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Introduction

Background

- 15.1 This Environmental Impact Assessment Report (EIAR) has been prepared by SLR Consulting Ireland Limited ('SLR') on behalf of Roadstone Limited ('the Applicant') to document the Environmental Impact Assessment (EIA) process carried out in respect of a planning application submitted pursuant to Section 34 of the Planning & Development Act 2000 (as amended) ('the Act') for the proposed development: a bio-renewables production facilities, buffer screening, ancillary facilities and site access via the existing permitted quarry entrance ('the project').
- 15.2 The proposed development being applied for under this planning application will consist of:
- The proposed bio-renewables production facility (incorporating anaerobic digestion) compound will cover an area of c. 4 hectares with c. 16,821.5m² of new buildings consisting of an administration building; a dry matter reception building; a workshop; a bio-conversion building; a pre-treatment, equalisation and gas upgrading building; a digestate handling building; a warehouse storage building; a bio-filling station building; an odour abatement and pumping station building; a linear generator building; and an ESB sub-station building.
 - Ancillary facilities to be provided will include, a wheelwash; a weighbridge; surface water and fire water storage ponds; storage tanks for water, silage feed, cattle manure, pot ale and spent grain, maize, chicken litter and gas; effluent collection and storage tanks; staff and visitor car parking and bicycle storage; HGV parking; roof mounted solar panels; hydrocarbon interceptors; wastewater treatment equipment; bunding and surface treatments; boundary treatments and fencing; lighting; services; drainage; landscaping; and all associated ancillary works.
- 15.3 A full description of the project is presented in EIAR Chapter 2.
- 15.4 The proposed development is located at the existing Killough quarry facility in Gaile townland, Holycross, County Tipperary. The site is approximately 3.5km and 6.5km south of Holycross and Thurles respectively.
- 15.5 This chapter considers the vulnerability of the proposed project site, as well as potential risks of the proposed project to result in major accidents and/or natural disasters. In the assessment of potential vulnerability and risks, both embedded and additional mitigation measures that will be implemented through the proposed development site are clearly identified.
- 15.6 The assessment of the vulnerability of the proposed project to major accidents and natural disasters is carried out in compliance with the EIA Directive as amended which states the need to assess:
- "The expected significant adverse effects of the project on the environment deriving from the vulnerability of the project to risks of major accidents and/or natural disasters which are relevant to the project concerned."*
- 15.7 The assessment also follows guidance set out by the Environmental Protection Agency (EPA) in 'Guidelines on Information to be contained in Environmental Impact Statements' (EPA, 2022) and the European Commission 'Guidance on the preparation of the Environmental Impact Assessment Report' (Directive 2011/92/EU, as amended by 2014/52/EU) (European Commission, 2017).

Statement of Authority

- 15.8 This assessment has been undertaken by Lauren Jones, a Consultant with SLR. Lauren joined SLR in March 2023 after graduating from Lancaster University with a BA in Geography. She has worked on a number of EIAs, producing Major Accidents and Natural Disasters chapters. Lauren is also a Graduate member of the Institute of Environmental Management and Assessment.
- 15.9 It was reviewed by Lynn Hassett, an Associate with SLR. Lynn is an EIA co-ordinator with a BSc in Applied Ecology (2000) and a MSc in Environmental Impact Assessment (2001). She has over 16 years of experience in EIA across the not-for-profit, public and private sectors in the UK and Ireland. She has worked on both the review of EIA on behalf of planning authorities assessing applications and in the production of them to support planning applications being lodged. She is a Practitioner member of the Institute of Environmental Management and Assessment, which she is a member of since 2001. She is also a Full Member of the Institution of Environmental Sciences, which she joined in 2023.

Proposed Project

- 15.10 A full description of the proposed project is presented in Chapter 2 of this EIAR.
- 15.11 In summary, the proposed project comprises the development of a bio-renewables production facility, buffer screening, ancillary facilities and site access via the existing permitted quarry entrance, across 6.3 hectares of the existing permitted rock quarry at Killough.

Methodology

Scope of the Assessment

- 15.12 The scope of the assessment has been informed by the contents of the EIA Directive and associated guidelines as identified in this chapter. A programme of public and stakeholder consultation is being implemented through the Applicant's pre-planning consultations with the local community, and through the informal EIA Scoping process that is described in Chapter 1. Any additional issues raised through consultation in relation to Major Accidents and Natural Disasters has been included to the assessment.

Relevant Legislation and Guidance

- 15.13 The requirement for this assessment arises from the European Union Directive in relation to Environmental Impact Assessment of proposed developments (Directive 2011/92/EU, as amended by 2014/52/EU).
- 15.14 The information relevant to major accidents and/or disasters to be included in the EIAR is set out in paragraph 8 of Annex IV of the EIA Directive (as amended) is as follows:

“(8) A description of the expected significant adverse effects of the proposed development on the environment deriving from the vulnerability of the proposed development to risks of major accidents and/or disasters which are relevant to the proposed development concerned. Relevant information available and obtained through risk assessments pursuant to Union legislation such as Directive 2012/18/EU of the European Parliament and of the Council or Council Directive 2009/71/Euratom or relevant assessments carried out pursuant to national legislation may be used for this purpose provided that the requirements of this Directive are met. Where appropriate, this description should include measures envisaged to prevent or mitigate the significant adverse effects of such events on the environment and details of the preparedness for and proposed response to such emergencies”.

- 15.15 Therefore, the following key issues were investigated in relation to the site and the proposals for it:
- the vulnerability of the proposed project to potential accidents and disasters; and
 - the proposed project's potential to cause major accidents or disasters which pose a risk to the environment.
- 15.16 The following guidance documents have informed the assessment:
- Department of Housing, Local Government and Heritage (2006) Framework for Major Emergency Management;
 - Department of Environment, Heritage and Local Government (2010) A Guide to Risk Assessment in Major Emergency Management;
 - Department of Housing, Planning and Local Government (2018) Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment;
 - Environmental Protection Agency (2014) Guidance on Assessing and Costing Environmental Liabilities;
 - Environmental Protection Agency (2022) Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
 - European Commission (2017) Environmental Impact Assessment of Proposed Developments – Guidance on the preparation of Environmental Impact Assessment Reports; and
 - Tipperary County Council (2014) Major Emergency Plan.
- 15.17 Requirements of legislation contained in European Directive (2012/18/EU), i.e. the Seveso – III Directive and Irish regulation S.I. No. 209 of 2015 Control of Major Accident Hazards involving Dangerous Substances have also informed the assessment contained herein.
- 15.18 The Tipperary County Council (2014) Major Emergency Plan has the objective of providing a co-ordinated response by the relevant agencies in the event of an emergency in the county. As alluded to in the Plan, their role in this should not restrict action by individual operators in such events. This assessment acknowledges the duty of the Applicant to ensure that all reasonable measures are taken to avoid the potential for any emergencies to arise.
- 15.19 In the unlikely event of a major emergency arising, An Garda Síochána, the Health Service Executive, and Tipperary County Council are the principal response agencies (PRA's) charged with managing the response to emergency situations which arise in the county.

Site-Specific Risk Assessment Methodology

- 15.20 A desk-study based on site knowledge, online mapping and consideration of the guidance identified above has been completed to establish the baseline environment for which the proposed risk assessment is being carried out. The baseline influences both the likelihood and the potential scale of impact of a major accident or natural disaster. Local and regional context has been established prior to undertaking the risk assessment to develop an understanding of the vulnerability and resilience of the area to emergency situations.
- 15.21 Site visits have been undertaken by hydrology specialists as set out in Chapter 7 to establish the pattern of existing drainage and to record existing hydrology features of the proposed project site. The site walkover included an initial review of available information gathered in a preliminary desk study. During the site visit, the GPS coordinates, descriptions, and

photographs of hydrology features were recorded to develop a better understanding of hydrology and drainage arrangements at the site.

- 15.22 As this is a site-specific assessment, the Study Area for this assessment is comprised of the proposed development site, taking into account the local wider context as relevant to the risk identified. A visual inspection was conducted to identify any likely constraints or issues. The access arrangements were considered as part of the site visit. The results of the traffic survey and access arrangements are provided Chapter 14 (Traffic and Transport).
- 15.23 Other specialist chapters of the EIAR provide assessments of some potential accidents and disaster scenarios such as pollution incidents to ground and watercourses as well as assessment of flooding events (see Chapter 7 Water) and ground stability (see Chapter 6 Land, Soils and Geology). In relation to Human Health, please refer to Chapter 4 Population and Human Health and Chapter 11 Material Assets for further detail.
- 15.24 With regard to the control of major accident hazards involving dangerous substances, an examination of upper and lower tier Seveso Establishments in the surrounding region of the proposed project identified no Seveso Establishments in immediate proximity to the site (less than 5km). The nearest Seveso Establishments to the site is approximately 35km to the south-east (MSD Ireland: Ballydine, Clonmel).
- 15.25 The approach to identifying and quantifying risks associated with the proposed project by means of a site-specific risk assessment is based on the EPA 'Guidance on Assessing and Costing Environmental Liabilities' document, which recommends that the identification of environmental liabilities/risks should focus on unplanned, but possible and plausible events. In accordance with best practice, and as set out in Section 3.3 of the guidance, the following steps were taken as part of the site-specific risk assessment:
- risk identification;
 - risk classification, likelihood and consequence; and
 - risk evaluation.

Risk Identification

- 15.26 Risks have been reviewed through the identification of reasonably foreseeable risks in consultation with relevant contributors to this EIAR (refer to Statements of Authority in **Chapters 4 to 14** of this EIAR). The identification of risks has focused on non-standard but plausible incidents that could occur at or as a result of the proposed project.
- 15.27 In accordance with the European Commission (2017) Guidance on Environmental Impact Assessment Reports, risks are identified in respect of the proposed developments:
- potential to cause accidents and/or disasters; and
 - vulnerability to potential disaster/accident.

Risk Classification

Classification of Likelihood

- 15.28 After identifying the potential risks, the likelihood of occurrence of each risk has been assessed. An analysis of safety procedures and proposed environmental controls was considered when estimating likelihood of identified potential risks occurring. **Table 15-1** defines the likelihood ratings that have been applied.
- 15.29 The approach adopted has assumed a 'risk likelihood' where one or more aspects of the likelihood description are met, based on definitions set out in Department of Environment, Heritage and Local Government (2010) guidance.

Table 15-1: Classification of Likelihood (Source: DoEHLG, 2010)

Ranking	Likelihood	Description
1	Extremely Unlikely	May occur only in exceptional circumstances; once every 500 years.
2	Very Unlikely	Is not expected to occur; and/or no recorded incidents or anecdotal evidence; and/or very few incidents in associated organisations, facilities or communities; and / or little opportunity, reason or means to occur; may occur once every 100-500 years.
3	Unlikely	May occur at some time; and /or few, infrequent, random recorded incidents or little anecdotal evidence; some incidents in associated or comparable organisation's worldwide; some opportunity, reason or means to occur; may occur once per 10-100 years.
4	Likely	Likely to or may occur; regular recorded incidents and strong anecdotal evidence and will probably occur once per 1-10 years.
5	Very Likely	Very likely to occur; high level of recorded incidents and/or strong anecdotal evidence. Will probably occur more than once a year.

Classification of Consequence

- 15.30 The consequence rating assigned to each risk has assumed that all proposed mitigation measures and/or safety procedures have failed to prevent the major accident and/or disaster. The consequence of the impact if the event occurs has been assigned as described in **Table 15-2**.
- 15.31 The consequence of a risk to/from the proposed project has been determined where one or more aspects of the consequence description are met, i.e., risks that have no consequence have been excluded from the assessment. Definitions of consequence ratings are also based on Department of Environment, Heritage and Local Government (2010) guidance.

Table 15-2: Classification of Impact (Source: DoEHLG, 2010)

Ranking	Classification	Impact	Description
1	Minor	Life, Health, Welfare	Small number of people affected; no fatalities and small number of minor injuries with first aid treatment.
		Environment	No contamination, localised effects
		Infrastructure	<€0.5M
		Social	Minor localised disruption to community services or infrastructure (<6 hours).
2	Limited	Life, Health, Welfare	<ul style="list-style-type: none"> • Single fatality; limited number of people affected; a few serious injuries with hospitalisation and medical treatment required. • Localised displacement of a small number of people for 6-24 hours. Personal support satisfied through local arrangements.
		Environment	Simple contamination, localised effects of short duration

		Infrastructure	€0.5-3M
		Social	Normal community functioning with some inconvenience.
3	Serious	Life, Health, Welfare	<ul style="list-style-type: none"> • Significant number of people in affected area impacted with multiple fatalities (<5), multiple serious or extensive injuries (20), significant hospitalisation. • Large number of people displaced for 6-24 hours or possibly beyond; up to 500 evacuated. • External resources required for personal support.
		Environment	Simple contamination, widespread effects or extended duration
		Infrastructure	€3-10M
		Social	Community only partially functioning, some services available.
4	Very Serious	Life, Health, Welfare	5 to 50 fatalities, up to 100 serious injuries, up to 2,000 evacuated
		Environment	Heavy contamination, localised effects or extended duration
		Infrastructure	Community functioning poorly, minimal services available
		Social	Community functioning poorly, minimal services available
5	Catastrophic	Life, Health, Welfare	Large numbers of people impacted with significant numbers of fatalities (>50), injuries in the hundreds, more than 2,000 evacuated.
		Environment	Very heavy contamination, widespread effects of extended duration.
		Infrastructure	>€25M
		Social	Serious damage to infrastructure causing significant disruption to, or loss of, key services for prolonged period. Community unable to function without significant support.

Risk Evaluation

- 15.32 Once classified, the likelihood and consequence ratings have been multiplied to establish a 'risk score' to support the evaluation of risks by means of a risk matrix.
- 15.33 The risk matrix derived from the DoEHLG "Guide to Risk Assessment in Major Emergency Management" (and as outlined in **Table 15-3**) indicates the critical nature of each risk. This risk matrix has therefore been applied to evaluate each of the risks associated with the

proposed project. The risk matrix is colour coded to provide a broad indication of the critical nature of each risk:

- The red zone represents 'high risk scenarios';
- The amber zone represents 'medium risk scenarios'; and
- The green zone represents 'low risk scenarios'.

15.34 The use of **Table 15-3** is intended as a framework for the objective assessment of predicted impacts based on informed judgements regarding their likelihood and potential consequences. The supporting text in this chapter provides clarity in instances where a predicted impact is deemed to be significant or not.

Table 15-3: Matrix for determining significance of effect (Source: DoEHLG, 2010)

Likelihood	Classification				
	1 Minor	2 Limited	3 Serious	4 Very Serious	5 Catastrophic
5 Very Likely	Low	Medium	High	High	High
4 Likely	Low	Medium	Medium	High	High
3 Unlikely	Low	Low	Medium	Medium	High
2 Very Unlikely	Low	Low	Low	Medium	Medium
1 Extremely Unlikely	Low	Low	Low	Low	Low
	Normal Emergency		Major Emergency		

15.35 The HSE, as one of the three principal response authorities¹, has prepared Major Emergency Plans for areas of the State in accordance with the requirements set out in Section 4.4.1 of the National Framework for Major Emergency Management (2006). The proposed development site is covered by the HSE Area 3 Major Emergency Plan, which covers North Tipperary². The Emergency Plan identifies the relevant roles and responsibilities of the HSE in relation to major emergency types and the planned procedure in case of such events. The hazard categories include the four categories specified in the National Framework, i.e. Natural, Transportation, Technological and Civil. The hazard categories, types and subtypes of potential relevance to the proposed project are listed below in **Table 15-4** and are based on a review of those identified in overarching HSE and Tipperary County Council Major Emergency Plans.

¹ An Garda Síochána, the Health Service Executive and the Local Authorities are the Principal Response Agencies charged by Central Government with managing the response to emergency situations

² [HSE Emergency Management Area 3 Major Emergency Plan 2024](#)

Table 15-4: HSE Emergency Plan Hazard Types (Source: HSE, 2022)

Category	Type	Subtype	Relevance to the Proposed Project
Natural Hazards			
Meteorological	Storm / Gale	Both coastal and inland areas can be affected by high winds	<ul style="list-style-type: none"> Poor driving conditions Damage to/loss of infrastructure Flooding Falling trees/infrastructure
	Heavy Snow	Blizzards – poor visibility	<ul style="list-style-type: none"> Poor driving conditions
		Icy / impassable roads	<ul style="list-style-type: none"> Poor driving conditions
		Hypothermia	<ul style="list-style-type: none"> Public health risk
		Freezing of supply network	<ul style="list-style-type: none"> Lack of road grit
	Severe Cold and Frost or extremes of temperature	Icy / impassable roads	<ul style="list-style-type: none"> Poor driving conditions
		Hypothermia	<ul style="list-style-type: none"> Public health risk
		Freezing	<ul style="list-style-type: none"> N/A
	Thunder and lightning Dense and persistent fog	Road traffic collisions	<ul style="list-style-type: none"> Damage to/loss of infrastructure Poor driving conditions
	Heat wave / drought	Heat	<ul style="list-style-type: none"> Public health risk Water shortage
Hydrological	Flooding / heavy rain	Coastal / inland	<ul style="list-style-type: none"> Potential for flooding May lead to flooding in low lying areas or areas with poor drainage
Geological	Landslide / Mine Collapse / Rock Slide		<ul style="list-style-type: none"> Damage to infrastructure
	Earthquake / Tsunami / Volcano		<ul style="list-style-type: none"> Damage to infrastructure
	Forest / wilderness fire Air pollution	Fire	<ul style="list-style-type: none"> Damage to adjacent forestry Public health risk
Transportation hazards			
Aviation	Aircraft collision / loss	Mid-air and land	<ul style="list-style-type: none"> N/A
Roads	Multiple road traffic collisions	Roads	<ul style="list-style-type: none"> Accidents/injuries on public roads via which staff and materials access the site.
	Hazmat		<ul style="list-style-type: none"> Fuel transport to/from site
	Bridges		<ul style="list-style-type: none"> N/A
Rail	Collisions		<ul style="list-style-type: none"> N/A
Water	Inland waterways	Pleasure craft / cruises	<ul style="list-style-type: none"> N/A

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Major Accidents and Natural Disasters 15

Category	Type	Subtype	Relevance to the Proposed Project
	Coastal / Ship and Port	Car ferry / passenger ferries	• N/A
	Rescue		• N/A
• Technological Hazards			
Industrial accidents	Explosions		• Damage to infrastructure, personal injuries / fatalities
	Petrochemical fires		• Personal injuries. Severe burns, fatalities, air pollution
	Industrial fires	Biomass source	• N/A
	Gas emission	Gas leak	• N/A
	Fluid / fuel emission	Accidental leak	• Damage to infrastructure, personal injuries / fatalities, ground/water pollution
Explosions	Domestic		• N/A
	Bomb		• N/A
	LPG		• N/A
	Pipeline	Gas Pipeline	• N/A
Fires			• Potential for spread, air pollution
Building Collapse			• Damage to/loss of infrastructure
Hazardous Substances	Biological	Accident at site	• Gas production from biological waste
		Transportation accident	• N/A
	Radiological	Weapons	• N/A
		Leak / weapons	• N/A
		“dirty bomb”	• N/A
		Industrial Accident	• N/A
	Health Facilities	• N/A	
Pollution / Contamination	Air / Water Pollution		• Fire
			• Sediment laden water run off
			• Fuel / hydrocarbon spill / leak
• Civil Hazards			
Major Crowd Safety	Movement, Crushing	Pop concerts, sports, events, firework displays, air shows	• N/A
Loss of Critical Infrastructure	Energy and Power Supply	Electricity	• Operational issues, disturbance to grid
		Natural gas	• N/A
		Fuel Oil	• N/A

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Category	Type	Subtype	Relevance to the Proposed Project
		Communications	<ul style="list-style-type: none"> Operational issues, disturbance to network
Food Situation Crisis		Food contamination or drought	<ul style="list-style-type: none"> N/A
Water Supply		Shortage / contamination, freezing or flooding	<ul style="list-style-type: none"> N/A
Epidemics and pandemic		Communicable diseases	<ul style="list-style-type: none"> N/A
Animal Disease		Foot & Mouth, Avian Influenza	<ul style="list-style-type: none"> Disease could be introduced through animal waste
Terrorism	Bombs Chemical, Biological, Radiological, Nuclear and high yield Explosives (CBRNE) disruption	Car bombs	<ul style="list-style-type: none"> N/A
		Bombs in buildings	<ul style="list-style-type: none"> N/A
		Fire bombing	<ul style="list-style-type: none"> N/A
		Bomb scares	<ul style="list-style-type: none"> N/A

Description of Proposed Development Site

- 15.36 The application site is located wholly within the townland of Gaile, Holycross, Co. Tipperary, and within the existing footprint of the Killough quarry development, owned and operated by Roadstone Limited. The site is approximately 3.5km and 6.5km south of Holycross and Thurles respectively.
- 15.37 The existing main extraction void of the quarry covers approximately the southern three quarters of Killough Hill. To the immediate northwest, north and east of the void, the land slopes fairly steeply towards the surrounding plain, covering a height difference of between 50-80m over a distance of less than 200m. These steep slopes are covered by conifer and mixed woodland. To the immediate southeast and south of the void the land slopes slightly less steeply and is made up from pasture as well as some woodland scrub areas. To the immediate southwest of the void the quarry processing facilities are located at levels between 140m AOD and 170m AOD.
- 15.38 The existing quarry has been in operation since the 1950's. Material extracted from the quarry area is processed within the quarry void using mobile processing plant. The materials are then stockpiled, pending further use on site for value added asphalt and concrete production or for transport off-site to market.
- 15.39 The land immediately surrounding Killough Hill lies at levels of between 110 and 120m AOD. The flat landscape surrounding Killough Hill is almost exclusively made up from agricultural land (mostly pasture interspersed with some arable fields). The fields, which are usually enclosed by hedgerows, are also variable in size.
- 15.40 The main transport route within the area is the M8 motorway, approximately 2.5km to the southeast of the site. There are also a number regional routes in the area, the R659 and R660, east and south of Holycross respectively; and the R639, the former N8, just east of the M8). Access from the site to the primary road network is via c. 2.5km of local road onto the M8 Motorway between Urlingford and Cashel.

Vulnerability to Major Accidents and Natural Disasters

15.41 The recitals to the EU Directive 2014/52/EU which amends Directive 2011/92/EU states the following in relation to vulnerability of a proposed development to natural disaster:

“In order to ensure a high level of protection of the environment, precautionary actions need to be taken for certain proposed developments which, because of their vulnerability to major accidents, and/or natural disasters (such as flooding, sea level rise, or earthquakes) are likely to have significant adverse effects on the environment. For such proposed developments, it is important to consider their vulnerability (exposure and resilience) to major accidents and/or disasters, the risk of those accidents and/or disasters occurring and the implications for the likelihood of significant adverse effects on the environment.”

15.42 The following section considers the current situation at the proposed development site, its vulnerability to major accidents and natural disasters, and the potential of those inherent conditions to contribute to major accidents or disasters which pose a risk to the environment.

Environment Management System

15.43 There is an existing Environmental Management System (EMS) at the quarry. A new Environmental Management System (EMS) will be put in place for the facility, as will be required by the IE Licence. The operator shall develop the EMS in accordance with ISO14001:2015, applying for accreditation when operational. This EMS will include but not be limited to the following:

- Measures to comply with the IE licence and other relevant environmental legislation;
- Materials Acceptance Procedures;
- Standard Operating Procedures;
- Measures to comply with the corporate sustainability goals (e.g., reducing water and energy consumption);
- Accident prevention and emergency response procedures; and
- Complaints Register.

Sources of Vulnerability

15.44 Ireland has historically not suffered from extreme temperatures like that of many countries at a similar latitude due to the dominant influence of the Gulf Stream. This has provided Ireland with a mild temperate climate, even as climate change trends began to appear in the last decade. Recent studies from the Potsdam Institute in Germany (in the last three years) suggest that northwest Europe, and Ireland in particular, are on course for a dramatic drop in temperatures associated with earlier than predicted changes to the Gulf Stream if greenhouse gas emissions are not lowered in time to prevent an average global temperature rise. The risk of other natural disasters such as earthquakes is still low. Potential vulnerabilities are considered as follows:

- Extreme temperatures (especially cold);
- Flooding;
- Fire;
- Major incidents involving dangerous substances; and
- Other potential catastrophic events.

Extreme Temperatures

- 15.45 The potential vulnerability of the proposed development to extreme temperatures is predominantly linked to the resilience / capacity for adaptation of the built infrastructure to the possible changes.
- 15.46 In the event of extreme heat induced fires, the site has emergency escape procedures in place for operational staff.
- 15.47 The relevant chapters of the EIAR (in particular **Chapter 6** and **Chapter 7**) identify any potential vulnerabilities of the ground and water conditions at the site and their suitability for the proposed use.

Flooding (Meteorological and Hydrological)

- 15.48 The risk of flooding is addressed in **Chapter 7**, which highlights that the site is at low risk of fluvial flooding (based on existing CFRAM and NIFM flood maps) and that the site is not vulnerable to groundwater flooding (based on available GSI data). Due to the location of the proposed development site, the risk of coastal flooding is also low. There are no records of historic flooding in the OPW database within 2 km of the site.

Fire

- 15.49 A review of surrounding land uses, activities and proposed activities at the site has not identified any particular vulnerability to fire risks.
- 15.50 In the unlikely event that a fire does occur, the local fire station will be contacted and emergency response procedures will be implemented. A range of fire extinguishers (water, foam and CO₂) will be kept at the site office to deal with any localised small scale fires which might occur.
- 15.51 Additional fire-fighting capacity will be provided through two fire water supply tanks (internal size Ø 21.35m x 14m height and volume 5,020m³) and by storing water in a dedicated firewater pond (13,320m³).
- 15.52 Further accident prevention and emergency response procedures will be developed as part of the Environmental Management System. Emergency response procedures will highlight fire safety and fire prevention, including risks of and control measures to prevent fire outbreak, evacuation procedures and those responsible for their implementation, and the use of firefighting equipment, in line with HSA guidance.

Major Accidents Involving Dangerous Substances

- 15.53 Major industrial accidents involving dangerous substances pose a significant risk to human health and to the environment both on and off the site of the accident. The Health and Safety Authority (HSA) of Ireland list all upper and lower tier SEVESO establishments throughout Ireland. The proposed development site is, at its nearest, c. 35km south-east of the nearest site regulated under the Control of Major Accident Hazards Involving Dangerous Substances Regulations i.e. SEVESO site, MSD Ireland (upper tier SEVESO site).
- 15.54 Given the quantities of biogas and biomethane to be produced and stored at the proposed facility, it will be regulated under EU Council Directive 2012/18/EU on the Control of Major Accident Hazards Involving Dangerous Substances (COMAH Directive/ Seveso III Directive) and the European Communities Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2015 (S.I. No. 209 of 2015) (the "COMAH Regulations").

- 15.55 The legislation aims to prevent major accidents involving dangerous substances, and the proposed development falls under the remit of both because of the proposed storage of biogas and biomethane at the facility.
- 15.56 The facility will be categorised as a 'Lower Tier Seveso' site, being an establishment that holds a quantity of dangerous substance above the lower threshold contained in the Seveso Directive. It is not an 'Upper Tier Seveso' site, which holds dangerous substances above the upper threshold contained in the Seveso Directive (but below the upper threshold).
- 15.57 Given its status as a Lower Tier Seveso site, the facility will need to comply with the lower tier requirements including to notify the competent authority of their existence, provide specified details in relation to the operations, substances, inventories, and immediate environment of the establishment. It will also need to establish a safety management system (detailed in a Major Accident Prevention Policy).
- 15.58 The facility will be strictly regulated under the COMAH regulations, as well as the 2005 Safety, Health & Welfare at Work Act. There will also be strict reporting and regulation requirements associated with the EPA Licence which will require to be sought following grant of planning permission.
- 15.59 The applicability of the above regulations will have implications for the consideration of the planning application and the extent of consultation with the HSA to ensure the safe handling of dangerous substances. A Land Use Planning Risk Assessment is therefore submitted as part of the planning application documentation, a copy provided in **Appendix 15-A**.
- 15.60 SLR Consulting Limited Safety Advisory team conducted a semi-quantitative risk assessment (sQRA) in line with Health and Safety Authority (HSA) guidance on land-use planning decisions.
- 15.61 The initial findings were that none of the modelled scenarios result in hazardous thermal radiation or overpressure levels being reached at the nearest residential properties. An adverse impact on land use planning decisions for residential properties in the vicinity of the facility is therefore predicted as unlikely.

Other Potential Catastrophic Events

- 15.62 A review of **Table 15-4** enables identification of vulnerability to other potential catastrophic events that could reasonably be considered for the proposed development site, based on its location, baseline conditions, surrounding uses and proposed project.
- 15.63 All persons who have control to any extent over the proposed project have duties to ensure, so far as reasonably practicable, that the facility does not pose a risk to those working there or to anyone not employed there but who may be affected by activities on the site. The rights and obligations of employers and employees are set out in domestic legislation (in particular the Safety, Health and Welfare at Work Act 2005 (as amended)), which require to be followed in the event of such circumstances. Also in the event of operational failures, the employer will have duties in relation to the protection of staff.
- 15.64 **Chapter 14** of this EIAR states that HGV traffic levels would remain well within the design capacity of the local road network and no significant effects on road safety are anticipated.
- 15.65 The proposed development site is not situated in close proximity to any strategic infrastructure hence no particular vulnerability in terms of impacts on wider infrastructure has been identified.
- 15.66 In terms of crowd safety and terrorism risks the site is not open to the public so is not considered to attract visitors, nor is it considered to be a target for any political or other activists.

Health and Safety

- 15.67 Existing Health and Safety measures already required at the proposed project site (at the existing quarry site) and will continue to be followed by staff. This will encompass the use of all necessary Personal Protective Equipment and adherence to the Applicant's internal Health and Safety policies.
- 15.68 On the basis of the designation of the proposed facility as a COMAH and Lower Tier Seveso site, it will be regulated by the HSA so that the protection of public and environmental health and safety is safeguarded and so that any potential conflict with future or existing land use can be removed through forward planning and consultation.
- 15.69 The proposed facility will have its own internal Health and Safety management plan, a Major Accident Prevention Policy in line with its Lower Tier Seveso responsibilities, and it will be strictly regulated by the EPA Licencing regime, with its attendant monitoring and reporting requirements.

Conclusion Regarding Vulnerability

- 15.70 Considering the information set out above, it is considered that the overall vulnerability of the proposed project to risks of major accidents and natural disasters is low.

Risk Assessment

- 15.71 This section provides a breakdown of the possible risks associated with the proposed project. These risks have been assessed in accordance with the relevant classification as outlined in **Table 15-1** and **Table 15-2**.
- 15.72 As outlined earlier, the consequence rating assigned to each potential risk assumes the unlikely event that all proposed mitigation measures and safety procedures have failed to prevent the major accident and/or disaster.

Do-Nothing Scenario

- 15.73 If the proposed development is not permitted, this sustainability project, which is the first of a number of such sustainability projects to be initiated by Roadstone to reduce Carbon Footprint (CF) and greenhouse gas (GHG) emissions while also addressing the changeover to regenerative agriculture utilising organic fertilisers to increase carbon sequestration, will not proceed.

Assessment of Effects During Construction

- 15.74 A risk register has been developed which contains all potentially relevant risks identified during the construction phase of the Proposed Development. Six risks (a – f) specific to the construction of the Proposed Development have been identified and are presented in **Table 15-5**.

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Table 15-5: Risk Register - Construction Phase

Risk ID	Potential Risk	Potential Cause
Potential Vulnerability to disaster risk		
A	Severe Weather / Extreme Temperatures	<ul style="list-style-type: none"> extreme weather/ temperatures- periods of heavy rainfall, taking into account climate change and strong winds
B	Flooding- high levels of surface water on site	<ul style="list-style-type: none"> extreme weather-periods of heavy rainfall, taking into account climate change and strong winds
Potential to cause accidents and / or disasters		
C	Industrial Accident - Fluid/ fuel emission	<ul style="list-style-type: none"> maintenance work vehicle use employee negligence
D	Collapse/ damage to structures	<ul style="list-style-type: none"> vehicular collisions due to driver negligence on public roads weather conditions
E	Traffic Incident- Collisions onsite and offsite with vehicles involved in operation of the proposed project.	<ul style="list-style-type: none"> driver negligence or failure of vehicular operations on site roads. traffic management not implemented
F	Water contamination	<ul style="list-style-type: none"> ground disturbance/sedimentation maintenance work vehicle use employee negligence

Assessment of Effects During Operation

15.75 Seven potential risks specific to the operation of the proposed project have been identified and are presented in **Table 15-6**.

Table 15-6: Risk Register- Operational Phase

Risk ID	Potential Risk	Potential Cause
Potential Vulnerability to disaster risk		
G	Severe Weather / Extreme Temperatures	<ul style="list-style-type: none"> extreme weather/temperatures- periods of heavy rainfall, taking into account climate change and strong winds
H	Flooding- high levels of surface water on site	<ul style="list-style-type: none"> extreme weather- periods of heavy rainfall, taking into account climate change and strong winds
Potential to cause accidents and / or disasters		
I	Industrial Accident - Fluid/fuel emission	<ul style="list-style-type: none"> maintenance work vehicle use employee negligence gas production through biological waste/ handling of gas to/from site

J	Collapse/ damage to structures	<ul style="list-style-type: none"> • vehicular collisions due to driver negligence on public roads • weather conditions • gas explosion
K	Traffic Incident- Collisions onsite and offsite with vehicles involved in operation of the proposed project.	<ul style="list-style-type: none"> • driver negligence or failure of vehicular operations on site roads. • traffic management not implemented
L	Water contamination	<ul style="list-style-type: none"> • escape of run-off • maintenance work • vehicle use • employee negligence
M	Infectious diseases	<ul style="list-style-type: none"> • attraction of pests to site • introduction of disease through animal waste

15.76 The risk register is based upon possible risks associated with the proposed project. As outlined previously, the consequence rating assigned to each potential risk assumes that all proposed mitigation measures and safety procedures have failed to prevent the major accident and/or disaster.

15.77 **Table 15-7** sets out a reasoned 'Risk Score' for each potential risk, which is a factor of the allocated 'Risk Likelihood' based on the definitions set out in **Table 15-1** and the allocated 'Risk Consequence' as defined in **Table 15-3**.

Table 15-7: Assessment of Effect - Summary

Risk ID	Potential Risk	Possible Cause	Environmental Effect	Likelihood Rating	Basis of Likelihood	Consequence Rating	Basis of Classification	Risk Score (Consequence x Likelihood)
Construction Phase								
A	Severe Weather / Extreme Temperatures	<ul style="list-style-type: none"> extreme weather- extreme heat/ extreme cold, periods of heavy rainfall, taking into account climate change and strong winds 	<ul style="list-style-type: none"> illness or loss of life sedimentation of nearby watercourse damage to, or depletion of aquatic habitats and species 	2	The risk of severe weather is very unlikely when considering the assessment in Chapter 8 of this EIAR and weather conditions recorded over the last 30 years within the area, however it is assessed here as 'unlikely' given that trends are changing.	1	<p>The risk of severe weather conditions during the operational phase will result in a minor classification in that 'small number of people would be affected' (given low workforce numbers involved and low number of immediate neighbours) should a severe weather occur, with 'no fatalities and a small number of minor injuries with first aid treatment'.</p> <p>Potential localised contamination</p> <p>Minor localised disruption to community services or infrastructure (<6 hours).</p>	2
B	Flooding	<ul style="list-style-type: none"> extreme weather- periods of heavy rainfall, taking into account climate change and strong winds 	<ul style="list-style-type: none"> illness or loss of life sedimentation of nearby watercourse damage to, or depletion of aquatic habitats and species 	2	The risk of flooding is considered very unlikely when taking into account the assessment in Chapter 7 of this EIAR.	1	The risk of flooding during the operational phase will result in a minor classification in that 'small number of people would be affected' (given low workforce numbers involved and low number of immediate neighbours) should a severe weather event occur, with 'no	2

Major Accidents and Natural Disasters 15

Risk ID	Potential Risk	Possible Cause	Environmental Effect	Likelihood Rating	Basis of Likelihood	Consequence Rating	Basis of Classification	Risk Score (Consequence x Likelihood)
							fatalities and a small number of minor injuries with first aid treatment' Potential localised contamination Minor localised disruption to community services or infrastructure (<6 hours)	
C	Industrial Accident - Fluid/fuel emission	<ul style="list-style-type: none"> equipment or infrastructure failure fuel spillage/storage electrical problems employee negligence 	<ul style="list-style-type: none"> illness or loss of life damage to, or depletion of habitats and species impacts on ambient air quality 	2	Considered very unlikely due to the Construction Environmental Management Plan implementation and standard construction practices to be employed.	1	Should an accident occur at the proposed development site, this should result in a minor classification in that 'small number of people would be affected' (given low workforce numbers involved and low number of immediate neighbours). Localised contamination possible.	2
D	Collapse/ damage to structures	<ul style="list-style-type: none"> extreme weather conditions such as flooding and storms vehicular collisions due to driver negligence 	<ul style="list-style-type: none"> injury or loss of life sedimentation of nearby watercourse damage to, or depletion of aquatic habitats and species 	2	Extreme weather or accidents could cause damage to buildings. Having regard to small extent of building surrounding the construction site it is considered very unlikely.	1	The risk of infrastructure collapse or damage to structures could result in a minor classification in that 'small number of people would be affected, with 'no fatalities and a small number of minor (given low workforce numbers involved and low number of immediate neighbours) injuries with first aid treatment'.	2

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Risk ID	Potential Risk	Possible Cause	Environmental Effect	Likelihood Rating	Basis of Likelihood	Consequence Rating	Basis of Classification	Risk Score (Consequence x Likelihood)
							Potential localised contamination. Unlikely to be wider impact to community services.	
E	Traffic Incident	<ul style="list-style-type: none"> • driver negligence or failure of vehicular operations on site roads • traffic management not implemented 	<ul style="list-style-type: none"> • injury or loss of life 	1	<p>Chapter 14 highlights that there are no recorded incidents on the site, and therefore the impact of the proposed development, in relation to road safety and the existing road infrastructure, was determined to be imperceptible.</p> <p>An extremely unlikely risk is predicted given the low speeds involved.</p>	1	<p>A minor classification is predicted. Having regard to relatively small site area and lack of potential to gain speed on-site speed limits and, a 'small number of people would be affected' should a vehicular collision occur, with 'no fatalities and small number of minor injuries with first aid treatment.'</p> <p>Unlikely to cause widespread community disruption</p>	1
F	Water contamination	<ul style="list-style-type: none"> • a vehicular incident, refuelling transportation in the operational phase 	<ul style="list-style-type: none"> • damage to, or depletion of aquatic habitats and species • sedimentation of nearby watercourse 	2	Classed very unlikely as many mitigation measures to be put in place to prevent accidents.	2	The risk of a fuel spillage or impact on surrounding drainage during the operational stage could result in a limited classification in that there would be 'a limited number of people affected' (given workforce numbers involved and number of immediate neighbours) with	4

Major Accidents and Natural Disasters 15

Risk ID	Potential Risk	Possible Cause	Environmental Effect	Likelihood Rating	Basis of Likelihood	Consequence Rating	Basis of Classification	Risk Score (Consequence x Likelihood)
							'localised effects of short duration'. Localised contamination possible.	
Operational Phase								
G	Severe Weather / Extreme Temperatures	<ul style="list-style-type: none"> extreme weather- extreme heat/ extreme cold, periods of heavy rainfall, taking into account climate change and strong winds 	<ul style="list-style-type: none"> illness or loss of life sedimentation of nearby watercourse damage to, or depletion of aquatic habitats and species 	3	The risk of severe weather is very unlikely when considering the assessment in Chapter 8 of this EIAR and weather conditions recorded over the last 30 years within the area, however it is assessed here as 'unlikely' given that trends are changing.	1	<p>The risk of severe weather conditions during the operational phase will result in a minor classification in that 'small number of people would be affected' (given low workforce numbers involved and low number of immediate neighbours) should a severe weather occur, with 'no fatalities and a small number of minor injuries with first aid treatment'.</p> <p>Potential localised contamination</p> <p>Minor localised disruption to community services or infrastructure (<6 hours).</p>	3
H	Flooding	<ul style="list-style-type: none"> extreme weather- periods of heavy rainfall, taking into account climate change and strong winds 	<ul style="list-style-type: none"> illness or loss of life sedimentation of nearby watercourse damage to, or depletion of aquatic habitats and species 	2	The risk of flooding is considered very unlikely when taking into account the assessment in Chapter 7 of this EIAR.	1	The risk of flooding during the operational phase will result in a minor classification in that 'small number of people would be affected' (given low workforce numbers involved and low number of immediate neighbours) should a severe	2

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Major Accidents and Natural Disasters 15

Risk ID	Potential Risk	Possible Cause	Environmental Effect	Likelihood Rating	Basis of Likelihood	Consequence Rating	Basis of Classification	Risk Score (Consequence x Likelihood)
							weather event occur, with 'no fatalities and a small number of minor injuries with first aid treatment' Potential localised contamination Minor localised disruption to community services or infrastructure (<6 hours)	
I	Industrial Accident - Fluid/fuel emission	<ul style="list-style-type: none"> • equipment or infrastructure failure • fuel spillage/storage • electrical problems • employee negligence • gas explosion 	<ul style="list-style-type: none"> • illness or loss of life • damage to, or depletion of habitats and species • impacts on ambient air quality 	2	Considered very unlikely due to the incoming Environmental Management System and strong regulation.	1	Should a fire/explosion occur at the proposed development site, this should result in a minor classification in that 'small number of people would be affected' (given low workforce numbers involved and low number of immediate neighbours). Localised contamination possible.	2
J	Collapse/ damage to structures	<ul style="list-style-type: none"> • extreme weather conditions such as flooding and storms • vehicular collisions due to driver negligence • gas explosion 	<ul style="list-style-type: none"> • injury or loss of life • sedimentation of nearby watercourse • damage to, or depletion of aquatic habitats and species 	2	Having regard to the limited scale of built development, lack of height and strong materials to be used, this is considered very unlikely.	1	The risk of infrastructure collapse or damage to structures could result in a minor classification in that 'small number of people would be affected, with 'no fatalities and a small number of minor (given low workforce numbers involved and low number of immediate neighbours) injuries with first aid treatment'.	2

Major Accidents and Natural Disasters 15

Risk ID	Potential Risk	Possible Cause	Environmental Effect	Likelihood Rating	Basis of Likelihood	Consequence Rating	Basis of Classification	Risk Score (Consequence x Likelihood)
							Potential localised contamination. Unlikely to be wider impact to community services.	
K	Traffic Incident	<ul style="list-style-type: none"> • driver negligence or failure of vehicular operations on site roads • traffic management not Implemented 	<ul style="list-style-type: none"> • injury or loss of life 	1	<p>Chapter 14 highlights that there are no recorded incidents on the site, and therefore the impact of the proposed development, in relation to road safety and the existing road infrastructure, was determined to be imperceptible.</p> <p>An extremely unlikely risk is predicted given the low speeds involved.</p>	1	<p>A minor classification is predicted. Having regard to relatively small site area and lack of potential to gain speed on-site speed limits and, a 'small number of people would be affected' should a vehicular collision occur, with 'no fatalities and small number of minor injuries with first aid treatment.'</p> <p>Unlikely to cause widespread community disruption</p>	1
L	Water contamination	<ul style="list-style-type: none"> • a vehicular incident, refuelling transportation in the operational phase 	<ul style="list-style-type: none"> • damage to, or depletion of aquatic habitats and species • sedimentation of nearby watercourse 	2	Classed very unlikely as no discharge off site and multiple mitigation measures to prevent accidents.	2	The risk of a fuel spillage or impact on surrounding drainage during the operational stage will result in a limited classification in that there would be 'a limited number of people affected' (given low workforce numbers involved and low number of immediate	4

Major Accidents and Natural Disasters 15

Risk ID	Potential Risk	Possible Cause	Environmental Effect	Likelihood Rating	Basis of Likelihood	Consequence Rating	Basis of Classification	Risk Score (Consequence x Likelihood)
							neighbours) with 'localised effects of short duration'. Localised contamination possible.	
M	Infectious Disease	<ul style="list-style-type: none"> • attraction of pests to site • introduction of disease through animal waste 	<ul style="list-style-type: none"> • infection to local livestock 	2	Very unlikely given the strict handling and inspection controls, plus containment of activity	3	Could be serious, with widespread effects or extended duration	6

15.78 The risk assessment for each of the potential risks identified during construction and operation of plant are consolidated in **Table 15-8** which provides their 'risk score.' All risks identified can be classified as 'low risk scenarios'.

Table 15-8: Consolidated Risk Score

Risk ID	Potential Risk	Likelihood Rating	Classification Rating	Risk Score
Construction Phase				
A	Severe weather	2	1	2
B	Flooding	2	1	2
C	Industrial accident	2	1	2
D	Collapse/ damage to structures	2	1	2
E	Traffic incident	1	1	1
F	Water contamination	2	2	4
Operational Phase				
G	Severe weather	3	1	3
H	Flooding	2	1	2
I	Industrial accident	2	1	2
J	Collapse/ damage to structures	2	1	2
K	Traffic incident	1	1	1
L	Water contamination	2	2	4
M	Infectious disease	2	3	6

15.79 A corresponding risk matrix is provided in **Table 15-9** which is colour coded in order to provide an indication of the critical nature of each risk. As outlined earlier in the chapter, the red zone represents 'high risk' scenarios', the amber zone represents 'medium risk scenarios and the green zone represents 'low risk' scenarios. The rationale for the classification of risks in this way is based on the DoEHLG (2010) Guidance which is used as a best practice guidance framework in the absence of specialist guidelines for EIA. The DoEHLG guidance uses a similar matrix to that set out below in which 'emergencies' are classified as either 'Normal' or 'Major'. Within the so-called 'Major' emergency zone, where hazards are extremely/ very unlikely it is stated that they do not warrant specific preparedness and that preparation by emergency agencies should select a scenario of a more extreme version of a more likely event to prepare for such risk. On this basis, the risk score matrix below categorises extremely likely and unlikely events within the 'green' 'low risk scenario'.

Table 15-9: Risk Score Matrix

		Consequence				
		1 Minor	2 Limited	3 Serious	4 Very Serious	5 Catastrophic
Likelihood	5 Very Likely					
	4 Likely					
	3 Unlikely	G				
	2 Very Unlikely	A, B, C, D, H, I, J,	F, L	M		
	1 Extremely Unlikely	E, K				
		Normal Emergency		Major Emergency		

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Mitigation Measures

- 15.80 Although indicated as low risk, the highest-risk scenario regarding the occurrence of major accidents or disasters for the proposed project is identified as the risk of infectious diseases. This is a risk that will be managed with paramount importance and is unlikely to represent a higher risk than for the alternative option of sending animal waste to landfill.
- 15.81 The design and construction of the proposed project adhere to the best practices outlined in this EIAR, incorporating mitigation measures to address the risk of major accidents or disasters. **Chapter 7** of this EIAR provides an assessment of the receiving waterbodies and the potential for these to be impacted, thereby enabling an emphasis to be provided on the most important water management measures to be employed at the proposed development site.
- 15.82 An Environmental Management System (EMS) will be put in place for the facility, as will be required by the IE Licence. The operator shall develop the EMS in accordance with ISO14001:2015, applying for accreditation when operational. The purpose of the EMS is to control and mitigate the environmental impacts of each of their sites.

Residual Effects

- 15.83 Based on the approach followed by the DoEHLG (2010) which guides the state emergency’s efforts in mitigating and preparing for potential risks. As with the DoEHLG guidance, an element of professional judgement has been used to inform the assessments of risk likelihoods and consequences presented in this chapter. The risks identified have all been categorised as low.
- 15.84 Given that the risks are identified as ‘low’ it can be inferred that the risk of major accidents does not represent a significant effect in the context of the proposed project. It is anticipated that the implementation and strict adherence to the mitigation measures have been identified in each of the technical chapters of the EIAR to reduce the potential emissions from the project as far as possible. These measures have not been taken into account in the conservative assessment of risks set out herein. It is reasonable to conclude that the implementation of these measures will reduce the potential risks further than the low levels already identified. This will effectively eliminate any significant residual impacts related to the construction and operation of plant of the proposed project.

Cumulative Effects

- 15.85 The nearest other identified Seveso site is c. 35km southeast of the application site, which is well beyond its consultation distance.
- 15.86 A review of planned and recently permitted projects within 5km of the proposed development has not identified any proposals with a potential to conflict with it.
- 15.87 The inherent design and management features of the proposed development, along with the strict EPA and HSA regulation it will be subject to, will ensure that the proposed facility will not represent a potential to cause impacts in association with any other development in the vicinity.

Conclusion

- 15.88 It is assessed that the proposed project carries no likely significant effect with respect to major accidents or disasters, nor is it vulnerable to potential disasters or accidents, including both natural and man-made incidents.

References

Department of Housing, Local Government and Heritage (2006) Framework for Major Emergency Management

Department of Environment, Heritage and Local Government (2010) A Guide to Risk Assessment in Major Emergency Management

Department of Housing, Planning and Local Government (2018) Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment

Environmental Protection Agency (2014) Guidance on Assessing and Costing Environmental Liabilities

Environmental Protection Agency (2022) Guidelines on the Information to be Contained in Environmental Impact Assessment Reports

European Commission (2017) Environmental Impact Assessment of Proposed Developments – Guidance on the preparation of Environmental Impact Assessment Reports

Seveso

<https://www.arcgis.com/apps/webappviewer/index.html?id=a01b5a0a6ff24f10adff30beaa3b6fd0>

Tipperary County Council (2014) Major Emergency Plan

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Appendix 15-A

Land Use Planning: Safety Risk Assessment

Report prepared by SLR Consulting Limited Safety Advisory Team

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Killough Safety Risk Assessment

To Support Land Use Planning Applications for the Killough Quarry Bio-Renewables (Anaerobic Digestion) Plant

Roadstone Limited

Killough Quarry, Thurles, Co. Tipperary

Prepared by:

SLR Consulting Limited

5th Floor, 35 Dale Street, Manchester, M1 2HF

SLR Project No.: 501.065577.00001 (SA1)

Client Reference No: IR.001800

18 December 2024

Revision: 00

Quality Assurance

The SLR Consulting Safety Advisory team (SLR-SA) operates within a Quality Management System (QMS) certified to the requirements of ISO 9001:2015. Therefore, this report has been developed and issued a three-stage checking and approval system, involving the following personnel:

- Report Author: David JG Clark (Principal Consultant, SLR-SA)
- Checking by: Phillip Ball (Associate Consultant, SLR-SA)
- Approved by: Ian Walker (Technical Director – Compliance, SLR-SA)

Revision Record

Revision	Project	Date	Description
00	501.065452.00001	December 2024	Issued to client.

Basis of Report

This document has been prepared by SLR Consulting Limited (SLR) with reasonable skill, care and diligence, and taking account of the timescales and resources devoted to it by agreement with Roadstone Limited (the Client) as part or all of the services it has been appointed by the Client to carry out. It is subject to the terms and conditions of that appointment.

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Executive Summary

SLR Consulting Limited are preparing an Environmental Impact Assessment for a planning application for a bio-renewables plant at an existing operational quarry site in Co. Tipperary, Ireland, operated by Roadstone Limited (RL).

Part of this facility will include an anaerobic digestion (AD) plant. The plant is expected to convert organic feedstock into carbon dioxide and methane, with further processing to produce synthetic biofuel, which will be stored and exported at high pressure. Carbon dioxide is an asphyxiant whilst methane is a highly flammable gas, with the latter especially raising concerns at a public consultation meeting for land-use planning (LUP).

RL have therefore appointed the SLR Consulting Limited Safety Advisory team (SLR-SA) to conduct a semi-quantitative risk assessment (sQRA) in line with the Health and Safety Authority (HSA) guidance on land-use planning decisions.

This report considers only the findings of the consequence modelling; future issues may require the application of sQRA principles.

The initial findings of the consequence modelling is that none of the modelled scenarios result in hazardous thermal radiation or overpressure levels being reached at the nearest residential properties, with a safety factor of over 200m. A negative LUP decision based on residential properties in the vicinity of the AD plant is therefore unlikely. However, how the HSA treats populations off-site that may be using or working the fields around the site is not clear.

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Appendices

Appendix A Modelling Summary Tables

- A.1 Scenario Group 1
- A.2 Scenario Group 2
- A.3 Scenario Group 3

Appendix B PHAST Outputs



Acronyms and Abbreviations

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AD	Anaerobic Digestion
ALARP	As Low As Reasonably Practicable
BT	Buffer Tank
CD	Consultation Distance
CIA	Chemical Industries Association
EIA	Environmental Impact Assessment
EIGA	European Industrial Gases Association
EV	Expectation Value
FN	Frequency-Number
HSA	Health and Safety Authority
LFL	Lower Flammable Limit
MEGC	Multiple Element Gas Container
PHAST	Process Hazard Analysis Software Tool
PIZ	Public Information Zone
LPIGH	Low Pressure Inflatable Gas Holder
LUP	Land Use Planning
LSIR	Location Specific Individual Risk
RIVM	National Institute for Public Health and the Environment (The Netherlands)
RL	Roadstone Limited
SEP	Surface Emissive Power
SLR-SA	SLR Consulting Limited's Safety Advisory team
sQRA	Semi-Quantitative Risk Assessment
SR	Societal Risk
VCE	Vapour Cloud Explosion



1.0 Introduction

SLR Consulting Limited are preparing an Environmental Impact Assessment (EIA) for a planning application for a bio-renewables plant at an existing operational quarry site in Co. Tipperary, Ireland, operated by Roadstone Limited (RL).

Part of this facility will include an anaerobic digestion (AD) plant. The plant is expected to convert organic feedstock into carbon dioxide and methane, with further processing to produce synthetic biofuel, which will be stored and exported at high pressure. Carbon dioxide is an asphyxiant whilst methane is a highly flammable gas, with the latter especially raising concerns at a public consultation meeting for land use planning (LUP).

RL have therefore appointed the SLR Consulting Limited Safety Advisory team (SLR-SA) to conduct some semi-quantitative risk assessment (sQRA) in line with the Health and Safety Authority (HSA) guidance on land-use planning decisions (Ref. [1]).

This report details the methodology followed, including any deviations from the HSA guidance and the findings of the study.

This report considers only the findings of the consequence modelling; future issues may require the application of sQRA principles.

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2.0 Information & Data

The methodology followed in this report follows the Health and Safety Authority (HSA) guidance for land-use planning decisions (Ref. [1], “the guidance”) as closely as possible without further reference for the remainder of this section.

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2.1 Tolerability Criteria

2.1.1 Approval Criteria

The guidance provides the following location-specific individual risk (LSIR) criteria applies to new establishments:

- Maximum tolerable risk to a member of the public: 1×10^{-6} /yr.
- Maximum tolerable risk to a person at an off-site work location: 5×10^{-6} /yr.

Where the above criteria are exceeded, the HSA is likely to advise against a development.

Where a large number of fatalities may be expected from the site operations, societal risk (SR) may also need to be considered. This is estimated using expectation value (EV), which is calculated through the multiplication of the likelihood (= frequency/yr. \times 1,000,000) and the number of people potentially harmed. Based on the guidance the following decisions apply:

- EV <100: do not advise against;
- EV >100 <10,000: do not advise against, providing it can be demonstrated that the risk is ‘as low as reasonably practicable’ (ALARP); and
- EV > 10,000: advise against.

Where the developmental EV is >450, a frequency-number (FN) curve will also be required and will be discussed further if required.

Should the development contribute societal risk to an existing facility, this may also require consideration. It is assumed for the purposes of this report that there is no such facility.

2.1.2 Post Approval Restrictions

Should the development be approved, the following LUP zones are defined around the establishment comprising three zones at the following LSIR principles as follows (Ref. [1]):

- Inner zone: 1×10^{-5} /yr.
- Middle zone: 1×10^{-6} /yr.
- Outer zone: 1×10^{-7} /yr.

These zones place future restrictions on the types of developments that can be built within them, but do not affect existing developments, as long as the risk criteria above are met.

The outer zone also forms the public information zone (PIZ), within which emergency response information should be provided to included populations.

Additionally, an LSIR contour will be used to define a consultation distance (CD) around the establishment. New establishments are required to propose an appropriate CD, however, the guidance states 1×10^{-9} /yr. as likely to be required.

A separation distance for harm to the environment may also be defined, however, this is outside of the scope of this study, which focuses on process safety incidents only. Environmental matters are addressed in the EIA for the project.



2.2 Harm Severity

2.2.1 Consequence Modelling

2.2.1.1 Software

The guidance does not specifically state what consequence modelling software should and should not be used. SLR-SA have thus used the PHAST consequence modelling software package, which is considered an industry standard.

PHAST (Process Hazard Analysis Software Tool) is a software package used for chemical release consequence analysis. It uses built in chemical and parameter data, along with scenario and meteorological data supplied by the user to predict the flammable and toxic effects from designed and accidental atmospheric releases.

In the risk analysis presented, PHAST Version 9.0 (the current version at the time of model development) has been used to model the thermal radiation and explosion overpressure hazards from releases occurring from the substances present on site. PHAST consists of multiple hazard models that are stated within supporting documentation to be extensively validated and verified as part of development.

The assessment is considered conservative as unless otherwise specified, PHAST default conditions have been used throughout this analysis; due to uncertainties in a commercial package, the suppliers of the software intentionally provide conservative results wherever development of the models have highlighted any uncertainty.

Due to the variability of atmospheric conditions a dispersing plume meanders and therefore the concentration at a fixed point downstream varies. Modelling programmes allow for this effect by introducing an averaging time. The averaging times used in consequence modelling are discussed, where relevant, in Section 2.2.2.

The guidance does not state what reference height should be used. 1m is used in all modelling which will broadly compare to most release heights used.

2.2.1.2 General Rules

The following general rules are stated in the guidance to be applied when developing modelled scenarios:

- Maximum surface emissive power (SEP) values are provided for a range of flammable materials, which will be used where applicable. Otherwise, SLR-SA will assume the PHAST default value is appropriate.
- Unbundled pools limited to a diameter of 100m, but a constrained pool size can be used with justification, e.g. topography, tertiary containment. This will be discussed as relevant.
- Jet fires are to be modelled as vertical, which is stated as conservative. This is not in line with SLR-SA findings, who will model horizontally at ground level. Results are provided for both in order to demonstrate this.

2.2.1.3 Site Specific Conditions

The guidance implies the use of D5 and F2 weather conditions for toxic modelling, where the letter refers to Pasquill stability category and the number refers to wind speed, modelled 10m above ground level in metres per second. The guidance states that ambient temperature should be 15°C for D5 and 10°C for F2. No other weather conditions are stated.

Surface roughness is also provided in the guidance, itself sourced from RIVM (Ref. [2]). This will be selected in later modelling and is not replicated.



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Atmospheric humidity is not discussed in the guidance, thus the PHAST default of 70% is used.

2.2.1.4 Vapour Cloud Explosions

The guidance advocates the use of the multi-energy method, which is available in PHAST. An explosion strength of 7 is applied to confined volumes, where appropriate, and 2 is used otherwise. It does not provide guidance on how to determine whether something is confined, other than reference to “*many vessels or other obstacles*” or than assuming that 20% of the stoichiometric cloud volume being within the congested area.

2.2.2 Harm Criteria

Harm criteria is generally provided with different values for outdoor and indoor harm.

2.2.2.1 Thermal Radiation

Harm due to thermal radiation could be as a result of thermal radiation flux (e.g. pool fires, jet fires) or exposure to burning plumes (i.e. flash fires).

Thermal Radiation Flux (Pool Fires, Jet Fires)

For outdoor harm, the guidance uses a probit equation to calculate a thermal radiation flux that can be used to estimate a probability of harm, as follows:

- 8.02 kW/m² = 1% probability of fatality;
- 10.9 kW/m² = 10% probability of fatality; and
- 15.9 kW/m² = 50% probability of fatality.

This is based on a 60-second exposure, which PHAST applies as a ‘maximum exposure duration’ and using a two-zone pool fire model.

For indoor harm, the guidance quotes the following:

- <12.7 kW/m²: building provides adequate protection, 0% probability of fatality
- ≥12.7 < 25.6 kW/m²: people have escaped, use outdoor lethality
- ≥25.6 kW/m²: people cannot escape before building catches fire, 100% probability of fatality.

The same averaging time is assumed.

The guidance also discusses potential damage to buildings; however, this is outside of the scope of this study, which focuses on process safety incidents only.

Flash Fires

The guidance states that the lower flammable limit (LFL) should be used to determine potential for harm.

For populations outdoors, 100% of people are assumed to be killed within the LFL and 0% fatality is assumed outside it. No LFL fractions are thus used, but may be presented in summary files (note that the standard is a 0.5LFL).

For population indoors, a 10% probability of harm is applied.

The guidance does not discuss averaging times for flash fire modelling, thus the PHAST default averaging time of 18.75s is used.



Fireballs

The guidance advocates the use of the fireball radius, which is assumed to be grounded.

2.2.2.2 Explosion Overpressure

Overpressures could be a result of a vapour cloud explosion (VCE).

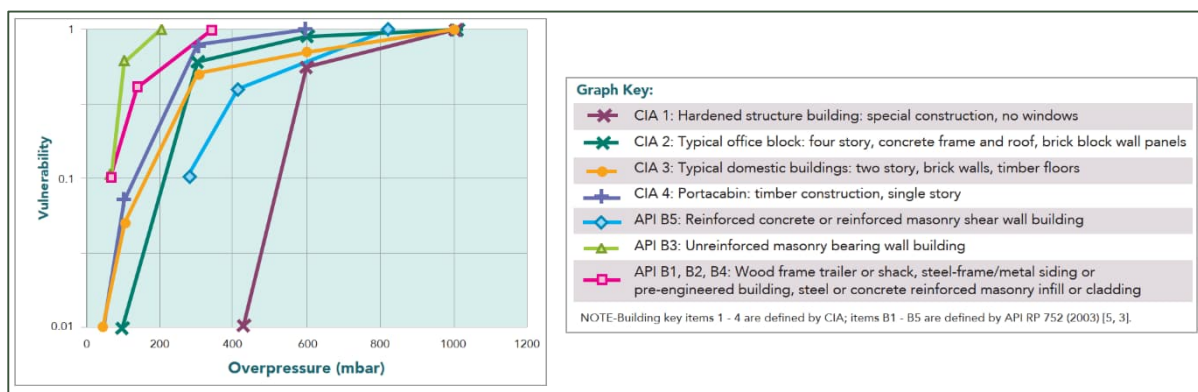
For outdoor harm, the guidance uses a probit equation to calculate an overpressure that can be used to estimate a probability of harm, as follows:

- 168 mbarg = 1% probability of fatality;
- 365 mbarg = 10% probability of fatality; and
- 942 mbarg = 50% probability of fatality.

Impulse and projectiles are considered by the guidance to be captured in the above ranges. In PHAST modelling the explosion location is taken to be the cloud centroid and there is no minimum mass requirement used.

For people within buildings, the guidance provides the following by way of the European Industrial Gases Association (EIGA) guidance (Ref. [3]), retained for ease of reference:

Figure 2.2.2.2: EIGA Overpressure Vulnerability Graphs



The above approach taken is heavily based on the Chemical Industry Association (CIA) guidance (Ref. [4]), which states that an overpressure of 30mbarg or less will cause no harm to occupied buildings, with a probability of harm of 1% applied to most building types up to 50mbarg; this will be used as a screen for the purpose of this report.

The guidance also discusses potential damage to buildings; however, this is outside of the scope of this study, which focuses on process safety incidents only.

2.2.2.3 Toxic Plumes

Toxic effects are to be assessed using a toxic probit function: $a + b \ln(C^n t)$, where a , b and n are constants, c is the concentration (ppm) and t is the exposure duration (minutes).

Constants are provided for 16 toxic compounds and encourages a literature review for other dangerous substances; no guidance is provided where these constants are not available, and no equivalent concentrations or vulnerability criteria are provided.

Where not available another approach may be used.

For outdoor populations, the guidance suggests that the outcomes of the modelling should be used verbatim, where a 30-minute exposure would be used. For indoor harm air change rates of 2.5 and 2 should be used for D5 and F2 weather conditions, respectively, and the length of exposure should be increased to account for gas infiltration and accumulation.



2.2.2.4 Domino Effects

The guidance states that domino effects should be included, however, this is considered outside of scope of this report.

2.3 Risk Assessment

The guidance allows a semi-quantitative risk assessment approach, where appropriate.

The guidance states people should be assumed to be indoors 90% of the time, which is taken to be applicable to residential dwellings. This may be modified for those at operational establishments.

The guidance allows a probability of 80% to be applied to D5 and 20% to F2, whilst wind direction probability can also be claimed.

Ignition probabilities are provided in the guidance, based on three classifications of flammable material. Where applicable, an appropriate ignition probability will be discussed later.

In some instances, the guidance provides the ignited frequency for each event, whilst for others it will need to be calculated.

The guidance provides failure rate data for all scenarios that it suggests to model.

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3.0 Consequence Modelling

3.1 Scenario Selection

The facility will consist of a series of digestors, which produce a feedstock for storage in a low-pressure inflatable gas holder (LPIGH). The gas can be compressed for transfer into high pressure multiple-element gas containers (MEGC) and buffer tanks (BTs) are also available to provide storage during switchover or in times of high demand. The principal material of concern is methane, which will exist as a gas throughout the process, i.e. no liquefaction is planned to take place.

The guidance (Ref. [1]) provides 13 different applicable sectors. This facility most closely resembles the following sectors:

Table 3.1: Scenario Selection

Industry Type	Equipment Type	Failure types	Read-across to design and further notes
3) Renewable natural gas (RNG) installations, which <i>“includes the activity of generating methane from biological digesters”</i> :	Bulk biomethane storage.	Instantaneous failure. Continuous leak over 10 minutes.	Both scenarios suitable for the LPIGH. The scenario is designed more for digestors; however, these are expected to have a lower volume of gas present, which will be high in carbon dioxide and of a similar volume. The LPIGH is thus expected to present the worst-case.
	Pressurised drums of process biogas.	Instantaneous release. Release over 10 minutes. Release through 10mm pipe.	First two scenarios suitable for the MEGC and the BTs. 10mm pipe not to be modelled (will be picked up under pipeline below).
5) Natural gas pipelines (within an establishment).	Overground pipes of varying diameters.	Pipeline rupture. Pipeline leak of 0.1D (max. 50mm)	LPIGH pipework is 100mm at the same conditions. MEGC pipework is 32mm at the same conditions. BT pipework is 50mm at the same conditions.
	Underground pipes of varying diameters.	Pipeline rupture. Pipeline leak of 0.1D (max. 50mm)	N/A – no underground pipes as part of design.

3.2 Source Terms

3.2.1 Software Set-Up

It will be assumed that any loss of containment could be pure methane. Whilst formation of a liquid pool is unlikely, the guidance (Ref. [1]) states that a maximum SEP for methane of 265kW/m² should be used. This is greater than the PHAST default of 220kW/m², which is overridden.

Weather is set up using D5 (15°C ambient and ground temperature) and F2 (10°C ambient and ground temperature), with an atmospheric humidity at the PHAST default 70%. In terms of surface roughness, the surrounding environment is largely open flat terrain with few isolated objects, thus 0.03m is used as per Ref. [1] Table 17.



3.2.2 Model Set-Up

Scenario Group 1 will cover both the LPIGH and associated pipework. The LPIGH has a maximum physical storage capacity of 11,000m³ of gas at up to 100mbarg; this is used for the source assuming pure methane. Pipework will operate up to this pressure and is taken to be 100mm internal diameter bore. The following sub-scenarios are then defined:

- 1.1 LPIGH Instantaneous failure: cold catastrophic failure model, 1m elevation.
- 1.2 LPIGH Continuous leak over 10 minutes: 600-second fixed duration release, 1m elevation, horizontal release direction only (vertical would be at considerable height and not expected to cause harm at ground level).
- 1.3 LPIGH Pipeline rupture: 100mm hole failure, 1m elevation, horizontal orientation only (pipework orientated vertically would be at height and not expected to cause harm at ground level).
- 1.4 LPIGH Pipeline 0.1D: 10mm hole failure, 1m elevation, vertical (a) and horizontal (b) orientation.

Scenario Group 2 will cover the MEGC and associated pipework. Each MEGC has a physical capacity of 40m³ at 250barg; this is used for the source assuming pure methane. Pipework will operate up to this pressure and is taken to be 32mm internal diameter bore. The following sub-scenarios are then defined:

- 2.1 MEGC Instantaneous release: cold catastrophic failure model, 1m elevation.
- 2.2 MEGC Release over 10 minutes: 600-second fixed duration release, 1m elevation vertical (a) and horizontal (b) orientation.
- 2.3 MEGC Pipeline rupture: 32mm hole failure, 1m elevation, horizontal orientation only (pipework orientated vertically would be at height and not expected to cause harm at ground level).
- 2.4 LPIGH Pipeline 0.1D: 3.2mm hole failure, 1m elevation, vertical (a) and horizontal (b) orientation.

Scenario Group 3 will cover the BTs and associated pipework. Each BT has a physical capacity of up to 77m³ at 250barg; this is used for the source assuming pure methane. Pipework will operate up to this pressure and is taken to be 50mm internal diameter bore. The following sub-scenarios are then defined:

- 3.1 BT Instantaneous release: cold catastrophic failure model, 1m elevation.
- 3.2 BT Release over 10 minutes: 600-second fixed duration release, 1m elevation vertical (a) and horizontal (b) orientation.
- 3.3 BT Pipeline rupture: 50mm hole failure, 1m elevation, horizontal orientation only (pipework orientated vertically would be at height and not expected to cause harm at ground level).
- 3.4 BT Pipeline 0.1D: 5mm hole failure, 1m elevation, vertical (a) and horizontal (b) orientation.

For all scenarios a bund input of 7853.98m² is used (equivalent to 100m diameter) with a height of 1m and overflowing prevented, even though it is considered unlikely that a pool will be formed by the model.

For multi-energy explosion modelling, the design has been reviewed and areas of significant confinement and congestion has not been identified, other than smaller pockets. As such, a confined source strength for the facility has been defined based on the Kinsella method from the RIVM Yellow Book (Ref. [5]). Where the facility is outdoors (i.e. not confined vented) with



insufficient parallel plane confinement but the possibility that in some areas the blockage could be at the 30% criteria, a source strength of 2-3 is suggested. This would suggest in the HSA methodology (Ref. [1]) that the area is unconfined (thus use of 2 appropriate), however, a source strength of 3 has been used as conservative with an efficiency of 100% across the entire area.

3.3 Initial Results Discussion (Screening)

Preliminary results are summarised in Appendix A, with PHAST modelling outputs provided electronically as Appendix B. Some notes on interpretation as follows:

- Fireballs: PHAST provides the fireball diameter, which is halved to provide the radius in Appendix A.
- VCEs: It is assumed that the VCE occurs centrally to the plant area. PHAST provides a diameter of overpressure from a point that includes an assumed drift. The drift is ignored, and the diameter is halved to provide a radius in Appendix A.
- Pool Fires: PHAST does predict early pool fires for catastrophic failures, seemingly due to a rapid drop in temperature following release. These are not transposed but show distances comparable with other associated hazards.

The maximum distance to any single harm criteria across all 17 models is 149m. This is related to model 3.1, which is a catastrophic failure of a buffer tank, specifically a distance to 30mbarg VCE overpressure.

Using satellite imagery software, the distance between the operational boundary to the nearest of the residences identified for the submission (Ref. [6]) is a little over 370m.



4.0 Conclusions & Recommendations

SLR-SA have conducted some preliminary consequence modelling for the RL Killough AD plant in line with HSA guidance (Ref. [1]).

The initial findings of the consequence modelling is that none of the modelled scenarios result in hazardous thermal radiation or overpressure levels being reached at the nearest residential properties, with a safety factor of over 200m. A negative LUP decision based on residential properties in the vicinity of the AD plant is therefore unlikely. However, how the HSA treats populations off-site that may be using or working the fields around the site is not clear.

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5.0 References

Table 5.0: References

Ref.	Source
[1]	Health and Safety Authority. 2023. <i>Guidance on technical land-use planning advice for planning authorities and COMAH establishment operators</i> . Version 2, February 2023.
[2]	Rijksinstituut voor Volksgezondheid en Milieu (The Netherlands). Reference Manual Bevi Risk Assessments. Bilthoven: RIVM.
[3]	European Industrial Gases Association, 2014: Guideline for the Location of Occupied Buildings in Industrial Gas Plants, IGC Doc 187/14/E.
[4]	Chemical Industries Association. 2020. <i>Guidance for the location and design of occupied buildings on chemical manufacturing and similar major hazard sites</i> . 4th Edition. London: CIA.
[5]	Publicatiereeks Gevaarlijke Stoffen. 2005. <i>Methods for the calculation of physical effects due to releases of hazardous materials (liquids and gases) – ‘Yellow Book’</i> . CPR 14E. 3rd Edition, Second Revised Print. The Hague.
[6]	SLR Consulting Limited. 2024. <i>Bio-Renewables Production Facility at Killough Quarry: Figure 4-1: Residence Location Plan</i> . Project 501.065577.00001, Rev 0.

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Appendix A Modelling Summary Tables

Killough Safety Risk Assessment

To Support Land Use Planning Applications for the Killough Quarry Bio-Renewables (Anaerobic Digestion) Plant

Roadstone Limited

SLR Project No.: 501.065577.00001 (SA1)

18 December 2024

In the following tables, all distances are rounded to the nearest whole metre and are recorded at a height of 1m above ground level. A hyphen denotes either that there is no hazard or that the stated hazard level is not reached within the model.

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A.1 Scenario Group 1

Table A.1: Scenario Group 1 Results Summary

Hazard <i>Distance downwind to (m)</i>	1.1		1.2		1.3		1.4a		1.4b	
	F2	D5	F2	D5	F2	D5	F2	D5	F2	D5
Fireball radius	59	59								
Flash Fire, LFL	36	50	36	43	8	7	0	0	1	1
Jet Fire, 8.02 kW/m ²			59	56	13	15	-	1	-	-
Jet Fire, 10.9 kW/m ²			55	55	13	15	-	1	-	-
Jet Fire, 12.7 kW/m ²			53	54	12	15	-	1	-	-
Jet Fire, 15.9 kW/m ²			50	53	11	15	-	1	-	-
Jet Fire, 25.6 kW/m ²			42	51	10	14	-	-	-	-
VCE, 30mbarg	128	134	25	23	5	4	-	-	-	-
VCE, 168mbarg	-	-	-	-	-	-	-	-	-	-
VCE, 365mbarg	-	-	-	-	-	-	-	-	-	-
VCE, 942mbarg	-	-	-	-	-	-	-	-	-	-

A.2 Scenario Group 2

Table A.2: Scenario Group 2 Results Summary

Hazard <i>Distance downwind to (m)</i>	2.1		2.2a		2.2b		2.3		2.4a		2.4b	
	F2	D5	F2	D5	F2	D5	F2	D5	F2	D5	F2	D5
Fireball radius	57	57										
Flash Fire, LFL	30	77	-	0	30	29	57	57	-	0	4	4
Jet Fire, 8.02 kW/m ²			21	27	57	49	93	81	3	5	12	10
Jet Fire, 10.9 kW/m ²			13	22	54	47	89	76	1	4	11	9
Jet Fire, 12.7 kW/m ²			8	20	53	45	86	74	-	4	11	9
Jet Fire, 15.9 kW/m ²			1	16	51	43	84	71	-	3	11	9
Jet Fire, 25.6 kW/m ²			-	5	48	40	77	65	-	1	10	8
VCE, 30mbarg	115	116	14	13	25	24	-	-	-	-	-	-
VCE, 168mbarg	-	-	-	-	-	-	-	-	-	-	-	-
VCE, 365mbarg	-	-	-	-	-	-	-	-	-	-	-	-
VCE, 942mbarg	-	-	-	-	-	-	-	-	-	-	-	-



A.3 Scenario Group 3

Table A.3: Scenario Group 3 Results Summary

Hazard <i>Distance downwind to (m)</i>	3.1		3.2a		3.2b		3.3		3.4a		3.4b	
	F2	D5	F2	D5	F2	D5	F2	D5	F2	D5	F2	D5
Fireball radius	71	71										
Flash Fire, LFL	37	101	0	0	44	44	95	97	0	0	7	6
Jet Fire, 8.02 kW/m ²			29	35	77	67	140	121	5	8	18	15
Jet Fire, 10.9 kW/m ²			19	29	73	63	132	113	2	7	17	14
Jet Fire, 12.7 kW/m ²			12	25	71	61	129	110	0	6	16	14
Jet Fire, 15.9 kW/m ²			2	20	69	58	124	106	-	5	16	13
Jet Fire, 25.6 kW/m ²			-	6	64	54	115	97	-	-	15	12
VCE, 30mbarg	149	147	20	19	40	38	3	3	-	-	-	-
VCE, 168mbarg	-	-	-	-	-	-	-	-	-	-	-	-
VCE, 365mbarg	-	-	-	-	-	-	-	-	-	-	-	-
VCE, 942mbarg	-	-	-	-	-	-	-	-	-	-	-	-

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Appendix B PHAST Outputs

Killough Safety Risk Assessment

To Support Land Use Planning Applications for the Killough Quarry Bio-Renewables (Anaerobic Digestion) Plant

Roadstone Limited

SLR Project No.: 501.065577.00001 (SA1)

18 December 2024



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Input Report

Workspace: 501.065452 AD Plant LUP (Rev 0, p9.0)

EG1

Study

501.065452 AD Plant LUP (Rev 0, p9.0)

Tab	Group	Field	Value
Context of calculations	Selection of context	Weathers to use for this study	HSA Standards
		Parameters to use for this study	Parameter set
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land
		Type of pool substrate and bunds	Limited Bund
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected
		Building type (downwind building type)	Buildings\Building type



LPIGH

Pressure vessel
501.065452 AD Plant LUP (Rev 0, p9.0)\EG1

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Tab	Group	Field	Value	Units
Material	Material	Material	METHANE	
		Specify volume inventory?	Yes	
		Mass inventory	8217.56	kg
		Volume inventory	11000	m3
		Material to track	METHANE	
	Phase	Specified condition	Pressure/temperature	
		Temperature	15	degC
		Pressure (gauge)	0.1	bar
		Fluid state	Vapour	
		Liquid mole fraction	0	fraction
Scenario	Pipe dimensions	Pipe length		m
	Release location	Elevation	1	m
		Tank head	0	m
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation	
		Droplet break-up mechanism - continuous	Do not force correlation	
Short pipe	Pipe characteristics	Pipe roughness	0.045	mm
	Frequencies	Frequency of bends in pipe	0	/m
		Frequency of couplings in pipe	0	/m
		Frequency of junctions in pipe	0	/m
	Frequencies of valves	Frequency of excess flow valves	0	/m
		Frequency of non-return valves	0	/m
		Frequency of shut-off valves	0	/m
	Velocity head losses	Excess flow valve velocity head losses	0	
		Non-return valve velocity head losses	0	
		Shut-off valve velocity head losses	0	
Time varying releases	Modelling of time-varying leaks and line ruptures	Vacuum relief valve	Operating	
		Vacuum relief valve set point	0	bar
	Inventory data for time-varying releases	Tank volume	11000	m3
		Tank vapour volume	11000	m3
		Tank liquid volume	0	m3
		Tank liquid level	0	m
		Maximum vapour release height		m
		Minimum mass inventory	0.1	kg

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		Maximum mass inventory	1E+09	kg
	Safety system modelling for time-varying releases	Safety system modelling (isolation and blowdown)	No	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
	Building definition	Release building		
		In-building release?	Outdoor	
		Building wake effect	Roof/lee	
		Wind or release angle from North	0	deg
		Handling of droplets	Trapped	
		Indoor mass modification factor	3	
Explosion parameters	Explosion method (Consequence calculations only)	Explosion method	Multi-Energy: User-defined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3	
		Unconfined explosion efficiency	100	%
	Confined explosion sources	Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
		Volume of confined source		m3
		Volume fraction of confined source		fraction
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	Yes	
		Calculate lethality	Yes	
	Radiation levels	Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure	20	s

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		duration		
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Horizontal options	Use standard method	
		Correlation	Recommended	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s
Geometry	Geometry	East	0	m
		North	0	m

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1.1 Instantaneous failure

Catastrophic rupture

501.065452 AD Plant LUP (Rev 0, p9.0)\EG1\LPIGH

Tab	Group	Field	Value	Units	
Scenario	Release location	Elevation	1	m	
		Tank head	0	m	
	Fireball emissive power	Use vessel burst pressure	No		
		Vessel burst pressure - gauge		bar	
Material	Material	Material characteristics	Flammable only		
		Material to track	METHANE		
Discharge parameters	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation		
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm	
		Distances of interest		m	
		Averaging time for concentrations and distances of interest			
		Specify user-defined averaging time	No		
		User defined averaging time		s	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land		
		Type of pool substrate and bunds	Limited Bund		
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined		
		Ignition	Supply late ignition location	No ignition location	
	Vapour liquid method	Location of late ignition		m	
		Use explosion mass modification factor	Yes		
Multi-Energy	Multi-Energy: User-defined	Explosion mass modification factor	3		
		Unconfined explosion strength	3		
	Confined explosion sources	Unconfined explosion efficiency	100	%	
		Number of confined sources	0		
		Option for specifying size of confined sources	Use volumes		
		Strength of confined source			
Fireball	Result types to calculate	Volume of confined source		m ³	
		Volume fraction of confined source		fraction	
		Calculate probit	No		
	Radiation levels	Parameters	Calculate dose	Yes	
			Calculate lethality	Yes	
			Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m ²	
		Probit levels	2.73, 3.72, 7.5		
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07		
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction	
Calculation method	Mass modification factor	3			
	Fireball maximum exposure duration	20	s		
Pool fire	Result types to calculate	Fireball model	Martinsen time varying		
		TNO model flame temperature	1726.85	degC	
Pool fire	Result types to calculate	Calculate probit	No		



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		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6 kW/m ²	
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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1.2 Continuous leak over 10 minutes

Fixed duration release

501.065452 AD Plant LUP (Rev 0, p9.0)\EG1\LPIGH

Tab	Group	Field	Value	Units	
Scenario	Scenario	Duration for fixed duration release	600	s	
	Hole	Orifice diameter		mm	
		Use specified discharge coefficient?	No		
		Discharge coefficient		fraction	
	Release location	Elevation	1	m	
		Tank head	0	m	
	Direction	Outdoor release direction	Horizontal		
		Outdoor release angle	0	deg	
	Material	Material	Material characteristics	Flammable only	
			Material to track	METHANE	
Phase		Phase to be released	Vapour		
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended		
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)		
	Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation		
	Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
Distances of interest				m	
		Averaging time for concentrations and distances of interest			
		Specify user-defined averaging time	No		
		User defined averaging time		s	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land		
		Type of pool substrate and bunds	Limited Bund		
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined		
	Ignition	Supply late ignition location	No ignition location		
		Location of late ignition		m	
	Vapour liquid method	Use explosion mass modification factor	Yes		
Explosion mass modification factor		3			
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3		
		Unconfined explosion efficiency	100	%	
	Confined explosion sources	Number of confined sources	0		
		Option for specifying size of confined sources	Use volumes		
		Strength of confined source			
	Volume of confined source		m3		
	Volume fraction of confined source		fraction		
Fireball	Result types to calculate	Calculate probit	No		
		Calculate dose	Yes		
		Calculate lethality	Yes		
	Radiation levels	Number of input radiation levels	4		
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2	

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		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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1.3 Pipeline rupture

Leak

501.065452 AD Plant LUP (Rev 0, p9.0)\EG1\LPIGH

Tab	Group	Field	Value	Units
Scenario	Hole	Orifice diameter	100	mm
		Use specified discharge coefficient?	No	
		Discharge coefficient		fraction
	Release location	Elevation	1	m
		Tank head	0	m
	Direction	Outdoor release direction	Horizontal	
Outdoor release angle		0	deg	
Material	Material	Material characteristics	Flammable only	
		Material to track	METHANE	
	Phase	Phase to be released	Vapour	
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
	Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3	
		Unconfined explosion efficiency	100	%
	Confined explosion sources	Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
		Volume of confined source		m3
	Volume fraction of confined source		fraction	
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	Yes	
		Calculate lethality	Yes	
	Radiation levels	Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2
		Probit levels	2.73, 3.72, 7.5	

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		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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1.4a Pipeline 0.1D (Vertical)

Leak

501.065452 AD Plant LUP (Rev 0, p9.0)\EG1\LPIGH

Tab	Group	Field	Value	Units
Scenario	Hole	Orifice diameter	10	mm
		Use specified discharge coefficient?	No	
		Discharge coefficient		fraction
	Release location	Elevation	1	m
		Tank head	0	m
	Direction	Outdoor release direction	Vertical	
Outdoor release angle		90	deg	
Material	Material	Material characteristics	Flammable only	
		Material to track	METHANE	
	Phase	Phase to be released	Vapour	
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
	Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3	
		Unconfined explosion efficiency	100	%
	Confined explosion sources	Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
		Volume of confined source		m3
		Volume fraction of confined source		fraction
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	Yes	
		Calculate lethality	Yes	
	Radiation levels	Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2
		Probit levels	2.73, 3.72, 7.5	

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		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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1.4b Pipeline 0.1D (Horizontal)

Leak

501.065452 AD Plant LUP (Rev 0, p9.0)\EG1\LPIGH

Tab	Group	Field	Value	Units
Scenario	Hole	Orifice diameter	10	mm
		Use specified discharge coefficient?	No	
		Discharge coefficient		fraction
	Release location	Elevation	1	m
		Tank head	0	m
Direction	Outdoor release direction	Horizontal		
	Outdoor release angle	0	deg	
Material	Material	Material characteristics	Flammable only	
		Material to track	METHANE	
	Phase	Phase to be released	Vapour	
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
		Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3	
		Unconfined explosion efficiency	100	%
	Confined explosion sources	Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
	Volume of confined source		m3	
	Volume fraction of confined source		fraction	
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	Yes	
		Calculate lethality	Yes	
	Radiation levels	Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2
	Probit levels	2.73, 3.72, 7.5		

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		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s



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Consequence Summary Report

Workspace: 501.065452 AD Plant LUP (Rev 0, p9.0)

Study: EG1

Summary Basis

These tables will only report global values set in the parameters. Values that are modified in the study tree will not be reported. The report is context sensitive, and filters up to the study level. You will need to generate multiple summary reports if you have multiple studies in your workspace.

The results in this report are from the non-CFD calculations only.

Discharge Results (after atmospheric expansion)

Path	Scenario	Weather	Peak Flowrate [kg/s]	Temperature [degC]	Liquid mass fraction in material [fraction]	Droplet diameter [um]	Expanded diameter [m]	Velocity [m/s]	End time of release [s]
EG1\LPIGH	1.1 Instantaneous failure	F2		8.65037	0	0		33.3118	
		D5		8.65037	0	0		33.3118	
	1.2 Continuous leak over 10 minutes	F2	13.6959	8.65037	0	0	0.388058	166.559	600
		D5	13.6959	8.65037	0	0	0.388058	166.559	600
	1.3 Pipeline rupture	F2	0.561881	8.65037	0	0	0.0786	166.559	3600
		D5	0.561881	8.65037	0	0	0.0786	166.559	3600
	1.4a Pipeline 0.1D (Vertical)	F2	0.00561881	8.65037	0	0	0.00786	166.559	3600
		D5	0.00561881	8.65037	0	0	0.00786	166.559	3600
	1.4b Pipeline 0.1D (Horizontal)	F2	0.00561881	8.65037	0	0	0.00786	166.559	3600
		D5	0.00561881	8.65037	0	0	0.00786	166.559	3600



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Dispersion Results

Input dispersion parameters

Core averaging time	18.75	s
Flammable averaging time	18.75	s
Toxic averaging time	600	s
Height of interest	1	m

Distance downwind to flammable concentrations

Path	Scenario	Weather	Distance to UFL [m]	Distance to LFL [m]	Distance to LFL fraction [m]
EG1\LPIGH	1.1 Instantaneous failure	F2	22.4413	36.2181	54.9156
		D5	22.8902	49.7159	84.7206
	1.2 Continuous leak over 10 minutes	F2	13.7742	36.2559	50.5308
		D5	13.4265	42.5337	61.2262
	1.3 Pipeline rupture	F2	2.66518	7.91169	14.0312
		D5	2.58972	6.83973	12.1894
	1.4a Pipeline 0.1D (Vertical)	F2	0.00508844	0.00610366	0.00664549
		D5	0.00546318	0.00687469	0.00763149
	1.4b Pipeline 0.1D (Horizontal)	F2	0.282688	1.13014	1.64438
		D5	0.296225	0.878475	1.53093

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Jet Fire Results

Distance downwind to defined radiation levels

The reported radiations are defined in the parameters

Path	Scenario	Weather	Flame length [m]	Distance downwind to intensity level 1 (8.02 kW/m2) [m]	Distance downwind to intensity level 2 (10.9 kW/m2) [m]	Distance downwind to intensity level 3 (12.7 kW/m2) [m]	Distance downwind to intensity level 4 (15.9 kW/m2) [m]	Distance downwind to intensity level 5 (25.6 kW/m2) [m]
EG1\LPIGH	1.2 Continuous leak over 10 minutes	F2	38.7009	59.3167	54.7511	52.6257	49.6114	42.4698
		D5	45.1378	56.1686	54.5634	53.8422	52.8686	51.0882
	1.3 Pipeline rupture	F2	10.8614	13.4482	12.6346	12.216	11.3645	10.3969
		D5	13.2111	15.2043	14.8897	14.7483	14.5561	14.2122
	1.4a Pipeline 0.1D (Vertical)	F2	1.35355	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		D5	1.06097	1.12104	1.00567	0.938623	0.798358	Not reached at height of interest
	1.4b Pipeline 0.1D (Horizontal)	F2	1.6222	0.448933	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		D5	1.85414	1.59797	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest



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Fireball Results

Distance downwind to defined radiation levels

The reported radiations are defined in the parameters

Path	Scenario	Weather	Fireball diameter [m]	Distance downwind to intensity level 1 (6.3 kW/m2) [m]	Distance downwind to intensity level 2 (12.5 kW/m2) [m]	Distance downwind to intensity level 3 (25 kW/m2) [m]	Distance downwind to intensity level 4 (37.5 kW/m2) [m]
EG1\LPIGH	1.1 Instantaneous failure	F2	117.042	240.498	170.319	117.458	91.5559
		D5	117.042	236.631	167.716	115.703	90.1375

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Flash Fire Results

Distance downwind to defined concentrations

The reported LFL and LFL fraction are defined in the respective material property

Path	Scenario	Weather	Distance downwind to LFL [m]	Distance downwind to LFL Fraction [m]
EG1\LPIGH	1.1 Instantaneous failure	F2	36.2181	54.9156
		D5	49.7159	84.7206
	1.2 Continuous leak over 10 minutes	F2	36.2559	50.5308
		D5	42.5337	61.2262
	1.3 Pipeline rupture	F2	7.91169	14.0312
		D5	6.83973	12.1894
	1.4a Pipeline 0.1D (Vertical)	F2	0.00610366	0.00664549
		D5	0.00687469	0.00763149
	1.4b Pipeline 0.1D (Horizontal)	F2	1.13014	1.64438
		D5	0.878475	1.53093

Maximum distance to LFL fraction at any height

Path	Scenario	Weather	Max flash fire distance [m]	Height of the max flash fire distance [m]	Time [s]
EG1\LPIGH	1.1 Instantaneous failure	F2	68.9061	31.41	17.2311
		D5	110.716	31.1304	17.2311
	1.2 Continuous leak over 10 minutes	F2	61.037	5.16796	58.2011
		D5	74.7954	5.35144	25.2154
	1.3 Pipeline rupture	F2	14.4475	1.3639	23.8468
		D5	12.3017	1.13052	7.51483
	1.4a Pipeline 0.1D (Vertical)	F2	-0.0157803	1.4346	1.91793
		D5	0.153625	1.05928	1.91792
	1.4b Pipeline 0.1D (Horizontal)	F2	1.6413	1.00923	1.91793
		D5	1.6731	1.0034	1.91793

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Explosion Results

Explosion scenarios for worst-case maximum downwind distance to defined overpressures.

The reported overpressures are defined in the explosion parameters

Path	Scenario	Weather	Overpressure level [bar]	Maximum distance [m]	Diameter [m]	
EG1\LPIGH	1.1 Instantaneous failure	F2	0.03	130.768	256.256	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	
			D5	0.03	144.78	268.009
				0.168	Not reachable	0
				0.365	Not reachable	0
				0.942	Not reachable	0
	1.2 Continuous leak over 10 minutes	F2		0.03	51.7764	50.9058
				0.168	Not reachable	0
				0.365	Not reachable	0
				0.942	Not reachable	0
		D5	0.03	47.8619	45.9075	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	
1.3 Pipeline rupture	F2		0.03	9.00482	9.05684	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	
		D5	0.03	7.57353	7.66466	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	

Supplementary data for worst-case explosion scenarios

Path	Scenario	Weather	Overpressure level [bar]	Explosion flammable mass [kg]	Ignition time [s]	Ignition source [m]	Cloud centre [m]	Explosion centre [m]	
EG1\LPIGH	1.1 Instantaneous failure	F2	0.03	3367.09	1.21236	40	2.64008	2.64008	
			0.168		0	Not reachable	Not	0	
			0.365		0	reachable	reachable	0	
			0.942		0	Not reachable	Not	0	
			D5	0.03	3851.96	2.34904	50	10.7754	10.7754
				0.168		0	Not reachable	Not	0
				0.365		0	reachable	reachable	0
				0.942		0	Not reachable	Not	0
	1.2 Continuous leak over 10 minutes	F2		0.03	26.3959	18.9937	60	26.3235	26.3235
				0.168		0	Not reachable	Not	0
				0.365		0	reachable	reachable	0
				0.942		0	Not reachable	Not	0
		D5	0.03	19.3591	9.34312	70	24.9082	24.9082	
			0.168		0	Not reachable	Not	0	
			0.365		0	reachable	reachable	0	
			0.942		0	Not reachable	Not	0	
1.3 Pipeline	F2		0.03	0.14865	1.91803	10	4.4764	4.4764	



rupture	0.168	0	Not	Not	0
	0.365	0	reachable	reachable	0
	0.942	0	Not	Not	0
			reachable	reachable	
			Not	Not	
			reachable	reachable	

		D5	0.03	0.0900972	1.91802	10	3.7412	3.7412
			0.168		0	Not	Not	0
			0.365		0	reachable	reachable	0
			0.942		0	Not	Not	0
						reachable	reachable	
						Not	Not	
						reachable	reachable	

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Input Report

Workspace: 501.065452 AD Plant LUP (Rev 0, p9.0)

EG2

Study

501.065452 AD Plant LUP (Rev 0, p9.0)

Tab	Group	Field	Value
Context of calculations	Selection of context	Weathers to use for this study	HSA Standards
		Parameters to use for this study	Parameter set
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land
		Type of pool substrate and bunds	Limited Bund
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected
		Building type (downwind building type)	



MEGC

Pressure vessel
501.065452 AD Plant LUP (Rev 0, p9.0)\EG2

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Tab	Group	Field	Value	Units
Material	Material	Material	METHANE	
		Specify volume inventory?	Yes	
		Mass inventory	7637.73	kg
		Volume inventory	40	m3
		Material to track	METHANE	
	Phase	Specified condition	Pressure/temperature	
		Temperature	15	degC
		Pressure (gauge)	250	bar
		Fluid state	Vapour	
		Liquid mole fraction	0	fraction
Scenario	Pipe dimensions	Pipe length		m
	Release location	Elevation	1	m
		Tank head	0	m
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation	
		Droplet break-up mechanism - continuous	Do not force correlation	
Short pipe	Pipe characteristics	Pipe roughness	0.045	mm
	Frequencies	Frequency of bends in pipe	0	/m
		Frequency of couplings in pipe	0	/m
		Frequency of junctions in pipe	0	/m
	Frequencies of valves	Frequency of excess flow valves	0	/m
		Frequency of non-return valves	0	/m
		Frequency of shut-off valves	0	/m
	Velocity head losses	Excess flow valve velocity head losses	0	
		Non-return valve velocity head losses	0	
		Shut-off valve velocity head losses	0	
Time varying releases	Modelling of time-varying leaks and line ruptures	Vacuum relief valve	Operating	
		Vacuum relief valve set point	0	bar
	Inventory data for time-varying releases	Tank volume	40	m3
		Tank vapour volume	40	m3
		Tank liquid volume	0	m3
		Tank liquid level	0	m
		Maximum vapour release height		m
		Minimum mass inventory	0.1	kg

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		Maximum mass inventory	1E+09	kg
	Safety system modelling for time-varying releases	Safety system modelling (isolation and blowdown)	No	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
	Building definition	Release building		
		In-building release?	Outdoor	
		Building wake effect	Roof/lee	
		Wind or release angle from North	0	deg
		Handling of droplets	Trapped	
		Indoor mass modification factor	3	
Explosion parameters	Explosion method (Consequence calculations only)	Explosion method	Multi-Energy: User-defined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3	
		Unconfined explosion efficiency	100	%
	Confined explosion sources	Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
		Volume of confined source		m3
		Volume fraction of confined source		fraction
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	Yes	
		Calculate lethality	Yes	
	Radiation levels	Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure	20	s

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		duration		
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Horizontal options	Use standard method	
		Correlation	Recommended	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s
Geometry	Geometry	East	0	m
		North	0	m

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2.1 Instantaneous release

Catastrophic rupture

501.065452 AD Plant LUP (Rev 0, p9.0)\EG2\MEGC

Tab	Group	Field	Value	Units
Scenario	Release location	Elevation	1	m
		Tank head	0	m
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge		bar
Material	Material	Material characteristics	Flammable only	
		Material to track	METHANE	
Discharge parameters	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined	
		Ignition	Supply late ignition location	No ignition location
	Vapour liquid method	Location of late ignition		m
		Use explosion mass modification factor	Yes	
Multi-Energy	Multi-Energy: User-defined	Explosion mass modification factor	3	
		Unconfined explosion strength	3	
	Confined explosion sources	Unconfined explosion efficiency	100	%
		Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
		Volume of confined source		m ³
Volume fraction of confined source		fraction		
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	Yes	
		Calculate lethality	Yes	
	Radiation levels	Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m ²
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
	Parameters	Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
		Mass modification factor	3	
		Fireball maximum exposure duration	20	s
Calculation method	Fireball model	Martinsen time varying		
	TNO model flame temperature	1726.85	degC	
Pool fire	Result types to calculate	Calculate probit	No	

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		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6 kW/m ²	
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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2.2a Release over 10 minutes (Vertical)

Fixed duration release

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Tab	Group	Field	Value	Units	
Scenario	Scenario	Duration for fixed duration release	600	s	
	Hole	Orifice diameter		mm	
		Use specified discharge coefficient?	No		
		Discharge coefficient		fraction	
	Release location	Elevation	1	m	
		Tank head	0	m	
	Direction	Outdoor release direction	Vertical		
		Outdoor release angle	90	deg	
	Material	Material	Material characteristics	Flammable only	
			Material to track	METHANE	
Phase		Phase to be released	Vapour		
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended		
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)		
	Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation		
	Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
Distances of interest				m	
		Averaging time for concentrations and distances of interest			
		Specify user-defined averaging time	No		
		User defined averaging time		s	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land		
		Type of pool substrate and bunds	Limited Bund		
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined		
	Ignition	Supply late ignition location	No ignition location		
		Location of late ignition		m	
	Vapour liquid method	Use explosion mass modification factor	Yes		
Explosion mass modification factor		3			
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3		
		Unconfined explosion efficiency	100	%	
	Confined explosion sources	Number of confined sources	0		
		Option for specifying size of confined sources	Use volumes		
		Strength of confined source			
	Volume of confined source		m3		
	Volume fraction of confined source		fraction		
Fireball	Result types to calculate	Calculate probit	No		
		Calculate dose	Yes		
		Calculate lethality	Yes		
	Radiation levels	Number of input radiation levels	4		
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2	

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		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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2.2b Release over 10 minutes (Horizontal)

Fixed duration release

501.065452 AD Plant LUP (Rev 0, p9.0)\EG2\MEGC

Tab	Group	Field	Value	Units	
Scenario	Scenario	Duration for fixed duration release	600	s	
	Hole	Orifice diameter		mm	
		Use specified discharge coefficient?	No		
			Discharge coefficient		fraction
	Release location	Elevation	1	m	
		Tank head	0	m	
	Direction	Outdoor release direction	Horizontal		
		Outdoor release angle	0	deg	
	Material	Material	Material characteristics	Flammable only	
			Material to track	METHANE	
Phase		Phase to be released	Vapour		
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended		
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)		
	Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation		
	Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
Distances of interest				m	
		Averaging time for concentrations and distances of interest			
		Specify user-defined averaging time	No		
		User defined averaging time		s	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land		
		Type of pool substrate and bunds	Limited Bund		
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined		
	Ignition	Supply late ignition location	No ignition location		
		Location of late ignition		m	
	Vapour liquid method	Use explosion mass modification factor	Yes		
Explosion mass modification factor		3			
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3		
		Unconfined explosion efficiency	100	%	
	Confined explosion sources	Number of confined sources	0		
		Option for specifying size of confined sources	Use volumes		
		Strength of confined source			
	Volume of confined source		m3		
	Volume fraction of confined source		fraction		
Fireball	Result types to calculate	Calculate probit	No		
		Calculate dose	Yes		
		Calculate lethality	Yes		
	Radiation levels	Number of input radiation levels	4		
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2	

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		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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2.3 Pipeline rupture

Leak

501.065452 AD Plant LUP (Rev 0, p9.0)\EG2\MEGC

Tab	Group	Field	Value	Units
Scenario	Hole	Orifice diameter	32	mm
		Use specified discharge coefficient?	No	
		Discharge coefficient		fraction
	Release location	Elevation	1	m
		Tank head	0	m
	Direction	Outdoor release direction	Horizontal	
Outdoor release angle		0	deg	
Material	Material	Material characteristics	Flammable only	
		Material to track	METHANE	
Discharge parameters	Model settings	Phase	Vapour	
		Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Droplet break-up mechanism	Do not force correlation	
		Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
Multi-Energy	Multi-Energy: User-defined	Explosion mass modification factor	3	
		Unconfined explosion strength	3	
	Confined explosion sources	Unconfined explosion efficiency	100	%
		Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
Fireball	Result types to calculate	Volume of confined source		m3
		Volume fraction of confined source		fraction
		Calculate probit	No	
	Radiation levels	Calculate dose	Yes	
		Calculate lethality	Yes	
		Number of input radiation levels	4	
	Intensity levels	6.3, 12.5, 25, 37.5	kW/m2	
	Probit levels	2.73, 3.72, 7.5		

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		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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2.4a Pipeline 0.1D (Vertical)

Leak

501.065452 AD Plant LUP (Rev 0, p9.0)\EG2\MEGC

Tab	Group	Field	Value	Units
Scenario	Hole	Orifice diameter	3.2	mm
		Use specified discharge coefficient?	No	
		Discharge coefficient		fraction
	Release location	Elevation	1	m
		Tank head	0	m
	Direction	Outdoor release direction	Vertical	
Outdoor release angle		90	deg	
Material	Material	Material characteristics	Flammable only	
		Material to track	METHANE	
Discharge parameters	Model settings	Phase	Vapour	
		Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Droplet break-up mechanism	Do not force correlation	
		Droplet break-up mechanism - continuous		
		Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
	User defined averaging time		s	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3	
		Unconfined explosion efficiency	100	%
	Confined explosion sources	Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
		Volume of confined source		m3
	Volume fraction of confined source		fraction	
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	Yes	
		Calculate lethality	Yes	
	Radiation levels	Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2
		Probit levels	2.73, 3.72, 7.5	

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		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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2.4b Pipeline 0.1D (Horizontal)

Leak

501.065452 AD Plant LUP (Rev 0, p9.0)\EG2\MEGC

Tab	Group	Field	Value	Units
Scenario	Hole	Orifice diameter	3.2	mm
		Use specified discharge coefficient?	No	
		Discharge coefficient		fraction
	Release location	Elevation	1	m
		Tank head	0	m
	Direction	Outdoor release direction	Horizontal	
Outdoor release angle		0	deg	
Material	Material	Material characteristics	Flammable only	
		Material to track	METHANE	
	Phase	Phase to be released	Vapour	
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
		Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3	
		Unconfined explosion efficiency	100	%
	Confined explosion sources	Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
	Volume of confined source		m3	
	Volume fraction of confined source		fraction	
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	Yes	
		Calculate lethality	Yes	
	Radiation levels	Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2
	Probit levels	2.73, 3.72, 7.5		

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		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s



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Consequence Summary Report

Workspace: 501.065452 AD Plant LUP (Rev 0, p9.0)

Study: EG2

Summary Basis

These tables will only report global values set in the parameters. Values that are modified in the study tree will not be reported. The report is context sensitive, and filters up to the study level. You will need to generate multiple summary reports if you have multiple studies in your workspace.

The results in this report are from the non-CFD calculations only.

Discharge Results (after atmospheric expansion)

Path	Scenario	Weather	Peak Flowrate [kg/s]	Temperature [degC]	Liquid mass fraction in material [fraction]	Droplet diameter [um]	Expanded diameter [m]	Velocity [m/s]	End time of release [s]
EG2\MEGC	2.1 Instantaneous release	F2		-161.484	0.302261	0.01		160.091	
		D5		-161.484	0.302261	0.01		160.091	
	2.2a Release over 10 minutes (Vertical)	F2	12.7295	-161.484	0.0430029	0.362847	0.118867	607.17	600
		D5	12.7295	-161.484	0.0430029	0.369717	0.118867	607.17	600
	2.2b Release over 10 minutes (Horizontal)	F2	12.7295	-161.484	0.0430029	0.362847	0.118867	607.17	600
		D5	12.7295	-161.484	0.0430029	0.369717	0.118867	607.17	600
	2.3 Pipeline rupture	F2	37.391	-161.484	0.0430029	0.362847	0.203722	607.17	204.266
		D5	37.391	-161.484	0.0430029	0.369717	0.203722	607.17	204.266
	2.4a Pipeline 0.1D (Vertical)	F2	0.37391	-161.484	0.0430029	0.362847	0.0203722	607.17	3600
		D5	0.37391	-161.484	0.0430029	0.369717	0.0203722	607.17	3600
	2.4b Pipeline 0.1D (Horizontal)	F2	0.37391	-161.484	0.0430029	0.362847	0.0203722	607.17	3600
		D5	0.37391	-161.484	0.0430029	0.369717	0.0203722	607.17	3600

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Dispersion Results
Input dispersion parameters

Core averaging time	18.75	s
Flammable averaging time	18.75	s
Toxic averaging time	600	s
Height of interest	1	m

Distance downwind to flammable concentrations

Path	Scenario	Weather	Distance to UFL [m]	Distance to LFL [m]	Distance to LFL fraction [m]
EG2\MEGC	2.1 Instantaneous release	F2	18.0899	29.7091	55.6769
		D5	18.5007	77.4489	123.194
	2.2a Release over 10 minutes (Vertical)	F2	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		D5	0.0812568	0.102069	0.1133
	2.2b Release over 10 minutes (Horizontal)	F2	8.06381	29.6994	66.6298
		D5	7.79707	29.1562	72.2214
	2.3 Pipeline rupture	F2	14.455	56.5844	125.163
		D5	13.9392	56.8745	138.41
	2.4a Pipeline 0.1D (Vertical)	F2	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		D5	Not reached at height of interest	0.0175088	0.0194401
	2.4b Pipeline 0.1D (Horizontal)	F2	1.59099	4.22853	7.98195
		D5	1.38389	4.11194	7.31767

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Jet Fire Results

Distance downwind to defined radiation levels

The reported radiations are defined in the parameters

Path	Scenario	Weather	Flame length [m]	Distance downwind to intensity level 1 (8.02 kW/m2) [m]	Distance downwind to intensity level 2 (10.9 kW/m2) [m]	Distance downwind to intensity level 3 (12.7 kW/m2) [m]	Distance downwind to intensity level 4 (15.9 kW/m2) [m]	Distance downwind to intensity level 5 (25.6 kW/m2) [m]
EG2\MEGC	2.2a Release over 10 minutes (Vertical)	F2	26.6162	20.6884	12.6746	7.57441	1.30755	Not reached at height of interest
		D5	20.6895	27.0505	22.1513	19.7061	15.9577	5.72454
	2.2b Release over 10 minutes (Horizontal)	F2	41.1566	57.4107	54.4646	53.1096	51.2277	47.7721
		D5	31.9921	49.435	46.5563	45.2495	43.451	40.0869
	2.3 Pipeline rupture	F2	66.2006	93.469	88.561	86.3059	83.1827	77.1567
		D5	51.4595	80.5953	75.7988	73.6158	70.6223	64.9823
	2.4a Pipeline 0.1D (Vertical)	F2	5.49002	3.23602	0.873376	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		D5	4.26754	5.37826	4.44745	3.97252	3.22062	0.751572
	2.4b Pipeline 0.1D (Horizontal)	F2	8.48922	11.6913	11.1774	10.946	10.6264	10.0246
		D5	6.5989	9.96786	9.45532	9.22618	8.91465	8.33001



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Late Pool Fire Results

Distance downwind to defined radiation levels

The reported radiations are defined in the parameters

Path	Scenario	Weather	Pool diameter [m]	Distance downwind to intensity level 1 (8.02 kW/m2) [m]	Distance downwind to intensity level 2 (10.9 kW/m2) [m]	Distance downwind to intensity level 3 (12.7 kW/m2) [m]	Distance downwind to intensity level 4 (15.9 kW/m2) [m]	Distance downwind to intensity level 5 (25.6 kW/m2) [m]
EG2\MEGC	2.1 Instantaneous release	F2	17.7022	80.3494	70.7933	66.389	60.2653	48.2915
		D5	17.5553	83.3016	74.2215	70.0263	64.158	53.9235



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Fireball Results

Distance downwind to defined radiation levels

The reported radiations are defined in the parameters

Path	Scenario	Weather	Fireball diameter [m]	Distance downwind to intensity level 1 (6.3 kW/m2) [m]	Distance downwind to intensity level 2 (12.5 kW/m2) [m]	Distance downwind to intensity level 3 (25 kW/m2) [m]	Distance downwind to intensity level 4 (37.5 kW/m2) [m]
EG2\MEGC	2.1 Instantaneous release	F2	114.222	357.7	257.195	182.181	147.553
		D5	114.222	351.46	253.012	179.382	145.333

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Flash Fire Results

Distance downwind to defined concentrations

The reported LFL and LFL fraction are defined in the respective material property

Path	Scenario	Weather	Distance downwind to LFL [m]	Distance downwind to LFL Fraction [m]
EG2\MEGC	2.1 Instantaneous release	F2	29.7091	55.6769
		D5	77.4489	123.194
	2.2a Release over 10 minutes (Vertical)	F2		
		D5	0.102069	0.1133
	2.2b Release over 10 minutes (Horizontal)	F2	29.6994	66.6298
		D5	29.1562	72.2214
	2.3 Pipeline rupture	F2	56.5844	125.163
		D5	56.8745	138.41
	2.4a Pipeline 0.1D (Vertical)	F2		
		D5	0.0175088	0.0194401
	2.4b Pipeline 0.1D (Horizontal)	F2	4.22853	7.98195
		D5	4.11194	7.31767

Maximum distance to LFL fraction at any height

Path	Scenario	Weather	Max flash fire distance [m]	Height of the max flash fire distance [m]	Time [s]
EG2\MEGC	2.1 Instantaneous release	F2	67.2776	0	199.283
		D5	92.2959	0	42.149
	2.2a Release over 10 minutes (Vertical)	F2	3.77963	24.7558	4.10986
		D5	5.19714	19.1552	1.26027
	2.2b Release over 10 minutes (Horizontal)	F2	66.3262	0.859319	25.126
		D5	72.1433	0.931179	10.5622
	2.3 Pipeline rupture	F2	125.891	0.642192	53.0043
		D5	137.733	0.697407	13.3412
	2.4a Pipeline 0.1D (Vertical)	F2	0.663895	6.01869	1.91795
		D5	0.848714	4.35715	1.91794
	2.4b Pipeline 0.1D (Horizontal)	F2	7.97585	1.00553	7.51437
		D5	7.26835	1.00057	1.91794

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Explosion Results

Explosion scenarios for worst-case maximum downwind distance to defined overpressures.

The reported overpressures are defined in the explosion parameters

Path	Scenario	Weather	Overpressure level [bar]	Maximum distance [m]	Diameter [m]	
EG2\MEGC	2.1 Instantaneous release	F2	0.03	115.271	229.055	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	
		D5		0.03	119.919	232.99
				0.168	Not reachable	0
				0.365	Not reachable	0
				0.942	Not reachable	0
	2.2b Release over 10 minutes (Horizontal)	F2		0.03	29.9271	27.6355
				0.168	Not reachable	0
				0.365	Not reachable	0
				0.942	Not reachable	0
	D5		0.03	28.1562	25.8652	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	
2.3 Pipeline rupture	F2		0.03	54.7928	49.7309	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	
	D5		0.03	52.5925	47.0098	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	

Supplementary data for worst-case explosion scenarios

Path	Scenario	Weather	Overpressure level [bar]	Explosion flammable mass [kg]	Ignition time [s]	Ignition source [m]	Cloud centre [m]	Explosion centre [m]	
EG2\MEGC	2.1 Instantaneous release	F2	0.03	2404.65	0.374268	30	0.744104	0.744104	
			0.168		0	Not reachable	0		
			0.365		0	reachable	reachable	0	
			0.942		0	Not reachable	Not reachable	0	
		D5		0.03	2530.74	0.730535	40	3.42432	3.42432
				0.168		0	Not reachable	0	
				0.365		0	reachable	reachable	0
				0.942		0	Not reachable	Not reachable	0
	2.2b Release over 10 minutes (Horizontal)	F2		0.03	4.22313	10.4108	60	16.1093	16.1093
				0.168		0	Not reachable	0	
				0.365		0	reachable	reachable	0
				0.942		0	Not reachable	Not reachable	0
	D5		0.03	3.46245	3.71249	60	15.2236	15.2236	
			0.168		0	Not reachable	0		
			0.365		0	reachable	reachable	0	
			0.942		0	Not reachable	Not reachable	0	
2.3 Pipeline	F2		0.03	24.6101	30.3464	120	29.9273	29.9273	



rupture	0.168	0	Not	Not	0
	0.365	0	reachable	reachable	0
	0.942	0	Not	Not	0

		D5	0.03	20.7873	6.3044	110	29.0876	29.0876
			0.168		0	Not	Not	0
			0.365		0	reachable	reachable	0
			0.942		0	Not	Not	0
						reachable	reachable	
						Not	Not	
						reachable	reachable	

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Input Report

Workspace: 501.065452 AD Plant LUP (Rev 0, p9.0)

EG3

Study

501.065452 AD Plant LUP (Rev 0, p9.0)

Tab	Group	Field	Value
Context of calculations	Selection of context	Weathers to use for this study	HSA Standards
		Parameters to use for this study	Parameter set
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land
		Type of pool substrate and bunds	Limited Bund
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected
		Building type (downwind building type)	



Buffer Tanks

Pressure vessel

501.065452 AD Plant LUP (Rev 0, p9.0)\EG3

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Tab	Group	Field	Value	Units
Material	Material	Material	METHANE	
		Specify volume inventory?	Yes	
		Mass inventory	14702.6	kg
		Volume inventory	77	m3
		Material to track	METHANE	
	Phase	Specified condition	Pressure/temperature	
		Temperature	15	degC
		Pressure (gauge)	250	bar
		Fluid state	Vapour	
		Liquid mole fraction	0	fraction
Scenario	Pipe dimensions	Pipe length		m
	Release location	Elevation	1	m
		Tank head	0	m
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation	
		Droplet break-up mechanism - continuous	Do not force correlation	
Short pipe	Pipe characteristics	Pipe roughness	0.045	mm
	Frequencies	Frequency of bends in pipe	0	/m
		Frequency of couplings in pipe	0	/m
		Frequency of junctions in pipe	0	/m
	Frequencies of valves	Frequency of excess flow valves	0	/m
		Frequency of non-return valves	0	/m
		Frequency of shut-off valves	0	/m
	Velocity head losses	Excess flow valve velocity head losses	0	
		Non-return valve velocity head losses	0	
		Shut-off valve velocity head losses	0	
Time varying releases	Modelling of time-varying leaks and line ruptures	Vacuum relief valve	Operating	
		Vacuum relief valve set point	0	bar
	Inventory data for time-varying releases	Tank volume	77	m3
		Tank vapour volume	77	m3
		Tank liquid volume	0	m3
		Tank liquid level	0	m
		Maximum vapour release height		m
		Minimum mass inventory	0.1	kg

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		Maximum mass inventory	1E+09	kg
	Safety system modelling for time-varying releases	Safety system modelling (isolation and blowdown)	No	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
	Building definition	Release building		
		In-building release?	Outdoor	
		Building wake effect	Roof/lee	
		Wind or release angle from North	0	deg
		Handling of droplets	Trapped	
		Indoor mass modification factor	3	
Explosion parameters	Explosion method (Consequence calculations only)	Explosion method	Multi-Energy: User-defined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3	
		Unconfined explosion efficiency	100	%
	Confined explosion sources	Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
		Volume of confined source		m3
		Volume fraction of confined source		fraction
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	Yes	
		Calculate lethality	Yes	
	Radiation levels	Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure	20	s

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		duration		
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Horizontal options	Use standard method	
		Correlation	Recommended	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s
Geometry	Geometry	East	0	m
		North	0	m

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3.1 Instantaneous release

Catastrophic rupture
501.065452 AD Plant LUP (Rev 0, p9.0)\EG3\Buffer Tanks

Tab	Group	Field	Value	Units	
Scenario	Release location	Elevation	1	m	
		Tank head	0	m	
	Fireball emissive power	Use vessel burst pressure	No		
		Vessel burst pressure - gauge		bar	
Material	Material	Material characteristics	Flammable only		
		Material to track	METHANE		
Discharge parameters	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation		
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm	
		Distances of interest		m	
		Averaging time for concentrations and distances of interest			
		Specify user-defined averaging time	No		
		User defined averaging time		s	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land		
		Type of pool substrate and bunds	Limited Bund		
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined		
		Ignition	Supply late ignition location	No ignition location	
	Vapour liquid method	Location of late ignition		m	
		Use explosion mass modification factor	Yes		
Multi-Energy	Multi-Energy: User-defined	Explosion mass modification factor	3		
		Unconfined explosion strength	3		
	Confined explosion sources	Unconfined explosion efficiency	100	%	
		Number of confined sources	0		
		Option for specifying size of confined sources	Use volumes		
		Strength of confined source			
Fireball	Result types to calculate	Volume of confined source		m ³	
		Volume fraction of confined source		fraction	
		Calculate probit	No		
	Radiation levels	Parameters	Calculate dose	Yes	
			Calculate lethality	Yes	
			Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m ²	
		Probit levels	2.73, 3.72, 7.5		
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07		
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction	
Calculation method	Fireball model	Mass modification factor	3		
		Fireball maximum exposure duration	20	s	
		TNO model flame temperature	1726.85	degC	
Pool fire	Result types to calculate	Calculate probit	No		



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		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6 kW/m ²	
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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3.2a Release over 10 minutes (Vertical)

Fixed duration release

501.065452 AD Plant LUP (Rev 0, p9.0)\EG3\Buffer Tanks

Tab	Group	Field	Value	Units	
Scenario	Scenario	Duration for fixed duration release	600	s	
	Hole	Orifice diameter		mm	
		Use specified discharge coefficient?	No		
		Discharge coefficient		fraction	
	Release location	Elevation	1	m	
		Tank head	0	m	
	Direction	Outdoor release direction	Vertical		
		Outdoor release angle	90	deg	
	Material	Material	Material characteristics	Flammable only	
			Material to track	METHANE	
Phase		Phase to be released	Vapour		
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended		
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)		
	Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation		
	Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
Distances of interest				m	
		Averaging time for concentrations and distances of interest			
		Specify user-defined averaging time	No		
		User defined averaging time		s	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land		
		Type of pool substrate and bunds	Limited Bund		
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined		
	Ignition	Supply late ignition location	No ignition location		
		Location of late ignition		m	
	Vapour liquid method	Use explosion mass modification factor	Yes		
Explosion mass modification factor		3			
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3		
		Unconfined explosion efficiency	100	%	
	Confined explosion sources	Number of confined sources	0		
		Option for specifying size of confined sources	Use volumes		
		Strength of confined source			
	Volume of confined source		m3		
	Volume fraction of confined source		fraction		
Fireball	Result types to calculate	Calculate probit	No		
		Calculate dose	Yes		
		Calculate lethality	Yes		
	Radiation levels	Number of input radiation levels	4		
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2	

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		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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3.2b Release over 10 minutes (Horizontal)

Fixed duration release
501.065452 AD Plant LUP (Rev 0, p9.0)\EG3\Buffer Tanks

Tab	Group	Field	Value	Units	
Scenario	Scenario	Duration for fixed duration release	600	s	
	Hole	Orifice diameter		mm	
		Use specified discharge coefficient?	No		
		Discharge coefficient		fraction	
	Release location	Elevation	1	m	
		Tank head	0	m	
	Direction	Outdoor release direction	Horizontal		
		Outdoor release angle	0	deg	
	Material	Material	Material characteristics	Flammable only	
			Material to track	METHANE	
Phase		Phase to be released	Vapour		
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended		
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)		
	Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation		
	Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
Distances of interest				m	
		Averaging time for concentrations and distances of interest			
		Specify user-defined averaging time	No		
		User defined averaging time		s	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land		
		Type of pool substrate and bunds	Limited Bund		
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined		
	Ignition	Supply late ignition location	No ignition location		
		Location of late ignition		m	
	Vapour liquid method	Use explosion mass modification factor	Yes		
Explosion mass modification factor		3			
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3		
		Unconfined explosion efficiency	100	%	
	Confined explosion sources	Number of confined sources	0		
		Option for specifying size of confined sources	Use volumes		
		Strength of confined source			
	Volume of confined source		m3		
	Volume fraction of confined source		fraction		
Fireball	Result types to calculate	Calculate probit	No		
		Calculate dose	Yes		
		Calculate lethality	Yes		
	Radiation levels	Number of input radiation levels	4		
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2	

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		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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3.3 Pipeline rupture

Leak

501.065452 AD Plant LUP (Rev 0, p9.0)\EG3\Buffer Tanks

Tab	Group	Field	Value	Units
Scenario	Hole	Orifice diameter	50	mm
		Use specified discharge coefficient?	No	
		Discharge coefficient		fraction
	Release location	Elevation	1	m
		Tank head	0	m
	Direction	Outdoor release direction	Horizontal	
Outdoor release angle		0	deg	
Material	Material	Material characteristics	Flammable only	
		Material to track	METHANE	
Discharge parameters	Model settings	Phase	Vapour	
		Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
Dispersion	Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation	
		User-defined dispersion scope (N.B Based on the material to track)		
	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
	User defined averaging time		s	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3	
		Unconfined explosion efficiency	100	%
	Confined explosion sources	Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
	Volume of confined source		m3	
	Volume fraction of confined source		fraction	
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	Yes	
		Calculate lethality	Yes	
	Radiation levels	Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2
	Probit levels	2.73, 3.72, 7.5		

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		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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3.4a Pipeline 0.1D (Vertical)

Leak

501.065452 AD Plant LUP (Rev 0, p9.0)\EG3\Buffer Tanks

Tab	Group	Field	Value	Units
Scenario	Hole	Orifice diameter	5	mm
		Use specified discharge coefficient?	No	
		Discharge coefficient		fraction
	Release location	Elevation	1	m
		Tank head	0	m
	Direction	Outdoor release direction	Vertical	
Outdoor release angle		90	deg	
Material	Material	Material characteristics	Flammable only	
		Material to track	METHANE	
	Phase	Phase to be released	Vapour	
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
	Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3	
		Unconfined explosion efficiency	100	%
	Confined explosion sources	Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
		Volume of confined source		m3
	Volume fraction of confined source		fraction	
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	Yes	
		Calculate lethality	Yes	
	Radiation levels	Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2
		Probit levels	2.73, 3.72, 7.5	

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		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s

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3.4b Pipeline 0.1D (Horizontal)

Leak

501.065452 AD Plant LUP (Rev 0, p9.0)\EG3\Buffer Tanks

Tab	Group	Field	Value	Units
Scenario	Hole	Orifice diameter	5	mm
		Use specified discharge coefficient?	No	
		Discharge coefficient		fraction
	Release location	Elevation	1	m
		Tank head	0	m
	Direction	Outdoor release direction	Horizontal	
Outdoor release angle		0	deg	
Material	Material	Material characteristics	Flammable only	
		Material to track	METHANE	
Discharge parameters	Model settings	Phase	Vapour	
		Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation
		Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Limited Bund	
Explosion parameters	Explosion method	Explosion method	Multi-Energy: User-defined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Multi-Energy	Multi-Energy: User-defined	Unconfined explosion strength	3	
		Unconfined explosion efficiency	100	%
	Confined explosion sources	Number of confined sources	0	
		Option for specifying size of confined sources	Use volumes	
		Strength of confined source		
		Volume of confined source		m3
	Volume fraction of confined source		fraction	
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	Yes	
		Calculate lethality	Yes	
	Radiation levels	Number of input radiation levels	4	
		Intensity levels	6.3, 12.5, 25, 37.5	kW/m2
		Probit levels	2.73, 3.72, 7.5	

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		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.5, 0.99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726.85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	60	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	8.02, 10.9, 12.7, 15.9, 25.6	kW/m2
		Probit levels	2.73, 3.72, 7.5	
		Dose levels	5E+06, 1E+07, 1.8E+07, 3E+07	
		Lethality levels	0.01, 0.1, 0.99	fraction
	Parameters	Radiative fraction for general fires	0.4	fraction
		Pool fire maximum exposure duration	60	s



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Consequence Summary Report

Workspace: 501.065452 AD Plant LUP (Rev 0, p9.0)

Study: EG3

Summary Basis

These tables will only report global values set in the parameters. Values that are modified in the study tree will not be reported. The report is context sensitive, and filters up to the study level. You will need to generate multiple summary reports if you have multiple studies in your workspace.

The results in this report are from the non-CFD calculations only.

Discharge Results (after atmospheric expansion)

Path	Scenario	Weather	Peak Flowrate [kg/s]	Temperature [degC]	Liquid mass fraction in material [fraction]	Droplet diameter [um]	Expanded diameter [m]	Velocity [m/s]	End time of release [s]
EG3\Buffer Tanks	3.1 Instantaneous release	F2		-161.484	0.302261	0.01		160.091	
		D5		-161.484	0.302261	0.01		160.091	
	3.2a Release over 10 minutes (Vertical)	F2	24.5044	-161.484	0.0430029	0.362847	0.164921	607.17	600
		D5	24.5044	-161.484	0.0430029	0.369717	0.164921	607.17	600
	3.2b Release over 10 minutes (Horizontal)	F2	24.5044	-161.484	0.0430029	0.362847	0.164921	607.17	600
		D5	24.5044	-161.484	0.0430029	0.369717	0.164921	607.17	600
	3.3 Pipeline rupture	F2	91.2866	-161.484	0.0430029	0.362847	0.318316	607.17	161.06
		D5	91.2866	-161.484	0.0430029	0.369717	0.318316	607.17	161.06
	3.4a Pipeline 0.1D (Vertical)	F2	0.912866	-161.484	0.0430029	0.362847	0.0318316	607.17	3600
		D5	0.912866	-161.484	0.0430029	0.369717	0.0318316	607.17	3600
	3.4b Pipeline 0.1D (Horizontal)	F2	0.912866	-161.484	0.0430029	0.362847	0.0318316	607.17	3600
		D5	0.912866	-161.484	0.0430029	0.369717	0.0318316	607.17	3600

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Dispersion Results

Input dispersion parameters

Core averaging time	18.75	s
Flammable averaging time	18.75	s
Toxic averaging time	600	s
Height of interest	1	m

Distance downwind to flammable concentrations

Path	Scenario	Weather	Distance to UFL [m]	Distance to LFL [m]	Distance to LFL fraction [m]
EG3\Buffer Tanks	3.1 Instantaneous release	F2	22.5892	37.1715	96.3487
		D5	40.8422	100.534	160.633
	3.2a Release over 10 minutes (Vertical)	F2	0.106226	0.128395	0.139649
		D5	0.112691	0.141825	0.157441
	3.2b Release over 10 minutes (Horizontal)	F2	11.4352	44.021	98.0629
		D5	10.9609	43.9424	107.791
	3.3 Pipeline rupture	F2	24.1675	95.2379	206.892
		D5	23.5769	96.6764	230.726
	3.4a Pipeline 0.1D (Vertical)	F2	0.0205094	0.0245888	0.0266719
		D5	0.0217862	0.0273688	0.03039
	3.4b Pipeline 0.1D (Horizontal)	F2	2.1751	6.63615	13.1675
		D5	2.13059	6.28709	11.7849

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Jet Fire Results

Distance downwind to defined radiation levels

The reported radiations are defined in the parameters

Path	Scenario	Weather	Flame length [m]	Distance downwind to intensity level 1 (8.02 kW/m2) [m]	Distance downwind to intensity level 2 (10.9 kW/m2) [m]	Distance downwind to intensity level 3 (12.7 kW/m2) [m]	Distance downwind to intensity level 4 (15.9 kW/m2) [m]	Distance downwind to intensity level 5 (25.6 kW/m2) [m]
EG3\Buffer Tanks	3.2a Release over 10 minutes (Vertical)	F2	35.5442	29.0038	18.6903	12.4214	2.22754	Not reached at height of interest
		D5	27.6295	35.2004	28.613	25.308	20.2059	6.38882
	3.2b Release over 10 minutes (Horizontal)	F2	54.9621	77.2123	73.1911	71.3433	68.7825	63.8307
		D5	42.7235	66.5383	62.6129	60.8252	58.373	53.7474
	3.3 Pipeline rupture	F2	97.9214	139.883	132.419	128.992	124.253	115.144
		D5	76.117	120.761	113.461	110.142	105.586	97.0209
	3.4a Pipeline 0.1D (Vertical)	F2	8.21344	5.19744	2.04218	0.329624	Not reached at height of interest	Not reached at height of interest
		D5	6.38453	8.14906	6.71672	5.99199	4.85756	Not reached at height of interest
	3.4b Pipeline 0.1D (Horizontal)	F2	12.7004	17.5213	16.7277	16.3658	15.8736	14.9478
		D5	9.8724	15.0069	14.22	13.8653	13.3825	12.4857



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Late Pool Fire Results

Distance downwind to defined radiation levels

The reported radiations are defined in the parameters

Path	Scenario	Weather	Pool diameter [m]	Distance downwind to intensity level 1 (8.02 kW/m ²) [m]	Distance downwind to intensity level 2 (10.9 kW/m ²) [m]	Distance downwind to intensity level 3 (12.7 kW/m ²) [m]	Distance downwind to intensity level 4 (15.9 kW/m ²) [m]	Distance downwind to intensity level 5 (25.6 kW/m ²) [m]
EG3\Buffer Tanks	3.1 Instantaneous release	F2	24.2119	106.892	94.0115	88.0822	79.8614	63.8693
		D5	23.9896	110.496	98.2652	92.6273	84.7467	71.1081



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Fireball Results

Distance downwind to defined radiation levels

The reported radiations are defined in the parameters

Path	Scenario	Weather	Fireball diameter [m]	Distance downwind to intensity level 1 (6.3 kW/m ²) [m]	Distance downwind to intensity level 2 (12.5 kW/m ²) [m]	Distance downwind to intensity level 3 (25 kW/m ²) [m]	Distance downwind to intensity level 4 (37.5 kW/m ²) [m]
EG3\Buffer Tanks	3.1 Instantaneous release	F2	142.089	438.579	315.587	223.619	181.121
		D5	142.089	430.54	310.194	220.009	178.256

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Flash Fire Results

Distance downwind to defined concentrations

The reported LFL and LFL fraction are defined in the respective material property

Path	Scenario	Weather	Distance downwind to LFL [m]	Distance downwind to LFL Fraction [m]
EG3\Buffer Tanks	3.1 Instantaneous release	F2	37.1715	96.3487
		D5	100.534	160.633
	3.2a Release over 10 minutes (Vertical)	F2	0.128395	0.139649
		D5	0.141825	0.157441
	3.2b Release over 10 minutes (Horizontal)	F2	44.021	98.0629
		D5	43.9424	107.791
	3.3 Pipeline rupture	F2	95.2379	206.892
		D5	96.6764	230.726
	3.4a Pipeline 0.1D (Vertical)	F2	0.0245888	0.0266719
		D5	0.0273688	0.03039
	3.4b Pipeline 0.1D (Horizontal)	F2	6.63615	13.1675
		D5	6.28709	11.7849

Maximum distance to LFL fraction at any height

Path	Scenario	Weather	Max flash fire distance [m]	Height of the max flash fire distance [m]	Time [s]
EG3\Buffer Tanks	3.1 Instantaneous release	F2	90.2743	0	21.6374
		D5	157.64	0	64.8891
	3.2a Release over 10 minutes (Vertical)	F2	5.44375	32.863	4.11067
		D5	7.25314	25.5017	4.10945
	3.2b Release over 10 minutes (Horizontal)	F2	97.9017	0.683026	58.1242
		D5	107.848	0.828128	10.5729
	3.3 Pipeline rupture	F2	208.079	0.226917	83.3782
		D5	229.739	0.401373	23.0337
	3.4a Pipeline 0.1D (Vertical)	F2	1.02398	8.18277	1.91797
		D5	1.34782	6.02683	1.91795
	3.4b Pipeline 0.1D (Horizontal)	F2	13.2421	1.0137	7.51445
		D5	11.767	1.00876	1.91796

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Explosion Results

Explosion scenarios for worst-case maximum downwind distance to defined overpressures.

The reported overpressures are defined in the explosion parameters

Path	Scenario	Weather	Overpressure level [bar]	Maximum distance [m]	Diameter [m]	
EG3\Buffer Tanks	3.1 Instantaneous release	F2	0.03	149.733	297.256	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	
			D5	0.03	151.617	294.919
				0.168	Not reachable	0
				0.365	Not reachable	0
				0.942	Not reachable	0
	3.2b Release over 10 minutes (Horizontal)	F2		0.03	43.282	39.6739
				0.168	Not reachable	0
				0.365	Not reachable	0
				0.942	Not reachable	0
		D5	0.03	41.185	37.3978	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	
3.3 Pipeline rupture	F2		0.03	89.1631	79.2279	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	
		D5	0.03	86.1082	75.0597	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	
3.4b Pipeline 0.1D (Horizontal)	F2		0.03	6.93856	6.6139	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	
		D5	0.03	6.39642	6.12071	
			0.168	Not reachable	0	
			0.365	Not reachable	0	
			0.942	Not reachable	0	

Supplementary data for worst-case explosion scenarios

Path	Scenario	Weather	Overpressure level [bar]	Explosion flammable mass [kg]	Ignition time [s]	Ignition source [m]	Cloud centre [m]	Explosion centre [m]	
EG3\Buffer Tanks	3.1 Instantaneous release	F2	0.03	5255.65	0.457258	40	1.10494	1.10494	
			0.168		0	Not reachable	Not	0	
			0.365		0	reachable	reachable	0	
			0.942		0	Not reachable	Not	0	
			D5	0.03	5132.65	0.872157	50	4.15752	4.15752
				0.168		0	Not reachable	Not	0
				0.365		0	reachable	reachable	0
				0.942		0	Not reachable	Not	0
	3.2b Release over 10 minutes (Horizontal)	F2		0.03	12.4953	9.86648	80	23.4451	23.4451
				0.168		0	Not reachable	Not	0
				0.365		0	reachable	reachable	0
				0.942		0	Not reachable	Not	0
		D5	0.03			80	23.4451	23.4451	
			0.168		0	Not reachable	Not	0	
			0.365		0	reachable	reachable	0	
			0.942		0	Not reachable	Not	0	

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		D5	0.03	10.4658	4.26591	80	22.4561	22.4861
			0.168		0	Not	Not	0
			0.365		0	reachable	reachable	0
			0.942		0	Not	Not	0
						reachable	reachable	
						Not	Not	
						reachable	reachable	
						Not	Not	
						reachable	reachable	
	3.3 Pipeline rupture	F2	0.03	99.5103	52.644	200	49.5492	49.5492
			0.168		0	Not	Not	0
			0.365		0	reachable	reachable	0
			0.942		0	Not	Not	0
						reachable	reachable	
						Not	Not	
						reachable	reachable	
						Not	Not	
						reachable	reachable	
		D5	0.03	84.6161	19.8985	220	48.5783	48.5783
			0.168		0	Not	Not	0
			0.365		0	reachable	reachable	0
			0.942		0	Not	Not	0
						reachable	reachable	
						Not	Not	
						reachable	reachable	
						Not	Not	
						reachable	reachable	
	3.4b Pipeline 0.1D (Horizontal)	F2	0.03	0.0578904	1.91795	10	3.63161	3.63161
			0.168		0	Not	Not	0
			0.365		0	reachable	reachable	0
			0.942		0	Not	Not	0
						reachable	reachable	
						Not	Not	
						reachable	reachable	
						Not	Not	
						reachable	reachable	
		D5	0.03	0.0458815	1.91796	10	3.33607	3.33607
			0.168		0	Not	Not	0
			0.365		0	reachable	reachable	0
			0.942		0	Not	Not	0
						reachable	reachable	
						Not	Not	
						reachable	reachable	



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