Heytesbury Underground Gas Storage (HUGS) Pipeline

Attachment N

Basis of Design

LONG Energy and Resources

Heytesbury Underground Gas Storage Project

Pipelines Basis of Design

UGS-ZD-0020

REV P.E

Attachment N

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1. INTRODUCTION

1.1 PROJECT BACKGROUND

The Iona Gas Storage Facility (IGSF) is owned and operated by Lochard Energy and is located near Port Campbell in south-west Victoria. The facility provides gas storage services for customers and is connected to the SEAGas Pipeline (SEAGas), South West Pipeline (SWP), Mortlake Pipeline, and the adjacent Otway Gas Plant. The IGSF utilises depleted gas fields of natural sandstone formations to store the gas on behalf of customers. Within Iona there are seven (7) production/injection wells (Iona-1, 2, 3, 4, 5, 7 and Seamer-2). In addition, there are three (3) production/injection wells at the remote sites (North Paaratte-4/5 and Wallaby Creek-2) which are connected to the Iona facility via a gathering line network.

Lochard Energy is the proponent of the Heytesbury Underground Gas Storage (HUGS) Project and the proposed new Mylor, Fenton Creek and Tregony Wellsite (MFCT wellsite) and the HUGS Pipeline, which will expand the storage capacity of the Iona Gas Storage Facility (IGSF).

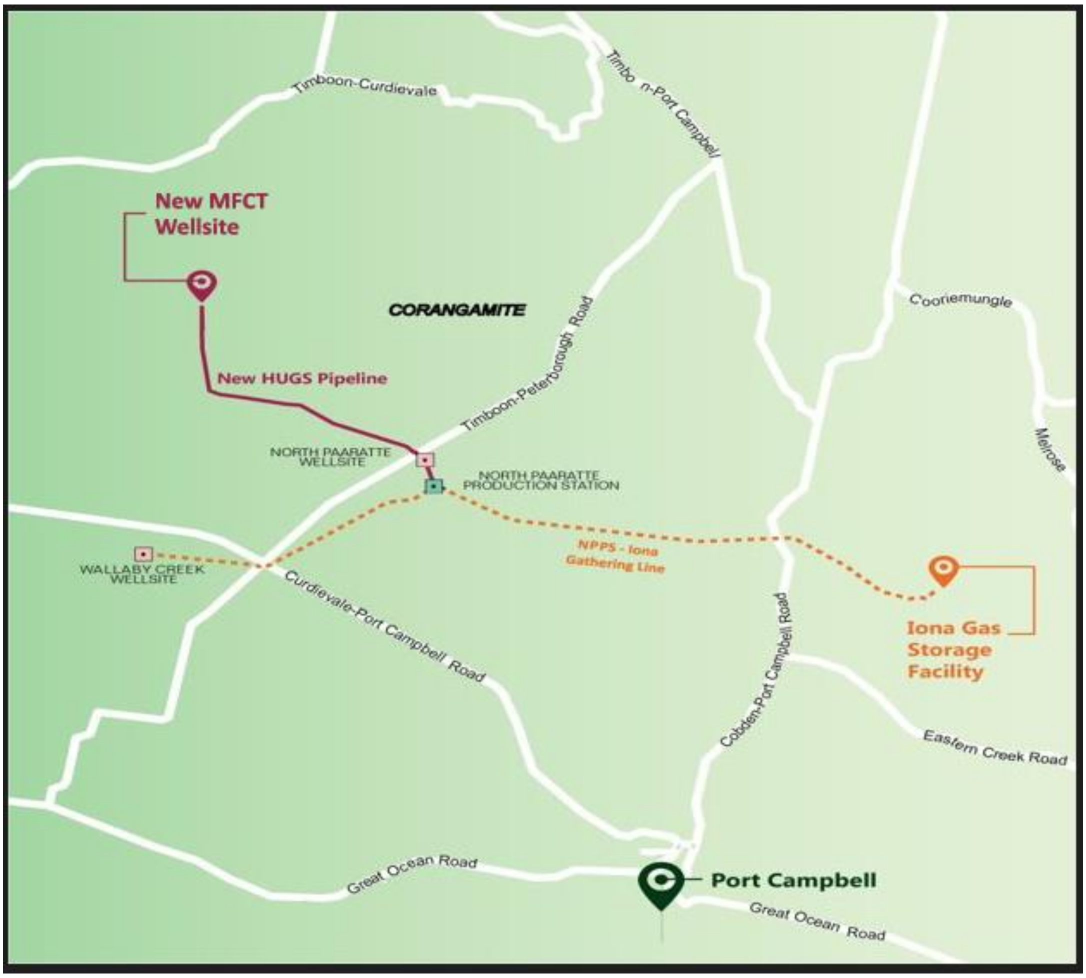

Figure 1 Facilities and Pipelines

Underground storage capacity of the IGSF will be increased through the development of the existing Heytesbury depleted gas fields. The Heytesbury depleted gas fields are all natural sandstone formations that have had pre-existing natural gas extracted and are therefore ideal as a natural geological reservoir for the storage of gas. The HUGS Project will develop a new wellsite which will access three depleted gas fields being Mylor, Fenton Creek, and Tregony (referred to as the MFCT wellsite). The current plan is to develop the Mylor field with 1-2 new gas storage well(s).

In order to connect the MFCT wellsite to the Iona Gas Storage Facility, a new pipeline is required. This proposed new 5.3km pipeline (the HUGS Pipeline) will transport gas and potentially hydrogen in the future, to and from the proposed new MFCT wellsite and underground gas storage fields. The HUGS Pipeline will be an extension to Lochard's existing gathering line network from North Paaratte Production Station (NPPS).

1.2 PURPOSE OF DOCUMENT

This document presents the Basis of Design (BoD) for the Pipelines scope of the Heytesbury Underground Storage (HUGS) Project front end engineering design (FEED). The purpose of the BoD is to clearly define the criteria and key assumptions to be used to develop this project.

This BoD will be updated throughout the lifecycle of the project, typically at each project phase. This BoD is to be read in conjunction with HUGS Project Basis of Design [Ref 5].

1.3 HUGS PROJECT SCOPE

The HUGS Project scope is to increase the storage capacity of the Iona Gas Storage Facility which is broken down into the following elements:

- Development of a new wellsite which has the ability to access three depleted gas fields being Mylor, Fenton Creek and Tregony (MFCT). The project aims to develop the Mylor field with one to two new gas storage wells. The new gas storage wells will be accessed via a drilling program.
- In order to connect the MFCT Wellsite to the IGSF, a new pipeline is required. This new DN300 5.3km pipeline (HUGS Pipeline) will transport natural gas and potentially hydrogen in the future, to and from the new MFCT Wellsite. The HUGS Pipeline will be an extension to Lochard Energy's existing gathering line network from North Paaratte Production Station (NPPS)
- Infrastructure upgrades ats the Iona Gas Plant, NPPS and North Paaratte 4 and 5 Wellsite (NP4/5 Wellsite.

The scope for the pipeline element of the project includes a new hydrogen-ready pipeline from the MFCT field to the NPMS that will be routed by the existing NP-4/5 Wellsite. A new monoethylene glycol (MEG) pipeline and fibre optic cable will also be installed to the new remote fields from the NPPS. The new MFCT Wellsites will be configured for both withdrawal and injection per the existing NP-4/5 and WC-2 Wellsite configurations.

A new pig launcher will be installed at the MFCT Wellsite, allowing pigging from MFCT through to Iona via a single DN300 16.0 MPag MFCT to IGP Gas Pipeline. At NPMS, the existing Wallaby Creek to NPMS DN300 Gathering Line will need to be modified so that it has a separate pig receiver and is connected to the NPPS – IGP Gas Pipeline section via piping with pressure protection for the lower 14.6 MPag MAOP Wallaby Creek to NPMS Gathering Line. The HUGS Project pigging arrangements and pipeline pressure protection systems are depicted on the Wellheads and Flowlines Process Safety Diagram in Appendix A.

1.4 STANDARDS AND CODES

1.4.1 GENERAL

All design and installation work shall be carried out in accordance with the relevant Australian Standards and Lochard Energy specifications. Should any conflict arise between an Australian Standard and a Lochard Energy specification, the more arduous requirements shall be complied with and Lochard Energy shall be notified of the conflict.

The following order of precedence shall be applied:

1. Australian Federal/State government legislation and regulations;
2. Project Specific Codes and Standards;
3. Iona Gas Plant Standards;
4. Australian Standards; and
5. International Standards.

1.4.2 PROJECT STANDARDS

Refer to the HUGS Project Basis of Design [Ref 5] for a detailed listing of project standards.

1.4.3 AUSTRALIAN AND NEW ZEALAND STANDARDS

Reference	Description
AS ISO 1000	The international system of units (SI) and its application
AS 1170.0	Structural design actions – Part 0: General principles
AS 1170.4	Structural design actions – Part 4: Earthquake actions in Australia
AS 1319	Safety signs for the occupational environment
AS 1330	Metallic materials- Drop weight tear test
AS/NZS 1518	External extruded high-density polyethylene coating system for pipes
AS 1544.2	Method for impact tests on metals – Part 2: Charpy V-notch
AS 1726	Geotechnical site investigations
AS 1855	Methods for the determination of transverse tensile properties of round steel pipe
AS/NZS 2312.1	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Part 1: Paint coatings
AS/NZS 2312.2	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Part 2: Hot dip galvanizing
AS/NZS 2648.1	Underground marking tape – Part 1: Non-detectable
AS 2832.1	Cathodic protection of metals – Part 1: Pipes and cables
AS 2885.0	Pipelines- Gas and liquid petroleum- Part 0: General requirements
AS/NZS 2885.1	Pipelines- Gas and liquid petroleum- Part 1: Design and construction
AS/NZS 2885.2	Pipelines- Gas and liquid petroleum- Part 2: Welding
AS/NZS 2885.3	Pipelines- Gas and liquid petroleum- Part 3: Operation and maintenance
AS/NZS 2885.5	Pipelines- Gas and liquid petroleum- Part 5: Field Pressure testing
AS/NZS 2885.6	Pipelines- Gas and liquid petroleum- Part 6: Pipeline safety management
AS/NZS 3000	Electrical Installations
AS 3862	External fusion-bonded epoxy coating for steel pipes
AS 3894.0	Site testing of protective coatings – Part 0: Introduction and list of test methods
AS 3894.1	Site testing of protective coatings – Method 1: Non-conductive coatings – Continuity testing – High voltage ('brush') method
AS 3894.3	Site testing of protective coatings – Method 3: Determination of dry film thickness
AS 3990	Mechanical equipment - Steelwork
AS 4100	Steel structures
AS 4822	External field joint coatings for steel pipelines
AS/NZS 4853	Electrical hazards on metallic pipelines
AS 5100.2	Bridge design- Design loads

Table 1: Australian and New Zealand Standards

1.4.4 INTERNATIONAL STANDARDS

Reference	Description
API Spec 5L	Specification for Line Pipe
API RP 5LW	Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels
API Spec 6D	Specification for Pipeline Valves
API 6FA	Specification for Fire Test for Valves
API RP 1102	Steel Pipelines Crossing Railroads and Highways
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.9	Factory Made Wrought Steel Buttwelding Fittings
ASME B16.10	Face-to-Face and End-to-End Dimensions of Valves
ASME B16.34	Valves Fanged, Threaded, and Welding End
ASME B31.12	Hydrogen Piping and Pipelines
ASME B36.10M	Welded and Seamless Wrought Steel Pipe
ASTM A860/A860M	Wrought High-Strength Ferritic Steel Butt-Welding Fittings
ISO 15590-1	Petroleum and natural gas industries – Induction bends, fittings and flanges for pipeline transportation systems – Part 1: Induction bends
MSS SP-44	Steel Pipe Line Flanges
MSS SP-75	High-Strength, Wrought, Butt-Welding Fittings

Table 2 International Standards

1.5 PROJECT REFERENCE DOCUMENTS

Ref	Doc Number	Document Title
1	UGS-MS-0206	Protective Coatings Specifications
2	UGS-MU-0003	DN300 Gathering Line and DN50 MEG Pipeline Corrosion Report
3	UGS-PS-0012	North Paaratte and Wallaby Creek Process Safety Diagram
4	UGS-XS-0003	Project 570 Phase 3C Low Temperature Study
5	UGS-ZD-0021	HUGS Project Basis of Design
6	UGS-ZP-0036	Project 570 Phase 3C Basis of Design
7	UGS-XS-0004	Operating Philosophy
8	UGS-MU-0171	FEED SMS Report
9	UGS-MS-0049	HUGS Pipeline Fracture Control Plan
10	754-MELGE325319AB	Tetra Tech Coffey Geotechnical Investigation
11	PR-277-144507-E01	PRCI HDD Installation Design Guide Catalog

Table 3: Reference Project Documentation

1.6 ABBREVIATIONS, TERMS AND ACRONYMS

Abbreviation or Term	Description
AG/BG	Above Ground/Below Ground
AS	Australian Standard
AS/NZS	Australian and New Zealand Standard
CA	Corrosion allowance
CP	Cathodic protection
DCVG	Direct current voltage gradient
DN	Nominal diameter
FBE	Fusion bonded epoxy
FOC	Fibre optic cable
FEED	Front-end engineering design
FTPE	Equivalent test pressure factor
HDD	Horizontal directional drilling
HFW	High frequency welded
IGP	Iona Gas Plant
ILI	In-line inspection
LE	Lochard Energy
MAOP	Maximum allowable operating pressure
MEG	Monoethylene glycol
MIJ	Monolithic insulating joint
MLV	Mainline valve
MFCT	Mylor, Fenton Creek and Tregony
MW	McIntee Wellsite
NP	North Paaratte

NPMS	North Paaratte Metering Station which is part of the North Paaratte Production Station
NPPS	North Paaratte Production Station
ROW	Right of way
SCC	Stress Corrosion Cracking
SITHP	Shut in tubing head pressure
SMS	Safety management study
WC	Wallaby Creek
WPQT	Weld procedure qualification test
WPS	Weld procedure specification

Table 4: Terms & Abbreviations

1.7 REGULATORY REQUIREMENTS

The pipelines shall comply with the requirements of the Pipelines Act 2005.

1.8 EASEMENT AND TENURE

The pipelines shall be predominantly situated within a new Lochard Energy pipeline easement.

The easement width and location of pipeline within the easement is described in Section 4.2.

2. PROCESS DESIGN

2.1 GENERAL

This Pipeline Basis of Design describes the inputs and requirements for the design of the two (2) new pipelines for the HUGS Project:

- DN300 MFCT Wellsite (Mylor) to North Paaratte Metering Station (NPMS) pipeline (DN300 hydrogen-ready HUGS Pipeline); and
- DN50 NPPS to MFCT Wellsite MEG pipeline (DN50 MEG Pipeline).

For the complete design requirements of the project, refer to the HUGS Project Basis of Design [Ref 5]. Elements of the HUGS Project Basis of Design [Ref 5] have been referenced in this document where they impact or influence pipeline design.

2.2 DESIGN CAPACITY

The design capacity of the HUGS Pipeline is 80 TJ/day of natural gas. The design capacity of the MEG Pipeline is 294 l/hr, or 0.294 m^3/hr.

The pipeline design capacity and sizing criteria is referenced in detail in the HUGS Project Basis of Design [Ref. 5].

2.3 DESIGN LIFE

The DN300 HUGS Pipeline and all associated pipeline assemblies and station piping shall have a design life of 25 years.

The DN50 MEG Pipeline and all associated pipeline assemblies and station piping shall have a design life of 25 years.

2.4 PROCESS DESIGN CONDITIONS

The process design conditions for the DN300 HUGS Pipeline and DN50 MEG line are detailed in the HUGS Project Basis of Design [Ref 5] and are summarised in Table 5:

Item	DN300 HUGS Pipeline	DN50 MEG line
Maximum design temperature (°C)	70 [Note 1]	65 [Note 1]
Minimum design temperature (°C)	-20 [Notes 2 &3]	0
Maximum operating temperature (°C)	40	40
Minimum operating temperature (°C)	10	10
Design pressure (MPag)	16.0	16.0
Maximum operating pressure (MPag)	14.10 [Note 4]	14.55
Minimum operating pressure (MPag)	5.0 [Note 5]	9.0 [Note 5]
Maximum soil temperature (°C)	20	20
Minimum soil temperature (°C)	10	10
Soil temperature (at pipeline burial depth) (°C)	15 (Summer) 10 (Winter)	15 (Summer) 10 (Winter)

Table 5: Pipeline Design Conditions

Notes:

1. Maximum ambient solar ('black body') temperature.
2. Based on low temperature trip limit. Startup of MFCT Wellsite may lead to fluid temperatures < -10°C. Protection via low temperature trip considered acceptable per existing temperature protection systems for the WC Pipeline and current DN150 NP-4/5 Wellsite flowline, as described in the Project 570 Phase 3C Low Temperature Study (PRM-0014-UGS-XS-0003).
3. Temperatures down to -20°C may be reached during commissioning activities where pressurization of the pipeline may be carried out from the remote wells. Blowdown and repressurisation of the pipeline may also occur during the operating life of the pipeline. Design temperature has been set as -20°C accordingly.
4. MFCT SITHP. Max pressure at wellhead during injection is 14.05 MPag.
5. Based on low pressure trips.

2.5 FLUID DATA

The fluid data for the project for both the DN300 HUGS Pipeline and the DN50 MEG line can be found in HUGS Project Basis of Design [Ref 5].

2.6 PIPELINE CONFIGURATIONS

The DN300 HUGS Pipeline and DN50 MEG line are located in a new pipeline easement. Refer to Figure 2 estimated elevation profile of the pipeline route.

The DN300 HUGS Pipeline will commence at the MFCT Wellsite and run adjacent to the NP 4/5 Wellsite, where an offtake connection will be located to connect the NP 4/5 Wellsite piping to the new HUGS Pipeline.

The existing DN150 NP Gathering Line between the NP4/5 Wellsite and NPPS will be decommissioned and abandoned following the commissioning of the new DN300 HUGS Pipeline. The abandonment methodology shall be documented in a separate abandonment plan.

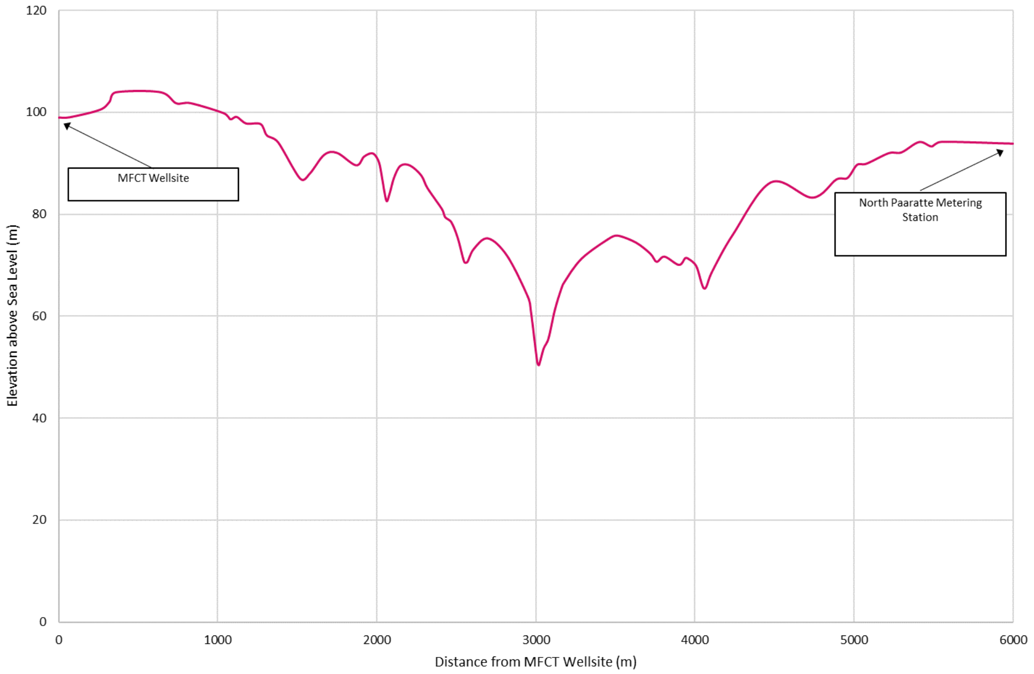

Figure 2 HUGS Pipeline to NPPS (Metering station) Elevation Profile

2.7 CORROSION ALLOWANCE

The DN300 HUGS Pipeline is proposed to be used for the injection of sales gas for 8 months of a year and in withdrawal mode for 4 months of a year. An initial corrosion study has been undertaken in pre-FEED to assess potential corrosion rates and identify preferred corrosion allowances (refer UGS-MU-0003 Corrosion Report) . This report recommended addition of 1.5 mm corrosion allowance to the DN300 HUGS Pipeline for internal corrosion, and this recommendation has been adopted for the pipeline design. The corrosion allowance will be added to the DN300 HUGS Pipeline's required wall thickness in accordance with AS2885.1 section 5.2.9.

The corrosion control philosophy shall be consistent with the that described in the Project 570 Phase 3C Corrosion Report [Ref 2], including but not limiting to managing flow regimes, cleaning pig runs and MEG injection.

No internal corrosion allowance is required for the DN50 MEG line as lean MEG is non-corrosive in an oxygen free service. The MEG tank (T-301) is blanketed with nitrogen of 99.99 % purity.

Both pipelines shall be protected from external corrosion via the use of external coatings and an impressed current cathodic protection system and as such will not require external corrosion allowances.

The base case is to extend the existing impressed current CP system installed on Project 570 Phase 3C and will be assessed and confirmed in FEED.

2.8 RADIATION CONTOURS & ENERGY RELEASE RATE

The 4.7 and 12.6 kW/m^2 radiation contours due to an ignition of the gas released from a full bore rupture of the DN300 HUGS Pipeline have been calculated in accordance with AS2885. 6 Clause 2.2 and Appendix B.

The radiation contour calculations were calculated in Phast by Elixir Consultants UK, on the basis of a full-bore rupture at the midpoint of the pipeline, with pressure at the 16 MPa,g MAOP, ground temperature at 20°C, and assuming the richest gas composition is present in the pipeline (the Mylor Well gas blend). For the purposes of the Phast model, the Weather setting was selected as Category 1.5/F (1.5 $m.s^{-1}$ wind speed), with DNV-recommended relative humidity and ambient temperature. The Phast Long Pipeline model was employed to model the ruptures.

Phast calculated the radiation contours at near ground level as shown in Table 6.

Parameter	Natural Gas Case (AS 2885 and Phast)	Hydrogen Case (Phast)	Note
Distance to 4.6 kW/m² radiation contour	440 m	132 m	Drives AS 2885 Measurement Length
Distance to 12.7 kW/m² radiation contour	196 m	44 m	
Distance to 37.5 kW/m² radiation contour	49 m	Not reached at height of interest	Provided for information only
Flame Length	309 m	213.3 m	Provided for information only

Table 6: AS2885 and Phast-derived Radiation Contours

There has been some variation in Hydrogen-case radiation contours calculated by the project to date. Early modelling using FlowTran and AS/NZS 2885.6 Appendix B2 equations, with the fraction of heat radiation set at 0.17 for hydrogen (compared to the AS/NZS 2885.6 suggestion for natural gas of 0.25), yielded incrementally longer radiation contours than Phast. In all cases, the contours calculated for hydrogen were less than for natural gas. Design decisions for the HUGS Pipeline shall be taken with consideration to natural gas radiation contours rather than hydrogen, as the natural gas distances will allow for additional design conservatism after any transition to hydrogen service. That is, design for natural gas radiation contours can be expected to provide additional safety in hydrogen service.

Assuming the Mylor gas composition at 16 MPa design pressure, the energy release rate 30 seconds after a full-bore rupture has been also modelled in FlowTran at approximately 51 GJ/second.

2.9 MEASUREMENT LENGTH

In accordance with AS2885.0 Clause 1.5.41, the measurement length of a gas pipeline is set by the radius of the 4.7 kW/m² radiation contour for an ignited rupture. For design purposes, this shall be set conservatively at the longest 4.7 kW/m² contour, which is the natural gas at 440 m.

The natural gas measurement length has been determined by release rate modelling in the FlowTranX transient flow modelling package, with thermal affects determined by applying the equations in AS/NZS 2885.6 Appendix B2. Assessment of the hydrogen measurement length resulted in a radiation contour radius lower than the natural gas radius. The measurement lengths will be validated and confirmed in detailed design.

The measurement length of the DN50 MEG pipeline is based on the environmental impact from a full-bore rupture of this line and will be determined with a full process safety study determining the speed at which automated systems may shut in the MEG Pipeline after sensing a release (the detection would be based on initiation of a low-low pressure alarm.

The extent of any release will be dependent on the ground profile and terrain type in the area of any leak, however, hence the impact area will vary along the pipeline. The maximum release rate from the MEG Pipeline will not be higher than 294 litres per hour, however, as this is maximum pump capacity. A volume of 10,080 litres would be present in the operating pipeline, so any release may be up to 10,080 litres plus 294 litres for every additional hour the MEG pump operates after a release.

Should a rupture occur in the MEG Pipeline low point, and the pump continue to operate for 4 hours, then approximately 11,260 litres of MEG would be released. At an average depth of 5cm, this would produce a MEG pool of approximately 40 m radius.

2.10 ISOLATION PHILOSOPHY

2.10.1 GENERAL

The DN300 HUGS Pipeline will have a manual isolation valve at the NPMS to isolate the new DN300 HUGS Pipeline from the existing WC Gathering Line. A pressure control valve will be installed downstream (injection mode) of the isolation valve to function as the primary pressure let-down control system for injection into the lower rated WC Gathering Line. An actuated valve will also be installed in the crossover line between the DN300 HUGS Pipeline and the WC Gathering Line within the NPMS to function as the secondary pressure limiting system and prevent the WC Gathering Line from over-pressurisation in accordance with AS 2885.1 Clause 7.2.1.2.

Refer to the Wellheads and Flowlines Process Safety Diagram in Appendix A for details.

At both the MFCT and NP wellsite connection ends, the pipeline shall have actuated isolation valves. Bypass lines with remotely actuated valves shall be provided to equalise the pressures on either side of final actuated shutdown valve leaving/entering the MFCT Wellsite.

Maintainable pipeline assemblies such as pig traps shall be isolatable via two independent double block and bleed valves. A pig launcher will be installed at the MFCT Wellsite, and a pig receiver will be installed at the NPMS to receive pigs from the WC Wellsite. Pigs launched at the MFCT Wellsite will be received at the Pig Receiver within the IGP.

The DN300 HUGS Pipeline will not require an intermediate mainline valve (MLV) due to the short length of the pipeline (less than 5.5 km) and the pipeline location classification being primarily rural (R1; see Table 4.8.3 of AS/NZS 2885.1).

The DN300 HUGS pipeline will join the existing DN300 Iona to NPPS gathering line by means of an above ground piping spool at the NPMS. This will form a pipeline/gathering line network of approximately 13 km long from MFCT through to IGP. Given the rural (R1) location classification for the new pipeline and the capability for the pressure sources to the pipeline to be remotely isolated, mainline valves (MLVs) have been deemed unnecessary (see Table 4.6.4 of AS/NZS 2885.1).

For the DN50 MEG Pipeline, a review of features along the pipeline route shall be performed to confirm any environmentally sensitive locations (including watercourse crossings) that could be significantly impacted by a MEG spill, with additional controls implemented as appropriate. This will be completed in detailed design SMS.

An Isolation Plan in accordance with the requirements of AS2885 shall be prepared and approved for the project.

2.10.2 VENTS AND DRAINS PHILOSOPHY

High and low points on all pipeline station piping shall be provided with vent and drain points, respectively. The valve size and connection type shall conform to LE piping specifications.

Vents and small-bore drains will be provided on pig traps to facilitate depressurisation and draining of liquids. Liquids will be swept under controlled process pressure, or drained to appropriate vessels via temporary hoses, and either removed from site for disposal or recycled into process in accordance with LE procedures.

The DN50 MEG line will not require a low point drain. Vents and drains shall be provided at the above ground sections of the MEG pipeline to enable draining of the MEG prior to the removal of blind flanges and attachment of temporary pig traps. The philosophy on liquid removal will be further analysed in detailed design.

Due to the anticipated infrequency of pigging (either for cleaning the line, ILI or draining it down for repairs) of the DN50 MEG Pipeline, permanent pigging infrastructure is not required. Instead, allowance shall be made at each end of the DN50 MEG Pipeline for the installation of temporary pig traps in the event the pigging is required.

The handling of MEG and flushing fluids shall be via temporary infrastructure such as tanks and vacuum trucks.

2.10.3 OVER-PRESSURISATION AND BLOWDOWN PHILOSOPHY

Blowdown of the DN300 HUGS Pipeline, including the NPMS-IGP Pipeline section, will be performed through the existing IGP HP Vent via a dedicated valve and restriction orifice arrangement. The individual wellsites may be blown down via local atmospheric vents.

The DN300 HUGS Pipeline is connected to pressure sources that have the following overpressure protection mechanisms:

- During injection, the gas pipeline is protected from overpressure individual compressor controls and discharge pressure trips, including:
    - PAHH-5852 on discharge of C-422, set at 15,800 kPag.
    - PAHH-4872 on discharge of C-404, set at 15,061 kPag.
    - PAHH-5072 on discharge of C-405, set at 15,061 kPag.
- During withdrawal, the maximum pressure that the wells can generate is the Shut-in Tubing Head Pressure (SITHP) at Start of Cycle (SOC) which is 14,100 kPa.g for MFCT, 12,330 kPag for NP-4/5, 13,830 kPag for WC-2 (set by reservoir management practices) which is below the WC, NP and new HUGS Pipeline MAOPs.

In addition to local operation, the wellhead isolation valves shall be able to be closed and opened remotely from the IGP Control Room. Blowdown duration will be confirmed and approved in Detailed Design.

The pig traps shall be provided with a maintenance vent to vent small quantities of gas in the aboveground station piping section.

The DN50 MEG line is connected to pressure sources that have overpressure protection and fail close isolation valves. This is described in detailed in the HUGS Project Basis of Design [Ref 5].

2.11 OPERATION AND CONTROLS PHILOSOPHY

In accordance with AS/NZS 2885.1 section 7.2.1, the pressures within the pipelines shall not be greater than 100% and 110% of the MAOP respectively under normal and transient operational conditions.

Control of flow from the new wells shall be identical to the existing control at the NP and WC wellsites, and at the Iona Gas Plant. Changes will be required at the Iona Gas Plant end to allow for a higher injection pressure up to the NP Pipeline MAOP of 16,000 kPag . A pressure control valve, a high-pressure trip and shutdown valve will be installed at the NPMS to ensure that the pressure limitations on the WC Gathering Line and WC Wellsite are isolated and protected from overpressure.

The NP Wellsite manifold will be isolated from the DCS prior to increasing the injection pressure above the MAOP of the WC Pipeline/NP and WC Wellsites to accommodate 16 MPa(g) up to the flow meters. The NP wellsite area will be protected from overpressure by a new high-pressure trip within the NP Wellsite. The overpressure protection is provided via PAHH-0609 and PAHH-0629, which act to isolate the lower pressure piping via closure of UV-0664 and UV-0665.

The HUGS Project will replace the existing Class 900 shutdown valve with a Class 1500 shutdown valve suitable for the MAOP of the HUGS Pipeline.

Refer to HUGS Project Basis of Design [Ref 5] for detailed automation and operation philosophy.

2.12 PIGGING PHILOSOPHY

The pigging philosophy is to pig from WC wellsite to NPMS, for the Wallaby Creek Gathering Line, and from MFCT Wellsite towards Iona Gas Plant for the HUGS Pipeline.

HUGS Pipeline will be provided with permanent pig launching and receiving facilities. The pig launcher and pig receiver are designed to accommodate both utility pigging and intelligent pigging tools. The pig traps are designed to be bi-directional, but typically would be operated from MFCT to IGP.

Utility pigging (typically using disk / cup pigs) is performed to remove liquids from the HUGS Pipeline prior to switching from withdrawal to injection mode. This would occur nominally on an annual basis and has the objective of preventing residual MEG or other liquids in the pipeline being pushed downhole during injection. Utility pigging is performed from MFCT to IGP and liquids sent to the MEG regeneration facilities.

Intelligent pigging is performed to assess pipeline integrity, nominally wall thickness loss due to corrosion. The traps are designed to accommodate a market-available high resolution MFL tool. Intelligent pig runs may be performed in either direction: i.e., from MFCT to IGP or IGP to MFCT.

The permanent pig launcher shall be located at the MCFT wellsite, to accommodate pigging to IGP. A new pig receiver at IGP will receive pigs.

A relocated pig receiver from IGP will be installed at the NPMS for the WC to NPMS Gathering Line section.

The new DN50 MEG line shall have provisions for temporary pig trap at MFCT Wellsite. The new DN50 MEG line is not intended to be intelligently pigged. Provision for pig traps is only for line clearing where required for maintenance purposes.

3. ENVIRONMENTAL AND GEOTECHNICAL DATA

3.1 GENERAL

Refer to the HUGS Project Basis of Design [Ref 5] for the environmental data.

The blackbody temperature for the above ground sections of the pipelines shall be 70°C.

3.2 GEOTECHNICAL

An initial assessment of geotechnical conditions along the pipeline and a geotechnical investigation at MFCT have been undertaken during FEED. Tetra Tech Coffey performed the geotechnical investigation [REF 10].

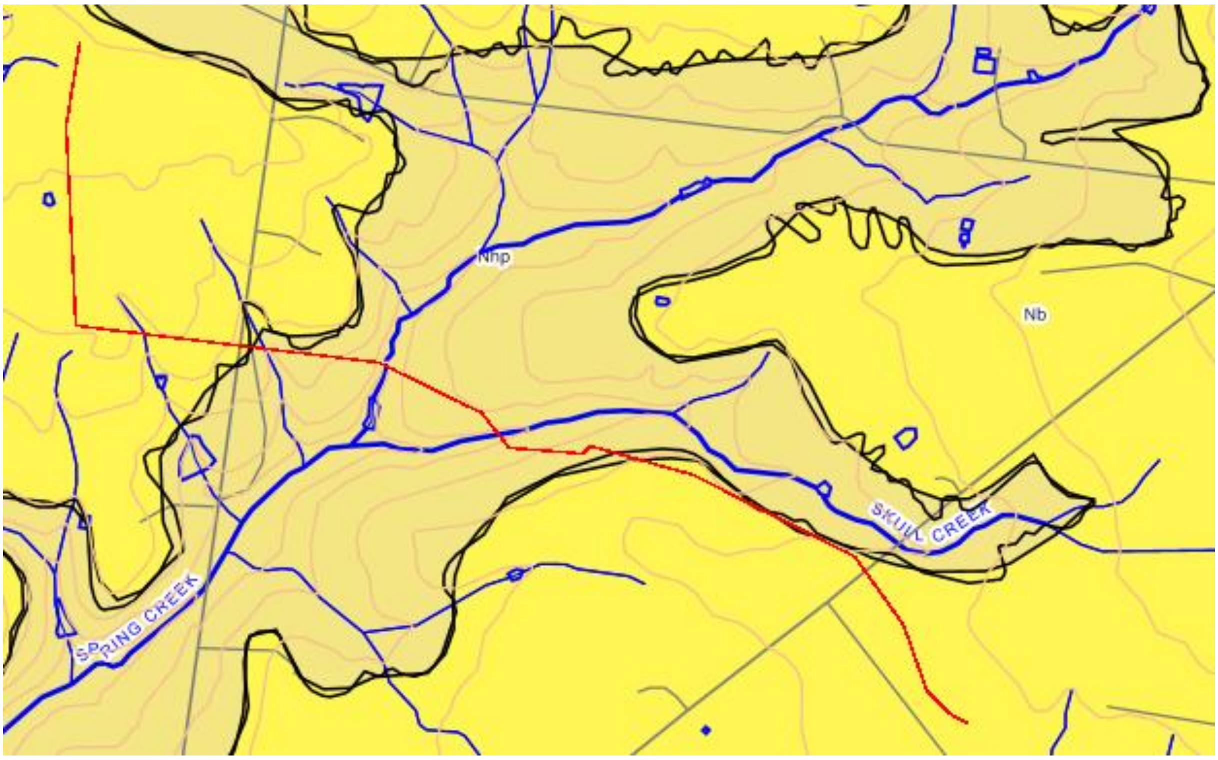

Figure 3 GeoVic Regional Overview (Pipeline Route Shown in Red)

The geotechnical groups encountered along the route are generally Brighton Group fluvial sediments (shown as Nb in Figure 3), crossing into and out of Port Campbell Limestones (shown as Nhp in Figure 3). Tetra Tech Coffey also reported Hanson Plain Sands in the vicinity of the MFCT Wellsite.

Based on the gathered information, pipeline excavations are generally likely to encounter clays, sands, and weathered limestones.

No seismic fault lines exist along the pipeline alignment. The closest fault lines are found in the vicinity Gellibrand Lower and Horden Vale, as can be seen from Figure 4; seismic faults were an active layer in this GeoVic view.

Figure 4 GeoVic Regional Overview – Fault Lines (Pipeline Route Shown in Red)

Further work can be performed in Detailed Design or in the period between FEED and Detailed Design, including by physical investigations along the pipeline route, and specifically at proposed bored crossings. This can include 'ground truthing' survey along the pipeline route with the selected Early Contractor Involvement party.

- Confirmation of surface conditions across the route, including characterisation of the encountered geological units (including but not limited to Karst formations/sinkholes and landslip);
- Seismic hazard assessment, for soil liquefaction and landslides, though the potential for these is not expected to exist;
- Geotechnical design parameters;
- Excavation stability and recommendations on temporary and permanent batters;
- Subgrade preparation, excavation method, suitability of reuse of site excavated materials for bedding and padding after passing through 19mm screen;
- Rock formation at HDD sites; and
- General environmental soil analysis including but not limited to contamination and acid sulfate soils, etc.

3.3 NOISE

The pipeline and its assemblies will not contribute to the noise level along the pipeline route under normal operating condition.

Noise levels related to operation activities including venting during pigging operations shall be considered in Detailed Design.

Refer to HUGS Project Basis of Design [Ref 5] for details on maximum allowable noise limits and requirements for noise modelling.

3.4 WIND

The aboveground pipeline station piping shall be adequately supported against wind action. The structural design shall incorporate the requirements of AS 1170.2. Refer to the HUGS Project Basis of Design [Ref 5].

3.5 SEISMIC

The aboveground pipeline station piping shall be adequately supported against earthquake action. The structural design shall incorporate the requirements of AS 1170.4. Refer to the HUGS Project Basis of Design [Ref 5].

No active fault lines are known to occur in close proximity of the pipeline route, and no fault lines are known to cross the pipeline route.

The threat to the buried pipeline from seismic action (e.g., pipeline stability from soil liquefaction and local strain at fault crossing) along the route has been assessed during the FEED SMS based on the geotechnical assessment findings. The selected controls for this threat include ensuring that the weld procedure design provides for weld overmatching. The objective of this measure will be to ensure that weld strength is equivalent to or higher than line pipe strength, allowing strain to be taken up by the line pipe rather than the welds.

3.6 TERRAIN

The proposed route elevation profile for the DN300 HUGS Pipeline is detailed in Figure 2 (refer to Section 2.6). The elevation from the MFCT Wellsite falls 50m to the Leech Creek crossing, then crosses Skull Creek and rises to be approximately 10m below the elevation at the NPMS, and 20m below the MFCT Wellsite elevation. The DN50 MEG line is in the same easement.

High gradient areas include the northern banks of Leech Creek. Trench breakers and erosion control berms are shown on typical detail drawings and shall be used as necessary to control erosion in such areas.

There are no significant watercourses and areas prone to inundation along the proposed pipeline routes.

3.7 CLIMATE CHANGE RESILENCE IN DESIGN

The HUGS Pipeline design life is 25 years which requires the HUGS Pipeline to be resilient to the effects of climate change. It is expected that the HUGS pipeline will be operated to 2051 as a minimum and it is not unreasonable to consider life extension studies will be completed to further extend the pipeline operation. The selected geographical location of the HUGS Pipeline provides design resilience to the effects of climate change.

3.7.1 RISING SEA LEVELS AND TIDAL FLOODING

The pipeline's distance from the coastline and elevation (lowest point 45-50m above sea level) prevents the proposed pipeline route from being inundated by the effects of rising sea levels and 1 in 100 year tidal storm events. Figure 5 shows DEECA's Victoria Future Climate Tool projection overlay for 2070 1 in 100 storm tide and sea levels for 2070 in relation to the HUGS Pipeline location (highlighted in green).

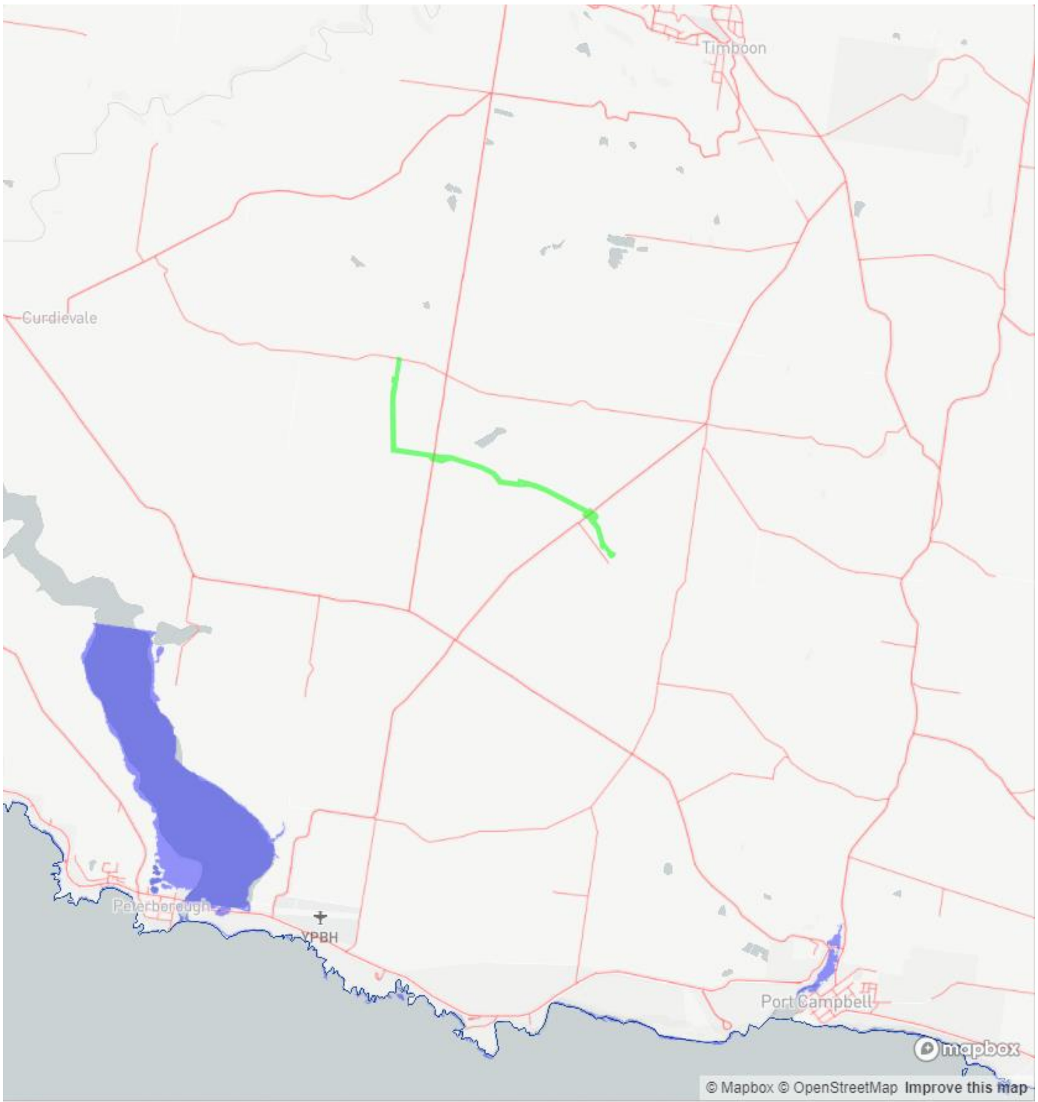

Figure 5: DEECA's Victoria's Future Climate Tool: 1 in 100 Storm Tide & Sea Level Projected in 2070

3.7.2 EXTREME TEMPERATURE AND BUSHFIRE RISK

The majority of the pipeline is below ground with the above ground sections located within facility compounds. The pipeline design temperature as noted in section 2.4 considers current weather events for the geographical location, in particular a safety factor is provided on black bulb temperatures of the above ground sections in the operating case where gas is not flowing.

Final stress analysis shall occur during detailed design, which shall include consideration of soil types and maximum and minimum operating temperatures, to ensure the effects of increased metal thermal expansion affecting the pipeline restraint and facilities support structures are controlled.

Figure 6 shows DEECA's Victoria Future Climate Tool projection overlay for the number of extreme temperature days >40°C per year from 2035-2064. It is projected that on average 4 to 8 days of temperature >40°C per year could be possible, which may not have a significant effect on the pipeline due to the design temperature of the pipeline.

Bushfire impacts onto the above ground piping sections is minimal as the facility compounds are located within cleared farmland. Grassfires and small vegetation fires, which typically have short exposure times, will be addressed in the detailed design AS 2885 Safety Management Study. The gas inventory in the pipeline and facility compounds have the ability to be blown down under emergency scenarios via vent facilities at the Iona Gas Plant.

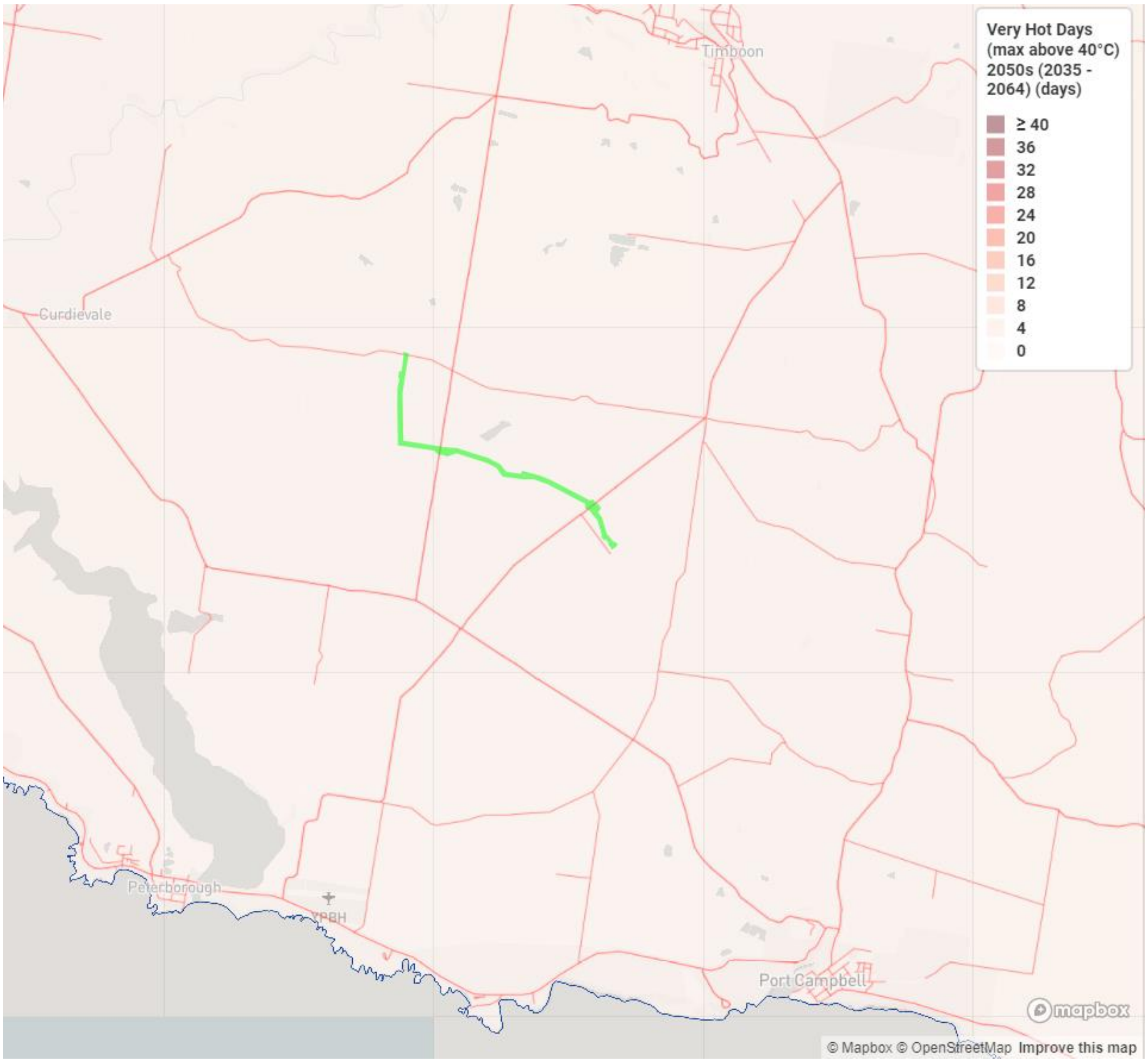

Figure 6: DEECA's Victoria's Future Climate Tool – Number of Extreme Temperature Days >40°C per year from 2035-2064

3.7.3 RAINFALL EVENTS

The region of Port Campbell is subjected to high rainfall with an average monthly maximum rainfall of 110 mm. The HUGS Pipeline route is currently not known as an area susceptible to land slips caused by extreme rainfall events.

Figure 7 shows DEECA's Victoria Future Climate Tool projection overlay for the number of days per year with a rainfall of >20 mm from 2035 – 2064. The projection is predicting approximately 3-6 days per year with greater than 20 mm rainfall expected, which may result in increases of extreme rainfall events from current weather patterns.

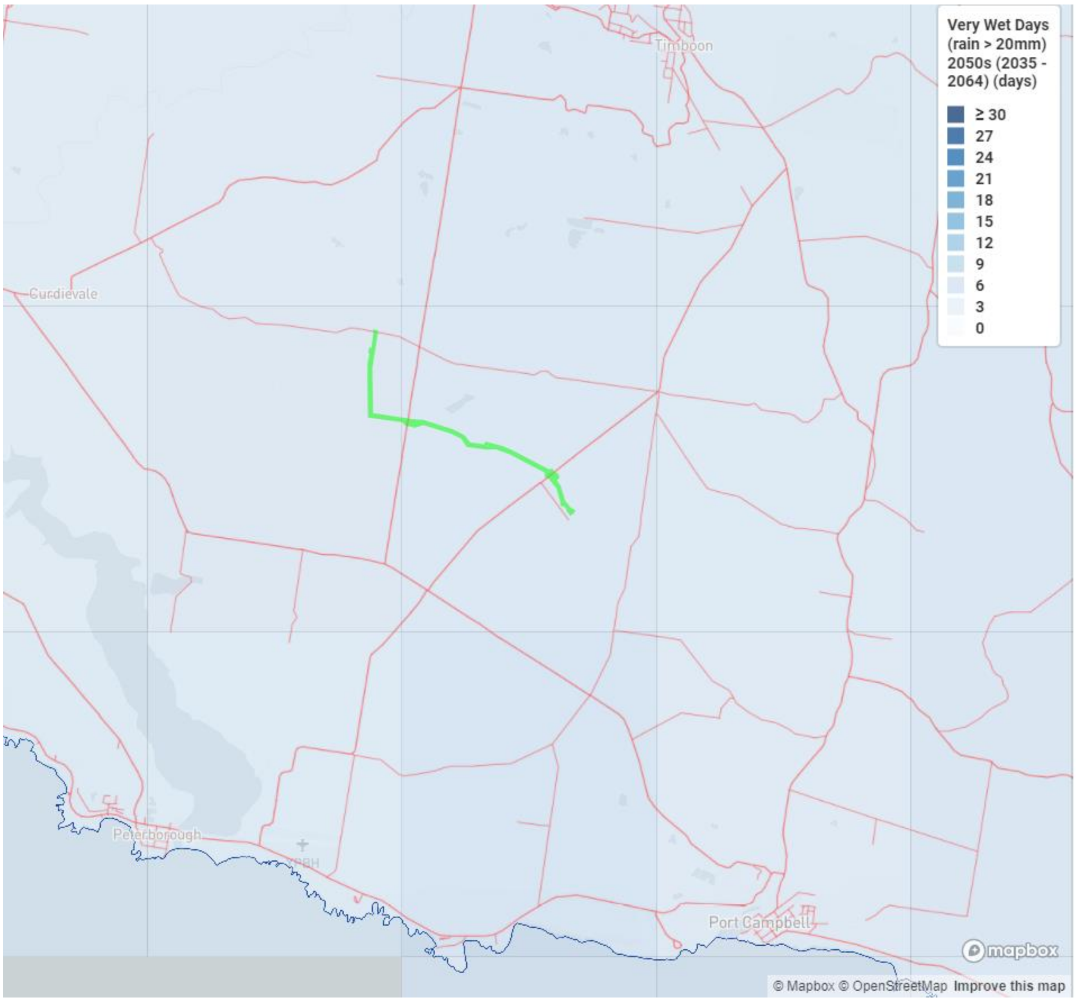

Figure 7: DEECA's Victoria's Future Climate Tool – Number of >20mm Rain Days per year from 2035-2064

Overall, modelling predicts a modest increase in rainfall intensity and the frequency of very hot days in the region over the next 40 years. Current design controls for existing infrastructure are in place to enable continuity of pipeline safety and operation during extreme weather events and during extended periods of hot conditions.

Bushfire or grass fire risk and pipeline scour from possible future extreme weather conditions will be incorporated into the Pipeline Safety Management Study assessment process.

The ability to remotely control the blow down of gas through the HUGS Pipeline from the Iona Gas Facility during an emergency scenario adds further robustness and resilience to the pipeline's safe continued operation.

4. PIPELINE ROUTE DESIGN

4.1 GENERAL

A pipeline route between MFCT Wellsite and NPMS, within a new easement, has been prepared based on preliminary assessments and may be refined in Detailed Design with minor re-routing to avoid sensitive areas.

A survey of the preferred pipeline route corridor will be conducted, and further assessed in accordance with AS2885.1 and stakeholder requirements.

Coordinate systems for the pipeline and plant is GDA2020 MGA zone 54.

4.2 EASEMENT CONFIGURATION

The DN300 HUGS Pipeline & DN50 MEG Line shall be predominantly located within a new permanent easement, 12 m wide. Both the DN300 HUGS Pipeline and DN50 MEG Line shall be installed in the same trench. The centreline of the DN300 HUGS Pipeline shall be positioned 3.5m from the edge of the permanent easement.

The easement width shall be assessed in FEED. Criteria shall include but not limited to, providing full access for LE to the pipelines for operations and maintenance, future requirements for expansion and asset protection from encroachment activities.

4.3 CONSTRUCTION ROW

All pipeline construction activities shall be undertaken within the construction ROW. The construction ROW width will generally be limited to 25 m, with width reduced at environmentally sensitive areas, or where other sensitive receptors exist.

Figure 4 shows the typical construction ROW section for the pipeline works.

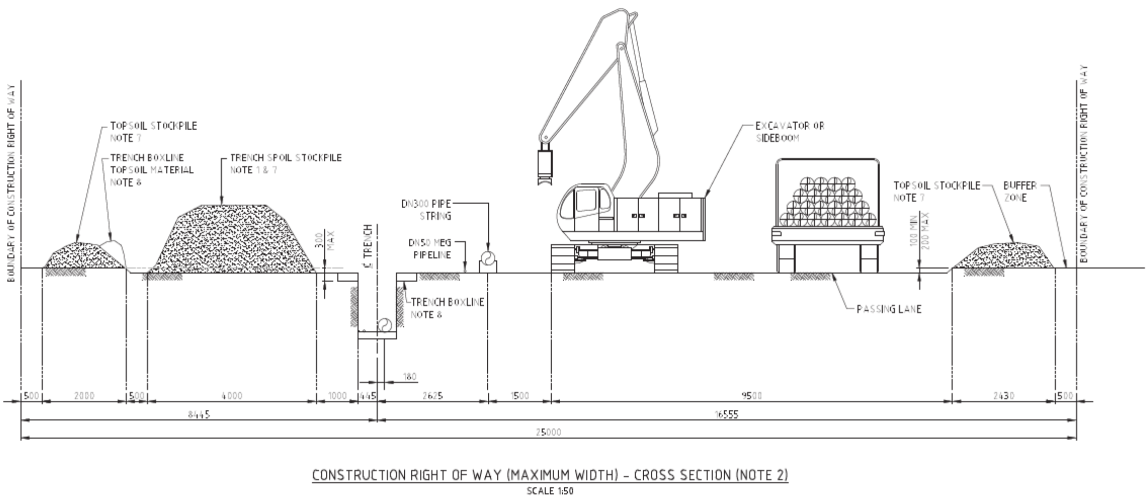

Figure 8 Typical Pipeline Construction RoW Section

4.4 TYPICAL TRENCH ARRANGEMENT

Both the DN50 MEG line and DN50 Conduit for the Fibre Optic Cable (FOC) shall be located in the same trench for the section from NP Wellsite to MFCT, on one side and 300 mm above the DN300 HUGS Pipeline. The nominated minimum depth of cover will be measured to the top of the DN50 MEG line. The vertical location of the FOC Conduit, either at the same level as the DN50 MEG Line or located in bottom of trench shall be determined in FEED. An option shall also be available to widen the trench and place all services at the bottom of the trench, with minimum separation from the DN300 pipeline to any other services of 300 mm.

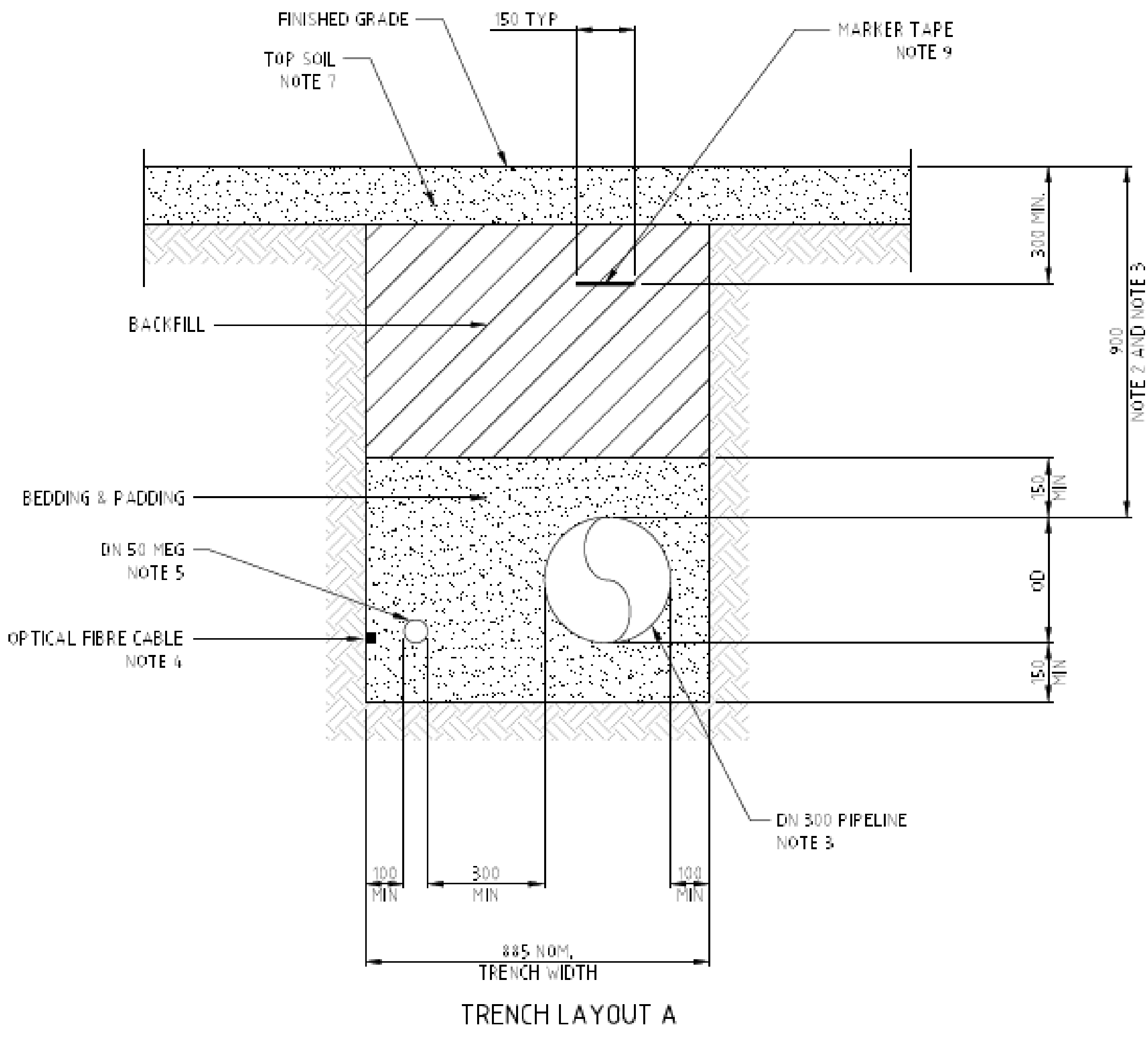

Figure 9 Typical Pipeline Trench Layout

4.5 LOCATION CLASSIFICATION AND HIGH CONSEQUENCE AREAS

The area within the nominal measurement length adjacent to the DN300 HUGS Pipeline (and DN50 MEG line) is mostly used for grazing and cropping purposes, with infrequent homesteads or other buildings within the measurement length. The base location classification is considered rural (R1) Rural.

There are no high consequence areas (HCA) identified along the route.

Location classes shall be recorded in the GIS and on the Alignment Sheets.

The pipelines shall be designed to conform with the requirements for the location classification determined for the pipeline. The pipeline location classification will be agreed in the SMS.

4.6 GEOGRAPHIC INFORMATION SYSTEM

The pipeline route design shall be performed in a Geographical Information System (GIS) which will hold the following collected survey and publicly available data:

- Aerial Imagery.
- Topographic feature survey.
- Buried services scan survey.
- Cadastral boundary survey.
- Environmental and cultural heritage survey.
- Geotechnical survey locations.
- Geohazard features.
- Hydrological features.
- Local government boundaries.
- Planning zones.
- An alignment sheet specification will be developed in FEED and Alignment Sheets generated.

4.7 DEPTH OF COVER

A minimum depth of cover of 900 mm will be implemented for this project with increased depth at crossing and special features. Depth of cover will be increased to 1200 mm where there are residences within the 12.6 kW/m^2 radiation contour.

A minimum depth of cover of 1200 mm shall be maintained inside new facilities. At road, watercourse, and floodplain crossings the minimum depth of cover is nominated in Table 8:

Location/Crossing Type	Minimum Depth of Cover (mm)
Normal (Location Class R1)	900
Facilities within measurement length	1200
Minor Gravel Road	1200
Open Cut and Bored Roading Crossing	1200
Minor Water Crossing	1200
Flood plains	1200
Foreign Crossing (separation distance)	600

Table 7: Minimum Depth of Cover levels for different crossing types

5. PIPELINE MECHANICAL DESIGN

5.1 MATERIALS

5.1.1 LINE PIPE

The line pipe for the DN300 HUGS Pipeline shall comply with the requirements of API Spec 5L X60M and shall be a hydrogen-ready design..

The battery limits of the hydrogen-ready design shall be the monolithic insulation joints at the extreme ends of the DN300 pipeline section. Pipe, fittings and equipment on the facility or station side of MIJs are not required to be hydrogen-ready.

The DN50 MEG line shall be constructed out of seamless pipe (ASTM A106 Grade B or better).

Any new pipe work required for the extension of the existing pipeline or above ground piping within the NPMS and NPPS shall meet the exact specification as the existing piping, or higher.

Wall thicknesses shall be selected in accordance with the most stringent requirements of ASME B31.12 and AS2885.1, in particular to achieve the following objectives:

- Contain pressure at the Design Pressure;
- Provide resistance to penetration;
- Allow production of induction bends;
- Provide necessary fatigue resistance;
- Ensure compliance with the stress and strain limits; and
- Allow field pressure testing to an AS 2885.5 Type 1 or Type 2 Strength Test.

A corrosion allowance is required for natural gas service, but is not required for hydrogen service. The wall thickness shall be selected such that the remaining wall thickness after natural gas service is compliant with B31.12 requirements. The remaining wall thickness shall assume that all vanishing allowances, including the corrosion allowance, are consumed

Installation stress analysis for HDD sections will be based on non-corroded wall thickness while operating stress of HDD section will be based on corroded wall thickness.

Mill test data shall be supplied by the line pipe supplier showing the actual yield and ultimate tensile strengths for each heat used.

Refer to Table 8 for a summary of line pipe data.

Parameters	HUGS Pipeline	MEG line
Nominal Pipe Size	DN300	DN50
Outside Diameter (mm)	323.9	60.3
Pipe Specification / Steel Grade	API 5L X60	API 5L Gr B
Delivery Condition	M (Thermomechanically rolled)	N (Normalised)
Pipe Manufacture	HFW	Seamless
Product Specification Level	PSL 2	PSL2
Pipe SMYS	415 MPa Derated to 400 MPa at 70° Design Temp	240 MPa
Nominal Wall Thickness (mm)	13.2 (Mainline – Straight Pipe)	5.54
Corrosion Allowance (mm)	1.5	0.0
Joint Length	Double and Triple Random (depending on location); approx. 12m to 18m	Double Random; approx. 12m

Table 8: Line Pipe Data

5.1.2 DESIGN FACTORS

AS/NZS 2885.1 puts forward required minimum design factors for various pipeline features. These design factors and the selected project design factors are shown in Table 9. Where the selected design factor is different to the required minimum design factor, this is for conservatism of design and to reduce the number of wall thickness changes along the pipeline.

Parameter	AS2885 Design Factor	Selected Minimum Design Factor
R1 Location Class	0.8	0.67
Minor River Crossings	0.8	0.67
Road Crossings	0.72	0.67
Induction Bends	0.67	0.67
Facility Assemblies	0.67	0.67
HDD	0.67	0.67

Table 9: AS 2885 Design Factors

Where B31.12 design factors for the hydrogen ready design are more stringent than the minimum AS 2885 desin factors, then the more stringent factors shall be used.

5.1.3 FRACTURE CONTROL

A fracture control plan shall be prepared for the DN300 HUGS Pipeline in conformance with Section 5.3.2 of AS/NZS 2885.1, refer document UGS-MS-0049.

A fracture control plan is not required for the DN50 MEG line as it transports a stable liquid and does not have a minimum design temperature below 0°C.

5.1.4 FATIGUE

The daily pressure cycling of the DN300 HUGS Pipeline is not expected to be severe. AS/NZS 2885.1 sets a limit on the daily hoop stress range limit of 35 MPa before fatigue assessment is required. For the HUGS Pipeline, this represents a daily pressure cycle of 2.4 MPa. Daily pressure changes of that magnitude are not planned or expected.

While significant daily changes in pressure are not expected, seasonal changes are intended to occur. In respect of the connected underground storage wells, the system is intended to operate in injection mode for part of the year then withdrawal for the remainder of the year. Pressure in the system will increase over part of the year, then decrease for the remainder of the year.

As this is an annual occurrence, a single pressure cycle per year will be experienced by the HUGS Pipeline. Considering the 25-year design life of the pipeline, which may well be increased by contemporaneous fitness for purpose assessments at the end of the initial design life, it would not be expected that the number of total pressure cycles would be significantly higher than 50.

The greatest range seen in Start of Cycle to End of Cycle pressure (per Table 4.7 of [Ref 5] is 14.1 MPa.g to 8.120 MPag at the Tregony well. This represents an amplitude of 5.980 MPag over the annual pressure cycle. This equates to a hoop stress range of approximately 86.5 MPa, well below the upper bound put forward by AS.NZS 2885.1 of 165 MPa before detailed fatigue assessment is required.

A fatigue assessment in conformance to Appendix J of AS/NZS 2885.1 shall be undertaken for the DN300 HUGS Pipeline. The historic pressure fluctuation data from the previous years needs to be reviewed to determine the number of pressure fluctuations including daily hoop stress fluctuations greater than 35 MPa, if any.

5.1.5 STRESS CORROSION CRACKING

Two forms of SCC have the potential to affect high pressure pipelines, including the HUGS Pipeline:

- High pH SCC
- Near-neutral SCC

High pH SCC occurs within a narrow electrochemical potential range of -600 to -750 mV, and in the presence of carbonate/bicarbonate environment with the pH between 9 to 13. High pH SCC is most commonly found in gas transmission pipelines where:

- The operating temperature is greater than 38°C;
- The operating stress is greater than 60% of SMYS (per ASME B31.8S A3), or 40% (per AS/NZS 2885.1 Appendix O);
- The distance from a compressor station (or processing facility involving compression) is 32 km or less;
- The age of the pipeline is 10 years or greater; and
- The pipeline is uncoated or coated in a protective coating other than FBE.

Near-neutral pH is commonly associated with dilute groundwater containing dissolved CO_2. The near-neutral-pH form of SCC is transgranular, with cracks propagating through the grains in the metal structure. In near-neutral SCC, cracks are often wider (more open) than the cracks that form in high-pH SCC. The crack sides can also experience metal loss from corrosion.

Near-neutral SCC is less temperature-dependent than high pH SCC. Susceptibility criteria for near-neutral SCC is the same as for high pH SCC, excluding the temperature factor.

The HUGS Pipeline's characteristics in relation to the SCC susceptibility factors are outlined in Table 10.

Factor	Susceptibility Factor	HUGS Pipeline Characteristics	Outcome
Operating Temperature	Susceptible if > 38°C	Max design temperature > 38°C, however, max operating temperature expected to be 40°C	Susceptible increases only if operated consistently at maximum operating temperatures
Operating Stress	Susceptible if > 40% SMYS	reater than 40 % SMYS with corrosion allowance in place, higher with corrosion allowance consumed	Susceptible per AS2885, particularly with CA consumed. Actual operating stress may be lower, however.
Distance from Compression Facility	Susceptible if within 32 kms	Within 10 kms of IGP while in Injection mode	Susceptible when in Injection mode
Age of Pipeline	Susceptible if greater than 10 years old	New pipeline	Not susceptible in early life
Coating	Susceptible if coating of pipeline is other than FBE	FBE proposed	Not susceptible if FBE coated

Table 10: SCC Susceptibility

It is not considered that the HUGS Pipeline will have high susceptibility to SCC due to the specification of a mill-applied fusion bonded epoxy coating. Further, the operating stress in the pipeline will generally be in the lower portion of the susceptibility range.

Ongoing pipeline integrity management, including monitoring of operating pressures, temperatures, and regular DCVG or other coating surveys will confirm that the pipeline's susceptibility to SCC remains low.

5.1.6 FITTINGS

The project shall develop a new project specific piping class specification for the fittings used for the DN300 HUGS Pipeline. Existing Lochard piping class specification shall be used for the DN50 MEG line.

Fittings used in the fabrication of pipeline assemblies connected to the main run of the DN300 HUGS Pipeline shall comprise of high strength fittings complying to ASTM A860/860M and MSS SP-75. The fitting strength shall be selected to allow selection of standard wall thicknesses while meeting pressure containment requirements and limiting the range between maximum and minimum internal diameter of the pipeline such that the piggabilty of the line is not adversely impacted.

Use of welded fittings shall not be permitted.

5.1.7 VALVES

The project shall develop a new piping class specification for the valves to be used for the DN300 HUGS Pipeline and DN50 MEG line.

Valves used on this pipeline shall be in accordance with standards and practices referenced in AS 2885.1.

Pipeline valves shall be:

- Designed in accordance with API 6D standard.
- Fire Safe in accordance with API 6FA / API 607 standards.
- Double block and bleed (energized seats and cavity bleed type) in accordance with API 6D.

Lochard Energy's preferences is to install pipeline isolation valves with flanged end connections rather than weld-end connections. This is to facilitate maintenance in the event that seals on critical isolation valves fail to hold pressure, requiring valve replacement to resolve. Given the relatively short length of the HUGS Pipeline, this is seen as a larger risk than the potential impact of a pipeline leak occurring at a flanged joint.

Valve operator type will be in accordance with Lochard Energy standards.

5.1.8 PIPELINE BENDS

5.1.8.1 GENERAL

Changes in horizontal and vertical direction shall be achieved using induction bends, cold field bends or roped bends. All bends shall be designed to be piggable, and in all cases, the radius of the DN50 bends will match the radius of the corresponding DN300 bend.

For the DN50 MEG line, induction bends shall be formed at the same radius as the DN300 induction bends, allowing both pipelines to follow the same curvature within a trench at bends. At all other locations, change in directions will be achieved by cold field bends or roped bends.

5.1.8.2 INDUCTION BENDS

Induction bends shall conform to ASME B31.12, Section 3.2.2 of AS/NZS 2885.1 and ISO 15590-1. Inductions bends shall be made from the line pipe procured for the project and DN300 induction bends shall have a minimum bend radius of 5D. DN50 bends, as discussed in 5.1.8.1, shall have the same actual radius as the DN300 bends.

5.1.8.3 COLD FIELD BENDS

Cold field bends shall conform to ASME B31.12, Section 10.7.7 of AS/NZS 2885.1. The maximum bend angle for the DN300 HUGS Pipeline shall be calculated based on a minimum bend radius equivalent to one degree per diameter. All cold field bends shall include a minimum of one-metre tangent length on either side of the bend, to allow appropriate weld fit-up.

Cold field bends shall be used where their use will ensure that the pipeline stays within the easement and maintains the required clearances to the existing assets within the easement.

5.1.8.4 ROPE BENDS

Roped bends shall conform to ASME B31.12, Section 10.7.5 of AS/NZS 2885.1 with the minimum bend radius limited to 500D for DN300 bends. DN50 bends shall be formed to the same actual radius as DN300 bends.

5.1.9 WELDING

Welding shall conform to AS 2885.2, Tier 1 acceptance criteria, and shall be compliant with the minimum requirements of ASME B31.12.

A list of required WPS shall be developed during subsequent phases of the project to ensure sufficient test pieces are available for the weld procedure qualification tests (WPQTs).

5.1.10 COATINGS

The pipelines shall be externally coated for external corrosion protection. The pipelines shall not be internally coated.

The pipelines shall be coated as follows:

- DN300 line pipe – dual-layer FBE;
- DN50 line pipe – three-layer polyethylene, or dual-layer FBE based on supplier proposals;
- DN300 bored crossing or HDD – dual-layer FBE with abrasion resistant overlay;
- DN50 bored crossing or HDD – additional PE outer layer thickness, abrasion resistant overlay, heat-shrink sleeves;
- Field joints for DFBE – liquid epoxy;
- Induction bends and buried fittings – high-build liquid epoxy; and
- Air to ground interfaces – LE-approved wrapping system (refer to UGS-MS-0206).

Note FBE and liquid epoxy coatings are suitable for the maximum design temperature of the HUGS Pipeline (70°C), whereas originally proposed yellowjacket coating is not.

Station piping and aboveground items such as structural piping supports shall be coated in accordance with the LE Protective Coatings Specifications (UGS-MS-0206).

5.2 STRESS AND STRAIN

The stress and strain on the DN300 HUGS Pipeline and DN50 MEG line shall be analysed in detailed design to ensure conformance with the limits listed in Table 5.7.7 of AS/NZS 2885.1 as well as the minimum requirements of ASME B31.12.

5.3 PIPELINE STABILITY

The pipelines shall be fully restrained past the virtual anchor length from the pipeline facilities.
The geometry and soil restraint, including 90° bends in the vicinity of above ground / below ground interfaces shall be implemented to reduce pipeline deflection above ground. This will be confirmed via pipe stress analysis during detailed design.

The Geotechnical assessment (as covered in Section 3.2) shall determine if unstable soils are anticipated along the pipeline route, and if buoyancy control measures are required.

5.4 ACCEPTANCE TESTING

The pipelines and their components shall be subjected to destructive and non-destructive tests to demonstrate their fitness for service as required by ASME B31.12, AS/NZS 2885.1, AS 2885.2, AS/NZS 2885.5 and the component specific design or materials codes.

5.4.1 WELD EXAMINATION

100% of girth welds shall be inspected for the entire weld length using X-ray examination or ultrasonic testing techniques and in accordance with the applicable assessment criteria under AS 2885.2.

Golden welds shall be also examined using two forms of non-destructive testing.

On shop-fabricated spools where geometry does not allow the use of X-ray examination, gamma ray may be permitted as an alternative.

5.4.2 FIELD PRESSURE TESTING

The pipelines shall be subject to strength and leak tests in accordance with the requirements of AS/NZS 2885.5. The intended minimum strength test pressure at the highest point of the pipelines shall not be lower than the design pressure times the equivalent test pressure factor (FTPE) as defined by equation 4.3.3(2) of AS/NZS 2885.1.

5.5 CROSSING DESIGN

5.5.1 ROADS AND TRACKS

Road and track crossing shall conform to the requirements of Section 5.8.8 AS/NZS 2885.1 and ASME B31.12. Loads on the pipelines shall be assessed in accordance with API RP 1102.

The depth of cover within sealed or gazetted road reserves, and for the extent of known access tracks shall be a minimum of 1200 mm. Where the minimum depths of cover cannot be met, additional protection methods such as slabbing shall be included.

Sealed roads shall be crossed using trenchless techniques. Where required, mini horizontal directional drilling (HDD) techniques shall be considered to minimise the need to extend the existing pipeline easements.

The crossing design for gazetted roads shall be approved by the relevant coordinating road authority.

5.5.2 WATERCOURSES

Watercourse crossings may typically be constructed by open cut method. Special construction measures will be utilised when required to limit environmental impact, including trenchless construction where required.

Designated water crossings will have site specific design which may include provisions such as buoyancy control measures and additional depth of cover. These measures shall extend from top-of-bank to top-of-bank.

5.5.3 HORIZONTAL DIRECTIONALLY DRILLED (HDD) CROSSINGS

Where HDD crossings are required, for example, under major roads and major watercourse crossings, the HDD design will follow the guidance in the PRCI HDD Installation Design Guide Catalog No. PR-277-144507-E01.

A detailed stress analysis shall be performed to evaluate pipeline stresses within the HDD section during construction and during operation. These stresses shall comply with the limits given in AS/NZS 2885.1 as well as ASME B31.12.

5.5.4 FOREIGN SERVICES

The pipelines shall be installed below other services except in situations where they can be safely installed above while maintaining the required clearances and depths of cover.

The pipelines shall have a minimum vertical clearance of 500 mm to power and communications cables.

For open cut installations, the pipelines shall have a minimum vertical clearance of 600 mm to other pipelines unless additional separation is required by the 3rd party owner.

A minimum vertical/horizontal separation of 300 mm is required from the MEG pipeline to the HUGS pipeline . A separation distance of 100mm is required for FOC from the MEG pipeline.

For HDD installations, the pipelines shall have a minimum vertical clearance of 1000 mm to other services.

The crossing design for foreign licensed pipelines shall be approved by the relevant asset owners.

5.6 PIPELINE ASSEMBLIES

Pipeline assemblies shall be designed to a design factor of 0.67 including the following items:

- Pipeline end of line facilities including above ground / below ground risers, pig trap assemblies and above ground piping spools; and
- Branch connections.

Note that all design factors for the pipeline are shown in Table 9.

Note that mid-line mainline valve assemblies are not required for this project.

For the piping and layout design requirements of pipeline assemblies including pig traps and barred tees, refer to the Piping & Layout section of the HUGS Project Basis of Design [Ref 5].

5.6.1 PIG TRAPS

The permanent pig traps shall be designed for launching and receiving non-abrasive cleaning, gauging, dewatering, and intelligent pigs and shall be compatible with the dimensions of the pigs typically used by LE. The pig traps shall have pressure indicators, vents, drains and a means to equalise pressure between the major and minor barrels.

The major barrel shall be a nominal 100mm larger than the minor barrel. The nominal diameter of the kicker line shall be half the nominal diameter of the pipeline.

Existing non-intrusive pig indicators will be used on the new pig trap and above ground riser assemblies. These will be installed prior to pigging operations and may be removed afterwards, at the discretion of LE Operations.

Pigging assemblies will be provided at the following locations:

- Provisions for a temporary pig trap shall be allowed for at the MFCT end of the DN50 MEG Pipeline.
- A permanent pig launcher shall be installed on the DN300 HUGS Pipeline at the MFCT well site.
- A relocated permanent pig receiver shall be installed at the end of the WC Gathering Line near NPMS.

5.7 MARKER SIGNS AND TAPE

Double-sided marker signs shall be installed along the pipeline routes in conformance with Section 4.10 of AS/NZS 2885.1. The design shall consider the potential for the use of offset marker signs where there are existing marker posts.

As a minimum, marker signs shall be installed:

- With intervisibility between signs, and with spacings conforming to Table 4.10.1 of AS 2885.1;
- On both sides of sealed road reserve boundaries;
- On both sides of watercourse crossings;
- At existing marker locations consistent with the LE parallel pipeline;
- On property and station fences; and
- At bends.

Marker tape shall be installed continuously in all open cut sections as per the typical drawings and alignment sheets.

6. CATHODIC PROTECTION DESIGN

6.1 GENERAL

The DN300 HUGS Pipeline and DN50 MEG line shall be protected against corrosion by a AS 2832.1 conforming impressed current cathodic protection (CP) system.

This CP system shall be defined in FEED and will be a new impressed current CP system. The CP system will be updated once agreed.

The CP system shall be designed to protect the new pipelines from stray currents and lightning.

The well head casings at the well sites shall be protected by a cathodic protection (CP) system which shall be defined in FEED.

6.2 TEMPORARY CP

A temporary CP system utilizing sacrificial anodes shall be connected to buried sections of the DN300 HUGS Pipeline and DN50 MEG Pipeline during construction until permanent CP system is commissioned. At the time of commissioning of permanent CP, the temporary anodes can be disconnected.

The temporary anodes will have a design life of 2 years.

6.3 IMPRESSED CURRENT CP

The impressed current cathodic protection system shall be designed by others and shall conform to the relevant Victorian Electricity Regulations. All necessary liaisons shall be made with the owners of other structures that may be affected by the impressed current CP system. Interference testing shall be carried out in accordance with AS 2832.1, Section 8.2. All affected parties shall be notified, and interference testing shall be carried out in accordance with the Victoria Electrolysis Committee guidelines.

6.4 PIPELINE ELECTRICAL ISOLATION

All earthed equipment shall be electrically isolated from the pipeline so that the CP is not short-circuited. Isolation of the HUGS Pipeline and the MEG Pipeline shall be by way of monolithic insulation joints (MIJ).

Pipe supports should generally not be installed between the MIJs and the buried pipeline where they are for small sections of aboveground pipeline. If required, they shall have insulated pads. Station piping shall be earthed via a solid-state polarisation cell to the facility earthing grid for personnel safety protection from fault currents, induced voltages and lightning.

The maximum stress applied to the MIJ shall not exceed the manufacturer's limits, by allowing suitable flexibility and/or displacement of the piping in the AG / BG riser assembly. The design shall consider differential settlement effects.

Isolation of the buried pipelines from earth shall be achieved by installation of isolation devices in each of the connections between the pipeline and earth. All insulating joints shall be protected against electrical surges by appropriately rated surge protection devices that are of a type to match the earthing material and earthing system design in the facilities.

All instrumentation and control cabling that is directly connected to the pipeline shall be treated such that the pipeline and the CP system do not become electrically continuous with the site earthing system. Cable armouring shall be electrically isolated using isolating gland adaptors.

All instrumentation impulse piping that is directly connected to the pipeline shall be treated such that the pipeline and the CP system do not become electrically continuous with the site earthing system by installing tubing or cable gland insulating joiners as applicable.

Where necessary, earth connections to cathodically protected pipelines such as at step-touch voltage mitigation features shall be made via solid-state polarisation cells (dc decoupling devices) to ensure cathodic protection current is not drained to earth.

Connections to the pipeline shall be in accordance with AS 2885.2.

7. PIPELINE SMS PLAN

7.1 GENERAL

The threats faced by new pipelines shall be controlled (or mitigated by design or with the application of appropriate procedural controls). Threats that cannot be sufficiently controlled by design alone shall be risk assessed. In these instances, the residual risk rankings shall not be higher than “low”. AS/NZS 2885.6 requires safety management studies be undertaken at various phases of the project. When a SMS is undertaken it is generally validated in a facilitated workshop setting with the group of suitably experienced participants covering the aspects of process design, safety and risk, pipeline design, construction, testing, commissioning, operation and maintenance. The types of SMS and the required inputs and expected outputs are discussed below.

7.2 PRELIMINARY DESIGN SMS COMBINED WITH FEED SMS

A front-end engineering design (FEED) SMS workshop has been undertaken to ensure that decisions taken early in the project such as the selection of a wall thickness appropriate for external interference protection can be made confidently and not hinder the procurement of long lead line pipe. The FEED SMS will incorporate the requirements of the Preliminary Design SMS per AS 2885.6 Clause 5.42. Where applicable, this will include the identification of high consequence areas which will invoke the “no rupture” design requirement as per Section 4.9 of AS/NS 2885.1.

7.2.1 INPUTS

- Process design philosophies and transient analysis;
- Control systems philosophies;
- Preliminary pipeline alignments (via satellite imagery or alignment sheets);
- Location classification report;
- Typical design for threats mitigated by design; and
- Calculations (wall thickness, resistance to penetration, critical defect length, fast tearing fracture arrest toughness, radiation contour, energy release, etc.).

7.2.2 OUTPUTS

- FEED SMS report summarising actions for route alignment changes or implementation of additional threat controls; and
- Determination of “no rupture” design requirement, as applicable.

7.3 DETAILED DESIGN SMS

A detailed design SMS shall be undertaken to demonstrate that the requirements of AS/NZS 2885.1 have been achieved for the two new pipelines. In addition to the inputs used during the FEED SMS, the detailed design SMS will require the additional inputs described below.

7.3.1 INPUTS

- FEED SMS report;
- Basis of design;climate
- Corrosion mitigation strategy;
- Final pipeline alignments;
- Land use assessments;
- Foreign asset owner conditions and typical right of way maintenance activities;
- Environmental constraints;
- Pipeline isolation plan;

- Fracture control plan;
- Hazard and operability study (HAZOP) report; and
- Process design philosophies.

7.3.2 OUTPUTS

- Detailed design SMS report summarising actions for route alignment changes or implementation of additional threat controls.

7.4 PRESSURE TEST DESIGN SMS

A separate pressure test design SMS is not anticipated for this project. The rural setting and low population density greatly diminish the threats to public safety during the field pressure tests. The risks associated with hydrotesting including injuries to personnel and environmental damage shall be assessed during the Detailed Design SMS and by the field pressure testing contractor as part of their construction hazard identification (HAZID) and risk assessment process.

7.5 PRE-CONSTRUCTION REVIEW SMS

A pre-construction SMS shall be undertaken to ensure actions from the detailed design SMS and controls to address material or construction defects are implemented.

7.5.1 INPUTS

- Detailed design SMS report;
- Quality control plans; and
- Surveillance plans.

7.5.2 OUTPUTS

- Updated SMS report.

7.6 REVIEW OF SMS POST CONSTRUCTION

The SMS shall be reviewed post construction to look at changes to design (TQ's, site instructions) and deviations from design to assess effectiveness of controls. All actions from detailed design shall be reviewed/ updated prior to commissioning of the pipeline.

7.7 PRE-COMMISSIONING SMS

A review of the SMS shall be undertaken prior to commissioning to ensure that all corrective actions affecting the pipelines' safety have been undertaken and confirm that procedural controls for the safe operation of the pipeline have been incorporated into the isolation plan, commissioning plan and pipeline management system.

7.7.1 INPUTS

- Updated SMS report;
- As-built records of the pipeline alignment (including re-routes), crossings and facilities;
- Records of any construction phase non-conformances;
- Field pressure testing records and MAOP confirmation;
- Commissioning plans; and
- Pipeline management system including operating procedures.

7.7.2 OUTPUTS

- Updated SMS report; and
- Updated commissioning plans.

8. INSTRUMENTATION AND ELECTRICAL DESIGN

For the complete instrumentation and electrical design requirements of the project, refer to the HUGS Project Basis of Design [Ref 5].

The FOC shall be installed in a conduit laid in the same trench as the DN300 HUGS Pipeline and the DN50 MEG Pipeline, per the trench layout shown in Figure 9.

9. CIVIL AND STRUCTURAL DESIGN

For the complete civil and structural design requirements of the project, refer to the HUGS Project Basis of Design [Ref 5].

10. HYDROGEN-SPECIFIC DESIGN PARAMETERS

The HUGS Pipeline shall be designed and constructed as a hydrogen ready pipeline. The hydrogen-ready design shall be in accordance with ASME B31.12, to the Option B design method.

The hydrogen-ready HUGS Pipeline shall be operated as an AS2885-compliant pipeline transporting natural gas for the initial part of its life and would transition to hydrogen when the operational need arises.

In order to deliver an AS 2885 compliant natural gas pipeline, AS 2885 shall be the overriding reference standard, and the minimum requirements of AS 2885 (as described in this Basis of Design) shall apply to the pipeline design. ASME B31.12 shall also be referenced in the mechanical and material design aspects of the pipeline design between the hydrogen-ready battery limits.

Where the requirements of AS 2885 and ASME B31.12 differ, the most stringent requirement of each shall be used.

The Safety Management aspects of pipeline design shall be performed in accordance with AS/NZS 2885.1 and AS/NZS 2885.6.

Design conditions relevant to the hydrogen-ready case are as outlined in Table 11.

Parameters	HUGS Pipeline
Nominal Pipe Size	DN300
Outside Diameter (mm)	323.9
Pipe Specification / Steel Grade	API 5L X60
Delivery Condition	M (Thermomechanically rolled)
Pipe Manufacture	HFW
Product Specification Level	PSL 2
Pipe SMYS	415 MPa
Nominal Wall Thickness (mm)	13.2 (Mainline – Straight Pipe)
Corrosion Allowance (mm)	0 (in Hydrogen Service)
Design Factor	0.6
Joint Length	Double and Triple Random (depending on location); approx. 12m to 18m
Design Life (overall)	25 years
Design Pressure	16 MPag
Design Temperature	-20°C to 70°C
Gas	100% hydrogen
Moisture Content	<20 ppm water content
Location Class	Class 1, Division 2

Table 11: Hydrogen-Specific Parameters

APPENDIX A. Process Safety Diagrams

1. UGS-PS-0012 North Paaratte and Wallaby Creek Wellheads and Flowlines
2. UGS-PS-0013 Wellheads and Slug Catcher
3. UGS-PS-0014 North Paaratte and Wallaby Creek Slug Catcher and Inlet Separation
4. UGS-PS-0016 MCFT
5. UGS-PS-0041 Gas Headers – LP, IP, HP, Import and Export

CONTROLLED INFORMATION APPROVAL AND DISTRIBUTION PAGE

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