Attachment II

Risk to the project from climate change

Prepared for
Viva Energy Gas Australia Pty Ltd
ABN: N/A

Attachment II: Risk to the project from climate change

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Viva Energy Gas Terminal Project

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Executive summary

This technical report provides an assessment of the risk to the Viva Energy Gas Terminal Project (the project) from climate change conducted to support the Environment Effects Statement (EES).

The purpose of the assessment was to identify and assess potential risks to the project from the projected impacts of climate change. The assessment identified potential climate change scenarios relevant to the project area, the risks posed to the project in context of those scenarios, the potential impact those risks could have on the project taking into consideration current risk controls and developed additional controls for risk mitigation. *Technical Report C: Greenhouse gas impact assessment* provides an assessment of the potential impacts of greenhouse gas emissions associated with the construction and operation of the project.

In December 2020, the Victorian Minister for Planning issued a decision that the project required assessment through an EES under the *Environment Effects Act 1978* (Vic). The reasons for the decision were primarily related to the potential for significant adverse effects on the marine environment of Corio Bay and the potential for contributing to greenhouse gas emissions. Secondarily, the EES was required to assess the effects of the project on air quality, noise, land use, Aboriginal and historic heritage, native vegetation, groundwater, traffic, and transport as well as visual amenity.

In January 2021, the project was also determined to require assessment and approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* ('EPBC Act') due to the potential for the project to have a significant impact on wetlands of international importance, listed threatened species and communities, and listed migratory species. The EES process is the accredited environmental assessment process for the controlled action decision under the EPBC Act in accordance with the bilateral agreement between the Commonwealth and Victorian governments.

Overview

Viva Energy Gas Australia Pty Ltd (Viva Energy) is planning to develop a gas terminal using a ship known as a floating storage and regasification unit (FSRU), which would be continuously moored at Refinery Pier in Corio Bay, Geelong. The key objective of the project is to facilitate supply of a new source of gas for the south-east Australian gas market where there is a projected supply shortfall in coming years.

The FSRU would store LNG received from visiting LNG carriers (that would moor directly adjacent to the FSRU), and regasify the LNG as required to meet industrial, commercial and residential customer demand. A 7 kilometre gas transmission pipeline would transfer the gas from the FSRU to the Victorian Transmission System (VTS) at Lara.

The gas terminal would be located adjacent to, and on, Viva Energy's Geelong Refinery in a heavily industrialised setting and would benefit from Viva Energy's experience and capability as an existing Major Hazard Facility (MHF) operator and potential synergies between the two facilities such as reuse of the FSRU seawater discharge within the refinery operations.

Victoria's *Climate Change Act 2017 (Vic)* recognises that *'Victoria is particularly vulnerable to the adverse effects of climate change'* and that it must *'build the resilience of the State's infrastructure, built environment and communities through effective adaptation and disaster preparedness action'*. The adverse impacts of climate change pose increased risks of damage, failure, disruption, reduced safety and cost to the construction and operation of infrastructure assets over their lifespans. Early preparation and planning through assessing the long-term risks and implementing appropriate adaptation measures supports safety and resilience throughout the project lifecycle.

Furthermore, assessment of physical climate risks when developing significant projects such as this is part of Viva Energy's approach to managing climate change risk more broadly.

Methodology applied

A climate change risk assessment was undertaken consistent with *AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk-based approach* (Standards Australia, 2013) focusing on the potential climate change risks that may impact the project. The assessment included the following tasks:

- identification of historical climate data and climate change projections for the project study area
- selection and agreement on the suitable risk assessment framework for the climate change risk assessment
- identification and assessment of climate change risks starting with a climate change risk workshop, held in March 2021 with representatives of the Environment Effects Statement (EES) team and relevant technical specialists from Viva Energy and Worley / Advisian as the facility designer.

The risk assessment method used in this climate change risk assessment is distinct from the risk assessment approach used by the other technical studies in the EES. This is because the climate change risk assessment seeks to identify the potential impacts of a changing climate on the project, while the broader EES assesses the potential impacts that the project poses to the environment.

Climate change projections and hazards

Hazards relevant to the project study area arising from climate change include extreme temperature and/or heatwave, extreme rainfall events, bushfire, drought, storm events, river flood, sea level rise, ocean acidity, ocean temperature and enhanced atmospheric concentrations of carbon dioxide (CO_2). These hazards were used as a basis for identifying risk scenarios during the risk workshop.

Risk assessment

Of the 47 risks identified in the March 2021 climate change risk workshop, eight risks to the project were rated ‘high’ mostly affecting the pier but also the FSRU, pipeline and treatment facility. The eight ‘high’ risks are primarily associated with storm weather, extreme rainfall events, sea level rise and extreme heat events. Adaptation measures were developed to treat each of the eight risks and, based on consultation with the project design team, have been considered appropriate to mitigate against the potential impacts of climate change on the project.

Abbreviations and glossary of terms

Abbreviation/Term	Definition
AECOM	AECOM Australia Pty Ltd
BoM	Bureau of Meteorology
CaLP Act	Catchment and Land Protection Act 1994
CO_2	Carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DMG	Dredged material ground
EES	Environment Effects Statement
EPA	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
FFG Act	Flora and Fauna Guarantee Amendment Act 2019
FSRU	Floating storage and regasification unit
GHG	Greenhouse gas
HDD	Horizontal directional drilling
IPCC	Intergovernmental Panel on Climate Change
LNG	Liquified natural gas
MHF	Major Hazard Facility
MLA	Marine loading arm
NCCARF	National Climate Change Adaptation Research Facility
RCP	Representative Concentration Pathways
ROW	Right of way
SLR	Sea level rise
SWI	Seawater intake
SWP	South West Pipeline
VCP	Victorian Climate Projections
VTS	Victorian Transmission System

1.0 Introduction

This technical report provides the outcomes of an assessment of the risk of climate change to the Viva Energy Gas Terminal Project (the project) conducted to support the project's Environment Effects Statement (EES).

Viva Energy Gas Australia Pty Ltd (Viva Energy) is planning to develop a gas terminal using a ship known as a floating storage and regasification unit (FSRU), which would be continuously moored at Refinery Pier in Corio Bay, Geelong. The key objective of the project is to facilitate supply of a new source of gas for the south-east Australian gas market, where there is a projected supply shortfall in coming years.

The FSRU would store liquefied natural gas (LNG) received from visiting LNG carriers (that would moor directly adjacent to the FSRU) and would convert LNG back into a gaseous state by heating the LNG using seawater (a process known as regasification) as required to meet industrial, commercial, and residential customer demand. A 7 kilometre gas transmission pipeline would transfer the gas from the FSRU to the Victorian Transmission System (VTS) at Lara.

The project would be situated adjacent to, and on, Viva Energy's Geelong Refinery, within a heavily developed port and industrial area on the western shores of Corio Bay between the Geelong suburbs of Corio and North Shore. Co-locating the project with the existing Geelong Refinery and within the Port of Geelong offers significant opportunity to minimise potential environmental effects and utilise a number of attributes that come with the port and industrial setting.

In December 2020, the Victorian Minister for Planning determined that the project requires assessment through an EES under the *Environment Effects Act 1978* (Vic). The reasons for the decision were primarily related to the potential for significant adverse effects on the marine environment of Corio Bay and the potential for contributing to greenhouse gas emissions. Secondarily, the EES was required to assess the effects of the project on air quality, noise, land use, Aboriginal and historic heritage, native vegetation, groundwater, traffic and transport as well as visual amenity.

In January 2021 the project was also determined to require assessment and approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* ('EPBC Act') due to the potential for the project to have a significant impact on the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site (a wetland of international importance), listed threatened species and communities, and listed migratory species. The EES process is the accredited environmental assessment process for the controlled action decision under the EPBC Act in accordance with the bilateral agreement between the Commonwealth and Victorian governments.

1.1 Purpose

The purpose of the climate change risk assessment is to identify and assess potential risks to the Viva Energy Gas Terminal from the projected physical impacts of climate change and develop adaptation measures to address these risks in the design, construction and operational phases of the project.

Technical Report C: Greenhouse gas impact assessment provides an assessment of the potential impacts of greenhouse gas emissions associated with the construction and operation of the project.

1.2 Why understanding climate change risk is important

Victoria's *Climate Change Act 2017(Vic)* ('Climate Change Act') recognises that *"Victoria is particularly vulnerable to the adverse effects of climate change"*[1] and that it must *"build the resilience of the State's infrastructure, built environment and communities through effective adaptation and disaster preparedness action"*[2]. The adverse impacts of climate change pose increased risks related to damage or failure of assets, disruption of construction or operation activities and health and safety. Early preparation and planning that considers long-term risks and implements appropriate adaptation measures supports safety and resilience throughout the project lifecycle.

[1] Victoria Climate Change Act 2017 no.5 of 2017, p. 1
[2] Victoria Climate Change Act 2017 no.5 of 2017, p. 21

1.3 Project area

The project would be located adjacent to, and on, the Geelong Refinery and Refinery Pier in the City of Greater Geelong, 75 kilometres (km) south-west of Melbourne. The project area is within a heavily developed port and industrial area on the western shores of Corio Bay between the Geelong suburbs of Corio and North Shore. The Geelong central business district is located approximately 7 km south of the project.

Corio Bay is the largest internal bay in the south-west corner of Port Phillip Bay and is a sheltered, shallow basin at the western end of the Geelong Arm, with an area of 43 square kilometres (km^2). The Point Wilson/Limeburners Bay section of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site is located along the northern shoreline of Corio Bay, approximately one kilometre to the north-east of the project.

The Port of Geelong has been in operation for over 150 years and is the largest industrial bulk cargo port in Victoria, attracting over 600 ship visits and handling more than 14 million tonnes of product annually. Geelong's shipping channels extend 18 nautical miles through Corio Bay from Point Richards through to Refinery Pier. Ports Victoria (formerly Victorian Regional Channels Authority) manages commercial navigation in the port waters in and around Geelong and is responsible for the safe and efficient movement of shipping, and for maintaining shipping channels and navigation aids. The channels are man-made having been deepened and widened through periodic dredging to support port trade development.

Refinery Pier is the primary location within the Port of Geelong for movement of bulk liquids. Vessels up to 265 metres in length currently utilise the four berths at Refinery Pier which service Viva Energy refinery operations. The majority of ship visits to the port are to Refinery Pier, with Viva Energy accounting for over half of the trade through the Port of Geelong.

The Geelong Refinery has been operating since 1954 with both the refinery and the co-located Lyondell Basell plant being licensed Major Hazard Facilities (MHFs). A range of industrial activities are situated in the Port environs including wood fibre processing and chemical, fertiliser and cement manufacturing.

To the north of the Geelong Refinery, along the proposed underground pipeline corridor, the area is predominantly rural. There are several other existing Viva Energy-owned underground pipelines running between the refinery and the connection point to the South West Pipeline (SWP) at Lara. The proposed pipeline route follows already disturbed pipeline corridors, where possible, through a mix of land uses.

The project area is shown in Figure 1.

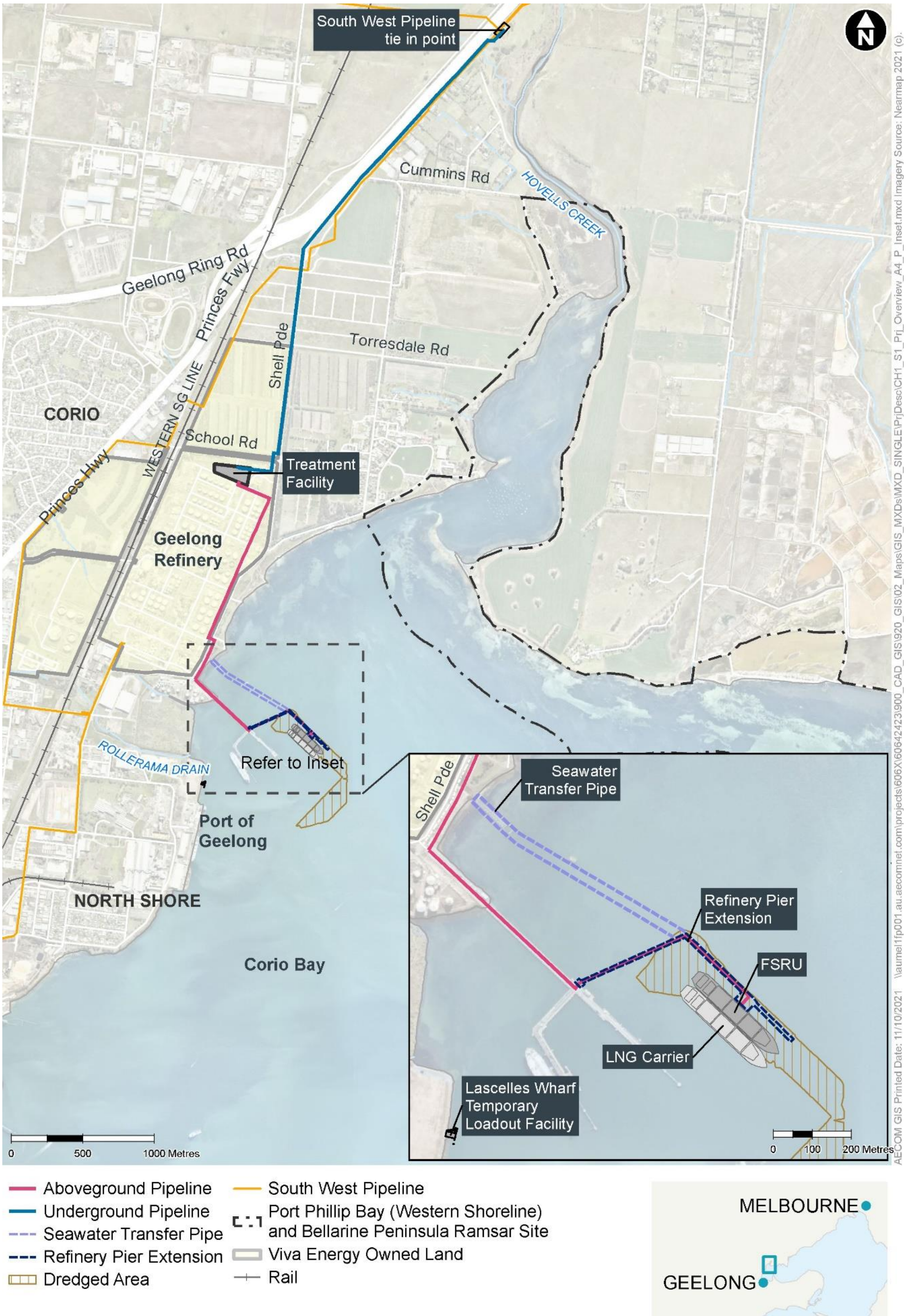

Figure 1: Project overview

1.4 Project description

This section summarises the project as described in Chapter 4 *Project description*. Key components of the project include:

- extension of the existing Refinery Pier with an approximately 570 m long angled pier arm, new berth and ancillary pier infrastructure including high pressure gas marine loading arms (MLAs) and a transfer line connecting the seawater discharge points on the FSRU to the refinery seawater intake
- continuous mooring of an FSRU at the new Refinery Pier berth to store and convert LNG into natural gas. LNG carriers would moor alongside the FSRU and unload the LNG
- construction and operation of approximately 3 km of aboveground gas pipeline on the pier and within the refinery site connecting the FSRU to the new treatment facility
- construction and operation of a treatment facility on refinery premises including injection of nitrogen and odorant (if required)
- construction and operation of an underground gas transmission pipeline, approximately 4 km in length, connecting to the SWP at Lara.

The Refinery Pier extension would be located to the north-east of Refinery Pier No. 1. The new pier arm would be positioned to allow for sufficient clearance between an LNG carrier berthed alongside the FSRU and a vessel berthed at the existing Refinery Pier berth No. 1. Dredging of approximately 490,000 cubic metres (m^3) of seabed sediment would be required to allow for the new berth pocket and swing basin.

The FSRU vessel would be up to 300 m in length and 50 m in breadth, with the capacity to store approximately 170,000 m^3 of LNG. The FSRU would receive LNG from visiting LNG carriers and store it onboard in cryogenic storage tanks at about -160 °C.

The FSRU would receive up to 160 PJ per annum (approximately 45 LNG carriers) depending on demand. The number of LNG carriers would also depend on their storage capacity, which could vary from 140,000 to 170,000 m^3.

When gas is needed, the FSRU would convert the LNG back into a gaseous state by heating the LNG using seawater (a process known as regasification). The natural gas would then be transferred through the aboveground pipeline from the FSRU to the treatment facility where odorant and nitrogen would be added, where required, to meet Victorian Transmission System (VTS) gas quality specifications. Nitrogen injection would occur when any given gas cargo needs to be adjusted (diluted) to meet local specifications. Odorant is added as a safety requirement so that the normally odourless gas can be smelt when in use. From the treatment facility, the underground section of the pipeline would transfer the natural gas to the tie-in point to the SWP at Lara.

1.4.1 Key construction activities

Construction of the project would occur over a period of up to 18 months. The key construction activities relate to:

- localised dredging of seabed sediments to enable the FSRU and LNG carriers to berth at Refinery Pier and excavation of a shallow trench for the seawater transfer pipe
- construction of a temporary loadout facility at Lascelles Wharf
- construction of the new pier arm and berthing infrastructure, and aboveground pipeline along Refinery Pier and through the refinery
- construction of the treatment facility on a laydown area at the northern boundary of the refinery site
- construction of the buried pipeline
- construction at the tie-in point to the SWP at Lara.

There are no construction activities required for the FSRU component of the project. The vessel would be built, commissioned and all production and safety systems verified prior to being brought to site.

An estimated 490,000 m^3 of dredging would be required, over an area of approximately 12 hectares (ha), adjacent to the existing shipping channel to provide sufficient water depth at the new berth and within the swing basin for visiting LNG carriers to turn. Dredging within the new berth would be undertaken to a depth of 13.1 m and the swing basin would be dredged to a depth of 12.7 m. The dredging footprint is shown in Figure 1. It is planned to deposit the dredged material within the Ports Victoria existing dredged material ground (DMG) in Port Phillip Bay to the east of Point Wilson, approximately 26 km from Refinery Pier.

The temporary loadout facility at Lascelles Wharf would be the first construction activity to take place in order to facilitate the Refinery Pier extension. This would involve the installation of 10 piles using hydraulic hammers.

Construction of the pier arm would be carried out once dredging was complete, primarily from the water using barge-mounted cranes. Steel piles would be driven into the seabed by cranes mounted on floating barges and pre-cast concrete and prefabricated steel components would be transported to site by barge and lifted into position. The installation of pier infrastructure such as the marine loading arms (MLAs), piping from the FSRU to the existing refinery seawater intake (SWI) and aboveground pipeline would also be undertaken from the water using barge-mounted cranes and construction support boats.

Installation of the 3 km above ground pipeline along the pier and through the refinery is anticipated to take 3.5 months to complete. The above ground pipeline would run along the pier to the existing pipe track east of Shell Parade within the pier foreshore compound. It would then pass through a road under-crossing to the existing refinery pipe track. The pipeline would then run north along the existing refinery pipe track to an existing laydown area where the treatment facility would be located.

The treatment facility would be located within an existing laydown area in the refinery site and cover an area of approximately 80m x 120m. Construction of the treatment facility would take approximately 18 months and would be undertaken by specialist crews across distinct phases of work. These would include initial earthworks and civil construction, mechanical installation and electrical and instrumentation works.

The 4 km underground pipeline would be installed in stages over an approximate 4-month period within a corridor which has been selected so as to avoid watercourses or other environmental sensitivities, where possible. Firstly, a construction right of way (ROW) would be established, clearly identified and fenced off where required. Typically, this would be between 15 and 20 m wide, and minimised where possible to reduce disturbance. Once the construction ROW is established, vegetation would be removed, and a trench excavated to a maximum depth of 2 m and a maximum width of 1 m for the pipeline to be placed. Following the placement of the pipeline, the construction ROW would be rehabilitated to its pre-existing condition as far as practicable for the purposes for which it was used immediately before the construction of that part of the pipeline.

Trenchless construction (including thrust boring or horizontal directional drilling (HDD)) would be used to install the underground pipeline in areas that are not suited to open trenching techniques, such as at intersections with major roads, which would be confirmed during detailed design. Trenchless construction would involve boring or drilling a hole beneath the ground surface at a shallow angle and then pushing or pulling a welded length of pipe through the hole without disturbing the surface. It is anticipated that the maximum depth of the trenchless section would be 25 m.

The anticipated trenching, HDD and thrust bore locations are presented in Figure 2. It is possible that along the northern section of Macgregor Court the pipeline would also be constructed using HDD, this will be confirmed during detailed design.

Construction at the tie-in point to the SWP at Lara would be undertaken by specialist crews across the distinct phases of works, as with the treatment facility.

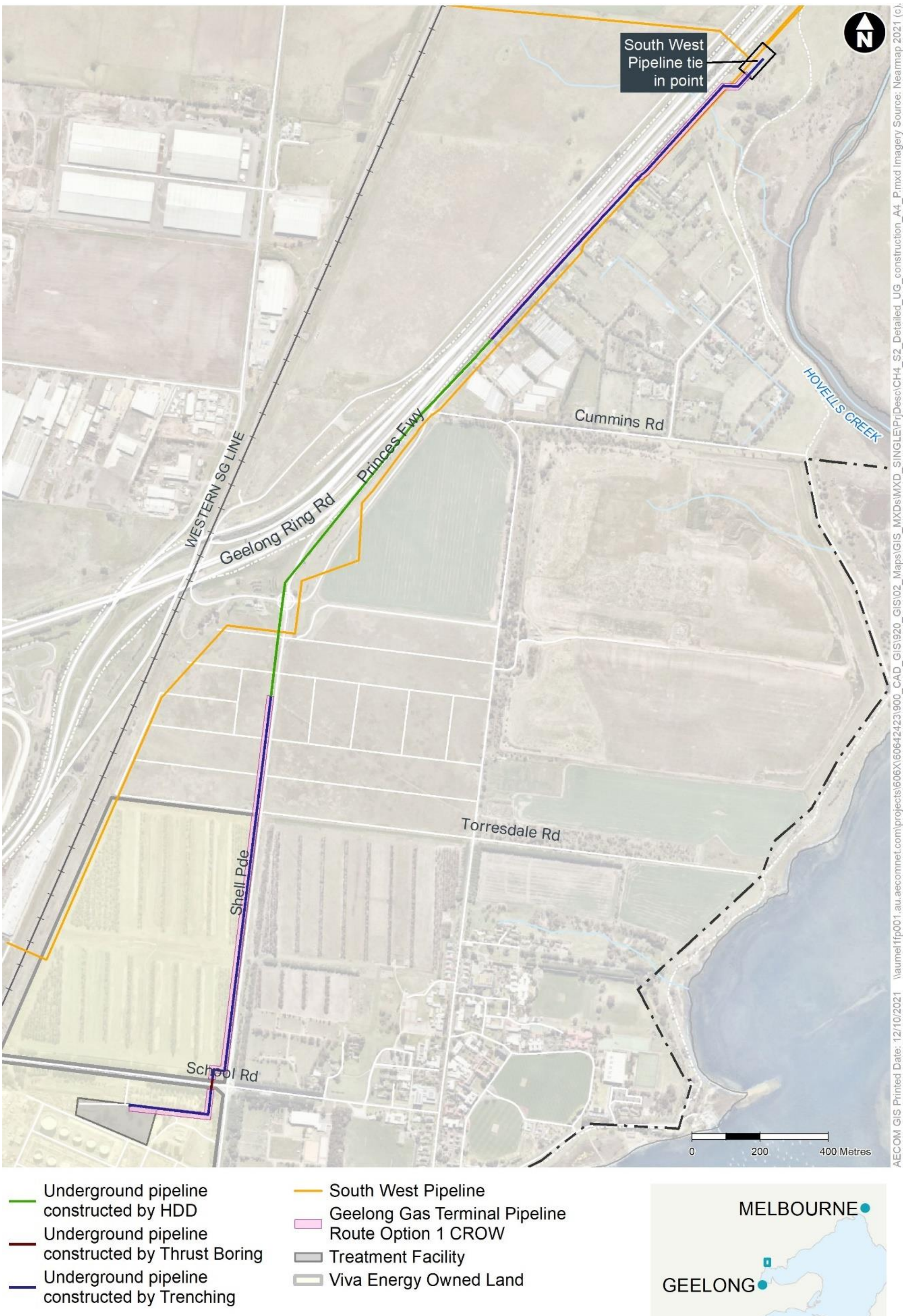

Figure 2: Proposed location of trenching construction techniques for the underground pipeline including open trenching, HDD and thrust boring

1.4.2 Key operation activities

The project is expected to be in operation for approximately 20 years. Key activities relating to project operation include:

- receipt of up to 45 LNG carriers each year at Refinery Pier – the number and frequency of LNG carriers arriving each year would depend on their storage capacity and gas demand
- regasification of LNG onboard the FSRU using seawater as a heat source, which would then be reused within the refinery as cooling water
- injection of nitrogen and odorant into the gas prior to distribution via the VTS
- monitoring and maintenance of the pipeline easement.

1.4.3 Key decommissioning activities

The FSRU, which continues to be an ocean-going vessel throughout the operation of the project, would leave Corio Bay on completion of the project life to be used elsewhere.

It is anticipated that the Refinery Pier berth and facilities would be retained for other port related uses. The underground pipeline would likely remain in situ subject to landholder agreements and either decommissioned completely or placed into care and maintenance arrangements.

Decommissioning activities may be subject to change, subject to legislative requirements at the time and potential repurposing of the infrastructure at the end of the project.

1.4.4 Project activities relevant to the assessment

The project lifecycle is forecast to be approximately 20 years, as such it will need to consider increasing risks of climate change over the coming decades. This assessment therefore focuses on design-related interventions and construction and operational management plans and procedures where these will support the safe and resilient delivery and operation of the project over its forecast lifecycle.

2.0 Scoping requirements

The scoping requirements for the EES set out the specific environmental matters to be investigated in the EES in accordance with the *Ministerial guidelines for assessment of environmental effects under the Environment Effects Act 1978 (Vic)*.

The following evaluation objective is relevant to the assessment of the risk to the project from climate change:

- **Energy efficiency, security, affordability and safety:** To provide for safe and cost-effective augmentation of Victoria's natural gas supply having regard to projected demand and supply in context of the State's energy needs and climate policy.

The scoping requirements of relevance to this assessment and where they are addressed in the report are shown in Table 2-1.

Table 2-1 Scoping requirements relevant to the risk to the project from climate change

Aspect	Scoping requirement	Section addressed
Key issues	Workforce, nearby operations and public safety risks associated with the construction or operation of the project, including risks associated with or compounded by potential external threats.	Section 6.0
Existing environment	N/A	N/A
Likely effects	Identify the risk associated with severe weather events on the project's infrastructure and operations in the context of climate change scenarios and extreme events.	Section 6.0
Mitigation measures	Describe proposed measures to minimise risk and ensure safety for workforce, nearby operations and the public during construction and operation of the project.	Section 6.0
Performance criteria	Describe the monitoring program to form part of the EMF to identify any potential hazards in time for corrective action to be taken.	Section 6.0

In addition, Victoria’s Climate Change Act outlines a set of policy objectives to embed climate change in government decision-making and to build the resilience of the built environment through effective adaptation planning. The Climate Change Act compels decision-makers to have regard to climate change, including potential biophysical impacts, in decisions made or actions taken that are authorised by the provision of the Acts relevant to this EES as listed in Section 3.

Furthermore, assessment of physical climate risks when developing significant projects such as this is part of Viva Energy’s approach to managing climate change risk more broadly.

Consideration of climate-related transition risks is outside the scope of this assessment. Climate-related transition risk is considered in Attachment I: *Energy demand and market statement* (i.e., impacts on the project associated with transition to a low carbon economy).

3.0 Legislation, policy and guidelines

The key legislation, policy and guidance documents relevant to the climate change risk assessment are summarised in Table 3-1.

Table 3-1 Key legislation and policy – climate change risk assessment

Legislation/policy	Relevance to climate change risk assessment
State	
Climate Change Act 2017 (Vic) ('Climate Change Act')	The Climate Change Act provides a legislative foundation to drive a just transition to net zero emissions and a climate resilient community and economy, by outlining policy objectives to embed climate change into government decision-making. The Climate Change Act requires decision-makers to have regard to climate change, including potential biophysical impacts, short and long economic, environmental, health and other social impacts, beneficial and detrimental impacts, direct and indirect impacts, and cumulative impacts.
Victoria's Climate Change Strategy 2021	Aims to strengthen Victoria's ability to withstand and recover from extreme weather events, including for the built environment, by addressing current climate change impacts and removing barriers to effective adaptation.
Catchment and Land Protection Act 1994 (Vic) ('CaLP Act')	The CaLP Act provides a legislative framework for integrated management and protection of land, water and biodiversity resources on catchment areas. The Climate Change Act requires decision makers to take climate change into account when making specified decisions under the CaLP Act.
Environment Protection Act 2017 (Vic)	The *Environment Protection Act 2017 (Vic)* empowers the Environment Protection Authority Victoria (EPA Victoria) to implement regulations to protect the environment. EPA Victoria is required to consider the potential impacts of climate change when making decisions related to Development Licence applications and Operating Licence applications. This covers both the potential impacts of climate change on the proposal as well as the proposal's contribution to Victoria's greenhouse gas emissions. Technical Report C: *Greenhouse gas impact assessment* provides an assessment of the potential impacts of greenhouse gas emissions associated with the construction and operation of the project
Flora and Fauna Guarantee Amendment Act 2019 (Vic) ('FFG Act')	The FFG Act is the key piece of Victorian legislation for the conservation of threatened species and communities. A principle of the FFG Act is to give proper consideration of the potential impacts of climate change.
Marine and Coastal Act 2018 (Vic)	The *Marine and Coastal Act 2018 (Vic)* sets objectives and guiding principles for the planning and management of the state's marine and coastal environment. The objectives include to '*promote the resilience of marine and coastal ecosystems, communities and assets to climate change.*'
Built Environment Climate Change Adaptation Action Plan (2022-2026) Draft for Consultation	The draft Plan sets out proposed actions for the next five years to respond to climate change risks to the built environment. Energy sector infrastructure is referred to in the draft Plan. The approach the project is taking is consistent with the draft Plan's intent of building infrastructure assets to withstand damage from extreme events and be resilient to a changing climate.
Marine and Coastal Policy 2020	The Marine and Coastal Policy is a requirement of the *Marine and Coastal Act 2018 (Vic)* and sets out policies for planning and managing the marine and coastal environment and provides guidance to decision makers. The policy requires decision makers to strengthen resilience to climate change by understanding how the marine and coastal environment could cope with and adapt to current and future climate change stressors.
Victorian Coastal Strategy 2014	The Victorian Coastal Strategy provides guidance for agencies and statutory decision-making for coastal, marine and estuarine

Legislation/policy	Relevance to climate change risk assessment
	environments. The Strategy requires planning for 'sea level rise of not less than 0.8 m by 2100 and not less than 0.2 m by 2040 for urban infill areas'.
Guidance documents	**Relevance to climate change risk assessment**
AS5334-2013 Climate change adaptation for settlements and infrastructure – A risk-based approach	Provides a general and widely applicable approach and framework on managing climate change risks and developing implementation plans for suitable and effective adaptation.

4.0 Methodology

The following sections outline the methodology for the climate change risk assessment. This approach is consistent with *AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk-based approach* (Standards Australia, 2013).

4.1 Identifying climate projections

Climate change is defined as a change in the state of the climate that persists for an extended period of time, typically decades or longer. To understand potential changes in the state of the climate, historical (baseline) climate data as well as climate change projections were identified for the project area.

Historical climate data was obtained from the Victorian Climate Project 2019 (VCP19) Barwon Climate Projections (CSIRO 2019) and the National Climate Change Adaptation Research Facility's (NCCARF) CoastAdapt (NCCARF 2017) website. Barwon Climate Projections provides historic climate data for the Geelong region sourced from the Grovedale (Geelong Airport) weather station. CoastAdapt provides historic and projected sea-level rise and extreme heat related climate data for coastal location government areas, including the City of Greater Geelong, within which the project is situated.

Climate projections were sourced from the VCP19 Barwon Climate Projections (CSIRO 2019), Climate Change in Australia Southern Slopes Cluster Report (Grose, et al. 2015), Australian Rainfall and Runoff (ARR 2019) and CoastAdapt (NCCARF 2017) data. These sources represent the most current, local downscaled projections relevant to the project area. To correspond with the 20-year design life of the project, near-term (2030) and medium-term (2050) time horizons were applied. In addition, far-term (2090) projections were considered in recognition that components of the project (i.e. the pier) may have a longer lifespan beyond the project.

In 2015, the CSIRO and Bureau of Meteorology (BoM) released a suite of climate change projections based on the Intergovernmental Panel on Climate Change's (IPCC) Representative Concentration Pathways (RCPs) (IPCC 2014). RCPs are designed to be 'representative' of possible future emissions and greenhouse gas (GHG) concentration trajectories to the year 2100. The pathways are characterised by radiative forcing, the extent of extra heat the lower atmosphere will retain as a result of additional greenhouse gases. There are four RCPs: RCP8.5, RCP6.0, RCP4.5 and RCP2.6. Each RCP, as shown in Figure 3, reflects a different concentration of global GHG emissions reached by 2100, based on assumptions of different combinations of possible future economic, technological, demographic, policy, and institutional trajectories. RCP2.6 represents a future resulting from the most ambitious mitigation scenario, while 8.5 represents a future with little curbing of emissions. RCP8.5 was applied as a worst-case scenario for the assessment. Using a worst-case scenario also aids the risk assessment process by focusing attention on the more extreme potential climate outcomes.

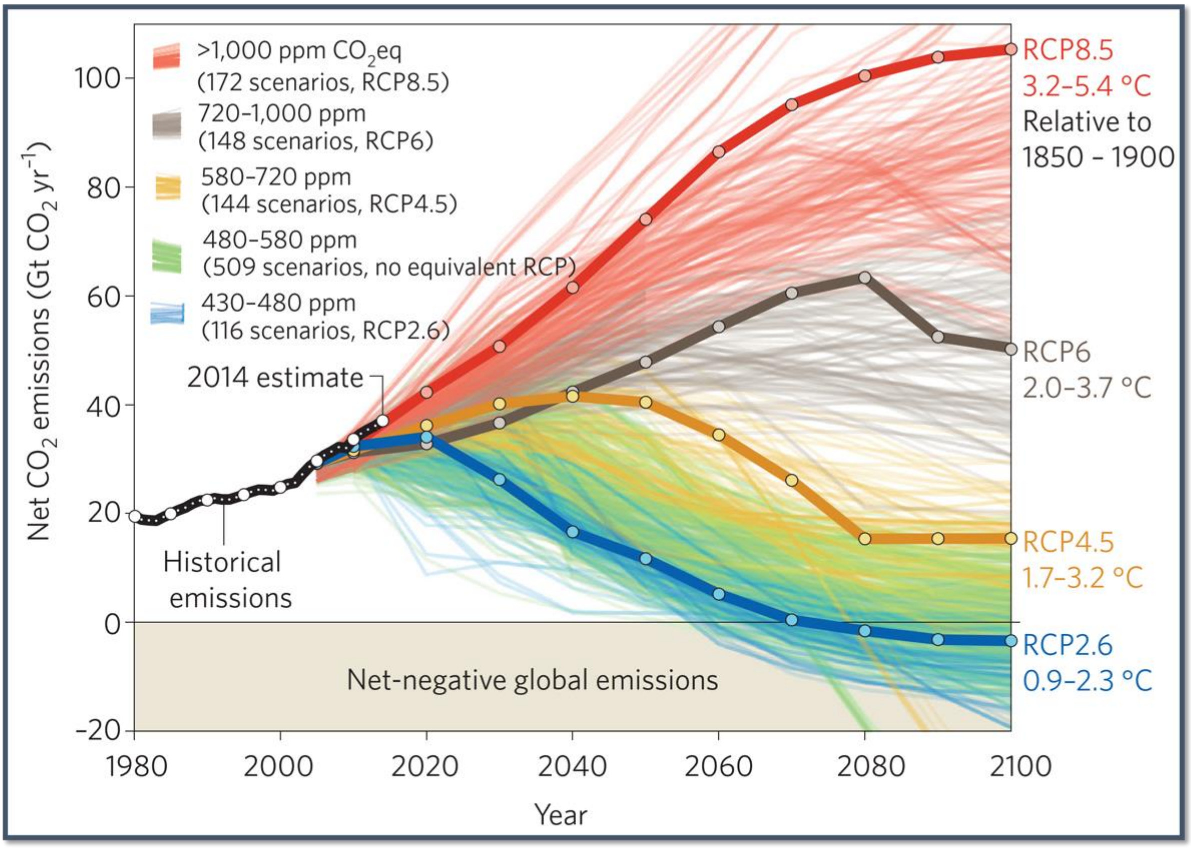

Figure 3 Representative concentration pathways for carbon dioxide emissions (TCFD 2017). Note the 2018 estimated emissions were 41.3Gt[3]

4.2 Risk assessment method

The risk assessment method used in this climate change risk assessment is distinct from the risk assessment approach used by the broader EES. This is because the climate change risk assessment seeks to identify the potential impacts of a changing climate on the project, while the broader EES assesses the risks that the project poses to the environment.

AS5334-2013 notes that climate change risks and treatments should be considered under the same risk assessment framework as used by the organisation to assess project and operational risks. As agreed with Viva Energy, Viva Energy's Risk Assessment Matrix was therefore used as the basis for this assessment. The Risk Assessment Matrix was adapted with additional likelihood categories drawn from AS5334-2013 to be more reflective of the timeframes associated with the life of the project and climate projections.

The risk assessment framework includes:

- consequence descriptions which include categories for people, assets, environment and reputation that range from zero (e.g., 'no impact') to five (e.g., 'severe impact')
- likelihood descriptions which range from 'almost certain' where the risk has greater than 90% chance of happening over the life of the project, to 'very unlikely' where the risk may occur in exceptional circumstances during the life of the project
- a consequence and likelihood risk assessment matrix which has been adapted from the Viva Energy Risk Assessment Matrix to include 'low', 'medium', 'high' and 'extreme' risk ratings.

The full list of the risk criteria applied in the climate change risk assessment is provided in Appendix C.

[3] Drawn from *Explainer: The high-emissions 'RCP8.5' global warming scenario* (https://www.carbonbrief.org/explainer-the-high-emissions-rcp8-5-global-warming-scenario, accessed 12 May 2021)

4.3 Assumptions and limitations

This climate risk assessment is based on the project design at the time of the assessment. The climate projections used in this assessment are sourced from publicly available data published by CSIRO (2019), NCCARF (2017 and 2021) and ARR (2019). These are the best available projections of likely future conditions and have inherent uncertainties. Confidence levels specific to each projection were provided by CSIRO and NCCARF and are included in Appendix A. No further climate or hazard modelling or detailed vulnerability analysis was undertaken for this level of assessment.

The risk assessment framework used to assess climate risks does not allow for an overall view of any cumulative impacts from several risks that may be minor in isolation, but cumulatively could have a significant impact on the project.

4.4 Climate change risk identification

To facilitate the identification and assessment of physical climate change risks to the project, a climate change risk workshop was held in March 2021 with representatives from the Viva Energy, Worley, Advisian and the EES team. Worley and Advisian are supporting Viva Energy with the design of the project. Participants from Viva Energy, Worley and Advisian included representatives from project management, design, environment, and sustainability.

The purpose of the workshop was to engage the project team to identify:

- How climate change will impact the project (risk identification)
- How significant the risks will be to the project (risk evaluation and analysis)
- How to make the project more resilient (risk treatment and adaptation measures)

Workshop participants were presented with climate change projections for the project area and potential hazards that may arise from these projections. In facilitated groups, participants worked together to:

- identify potential risks to the project – these included direct and indirect impacts of climate change, consistent with guidance outlined in AS5334-2013
- identify the current controls for each risk identified and, taking account of these current controls, rate the likelihood and consequence of each risk to determine the overall risk rating
- for the risks rated high and above, assess whether the current controls are adequate. Where controls were not considered adequate, identify additional adaptation measures to address the risk.

Identified risks and adaptation measures were captured in a risk register (refer to Appendix B). Following the workshop, participants were given the opportunity to review the risk register and provide additional commentary and feedback. Follow-up discussions were also held with select technical and specialist leads where additional clarification was required. Outcomes from this engagement are captured in the risk register.

5.0 Climate hazards and projections

A summary of climate hazards with potential to impact the project area is presented in Table 5-1. Note that confidence levels related to projections for the RCP8.5 scenario have been provided only where these are available.

Table 5-1 Summary of climate hazards with the potential to impact the project

Hazard	Description of trends
Extreme temperature and/or heatwave	• Average temperatures have been increasing in Victoria over the last two decades and are projected to continue to increase in the future (very high confidence) (CSIRO 2019). • In Victoria, average maximum temperatures are projected to increase by approximately 1.4ºC (average) and 2.6ºC (maximum) in 2050. The

Hazard	Description of trends
	highest recorded temperature at the weather station closest to the project area (Avalon airport) was 47.9ºC on the 7 February 2009. • The number of consecutive extreme heat days (days above 30ºC) is projected to increase from 3.6 days historically, to 4.3 days in 2050.
Extreme rainfall event	• The intensity of heavy rainfall events is projected to increase, however, the magnitude of change, and the time when change may be evident against natural fluctuations, cannot be reliably projected. • Australia Rainfall and Runoff (2019) recommends an allowance of 11.9% be made for increases in in the intensity of rainfall when undertaking flood assessments.
Bushfire	• Climate change is likely to result in increased frequency and intensity of bushfire weather conditions (high confidence) (CSIRO 2019). Historically the project area had an average of 1.7 days severe fire danger days per year. This is projected to more than double to 4.6 days in 2090 (data for 2050 not available) (CSIRO and BoM 2015).
Drought	• Annual rainfall is likely to decrease by an average of 11% and maximum of 20% by 2050, resulting in reduced water availability (average to high confidence) (CSIRO 2019). The impacts of reduced water availability are likely to be exacerbated by increased evapotranspiration, that is, the transfer of what from land or plants to the atmosphere.
Storm event / high wind speeds	• There is uncertainty over wind projections. Wind gust may increase in intensity, whereas average wind speed may decrease by an average of 2.6% and maximum of 3.3% by 2050 (CSIRO 2050). • Frequency of storm events may reduce; however, the intensity may increase.
River flood	• Riverine flooding from Hovells Creek may result from the increases in intensity of extreme rainfall events.
Sea level rise	• Changes in sea level are primarily the result of rising ocean temperatures leading to thermal expansion and changes in ocean mass due to the melting of glaciers and ice sheets. Sea level rise may be exacerbated by a combination of factors including astronomical tides, storm surges and wind events. Modelling for storm tide and storm surge has not been undertaken for this assessment. • In Greater Geelong, sea level is expected to increase by 0.15m to 0.32m in 2050.
Ocean acidity	• The ocean becomes more acidic as it absorbs CO_2 from the atmosphere. In 2090, pH is projected to be 0.3 units lower (a rise in acidity).
Ocean temperature	• Sea surface temperatures are projected to increase by 1.9 to 3.8ºC in 2090.
Enhanced atmospheric CO_2 concentration	• Current levels of background CO_2 are in excess of 400ppm, and these levels are likely to rise towards 930ppm in the next 80 years (CSIRO and BoM 2015) • Enhanced atmospheric concentrations of CO_2 and increased temperatures are projected to accelerate the penetration of CO_2 into concrete structures, resulting in more rapid carbonation / degradation of exposed concrete.

6.0 Risk to the project from climate change assessment findings

Of the 47 risks to the project identified through the climate change risk assessment, eight were rated 'High'. No risks were rated 'Extreme', with the remaining risks being rated 'Medium' or 'Low'. These ratings take into consideration existing controls and mitigation measures implemented for the project. The risks rated 'High' were primarily associated with the following hazards: storms; extreme rainfall, sea level rise and extreme heat. The climate change risk register is provided in Appendix B. The 'high' risks are summarised in Table 6-1 noting the relevant project component, climate hazard, existing controls and proposed additional controls or adaptation options.

Table 6-1 Summary of 'High' rated climate change risks to the project

ID*	Risk description	Project component	Hazard	Existing Controls	Risk rating	Proposed additional controls / adaptation options
9	Storm event (including storm surge, high wind speeds and hail) causes physical damage to the FSRU, safety impacts to workers onsite and delays to supply vessels resulting in reparation costs	FSRU	Storm event, high wind speeds	• Safe operating procedures • Pier designed for environmental conditions (e.g., mooring analysis) • Post-event inspections and maintenance	High	• Factor projections into basis of design (mooring analysis) for pier and associated structures
10	Sea level rise results in misalignment of mooring and marine loading arm (MLA) connections between pier and FSRU resulting in damage to assets and safety impacts to workers onsite	Refinery Pier extension	Sea level rise	• Safe operating procedures • Pier designed for environmental conditions (e.g., mooring analysis) • Post-event inspections and maintenance	High	• Factor projections into basis of design (mooring analysis) for pier and associated structures
20	Storm event (including storm surge, high wind speeds and hail) causes physical damage to the construction site and construction equipment (e.g. cranes, marine-based activities) resulting in damage to assets, loss of equipment and safety impacts to workers onsite	Refinery Pier extension	Storm event, high wind speeds	• Operational procedures in event of a storm	High	• Review operational procedures for pier personnel • Marine Contractor's 'Severe Weather Plan' to document weather criteria for protocols to stop work and make safe in the event / forecast of a storm
22	Storm event (including storm surge, high wind speeds and hail) causes damage to pier from berthed or	Refinery Pier extension	Storm event, high wind speeds	• Mooring lines / fenders	High	• Factor projections into basis of design for pier and associated structures

ID*	Risk description	Project component	Hazard	Existing Controls	Risk rating	Proposed additional controls / adaptation options
	berthing vessels resulting in reparation costs and safety impacts to workers			• Window of operation (environmental limits set by Ports Victoria		
23	Sea level rise coupled with storm surges and/or high tides causes inundation of facility site and access routes as well as accelerating coastal erosion, resulting in safety impacts to workers and damage or loss of asset	Refinery Pier extension	Sea level rise	• AS 1170 suite of codes (environmental loading), AS 4997 maritime structures and elements, AS 3600 for concrete, AS 4100 for steel, AS 2159 Piling	High	• Factor projections into basis of design for pier and associated structures
25	Extreme heat conditions cause exhaustion or heat related illness for the onsite workforce resulting in safety impacts to workers and production delays	Refinery Pier extension	Extreme temperature and/or heatwave	• Safe operating procedures • OHS protocols (fitness for work, etc.) • Continuous automated process	High	• Contractor Safety, Health, Environment and Sustainability (SHES) plan to document conditions to 'stop work' prior to dehydration / heat exhaustion
31	Sea level rise causes inundation of above ground pipeline and access routes situated close to the pier resulting in damage to the pipeline and safety impacts to workers	Aboveground pipeline	Sea level rise	• Safe operating procedures • Design to environmental conditions	High	• Factor climate change projections into basis of design for pipeline and associated structures
41	Extreme rainfall event causes temporary inundation of facility site and access routes resulting in safety impacts to workers, supply disruption and/or damage to or loss of assets	Treatment facility	Extreme rainfall event	• Multiple access points and suppliers • Remote operations	High	• Flexibility in supply of nitrogen • Agreement with Australia Energy Market Operator for relief of gas specification • Potential for onsite nitrogen production •

7.0 Conclusion

A climate change risk assessment was undertaken to determine the risks that climate change may pose to the Viva Energy Gas Terminal Project and develop adaptation measures to improve the project's resilience to these impacts. Of the 47 risks identified, eight were rated 'high' mostly affecting the pier but also the FSRU, pipeline and treatment facility. The eight 'high' risks are primarily associated with storm weather, extreme rainfall events, sea level rise and extreme heat events. Additional risk controls or adaptation measures were developed and can be summarised as follows:

- Factor climate projections into the basis of design, particularly the mooring analysis (alignment of FSRU and other vessels with the pier), materials and coatings choices and site hydrological modelling. This should be done using a risk-based design approach that, rather than simply picking a projection, considers the range of projections, the likely exposure of an asset (considering design life and projection timeframes), its criticality, sensitivity and adaptive capacity, in determining the appropriate design factors.
- Safety procedures and protocols updated to take into consideration severe weather conditions such as storm events and heatwaves

Viva Energy would maintain a register of risk to the project of climate change, monitor climate-related impacts, projections and policy, and update and implement adaptation measures to minimise climate change risk throughout the life of the project.

Consultation with the project design team has determined that the climate change risks posed to the project are considered manageable over the project lifecycle on the basis that the identified design- and operation-related adaptation measures would be adopted.

8.0 References

ARR 2019, *ARR Data Hub*, Australian Rainfall and Runoff. Accessed via <http://data.arr-software.org/>

BoM 2021, *Climate statistics Avalon Airport (station number 087113)*, Bureau of Meteorology. Accessed via <http://www.bom.gov.au/>

CSIRO and BoM 2015, *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report*, CSIRO and Bureau of Meteorology, Australia.

CSIRO 2019 Barwon Climate Projections 2019. Clarke JM, Grose M, Thatcher M, Round V & Heady C. CSIRO, Melbourne Australia

CSIRO 2021, *Climate Change in Australia Threshold Calculator*. Accessed via <https://www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/threshold-calculator/#>

DELWP 2015, *Climate ready Victoria Greater Melbourne Factsheet*, Department of Environment, Land Water and Planning. Accessed via: <www.climatechange.vic.gov.au/__data/assets/pdf_file/0019/60742/Greater-Melbourne.pdf>

Grose, M. et al. 2015, *Southern Slopes Cluster Report, Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports*, eds. Ekström, M. et al., CSIRO and Bureau of Meteorology, Australia.

IPCC 2014, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.

NCCARF 2017, *Climate change and sea-level rise based on observed data*, National Climate Change Adaptation Research Facility. Accessed via <https://coastadapt.com.au/climate-change-and-sea-level-rise-based-observed-data>

NCCARF 2021, *CoastAdapt: Sea-level rise and future climate information for coastal councils Greater Geelong*, National Climate Change Adaptation Research Facility. Accessed via <https://coastadapt.com.au/sea-level-rise-information-all-australian-coastal-councils#VIC_GREATER_GEELONG>

Standards Australia 2013, *AS5334-2013 Climate change adaptation for settlements and infrastructure- a risk-based approach*, Standards Australia.

TCFD 2017, *Technical Supplement* | *The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities*, TCFD, United States.

Appendix A – Climate change projections

Climate Variable	Historic Climate (Geelong) [4]	RCP 8.5 2030 scenario	RCP 8.5 2050 scenario	RCP 8.5 2090 scenario
Annual maximum temperature (Annual ºC) [4]	19.1 (1986–2005)	+1.1 (+0.9 to +1.5)	+1.9 (+1.4 to +2.6)	+3.8 (+2.6 to +4.9)
Extreme (ARI20) daily maximum temperature (Annual ºC) [4]	47.9 (Max recorded 7 Feb 2009) [5]	+0.2 (-0.3 to +2.7)	+2.6 (+1.5 to +5.2)	+4.4 (+2.2 to +5.8)
Average longest run of days in each year with maximum temperature > 30ºC [6]	3.6 days (1981–2010) [3]	4 days	4.3 days	5.4 days
Rainfall (Annual %) [4]	548.4 mm (1986–2005)	-10 (-19 to -2)	-11 (-20 to -4)	-24 (-27 to +5)
Increase in rainfall intensity [7]	-	4.0%	7.3%	11.9%
Surface wind speed (Annual %) [2]	18.2 km/h (9am 1965–2010) [5]	-2.2 (-2.9 to +0.8)	-2.6 (-3.3 to -0.3)	-2.5 (-5.5 to +0.2)
Fire conditions (# of severe fire danger days) [9]	1.7 (1995)	1.6 to 2.2	- [8]	2.2 to 4.6
Sea level rise (m) [6]	-	+0.12 (+0.08 to +0.17)	+0.24 (+0.15 to +0.32)	+0.39 (+0.25 to +0.54)
Sea surface temperature (ºC) (Stony Point) [9]	-	+0.6 (+0.3 to +0.9)	- [8]	+2.3 (+1.9 to +3.8)
Ocean acidity (pH) (Stony Point) [9]	-	-0.08 (-0.09 to -+0.08)	- [8]	-0.3 (-0.3 to -0.3)

[4] CSIRO 2019 Barwon Climate Projections 2019 (VCP19). Clarke JM, Grose M, Thatcher M, Round V & Heady C. CSIRO, Melbourne Australia
[5] Bureau of Meteorology climate statistics – Avalon Airport (http://www.bom.gov.au/, accessed 23 March 2021)
[6] CoastAdapt Sea-level rise and future climate information for coastal councils (https://coastadapt.com.au/, accessed 23 March 2021)
[7] Australian Rainfall and Runoff Data Hub (http://data.arr-software.org/, accessed 23 March 2021)
[8] 2050 data not available
[9] Climate Change in Australia South Slopes Cluster Report 2015

Note - confidence levels specific to each projection were provided by CSIRO and NCCARF

Appendix B – Register of risk to the project from climate change

#	Component	Climate hazard (exposure)	Impact	Risk description	Project phase (construction / operation / decommissioning)	Direct/ Indirect	Current risk controls	Life of asset (years)	People	Assets	Environment	Reputation	Max consequence	L/hood	Risk	Proposed additional risk controls / adaptation options
1	FSRU	Increasing frequency and intensity of bushfire weather conditions	Bushfire smoke impacts vessel operations and downstream operations (e.g. excess gas burned in gas concentration unit (GCU))	Human injury. Damage to asset	Construction / operation	Direct	Air quality and intake controls	20	2	1			2	A	2A	Inclusion of response to bushfire conditions in maritime operations plan (or equivalent)
2	FSRU	Increasing bushfire occurrence and intensity	Bushfire restricts ability of people to leave the vessel	Human injury. Damage to asset	Construction / operation	Direct	Safe operating procedures Bushfire management plan	20	2				2	A	2A	Inclusion of response to bushfire conditions in site incident management plan (or equivalent)
3	FSRU	Increasing bushfire occurrence and intensity	Regional bushfire event limits fire and rescue services (or local firefighting authority's) resources to attend to terminal	Human injury. Damage to asset	Construction / operation	Indirect	Safe operating procedures Bushfire management plan	20	2	1			2	C	2C	Inclusion of response to bushfire conditions in site incident management plan (or equivalent)
4	FSRU	Increased acidity of the ocean	Faster corrosion of exposed structures and components	Increased maintenance costs. Early replacement of components (e.g. buoys, tie downs, rubber elements)	Operation	Direct	Substitution of components. Replacement during maintenance windows. Routine inspection program considers premature degradation of components	20		2			2	B	2B	Material selection (e.g. coatings) Confirm anticorrosive elements suitable for future conditions
5	FSRU	Increased acidity of the ocean	Additional stress on receiving ecosystems reducing their tolerance for impacts from the project's operation	Environmental management impacts (increase treatment) and restrictions on releases into environment from FSRU (open loop mode)	Operation	Direct	Conditions of environmental approval	20			2		2	B	2B	Consider additional impact of climate change in EES technical study

#	Component	Climate hazard (exposure)	Impact	Risk description	Project phase (construction / operation / decommissioning)	Direct/ Indirect	Current risk controls	Life of asset (years)	People	Assets	Environment	Reputation	Max consequence	L/hood	Risk	Proposed additional risk controls / adaptation options
6	FSRU	Increased ocean temperature	Faster corrosion of exposed structures and components	Increased maintenance costs. Early replacement of components (e.g. buoys, tie downs, rubber elements)	Operation	Direct	Vessel designed from warm waters (sourcing from Egypt)	20		2			2	B	2B	Material and coatings selection
7	FSRU	Increased ocean temperature	Biota blooms (plant, larvae) leads to additional chlorine use accelerating corrosion of structures and components	Increased maintenance costs. Early replacement of components (e.g. buoys, tie downs, rubber elements)	Operation	Direct	Routine inspection program considers premature degradation of components	20		2			2	C	2C	
8	FSRU	Increased ocean temperature	Additional stress on receiving ecosystems reducing their tolerance for impacts from the project's operation	Environmental management impacts and restrictions on releases into environment from FSRU (open loop mode)	Operation	Direct	Conditions of environmental approval	20			2		2	B	2B	Consider additional impact of climate change in EES technical study
9	FSRU	Storm event, high wind speeds	Physical damage to the FSRU, safety impacts to workers onsite and delays to supply vessels bringing in inventory for FSRU to service customers	Damage to or loss of asset. Human injury. Loss of life. Replacement of components and equipment. Environmental contamination / management costs	Operation	Direct	Safe operating procedures Pier designed for environmental conditions (mooring analysis) Post-event inspections and maintenance	20	2	3			3	C	3C	Factor projections into basis of design (mooring analysis) for pier and associated structures. For example, site coastal/marine modelling to take into account sea level rise, and identify zones at risk

#	Component	Climate hazard (exposure)	Impact	Risk description	Project phase (construction / operation / decommissioning)	Direct/ Indirect	Current risk controls	Life of asset (years)	People	Assets	Environment	Reputation	Max consequence	L/hood	Risk	Proposed additional risk controls / adaptation options
10	Pier	Sea level rise	Misalignment of mooring and marine loading arm (MLA) connections between pier and FSRU	Damage to asset and FSRU/pier interfaces. Early renewal of asset. Human injury	Operation	Direct	Safe operating procedures Pier designed for environmental conditions (mooring analysis) Post-event inspections and maintenance	20	2	3			3	C	3C	Factor projections into basis of design (mooring analysis) for pier and associated structures. For example, site coastal/marine modelling to take into account sea level rise, and identify zones at risk
11	Pier	Increasing bushfire occurrence and intensity	Bushfire causes damage to facility / construction site	Damage to asset. Human injury. Increased maintenance costs. Early replacement of components	Construction / operation	Direct	Fire water at jetty Location - very low risk setting Safe operating procedures Bushfire management plan	20		1			1	A	1A	Inclusion of response to bushfire conditions in maritime operations plan (or equivalent)
12	Pier	Enhanced atmospheric carbon dioxide concentration	More rapid carbonation / degradation of exposed concrete structures.	Potential for failure of asset. Increased maintenance costs. Early replacement of structures	Operation	Direct	AS 1170 suite of codes (environmental loading) AS 4997 maritime structures and elements to AS 3600 for concrete, AS 4100 for steel, AS 2159 Piling	20		1			1	A	1A	
13	Pier	Decreasing water availability	Decreased capacity to extinguish fire at facility / facility site	Decreased capability to resolve an emergency. Emergency impact less mitigatable	Operation	Indirect	Sea water used at jetty for fire response	20		1			1	A	1A	
14	Pier	Decreasing water availability within environment	Increased dust generation at facility and site access routes	Decreased air quality. Decreased human health.	Construction	Direct	Recycled water sourced from Barwon Water Construction Environmental Management Plan (CEMP) for dust control	20				1	1	C	1C	

#	Component	Climate hazard (exposure)	Impact	Risk description	Project phase (construction / operation / decommissioning)	Direct/ Indirect	Current risk controls	Life of asset (years)	People	Assets	Environment	Reputation	Max consequence	L/hood	Risk	Proposed additional risk controls / adaptation options
15	Pier	Increased acidity of the ocean	Faster corrosion of exposed structures and equipment	Potential for failure of asset. Increased maintenance costs. Early replacement of structures	Operation	Direct	Operational procedures in event of a storm AS 1170 suite of codes (environmental loading) AS 4997 maritime structures and elements to AS 3600 for concrete, AS 4100 for steel, AS 2159 Piling Routine inspection program considers premature degradation of components	20		2			2	C	2C	Factor climate change projections into basis of design and selection of materials and coatings
16	Pier	Increased ocean temperature	Faster corrosion of exposed structures and equipment	Damage to asset. Increased maintenance costs. Early replacement of structures	Operation	Direct	AS 1170 suite of codes (environmental loading) AS 4997 maritime structures and elements to AS 3600 for concrete, AS 4100 for steel, AS 2159 Piling	20		3			3	B	3B	Factor climate change projections into basis of design and selection of materials and coatings
17	Pier	Extreme Rainfall event	Erosion / washout of pier access routes, threatening safety and/or facility integrity	Damage to or loss of asset. Human injury. Loss of life. Replacement of components and equipment. Environmental contamination / management costs	Construction / operation	Direct	AS 1170 suite of codes (environmental loading) AS 4997 maritime structures and elements to AS 3600 for concrete, AS 4100 for steel, AS 2159 Piling	20		3			3	B	3B	Stormwater drainage review of foreshore area Geelong Port access procedures

#	Component	Climate hazard (exposure)	Impact	Risk description	Project phase (construction / operation / decommissioning)	Direct/ Indirect	Current risk controls	Life of asset (years)	People	Assets	Environment	Reputation	Max consequence	L/hood	Risk	Proposed additional risk controls / adaptation options
18	Pier	Storm event, high wind speeds	Physical damage to facility site and/or access routes threatening safety and/or facility integrity	Damage to or loss of asset. Human injury. Loss of life. Replacement of components and equipment. Environmental contamination / management costs	Operation	Direct	Operational procedures in event of a storm AS 1170 suite of codes (environmental loading) AS 4997 maritime structures and elements to AS 3600 for concrete, AS 4100 for steel, AS 2159 Piling	20		3			3	B	3B	Factor climate change projections into basis of design
19	Pier	Storm event, high wind speeds	Coastal erosion from storm surges resulting in physical damage to the pier and its support structures	Damage to asset. Increased maintenance costs. Early replacement of structures	Operation	Direct	AS 1170 suite of codes (environmental loading) AS 4997 maritime structures and elements to AS 3600 for concrete, AS 4100 for steel, AS 2159 Piling	20		3			3	B	3B	Site erosion modelling to take into account increased storm intensity (coupled with sea level rise), and identify zones at risk
20	Pier	Storm event, high wind speeds	physical damage to the construction site and construction equipment (e.g. cranes, marine-based activities)	Damage to or loss of asset. Damage to or loss of construction equipment (e.g. cranes). Human injury. Loss of life. Replacement of components and equipment. Environmental contamination / management costs	Construction	Direct	Operational procedures in event of a storm	20	3				3	D	3D	Review operational procedures for jetty personnel Marine Contractor's 'Severe Weather Plan' to document weather criteria for protocols to stop work and make safe in the event / forecast of a storm
21	Pier	Storm event, high wind speeds	Interruption to LNG supply activities	Additional demurrage costs. Production delays. Loss of revenue / penalties	Operation	Direct	Shipping schedule (supply windows factor in extreme weather events) Weather Event Management Plan	20				4	4	A	4A	

#	Component	Climate hazard (exposure)	Impact	Risk description	Project phase (construction / operation / decommissioning)	Direct/ Indirect	Current risk controls	Life of asset (years)	People	Assets	Environment	Reputation	Max consequence	L/hood	Risk	Proposed additional risk controls / adaptation options
22	Pier	Storm event, high wind speeds	Damage to pier from berthed or berthing vessels	Damage or loss of asset. Human injury	Operation	Direct	Mooring lines / fenders Window of operation (environmental limits set by Ports Victoria)	20		5		4	5	A	5A	Factor projections into basis of design for pier and associated structures. For example, site coastal/marine modelling to take into account sea level rise, and identify zones at risk
23	Pier	Sea level rise	Inundation of facility site and access routes as well as accelerating coastal erosion	Damage or loss of asset. Lost revenue. Increased maintenance or renewal costs.	Operation	Direct	AS 1170 suite of codes (environmental loading) AS 4997 maritime structures and elements to AS 3600 for concrete, AS 4100 for steel, AS 2159 Piling	20		5			5	B	5B	Factor projections into basis of design for pier and associated structures. For example, site coastal/marine modelling to take into account sea level rise, and identify zones at risk
24	Pier	Extreme Heat / Heatwave	Heat damage to facility and/or access routes	Damage to asset. Increased maintenance costs. Early replacement of structures	Operation	Direct	AS 1170 suite of codes (environmental loading) AS 4997 maritime structures and elements to AS 3600 for concrete, AS 4100 for steel, AS 2159 Piling	20		3			3	B	3B	
25	Pier	Extreme Heat / Heatwave	Exhaustion or heat related illness of on site work force	Damage to / decreased human health. Loss of life. Project delay.	Construction / operation	Direct	Safe operating proceduresOHS protocols (fitness for work, etc.)Continuous automated process	20	3				3	C	3C	Contractor Safety, Health, Environment and Sustainability (SHES) plan to document conditions to 'stop work' prior to dehydration / heat exhaustion

#	Component	Climate hazard (exposure)	Impact	Risk description	Project phase (construction / operation / decommissioning)	Direct/ Indirect	Current risk controls	Life of asset (years)	People	Assets	Environment	Reputation	Max consequence	L/hood	Risk	Proposed additional risk controls / adaptation options
26	Pipeline	Increasing bushfire occurrence and intensity	Bushfire causes damage to above ground infrastructure.	Damage to or loss of asset. Human injury / loss of life. Cost of replacement and lost revenue. Limited access to pipeline easement	Construction / operation	Direct	Vegetation clearance Material selection Bushfire management plan	20	3	2			3	B	3B	
27	Pipeline	Change in groundwater conditions (decreased levels, increased salinity, movement of and exposure to contamination)	Destabilisation of soils and substrata	Destabilisation and corrosion of foundations. Damage to structures.	Operation	Direct	Conditions of environmental approval	20		2			2	C	2C	Materials and coatings selection Anticorrosive elements suitable for future conditions
28	Pipeline	Decreasing water availability within environment	Increased expansion and contraction of soil	Destabilisation of foundations. Damage to structures.	Operation	Direct	Basis of design includes groundwater modelling	20		2			2	C	2C	Factor climate change projections into basis of design for pipeline and associated structures.
29	Pipeline	Riverine Flooding	Erosion / washout of pipeline threatening safety and/or facility integrity	Damage to asset. Human injury. Maintenance and replacement costs. Limited access to pipeline easement	Construction / operation	Direct	Safe operating procedures Design to environmental conditions Controls for access to pipeline easement	20	2	3			3	A	3A	
30	Pipeline	Riverine Flooding	Temporary inundation of pipeline threatening safety and/or facility integrity	Damage to asset. Human injury. Maintenance and replacement costs. Limited access to pipeline easement	Construction / operation	Direct	Safe operating procedures Design to environmental conditions Controls for access to pipeline easement	20	2	3			3	A	3A	
31	Pipeline	Sea level rise	Inundation of above ground pipeline and access routes situated close to the pier	Damage to or loss of asset. Human injury. Cost of replacement and lost revenue.	Operation	Direct	Safe operating procedures Design to environmental conditions	20	3	3			3	C	3C	Factor climate change projections into basis of design for pipeline and associated structures.

#	Component	Climate hazard (exposure)	Impact	Risk description	Project phase (construction / operation / decommissioning)	Direct/ Indirect	Current risk controls	Life of asset (years)	People	Assets	Environment	Reputation	Max consequence	L/hood	Risk	Proposed additional risk controls / adaptation options
				Limited access to pipeline easement			Controls for access to pipeline easement									
32	Pipeline	Increase temperatures and extreme heat	Damage to pipeline operations and structures	Damage to asset. Operational disruption and loss of revenue. Limited access to pipeline easement	Construction / operation	Direct		20	2	2			2	C	2C	Factor climate change projections into basis of design for pipeline and associated structures.
33	Project wide	Storm event	Physical damage to electricity network resulting in power outage.	Temporary cease of operation. Loss of revenue. Follow-on supply delays. Energy provision / shortage.	Operation	Indirect	System back up Power fail safe FSRU generates own power	20		3			3	A	3A	Consider UPS system for critical functions at treatment facility
34	Project wide	Extreme Heat / Heatwave	Peak electricity usage exceeding system capacity resulting in electricity grid black or brown power outage.	Temporary cease of operation. Loss of revenue. Follow-on supply delays. Energy provision / shortage.	Operation	Indirect	System back up Power fail safe FSRU generates own power	20		3			3	A	3A	Consider UPS system for critical functions at treatment facility
35	Treatment facility	Increasing bushfire occurrence and intensity	Bushfire causes damage to facility	Damage to or loss of asset. Human injury. Increased maintenance and replacement costs.	Construction / operation	Direct	Design for fire Fire fighting facilities and rescue team Safe operating procedures Bushfire management plan	30	2	2			2	B	2B	Inclusion of response to bushfire conditions in maritime operations plan (or equivalent)
36	Treatment facility	Enhanced atmospheric carbon dioxide concentration	More rapid carbonation / degradation of exposed concrete structures.	Potential for failure of asset. Increased maintenance costs. Early replacement of structures	Operation	Direct	Material selections	30		1			1	A	1A	

#	Component	Climate hazard (exposure)	Impact	Risk description	Project phase (construction / operation / decommissioning)	Direct/ Indirect	Current risk controls	Life of asset (years)	People	Assets	Environment	Reputation	Max consequence	L/hood	Risk	Proposed additional risk controls / adaptation options
37	Treatment facility	Decreasing water availability	Decreased capacity to extinguish fire at facility	Decreased capability to resolve an emergency. Emergency impact less mitigatable	Construction / operation	Indirect	Use of sea water	30		1			1	A	1A	
38	Treatment facility	Decreasing water availability within environment	Increased dust generation at facility and site access routes	Decreased air quality. Decreased human health.	Construction	Direct	Recycled water sourced from Barwon Water Construction Environmental Management Plan (CEMP) for dust control	30			1		1	C	1C	Contractor SHES plans to document conditions to 'stop work' prior to potential dust inhalation if conditions are unsafe for personnel to work in.
39	Treatment facility	Change in groundwater conditions (decreased levels, increased salinity, movement of and exposure to contamination)	Destabilisation of soils and substrata	Destabilisation and corrosion of foundations. Damage to structures	Operation	Direct	Basis of design includes groundwater modelling	30		1			1	B	1B	Factor in climate change scenarios to basis of design.
40	Treatment facility	Extreme Rainfall event	Erosion / washout of pier access routes, threatening safety and/or facility integrity	Damage to or loss of asset. Human injury. Loss of life. Replacement of components and equipment. Environmental contamination / management costs	Operation	Direct	Flood and drainage design Groundwater monitoring	30		4			4	A	4A	

#	Component	Climate hazard (exposure)	Impact	Risk description	Project phase (construction / operation / decommissioning)	Direct/ Indirect	Current risk controls	Life of asset (years)	People	Assets	Environment	Reputation	Max consequence	L/hood	Risk	Proposed additional risk controls / adaptation options
41	Treatment facility	Extreme Rainfall event	Temporary inundation of facility site and access routes	Safety impacts to workers. Supply disruption. Damage to or loss of assets	Operation	Direct	Multiple access points and suppliers Margins in chemical quantities Remote operations	30	2	2		2	2	E	2E	Flexibility in supply of nitrogen Agreement with AEMO for relief of gas specification (Wobbe Index)) Potential for onsite nitrogen production
42	Treatment facility	Riverine Flooding	Temporary inundation or washout of transport network leading to facility	Operational disruption and loss of revenue. Limited access to pipeline easement	Construction / operation	Indirect	Safe operating procedures Design to environmental conditions Controls for access to pipeline easement	20	2	3			3	B	3B	
43	Treatment facility	Storm event, high wind speeds	Physical damage to facility site and/or access routes threatening safety and/or facility integrity	Damage to or loss of asset. Human injury. Loss of life. Replacement of components and equipment. Environmental contamination / management costs	Construction / operation	Direct	Work management during construction Weather events factored into basis of design	30	1	1			1	E	1E	Factor projections into basis of design for treatment facility and associated structures.
44	Treatment facility	Sea level rise	Inundation of facility site and access routes, threatening safety and/or facility integrity	Damage to or loss of asset. Human injury. Cost of replacement and lost revenue.	Operation	Direct	Weather events factored into basis of design	30		2			2	A	2A	Factor projections into basis of design for treatment facility and associated structures. For example, site coastal/marine modelling to take into account sea level rise, and identify zones at risk

#	Component	Climate hazard (exposure)	Impact	Risk description	Project phase (construction / operation / decommissioning)	Direct/ Indirect	Current risk controls	Life of asset (years)	People	Assets	Environment	Reputation	Max consequence	L/hood	Risk	Proposed additional risk controls / adaptation options
45	Treatment facility	Extreme Heat / Heatwave	Exhaustion / heat related illness of on site work force	Damage to / decreased human health. Loss of life. Project delay.	Construction / operation	Direct	Safe operating procedures OHS protocols (fitness for work, etc.)	30	1				1	E	1E	Contractor SHES plans to document conditions to 'stop work' prior to dehydration / heat exhaustion.
46	Treatment facility	Extreme Heat / Heatwave	Nitrogen gas needs to be boiled off at higher rates	Loss of revenue. Damage to asset	Operation	Direct	Sizing of tanks Material selection Insulation and pressure protection			1			1	E	1E	Factor climate change projections into basis of design for treatment facility and associated structures.
47	Treatment facility	Extreme Heat / Heatwave	Heat damage to facility and/or access routes	Damage to asset. Increased maintenance costs. Early replacement of structures	Operation	Direct	Design for high heat	30		1			1	A	1A	Factor climate change projections into basis of design for treatment facility and associated structures.

Appendix C -Risk assessment framework

As agreed with Viva Energy, Viva Energy’s Risk Assessment Matrix was applied for the assessment of risks to the project associated with climate change. The Risk Assessment Matrix was adapted with additional likelihood categories drawn from AS5334-2013 to be more reflective of the timeframes associated with the life of the project and climate projections. The consequence and likelihood risk assessment matrix were also adapted to include ‘low’, ‘medium’, ‘high’ and ‘extreme’ risk ratings. The adapted Risk Assessment Matrix and consequence descriptions are provided in Figure 4 and Table 0-1 respectively.

VIVA EnergyAustralia

Risk Assessment Matrix (RAM)

<< SEVERITY	CONSEQUENCES				INCREASING LIKELIHOOD >>				
	People	Assets	Environment	Reputation	A	B	C	D	E
					Never heard of in the industry, but may occur in exceptional circumstances	Has happened in the industry	Has happened in the company's history or in the industry in the past 10 years	Has happening in the company in the past 10 years	Has happened in the company in the past year
					Very unlikely **	Unlikely	Moderate	Likely	Almost certain
					May occur in exceptional circumstances during the life of the project **	Has a 10-40% chance of occurring during the life of the project	Has a 40-60% chance of occurring during the life of the project	Has a 60-90% chance of occurring during the life of the project	Has a greater than 90% chance of occurring during the life of the project
0	No injury or health effect	No damage / loss	No impact	No impact	0A	0B	0C	0D	0E
1	Slight injury or health effect	Slight damage / loss <$10K	Slight impact	Slight impact	1A	1B	1C	1D	1E
2	Minor injury or health effect	Minor damage / loss <$100K	Minor impact	Minor impact	2A	2B	2C	2D	2E
3	Serious injury or health effect	Moderate damage / loss <$1M	Moderate impact	Moderate impact	3A	3B	3C	3D	3E
4	PTD or a single fatality	Major damage / loss <$10M	Major impact	Major impact	4A	4B	4C	4D	4E
5	Multiple fatalities	Severe damage / loss >$10M	Severe impact	Severe impact	5A	5B	5C	5D	5E

Risk rating key

- Low
- Medium
- High
- Extreme

** The Viva Energy Australia Risk Assessment Matrix (RAM) has been adapted to include likelihood categories from *AS5334-2013 Climate change adaptation for settlements and infrastructure - A risk base approach* to reflect future consideration of climate change scenarios

Figure 4 Viva Energy Risk Assessment Matrix - adapted for likelihood criteria and risk ratings

Table 0-1 People, assets, environment and reputation consequence descriptions

	People	Assets	Environment	Reputation
Level	**Definition**			
0	**No injury or health effect**	**No damage**	**No impact**	**No impact**
1	**Slight injury or health effect** • No Treatment Case or First Aid Case • Illnesses that result in noticeable discomfort, minor irritation or transient effects that are reversible after exposure stops	**Slight damage** • Costs less than AUD $10,000	**Slight impact**: Slight environmental harm – contained within the premises. Example: • Small spill in process area or tank farm area that readily evaporates.	**Slight impact:** • Local public awareness but no discernible concern. • No media coverage.
2	**Minor injury or health effect** • Medical Treatment Case • Lost Workday Case or Restricted Work Case, where either has a duration of up to and including 5 days • Illnesses with reversible health effects such as food poisoning and dermatitis	**Minor damage** • Costs between AUD $10,000 and AUD $100,000	**Minor impact:** Minor environmental harm, but no lasting effect. Examples: • Small spill off-site that seeps into the ground. • On-site groundwater contamination. • Complaints from up to 10 individuals. • Single exceedance of statutory or other prescribed limit. • No permanent effect on the environment.	**Minor impact:** • Local public concern. • Local media coverage.
3	**Serious injury or health effect** (Definition aligns with the WHS Act 2011 s36 and the Victorian	**Moderate damage** • Costs between AUD $100,000 and AUD $1 million	**Moderate impact:** Limited environmental harm that will persist or require cleaning up. Examples:	**Moderate impact:** Significant impact in region or country • Regional public concern.

	Occupational Health and Safety Act 2004†) • Immediate treatment as an in-patient in a hospital; or • Immediate treatment for amputation of a body part; serious head injury or burns; de-gloving type injuries and/or serious lacerations; loss of a bodily function and /or spinal injury or; • Medical treatment within 48 hours of a workplace exposure to a substance; or. • Lost Workday Case or Restricted Work Case, where either has a duration exceeding 5 days; or • Illnesses with irreversible health effects such as sensitisation, noise induced hearing loss, chronic back disorders or repetitive strain injury; or • Work related mental illness.		• Spill from a pipeline into soil/sand that requires removal and disposal of a large quantity of soil/sand. • Observed off-site effects or damage, e.g. fish kill or damaged vegetation. • Off-site groundwater contamination. • Complaints from community organisations (or more than 10 complaints from individuals). • Frequent exceedance of statutory or other prescribed limit, with potential long term effect.	• Local stakeholders, e.g. community, NGO, industry and government, are aware. • Extensive attention in local media. Some regional or national media coverage.
4	**Permanent Total Disability or a single fatality** • Illnesses with irreversible health effects such as corrosive burns, asbestosis and silicosis • Cancer	**Major damage** • Costs between AUD $1 and AUD $10 million	**Major impact:** Severe environmental harm that will require extensive measures to restore beneficial uses of the environment. Examples: • Oil spill at a jetty during tanker (off) loading that ends up on	**Major impact:** Likely to escalate and affect reputation • National public concern. • Impact on local and national stakeholder relations. National government and NGO

	• Mental illness due to stress with irreversible health effects		local beaches, requiring clean-up operations. • Off-site groundwater contamination over an extensive area. • Many complaints from community organisations or local authorities. • Extended exceedances of statutory or other prescribed limits, with potential long term effects.	involvement with potential for international NGO action. • Extensive attention in national media. Some international coverage. • Potential for regulatory action leading to restricted operations or impact on operating licences.
5	**Multiple fatalities** • Illnesses with irreversible health effects such as multiple asbestosis cases traced to a single exposure situation • Cancer in a large exposed population **Multiple fatalities >10 or potential for offsite consequences to People also fall into severity 5 but will trigger a higher level of analysis criteria as defined in the HEMP Standard.**	**Massive damage** • Costs in excess of AUD $10 million	**Severe impact:** Persistent severe environmental harm that will lead to loss of commercial, recreational use or loss of natural resources over a wide area. • Crude oil spillage resulting in pollution of a large part of a river estuary and extensive clean-up and remediation measures. • Persistent severe environmental damage that will lead to loss of commercial, recreational use or loss of natural resources over a wide area. Example: • Crude oil spillage resulting in pollution of a large part of a river estuary and extensive	**Severe impact:** Severe impact on reputation • International public concern. • High level of concern amongst governments and action by international NGOs. • International media attention. • Significant potential for effect on national/international standards with impact on access to new areas, grants of licences and/or tax legislation.

			clean-up and remediation measures	