The location of the proposed gas transmission pipeline system is shown on Figure 2.1. The Walloons Gas Field and LNG Plant are also identified on this figure.

The Main Pipeline System will consist of the following pipelines:

- Condabri Lateral - 44 km lateral connecting the Condabri development with the main pipeline;
- Woleebee Lateral - 38 km lateral connecting the Woleebee development with the main pipeline; and
- APLNG Gladstone Pipeline - 362 km main pipeline from the junction with the laterals east of Wandoan to Curtis Island in the north.

The APLNG Gladstone Pipeline will include the submerged crossing of “The Narrows” to Curtis Island. The crossing is intended to be completed using horizontal directional drilling (HDD).

The design, construction, operation and rehabilitation will be in accordance with AS2885.

These pipelines and their associated infrastructure (surface facility stations, etc.) form the Scope of this Safety Management Study.

2.1 Route Description

The Main Pipeline System will be located in three local government areas: Western Downs Regional Council, Banana Shire Council and Gladstone Regional Council.

The methodology for determining the location of the proposed gas transmission pipeline was based on application of the following criteria and related constraints:

- Land Use, Social Aspects and Topography
- Environmental and Cultural Heritage
- Construction and operation requirements
- Engineering
- Safety
- Commercial
- Co-location opportunities
- CCIC and GSDA corridors defined by the Queensland State Government

Before selecting the preferred alignment, field surveys were conducted by specialists to assess engineering, construction, cultural heritage and environmental risk and opportunities.

The start of the Condabri Lateral will be approximately 8 km east of the township of Miles, Queensland. The route traverses around the Miles township and turns north to a junction (called the APLNG Hub) of the Condabri Lateral, Woleebee Lateral and APLNG Gladstone Pipeline.

The Woleebee Lateral commences in the vicinity of the proposed site of a gas processing facility, 25 km southwest of Wandoan and nearly 40 km to the west of the APLNG hub and passes eastward through Gurulmundi State Forest area to intersect the APLNG Gladstone Pipeline at the end of the 44 km Condabri Lateral.

The APLNG Gladstone Pipeline route will traverse north from the APLNG Hub toward Camboon bypassing Barakula, Rockybar and Borania State Forests. Co-location opportunities with Arrow's SGP-pipeline are being investigated. From Camboon the proposed alignment would run parallel to the Crowsdale-Camboon Road north where it is proposed to be co-located with the existing QGP pipeline and proposed GLNG to Gladstone.

After the Callide Range crossing, the alignment follows the Callide Common Infrastructure Corridor and the Gladstone State Development Area (GSDA). Both are defined and managed by the Queensland Government, Department of Infrastructure and Planning (DIP), with a width of 200 m and are intended to accommodate all proposed LNG transmission pipelines. The Callide Common Infrastructure Corridor runs from the east side of the Callide Range, northwest of Calliope Range State Forest to the intersection with the Bruce Highway (M1), which is the start point of the GSDA. The GSDA includes the submerged crossing of "The Narrows" and the route terminates at the LNG facility at Laird Point, Curtis Island.

2.2 Narrows Crossing

"The Narrows" crossing is approximately 5.0 km in total length, comprising approximately 3.4 km of mud flats from the western shore to Friend Point, and then approximately 1.6 km of water crossing to Laird Point on Curtis Island.

At this time it is proposed that the mud flat crossing be installed by the pipe flotation ditch methodology. Alternatively the wetlands may be crossed using ploughing or by sheet piling the trench walls.

Two options are being considered for the water crossing. Horizontal Directional Drilling is the preferred alternative and conventional dredging will also be evaluated during FEED as an alternative should the HDD be deemed either too risky or fail in execution.

2.3 Callide Gladstone corridor

The Callide Gladstone Corridor consists of the Callide Common infrastructure Corridor and the Corridor through the GSDA.

The Gladstone State Development Area is a defined area between the Bruce Highway and up to Curtis Island, through which all LNG Plant supply pipelines must pass in an orderly manner according to requirements imposed by the Queensland Government. The APLNG main pipeline will follow the corridor for approximately 34 km, before it enters the Australia Pacific LNG plant.

The Callide Common Infrastructure Corridor extends from the Bruce Highway westward for approximately 44km and terminates at the Callide Range.

Within both corridors each pipeline proponent is allowed an easement of 50 meters, and the easements are generally not allowed to cross over within the corridors. Other pipelines are also involved, which do result in a number of pipeline cross-overs as shown in the Schematic at Appendix C.

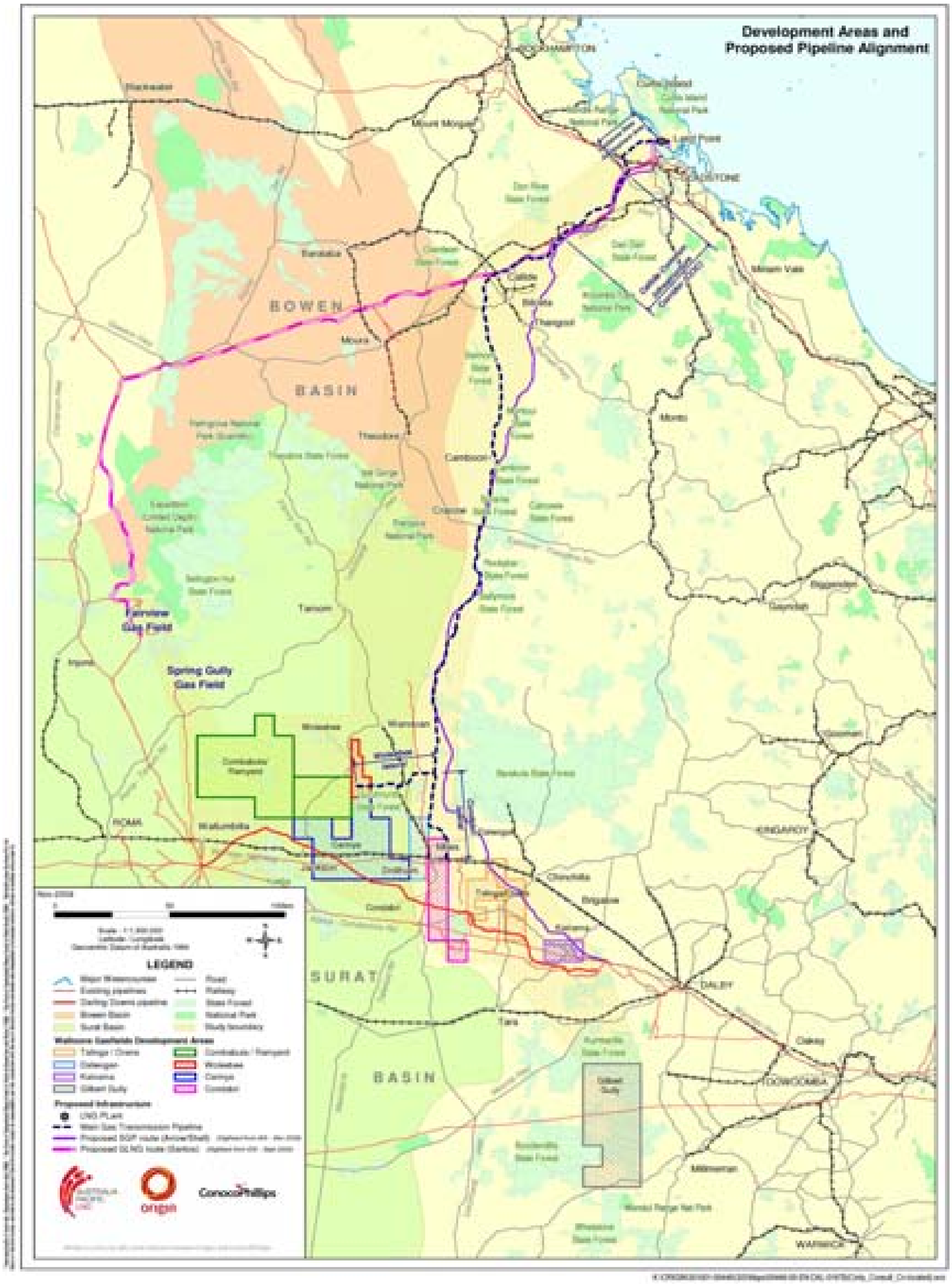

Figure 2.1 Main APLNG pipeline alignment option 3E

2.4 Associated Infrastructure

The following table summarises the proposed infrastructure and surface facilities proposed to be installed as part of the pipelines (and forming part of the Scope of this Safety Management Study).

Table 2.1 Proposed aboveground facilities, including buried MLV's

Kilometre Point	Facility	Comment
Condabri Lateral		
0	36" Launcher, Isolation Valve	At GPF CNN_04
44	36" Receiver, Isolation Valve; Metering	KP0 of Main Pipeline
Wolleebee Lateral		
0	30" Launcher, Isolation Valve	At GPF Wol_01
38	30" Receiver, Isolation Valve, Metering	KP0 of Main Pipeline
Main Pipeline		
0	42" Launcher, Isolation Valve, connection for future compression	Endpoint of Wolleebee and Condabri Laterals, proposed future booster compression facility
29	42" MLV_1	
58	42" MLV_2	
87	42" MLV_3	
116	42" MLV_4	
146	42" MLV_5	
174	42" MLV_6	
203	42" Launcher-Receiver, Isolation valve, connections for future compression	Proposed location of future booster compression facility
231	42" MLV_7	
260	42" MLV_8	
290	42" MLV_9	
320	42" MLV_10	
335	42" MLV_11	
350	42" MLV_12, Branch valve	Tie in point for future looping upstream of "The Narrows" crossing
362	42" Receiver, Isolation Valve, Filtering, Metering	Delivery point at Curtis island

All facilities installed as part of the pipelines will be designed to AS2885. Producing and receiving stations and future compression stations, all outside of the scope of this Study, will be designed to AS4041.

2.5 Control Systems

Local transmitters, indicators, and other instrumentation at each site will be connected via hard wiring to a local terminal/control panel to be located in a site hut, and powered either by mains power or solar power, both with battery back-up.

Each site will be capable of either remote operation or local (electronic or manual) operation.

Fibre Optic Cable is proposed to provide both data and voice communications between each site controls hut and the Operations Control Centre (expected to be located in Brisbane). Local connections to the LNG Plant Control Room as part of the LNG Plant ESD System will also be part of this overall Supervisory Control and Data Acquisition system.

2.6 Basic Pipeline Design Parameters

Following are the key design parameters of the pipelines.

Table 2.2 Pipeline Design Parameters

Parameter	Specification			
	Condabri lateral	**Woleebee lateral**	**Curtis Island**	**Narrows crossing**
Length	44km	38km	362km	
Design temperature	Maximum: 60 0c Minimum: 10 0c			
Design life	50 yr			
Nominal diameter	36inch/ 914.4mm	30inch/ 762.0mm	42inch/ 1066.8mm	42inch/ 1066.8mm
Wall thickness	TBC			
Pipeline coating	Three-layer polyethylene (3LPE) or Fusion Bonded Epoxy (FBE)			
Internal lining	flow coating, factory applied			
Maximum allowable operating pressure	Up to15.3 MPa (See Note Below)			
Cathodic protection	External coating and impressed current cathodic protection			
Depth of cover	Generally – minimum 750mm Residential, Agricultural – minimum 900mm Deep Ploughing – minimum 900mm Road crossings / road reserves – minimum 1200 mm			

Parameter	Specification			
	Condabri lateral	Woleebee lateral	Curtis Island	Narrows crossing
	Watercourse crossings – minimum 1200 mm Railway – minimum 2000 mm HDD directionally drilled			
Non Destructive Testing	Testing of welded joints and hydrostatic pressure testing of the pipeline in accordance with AS2885			
Buried Marker Tape	Installed at open cut roads, throughout Heavy Industrial Secondary Land Classification and other risk areas as defined in the Risk Assessment.			
Pipeline Monitoring System	SCADA system for remote monitoring and control of all facilities at each end of the pipeline; periodic patrolling along the pipeline.			

Note: Current design contemplates a MAOP in the range between 13.5 and 15.3 MPag. The highest pressure is assumed for EIS purposes. Although calculations at Reference 4 (Section 1.2) were completed at 13.5 MAOP, APLNG Engineering confirmed for the workshop participants that an increase to 15.3 MPag, if implemented, would not in fact change any of the conclusions regarding penetration resistance for the pipelines within the scope of this Safety Management Study.

3. Safety management study process

3.1 Study Team

The Safety Management Study team comprised the following personnel:

Table 3.1

Name	Organisation	Role
David West	APLNG	Pipeline Engineer
Jasper Tieland	APLNG	Engineering Manager - Pipelines
John Swanson	APLNG	Deputy Project Manager - Pipelines
Lynndon Harnell	APLNG	HP Network Pipeline Engineer
Geoff Penno	APLNG	Operations Representative
Milo Hernandez	APLNG	Upstream Health and Safety
Rob Ully	APLNG	EIS Co-ordinator
Jenny Thompson	APLNG	Compliance, Risk, and Op'ns.
Paul Shardlow	Marsh Risk Consulting	Risk Engineer
Ted Metcalfe	Metcalfe Engineering	Facilitator

3.2 Activities Undertaken

Planning for the preliminary Safety Management Study included review of the requirements of both AS2885 and the Terms of Reference for the Environmental Impact Statement. Available data was reviewed and collated into an early draft revision of this report and distributed to selected attendees. Although some threats and mitigations were defined in the draft revision for information, the primary means of identifying the potential threats and appropriate control measures was the workshop itself, as required by AS2885.

The workshop was held on Monday 7 December, 2009 and facilitated by Ted Metcalfe of Metcalfe Engineering Consultants Pty Ltd. A series of slides were used as an agenda to guide the preliminary discussion session, which included a detailed description of the pipelines supported by maps, schematics, and drawings.

The Safety Management Study process as defined in AS2885 was reviewed with the aid of the flow diagram shown at Figure 3.1. The differences between design, physical and procedural controls were reviewed and the importance of applying a combination of such controls was emphasised. The Scope of Pipelines applicable to the Study were discussed and agreed.

There was debate within the group regarding the suitability of the proposed AS2885 risk assessment matrix given that Origin Energy corporate risk assessments used a different matrix. After some discussion it was agreed to proceed with the AS2885 matrix in order to comply with the process nominated by the EIS Terms of Reference and by the Pipeline Licence requirements. It was agreed that if necessary modifications to the outcomes of this SMS could be made later to comply with Origin Corporate requirements.

The group then reviewed the AS2885 definitions of Severity class in terms of People, Supply, and the Environment and agreed that these text descriptions seemed appropriate.

However, the suggested numerical allocations of cost and schedule consequences to each of the Severity classes (from previous transmission pipeline projects) were reviewed and after some discussion it was agreed that the information necessary to understanding the ranking of consequences for this project in terms of cost and schedule figures was not available to the participants. It was agreed to proceed as far as practical without having defined cost and schedule magnitudes to compare consequences of the threats identified.

The actual identification and assessment portion of the workshop then progressed, on the basis of threats previously identified with encouragement that the group should feel free to define additional threats where considered applicable. Assessments of severity and frequency were discussed, agreed, and recorded on the spreadsheet, which automatically assigned the risk level by inspection of the AS 2885 matrix.

As required by the defined process, in each case for which the assessed risk was greater than Low or Negligible, additional control measures were defined, recorded, and assigned for close-out, and the assessments repeated to ensure that Low or Negligible could be achieved with the additional measures.

The process requires that where evaluation after additional control measures was still Intermediate, then consideration must be given to whether or not the threat with the control measures in place could be deemed ALARP (As Low As Reasonably Practicable). This requires agreement and documentation that “the cost of any additional controls would be grossly disproportionate to the benefit gained”. Threats remaining above Intermediate are not acceptable.

As shown in Section 8 (Study Outcomes) below, for a number of the threats identified it was agreed that adequate information was not yet available to this Preliminary Safety Management Study, and actions were assigned to carry these items forward to a subsequent SMS.

Although a worst case scenario against which the concept of “All Controls Fail” could be tested was not defined during the workshop, inspection of the various threats identified indicated that undetected corrosion over a significant area of the pipe leading to rupture was indeed an appropriate scenario against which the concept of All Controls Fail could be applied, and this was further discussed by the group on reconvening for the high pressure network SMS workshop.

Following the workshop the record of activities was edited for typos and references, and this draft Report was distributed to attendees for review and comment.

This Report with participant comments incorporated forms the documented record of the Preliminary Safety Management Study of the Main APLNG Pipeline System.

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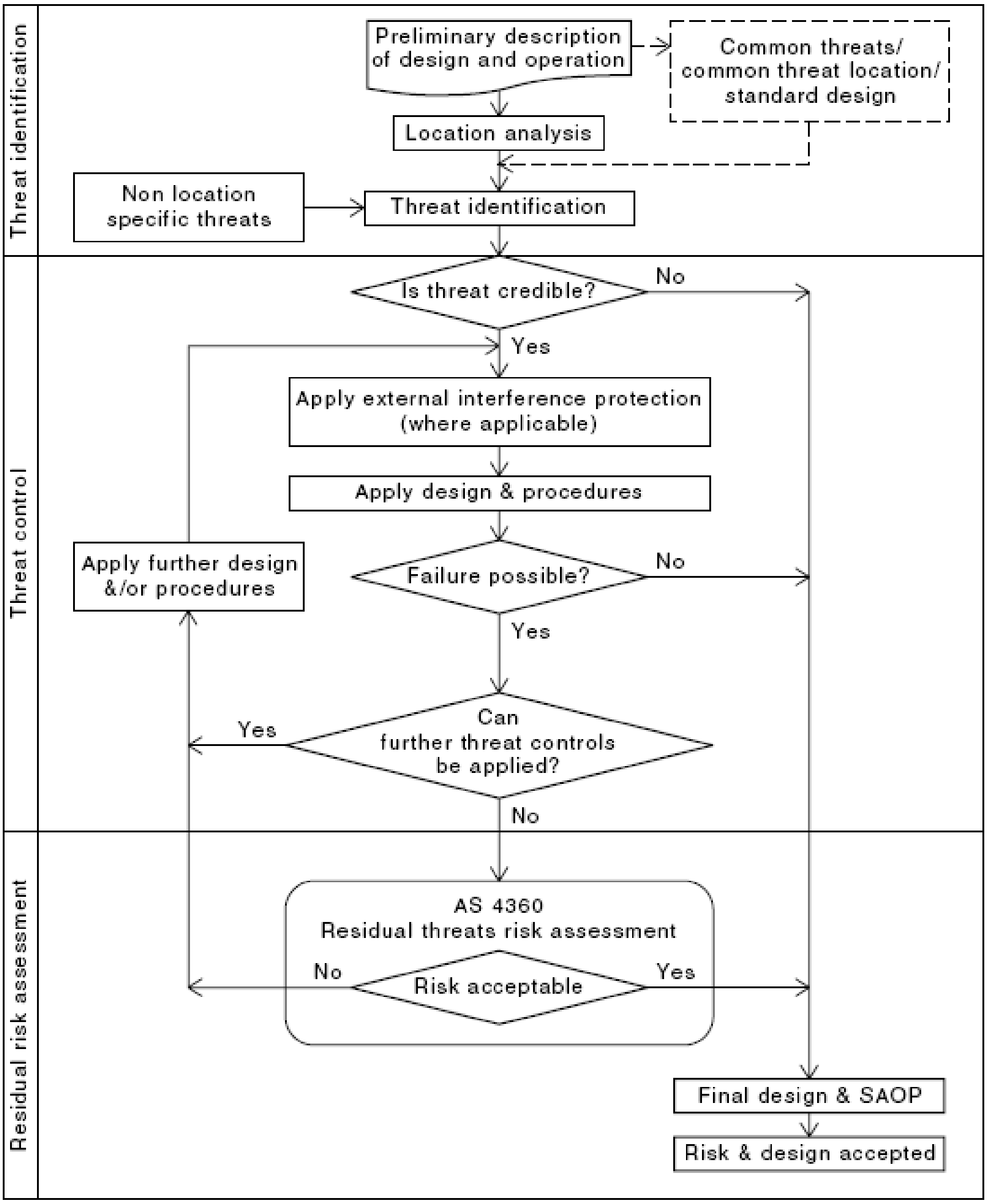


FIGURE 2.3.1 PIPELINE SAFETY MANAGEMENT PROCESS

Figure 3.1 Safety Management Study Process

4. Location analysis

The terrain of the project area is generally flat to undulating through rural areas, with some areas of forested hilly terrain.

Much of the route is in areas of very low population density with limited infrastructure development. However, on the approaches to Gladstone both parallel pipelines and adjacent industrial infrastructure developments must be considered.

4.1 AS 2885 Location Classifications

Brief descriptions of the primary location classes given in AS2885 are:

- Rural (R1) – Land that is unused, undeveloped or is used for rural activities.
- Rural Residential (R2) – Land that is occupied by single residence blocks typically in range 1 ha to 5 ha.
- Residential (T1) – Land that is developed for community living (i.e. where multiple dwelling exist in proximity to each other and are served by common public utilities).
- High Density (T2) – Land that is developed for high density community use (i.e. where multi-storey development predominates or where large numbers of people congregate in the normal use of the area).

Brief descriptions of the secondary location classes are:

- Sensitive Use (S) – Area's where consequence of failure may be increased, (i.e schools, hospital and aged care facilities). T2-design requirements apply in Sensitive areas.
- Industrial (I) – Industrial location are land that poses a wide range of threats because of its development. T1-design requirements apply in Industrial areas.
- Heavy Industrial (HI) - Site development or zoned for use of heavy industry or for toxic industrial use.
- Submerged (W) – land that is continuously or occasionally inundated with water, (i.e lakes, harbours, flood plains, watercourses and creeks), whether permanent or seasonal.
- Common Infrastructure Corridor (CIC) - multiple infrastructure developments within a common easement or reserve.

4.2 Discussion of Location Classifications

From the start of the pipelines to the beginning of the Callide Range the route is relatively easy to define as R1 with local R2 (around Miles and Camboon), being almost entirely rural with very low population density. There was significant debate during the workshop regarding the appropriate allocation of Location Class to the various segments of the pipelines within the scope of this SMS from the Callide Range through to Curtis Island.

It was observed that for this pipeline, particularly in the Gladstone region, population density, which forms the basis of the AS 2885 location classifications defined above, is not a useful means of determining whether or not particular design measures are appropriate, since the population density in the immediate vicinity of the pipeline route hardly varies. Instead, the following demonstrates the range of land use in these sections, and the Location Classifications initially considered by this workshop to be appropriate for each.

Table 4.1

Segment	General Land Use	Proposed Classification
Callide Range and adjacent Dawson Highway	Steep forested areas but within 200 meters of the Highway	R1 CIC
Callide Common Infrastructure Corridor	Generally rural with increasing population but little other infrastructure.	R2 CIC
Gladstone State Development Area	Similar population density, but significant potential industrial development and mining.	R2 HI
Narrows Crossing (within GSDA)	Tidal mudflats; then submerged crossing.	R2 - HI on flats, W on submerged
Onshore Curtis Island	Immediate proximity LNG plants	R2 - HI

Each of the above sections of the pipeline was considered by the workshop as a Specific Location of Interest for purposes of considering threats to the pipeline.

Available information regarding the nature and timing of future developments in the GSDA and activities associated with the crossing of the Narrows by several proponents, all to be managed by the Queensland Government, was inadequate for the workshop participants to feel confident with these initial Location Classifications, and the group strongly recommended that final designations of Location Class would require much more discussion with other proponents and with the Queensland Government to better understand these matters. Location Classifications should be reviewed and possibly revised regularly as additional information comes to hand throughout the FEED and Detailed Design period.

5. Failure and consequence analysis

The pipelines under review in this Safety Management Study are all have a design pressure of between 13.5 and 15.3 MPag and are proposed to built from steel rated to API 5L X-70. Following is the resulting table of wall thicknesses calculated for pressure containment:

Table 5.1

For MAOP of 13.5 MPag	30"	36"	42"
Wall Thickness (DF 0.80)			
Normal wall	13.35 mm	16.01 mm	18.68 mm
Heavy Wall	15.93 mm	19.12 mm	22.30 mm
Pipe induction bends	16.78 mm	20.13 mm	23.49 mm

Table 5.2

For MAOP of 15.3 MPag	30"	36"	42"
Wall Thickness (DF 0.80)			
Normal wall	15.12 mm	18.15 mm	21.17 mm
Heavy Wall	17.94 mm	21.53 mm	25.11 mm
Pipe induction bends	19.01 mm	22.82 mm	26.61 mm

These figures take into consideration that the pipe is subject to cold field bending during construction.

5.1 Penetration Resistance

For the diameters and MAOP range proposed, calculations of the wall thickness required for pressure containment at design factors of 0.80 (standard wall) and 0.67 (heavy wall) have been calculated. For each case the Critical Defect Length (CDL) and the wall thicknesses required to prevent penetration and prevent rupture have been calculated. For purposes of assessing the resistance to penetration, a worst-case scenario of impact by a 55 tonne excavator fitted with tiger teeth has been evaluated.

Table 5.3

MAOP 13.5 (mm.)	Woleebee (30 inch)	Condabri (36 inch)	Mainline (42 inch)
CDL (0.80)	129.90	155.80	181.80
CDL (0.67)	193.30	231.60	270.20
tw no rupture	13.50	15.10	16.65
t_w no penetrate	14.96	14.96	14.96
Standard Wall (bent)	13.35	16.01	18.56
Heavy Wall (bent)	15.93	19.12	22.16

Table 5.4

MAOP 15.3(mm.)	Woleebee (30 inch)	Condabri (36 inch)	Mainline (42 inch)
CDL (0.80)	138.26	165.91	193.56
CDL (0.67)	205.50	246.58	287.68
t_w no rupture	13.50	15.10	16.65
t_w no penetrate	14.96	14.96	14.96
Standard Wall (bent)	15.12	18.15	21.17
Heavy Wall (bent)	17.94	21.53	25.11

The compliance of the 30 inch Wolleebee Lateral design at 13.5 MPag is marginal. A 55 ton excavator penetrates a 13.35 mm pipe (FD of 0.8), with a B-factor of 1.3 and a single penetration tooth or a tiger tooth; the maximum equivalent hole will be 90 mm. The non rupture criteria as per AS2885 section 4.7.2 (T1, T2, I, H and S) is not satisfied for FD = 0.8 wall thickness but is satisfied for FD = 0.67 wall thickness of 15.93 mm. The acceptability of this penetration resistance will be further considered during FEED in reaching a final decision regarding MAOP.

Penetration and rupture is eliminated in all other proposed design wall thicknesses.

5.2 Energy Release and Radiation

Following are the calculated distances from the pipeline in the event of an ignited full bore rupture loss of containment event, for two nominated radiation levels: 15.3

Table 5.5

At 13.5 MAOP	30”	36”	42”
Radiation Contour			
Rupture full bore 12.6 kW/m2	591 m	723 m	854 m
Rupture full bore 4.7 kW/m2	985 m	1209 m	1434 m

Table 5.6

At 15.3 MAOP	30”	36”	42”
Radiation Contour			
Rupture full bore 12.6 kW/m2	636 m	784 m	913 m
Rupture full bore 4.7 kW/m2	1034 m	1284 m	1500 m

Given that in all cases (except the 30 inch Woleebee standard wall thickness) the non-rupture criteria is satisfied and maximum possible penetrated hole size is less than the Critical Defect Length, then full bore rupture resulting from third party interference is not credible.

However, the Safety Management Study is also required to consider the potential for corrosion-related loss of pressure containment integrity. (Refer discussion on corrosion loss of containment in Study Outcomes.)

For additional details on these matters refer to the Design Calculations Pre-FEED Q-LNG02-50-DK-0001.

6. Threat controls

A significant number of threats to any buried pipeline are associated with third party activities which inadvertently contact and cause damage to the pipeline. As further detailed following, AS2885 requires certain Controls be put in place as External Interference Protection.

Design practices are also used to protect the pipeline against typical threats, and other control mechanisms may also be implemented, also as discussed following.

6.1 External Interference Protection

AS2885 nominates minimum requirements for both Physical and Procedural Controls which can be applied to reduce the probability of particular third party interference threats.

The following shall apply:

a) *A minimum of 1 physical control and 2 procedural controls shall be applied in R1 and R2 location classes.*

b) *A minimum of 2 physical control and 2 procedural controls shall be applied in T1 and T2 location classes.*

c) *For each control, all reasonably practicable methods shall be adopted.*

d) *Physical controls for protection against high powered boring equipment or cable installation rippers shall not be considered absolute.*

e) *In CIC location class, agreements to control the activities of each user shall be implemented with other users of the CIC wherever possible.*

6.1.1 Physical Controls

AS2885 defines Physical Controls as follows:

Table 6.1

Physical Controls	Methods
Separation	Burial (depth of cover)
	Exclusion (Fencing, access prevented)
	Physical Barrier (Crash barrier, concrete slabs/coating)
Resistance to Penetration	Wall thickness (if adequate to prevent penetration)
	Barriers preventing penetration

6.1.2 Procedural Controls

Procedural Controls per AS2885 are as follows:

Table 6.2

Procedural Controls	Methods
Pipeline Awareness	Landowner / Third Party Liaison
	Community Awareness Program
	One Call service (Dial Before You Dig)
	Marker Signs or Marker Tape
	Activity Agreements with other entities
External Interference Detection	Planning Notification Zones
	Patrolling
	Remote Intrusion Monitoring

6.2 Controls by Design

The following are examples of design measures which will be implemented in a number of locations to protect the pipeline against potential threats.

Road Crossings:

- Extra depth of cover across the entire road easement.
- Extra wall thickness if required by potential loading.
- Concrete slabs in the areas of future table drain maintenance.
- Marker tape for the entire road easement.

Watercourse Crossings:

- Extra depth of cover.
- Concrete mechanical/weight protection if warranted by stream scour potential.
- Careful rehabilitation of banks to prevent future erosion.

7. Threat identification

This section summarises Typical and Location Specific Threats to the pipeline, and proposed application of Controls for each.

7.1 Review of Typical Threats

There are a number of threats which may be present generally or repeated at many places along the pipeline, and are not specific to defined locations.

Examples of these are readily listed as shown below, each with the mitigation currently proposed by the project.

(These were pre-populated for information and consideration only, and were then validated by the actual Safety Management Workshop.)

7.1.1 External Interference

Table 7.1

Potential Threat	Mitigation Proposed
Foreign Crossings	Depth of cover Marker Signs and Tape Activity Agreements
Accidental Third Party Interference	Depth of cover Marker Signs and Tape Liaison Programs
Agricultural Activities	Extra depth of cover Marker Signs Liaison Programs

7.1.2 Road Crossings

Table 7.2

Potential Threat	Mitigation Proposed
Traffic Loads	Extra depth of cover Liaison with haulage companies Marker signs
Maintenance of Table Drains	Extra depth of cover Concrete slabs Marker tape

7.1.3 Rail Crossings

Table 7.3

Potential Threat	Mitigation Proposed
Derailment	Extra depth of cover Concrete slabs (??) Marker signs
Maintenance	Extra depth of cover Liaison with railway authorities Marker signs
Fatigue	Extra depth of cover Extra wall thickness Liaison with railway authorities

7.1.4 Corrosion

Table 7.4

Potential Threat	Mitigation Proposed
Internal	Full time gas quality monitoring. Periodic intelligent pig for metal loss. Low point drain check ??
External	Quality external coating. Periodic DCVG inspection. Periodic intelligent pig for metal loss.

7.1.5 Natural Events

Table 7.5

Potential Threat	Mitigation Proposed
Land Slip	Routing to avoid potential slip areas. Routine patrols to observe movement. Design??
Subsidence (Natural or Mining) (Sinkholes, Underground mining, underground coal gasification)	Routing to avoid potential subsidence areas. Liaison with mining /gasification companies. Routine patrols to observe movement.

Potential Threat	Mitigation Proposed
Floods	Buoyancy control in flood-prone areas.
Scour	Extra depth of cover in water courses. Concrete protection in scour-prone locations.

7.1.6 Electrical Effects

Table 7.6

Potential Threat	Mitigation Proposed
Induced Voltages	Design of earthing systems. Procedures and training during construction and during operations.
Fault Currents	Design of earthing systems.
Lightning	Design of earthing systems. Procedures to stop work during lightning activity. Surge arrestors.
Power Failures	Back-up battery systems.

7.1.7 Operations and Maintenance Activities

Table 7.7

Potential Threat	Mitigation Proposed
Overpressure	Design of over-pressure protection systems. Monitoring and alarm via SCADA system. Training to ensure by-pass is prevented.
Repair Dig-ups	Procedures and training. Accurate location prior to excavation.
Maintenance of Equipment	Regular audits of equipment condition. Application of recommended programs.

7.1.8 Construction Defects

Table 7.8

Potential Threat	Mitigation Proposed
Coating Damage	Approved handling procedures. Backfill specification. Holiday detection on installation.

Potential Threat	Mitigation Proposed
Failed Field Joint Coating	Qualified coating application procedure approval. Design selection of appropriate system. Holiday detection after completion.
Dents and Wrinkles	Qualified bending procedure approval. Visual and internal gauge inspection.
Weld Quality	Qualified weld procedures approval. NDT inspection. Hydrostatic pressure and leak test.
Backfill quality	Backfill quality specification. Inspection during construction. DCVG follow-up inspection.
Blasting procedures	Qualified blasting procedures. Licensed personnel for design and implementation of blast programs. Exclusion zones.

7.1.9 Design Defects

Table 7.9

Potential Threat	Mitigation Proposed
Stress Corrosion Cracking	Engineering design and metal specification. High quality coating. Temperature control. Periodic intelligent pig inspection for cracking.
Incorrect wall thickness	Engineering design QA and audit procedures. Inspection on receipt. Hydrostatic pressure test.
Inadequate functionality	Operations and Maintenance input to engineering design. HAZOP and CHAZOP studies. Pre-commissioning inspection and testing.

7.1.10 Material Defects

Table 7.10

Potential Threat	Mitigation Proposed
Steel Quality	Engineering Design and QA. Inspections and QA in the pipe mills.
Coating Material Quality	Engineering coating selection. QA in the coating material supply and application.
Proprietary Equipment	Engineering Design specifications. QA and Inspection and Test Plans during fabrication. Inspection and acceptance on receipt. Pre-commissioning testing and inspection.

7.1.11 Intentional Damage

Table 7.11

Potential Threat	Mitigation Proposed
Wilful Damage External (Vandalism, Terrorism, Sabotage)	Markers and warning signs. Security fencing and locks. Routine patrols. CCTV installations in critical facilities??
Wilful Damage Internal (Sabotage)	Employee background checks. Human Resources management. Other??

7.1.12 Earthquake

A preliminary evaluation of the potential for damaging earthquake in the vicinity of the pipeline route has not yet been completed. There is some evidence of historical seismic activity in the Gladstone Region, and this will be more fully evaluated in the next Safety Management Study workshop.

7.1.13 Future Blasting

The pipeline route has intentionally avoided all known areas of likely future infrastructure development, or design has taken those into consideration.

It is possible that in future another third party will seek to conduct blasting in the vicinity of the pipeline for infrastructure development, quarrying, or mining. The proposed community liaison program and notification requirements would ensure that APLNG is aware of the proposed blasting and has the opportunity to evaluate and if appropriate, approve the blasting.

7.2 Review of Location-Specific Threats

Address areas known to be distinct from the general pipeline in terms of land use, population density, or potential threat to the pipeline. The threats associated with each are briefly described following.

7.2.1 The Narrows Crossing

The area of the narrows crossing is subject to a number of additional threats both during construction and during long term operations.

Construction period threats include:

- Failure of the HDD to successfully cross due to geotechnical challenges.
- Damage from other concurrent HDD's or crossings by other proponents.
- Failure to adequately develop temporary work sites at either side.

Operations period threats include:

- Damage during repair of an adjacent crossing.
- Damage by future dredging operations.
- Corrosion resulting in loss of containment into the Narrows environment.

7.2.2 Common User Corridors

Similarly, the Common User Corridors will be subjected to threats associated with development of parallel pipelines both during construction and during longer term operations. In addition, these areas may be subject to future re-zoning to allow adjacent infrastructure development not currently contemplated.

7.2.3 Areas of Co-located Pipelines

It was discussed and agreed that areas in which construction of a parallel pipeline by other parties was proposed, but outside of the defined Common User Infrastructure corridors, in fact were not subject to any threats not already defined for the area within the corridors.

The group recommended the formation of an effective "corridor management group" involving both parties in such locations.

7.2.4 Callide Range Crossing

The crossing of the Callide Range presents additional threats in two areas. Firstly, there are a number of steep slopes to be negotiated by the construction crews, and slope stability in the longer term is a concern.

Secondly, the pipeline is within about 200 meters of the Dawson Highway in this area, and while the Highway does not present a particular threat to the pipeline, it does represent challenges for traffic management during construction, as construction vehicles must enter and leave the busy highway safely.

The pipeline is only seen as a potential threat to the Highway in the event of an undetected corrosion leading to a rupture and ignition, in which case the Highway would be directly affected by the resulting radiation.

8. Study outcomes and recommendations

The details of the Safety Management Study assessment are recorded in the worksheets referenced from Appendix B.

8.1 Study Outcomes

8.1.1 Summary of Evaluation Results

A total of 58 threats were identified, most in the category of Typical threats as shown in the table below.

Table 8.1

40	Typical Threats
10	Narrows
2	GSDA
2	CCIC
3	Co-located Pipelines
1	Callide/Dawson Hwy Area
58	**Total**

Most were ranked Low or Negligible on initial evaluation.

Two were initially ranked High, and two more were ranked Intermediate however these and several others are subject to some degree of uncertainty and will require additional input information to allow evaluation at the next Safety Management Study during FEED.

Table 8.2

No.	Threat	Initial	Re-rank	Issue
5	Penetration damage by third party.	High	N/A	Require additional information regarding likely equipment sizes in the area.
12	Undetected corrosion leads to rupture	High	Int	Propose annual leak detection survey as additional control.
9	Liquid carryover from process into pipeline	Int	N/A	Require further evaluation of an existing CSG transmission pipeline.
30	Stress Corrosion Cracking	Int	N/A	To be further evaluated during FEED.
14	Natural Subsidence (sinkholes)	?		Geotechnical investigations required during FEED.
15	Man-made	Neg		Still to confirm proposed activities of Cougar Energy on

No.	Threat	Initial	Re-rank	Issue
	subsidence			Wolleebee Lateral.
16	Inundation	Neg		Hydrological and flood studies required to confirm during FEED.
17	Scour of watercourse banks	Neg		Hydrological and flood studies required to confirm during FEED.
36/37	Wilful damage (terrorism and sabotage)	Low		Recommending development of an integrated project policy by Origin Management.
38	Earthquake	?		Seismic Study to be conducted during FEED

8.1.2 Discussion of Other Key Outcomes

Undetected Corrosion

Wall thicknesses nominated for the diameters under study are all such that rupture due to penetration associated with third party interference is not a credible scenario. However, the workshop agreed that undetected corrosion leading to rupture (as recently occurred on Varanus Island in WA) represented a valid threat, and this was taken as the All Controls Fail scenario.

If indeed all controls did fail and widespread corrosion went undetected to the point of pipeline rupture, then the consequences of rupture in terms of radiation impact distances indicated in Section 5.2 above would eventuate.

Penetration by Drilling

The participants expressed some concern regarding the potential for future CSG drilling operations (either APLNG or other proponents) to damage the pipeline. Although the concept of penetration resistance to excavator teeth is reasonably well understood, the ability of pipelines to withstand sustained attack from drilling machinery is not as well understood.

Adjacent Construction

Threats from other operators of high pressure transmission pipelines may in fact be of lesser concern than those represented by owners and operators of other types of assets, as those parties will not have the same appreciation of the dangers of contacting and damaging the pipeline.

8.2 Study Recommendations

8.2.1 Design Phase

1. Improved understanding of the size and nature of equipment likely to be used in development of new infrastructure near the pipeline.
2. Study of the potential for liquid carryover into the pipeline from the processing plants, and the success or otherwise of routine pigging of an existing CSG pipeline.
3. Seismic Study of the pipeline route.
4. Geotechnical investigation of any areas of potential natural subsidence (sinkholes).

5. Hydrological Study of potential for Flooding along the pipeline route; as well as potential for migration of watercourse banks during flood periods.
6. Improved understanding of potential developments in the GSDA.
7. Further study of the potential for Stress Corrosion Cracking.
8. SMS workshops should be held again at the end of the FEED phase, and a final Detailed Safety Management Study held at the end of Detailed Design.

8.2.2 Safety and Operating Plan (SAOP)

Operations should develop and implement an annual leak detection survey over the pipeline.

8.2.3 Other

In addition to the above, this SMS recommends that Origin Energy management provide policy direction on matters of security particularly as regards terrorism.

The initial Location Classifications assigned to the common user corridors and the Narrows crossing will require reconsideration as further information regarding developments within and adjacent to these areas becomes available.

References

Terms of Reference for an Environmental Impact Statement Australia Pacific LNG Project – Under Part 4 of the *State Development and Public Works Organisation Act 1971* (The Coordinator-General - December 2009)

AS 2885.1-2007 Pipelines-Gas and liquid petroleum Part 1: Design and construction (as amended 2009)

Main APLNG Pipeline System Design Basis Q-LNG02-50-PH-0001

Main APLNG Pipeline – Design Calculations Pre-FEED Q-LNG02-50-DK-0001

Appendix A Abbreviations

Acronym	Meaning
3LPE	Three layer polyethyene
ALARP	As Low As Reasonably Practicable
APLNG	Australian Pacific LNG (Origin/ConocoPhillips)
AS	Australian Standard
CCIC	Callide Common Infrastructure Corridor
CDL	Critical Defect Length
CP	Cathodic Protection
CSG	Coal Seam Gas
DCVG	Direct Current Voltage Gradient
DN	Nominal Diameter
EIS	Environmental Impact Statement
ERW	Electric Resistance Welded
FEED	Front-End Engineering Design
GPF	Gas Processing Facility
GSDA	Gladstone State Development Area
HAZOP	Hazard and operability study
HDD	Horizontal Directional Drilling
KP	Kilometre post
Km	kilometre
LNG	Liquefied Natural Gas
MAOP	Maximum Allowable Operating Pressure
MLV	Mainline Valve
MPa	Megapascal
NDT	Non-Destructive Testing
PFD	Process Flow Diagram
QA	Quality Assurance
QGC	Queensland Gas Company
Qld	Queensland
RP	Recommended Practice
ROW	Right of Way
SAOP	Safety and Operating Plan
SCADA	Supervisory Control and Data Acquisition
SMS	Safety Management Study

Appendix B Safety Management Study Record

SAFETY MANAGEMENT STUDY IN ACCORDANCE WITH AS2885.1

Scope of Activities of Interest: Design, installation, and operation of: > High Pressure Transmission pipelines > Associated Infrastructure / Surface Facilities	**Project:** Mainline Pipeline System **Client:** APLNG **Date:** 7-Dec-09 **Facilitator:** Ted Metcalfe
Time Period of Activities of Interest: Installation through abandonment. Design Life of 50 years.	

CONSEQUENCE MEASURES		**SEVERITY CLASSES**				
		Catastropic	**Major**	**Severe**	**Minor**	**Trivial**
Occupational health and safety effects.	**People**	Multiple fatalities.	A few fatalities and/or life threatening injuries.	Hospitalisation required.	First Aid required.	Mimimal impact.
(per AS2885 as applicable to pipeline risk assessments).	**Supply / Commercial Impact**	Long term interruption	Prolonged interruption or long term restriction.	Short term interruption or long term restriction.	Short term interruption or restriction; alternatives available.	No impact.
Impact on flora or fauna or general area.	**Environment**	Widespread effects. Permanent major changes.	Major off-site impact. Long term severe effects. Rectification difficult.	Local short term effects. Easily rectified.	Very localised and short term. Easily rectified.	No effect. Negligible residual.
Information necessary to update Cost and Schedule ranking figures was not available to Workhop participants.	**Cost from**	$500,000	$100,000	$10,000	$1,000	Zero
	up to	??	$500,000	$100,000	$10,000	$1,000
	Schedule	One month	One week	Full working day	Few hours	No lost time.
	up to	??	One month	One week	Full working day	Few hours
FREQUENCY CLASSES:		**Catastropic**	**Major**	**Severe**	**Minor**	**Trivial**
Expected to occur at least once during the period.	**Frequent**	**Extreme**	**Extreme**	**High**	**Intermediate**	**Low**
May occur during the period.	**Occasional**	**Extreme**	**High**	**Intermediate**	**Low**	**Low**
Unlikely to occur during the period, but possible.	**Unlikely**	**High**	**High**	**Intermediate**	**Low**	**Negligible**
Not anticipated for this project during the period.	**Remote**	**High**	**Intermediate**	**Low**	**Negligible**	**Negligible**
Theoretically possible, but there is no precedent.	**Hypothetical**	**Intermediate**	**Low**	**Negligible**	**Negligible**	**Negligible**

Notes:

Re-assess consequence severity costs and durations for each study scope and circumstances.

Document any threats raised but deemed non-credible, with reasons.

Consider an "All controls fail" worst case scenario and assess.

Type of Threat	
External Interference	Ext
Corrosion	Corr
Natural Event	Nat
Electrical Effect	Elec
Operations and Maintenance	O&M
Construction Defect	Cons
Design Defect	Des
Intentional Damage	Int
Other	Oth

PROJECT: MAINLINES TO GLADSTONE **SECTION:** Typical Threats

No.	Threat	Category	Consequences	Frequency	Severity	Existing Controls (Must have one Physical and two Procedural if External Interference in R1 area) Physical / Design	Procedural / Awareness	Risk Rank	Additional Risk Reduction / Corrective Actions Required	Frequency	Severity	Revised Risk Rank	Responsible for Close-out
	(Specifically identify potential threatening event)		(Identify key negative consequences; or reason why non-credible.)										(Individual)
	Example Only *- Pipeline punctured by post hole driller.*	Ext	*Hydrocarbon leak.* *Personnel injury.* *Equipment damage.*	Unl	Sev	*Burial*	*Warning Signs*	Int	*Liason with local landowners and contractors.* *Permit to Work and supervision.*	Rem	Sev	Low	*Operations Manager*
	TYPICAL THREATS (Relevant to entire pipeline or to several locations on pipeline):												
1.0	**Activity by third party damages pipeline at pipeline crossing point (no loss of containment).**	Ext	Coating damage Surface scoring.	Unl	Min	Depth of Cover Separation between buried services.	Marker Signs Agreements in place with other asset owners.	Low					
2.0	**Activity by third party damages pipeline at pipeline crossing point (With penetration).**	Ext	Coating damage requiring repair. Surface scoring. Loss of containment.	Hyp	Maj	Depth of Cover. Separation between buried services.	Marker Signs DBYD Agreements in place with other asset owners.	Low					
3.0	**Activity by third party damages pipeline at road/rail crossing point (no loss of containment).**	Ext	Coating damage Surface scoring.	Unl	Min	Depth of Cover Additional wall thickness if required at crossings.	Marker Signs Agreements in place with other asset owners.	Low					
4.0	**Activity by third party damages pipeline at road/rail crossing point (Penetration).**	Ext	Coating damage requiring repair. Surface scoring. Loss of containment.	Hyp	Maj	Depth of Cover. Additional wall thickness if required at crossings.	Marker Signs DBYD Agreements in place with other asset owners.	Low					
5.0	**Activity by third party damages pipeline other than at crossing point. (Other CSG development activities; dam construction, mining, etc.)**	Ext	Coating damage requiring repair. Surface scoring. Loss of containment.	Unl	Maj	Depth of Cover	Marker Signs Liaison programs with local entities to advise of pipeline location and to learn of proposed future development.	Hi	Requires re-consideration with the benefit of more information regarding the size of equipment potentially used in the area for future developments.			#N/A	Engineering Manager
6.0	**Deep ripping or blade ploughing or irrigation channel construction damages pipeline.**	Ext	Severe coating damage. Scoring of metal surface. No penetration.	Rem	Min	Extra Depth of Cover in agricultural areas.	Marker Signs Liaison programs with local farmers.	Neg	Need further research in discussion with landholders regarding potential activities to allow determination of appropriate depth of cover.			#N/A	Engineering Manager
6.1	**Deep ripping or blade ploughing or irrigation channel construction damages pipeline.**	Ext	Severe coating damage. Scoring of metal surface. Assume small penetration.	Rem	Cat	Extra Depth of Cover in agricultural areas.	Marker Signs Liaison programs with local farmers.	Hi	Need further research in discussion with landholders regarding potential activities to allow determination of appropriate depth of cover.			#N/A	Engineering Manager
7.0	**Heavy traffic loads damage pipeline at crossing point.**	Ext	Potential fatigue. Some deformation.	Hyp	Maj	Design calculation. Depth of Cover	Liaison with haulage or coal companies.	Low				#N/A	
8.0	**Derailed train damages pipeline.**	Ext	Barely credible. Possible pipe deformation and coating damage.	Hyp	Sev	Depth of cover.	N/A	Neg				#N/A	
9.0	**Liquid carryover from processing facilities into pipeline.**	O&M	Accumulating liquid slug. LNG Plant feed gas quality issues.	Fre	Min	Coalescing filters at LNG Plant inlet.	Laterals may be pigged routinely to check for glycol accumulation.	Int	Additional study of an existing CSG pipeline is required to assist resolution.			#N/A	Engineering Manager

No.	Threat	Category	Consequences	Frequency	Severity	Existing Controls *(Must have one Physical and two Procedural if External Interference in R1 area)*		Risk Rank	Additional Risk Reduction / Corrective Actions Required	Frequency	Severity	Revised Risk Rank	Responsible for Close-out
	(Specifically identify potential threatening event)		(Identify key negative consequences; or reason why non-credible.)			**Physical / Design**	**Procedural / Awareness**						(Individual)
10.0	**Internal Corrosion damages pipeline.**	Corr	Metal loss. Pinhole leak.	Hyp	Maj	Transmission gas quality monitoring.	Periodic intelligent pigging to check for metal loss.	Low				#N/A	
11.0	**External corrosion damages pipeline. (Pinhole leak only)**	Corr	Loss of containment Metal loss.	Rem	Sev	High quality external coating (specs and installation procedures.). CP system design.	Monitoring of CP system operation. Routine DCVG survey. Routine intelligent pigging. Warning markers to prevent damage to coating.	Low				#N/A	
12.0	**External corrosion damages pipeline. PROPOSED AS "ALL CONTROLS FAIL" SCENARIO**	Corr	Widespread metal loss. Loss of containment (rupture)	Rem	Cat	High quality external coating (specs and installation procedures.). CP system.	Monitoring of CP system operation. Routine DCVG survey. Routine intelligent pigging. Warning markers to prevent initial damage to coating.	Hi	Consider annual leak detection survey for this pipeline system.	Hyp	Cat	Int	Operations Manager
13.0	**Land slip damages pipeline; probably side slope related.**	Nat	Deformation. Exceed design strain limits.	Rem	Sev	Route selection to avoid potential land slip areas. Slope stabilisation specified in high potential areas.	Routine patrols to note movements.	Low				#N/A	
14.0	**Natural subsidence (sink holes, etc.)**	Nat	(Review of threat still in progress)			(not yet specifically considered in route selection)	Routine patrols to note movements.	#N/A	Further study required.			#N/A	Engineering Manager
15.0	**Man-made subsidence (underground activities eg. Coal to liquids)**	Ext	Uneven settlement of the pipeline. Potential to exceed design strain limits.	Hyp	Min	Route selection to avoid existing and future underground developments.	Liaison programs.	Neg	Need to confirm future development activity proposed by Cougar Energy.			#N/A	Engineering Manager
16.0	**Flood activity exposes and damages pipeline.**	Nat	Pipe floats to surface. Coating damage.	Rem	Min	Buoyancy control in potential flood areas.	Routine patrols.	Neg	To be further addressed in FEED.			#N/A	Engineering Manager
17.0	**Scour activity exposes and damages pipeline in watercourses.**	Nat	Coating damage. Potential for flood debris to impact and strain pipe.	Rem	Sev	Depth of cover. Concrete mechanical protection. Bank rehabilitation after construction.	Routine patrols to identify bank progression.	Low	To be further addressed in FEED.			#N/A	Engineering Manager
18.0	**Induced HV power line voltage effects cause corrosion.**	Corr	Metal loss.	Rem	Sev	Earthing and CP system design. High quality coating system.	DCVG and intelligent pig surveys.	Low				#N/A	
19.0	**Induced HV power line voltage effects injure workers.**	Cons	Possible shock to personnel during construction.	Rem	Sev	Earthing and CP system design. High quality coating system.	Procedures to earth pipe during construction.	Low				#N/A	
20.0	**HV Fault currents damage coating and pipeline.**	Elec	Coating damage. Possible pitting.	Rem	Min	Earthing and CP system design.		Neg				#N/A	
21.0	**Lightning damages pipeline.**	Nat	Pinhole leak. Coating damage.	Rem	Sev	Design of earthing systems. Surge arrestors.		Low				#N/A	
22.0	**Power Supply Failure causes system shutdown.**		(Not really a threat to the pipeline)	Hyp	Sev	Battery back-up system. MLV to be fail last position controls design.		Neg				#N/A	
23.0	**Pipeline overpressure during operations.**	O&M	Exceeding design strain limit. (Rupture not credible.)	Hyp	Maj	Overpressure protection design. SCADA monitoring and alarms. Compressor capability limited.	Operations training.	Low				#N/A	

No.	Threat	Category	Consequences	Frequency	Severity	Existing Controls *(Must have one Physical and two Procedural if External Interference in R1 area)*		Risk Rank	Additional Risk Reduction / Corrective Actions Required	Frequency	Severity	Revised Risk Rank	Responsible for Close-out
	(Specifically identify potential threatening event)		(Identify key negative consequences; or reason why non-credible.)			**Physical / Design**	**Procedural / Awareness**						(Individual)
24.0	**Repair dig-up accidently damages pipeline.**	O&M	Coating damage. Scoring of the pipe surface.	Occ	Min	Wall thickness.	Pipeline location procedures. Operations training. Machinery size limitation.	Low				#N/A	
25.0	**Construction Defect - Damaged Coating**	Cons	Potential corrosion if not repaired.	Occ	Min	Construction Specification Backfill Specification	Inspection and QA checks. (DCVG) Job training.	Low				#N/A	
26.0	**Construction Defect - Incorrectly applied Field Joint Coating**	Cons	Potential corrosion if not repaired.	Occ	Min	Field Joint Coating application procedures. Design selection of appropriate system.	Qualified coating application procedure approval. Holiday detection after completion.	Low				#N/A	
27.0	**Construction Defect - Dents and Wrinkles in Pipe**	Cons	Pipe local deformation.	Occ	Min	Material and Bend Specifications.	Bend Procedure Qualification QA checks/guage plate.	Low				#N/A	
28.0	**Construction Defect - Failed Weld Undetected**	Cons	Pinhole leak.	Hyp	Sev	Welding specification.	Weld procedure qualification. QA and NDT checks. Hydrotest. DCVG Survey post-construction.	Neg				#N/A	
29.0	**Incorrect Construction Blasting damages nearby infrastructure**	Cons	Repair costs.	Rem	Min	Design of blasting charge size and timing.	Licenced personnel. Approved procedures. Pre and Post blast inspections.	Neg				#N/A	
30.0	**Design Defect - Stress Corrosion Cracking**	Des	MAOP limitation. Repair costs for clocksprings, etc.	Rem	Maj	Engineering Design and metallurgical specifications. High quality coating specified.	QA inspections in pipe mill. Process temperature control. Periodic intelligent pig inspection for cracks.	Int	Additional study required during FEED			#N/A	Engineering Manager
31.0	**Incorrect Wall Thickness / Material Strength supplied.**	Des	Replacement costs. Delay.	Rem	Min	Engineering Design and Specification.	Audit of design. MDR Review. Inspection in pipe mill; QA. Hydrotest.	Neg				#N/A	
32.0	**Inadequate system functionality.**	Des	Restricted operations.	Rem	Min	O&M input to Design.	HAZOP. CHAZOP. Pre-commissioning inspection. Post commissioning testing.	Neg				#N/A	
33.0	**Material Defect - Poor Steel Quality**	Des	Replacement costs. Delay.	Rem	Min	Engineering Design.	QA and inspection in pipe mills. Hydrotest.	Neg				#N/A	
34.0	**Material Defect - Poor Quality Coating Material or Application**	Des	Replacement costs. Delay.	Rem	Min	Engineering Design and Specification.	QA inspections in coating mill. Holiday testing during construction. DCVG survey post-construction.	Neg				#N/A	
35.0	**Material Defect - Failure of Proprietary Equipment**	Des	Replacement costs. Delay.	Rem	Min	Engineering Design and Specification.	Inspection and QA checks on fabrication and receipt. Pre-commissioning testing and inspections.	Neg				#N/A	
36.0	**Wilful Damage External (Vandalism, Terrorism)**	Int	Possible rupture.	Hyp	Maj	Security Fencing and monitoring at facility sites. High strength steel and wall thickness.	N/A	Low	Warrants elevation to senior management for consideration as part of an overall security plan implementation.			#N/A	Project Manager

No.	Threat	Category	Consequences	Frequency	Severity	Existing Controls *(Must have one Physical and two Procedural if External Interference in R1 area)*		Risk Rank	Additional Risk Reduction / Corrective Actions Required	Frequency	Severity	Revised Risk Rank	Responsible for Close-out
	(Specifically identify potential threatening event)		(Identify key negative consequences; or reason why non-credible.)			**Physical / Design**	**Procedural / Awareness**						(Individual)
37.0	**Wilful Damage Internal (Sabotage)**	Int	System shut-down or restriction. (Rupture unlikely)	Unl	Min		Employee interview and reference checks. Human resources management.	Low	Warrants elevation to senior management for consideration as part of an overall security plan implementation.			#N/A	Project Manager
38.0	**Earthquake**	Nat	(Potential for seismic activity in Gladstone area is still under study)					#N/A				#N/A	Engineering Manager
39.0	**Future Blasting by others near pipeline.**		Deformation of pipe. Coating defect.	Rem	Min	Depth of cover. Selected backfill.	Liaison programs. Warning markers.	Neg				#N/A	
40.0	**CP systems from adjacent pipelines interfere with each other**	Corr	Corrosion.	Rem	Min	Corridor pipeline CP system to be completed by one party only.	System monitoring. Routine intelligent pigging to detect metal loss.	Neg				#N/A	
41.0								#N/A				#N/A	
42.0								#N/A				#N/A	

PROJECT: MAINLINES TO GLADSTONE **SECTION:** Location Specific Threats

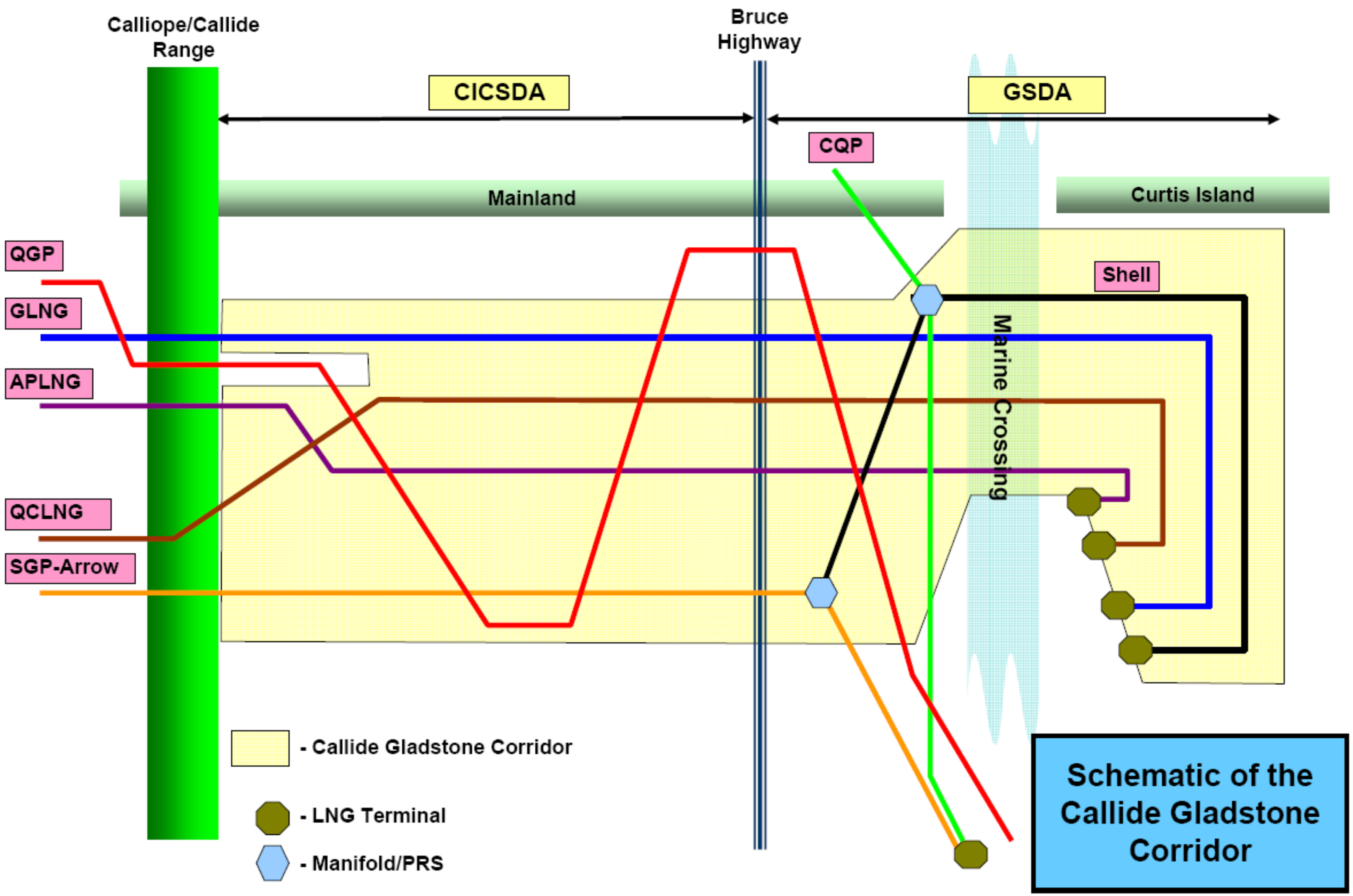
No.	Threat	Category	Consequences	Frequency	Severity	Existing Controls (*Must have one Physical and two Procedural if External Interference in R1 area*)		Risk Rank	Additional Risk Reduction / Corrective Actions Required	Frequency	Severity	Revised Risk Rank	Responsible for Close-out
	(Specifically identify potential threatening event)		(Identify key negative consequences; or reason why non-credible.)			**Physical / Design**	**Procedural / Awareness**						(Individual)
	NARROWS CROSSING (Submerged section HDD method, Mudflats push ditch):												
1.0	**Impact by ship broken free of moorings.**	Ext	Deformation of pipeline (if ship penetrates mud cover.)	Rem	Sev	Depth of cover. Water is shallow, ship would ground well away from pipe route.		Low					
2.0	**Anchor drag hooks pipe.**	Ext	Deformation of pipeline (if anchor penetrates mud cover.)	Hyp	Sev	HDD profile is well below anchor drag depth.	Identified on charts and Instructions to Mariners.	Neg				#N/A	
3.0	**Acid Sulfate Soils and additional corrosion / salt water / tidal concerns.**	Corr	Corrosion.	Unl	Sev	External Coating. CP system.	Routine monitoring of CP system> Intelligent pigging.	Int	Increased frequency of intelligent pigging. Additional CP system protections in designed system.	Rem	Sev	Low	Engineering design of CP systems. Operations SAOP re pigging frequency.
4.0	**Crossing construction by others hits APLNG crossing pipeline.**	Ext	Deformation. (Penetration unlikely given wall thickness and approximately parallel paths.)	Rem	Sev	Wall thickness.	Direct supervision and monitoring of construction activity. Exclusion zone around completed crossing pipe. Construction supervision.	Low				#N/A	
5.0	**Damage caused by future construction of bridge to Curtis Island.**	Ext	Deformation. Possible penetration.	Rem	Maj	Depth of Cover Wall thickness	As-built information readily available. Exclusion zone and separation distance from pipelines.	Int				#N/A	
6.0	**Flotation of pipe in wet crossing mudflat areas.**	Des	Repair and re-trenching costs.	Rem	Sev	Concrete weight coating or screw anchors. Anticipated 8 meter depth of cover.		Low				#N/A	
7.0	**Pipe exposed by cyclonic action on mud flats.**	Nat	Exposure alone is not a serious threat.	Rem	Min	Depth of cover. Concrete coating.		Neg				#N/A	
8.0	**Change in sea level**	Nat	Flooded end of line facilities?.	Hyp	Min	Location of sites outside known flood areas.	Lots of time to implement corrective and protective measures.	Neg				#N/A	
9.0	**High level of uncertainty in development methodology.**	Des	Delay. Duplicated engineering effort. (Not really a threat to the pipeline as being designed and when completed.)					#N/A				#N/A	
10.0	**Future dredging contacts the pipeline**	Ext	Not credible at depth of cover proposed in design.		Maj	HDD installation / depth of cover below proposed dredging. Wall thickness to resist penetration.	Warning Signs Location noted on all relevant charts. Routine patrols	#N/A			Maj	#N/A	
11.0								#N/A				#N/A	
12.0								#N/A				#N/A	

PROJECT:		MAINLINES TO GLADSTONE			SECTION:	Location Specific Threats						
No.	**Threat**	**Category**	**Consequences**	**Frequency**	**Severity**	**Existing Controls** *(Must have one Physical and two Procedural if External Interference in R1 area)*		**Risk Rank**	**Additional Risk Reduction / Corrective Actions Required**	**Frequency**	**Severity**	**Revised Risk Rank**	**Responsible for Close-out**
	(Specifically identify potential threatening event)		(Identify key negative consequences; or reason why non-credible.)			**Physical / Design**	**Procedural / Awareness**						(Individual)
	GSDA Corridor:												
1.0	**Any incident related to adjacent developments and infrastructure.**		Escalation given location of gas pipelines.			Separation distance. Depth of cover. Wall thickness.	Liaison programs with all adjacent parties.	#N/A					
2.0	**Uncertainty regarding future infrastructre developments, including population density increase.**							#N/A				#N/A	
3.0								#N/A				#N/A	
4.0								#N/A				#N/A	
5.0								#N/A				#N/A	
	Callide Corridor:												
1.0	**Construction activity of other proponents.**		Coating damage and deformation.	Unl	Min	Wall thickness. Depth of cover.	Close coordination between the parties. Proposed that blasting be completed for all proponents by the first proponent to encounter rock.	Low				#N/A	
2.0	**Significant elevation change and grade.**		Construction difficulty and delay. Hydrotest sections shorter. Potential land slip.	Fre	Min	Increased wall thickness to allow practical hydrotest.	Route selection to gain best available placement. Future monitoring re land slip.	Int				#N/A	
3.0								#N/A				#N/A	
4.0								#N/A				#N/A	
5.0								#N/A				#N/A	

PROJECT: MAINLINES TO GLADSTONE SECTION: Location Specific Threats

No.	Threat	Category	Consequences	Frequency	Severity	Existing Controls (*Must have one Physical and two Procedural if External Interference in R1 area*) Physical / Design	Procedural / Awareness	Risk Rank	Additional Risk Reduction / Corrective Actions Required	Frequency	Severity	Revised Risk Rank	Responsible for Close-out
	(Specifically identify potential threatening event)		(Identify key negative consequences; or reason why non-credible.)										(Individual)
	CO-LOCATED PIPELINES:												
1.0	**Construction activity by other party.**		Deformation and gouge.	Unl	Min	Easements are adjacent for the most part, providing separation between the pipelines.	Operating and maintenance with other party.	Low					
1.0	**Construction activity by other party.**		Loss of containment.	Hyp	Cat	Easements are adjacent for the most part, providing separation between the pipelines.	Operating and maintenance with other party.	Int	Recommend establishment of a pipeline corridor management group between the parties.				
2.0	**Future maintenance activity by other party.**				Cat	Wall thickness.	Sharing of as-built data. Routine patrols.	#N/A	Recommend establishment of a pipeline corridor management group between the parties.			#N/A	
3.0	**Knock-on effect of an incident on one pipeline affecting the other. (PARALLEL)**		Theoretical rupture, but not credible with adequate separation distance.	Hyp	Cat	Separation distance. Other pipeline designed and operated to AS2885 as well.		Int				#N/A	
3.0	**Knock-on effect of an incident on one pipeline affecting the other. (CROSSING)**		Theoretical rupture.			Refer in Typical Threats		#N/A	Mutual inspection of key maintenance records such as intelligent pigging and CP / DCVG results.			#N/A	
4.0								#N/A				#N/A	
5.0								#N/A				#N/A	
	ADJACENT DAWSON HIGHWAY IN CALLIDE RANGE:												
1.0	**Steep grades and slope stability challenges. Maybe land slip issues.**							####					
2.0								#N/A				#N/A	
3.0								#N/A				#N/A	
4.0								#N/A				#N/A	
5.0								#N/A				#N/A	

Appendix C Schematic of Corridor Pipeline Cross-overs



Appendix D PFD